ESTABLISHMENT OF AN AVOCADO INNOVATION PLATFORM TO ENHANCE SMALLHOLDER FARMERS' CAPACITY IN AVOCADO PRODUCTION AND MARKETING IN GISAGARA DISTRICT, RWANDA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy in Agricultural and Rural Innovation of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

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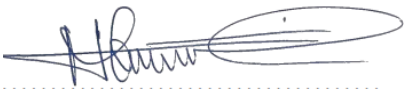
ED23/16553/18

Recommendation

This thesis has been submitted with our approval as university supervisors.

Signature :  Date : 28/09/2025

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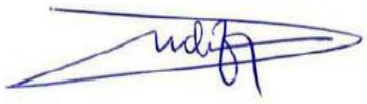
Signature:  Date……28/09/2025……

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DEDICATION

This thesis is dedicated to my beloved husband Dr. Nsengumuremyi Concorde, my beloved sons Hirwa Zidane and Hirwa Lucky, my beloved daughter Hirwa Celine, my father and mother, my brothers and sisters.

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ABSTRACT

Avocado is a high-value crop with increasing global and local demand due to its nutritional and health benefits. In Rwanda, despite favorable agro-climatic conditions, the production of high-quality avocados remains low for the local and international markets. Moreover, there is inadequate knowledge among farmers on avocado quality and varieties. The purpose of this study was to develop an innovation platform for building the capacity of smallholder farmers in avocado production and marketing in Gisagara District, Rwanda. The study employed participatory action research and survey research designs. A simple random sampling method was used to select 143 farmers to participate in the survey. A purposeful sampling method was used to select the four sectors in Gisagara District. The sample size per sector was allocated proportionately. A household questionnaire with closed and open-ended questions was used to collect data from household heads. Focus group discussions were held to get information from key informants including six extension staff, four input suppliers, six traders, two processors, and two exporters all of whom participated in the avocado innovation platform. The instruments were validated by the experts in the Department of Agricultural Education and Extension. Thirty farmers from Gatare Sector of Nyamagabe District were randomly selected for a pilot survey to pre-test the survey instruments and their reliability. Cronbach's alpha was used to measure the instrument's internal consistency and a reliability coefficient of 0.79 or higher was accepted. The data was analyzed using the Statistical Package for Social Science (SPSS) and NVivo. Quantitative and qualitative tests were used to analyze data. Analyzed data was presented descriptively using frequency, percentages, standard deviation, and means. Thematic analysis was used in qualitative data. chi-square and T-test statistics were used to test the hypotheses at $\alpha = 0.05$ level of significance. The findings indicated that the main challenges faced by the smallholder farmers in avocado production and marketing were the lack of access to land for avocado growing, (M=4.21, SD=.72) Obtaining quality avocado seedlings (M=4.12, SD=.74), the low quality of avocado fruits (M=4.16, SD=.71), and Low prices for avocado fruits in the market (M=3.97, SD=.79). The level of knowledge and skills acquired by the participants during the AIP process was found to be significantly higher statistically (t=-13.57, df=64, p <.001). The study found that innovation platforms significantly improved farmers' knowledge of pruning, grafting, pest management, post-harvest handling, and market access. The study recommends the continuity of the established Avocado Innovation Platform in Gisagara District and to scale it up in other districts of the country.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AIP	Avocado Innovation Platform
AIPS	Agricultural Innovation Platform Systems
EICV	Integrated Household Living Conditions Survey
FAO	Food and Agriculture Organization (United Nations)
FGDs	Focus Group Discussions
GAP	Good Agricultural Practices
GDP	Gross domestic Product
GoR	Government of Rwanda
IAR4D	Integrated Agricultural Research for Development
IPs	Innovation Platforms
MINAGRI	Ministry of Agriculture, Republic of Rwanda
MINECOFIN	Ministry for Finance and Economic Planning
NGOs	Non-Government Organizations
NISR	National Institute of Statistics of Rwanda
PAR	Participatory Action Research
RAB	Rwanda Agriculture Board
Rwf	Rwandan Francs
SHF	Smallholder Farmers
SPSS	Statistical Program for Social Sciences
VC	Value Chain

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Avocado (*Persea americana,* avoka) is a dicotyledonous plant that belongs to the Plantae kingdom, Magnoliophyta Division, Magnoliopsida Class, laurales order, and lauraceous family (Schaffer et al., 2013). It grows in countries with tropical and subtropical climates (Tan et al., 2017). Avocado has its origin in Mexico, from where it spread to the western countries in the early 1500s (Galindo-Tovar et al., 2008). Due to the nutritional properties and economic benefits of avocado, the crop has spread to Rwanda and other parts of the world. Approximately 141,130 metric tons of avocados are produced in Rwanda annually, however the majority of these are of export-unfit kinds (Thorsen & Woodbridge, 2011a). Southern and Eastern provinces are the highest producers of avocado in Rwanda. The avocado fruit plays an important role in human health, because of its nutritional value. Eating the fruit may result in solving health problems including heart diseases, cancer, obesity, and diabetes (Tabeshpour et al., 2017). The avocado fruit is also used in many cosmetic products including hair conditioners, makeup, and lip stick (Rodríguez-Carpena et al., 2012). The fruit contains vitamins A, B, C, K, and E, magnesium, potassium, sodium, folate, niacin, choline, sugar, pantothenic acid, riboflavin, lutein, kryptoxanthin, phytosterols, monounsaturated fatty acids, and dietary fibers (Iii et al., 2013), all of which are useful to the human body.

The avocado trees are also good for soil erosion control and are planted in high altitude areas. The avocado tree is also considered one of the important shade trees as it is mixed with coffee while farmers also benefit from the sale of the avocado fruits (Selladurai and Awachare, 2020). Avocado production has raised smallholder farmers' incomes in Gisagara District, and they can benefit even more while selling their produce to the international markets which generally offer higher prices in comparison with local markets (Norton, 2017). The most avocado-producing countries are Mexico, Australia, the United States, Malaysia, Colombia, Peru, Dominican Republic, Indonesia, Kenya, Brazil, Ethiopia, Haiti, Chili, and South Africa (Tan et al., 2017). For many nations, including Mexico, Indonesia, the Dominican Republic, the United States, Colombia, Chile, and Peru, the export of avocado fruit brings in significant sums of money.

Mexico is the largest producer and exporter of avocado fruits based on production per nation, and it has been for at least the last ten years. Colombia and Peru are the next two producers, with capacities of 2,393,849, 829,147, and 672,232 tons, respectively (FAO, 2020). With yearly output of 322,556, 245,336, 93,565, 84,775, 74,871, and 69,940 tons, respectively,

Kenya, Ethiopia, Malawi, South Africa, Cameroon, and Morocco are Africa's top producers of avocado fruits.

Avocado has economic importance in farming communities in East Africa (Gyau et al., 2016). *Fuerte* and *Hass* are the best popular avocadoes preferred for export purposes (Dreher & Davenport, 2013). The quantity of *Fuerte* and *Hass*'s avocado produced in Rwanda is not sufficient for local and export purposes. The annual production is about 141, 130t/yr and most of them are local varieties that are not preferred to the international market due to limited information on different avocado varieties and market access among smallholder farmers (Ministry of Agriculture and Animal Resources, 2013). Farmers' awareness and training on good agricultural practices for the growth of these high- value avocado varieties are still needed in the country. Extension services have to build the knowledge stock of avocado farming communities in avocado production and marketing (George et al., 2018). The international markets for agricultural commodities offer good prices but require good quality as well compared to the local markets in developing countries (Minten et al., 2009). Targeting these markets could increase the income and improve the livelihood of the farmers and yet the production of high-quality fruits of this crop as required by the international market has several limiting factors (Ramírez & Morales, 2019).

The primary obstacle has been determined to be farmers' lack of technical and scientific knowledge on the proper application of agronomical procedures. that results in low-quality avocados that are not preferred in the international markets (Ramírez-Gil, 2018). Other limiting factors include the use of low-quality seedlings, lack of knowledge on disease management, and lack of information on good horticultural practices including fertilizer and water (Zohra et al., 2022). Moreover, the farmers have not been introduced to international markets, but majorly produce for the local market. This has continued to make it difficult for smallholder farmers to access the export market. If participants in the chain collaborate to build the value chain from fruit production, processing, and marketing, the avocado fruit value chain can significantly reduce poverty by creating jobs and income for nearby small-scale farmers (Faris, 2016). Thus, there is a need to initiate interventions to build capacity among the smallholder farmers to produce for the export market. This will require collective action among the main stakeholders in the avocado value chain. Building the capacity of smallholder farmers in avocado production and marketing was through the establishment of avocado innovation platform in Gisagara District of Rwanda.

Numerous nutrients are needed by the avocado tree. Avocado tree growth and development can be impacted by infertile soil and inadequate fertilizer availability, which can

lower production (Selladurai & Awachare, 2020). The nutrient required by an avocado tree depends on its growth stage (Food Agriculture Organization, 2000). Farmers have to apply the appropriate fertilizers to their avocado trees. The use of organic farming in avocado production is considered a means to obtain premium prices for produce as international markets are mostly demanding organic avocados (Hattam & Lacombe, 2012). Synthetic chemical fertilizers and pesticides are avoided in organic farming. The ways that conventional and organic farms manage diseases, weeds, pests, and fertilizers like manures and composts vary greatly (Villamil et al., 2018).

Trees that produce avocados are susceptible to water scarcity. Fruit drops can happen at any stage of growth if there is a shortage of water. Fruit quality is adversely affected by water stress in the later stages of fruit growth. The quantity and quality of the fruit produced by the avocado tree may also be impacted by the amount of water it receives (Holzapfel et al., 2017). The recommended amount of water to irrigate avocados varies between 800 and 900 mm per year. Smallholder farmers in Rwanda who have ventured into avocado production may not have all this information (Norton, 2017).

Disease control in the crop is yet another area where the farmers have shown weaknesses (Fischer et al., 2019). Since diseases can result in significant financial losses if they are not promptly identified and treated, they are regarded as one of the primary obstacles to crop management (Hardham & Blackman, 2018). The main loss of avocado production increases when pest feeds on the immature fruits which leads to a serious reduction in fruit quality and quantity.

The productivity potential of crops may be affected also by management practices. The farmer needs strong knowledge and information on the management practices of avocado trees to increase avocado yield, quality, and income as well. Organizing smallholder farmers into a platform or crop production groups could be very ideal for capacity building on the avocado value chain (Cechin et al., 2013; Ramirez et al., 2018). The development of an innovation platform (IP) could serve as a good means to achieve this (Dondofema & Grobbelaar, 2020). IP engaged the different players in the nation's avocado value chain through a participatory approach. In order to solve value chain problems and create and execute local policies, the innovation system approach is a multi-stakeholder, participatory strategy that integrates the knowledge of stakeholders (Davies et al., 2018).

The key stakeholders in avocado production and marketing in Rwanda are input suppliers, traders, processors, exporters, collectors, mini markets, and supermarkets. They help to create space for learning, action, and change and they are inherently inclusive and

participatory (Pamuk & Van Rijn, 2019). Despite the potential of using an IP to find solutions to the challenges faced by smallholder farmers in the Gisagara District of Rwanda, to date, it has not been done specifically for avocado production and marketing. There is no accurate data on avocado production and marketing in Gisagara District as the avocado farmers are not organized in any recognized cooperatives, they are just producing and selling their avocados on their own. This study used an innovation platform as a tool for empowering smallholder farmers in avocado production and marketing in the Gisagara District of Rwanda.

1.2 Statement of the Problem

Avocado fruits are of high nutritional value, find use in cosmetics, and thus can have high economic value to the growers. The global market for this crop is also expanding rapidly. These fruits are being used as food and can be consumed as plain fruit in salads or as juice. Despite the importance of the avocado crop in Rwanda, the country is yet to see any advances in its production in which farmers have embraced good management practices and are realizing high yields of good quality crops that can fetch good prices in the local and international markets. Moreover, there is limited knowledge among farmers on avocado quality and varieties, both for the local and export markets. This inevitably means low prices for the farmers for their produce, which is reflected in their livelihoods, especially in Gisagara District which has a high potential for avocado production. In contrast, the increased local consumption of avocadoes and the possibility of exporting some should be matched with improved productivity to meet the demand and fetch a good price for the farmer. Therefore, there is a need to address the knowledge and information gaps among smallholder farmers on high-quality avocado production and building their capacity. A joint innovation platform that brought on board various stakeholders in avocado along the avocado value chain was proposed, without which it would continue to be difficult to realize profitability for smallholders in avocado production and marketing in Gisagara District of Rwanda.

1.3 Objectives of the Study

1.3.1 Purpose of the Study

The purpose of this study was to develop in a participatory manner, an innovation platform for building the capacity of smallholder farmers in avocado production and marketing in Gisagara District, Rwanda.

1.3.2 Specific objectives of the Study

This study aimed to achieve the following specific objectives:

i. To determine the challenges and opportunities to produce quality avocado fruits for local and export markets in Gisagara District, Rwanda.
ii. To assess the roles of avocado value chain stakeholders in avocado production and marketing in Gisagara District, Rwanda.
iii. To determine the multi-stakeholder network features that could effectively promote high-quality avocado production in Gisagara District, Rwanda.
iv. To establish an innovation platform for enhanced avocado production and marketing in Gisagara District, Rwanda.
v. To determine the contribution of the Avocado Innovation platform in enhancing the acquisition of farmers' knowledge and skills in the production and marketing of Avocados in Gisagara District, Rwanda.

1.4 Research Questions

The study attempted to answer the following research questions:

i. What are the challenges and opportunities to produce quality avocadoes for local and export markets in Gisagara District, Rwanda?
ii. What are the roles of avocado value chain stakeholders in avocado production and marketing in Gisagara District, Rwanda?
iii. What are the multi-stakeholder network features that could effectively promote high-quality avocado production in Gisagara District, Rwanda?
iv. How can an innovation platform build the capacity of smallholder farmers to enhance avocado production and marketing in Gisagara District, Rwanda?
v. What is the contribution of the avocado innovation platform in enhancing the acquisition of farmers' knowledge and skills in the production and marketing of Avocados in Gasagara District, Rwanda.

1.5 Significance of the Study

This study was conducted in Gisagara District. The district was deliberately selected as the study area due to its socio-economic, agro-ecological, and strategic importance in avocado production in Rwanda. The district has favorable climatic conditions and fertile soils suitable for avocado cultivation, making it one of the potential hubs for both subsistence and commercial production. Avocado farming is already a common livelihood activity in Gisagara,

yet productivity and market access remain constrained by limited technical knowledge, poor post-harvest handling, and weak value chain linkages. This study through participatory action research sought to link the new knowledge and existing knowledge to increase the capacity of smallholder farmers in avocado production and marketing. This would help the smallholder farmers to meet the standard quality required in the local and international markets. The study findings provided useful information among the avocado value chain actors on avocado production and marketing particularly in Gisagara District, and Rwanda in general. The results derived from the study could also guide other avocado farmers in best practices elsewhere in the country to boost productivity and ensure the high quality of the crop. The information derived from this study could further help other actors along the avocado value chain to effectively play their roles by assisting farmers in matching their production with the demand. Lastly, any successes in high-quality avocado production in Gisagara District could be scaled up to other districts in the country for improved livelihoods.

1.6 Scope of the Study

This study was conducted in Gisagara District, Rwanda. It focused on building the capacity of smallholder farmers in avocado production and marketing. The study first determined the challenges and opportunities for the production of quality avocadoes for local and export markets, key stakeholders, and their roles in avocado production and marketing. The study further assessed multi-stakeholder network features that could effectively promote avocado production, and finally, the study established an innovation platform (IP) to enhance avocado productivity and marketing, and it also evaluated the effect of an innovation platform on the production and marketing of avocadoes in Gisagara District, Rwanda. The IP aimed to bring together different actors in the avocado value chain in order to identify challenges and find solutions in avocado the value chain.

1.7 Assumptions of the Study

In this study, it was assumed that:

i. Avocado value chain actors were willing to participate actively in the innovation platform to build the capacity of smallholder farmers in avocado production and marketing in Gisagara District, Rwanda.
ii. Participants provided honest responses to the questions regarding avocado production and marketing.
iii. Adequate avocado germplasm was available in the country in sufficient quantities.

1.8 Limitations of the Study

The following were the limitations of the study:

i. The research used enumerators. There is a chance for farmers and enumerators to misinterpret some concepts during interviews with farmers. To counteract this, the researcher provided appropriate training to enumerators and translated the research instruments into the local language (i.e. the research instruments were administered in Kinyarwanda).
ii. Caution should be exercised in generalization of the findings from this study.

1.9 Definition of Terms

Building capacity: The phrase refers to improving or fortifying an individual's or organization's ability to accomplish their objectives (Zohra et al., 2022). In this study, building capacity means increasing the abilities of avocado smallholder farmers to learn and get knowledge packages on avocado production and marketing through an innovation platform.

Good agricultural practices (GAP): GAP are a collection of standards for postproduction and on-farm production processes that result in wholesome and safe food and non-food agricultural products while taking sustainability in the social, economic, and environmental domains into consideration (FAO, 2016). In this study, good agricultural practices mean the certification system for avocados, specifying procedures that must be implemented to create avocados for consumers or further processing that is safe and using sustainable methods.

Innovation: is the process of altering goods, procedures, and services in both major and minor ways, drastically and gradually, in order to introduce something new for the company that benefits clients and adds to its knowledge base (Zohra et al., 2022). In this study, the term innovation is used to mean the action or process of innovating. In avocado production and marketing, it means the use of new a method and the practical implementation of ideas that result in good quality avocados for the local and international market.

Innovation platform: is a place where people can learn, act, and transform (Schut et al., 2017). In order to empower smallholder farmers in the production and selling of avocados, this study defines an innovation platform as networks of many stakeholders that collaborate and communicate in order to create a common vision and find solutions to a problem together.

Marketing: is the process of planning and executing the development, pricing, promotion, and distribution of ideas, goods, and services to create transactions that satisfy the goals of the business and the individual (Baker, 2016). The term marketing in this study refers to precisely identifying the needs and desires of avocado markets and providing the intended satisfactions.

The established IP in this study helped the farmer to know how to produce what they can sell, instead of trying to sell what they have.

Market chain: is a network of businesses, supply chains, or markets that work together to produce, distribute, and deliver goods or services to consumers (Barney, 1991). The term market was used by this study to show the network or system of interconnected markets, of the avocado fruit.

Productivity: The ratio of input volume to output volume is a common definition of productivity. In other words, it measures how well an economy generates a given amount of output using labor and capital as production inputs. Productivity is thought to be a key factor in economic growth and competitiveness (Linna, 2010). For this study, productivity is about the amount and caliber of avocado fruits that the avocado tree produces.

Smallholder farmers are those who work in less than one hectare as farmers, ranchers, forest guardians, and fishermen (FAO, 2012). In this study, a smallholder farmer will be a farmer whose farm size varies from one hectare and below.

Stakeholders: Individuals, organizations, or groups that are interested in or worried about the management of particular resources are known as stakeholders. Anybody who influences or is impacted by the innovation platform's decisions, policies, and actions is considered a stakeholder in this study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The literature review covers the overview of the agricultural sector in Rwanda and the global and regional perspectives of avocado production. It also includes information on the requirements for a productive avocado enterprise, management of avocado diseases and pests in Rwanda, harvesting and post- harvest handling of avocado, avocado production, and marketing in Rwanda. The review further presents the role of innovation platforms in agriculture and networks in a multistakeholder platform for avocado production. The chapter lastly outlines a conceptual framework that illustrates the relationship between the dependent and independent variables and how the study utilized the variables in developing an innovation platform.

2.2 Overview of the Agricultural Sector in Rwanda

Trade in agricultural products plays a significant role in Rwanda's economy (MINAGRI, 2019). With an annual GDP growth rate of almost 7% between 2007 and 2019, the Rwandan economy has been expanding steadily during the last ten years (NISR, 2018). The combined efforts of several economic sectors primarily the industrial, agricultural, and service sectors have led to this economic expansion. Although the agricultural sector makes up a large portion of a nation's GDP, its share varies over time due to factors including changing weather patterns, dwindling soil fertility, and plant pests and diseases that reduce output. Rwanda's performance in the global market is also influenced by the agriculture sector's growth in exports (NISR, 2019).

Not only does agriculture contribute significantly to the country's economic growth, but it also advances a number of other socioeconomic domains, such as industry, trade, health, and community well-being. This is accomplished by providing basic resources for agricultural processing, guaranteeing the supply of sufficient, healthy, and nutritious food, and providing economic and entrepreneurial opportunities at various stages of the value chain. Additionally, the agricultural industry creates jobs and new work prospects for Rwandans. Approximately 69% of Rwanda's total population currently works in agriculture, with 80% of them living in rural areas. Approximately 87% of people without formal education and 76% of people with only an elementary education work in this sector. Agriculture employs less than 8% of highly educated people with a university degree (NISR, 2018). As such, the vast majority of the

agricultural workers may have few opportunities for joint learning and experience sharing. This makes it more difficult to combine new ideas with existing knowledge.

Two important national development initiatives that support Rwanda's agricultural development plans and policies are Rwanda Vision 2050 and the National Transformation Strategy. The foundation of these initiatives is Vision 2020. A key document that directs Rwanda's agricultural development is the Fourth Strategic Agriculture Transformation Plan 2018–2024 and the National Agricultural Policy. Rwanda and the majority of sub-Saharan African nations have reaffirmed their commitment to modernizing their agricultural industries. Agricultural transformation is employed in these agriculture-based nations to lower poverty, guarantee population food security, and promote general economic growth (Wiggins, 2014). According to Olwande et al. (2015), transformation is typically defined as a change from low-productivity subsistence farming to a production system focused on the market. Alongside this, better inputs are being used to increase agricultural productivity for food marketing and self-sufficiency.

While incorporating gender problems into all policies, the Rwandan government has been working to assist farmers to transition from subsistence to market-oriented agriculture during the past 15 years. Numerous initiatives have been undertaken to boost farmers' access to markets, support agricultural cooperatives, and fortify production systems (Verhofstadt & Maertens, 2014). About 76% of Rwandans depend on subsistence farming as their main source of income (NISR 2020), which makes it difficult to achieve the government's intended agricultural transformation. The high proportion of subsistence farmers can be attributed to a number of factors, such as their reliance on rain-fed production, limited use of modern inputs, and small plots of land (MINAGRI, 2019).

By denying access to internationally linked markets, market rigidities such as financial barriers, both public and private further impede commercialization (NEPAD, 2017). To guarantee that Rwanda's plan to revolutionize the agricultural sector (MINAGRI, 20113) aligns with a larger initiative to bring about a Green Revolution in Sub-Saharan Africa, the National Agriculture Policy offers guidance.

By favoring contemporary commercial agriculture over subsistence farming, Rwandan politicians aimed to change the country's agricultural landscape. In order to raise the incomes of Rwanda's smallholder farmers from subsistence farming, which traps them in poverty, to monocropping and trade, the Ministry for Finance and Economic Planning (MINECOFIN) proposed land reforms, agricultural resources, modern agricultural practices, and value chain supports (MINAGRI, 2019). The widespread commercialization of agricultural production and

the use of land as a method of securing and financing investment in innovative agricultural processes were made possible by the land reforms.

A number of changes and programs were implemented, including as the National Agriculture Policy in 2004, which included four stages of the National Agricultural Export Board's Strategic Plan for Agriculture Transformation (NAEB, 2018). Every phase builds on the achievements of previous strategies, beginning with those that reduced rural poverty through commodity diversification and productivity gains, and then moving on to strategic efforts that encouraged smallholder market participation. In order to maximize commercial uses, these were achieved by updating smallholder practices and offering better agricultural inputs and extension services (Rispoli et al., 2019). More ambitious plans to lower malnutrition and enhance food security for all Rwandans through diffused economic growth were made possible by these poverty-reducing measures (MINAGRI, 2019).

2.3 Horticulture Sector in Rwanda

Rwanda's horticultural sector is dedicated to producing high-quality, eco-friendly goods while protecting the consumers' health and well-being. If properly utilized, the horticulture subsector has a lot of potential and can help reduce poverty and promote economic growth (NAEB, 2020). The horticulture industry in the nation is distinguished by its favorable climate, rich soil, and a large, industrious workforce. Due to its comparative advantages' fertile soils, an abundance of water resources, and a large labor force the nation has a strong competitive base that is leveraged to generate competitive and high-quality horticultural goods that are sold on both the regional and global markets.

In Rwanda, vegetables such as tomatoes, green peppers, French beans, chili peppers, carrots, hot paper, and onions are the primary horticultural crops. Fruits: bananas, strawberries, passion fruit, pineapples, avocados, and mangoes; groundnuts and macadamia nuts; Spices: celery, processed pepper, ginger, garlic, lemongrass, parsley, and chilli; blooms include alstroemeria, calla lilies, agapanthus, tuberoses, roses, Zantedeschia blooms, and decorative sunflowers.

The topography and temperature of Rwanda are ideal for growing a variety of fruits, vegetables, and flowers. European-style fruits and vegetables, such as beans, peas, cauliflower, mushrooms, citrus fruit, and strawberries, thrive in a wide swath of cool, humid terrain in the west. Tropical fruits like pineapple, passion fruit, and bananas thrive in the warm, humid central south. Groundnuts, sunflowers, and pulses thrive in the arid, warm northeast (NAEB, 2010). Because of its diverse geography, Rwanda has certain unique natural niche advantages

for horticulture in addition to the same agroclimatic benefits enjoyed by other East African nations.

horticultural yields in 2009 were already within the regional range between Ethiopia and Kenya at the top and Uganda and Tanzania at the bottom. This was prior to significant investments being made in better planting supplies or techniques (NAEB, 2010). This is seen by the government as a sign of exceptional growth potential. Compared to Kenya, Tanzania, Uganda, and Ethiopia, Rwanda is starting from a relatively low base when it comes to growing commercial horticulture. horticulture is now the export industry with the quickest rate of growth. The current resurgence of demand for horticultural products worldwide (from China, India, and the Gulf more than from Europe), as well as in sub-regional markets (Congo) and domestically, appears to be a boon to Rwandan horticulture (MINECOFIN, 2011).

The majority of Rwanda's horticulture exports go to markets in the region and Europe. About half of Rwanda's non-traditional exports to markets including Burundi, the Democratic Republic of the Congo, and South Sudan, as well as international destinations like the US and the EU, originate from this sector, which has grown to be significant to the country's economy. As a result, horticultural farmers, particularly avocado growers, have a high chance of receiving premium pricing for their produce. However, avocado farmers must produce quality avocados that can be sold at the international markets. The smallholder farmers need to be trained and have adequate knowledge and skills on quality avocados required by the international markets. They also need to be in the platform which can facilitate them to access all information and knowledge sharing. It also helps smallholder farmers to get good prices and income in order to improve their livelihood.

2.4 Importance of Avocado in Rwanda

The demand for avocados is high and rising worldwide, especially in developed economies where consumers are drawn to the fruit's flavor and nutritional content (Thorsen & Woodbridge, 2011b). When it comes to growing and exporting avocados, Rwanda offers a variety of inherent competitive advantages. Almost everywhere in the nation, cooperatives and small-scale farmers grow the crop. Avocado plantations can be found in the provinces of Kigali City, the South, the North, the East, and the West. In Rwanda, avocados are a popular fruit for both domestic and international markets. The two avocado types that are most commonly farmed for the export market are Hass and Fuertes. There are about 15 kinds of Fuertes that are grown and sold with a high fat content. Additionally, the local avocados have a good local market and a superior taste.

These races serve as the foundation for the major avocado cultivars. While a variety of cultivars are cultivated, the *hass* cultivar is the most extensively farmed and exported kind worldwide. The fact that *hass* yields large quantities of rich fruit with superior storage and shipping qualities is one among the factors contributing to its appeal. Seeds or seedlings can be used to grow avocados. Grafting enhances the variety's ability to withstand disease, increase yield, and adapt to various soil types.

The avocado value chain can make a significant direct contribution to poverty reduction by providing jobs, nutritious food and supporting other household activities that generate income for smallholder farmers if the stakeholders of the chain cooperate to develop the value chain from fruit production, processing, and marketing (Abduselam Faris, 2016). To make it easier to do business in Rwanda and to invest in the country's avocado exporting industry specifically, the Rwandan government is working with a number of public and donor players (Thorsen & Woodbridge, 2011b). The establishment of an avocado innovation platform that brings together different stakeholders along the avocado value chain is also necessary in order to facilitate communication.

In addition to being used in the oil, cosmetic, soap, and shampoo industries, avocados are also eaten as fresh fruit. Avocados have a rich flavor and a smooth, buttery texture, in contrast to many other fruits that are usually sweet or acidic. Avocados are often used as a salad fruit, but they can also be used to make guacamole and spreads for sandwiches. You may also make ice cream with avocado paste, flavor extracts, and skim milk. Avocado oil can be used to cook and prepare marinades, sauces, and salads. Additionally, avocado oil can be utilized in skin care items like makeup bases, moisturizers, hair conditioners, cleaning creams, and sunscreen lotions (Yahia, 2012). This information shows that avocado fruits have a very large demand on the market which should reflect with its production. Therefore, avocado farmers need to fulfill this demand by producing enough quantity and quality required by the consumers. The smallholder farmers have to be assisted through capacity building in avocado production and marketing.

2.5 Global and Regional Perspective of Avocado Production

The avocado (*Persea americana*) has been introduced in practically every country in the world because of its economic significance and nutritional qualities. A total of 5.57 million metric tonnes (MMTs) of avocados were produced in 2016, with 1.89 MMT, or 34%, coming from Mexico alone. The Dominican Republic, Indonesia, Peru, and Colombia are also excellent avocado-producing nations, contributing over 1.67 million metric tons, or 30% of the world's

total production. Tropical and subtropical regions, including Asia and Sub-Saharan Africa, have been exposed to avocados (Arpaia et al., 2012). Over 500 variants have been categorized by various studies. However, many are not commercial due to issues with commercial handling, such as resistance to transportation, and productivity issues, such as production time, fruit quantity, and quality, such as protein and fat content (Yahia, 2012).

Avocado output rose from 1183 tons in 1974 to 1578 tons in 1984, with an average growth rate of almost 9% worldwide (Abraham & Takrama, 2018). An estimated 6.3 million tonnes of avocados were produced worldwide in 2018, a 6.7% increase over 2017. Avocado is a crop that contributes significantly to employment, income, and foreign exchange profits in several sub-Saharan African nations FAOSTAT (2021). It helps East Africa's economy flourish (Toukem et al., 2020). Many avocado farmers in African countries including Rwanda are small-scale farmers. A growing number of small landholders in some African nations are growing avocados as an alternative crop to coffee (Doijode, 2020). With yearly output of 322,556, 245,336, 93,565, 84,775, 74,871, and 69,940 tons, respectively, Kenya, Ethiopia, Malawi, South Africa, Cameroon, and Morocco are Africa's top producers of avocado fruits (Nyakang'i et al., 2023). Avocado fruits are preferred by smallholder farmers or customers due to its flavor, odor, texture, fresh color, and fruit size (Mpho et al., 2013). Furthermore, the primary factors influencing its consumption include ripeness, attractiveness, quality, convenience, and value for money (Mpho et al., 2013). With an annual export value of US$12.7 million, the Tanzania value Authority lists avocado cultivation as one of the top ten export products in Tanzania, making it a growingly significant industry (Wangithi et al., 2022).

Due to low-quality seedlings, a lack of knowledge about avocado varieties, and a lack of knowledge about international markets, smallholder farmers (SHFs) in Rwanda have not grown many of the Hass or Fuerte avocado varieties that are in high demand on global markets, which has resulted in low exports of avocados (Zohra et al., 2022). The 82,000 metric tons of avocados grown in Rwanda each year are of local, non-export-grade cultivars (Thorsen & Woodbridge, 2011a). Over the past ten years, avocado output has increased at the highest rate of any major tropical fruit, averaging 6% annually (FAO, 2019b). However, with only 6% of all major tropical fruit production in 2018, avocados continue to be the smallest of the major tropical fruits (FAO, 2019b).

In both rich and developing nations, avocado consumption has grown dramatically (Tan et al., 2017). The main producing regions are where most avocados are consumed. Fresh avocado consumption per capita in the United States rose from 0.18 kg in 1970 to 0.68–1.0 kg in the late 1980s. This is comparable to pineapples (0.77 kg) and equal to nectarines, but it is

significantly less than that of bananas (11 kg), apples (8.7 kg), and oranges (6.6 kg) (Gyau et al., 2016).

Due to inadequate storage facilities and postharvest handling mechanisms, almost 30% of the avocados grown in Rwanda are lost after harvest and are primarily sold to local markets (Kitinoja & AlHassan, 2018). The major problem is the lack of good markets with good prices. The establishment of an innovation platform could help farmers meet with potential stakeholders who can buy their avocado produce at a very good price without a lot of damage and loss due to the proper harvesting methods.

2.6 Management Practices of Avocado Trees

2.6.1 Requirements for a productive avocado enterprise

Avocado trees are typically 9 meters tall, although they can grow up to 18 meters or more. Their trunks can be 30 to 60 cm in diameter, or they might be short and spreading, with branches near the ground. Only a few leaves are momentarily shed during dry seasons while the avocado tree is in blossom, making it nearly evergreen. The leaves vary in shape (lanceolate, elliptic, oval, ovate, or obovate), are 7.5 to 40 cm long, alternating, dark green, glossy on the upper surface, and whitish on the underside (Pliego et al., 2013).

The avocado's skin can have different colors and textures, while the fruit itself can be round, pear-shaped, or oblong. The skin can be smooth or rough, green-yellow, reddish-purple, purple, or black, and it can be supple or woody. When ripe, the fruit's flesh is buttery and greenish yellow to bright yellow, but less-than-ideal types may have fibrous flesh. Ten to twenty-five percent of the weight of the avocado fruit is made up of one big seed. The moisture and oil content of the fruit of various avocado types ranges from less than 5% to over 30% (Yahia, 2012).

Its favorable growing condition is a warm temperature and subtropical climatic condition (Tan et al., 2017). The fruit is composed of 60% of oil, 7% of skin, and 2% of seed (Wong et al., 2010). avocado trees can range in morphology from tall, upright examples to widely spreading forms with numerous branches. Fruit skins can be reddish-purple, deep-green, yellow-green, or very dark purple to nearly black. Pliable or granular and brittle, smooth or pebbled, shiny or dull, thin or leathery, and with a skin thickness of up to 6 mm, the fruit may be studded with tiny yellow dots (Menzel & Le Lagadec, 2014). Avocado plants are susceptible to both excess soil water brought on by inadequate drainage and water shortages. In regions with weak soils or high-water tables, the trees are particularly vulnerable to *Phytophthora cinnamomi*-caused root rot (Abraham & Takrama 2018).

According to botanical classification, there are three races of avocados: the West Indian, *Persea americana* Mill. var. *Americana* (P. *gratissima* Gaertn.), is tropical and has large, variably shaped fruit with a lower oil content; the Mexican, Persea *americana* Mill. var. *drymifolia* Blake (P. *drymifolia*), is semi-tropical and has smaller, elongated, thin-skinned fruit with a higher oil content; and the Guatemalan, P. *nubigena* var. *guatemalensis* L. Wms., is subtropical, with mostly round, thick-skinned fruit and medium oil content (Yahia, 2023). Originating in the mountains of Mexico and Central America, the Mexican race is distinguished by its thin, silky skin and very small fruit, weighing between 75 and 300 g. Native to Central America's highlands, Guatemalan fruit is not as resilient to cold weather as Mexican fruit, which is distinguished by its enormous, typically 500–600 g fruit and thick, brittle peel. The West Indian race, which is indigenous to the lowlands of northern South America and Central America, is distinguished by its smooth, leathery, and occasionally glossy skin and intermediate fruit size. The various breeds differ in terms of fruit ripeness and oil content (Carvalho et al., 2015). Avocado trees from the West Indies are often the most vulnerable to cold, and temperatures below 1.2°C can harm them (Yahia, 2023).

Mature Mexican trees can endure temperatures as low as -4°C without suffering any harm (Tripathi & Karunakaran, 2014). Mexican cultivars are the coldest tolerant of the three races and are best suited to the cool tropical and subtropical regions. The West Indian cultivars thrive in lowland tropical climates with high humidity and temperatures. In terms of climatic adaptation, the Guatemalan cultivars fall somewhat in the middle of these two varieties (Yahia, 2012). Avocado farmers need to know avocado races and varieties which is appropriate to their location in order to facilitate them choosing a proper variety that will not bring them a lot of challenges after the plantation. Training the farmers on quality seedlings and avocado varieties required for the local and export markets is also a goal of this study.

2.6.2 Climatic conditions

Avocados may not be productive if the temperatures exceed 38ºC for long periods. This causes poor fruit sets and excessive drops of the fruit. This can also occur when the temperature remains below 21ºC for extended periods which can affect the set of fruit poorly (Bender, 2012). The cold and heat in desert areas make it impossible to cultivate avocados successfully (Ramírez-Gil & Morales-Osorio, 2018). The climate in Rwanda is especially favorable for growing avocados. Rwanda is situated at an average elevation of 16400 meters, two degrees south of the equator. Rainfall occurs throughout the year, with averages exceeding 1,000

millimeters annually. With minimal fluctuation, the average temperature is 22 degrees Celsius and the humidity is 75% (Norton, 2017).

2.6.3 Soil requirements

For the tree to live a long and healthy life, it needs a fine sandy loam with sufficient drainage. Although well-drained shallow soils work well if watering occurs often, deep soils are preferable. Clay soils and shallow soils with impermeable subsoils are not suitable for avocado cultivation (Bender, 2012). Composted green waste is a great mulch for avocados, but composts made from manure and mushrooms are typically excessively heavy in salt and ammonia, which can cause excessive root burn and "tip-burn" in the leaves. When planting a tree, manures shouldn't be put to the soil backfill. Soil infertility and lacking nutrient supply can affect the growth and development of avocados leading to a decrease in yield (Selladurai & Awachare, 2020).

Degradation of Rwanda's soil quality has been caused by the loss of soil nutrients from ongoing cultivation with little to no inputs and no fallow periods as household land holdings have shrunk. Other factors include the cultivation of inappropriate areas like wetlands and steep slopes (Bizoza & Havugimana, 2013). Lack of soil-specific fertilizers and lack of skills on soil requirements for the avocado trees remain a concern among avocado producers in Rwanda (Nabahungu & Visser, 2013). Better management of soils is necessary to ensure that avocado yields can be sufficient and provide income to the farmers. Thus, there was a need to build capacity among the smallholder farmers in Rwanda on soil requirements for an avocado tree.

2.6.4 Irrigation

Both the frequency of irrigation and the amount of water to use during an irrigation event must be understood by the farmer. It is advised that sandy loam soils on the hillsides receive frequent, somewhat shallow irrigations (Silber et al., 2019). Less frequent irrigation is necessary for heavier soils, but it's crucial to prevent the shallow feeder roots from drying out too much (Bender, 2012). A tensiometer measurement or the feel of the soil are used to decide how often to water. Sunlight, temperature, humidity, wind speed, and wind run duration are some of the environmental elements that affect how much water the tree uses (Kiggundu et al., 2012). Fruit quality is adversely affected by water stress in the later stages of fruit growth. The quantity and quality of the fruit produced by the avocado tree may also be impacted by the amount of water that is applied to it (Holzapfel et al., 2017).

2.6.5 Fertilizer application

The majority of the mineral elements required for growth are found in the soil, but nitrogen and zinc are frequently deficient and must be supplied by the grower in the form of mulch or composted manure or chemical fertilizer. A lack of nitrogen causes the leaves to generally become yellow. The most widely used fertilizers are calcium nitrate, ammonium nitrate, urea, and calcium ammonium nitrate. Smaller leaves, more spherical fruit, and patchy yellowing between the veins are signs of zinc deficiency. According to some long-term research, applying potassium and phosphorus may increase yield (Bender, 2012). Inadequate fertilization of the soil can reduce production by as much as 70%, and the signs of a nutrient shortage differ depending on the mineral. Each tree should receive fertilization based on its age, size, and unique requirements. A surplus of fertilizer could contaminate the phreatic water if these elements are not appropriately evaluated (Sanchez & Ortiz, 1991; Selladurai & Awachare, 2020). Smallholder farmers in Rwanda who are involved in avocado production may not be having all this information (RDB, 2012). Inadequate farmer skills in agronomic techniques and knowledge of production are the main constraints of the avocado enterprise (Sina et al., 2024). Farmers' awareness and training on good agricultural practices for the growth of high-value avocado varieties are still needed in the country. Extension services have to build the knowledge stock of avocado farming communities in avocado production and marketing (George et al., 2018). One of the main issues that leads to low-quality avocados that are not sought after on global markets is farmers' lack of technical and scientific knowledge on the proper application of agronomical procedures (Ramírez-Gil, 2018).

2.6.6 Pruning

An avocado tree that receives a lot of pruning will grow healthier and produce more fruit. Compared to trees established in the wild, trees kept at lower elevations have higher overall vigor and fruit yield (Thorp & Stowell, 2001). Pruning also increases output by decreasing overcrowding, regardless of the health of the tree. Pruning is a crucial management technique in avocado cultivation to avoid crowding, enhance canopy light availability, and encourage regeneration. Avocado pruning, which includes making sure every section of the canopy receives enough light, is especially crucial for high-energy fruit trees (Westling et al., 2021).

2.7 Avocado Pest and Diseases Management

Pests and illnesses are among the biggest obstacles to the production of avocados. In addition to having a substantial effect on avocado productivity and growth, pests and illnesses

also raise production costs for farmers who must contain outbreaks (Ramírez-Gil et al., 2018). The avocado wilt complex is unique among avocado diseases. The avocado wilt complex is linked to a number of biotic and abiotic causative agents, each of which can cause the host to experience comparable or distinct symptoms (Ramírez-Gil, 2018). Because of its frequency, aggression, and the losses it causes, the oomycete *Phytophthora cinnamomi* Rands is thought to be the most important causative agent in the avocado wilt complex (Belisle, 2019). This does not rule out the presence of additional pathogenic agents linked to the avocado wilt complex, including *Phytophthora heveae Thompson*, *Phytophthora citricola Sawada, Verticillium sp., Armillaria mellea* (Vahl: Fr.) *Kumm, Armillaria* sp., *Cylindrocladium* sp., *Fusarium solani* Sacc., Fusarium *oxysporum* Schlecht, Fusarium *equiseti* (Corda) Sacc. *sensu* Gordon, Rhizoctonia sp., Phymatotrichum omnivorum (Shear) Duggar, Cylindrocladiella sp., *Pythium* sp., Pythium vexans, *Cilindrocarpon destructans*, and the nematodes *Helicotylenchus* sp., *Rotylenchulus* sp., and *Pratylenchus* sp (Pérez, 2008). There have also been reports of additional abiotic origin-related elements. For instance, one of the main reasons why avocado crops die is hypoxia-anoxia (Ramírez-Gil, 2018).

There is a dearth of information on the economic loss of avocado wilt complex worldwide, and the great majority of reports that are currently available are related to P. *cinnamonomi*. According to Van den Berg et al. (2021), losses in commercial plantations range from 45 to 90%, and it reduces avocado productivity by 20 to 25%. Its impact is so great that Ramírez-Gil, Morales-Osorio, and Peterson (2021) estimated that this virus was present in all of the producing municipalities and affected 5% of the surface area planted with avocado in Mexico. To calculate the avocado wilt complex's economic impacts, Ramírez-Gil and Morales-Osorio (2018) put out a novel method based on a seven-year study that encompassed all developmental stages, under various production systems, and quantified the losses in terms of mortality, production reduction, and management consequences. There is a lack of agreement on the outcomes of known research conducted for P. *cinnamonomi* in relation to the management of the avocado wilt complex, indicating the necessity of an integrated approach. According to Ramírez-Gil and Morales (2019), some of the strategies that have been reported so far include the use of resistant rootstocks, antagonism with microorganisms, solarization, pruning, reducing soil moisture, applying fertilizer rich in calcium, phosphorous, and silicon, applying fungicides to the soil and foliar products like potassium and aluminum phosphite, and metalaxyl, and reducing soil moisture levels.

By altering the canopy's humidity, adding light, and altering the environment that encourages disease and pests, pruning can alter the strain on pests. Pruning also makes it

possible for more complete and efficient spray coverage. The most crucial cultural element in controlling tree disease is most likely irrigation. Many root infections require irrigations that are too frequent, too infrequent, or timed incorrectly. Distressed root systems caused by waterlogging and other stressful situations encourage fungus called Phytophthora spp. Harvest timing to avoid pests and diseases is also necessary. Many smallholder farmers have basic knowledge about common pests and diseases affecting avocados as they can identify symptoms (Thorsen & Woodbridge, 2011b). there are ongoing challenges related to access to resources and adapting to new threats. Continued support through education, access to inputs, and climate-smart agriculture practices will be crucial in improving their resilience and productivity in avocado cultivation. Collaborative efforts of various stakeholders in the avocado value chain are needed.

2.8 Management of Avocado Diseases and Pests in Rwanda

Fruit flies and caterpillars attacking the avocado plants are the main pests and illnesses affecting the crop in Rwanda. The two main illnesses are (i) *Phytophthora cinnamomi*-induced avocado root rot and decline, which seriously damages avocado roots. It is regarded as one of the most restrictive elements affecting avocado output. The disease has the potential to be quite damaging, spreading quickly and destroying the majority of trees. (ii) *Colletotrichum gloeosporioides* and *Colletotrichum acutatum* are two distinct fungal species that produce anthracnose. The most frequent cause of rot on mature avocado fruits, this disease can result in up to 37% fruit loss (MINAGRI, 2013). Lack of knowledge on diseases and pest management by smallholder farmers in Rwanda is another challenge that leads to low-quality avocados which are not preferred in the international markets (Ramírez-Gil, 2018). Hence, there is a need to train smallholder farmers in Rwanda on avocado diseases and pests and how to control them.

Other challenges in avocado production that are based on diseases and pests include root rot and the drying of tree mites. In Rwanda, avocados are primarily grown without irrigation, relying on rainfall to sustain output. This implies that the tree's behavior, particularly during its flowering stage and fruit filling, may be impacted at specific seasons of the year when there is little rainfall. Applying an irrigation system to avocado may increase production by at least 23%. Avocado trees are being planted without considering the local soil and climate conditions (García et al., 2021). This study developed an Innovation Platform in order to overcome challenges in avocado production and marketing.

2.9 Harvesting and Post-Harvest Handling of Avocado

In contrast to most other fruits, avocados typically mature after being picked rather than on the tree (Pedreschi, 2019). There is a lot of natural variation in avocados. When to begin harvesting avocado fruit is a crucial commercial decision. Fruit that is harvested before it reaches its ideal stage may not ripen or be of high quality. On the other side, the fruit's post-harvest life may be shortened if it is harvested after the ideal time. The two most crucial quantitative indices utilized to identify this ideal harvest are the dry matter content and oil content. Other complementing indicators, such as the weakening of the flesh and the turning of the green skin into black in certain cultivars, such Hass, may be taken into consideration. It takes experience to know when to harvest avocados. Maturity is indicated by a brown seed coat, a slight change in skin color, or a lack of glossiness. The amount of oil in avocado fruit has a significant impact on its flavor. In most avocado-producing regions, the percentage of dry matter is utilized as a maturity metric and has a strong correlation with oil content (Rodrigue et al. 2018). Depending on the cultivar, a minimum dry matter content of 17% to 25% is needed. Smallholder farmers in Rwanda lack this vital knowledge that is critical in ensuring that the harvesting of the fruit is properly done (George et al., 2018).

Accurately identifying the harvesting time is necessary since avocado fruits are harvested mature but not yet ready to consume. Low eating quality results from fruits that are harvested at an immature stage since they are likely to shrivel, ripen unnaturally, or have a rubbery feel after postharvest storage time (Rodriguet al., 2018). However, because avocados ripen quickly due to lipid auto-oxidation and high enzymatic concentration, maintaining their high nutritional content across supply chains and/or processing presents a substantial hurdle to increasing their consumption. The following are the methods used in Mexico in harvesting and post-harvest handling: In order to permit long-distance export or storage in distribution hubs, harvested avocados may need to be kept immature for up to two or four weeks under normal air conditions. In general, storage involves keeping the fruits between 4 and 6 degrees Celsius, which slows down ripening without causing the negative effects of chilling damage that are seen when avocados are kept at lower temperatures. Flesh firmness and skin color are two crucial quality indicators used to assess avocado ripening, even though signs of rot and chilling damage, such as skin or flesh discoloration, are the main quality problems connected with avocados (Matsui et al., 2025). Avocado postharvest management entails a number of procedures, such as receiving the fruit, weighing it, and identifying the lots (various plots on the same property, partner producers, variety, harvest date). Removal of the peduncle and any faulty fruits is the first selection; hygiene using a product containing chlorine; Using a drying

tunnel or room temperature; applying a fungicide and then drying again are optional. removing any leftover faulty fruits as the second selection; Sort fruits according to their size and category. packing in boxes made of cardboard; box labeling with identification and sorting information; Palletizing, shipping, and storage for retail sales.

Despite the great economic value of avocado fruit, anthracnose, which is caused by the fungus *Colletotrichum gloeosporioides*, is the main source of significant post-harvest losses that occur along the supply chain. Avocado fruit quality, marketability, and shelf life are all impacted by *anthracnose*, a prevalent postharvest disease (Geremu, et al., 2022). To prevent contamination and physical harm, fruits should be picked and delivered in pristine, undamaged plastic containers. To lessen vibration, abrasion, and impacts on the skin, roads need to have high-quality asphalt. Fruits that sustain physical damage will have a number of effects that are only noticeable when they are being sold and consumed (Rojas-Reyes et al., 2024). As near to the field as feasible is the ideal site for the packinghouse. Following harvest, the avocados will be sent to a designated location within the packinghouses. To make load handling easier, the boxes will be stacked on pallets. Fruits should be stored in a refrigerated chamber at a maximum temperature of 20ºC if they are not handled in the packinghouses right away (Ait-Oubahou et al., 2019).

2.9.1 post-harvest losses in avocadoes

Avocado waste and avocado losses are not the same thing. Avocados that spill, deteriorate, have an unusual decline in quality, including bruising or wilting, or otherwise disappear before they are used are referred to as avocado losses (Lipinski et al., 2013). Poor transportation, refrigeration, packaging, infrastructure, and technology are frequently the cause of these losses (Gustavsson et al., 2011). Avocado of good quality and fit for human consumption but that does not get consumed because it is discarded, either before or after it spoils" is how they define avocado waste (Lipinski et al., 2013). Since addressing losses early in the food science process would avoid the environmental, social, and economic costs that accumulate with each additional step of the food science process, postharvest losses the losses and waste of avocados that occur after harvesting but before they reach the consumer are of particular interest (FAO, 2013). Therefore, it is becoming more widely acknowledged that minimizing postharvest losses is essential to the sustainability of food supply chains (Kiaya, 2014).

Food lost after harvest due to crop processing, distribution, marketing, and retailing shortly before it reaches the customer is referred to as postharvest losses (Hodges et al., 2011).

Avocado waste is defined as avocado that is thrown away at the consumer level and is not included in postharvest losses. Reducing postharvest losses could improve food availability, lessen the strain on the natural resources required to produce food, and save farmers' and businesses' financial resources. Farmers must receive training on how to handle postharvest losses.

2.9.2 Causes of post-harvest losses in avocadoes

From a physiological perspective, fruits' nutritional value and appearance may be impacted, especially in the postharvest phase, which may result in a reduction in postharvest life (Gardas et al., 2018). Avocado quality is frequently lowered throughout the packing and marketing procedures, and occasionally it does not arrive at its destination in optimal condition. Chilling injury is the primary source of post-harvest loss. The primary environmental factor influencing the ripening of food is temperature. Therefore, it is crucial to manage this element appropriately in order to get successful outcomes, ensuring that the fruit is kept at low, precise temperatures that should never fall below 0ºC. However, at temperatures much above the freezing point, some fruits have a chilling injury.

According to Florissen et al. (1996), Avocado is a subtropical fruit that is susceptible to chill injury when exposed to low temperatures, even if they are above the freezing point (for instance, 2 to 4ºC). Black stains in the epidermis and a gray or brown discoloration in the mesocarp are the primary signs of chilling injury. Pesis et al. (2002) reported that another symptom is is the change in internal metabolism, which raises anaerobic respiration levels and, consequently, produces aberrant metabolites that cause bad taste and odor. Nevertheless, chilling damage to avocados only manifests itself when the fruit is mature, which in certain situations might be too late to have an impact on marketing (Pesis et al., 2002). However, cooling delays ripening and senescence by slowing down the fruit's biological activities. Avocados should not be kept in the refrigerator for longer than 30 to 40 days. A pre-cooling procedure is advised to provide increased refrigeration treatment efficiency (Woolf et al., 2003).

Anthracnose (*Colletotrichum gloeosporioides*) can also result in post-harvest losses. Damage to a green fruit starts with discolored circular patches. Fruit rots as a result of the fungus penetrating it. The lesions are dark brown in appearance and vary in size (Kendra et al., 2020). Cotton-like patches show up on the lesions' surface. it thrives in environments with high relative humidity, damaged fruit and foliage, and branches touching the ground (De La Rosa-García et al., 2018). The chemical control is made with copper-based fungicides that are also

applied as a preventive measure on leaves and fruit that are still on the tree (De La Rosa-García et al., 2018).

Fruits that are not handled properly from harvest to packaging suffer significant harm. One of the most common issues during harvest is friction damage, which is defined by oxidation of the tissue that subsequently slopes downhill and turns necrotic. It has been reported that up to 78% of the fruits have friction damage (Perkins, 2019). The surface organization of the tissue is disrupted by mechanical trauma, which speeds up gas exchange and promotes water loss. The fruit's protective layer is totally broken by cuts, exposing the tissue to the outside world. As avocado ripens, less cicatrization and antifungal material is produced (Munhuweyi et al., 2020). Fruits are more infamously damaged during the packaging process, mostly as a result of poor handling, which reduces the quantity of fruits that are suitable for shipment. Perkins et al. (2019) explained fruit friction during growth or friction with leaves or short branches might cause friction damage prior to harvest. At this stage, the damage percentage could range from 2 to 35%, and it could rise from 10% to 62% at the packinghouse. Fruit that was harvested right away had a longer shelf life than fruit that was packed. Fruit recovered from the latter stages of packaging produced more ethylene, although their respiration rate was lower, most likely as a result of mechanical damage.

The configuration of the vascular tissue and the makeup of the epidermis' cells provide resistance to mechanical harm. Mishandling won't cause any damage to a strong, elastic peel (Perkins et al., 2019). Fruit loss during growth may result from a lack of expert advice on proper tree nutrition, disease prevention, and pest management. Lack of preparation and organization during harvest can result in: 1) avocados that are cut off the trees due to improper sizes and dry matter contents (at least 21 percent in the pulp); 2) contaminated fruit that is pulled from the tree or cut improperly and falls to the ground; and 3) sunburns from the fruit being exposed to the sun. Another cause of contamination during transportation is soiled boxes and containers. When being transported to the packinghouse, fruit may get very hot if trucks and containers are not suitable. In Rwanda, poor harvesting methods, limited producers' capacity to add value, packaging, and transport are reported to be the biggest challenges that cause post-harvest losses in the avocados value chain (MINAGRI, 2013).

2.9.3 Management of post-harvest losses in avocado fruits

Research by Kassim et al. (2013) showed that including appropriate pre-packing, packaging, and storage conditions had a favorable impact on the quality of mangos in Ethiopia. From harvest to the ultimate market location, cold chain management is a critical component

of avocado quality (Groom, 2022). Adikaram (2024) advised against harvesting avocados when they are wet because this raises the risk of lenticel damage, pulp spot, and cold harm. Fruits harvested in the morning or late afternoon tend to have less field heat. The best time to harvest is usually indicated by factors like color, size, or oil content (Afzal et al., 2022). The maturity and anticipated shelf life of avocados are significantly influenced by the moment of harvest. Low pulp dry matter is a result of harvesting too early in the growing season. Harvesting before physiological maturity causes uneven softening, a bad taste, and increased decay susceptibility. Perez et al. (2004) Fruit that is not harvested at the right time usually has a worse quality and a shorter shelf life. Generally, if the fruit is not harvested at the correct time, the quality becomes compromised and the shelf life is shortened (Wu et al., 2011). When paired with appropriate packing and storage circumstances, pre-packaging treatments can also improve avocado quality and extend shelf life (Lieu et al., 2013).

It takes a lot of logistical planning to move avocados from South Africa's growing regions to the port in Cape Town and then to shops in Europe (Groom, 2022). Avoiding soft fruit with physiological abnormalities requires maintaining the cold chain (Amwoka, 2021). Recommendations and guidelines for managing avocados during export are provided by the Perishable Products Export Control Board in collaboration with the South African Avocado Growers' Association (Sibulali, 2020). A method called "step-down temperature" is used to progressively lower the avocados' storage temperature (Woolf, 2020). This has been demonstrated to lessen pulp spot symptoms and chilling harm. Avocado quality in South Africa has improved with the use of waxes, pre-treatments, and biodegradable packaging.

According to Shivachi (2023), harvesting activities are done using secateurs, knives, or sticks. Fruits are then placed on the ground, in gunny bags, or in crates and transported using open small pickup trucks in Kenya. Harvesting is a component of avocado postharvest chain management, where the fruit must be removed without causing mechanical harm, Sorting and grading, Pre-cooling, Fungicide treatment, and waxing (Kaur & Watson, 2024). The is a gap among avocado stakeholders' organizations as they are not able to share information. Organizing an avocado innovation platform is a better solution for post-harvest loss of avocados. Avocado innovation platforms play a crucial role in addressing post-harvest losses, which are a significant challenge for smallholder farmers. Through knowledge sharing and training, avocado innovation platforms facilitate the exchange of knowledge and best practices among stakeholders that promote the adoption of innovative technologies and practices that can improve post-harvest handling. The platform also promotes market access and linkages by

connecting farmers with markets and buyers, which reduces delays in selling harvested avocados.

2.10 Avocado Marketing in Rwanda

Over the past ten years, avocado output has increased at the highest rate of any major tropical fruit, averaging 6% annually (FAO, 2019b). In both rich and developing nations, avocado consumption has grown dramatically (Menzel & Le Lagadec, 2014). there are three races of commercial avocado cultivars: Mexican, West Indian, and Guatemalan (Yahia, 2012). The Mexican race's mature trees can tolerate temperatures as low as -4°C without suffering any harm. Mexican cultivars are the coldest tolerant of the three races and are best suited to the cool tropical and subtropical regions. The West Indian cultivars thrive in lowland tropical climates with high humidity and temperatures. In terms of climate adaptation, the Guatemalan cultivars fall somewhat in the middle of these two varieties.

The country produces about 82,000 tons of avocado fruits every year. The Southern Province of Rwanda produces 49% of the country's avocados, with the Western Province coming in second (26%). There is little avocado production in the Northern and Eastern Provinces (MINAGRI, 2013). The most grown avocado varieties in the country include Nabal, Puebla, Reed, Simmonds, Pinkerton, Bacon, Fuerte, and Hass. Avocado has economic importance in farming communities in Rwanda as farmers sell their produce to the local and international markets. The international markets for agricultural commodities offer good prices but require good quality as well compared to the local markets (Thorsen & Woodbridge, 2011a). The total area cultivated with avocado in Rwanda consists of locally grown varieties that are not export-grade. Rwandan smallholder farmers needed to know how to distinguish different avocado varieties seedlings, the ones for local markets and others for international markets. Establishment of innovation platform allow avocado farmers to access better markets with a good price through the information sharing among the members of the platform.

2.11 Role of Innovation Platforms in Agriculture

The agricultural innovation process heavily relies on technology advancement and institutional change in the agricultural sector, which is the focus of Agricultural Innovation Platform Systems (AIPS). A major shift in agricultural domains, including agriculture education, women's participation, policy, markets, and stakeholder engagements, is referred to here as institutional transformation. New seeds, new animal breeds, new production methods, and new insecticides are examples of technology advancement (Klerkx et al., 2010). In order to accomplish sustainable agriculture and rural development, the AIPS strategy was first

presented in the 1990s (Nederlof et al., 2011). an AIPS is a forum for collaboration where agricultural stakeholders identify problems and create solutions together (Kilelu et al., 2013).

Among the several methods used by innovation platforms are the Value Chain (VC) and Innovation Systems (IS) approaches (Ayele et al., 2012). The IS approach takes into account the people, institutions, infrastructure, and networks that make up system-building components (Kilelu et al., 2013). The creation, functioning, and successful innovation activities of individual platforms from an IS perspective have been a major focus of AIPS research (Barrantes & Yagüe, 2015). The VC viewpoint, on the other hand, is centered on investigating potential rents and inefficiencies inside agricultural VCs in order to find new ways to create value. an agricultural venture capital (VC) is an economic unit of study of a specific product or a group of commodities that includes a cluster of economic activities connected by market interactions (Ayele et al., 2012). Innovation platforms serve both the chain's governance framework and a venue for cooperation. Understanding how the platform regulates economic activity and market linkages is the goal of the venture capital approach (Thiele et al., 2011).

Some successful IPs have been used in Rwanda including for milk, potato, beans, and maize crops. Prior to the application of IAR4D principles using IP systems, the Mudende sector was capable of producing 6,000 L of milk per day. Due to improper handling practices, this milk was of poor quality and sold to multiple middlemen at a very low price. Not more than 1,000 L were sold each day, and a large portion of that amount was lost. Milk farmers were connected to marketplaces and able to sell up to 3,000 L per day at a better price when the IP system was put in place. Additionally, they had connections to banks and were able to build a state-of-the-art milk collector, which allowed them to store and thereafter sell the remaining 3,000 L each day to markets as far away as Kigali city (Ngaboyisonga et al., 2014).

The main staple crop of the Gataraga sector was potatoes, which were either interplanted with maize or grown in rotation. Nevertheless, a variety of potatoes were gathered in large quantities, were of low quality, and came in a range of sizes. Rural assemblers were offered very low prices for both corn and potatoes. There was less communication between the marketplace and producers. Ensuring accessibility to Kigali-City marketplaces, which are made up of supermarkets, lodging facilities, and dining establishments, moved the stakeholders. Due to their ability to access Kigali marketplaces, potatoes were able to command premium prices (Ngaboyisonga et al., 2014). High-quality potato produce was acquired by Kigali's hotels, restaurants, and stores, while research and extension organizations distributed fresh packages of cutting-edge innovations.

Very little of the harvest was sold in the local markets because the majority of the beans and maize in the Remera sector were consumed domestically. In order to give producers access to markets and enough produce for marketing, two improved bean varieties were introduced, tested, multiplied, and distributed through the use of an IP system. Additionally, collective marketing was encouraged and the land consolidation system was adopted (Ngaboyisonga et al., 2014).

Beyond its initial development, multi-stakeholder innovation platforms are thought to be a useful strategy for enhancing the effect of research in the agriculture sector (Sartas et al., 2018, Schut et al., 2019). Moreover, it is thought that innovation platforms (IPs) bring together pertinent parties to accomplish a broader effect (Schut et al., 2018). However, only a small number of businesses are able to establish innovation management; in order to achieve creative performances, actors and organizations must collaborate (Story et al., 2009). Furthermore, it said that a new product or service's commercialization process is more likely to fail if stakeholders are not included in the acceptance and market diffusion process.

Stakeholders are the cornerstone of an IP, without them, the platform cannot happen and cannot function (Tenywa, 2011). On the other hand, their willingness to engage, their ability to advance the process toward the realization of shared interests, and the possible advantages they stood to gain from the IP were the main factors in selecting the stakeholders (Gyau et al., 2016). For IP to remain appealing and lucrative, contributions and benefits must be balanced (Schut et al., 2019). The potential stakeholders in an IP included smallholder farmers, input suppliers, collectors, traders, processors, exporters, researchers, and Sectors and District extension officers.

2.12 Operational Innovation Platform

The size of an active innovation platform varies depending on the particular opportunity or challenge that exists. Working with 20–40 people may be appropriate for farm-level experiments. Over time, membership and size may fluctuate as new farmer groups join, or new members are invited to address specific challenges, or partners may lose interest or leave the platform if their needs have been met (Lamers et al., 2017). If partners' needs are addressed, they may lose interest in the platform or leave, and members are urged to address specific difficulties (Lamers et al., 2017). An increasingly common strategy for improving multi-stakeholder collaboration in agricultural research for development (AR4D) programs is the use of innovation platforms. According to Schut et al. (2016), innovation platforms enable communication and cooperation both inside and across networks of farmers, including

researchers, policymakers, governmental and non-governmental service providers, private sector players, and other stakeholders in the agricultural system.

Innovation platforms foster learning and innovation while offering a secure setting for many stakeholders to test ideas and look for answers to problems they face together. The goal of an Innovation Platform may be to address a particular technological, organizational, or institutional challenge in a value chain (such as marketing avocado produce) or a more general issue that needs to be addressed across value chains, depending on the level at which the platform is established and those who are initiating it (Schut et al., 2016). Members of the innovation platform may or may not choose to take on new challenges after the platform has accomplished its goal. Formalized structures can be formed from informal networks that serve as foundations for innovation platforms such as public-private partnerships, with the ultimate goal of becoming self-sustaining entities (Homann- Kee et al., 2015).

Agricultural innovation can have both indirect and direct special effects on the productivity and livelihoods of the members of the platform. As a result, technology transfer in agriculture should concentrate on key interventions at various stages of avocado production and marketing. The first and earlier perspective holds that innovation is primarily driven by scientific research, which produces new technologies and knowledge that may be applied to many contexts. In addition to knowledge generation, the process of innovation and productivity growth encompasses the entire system of technical diffusion, adoption processes, interactions, and market adjustments. The agricultural development of any economy is increasingly driven by markets rather than production, as the market drives the production of any given product.

According to Tucker et al. (2013), innovation platforms can be created at several levels, including the village or community level, the district level, the province level, and the national level. At what level or levels can a challenge be addressed most efficiently? That should be the guiding question. For instance, a village or community may be the best place to handle the issue of the availability of high-quality planting material, but stakeholders at the watershed level would need to be involved in the process of investigating irrigation solutions (Tucker et al., 2013). Given that issues at the local level are frequently the result of and linked to issues at the higher levels (for example, a lack of input certification resulting in the sale of subpar fertilizer), it may eventually be advantageous for national level policy players to strategically become involved.

Following the identification of successful innovations at the local level, the Innovation Platform can offer mechanisms for the exchange of experiences and the adaptation and adoption of the innovation in other contexts. Therefore, higher levels of coordination are

needed (Lamers et al., 2017). Including policymakers in the process aids in their understanding of the potentials, limitations, and policy support required to achieve large-scale impact. Direct involvement can alert policymakers at the appropriate time and may be more persuasive than standard policy briefs. Making changes at higher levels is often more complex and takes more time. However, the spin-offs from achieving changes at the policy level may have a greater impact on society.

According to Touzard et al. (2015), innovation is the introduction of something new or improved whether technical or not, in processes, marketing strategies, organizational procedures, or products (goods or services). Put another way, it refers to introducing fresh concepts, expertise, or methods into an environment to bring about improvements that will aid in meeting needs, overcoming challenges, or seizing chances. Accordingly, innovations and beneficial alterations may be substantial improvements or cumulative (a number of minor adjustments that together result in a major improvement). For a considerable amount of time, best practices and technology transfer were linear processes. Researchers created innovations, and extension agents then shared them with both male and female farmers (Geels & Schot, 2007). These strategies might have included stakeholders in specific operations, like the delivery of inputs or new market connections, and they might have been successful in raising household production and food security, but they did not succeed in empowering smallholder farmers, who are frequently vulnerable, to enhance their standard of living, for example, by using markets as a vehicle for social and economic change. Additionally, they neglected to address the environmental factors that frequently prevent farmers from optimizing the use of their meager resources (Swaans et al., 2014).

Deeper structural changes across time and scales, as well as improved integration and synergy between institutional, technological, and policy alternatives, are necessary for systemic improvements that will lead to more sustainable futures for farmers including men and women alike according to Tourard et al. (2015). Deliberate system changes must occasionally be considered (Lachman, 2013). According to Geels and Schot (2007), innovation systems research encourages knowledge providers and users to pursue specialized innovations in order to establish new ecological regimes. These types of niche innovations are places where tiny networks of individuals, guided by common expectations and visions, create novelties in technology, institutions, and organizations. As learning processes connect the many dimensions, change is becoming more and more likely. IPs can provide these specialized markets with the systems dynamics and packages including novel solutions that have been tried out in less hazardous settings. According to Touzard et al. (2015), they aid in the development

of suitable treatments that are suited for the end users and consider technological, social, economic, and environmental issues. This leads to higher adoption rates.

According to Knierim et al. (2015), the systems of innovations approach (World Bank 2006) recently conceptualized innovation as an interactive and systemic process that arises from networks of actors and is both a technical and nonlinear social process wherein interactive learning occurs around a shared concern or impulse of change. As a result, consider innovations as coming from the Agricultural Knowledge Information System, which consists of various actor groups interactively engaged in the stages of the innovation process (Wielenga, 2016) along value chains, related to particular products or regions, or collaboratively addressing a cross-cutting challenge or problem (World-Bank, 2006). This is in line with the current rural and innovation policies.

2.13 Systems and Procedures to Increase the Influence of Innovation Platforms

Rebranding agriculture is necessary in order to dispel the long-held misconception that people who live in rural regions and agriculture are unable to find work elsewhere. It is necessary to position agriculture as the next untapped market for expansion (Njenga et al., 2012). The time and input costs associated with growing conventional staples which are dangerous, slow to develop, and frequently provide low returns are the main reasons why young people find agriculture unappealing. Since agricultural wages are seasonal and based on harvest and rainfall cycles, it stands to reason that young people would be without money for extended periods. Lack of innovation has resulted in a focus on a small number of agricultural commodities, mostly staple crops, and a dependence on labor-intensive, traditional methods of production.

The underutilization of information and communication technologies (ICTs) has impeded the flow of information on agricultural production and marketing to youth (International Institute for Communication and Development, 2013; Njenga et al., 2012). Digitizing agricultural production and marketing data into online tools is crucial, though. Since the few available extension officers cannot effectively reach many of the farmers at diverse places, this would allow for wider outreach and use. By actively contributing to the creation, posting, maintenance, and use of this information, the youth might make a significant contribution to the agricultural industry.

After the right mix of development and research partners has been secured, it is crucial to specify the procedure and related institutional setup for cooperation. Innovation platforms could begin by taking a very narrow approach to solving a single issue or a small number of

problems (Opoola et al., 2019). A relatively open structure that is founded on precisely stated objectives, responsibilities, tasks, outcomes, and resource requirements could be enough in the beginning. The accomplishment of an initial goal successfully leads to an expansion of partnership and the subsequent requirement for more intricate institutional arrangements. The formation of subgroups with particular institutional structures both inside and between them may be necessary to achieve this. An Innovation Platform may eventually find it beneficial to think about establishing a legal organization in order to improve its independence, member advantages (both financial and non-financial), and ability to receive donations or credit. Enhancing the capabilities of enthusiastic collaborators who can progress platform operations as a subset or within smaller networks is another possibility. According to Schut et al. (2017) recent evaluation of established innovation platforms, innovation platforms must be deeply ingrained in wider networks and private or public processes that can reach target groups outside of the platform's initial focus.

Innovation platforms have the potential to be an effective scaling strategy, with impacts that extend beyond the simple local adoption of innovations in the form of impact and instead involve longer-lasting effects or even more extensive system change (Schut et al., 2018). According to research on agricultural innovation systems, by bringing important stakeholders together for productive interactions, innovation platforms are supposed to start a process that leads to systemic change (Hounkonnou et al., 2018; Sartas et al., 2018). The goal of the platforms has steadily switched from knowledge transfer to strengthening the institutional capacity of platform members with 1) connectivity to market facilities in order to meet the production issues that farmers were encountering; and 2) Facilitating the acquisition of production inputs, such as financing and premium milk, in order to augment the expansion of the innovations advocated. The most prosperous IPs helped to scale results by emphasizing the interactive approach more when creating the network, seeing new prospects, encouraging cooperation, and revealing how scaling operations would ultimately affect farmers' income (Schut et al., 2018).

The role of agricultural advisory service providers has changed. Previously, they were viewed as the main actors to support innovation processes through technology and information transfer, but this view is no longer valid. Other new actors have emerged, promoting and enhancing innovation processes by offering new services offering innovation supporting activities and new methods to deliver these services. The required services range in terms of content (technical, economic, social, legal, etc.) and they can be provided by a variety of methods (transfer of knowledge, co-construction, participatory development, etc.) as well as

by a variety of providers (public, private, NGO) (Mathe et al. 2016). The services that are required change as innovation progresses and may call for the participation of several actors at a given point in order to optimize or change the "system" or the problematic circumstance (Beers et al., 2014). The complexity and interactions among the various actors, as well as the progressive co-construction of the demand and supply for services along the intricate and non-linear innovation process, make the coordination (at a given moment) or alignment (across time) of these services crucial (Kilelu et al., 2013). Therefore, there is a great desire to learn more about what makes innovations in the agricultural sector successful and how to better support innovation through public policy. In particular, it is important to identify cooperative forms and supportive actions that improve multi-actor innovation processes in rural settings (Kilelu et al., 2013). By encouraging interactions and creating knowledge, relevant innovation support services are required to enable innovation. Innovation support services can lead to various goods with a "wider intervention purpose" that is strongly associated with "the assumed nature of a problematic situation" according to a multi-actor perspective. The phrase "innovation support services" can initially be interpreted as referring to either an entity within an organization or an activity.

According to Labarthe et al. (2013) and adopting a process viewpoint, innovation support services are regarded as activities. AIS providers today are built on a far more diversified group of players than those in the previous public sector system, with intricate linkages between these actors and their clients, and where advice and other service provisions are interwoven (Knierim et al., 2015; Labarthe et al., 2013). According to Mathe et al. (2016), some examples of these new services include strengthening capacities for new business skills, facilitating networking, making it easier to access financial resources, improving the way innovation actors articulate their demands, offering institutional support, particularly for niche innovations, and providing general consultancy and backstopping.

According to Beers et al. (2014), the services that are required change as the innovation process progresses and may call for the participation of various players at certain points in order to optimize or change the system or problematic condition. Because of the variety of actors and their interactions as well as the progressive co-construction of the demand for and supply of services along the complex and non-linear innovation process (Le Coq et al., 2010), the coordination given or alignment of these services is a critical issue (Kilelu et al., 2013).

The potential impact of fragmented ASS on innovation processes is contingent upon the complexity of the innovation from a socio-technological standpoint, as well as the degree to which these components are balanced. These components include governance, funding

mechanisms, competence, and advice-giving techniques (Faure et al., 2012). If significant coordination is not required, a fragmented ASS with a large number of competing service providers may leave a lot of room for new ideas. Either the public or private sector might more readily lead the innovation process in this scenario. To effectively promote innovation, however, cooperation between service providers and other actors is necessary as soon as changes are needed in social systems, such as farmers' organizations, rural communities, etc (Beers et al., 2014). There are situations where this collaboration might be effective. The district's experience demonstrates the critical role that a single association plays in bringing together several players from various industries, including national parks, tourism, and agriculture; in other situations, there is insufficient coordination (Birner et al., 2009).

2.14 Obstacles to the Effectiveness of an Innovation Platform

Innovation platforms (IPs) and their functions in promoting and stimulating agricultural innovation are becoming increasingly recognized in science, but there are still many obstacles in the way of their success. IPs are particularly helpful when looking into methods and opportunities to increase value chains, sustainability, and agricultural productivity. Moreover, innovation platforms are thought to consist of a variety of stakeholders whose main objective is to bring about change inside a certain business or area. By making use of these opportunities, innovation platforms can more easily recognize and address obstacles to their success.

One of the main obstacles to the success of innovation platforms is the sustainability issue (Swaans et al., 2013). Innovation platforms are only valuable while they are in operation; otherwise, they become ineffectual. In the corporate world, things change quickly, making platforms outdated and requiring reconfiguration to satisfy new challenges and meet existing demands. Moreover, even while the platforms might be able to foster innovation inside the industry, they might eventually disappear (Swaans et al., 2013). It is also important to remember that a lot of these platforms are run by non-governmental organizations (NGOs), the main objective of which is to fulfill a particular need. The project coordinators for these NGOs, however, may not be aware of whether these platforms are accessed by the intended audience or serve the intended purpose because they live outside of the areas of operation. Moreover, NGOs are likely to stop supporting the project after the financing runs out, which begs the crucial question of the project's long-term viability. The results indicate that no particular category of service provider is exclusively in charge of providing this form of innovation support services. Of course, as demonstrated by Klerkx and Leeuwis (2010), it can be given by a specialized service provider.

On the other hand, it is uncommon to find specialized service providers committed to this kind of work. This type of innovation support services can be offered by other organizations (such as private companies or farmers' organizations) that are motivated to advance the innovation process, or by various organizations sharing this function and assigning each other particular coordination tasks, or by various organizations operating at different stages of the innovation process, or, in the end, by a multi-stakeholder innovation platform that has a facilitator specifically assigned to it (Klerkx and Leeuwis, 2008). The majority of innovation platforms seem to be complex processes involving many different components interacting to produce a range of unknown results. Moreover, the majority of innovation platforms are extremely unpredictable since they are doomed to fail and become outdated.

To ensure that farmers completely benefit from these interventions, various platforms for innovation can be merged, as opposed to being distinct and giving diverse interventions. Furthermore, it is not unusual to discover farmers favoring one platform over another because of competing interests, considering the range of platforms accessible (Stür et al., 2013). To emphasize this, people believe that innovation platforms offer unequal benefits since early adopters, or early adopters, frequently reap significantly greater benefits than do late adopters. According to Totin et al. (2020), advantages are also dispersed according to the asset thresholds of the farmers. These thresholds can be lower for minimum benefits, medium for large benefits, or higher for fewer benefits because of the region's already established market networks.

Smallholder farmers in particular are among the target receivers who are still not familiar with the idea of innovation platforms. However, there are some unknowns about what needs to be done to ensure that they get clear definitions of their goals, which will boost their acceptability among smallholder farmers in rural areas (Totin et al., 2020). Recipients of the innovation platforms generally feel that there are fees associated with the platforms, which they may or may not be able to pay, even though the platforms seem to boost the performance of many enterprises and farming communities. Chilundo et al. (2020) suggest that the success of innovation platforms is highly dependent on the advantages enjoyed by early adopters, as the majority of the target audience will only agree to participate once those who have already joined start to benefit. This means that the goals of internal and external stakeholders for agricultural innovation should receive more time, candid conversation, and particular attention. By proving that new technology can assist farmers in achieving their livelihood objectives, it is possible to pave the way for their acceptance (Eidt et al., 2020).

Offering these innovation support services to change agents entails new jobs and, for the most part, undiscovered capabilities (Koutsouris, 2014). Along with the now-well-known

abilities like effective communication, the capacity to listen and value the insights of farmers, along technical know-how and interactional expertise (Silva, 2023), these people also need to be able to work with a variety of actors and establish appropriate practices (Nettle et al., 2017). It is hard for traditional advisors to step into new roles and become skilled facilitators. According to Klerkx and Jansen (2010), advisers' unwillingness to leave their "comfort zone" and lack of the proper mindset and competencies particularly social competencies are among the other reasons for this. According to Labarthe et al. (2013), brokering functions are still not well-defined, operationalized, or adequately assessed. The brokerage praxeology the idea that theory guides practice and practice informs new theory should be studied, particularly as it relates to the role of innovation brokers in the various stages of the innovation process and the particular skills they need to do their jobs well. An agenda like this will aid in identifying more knowledge gaps and approaches to fill them, thereby creating a strong body of information that will be beneficial to scholars, practitioners, and policymakers (Koutsouris, 2017).

According to Albert (2000), the links that exist between the supply and demand actors of a service are regarded as functional relationships inside the service systems that are connected to various components like input delivery, financing, insurance, and so on. According to a review by Klerkx et al. (2013), innovation brokers can help make these services more real inside an innovation system. This may be especially relevant to the function of direction in resource discovery and the establishment of authority over them. Facilitating access to both financial and human capital Heemskerk et al. (2011) as a fundamental input for the innovation system may fall under this category, especially for resource mobilization. Providing funding for long-term research and development, government or industry-sponsored initiatives to advance specialized technological knowledge, and funding made available for the testing of novel technologies in specialized experiments are a few examples of these kinds of activities (Faure et al., 2014). While Hekkert et al. (2007) referred to these services collectively as resource mobilization functions in their study within the framework of innovation systems functions, we refer to this in our example of mapping ISS functions as enhancing access to resources.

While Gadrey (1994) refers to the institutional environment as an influential component of service construction, Faure et al. (2014) describe service relations as an institutional arrangement. Kilelu et al. (2013) define Institutional support similarly, defining it as efforts that bridge boundaries and bring about institutional change. According to Hekkert et al. (2009), institutional support for advocacy is defined as embracing and backing important people in order to promote the innovation process. This involves alerting decision-makers and

advocating for modifications to policies. Edquist (2011) and Heemskerk et al., (2011) emphasize that institutional support for specialized innovations should be provided; additionally, all administrative improvements are included in this category.

2.15 Networks in a Multistakeholder Platform for Avocado Production and Marketing

The network is seen as a coordination mechanism, or what is commonly called network governance. The network's efficacy indicates that individual organizations can work together to achieve a favorable result. To put it another way, the network's level determines how successful objectives and accomplishments are. networks are also seen as cooperative structures (Provan & Kenis, 2008). The goal of this study was to use participatory action research to bring together groups of people with various backgrounds, specialties, and interests in the production and marketing of avocados, such as farmers, traders, processors, and researchers, in order to give them a place to learn, act, and transform. Action research's ultimate goal is to bring about social change through a particular activity. Members of a community or group who are trying to change their circumstances work with an action researcher. Therefore, an agenda for social change that contains the idea of combining information to describe a problem in order to solve it is the focus of action research (Macdonald, 2015).

Literature studies report that the innovation platform has a positive impact on the agriculture value chain. A study in Burkina Faso (Cullen &Tucker, 2014), claims that value-chain stakeholders taking part in an innovation platform jointly planned activities, which directly led to the observed gains in crop and livestock production. A research conducted in Malawi found that 82.8% of participating families said that their household's food security had improved as a result of innovation platform activities, indicating that food security had grown as a platform impact (Makate & Mango, 2017). MSPs helped to improve seed systems. By learning how to "act in concert," participants in an innovation platform in Benin enhanced the seed system, increasing smallholder producers' incomes and productivity (Vissoh et al., 2017). These studies show the role of using the innovation platform on some agricultural commodities. However, establishing an innovation platform for the avocado value chain was not been documented yet in the literature. This study developed an innovation platform to build the capacity of smallholder farmers in avocado production and marketing.

Stakeholder groups collaborate to diagnose issues related to avocados and wider livelihoods, locate opportunities, and figure out how to accomplish their objectives. This is the primary advantage of innovation platforms (Klerkx et al., 2013). Analysis of networks between people and organizations was done in order to increase the efficacy of multi-stakeholder

intellectual property in the production and marketing of avocados. Many people agree that networks are crucial components of multi-organizational governance. Using network coordination in avocado production and marketing has several advantages, such as improved planning ability to handle complicated issues, effective resource usage, increased competitiveness, better services in terms of quality and quantity, and the learning process (Brass et al., 2004).

The potential stakeholders in avocado IP include smallholder farmers, input suppliers, collectors, traders, processors, exporters, researchers, and extension officers. The IP was started by researchers, who also supplied the cutting-edge technologies and technological know-how required to boost productivity and make the IP appealing and profitable. By guaranteeing the availability of goods in the value chains, smallholder farmers contributed. They ultimately received higher pricing for basic goods, which boosts their incomes, food security, and social advancement. They may also readily acquire new technologies. The input suppliers expand their businesses and generate revenues by offering highly sought-after agricultural inputs. Primary product supply is the responsibility of traders and collectors. The IP is driven by the processors, who are at the top of the value chain and contribute by using IP goods. They have steady supplies of primary products and generate a profit at the same time. Extension agents assist in spreading inventions and making sure they are used and acknowledged in return. Exporters have to export the primary products and communicate to the farmers which avocado varieties are preferred in the international markets. IP partners engage in multidirectional exchanges rather than linear ones. The development of relationships and communication between partners aids in guiding the entire IP system toward a shared objective. By integrating current resources that are pertinent to the markets, network actors can help support the commercialization of new goods and services. The benefit of an IP is that all of the value chain participants must have a shared objective and target in order to jointly solve the problems that arise along the avocado value chain.

2.16 Avocado Value Chain

One technique for breaking the chain in each of the activities that form and searching for actions that add value to the finished product is value chain analysis. In order to establish priorities and strategies for coordinated action amongst various actors, the value chain's focus examines the attributes of the various links that make up the chain and seeks to comprehend the factors influencing competitive advantages, evaluating their relative impact (Martínez, 2014). To improve the performance of various economic agents, it is crucial to consider the

identification of the foundations of the avocado value chain's competitive advantages. In other words, value chain analysis is basically a value creation system as an analytical tool that makes it easier to find and assess strategic options (Walters & Rainbird, 2007). To comprehend the competitive advantages, the value chain is a crucial analytical unit (Kwiatkowska, 2009). When a company employs a value-creating strategy that none of its present or prospective rivals are also using, it gains a competitive edge. The competitive advantage, then, is not something you have, but enough, not simply something that sets us apart from the competition but also something that generates a greater return than them (Barney, 1991). Figure 1 illustrates the avocado markets chain in Rwanda.

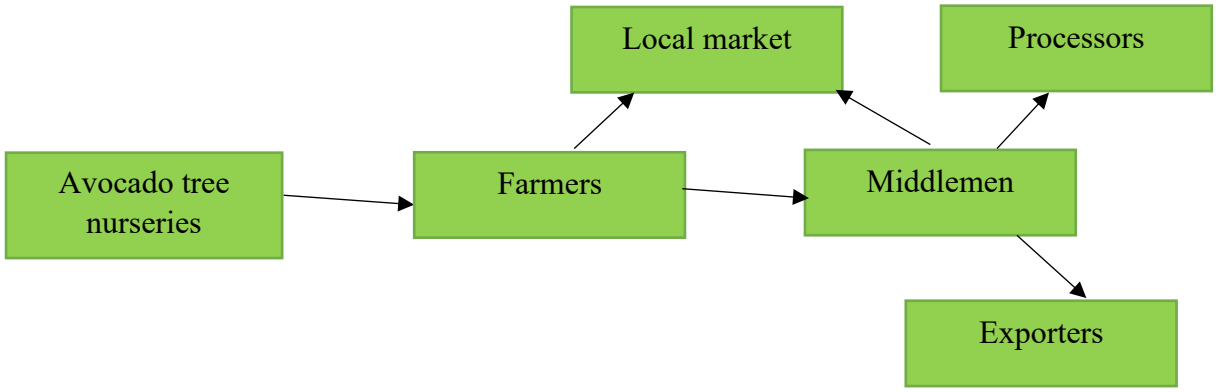

Figure 2.1: Chain of Avocado Markets in Rwanda

2. 17 Innovation Platform on Avocado Crop

Research, farmers and farmer organizations, consulting services, agro-food processors, traders, input dealers, policymakers, and transporters can all engage differently thanks to the IP (Pretty et al., 2011). the IP gives various social and economic players in an agricultural region the chance to talk about and comprehend one another's perspectives, conflicting interests, and resource access (Spielman & von Grebmer 2006). IP actors collaborate to identify opportunities and limitations, then choose how to proceed to get beyond obstacles and bottlenecks (Weyori et al., 2018). The actors' structural integration into the network and interconnectedness have a big influence on how they communicate and interact, hence it provides useful information for value chain stakeholders (Hermans et al., 2017).

There are maize and cassava successful IPs in African countries such as Mali, Burkina Faso, Gambia, and Sierra Leone (Pretty et al., 2011). There is also another successful IP in Benin for the rice crop which involved different actors along the rice value chain. This IP helped the rice farmers to get a good market with a premium price, and it also helped the processors to be connected with the producers Sanyang et al. (2013). The main players in the

Burkina Faso maize IP were the media, banks and microfinance institutions, input dealers, policymakers in local government, farmer and processor associations, and other stakeholders in the maize value chain that provided consulting services, such as public extension and NGOs. The established IP helped farmers access quality seed maize, soil fertility enhancement, processing, and value addition and marketing as well another benefit of the IP was the policy engagement as policies become more dynamic and responsive to the needs of the stakeholders. IPs provides a framework for examining intricate interactions and processes that occur between numerous actors, social and economic institutions, and organizational and technological opportunities (Lundvall, 2010).

the establishment of an innovation platform that enables growers to increase their profitability is essential to improving the avocado value chain in Colombia. The activities and behavior of players in the avocado value chain greatly influence their function. They do, however, also depend on other actors' presence to support their activities. The multi-stakeholder platform approach has improved avocado production and marketing in Kenya (Simon et al., 2023). In order to establish a stable agroecological system and lessen the factors causing land degradation, this strategy allowed smallholder farmers to increase their capacity to integrate avocados into farming systems (Hall, 2011).

2.18 Influence of Innovation Platform on Avocado Crop

An innovation platform is a structure that brings people together at different points in the value chain for ongoing action research-based learning to guarantee that technology is developed, shared, and adopted on specific goods or systems for stakeholders' financial gain. Participatory action research integrates outcome-oriented research with collaboratively conducting research with important stakeholders (Minh et al., 2014). According to Sreedhar et al. (2017), the innovation platform (IP) provides a forum for problem diagnosis, opportunity exploration, and solution research. Enhancing avocado output will also require market promotion, market connectivity, and the distribution of current market information at various market locations. In IPs, communication facilitates the exchange of ideas and expertise among participants, which helps to spark and produce new solutions (Victor et al., 2013). Effective communication is essential for promoting innovation. It does this not only by spreading knowledge but also by using communication channels to power platforms and other creative processes, as well as to establish trust and dependability through consistent feedback (Dantas et al, 2016).

In order to address the issue of adoption of new technology, innovation platforms are being used more and more in research and development projects as a way to coordinate actions by individual members or to bring stakeholders together as a platform (Francis et al., 2016; Homann-Kee et al., 2013). This is a technique for agriculture extension using a network architecture. It is a location where individuals can develop and change. Dynamic, equitable settings are designed to bring people together from different backgrounds and interests so they may share information and collaborate to solve problems (Homann-Kee et al., 2013). In order to address particular agricultural concerns that are specified, assessed, and prioritized, the group meets to discuss, plan, create, execute, and track agricultural innovations (Francis et al., 2016). The platform connects and collaborates with stakeholder networks in an attempt to foster agricultural innovation.

Solutions that best match the local context, both in terms of the farming system and the direction the community wishes to move in, will be developed by small-scale farmers who actively participate in the innovation process (Sell et al., 2018). Adopting a holistic innovations systems perspective facilitates understanding of innovations about food systems, markets, incentives, and local dynamics as well as power structures that influence these innovations. Long-term opportunities and ways to move toward ecologically and socially equitable societies where women's roles and agency are valued assets could result from this, according to smallholder farmers. Innovation platforms (IPs) are a common tool used to include smallholder farmers. If the concept is to be applied as a methodology or instrument in agricultural development and research, it needs to be operationalized. More understanding of real-world applications is required, despite the recent attempts to investigate obstacles, optimal techniques, and approaches for assessing IP efficiency being beneficial (Davis et al., 2016).

Three factors make it crucial for major avocado stakeholders to be involved in capacity building. First, stakeholder groups can expand the body of knowledge by offering a variety of complementary ideas regarding the problem's biophysical, technological, and institutional aspects (Odame et al., 2009). Stakeholders can thereby negotiate what kinds of innovations are technically feasible, commercially viable, and socially, culturally, and politically acceptable by participating in a process of social learning with one another. Second, through engagement and interaction, stakeholder groups learn about each other's needs, interests, and goals; they also learn about their inherent interdependencies and the necessity of coordinated action at several levels to overcome obstacles and accomplish goals. Third, when stakeholders participate in the design and testing phases of an invention, they are more likely to support its adoption and scaling (Esparcia, 2014).

The relationships between different players in the avocado sector are typically weak because there isn't a common vision among them. Aside from a few isolated instances of coordinated action, the industry lacks a cohesive structure for innovation that can solve problems and sustainably take advantage of opportunities to spur innovation (Odame et al., 2009). This is typified by supply-driven research, poor extension, and advisory support networks, insensitivity to industry demands, and education actors being unable to provide the industry's need for highly qualified workers (Muriuki 2011). According to Kilelu et al. (2013), these disparities reflect fundamental institutional issues such as a lack of reliability and trust among value chain participants. To promote co-learning and discourse, networks must be strengthened through platforms, which will stimulate innovation in the industry. Stakeholders in the industry must promote and lead these platforms. It is necessary to use innovative strategies to assist in the transfer of knowledge among avocado producers. The market orientation and demand-driven aspects of the avocado innovation platform ought to be the main focus.

There is no avocado innovation platform in Rwanda which could hinder the benefits provided by the platform including training, access to new technologies, and market information. Without this support, farmers might struggle with lower yields, poor quality produce, and lower incomes. Innovation platforms often streamline supply chains, improve logistics, and reduce wastage. Without these improvements, Rwanda's avocado supply chain might be less efficient, leading to higher costs and lower profit margins for farmers. An innovation platform can help in developing better farming practices, improving yields, and creating higher-quality products. Without it, Rwanda might fall behind other countries that invest in such platforms, leading to reduced competitiveness in the global avocado market. Avocado is a high-value export product. If Rwanda does not develop its avocado sector through innovation, it might miss out on export opportunities, affecting trade balances and economic growth.

2.19 Theoretical Framework of the Study

This study was based on transdisciplinary theory, sustainable livelihood framework, and system theory. The transdisciplinary theory is predicated on the idea that in order to generate solutions for societal problems, they must be connected to gaps in the body of existing knowledge (Popa et al., 2015). It seeks to facilitate processes of reciprocal learning. The different actors must participate in participatory research as individuals with unique roles, interests, and communication styles (Jahn et al., 2012).

There are three phases in the research process according to the transdisciplinary theory. The first step is problem transformation, which involves connecting scientific and societal issues to create a shared research effort. A diverse set of actors collaborates to create a cohesive team that is dedicated and adaptable enough to consider different viewpoints and meanings while still upholding a common identity that is understood by all. When a societal issue is chosen as the basis for research, problem transformation always occurs.

The creation of new information is what defines the theory's second phase. The framework for a research process that combines scientific and societal advancements to produce new information is established via an iterative process known as interdisciplinary integration, which involves stakeholders and researchers. The third stage assesses the transdisciplinary research process to ascertain how it advances society. It evaluates the results' validity and applicability to resolving the original social issue as well as the fresh perspectives acquired for advancement in science.

By creating an innovation platform where a diverse range of avocado value chain actors will collaborate to identify avocado production and marketing as a societal issue, this theory aligns well with enhancing the ability of smallholder farmers to produce and market avocados. The actors will devise solutions to the issues through participatory research.

A people-centered strategy, sustainable livelihood seeks to find ways to enhance local ability and address local needs without being controlled by certain sectors or disciplines (Department for International Development, 1999). Figure 3 demonstrates the sustainable livelihood framework. The primary elements influencing the livelihood of the impoverished and their coping strategies are to be analyzed and comprehended with the aid of this framework tool (DFID, 1999). The tool can be applied in a variety of contexts, such as program analysis, monitoring, and evaluation, and the planning phase. Figure 2 illustrates the sustainable livelihoods framework.

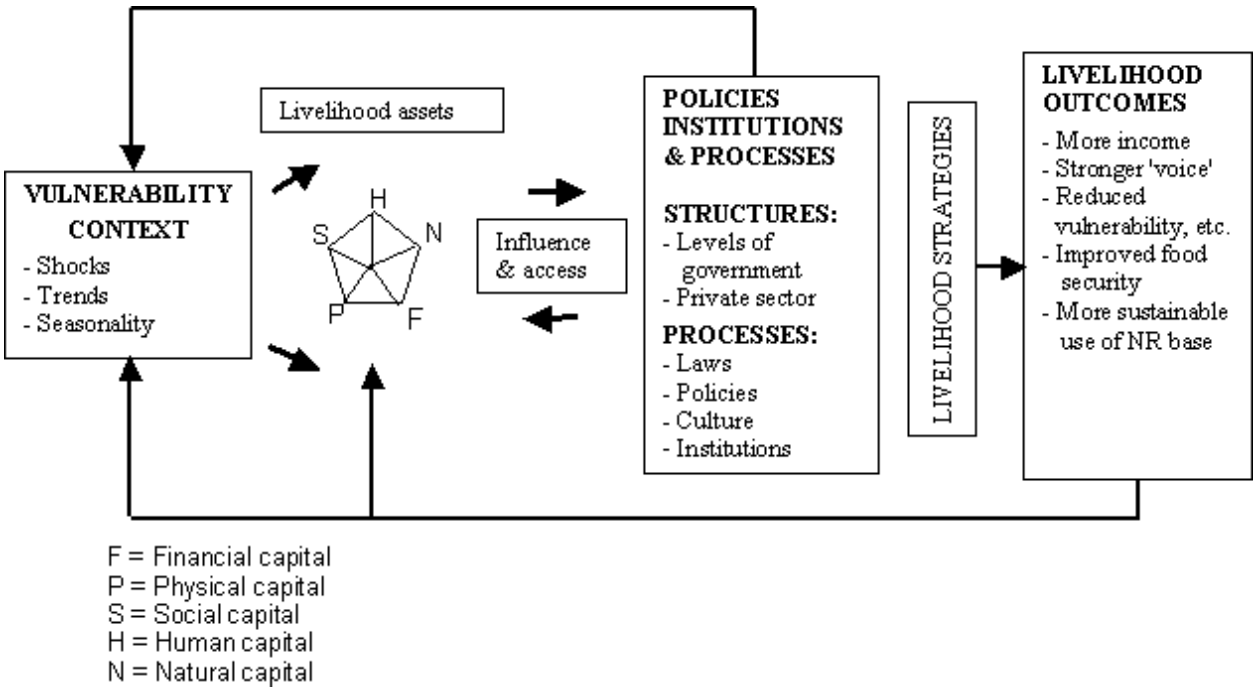

Figure 2.2: Sustainable Livelihood Framework (Source: DFID, 1999)

The framework for sustainable livelihoods outlines the primary determinants of people's livelihoods as well as the common connections among them. People are at the heart of the framework. It does not attempt to provide a model of reality and does not operate in a linear fashion. It seeks to facilitate organized and cogent discussion among stakeholders with disparate viewpoints regarding the various elements influencing livelihoods, their relative significance, and their interactions (DFID, 1999).

System Theory was also applied in this work. A collection of elements that interact within a setting and create a bigger pattern distinct from any of the individual elements is called a system. A system is a collection of interconnected and related components assembled to form a cohesive whole. Information communications make up systems (Luhmann, 1995). The focus of systems theory is on how both human and non-human organized systems adapt to major changes in their external contexts while preserving their fundamental structural integrity. Systems theory models of human groups' and organizations' decision-making place a strong emphasis on their interactions with external actors and organizations and focus on pinpointing the specific aspects of the group's or organization's surroundings that have a major impact on the decisions it makes (Paul, 2005). Real systems can gain qualitatively new qualities through emergence, which leads to ongoing evolution, and they are open to and interact with their surroundings. System environment boundary, input, output, process, state, hierarchy, goal directedness, and information are examples of systems concepts (Bertalanffy, 1968). For

transformations to yield the intended results, inputs are required. According to systems theory, inputs are things that are put into a system, and outputs are the outcomes that a complete process or a specific portion of a process produces (Krippendorf, 2005). There are two fundamental kinds of systems: closed and open. Closed systems don't interact with or get influenced by their surroundings. An open system is aware of its dynamic relationship with its surroundings (Anderson, 1984). As a system, the productive sectors rely on government policy as a key input. The production and marketing of the avocado commodity are more significantly impacted by stakeholders in the avocado value chain. The farmers' ability to generate high-quality output will be influenced by their integration.

2.20 Conceptual Framework of the Study

The conceptual framework of this study is a reflection of the transdisciplinary theory, sustainable livelihood framework, and system theory which emphasizes developing solutions to societal problems by a heterogeneous group of actors that cooperate to form a committed team (Lang et 2012). It identifies the societal problem as avocado production and marketing vulnerability in the context of low avocado yield, inadequate knowledge of avocado production and marketing, weak linkages between avocado value chain actors, inadequate access to good avocado seedlings, and inadequate access to a good avocado market.

Figure 3 illustrates the interactions between the variables conceived for this study. The independent variables in the framework are building the capacity of farmers. It shows how they influence the dependent variable, which is avocado production and marketing as indicated by the increased avocado yields, improved access to good avocado seedlings, and linkage to the avocado market. Capacity building of smallholder farmers was indicated by the key stakeholders and their roles in multi-stakeholder network features, and the innovation platform.

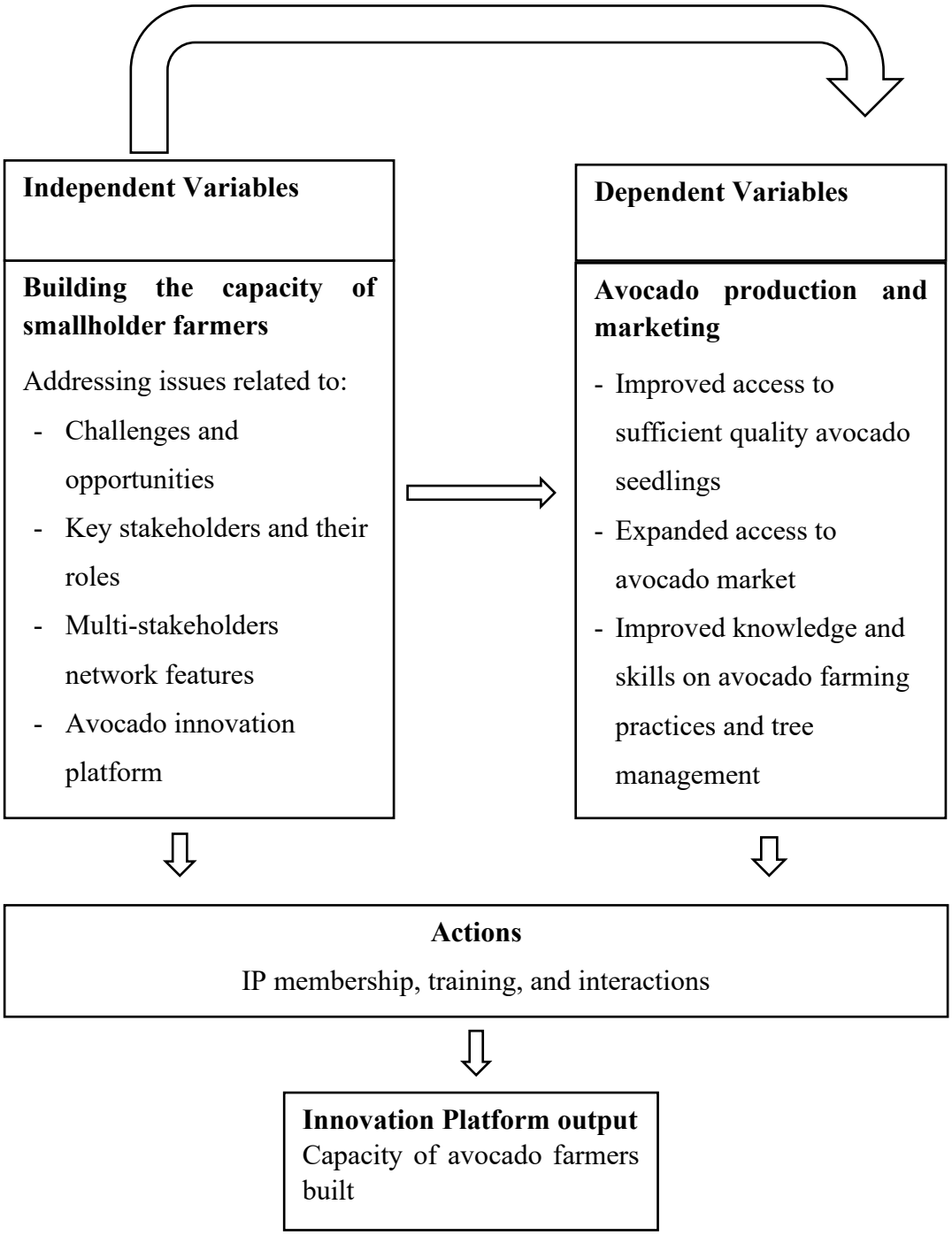

Figure 2.3: Conceptual Framework of Developing an Avocado Innovation Platform for Building the Capacity of Smallholder Farmers in Avocado Production and Marketing in Gisagara District, Rwanda

The dependent variable of the study was avocado production and marketing. The indicators were improved access to sufficient quality avocado seedlings, expanded access to the avocado market, improved knowledge and skills on avocado farming practices and tree management, and improved post-harvest handling and management. The actions in the

conceptual framework involves avocado innovation platform membership, training farmers on avocado production and marketing, and the interactions among the stakeholders of the platform. The main output of the innovation platform was the capacity of avocado farmers built in production and marketing aspects.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methodology that was used to achieve the objectives of the study. It presents the research design, the location of the study, the target population, sampling procedures and sample size, the instrumentation, reliability and validity, data collection, data analysis, and ethical research considerations.

3.2 Location of the Study

The study was carried out in Gisagara District, which is located in the South Province of Rwanda (Figure 3.1).

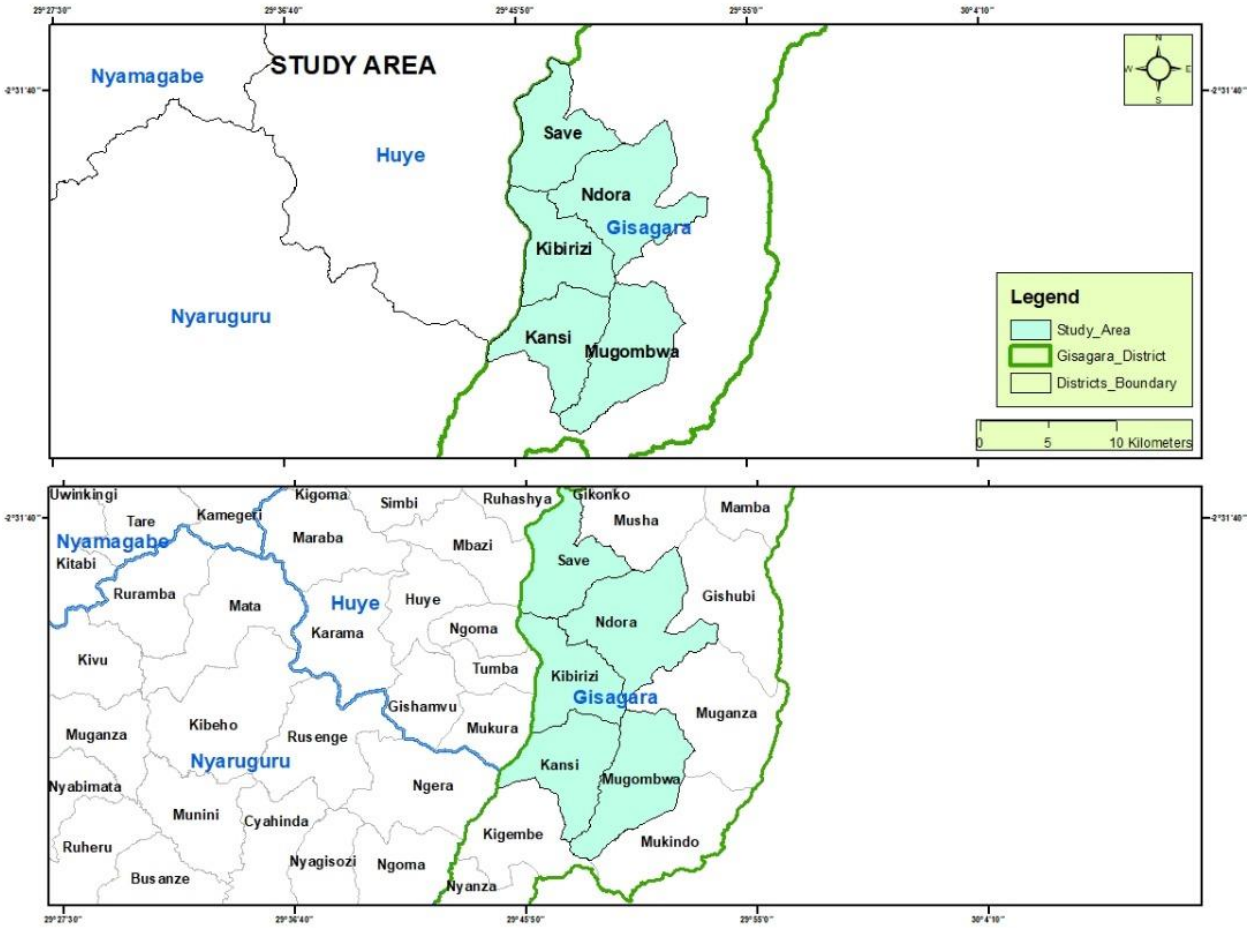

Figure 3.1: Location of the Study Area (source: CGIS)

Gikonko, Gishubi, Kansi, Kibilizi, Kigembe, Mamba, Muganza, Mugombwa, Mukindo, Musha, Ndora, Nyanza, and Save are the 13 sectors that make up Gisagara District, they have 54 cells. Gisagara District has a total area of 816.4 km2, with 1.6% of the population living in urban areas and 98.4% in rural regions. With more than 320 people per square

kilometer, Gisagara District has one of Rwanda's highest population densities. Agriculture is the district's main source of income (NISR, 2022). The Gisagara District is between 1600 and 1800 meters above sea level, and slope inclinations of 13-25% indicate the relief. The majority of the soils have a sandy-clay loam texture and contain a lot of gravel. The key crops grown in Gisagara are maize, sorghum, beans, potatoes, cassava, soya, banana, avocados, orange, citrus, and mangos. The study was conducted in Gisagara District due to its agro-climatic, demographic conditions, and economic characteristics of the avocado farmers. The avocado crop is highly cultivated in the South Province including Gisagara District due to the agro-climatic conditions that are favorable for the crop (NISR, 2018b).

3.3 Research Design

A mixed approach research design was used. The approach incorporated three research designs: a participatory action research (PAR), a cross-sectional household survey research and a pre-experimental research design involving a one group pretest-posttest test method. Three data collection techniques were used, these included: a household survey, an in-depth Key Informants Interview (KII) and Focus Group Discussion (FGD). Secondary data collection methods were also used to collect information from existing sources, these included data on historical information related to the farming community characteristics and skills in the production of Avocado, utilization, preservation and marketing of Avocado (*Persia americanum*).

Survey research design and participatory action research were used in the study. A subset of action research, which is the methodical gathering and analysis of data in order to take action and effect change by producing useful knowledge, is known as participatory action research (PAR) (Macdonald, 2015). According to Penrod et al. (2017), Participatory research techniques have been created to increase community engagement and improve capacity in order to close the gap between science and practice. By encouraging meaningful group work, active learning, and community decision-making, the participatory action research technique gives participants the ability to identify their priorities and take action (Blangy et al., 2018). In this way, the use of participatory action research through an innovation platform can lead to community empowerment and build the capacity of smallholder farmers, especially in terms of both the quality and quantity of avocado production and how to access good markets at the local and international levels. Participatory action research has been recognized as an effective strategy for working with stakeholders to identify institutional capacity needs and catalyze change (Shames et al., 2016).

Surveys are important in research, and as used here they were useful in describing the characteristics of the avocado smallholder farmers in Gisagara District. Survey research was used to describe and explore the information on avocado production and avocado marketing in Gisagara District. It entails examining a situation as it is and trying to explain why it is the way it is. Preliminary and exploratory studies employ survey design to enable researchers to collect data, compile, present, and interpret for clarification (Orodho, 2004). Therefore, through a descriptive survey, the researcher gathered information on avocado production and marketing in Gisagara District.

survey research is the process of gathering data from a sample of people by asking them questions (Check & Schutt, 2012). In applied social research, it is among the most crucial techniques. It includes any measurement that includes posing queries and obtaining answers from participants.

In research, surveys are crucial and have been shown to be effective in characterizing the traits of a group being studied (Fraenkel et al., 2011). Numerous approaches to participant recruitment, data collection, and instrumentation are possible in survey research. This design may employ qualitative research techniques like asking open-ended questions, quantitative research techniques like employing numerically rated items, or both techniques simultaneously. Survey research is widely utilized in social and psychological research because it is regularly used to examine human behavior (Groves et al., 2004). The survey research design has some disadvantages the first one is the risk that people may provide the wrong answers intentionally. Ensuring people that their privacy is our priority and using an anonymous survey reduced the risk of receiving dishonest responses. The second is the limitation on some questions that do not get answers. This limitation was avoided by asking questions and answering them systematically. The third one is that there may be individual differences in the understanding of survey questions, this was avoided by keeping the questions as simple as possible and by giving everyone a chance to understand the question properly. The last limitation of survey research design is the respondents' fatigue in order to avoid trouble due to this disadvantage the questions were easy as possible.

The one group pretest-posttest research design is termed as pre-experimental research designs (Gichohi & Kathuri, 2023). It starts with an observation (or measurement), which provides information about the experimental sample (a pretest). The pretest is a description of the initial state of the selected subjects. A treatment or the presence of a treatment is then undertaken and then a second observation (or measurement) is undertaken to provide

information for the post test of the experimental subjects or the change that has occurred. The one group pretest-posttest research design can be summarized using symbols as follows:

O_1 X O_2

Where,

O = observation, representing measurement of the changes on the variables

O_1, is the first observation before the treatment (pretest)

X, is the treatment, for this is one treatment

O_2, is the second observation after the treatment (posttest)

The design was used to collect data to assess the changes that occurred due to the implementation of the Avocado Innovation platform undertaken by the multi-stakeholder agencies in Gisagara district.

3.4 Target Population

The target population was 322,803 farm households in Gisagara District. The study also targeted other actors in the avocado value chain including, five input suppliers, five collectors/traders, two processors, two exporters, five agencies and six extension officers from Gisagara District. The accessible population was 22,143 households engaging in avocado farming (NISR, 2022).

3.5 Sampling Procedure and Sample Size

The study was conducted in Gisagara District. This study location was purposively selected based on its agro-climatic, demographic conditions, economic characteristics of the avocado farmers, and the researcher's prior knowledge of avocado farming in the country. A purposive sampling method was used to select the sectors. Kansi, Mugombwa, Ndora, and Save Sectors were selected to represent all sectors in Gisagara District as they have the same agro-climatic conditions as the other sectors, and their soils have proved to be more suitable for growing avocadoes.

The sampling frame consisted of the total number of households in selected sectors based on the NISR (2022) report. A proportionate sample allocation method was used to determine the number of farmers to be interviewed in each sector. The following formula was used to come up with an appropriate sample size for the study. It is proposed in Nassiuma (2000).

$$\mathbf{n} = \frac{\boldsymbol{NC^2}}{\boldsymbol{C^2 + (N-1)e^2}}$$

Where:

n= the required sample size,

N = the population within the study area,

C = Coefficient of Variation,

e = Standard error.

Nassiuma, (2000) asserts that in most surveys or experiments, a coefficient of variation is in the range of 21%≤ C ≤ 30%, and a standard error in the range of 2% ≤ e ≤ 5% is usually acceptable. Therefore, a coefficient of variation of 21% and a standard error of 2% were preferred for this study. The lower limit for the coefficient of variation and standard error was selected to ensure low variability in the sample and minimize the degree of error.

$$\mathrm{n} = \frac{22143 \times (0.21)^2}{(0.21)^2 + (22143 - 1)(0.02)^2}$$

For this study N = 22143 households in the five sectors, C =21% and e =2%

Based on the population of the area and the formula the required sample size was 109.71 households which are rounded to 110 households. However, this study employed a straightforward random sampling technique to choose 143 farmers to take part in the household survey in order to address the non-responses, which are frequently in the range of 30 percent (Moore, 2000), When a targeted respondent refuses to assist by stating that they are too busy or secretive, survey non-response increases (University of Reading Statistical Centre, 2000). The number of respondents interviewed in each of the four sectors was chosen proportionately once the overall sample size was established based on the target population. The sample size per sector was allocated proportionately as shown in Table 3.1.

Table 3.1: Sample Size for Households in the Sectors in Gisagara District

Sectors	**Proportional allocation**	**Percentage**	**Households**
Ndora	4181	18.9	27
Kansi	4955	22.4	32
Mugombwa	4181	18.9	27
Save	8826	39.9	57
Total	**22143**	**100**	**143**

To find the pertinent stakeholders in the avocado value chain who participated in focus groups to get the necessary data and to significantly impact the intervention's performance, stakeholder analysis was conducted. According to Golder (2005), stakeholder analysis helps

identify the interests of all stakeholders who may affect or be affected by a project. The number of key informants was based on their availability and the survey instrument was a checklist. The sample size including smallholder farmers and key informants is presented in Table 3.2.

Table 3.2: Participants Sample Size Distribution

Participants	**Sample size**
Farmers	143
Input suppliers	5
Collectors/ Traders	5
Processors	2
Exporters	2
Extension officers	6
Agencies	5
Total	**168**

3.6 Instrumentation

Three instruments were used to collect data for this study including a household questionnaire used on the baseline survey, a focus group discussion, and a questionnaire used for an end-line survey. A baseline survey was carried out using a questionnaire to collect information from the avocado farmer. The farmers were interviewed in a face-to-face situation. Both closed and open-ended items were included in the questionnaire. The questionnaire had three sections: Section A covered the socio-economic background of the respondents, section B covered knowledge, skills, and practices on avocado production, and Section C was about the challenges that hinder the production of high-quality avocadoes for local and export markets. The items for farmers were translated into the Kinyarwanda language to cater to the farmers who do not understand English. A baseline survey questionnaire offers a representative viewpoint on the challenges faced by smallholder farmers in avocado production and marketing in the area of the study.

A guide for the Focus Group Discussion was developed, which helped to have in-depth primary data from key informants in the avocado value chain in the study area. FGD guide was used to collect information from key informants including input suppliers, extension officers, traders, processors, and exporters.

After establishing and implementing an avocado innovation platform for a period of six months an end-line survey questionnaire was administered in the same households where the

baseline survey took place to evaluate the effect of the avocado IP on avocado production and marketing. The questionnaire items were similar to those used in the baseline survey. Additional questions were added to track aspects of change in avocado farming practices and the other changes in avocado production and marketing.

The focus of the end-line survey was to establish changes brought about by capacity building of smallholder avocado farmers on farming practices in order to overcome the challenges in avocado production and marketing. The questionnaires had reflective questions to allow IP members to think back and compare their knowledge, skills, and experiences before and after participation in the IP while focusing on study objectives and research questions.

3.6.1 Validity

To improve the validity of the collected data, the research objectives and the data collection instruments were presented to a panel of experts. Experts from the Department of Agricultural Education and Extension of Egerton University, Kenya, and the Department of Forestry and Nature Conservation, University of Rwanda reviewed the instruments to address content and face validities. The panel made sure that the instruments' questions accurately assessed how well the data gathered reflected concepts and addressed all pertinent topics being studied (Mugenda & Mugenda, 2003). The degree to which the test items reflect the domain or universe of the characteristic or feature being tested is known as content validity (Mugenda & Mugenda, 2003). The issue, study goals, conceptual framework, and tools to address face and content validity were presented to the panel. Their feedback was utilized to increase the instrument's validity. The items' appropriateness and intricacy were examined, and where necessary, reframing was carried out. This is to make sure that before being used in the field, the items are unambiguous, clear, succinct, thorough, and well-organized.

3.6.2 Reliability

The degree to which a research tool produces consistent data outcomes over several trials is known as reliability (Kothari, 2004). To guarantee the instrument's consistency, the questionnaire (Appendix B) was tested in a pilot survey. The sample for the pilot test was 30 randomly selected farmers from Gatare Sector of Nyamagabe District. The selected number was within the acceptable range of 20 to 50 subjects recommended by Kathuri and Pals (1993). The reliability of the instruments estimated using Cronbach coefficient alpha was 0.79, which was above the acceptable level. The reliability should be greater or equal to 0.7 (Frankel & Wallen, 2011).

3.7 Data Collection Procedure

A letter of clearance was obtained from the Egerton University Board of Post Graduate Studies, to enable the researcher to seek a research permit from the National Council for Science and Technology (NCST) of Rwanda. The research permits were distributed to selected sector offices in Gisagara District, where the study was conducted. The researcher was given a list of avocado farmers that made up the sampling frame by the agronomists of particular sectors. The identification of the sampled respondents was aided by the farmer facilitators.

There were three data collection phases. The first phase was the baseline survey. A baseline survey assesses the state of affairs at the start of the project. To determine what has changed, this can then be contrasted with the circumstances following the conclusion of the intervention. It facilitates the collection of data regarding the condition of various variables in the methodical study. This involved finding two enumerators who had some social studies experience and teaching them how to do the household survey. With the help of skilled enumerators, the researcher scheduled precise times to meet with the sampled respondents in order to present the questionnaire, conduct an interview, and record the results. The information was then gathered through in-person interviews with the farmers. The interviews with the respondents were at designated places, times, and dates. Confidentiality was guaranteed. Focus Group Discussions were organized to obtain cross information from key informants in the avocado value chain including 6 Extension officers, 5 input suppliers, 5 collectors/ traders, 2 processors, and 2 exporters. They received an invitation by phone before the meeting. All the events during the FGD were recorded using the recording tools including minutes-taking. FGDs were carried out at selected sectors of Gisagara District.

3.7.1 Innovation platform development

The second phase was IP development and testing for a period of six months. This study engaged key stakeholders to participate in the innovation platform, 40 Farmers from those who participated in the baseline survey from each sector and other avocado stakeholders including 6 Extension officers, 5 input suppliers, 5 collectors/ traders, 2 processors, and 2 exporters were engaged through participatory forums to obtain insight into their knowledge and experiences in avocado production and marketing. The chosen farmers participated in focus groups and interviews to gain their opinions on the issues affecting the production of premium avocados for Gisagara District's domestic and international markets. Together, they came up with a solution. In order to develop strategies for strengthening ties between avocado farmers and other value chain actors in avocado production and marketing, an analysis of the avocado value chain was conducted to comprehend the difficulties encountered throughout the chain. Value chain analysis shows how players are related to one another, highlights opportunities and important chain restrictions, and may help find market-based solutions that boost competitiveness (Donald, 2009).

The avocado innovation platform has been serving as a learning forum in which the production of high-quality avocadoes for local and export markets would be further advanced and disseminated to other farmers. There were four days per month for interactive training with members being facilitated by an expert in the avocado value chain to engage freely on the topics. The participants were taken through a six-month training to cover the topics that were developed. There was one IP site per sector that made a total of four avocado IPs in Gisagara District. The topics covered include varieties of avocado, land preparation, irrigation, fertilization, pruning, pests and diseases, harvesting and post-harvest handling techniques/management, and marketing of the produce. These topics were developed in order to overcome the challenges faced by smallholder farmers in avocado production and marketing in the area of the study

The third phase was IP evaluation. The evaluation was done to compare the situation of avocado production and marketing before and after the establishment of IP and conducting training, here we were comparing the data of the baseline survey and the data after the intervention, this helped to know if there is a change in the avocado value chain. At the end of the training period in the avocado innovation platforms, a survey was conducted on the effect of the training on avocado production and marketing for the participants. The development and implementation of strategies were accompanied by ongoing monitoring and evaluation to identify the added value of measures jointly developed by stakeholders. Regular field visits

allowed the innovation platform to discuss and consider ideas and their effects on the avocado farming system. Farmers were monitored to determine overall farm conditions and their opportunities to produce high-quality avocadoes for local and export markets.

3.8 Data Analysis

The data was analyzed using both qualitative and quantitative methods. The quantitative data analysis that was used includes descriptive statistics (frequency, percentage, and means) and inferential statistics that include t-test and chi-square for survey data analysis. After data collection, survey data were edited, coded, and analyzed using SPSS and NVivo. Each questionnaire item's scale of measurement served as the basis for the coding of replies.

The qualitative information gathered from focus groups with the main informants was analyzed using thematic analysis. This involved data logging, vignette, and data coding. The technique of capturing raw data from focus groups, interviews, and other qualitative data collection methods on a recording sheet or notebook was known as data logging. When providing narratives or story investigations on the interpretation of a person, piece of knowledge, or situation that the researcher was describing, vignettes were helpful. The process of breaking apart and categorizing text to create thorough themes and explanations in the data was known as data coding.

A five-point Likert scale was used to grade the IP according to how much it promoted knowledge sharing. Training farmers in the production and marketing of avocados was referred to as capacity building. Based on the type of activities carried out in the IP, a Likert scale was created for farmers and other stakeholders to score their degree of knowledge acquisition and skill development. Strongly agree, agree, disagree, disagree, and strongly disagree were on the first Likert scale; very high, high, medium, low, and very low were on the second. The IP group members' interactions to improve information sharing and learning were used to determine the network features, which were then gauged by how frequently they attended meetings. A five-point Likert scale was developed to measure the level of knowledge IP members had acquired on avocado production and marketing. The paired t-test was used to compare the level of knowledge and skill acquisition from the Avocado Innovation Platform using measurements obtained from the pretest and post -test analysis.

3.9 Ethical Consideration

The researcher obtained a research clearance from Egerton University and a research permit from the National Council for Science and Technology (NCST) of Rwanda and permission from the respective authorities of the study sites in Gisagara District. The researcher

explained the purpose of the study to potential participants, what is required of them, the data collection process and the interview duration (20-30 minutes). After clearing all concerns and possible risks in participating, and assurance of the confidentiality and anonymity of their identity and information, the participant responded to a YES/NO question to start the interview. The researcher respected the Ministry of Health guidelines to prevent the spread of Covid-19. The researcher preserved the anonymity and confidentiality of participants by optional identification of their names and identities other than their sex and age. The study was also cleared by the Research Ethics Committee at Egerton University.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the results of the study based on formulated objectives and hypotheses as presented in Chapter One. This study was on building the capacity of smallholder farmers in avocado production and marketing in Gisagara District, Rwanda. The results of the findings are discussed in relation to other studies as given in the following sections.

The chapter is subdivided into the following sections: (i) introduction, (ii) demographic characteristics of the smallholder farmers, (iii) characteristics of smallholder Avocado farming systems, (iv) Farmer knowledge and skills on Avocado production, (v) Farmer knowledge and skills on Avocado marketing, (vi) challenges and opportunities in the production of quality avocado fruits, (vii) avocado value chain stakeholders and their roles in avocado production and marketing , (viii) multi-stakeholder network features that could promote high-quality avocado production, (ix)the establishment of avocado innovation platform for farmers in Gisagara district, (x) evaluation of the contribution of the avocado innovation platform on the production and marketing of avocados in Gisagara district. Figure 4.1 shows the location of the sampled household.

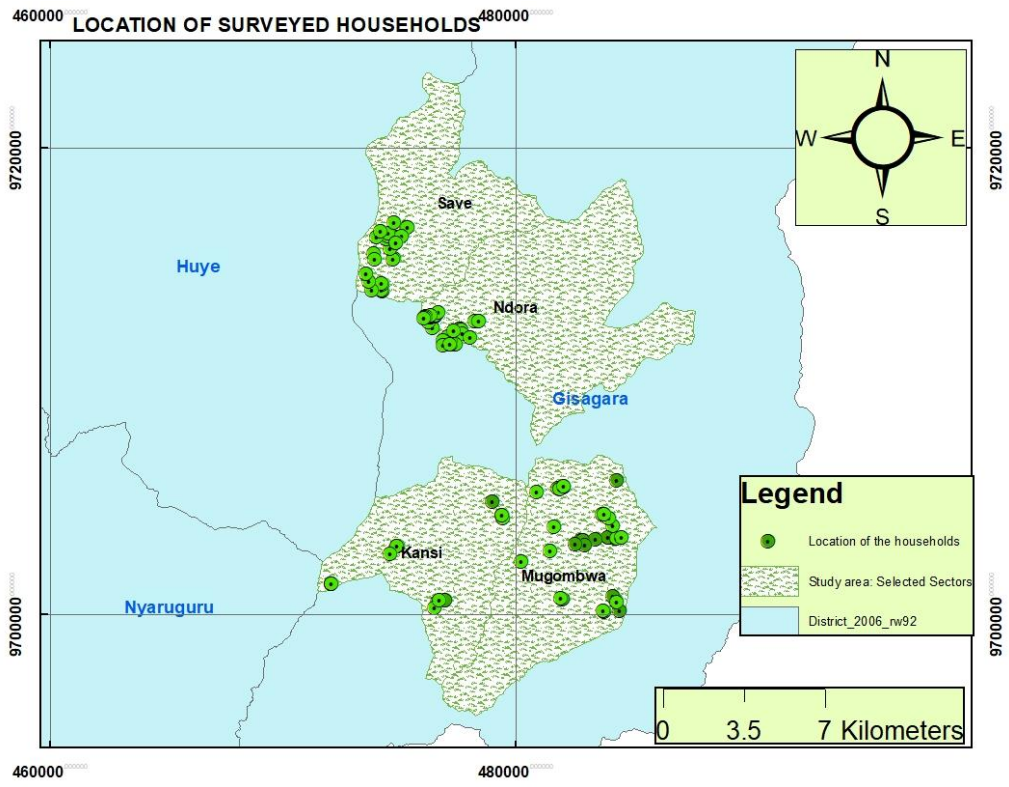

Figure 4.1: Location of the Surveyed Households (source: CGIS)

Four centers of avocado innovation platforms were established in Kansi, Save, Ndora, and Mugombwa Sectors of Gisagara District, Rwanda. A group of 10 smallholder avocado farmers in each sector was purposively selected to participate in the establishment and implementation of the interventions through Participatory Action Research in partnership with the researchers, 6 Extension officers one from each sector and other one from the district, 5 input suppliers, 5 collectors/ traders, 2 processors, 5 agencies, and 2 exporters. Training and demonstrations were held regularly where the challenges and opportunities that are in avocado were discussed and reflected upon within the avocado innovation platform.

4.2 Socio-Economic Characteristics of Smallholder Avocado Farmers

Out of 143 farmers interviewed, there were 61 males, which represented 42.7%, and 82 females corresponding to 57.3% of respondents. According to the education level of the farmers, the analysed data shows that the majority of the respondents (61.5%) had attained the primary level of formal education, this means that they are literate people who can read and write and they can easily understand the concepts essential to this study. The results on age show that out of 143 farmers interviewed 49.6% were above 50 years old, and only 1.4% were below 30 years old. The low percentage of youth in the respondents is mainly because the interview was targeting the head of the household. The findings about the socio-economic characteristics of the respondents including gender, age, and education are presented in Table 4.1.

Table 4.1: Socio-Economic Characteristics of Avocado Farmers

Socio-economic groups	**Category**	**Frequency of the farmers**	**Percent of the farmers**
Gender	Male	61	42.7
	Female	82	57.3
Education	No formal education	45	31.5
	Primary	88	61.5
	Secondary	7	4.9
	University	3	2.1
Age	Below 30	2	1.4
	Between 30-39	23	16
	Between 40-50	47	32.9
	Above 50	71	49.6

The high percentage of women among respondents could be because women are more involved in agricultural activities than men. Most men are not engaged in agriculture, they are instead mainly responsible for economic well-being activities such as construction, and carpentry in order to get money outside farming so that they can financially support the household. This sample population distribution is in line with the one given by the National Institute of Statistics of Rwanda (2018), which shows that there are more females than males in Gisagara district (NISR, 2018c). Comprehending the socio-cultural context of a particular community aids researchers and extension agents in creating and distributing technologies that align with the views of the target population. Men and women play a conscious and determinant role in the generation and maintenance of agricultural diversity through dynamic interactions with the environment (Farnworth et al., 2016). In avocado-related activities studied elsewhere, it has been shown that each member of a family has a complementary role to play from land preparation up to harvesting (Muriithi & Kabubo-Mariara, 2022). Males participated in land preparation, seedlings preparation, transplanting, and fruit harvesting whereas females participated in fruit collection and selling the fruits to the local market (Feyisa & Megersa, 2020).

In many African communities, the gender of farmers has a crucial role in how resources are used and owned, how farming operations are carried out, how new ideas and technology are viewed, and how information is shared (Kilic et al., 2015). This information helped in gender mainstreaming during the establishment and management of the avocado innovation platform. The process of gender mainstreaming IPs entails reevaluating and reframing the socioeconomic ideals and development objectives that IPs envision. In addition to fostering a sensible use of resources that permeates every part of a community, the gender mainstreaming process aids the IP institution in achieving justice and fairness. Communities can reach their full potential with the support of gendered IPs. In addition to providing smallholder farmers with sustainable options, the avocado innovation platform might pave the road for ecological and social change that values women's autonomy and roles.

The findings about the farmer's educational attainment align with nationally conducted surveys, including the Integrated Household Living Conditions Survey. According to the study, 57.4% of Gisagara District residents had completed at least their primary education (NISR, 2018a). Since it is thought to influence the farmer's involvement in the agriculture innovation platform, the farmer's educational attainment was a significant element in this study. The level of formal education can affect the adoption of agricultural technologies as it can determine the farmer’s readiness to accept and properly apply technologies (Vecchio et al., 2020). It was

revealed that educated farmers had greater access to information than uneducated farmers (Diederen et al., 2003). The more literate farmers are, the more they can comprehend technologies (Läpple et al., 2015). The level of formal education attained by the farmers determines their potential to acquire and understand information, use new farming practices, and disseminate technologies learned or practiced over a long period of time in a simple manner (Walton et al., 2010). The level of education directly affects one's ability to adapt, to change, and to accept new ideas (Isgin et al., 2008). It is anticipated that farmers with higher levels of education will possess the knowledge and abilities to use better market information, which can lower transaction costs and enable them to engage in lucrative high-value markets (Geoffrey et al., 2013). The education level of the farmer was taken into consideration during the establishment and management of the Avocado innovation platform where the IP members had different education backgrounds. Participation of people with different educational backgrounds helps to have different ideas during discussion and participants were eager to learn from one another. The players who make up innovation platforms collaborate, communicate, and share tasks in order to carry out the tasks required for innovation to occur. Innovation platforms' primary potential is to encourage users to behave differently, which could eventually have significant, observable effects. The results on the age of the farmers differ from the one given by the National Institute of Statistics of Rwanda (2018), which shows that the population Gisagara District is mostly young where 60.3% of the resident population of Gisagara were under 25 years old. This could be because this study was interviewing the head of the household and most of them were mature and their age were above 40 years old. The respondents' ages were examined since they may have an impact on their decision to use new technologies and engage in group activities. The adoption of technologies is positively correlated with age. A farmer's ability to learn by doing and improve management abilities is influenced by the age of the head of the household (Muriithi & Kabubo-Mariara, 2022). Farmers are more likely to reject new advances and technology if they lack the necessary training and information. Age and farmer market participation are positively correlated (Anh & Bokelmann, 2019). Because they have greater experience, older farmers are more interested in planting trees. The age of the farmer was also considered during the establishment of the avocado innovation platform. The platform was operated with the hind set of different age groups of the participants. This saw a mix of participants with different ideas, different interests, different experiences, and different ways to influence and exercise power. Innovation is the process of implementing novel concepts in a particular place, improving the status of

local residents in the process. When several players collaborate and exchange ideas, information, and viewpoints to develop novel solutions, innovation is sparked.

4.2.4 Farm size

The analysed data (Table 4.2) shows that the majority of the Avocado farmers (53.8 %) had pieces of farms that were less than 0.50 ha, while 19.6 % had farms that were between 0.60 ha and 0.90 ha, 21.7 % had farms that were between 1.0 ha and 3.0 ha, and 4.9 % of the farmers had farms that were above 4.0 ha. The results on farm size are presented in Table 4.2.

Table 3.2: Descriptive Statistics and Frequency Distribution of Farm Sizes Owned by Avocado Farmers in Gisangara District

Size of Farm Owned by Farmers	Frequency	Percent
Below 0.5 ha	77	53.8
Between 0.60-0.90 ha	28	19.6
Between 1-3ha	31	21.7
Above 4 ha	7	4.9
Total	**143**	**100**

Mean 0.917±.098, Median .5, Mode .40, Std. Dev. 1.172, Minimum .10, Maximum 7

The size of the farm is an important factor because it determines the category of the farmer either a smallholder farmer or a big farmer. The smallholder category includes farmers with less than 1hectares of arable land, while large farmers have more than 1 hectare of arable land. The results in Table 4.2 mean that the majority of the farmers operating in the area are smallholder farmers. They could not allocate a big land to avocado plantations as a monoculture. Therefore, the avocado trees were mixed with other crops. The results are in line with the National Institute of Statistics of Rwanda which reported that the mean farm size owned by the farmers in Gisagara District was found to be 0.3 ha obtained by the national survey in 2018 (NISR, 2018a). Farm size influences farmers' participation in the adoption of new technologies thus adequate farm size can affect a farmer's decision of planting avocado. A study in Cameroon and Nigeria revealed that farm size influences the number of fruit trees owned by smallholders (Degrande et al., 2006). Farmers with large landholdings have more freedom to allocate land to planting trees. The information on the farm size of the farmer gave the overview of the farming system in the area of the study, and the farmers with different farm sizes were engaged to be members of the avocado innovation platform. The various and diverse stakeholder groups that make up innovation platforms have varying interests, perspectives, and

skill sets that they can contribute to the platform. Tensions, disputes, advantage-seeking, and even group displacement are likely to arise when a collection of stakeholders with disparate needs, interests, and goals are brought together. This can impede collaborative efforts to achieve development goals. Incorporating smallholder farmers into the innovation process actively results in solutions that are best suited to the local environment, both in terms of the agricultural system and in terms of reflecting the development goals of the local community.

4.3 Avocado Production in the Gisagara District of Rwanda

The avocado production studied in Gisagara District included the average production of avocados per year, avocado varieties planted by the farmers, pests, and diseases in avocado farming, agronomic practices used on avocados, and the number of avocado trees owned by the farmer.

4.3.1 Number of avocado trees owned by the farmer

The number Avocado trees growing on individual farmer plots in Gisagara District were assessed and the data was analyzed using descriptive statistics and frequency distributions and the results are presented in Table 4.3.

Table 4.3: Descriptive Statistics and Frequency Distributions of the Number of Avocado Trees Owned by Farmers in Gisagara District

Number of Trees	Frequency	Percent
Below 10	107	74.8
Between 11-20	19	13.3
Between 21-30	5	3.5
Between 31-40	5	3.5
Between 41-50	3	2.1
Between 51-100	3	2.1
Above 100	4	2.8
Total	**143**	**100**

Mean 12.5±1.71. Median 6, Mode 5, Std. Dev. 20.5, Minimum 5, Maximum 121

The majority (74.8 %) of sampled Avocado farmers in Gisagara District had Avocado trees that were below ten (10), whereas 2.8 % of the farmers had above 100 Avocado trees on their farm. This means that all interviewed farmers were able to take their Avocado produce to the market but with different quantities depending on the number of trees they had. The number of trees owned by a farmer determines the overall production which means that if a farmer has

many trees, he/she will harvest many avocado fruits which can be taken to the markets and get more money than the one who has few trees.

The number of avocado trees planted by the farmer was highly attributed to some factors including the size of the land owned by the farmer. The farmer with a big land tends to have many avocado trees in their farm. More trees can lead to higher potential yields and income if the trees are healthy and well-managed. Planting a large number of avocado trees requires significant land. This could impact land availability for other uses. 82.0% of households in Gisagara District are engaged in crop farming such as cassava, banana, maize, bean, soybean, sweet potatoes, and fruits including avocados (NISR, 2023). The avocado crop is highly cultivated in the South Province including Gisagara District due to the agro-climatic conditions that are favorable for the crop (NISR, 2018b). Mwambi et al. reported that tiny farms of roughly two acres, with an average of 13 avocado trees per household, are typically used for avocado cultivation in Kenya. The number of avocado trees planted by farmers can have implications for the formulation and effectiveness of an avocado innovation platform.

The number of avocado trees planted by farmers influences the scale, data richness, economic feasibility, and potential impact of innovations within the avocado industry. Tailoring the innovation platform's strategies to the scale of planting helps maximize its effectiveness and relevance. During the establishment of the avocado innovation platform, the farmer with at least ten avocado trees was invited to be a member of the platform. Smallholder farmers and other stakeholders from various backgrounds can communicate, make agreements, find promising entry points, and have an impact on the development of new models and opportunities through innovation platforms.

4.3.2 Average production per year

The majority of sampled avocado farmers had average production of less than 500kg per year accounting for 71.3% of the respondents. The farmer's responses on average production are presented in Table 4.5.

Table 4.5: Average Production Per Year

Average Production in Kgs	Frequency	Percent
Below 500	102	71.3
Between 500-1,000	24	16.8
Between 1,001-1,500	7	4.9
Above 1,500	10	7.0
Total	**143**	**100**

The average production of the avocado farmer influences the income generated from avocado farming. The farmer with high avocado production will receive more income from avocado farming. To gauge differences within the families, respondents were asked about their average production. Farmers' income is crucial since it dictates the kinds of investments they may make. The farmers were asked to state their average production from avocado farming. Low avocado yields are the result of pests, diseases, and inadequate management practices on avocado trees, and climate change as well which cause the prolonged drought period and avocado farmers are not familiar with irrigation. This implies that avocado farmers in the area of the study needed training on agronomic practice and management of avocado crops. The productivity potential of crops may be affected by management practices. The lack of technical and scientific knowledge information among farmers related to the correct implementation of agronomical practices has been identified as the main challenge that results in low-quality and quantity avocados that are not preferred in the international markets (Ramírez-Gil, 2018). This study built the capacity of avocado farmers and provided information on the management practices of avocado trees to increase avocado yield, quality, and income as well. The average production of Avocado in Rift Valley Province, Kenya varies between 5-1700 t of avocado but this kept changing due to avocado pests and diseases and other agronomic factors which led to 60% of avocado production being lost (Wasilwa et al., 2007).

4.3.3 Avocado varieties planted by the farmers

The results indicate that the main varieties planted by the farmers included *Reed* (49%), *Hass* (37.1%), *Simmonds* (32.2%), and *Fuerte* (30.1%). The farmer's responses on the avocado trees planted were analyzed and the results showing the frequency of varieties and their ranks are presented in Table 4.6.

Table 4.6: Avocado Varieties

Variety	Frequency n=143	Percent	Rank
Reed	70	49	1
Hass	53	37.1	2
Simmonds	46	32.2	3
Fuerte	43	30.1	4
Ettinger	35	24.5	5
Pinkerton	10	7	6
Bacon	10	7	7
Nabal	9	6.3	8
Others	6	4.2	9

The varieties of avocados planted by the farmers are a crucial factor as they influence the marketability of the fruits. Some varieties are more specific for export purposes like *Hass* and *Fuertes* varieties and are also preferred to the local market as well because the customer is sure that those avocadoes are very sweet and can be stored for a long time due to high lifespan. The farmers were asked to state the avocado varieties they planted on their farms. The majority of the farmers grew a *Reed* variety as the local one which is not grafted, this is the reflection of the situation in the study area where most of the planted trees are from their own seed, this means when a farmer buys and ate avocado, they just throw the seed into their farm and once the seed germinated and it grew itself that is the way of propagation of the available variety in the area.

Reed is the most popular variety among farmers, accounting for nearly half of the production. This suggests that *Reed* may have characteristics that are particularly favorable to local growing conditions or market demands but it yields low prices. *Hass* is the second variety in the area of the study because they were given the seedlings by the local leaders. The majority of them are still young they have not yet reached to harvesting stage. The results are in line with the National Agriculture Export Board that says the types of avocado varieties grown in Rwanda include *Hass*, *Fuerte*, *Ettinger*, *Booth*, *Choquette*, *Collisson*, *Nabal*, *Puebla*, *Reed*, *Simmonds*, *Pinkerton,* and *Bacon* (National Agricultural Export Development Board, 2015).

Some varieties seem not to be found in the study area because they are no longer being promoted and are not available in many nurseries because they take a long time to be harvested and They have a limited shelf life, which results in significant losses after harvest. Due to its longer shelf life, resistance to physical damage, and reduced susceptibility to pests and diseases, hass is the most popular avocado cultivar worldwide (Mwambi et al., 2016). The most popular avocados that are chosen for export are *Fuerte* and *Hass* (Dreher & Davenport, 2013).

The avocado variety determines the price of avocado and good quality avocado fruits will have a better price on the market. The majority of the respondents preferred to grow *Hass* avocado for several market and production reasons. Most felt that *Hass* varieties had a better market, good taste, higher price, and longer shelf life, and therefore were good for processing and export purposes. At the production level, *farmers felt that the variety was high-yielding, disease, and pest-tolerant, required a short period to mature, was easy to harvest, and had a lower post-harvest loss. A little more than half of those surveyed preferred to grow Fuerte avocadoes because they felt that the variety fetched a good price, the variety was "very sweet", and was fast-growing.*

The crop is cultivated for both domestic and international markets. *Hass* and *Fuerte* are the most widely exported cultivars in Rwanda (MINAGRI, 2012). In addition to generating foreign exchange, avocado fruits are a reliable source of revenue for farmers (NAEB, 2015). A study in Kenya shows that *Hass* and *Fuerte* varieties yield a better price than the local varieties, and those varieties have better disease resistance, and pests, higher oil content, and higher capacity to stay for long without being damaged (Amare et al., 2019). which explains why they are also preferred for the export markets.

During the discussion with the respondents, it came out that the farmers were not aware of the avocado varieties planted on their farms, they just described the avocado fruits based on their shape and color. This leads to planting avocado trees that are not preferred by the markets and by the farmers as well. Accessing quality seedlings was an issue for the avocado farmers in the study area. This implies that enhancing smallholder avocado farmers' access to quality seedlings is critical to promoting high quality avocados for local and export markets. This study provided training on avocado varieties preferred to the local and international markets. It also trained the farmers on the grafting techniques of avocados. Training SHFs on the value of different avocado varieties assisted them in benefiting more from avocado farming. This was done through the formulation of an innovation platform where farmers and other actors along

the avocado value chain came together to express their challenges and opportunities in avocado production and marketing and also learned together.

The distribution of avocado varieties among farmers highlights a strong preference for *Reed* and *Hass*, with significant but smaller shares for *Simmonds* and *Fuerte*. This distribution provides insights into market demands, variety characteristics, and areas for potential innovation. Avocado innovation platform design strategies to the specific needs and preferences related to these varieties can enhance productivity, market competitiveness, and overall success within the avocado industry.

4.3.4. Pest and diseases affecting avocado trees

The results on the incidence of pests and diseases show that 62.9% of the respondents had seen some pests and diseases in their avocado trees and 37.1% had not observed any pests or diseases in their avocado trees Table 4.7.

Table 4.7: Frequency Distribution of Common Pests and Diseases Affecting Avocado Trees in Gisagara District

Pests and Diseases	Frequency	Percent
Farmers were able to observe and recognize Avocado pests and diseases	89.95	62.9
Farmers were not able to observe and recognize Avocado pests and diseases	53.05	37.1

Avocado pests and diseases are another important element as they can cause some big losses if they are not well taken care of. The farmers were asked if they were experiencing any pest infestation or diseases in their avocado plantations. The results on avocado pests and diseases are in line with the Ministry of Agriculture and Animal Resource which found that there is a pest called Anthracnose *Colletotrichum gloeosporioides* and *Colletotrichum acutatum* in avocado farming in Rwanda (Daniel, 2013). The losses caused by pests and diseases have been reported in avocado farming in different areas all over the world. Pests and illnesses affecting avocados can have a direct effect on the sector by lowering sales, causing damage to property, and raising management expenses (Evans & Jonathan Crane, 2011). Farmers are unable to continue producing avocados if illnesses and pests are ignored, as this can cut production and market value by 50%. The reported and observed pests and diseases by

the avocado farmers in the study area include root rot, insects, anthracnose, leaf rust, bacterial blast, falling of immature fruits, aphids, termites, ants, falling of flowers, leaves, and branches; insects; snow inside the fruits and fruit rotting. These pests and diseases affect the quality of the fruits and the quantity as well. The avocado smallholder farmers in the study area were struggling with the management of pests and diseases because they were not aware of how to manage pests and diseases specifically on avocado crops.

Farmers' preparedness and ability to manage avocado pests and diseases are crucial for maintaining healthy crops and ensuring high yields. Workshops and training sessions can help farmers stay updated on the latest management practices and technologies. This study provided training to avocado farmers on the management of pests and diseases in avocado plantations.

4.3.5 Agronomic practices on avocado

The results (Table 4.8) show that eleven (11) Avocado agronomic practices were undertaken by farmers in Gisagara District. Land preparation accounted 49 %, pruning was found to be applied by 45.7 % of the respondents whereas irrigation accounted for 15.4 % in the study area.

Table 4.8: Agronomical Practices on Avocado Crop

No	Agronomic Practices	Frequency	Percent.
1	Pruning of branches	65	45.4
2	Grafting	21	14.6
3	Irrigation in the dry season	22	15.4
4	Mulching	36	25.2
5	Planting seedlings	47	33.0
6	Land preparation	70	49.0
7	Pests control	10	7
8	Disease management	13	9
9	Manure application	20	14
10	Managing Crop/Livestock/ Tree interactions	7	5
11	Fertilizer application	24	16.8

There is a need to understand the agronomical practices applied to avocado trees as they can affect the overall production of avocados. Pruning was found to be applied by the majority

of the respondents due to the farmers' need to reduce the shade on other crops mixed with avocado and they want to use branches as firewood and stakes and then use the leaves as mulching. The application of fertilization and irrigation was low in the study area before the establishment of the innovation platform, the majority of smallholder farmers apply fertilizer and mulching when they are applying on other crops that are mixed with avocado trees, not specific to avocado trees. However, the farmers also applied fertilizers when avocado trees were still very young. The application of agronomic practices on avocado trees was very low in the area of study due to the farmers were not aware that the avocado trees should be taken care of as other crops, they were just thinking trees could grow themselves without any other follow-up. This may reflect limited access to resources or knowledge about these techniques. The farmers think that they can plant trees and wait for the harvesting period without applying any agronomic practices.

Mulching avocados with composted green waste is highly important for avocado growth. Mulching can improve the avocado rooting system and productivity as well (Bergh, 1992). Soil infertility and lacking nutrient supply can affect the growth and development of avocados leading to a decrease in yield (Selladurai & Awachare, 2020). There are several benefits of pruning avocado trees, these include lowering tree height to reduce harvesting costs and cross-shading between branches, reducing crowding between trees, promoting regrowth, and reducing risk (Wilkie et al., 2019).

A study in Ethiopia on avocado productivity and production systems by smallholder farmers productivity found that the low level of implementing the application of agronomic practices including pruning, application of fertilizer, irrigation, and, mulching was positively correlated to the limited knowledge of the importance of these practices in improving the productivity of avocado (Biazin et al., 2018). Irrigation has a positive effect on avocado tree development and yield (Silber et al., 2019). Avocado farmers in the study area do not apply fertilizer and irrigation on their avocado trees because they still have in mind that the trees are crops that can grow themselves without irrigation and fertilizers, they think the tree should wait for the rainwater and absorb the normal nutrient that is already in the soil without any additional support from the farmers that affect the quality and quantity of avocado fruits as well. This study provided training to smallholder avocado farmers on agronomical practices needed by avocado trees in order to get high quality and quantity in avocado farming. Smallholder farmers in Rwanda have to acquire knowledge and skills in water management for avocado production. This was done through building initiatives in water management and other agronomic practices that led to the adoption of appropriate technologies.

4.4. Knowledge, Skills, and Management Practices on Avocado Production

Various parameters were analyzed to determine the level of knowledge that smallholder farmers have on the avocado crop which includes experience in avocado farming; participation in the avocado groups, cooperatives, or platforms; spacing between avocado trees; avocado harvesting methods used by the farmers in Gisagara District, training on avocado, and frequency of contact between farmers and extension agents.

4.4.1 Membership in avocado growers' association

The avocado farmers were asked if they belong to any avocado group, cooperative, or platform, and their reasons for membership or non-membership. All respondents said that they do not belong to any avocado platform because there is no avocado group in their area and they also said if they can get one, they will participate actively. After receiving this information, the study organized the establishment of an avocado innovation platform in Gisagara District. The avocado platform has four sub-platforms in four sectors including Save, Ndora, Kansi, and Mugombwa sector. Whereas avocado farmers have regular meetings in each sector. The stakeholders of the IP included avocado farmers, input suppliers, collectors, extension officers, researchers, exporters, and processors.

4.4.2 Experience in avocado farming

About 42.7% of respondents had more than 20 years of experience in avocado farming, while 20.3% had experience ranging between 10-20 years in avocado farming. The results are presented in Table 4.9.

Table 4.9: Experience in Avocado Farming

Experience	Frequency	Percent
Below 10 years	53	37.1
10-20 years	29	20.3
Above 20 years	61	42.7
Total	**143**	**100**

Experience is an important component as it may affect the sustainability of practices, productivity, and adaptability to new techniques. The group of farmers with below 10 years of experience in avocado farming represents a significant portion of the farmers who are relatively new to avocado farming. Farmers in this category might be more open to adopting new farming

techniques and technologies but may lack the deep-rooted knowledge and expertise that come with years of experience. They might face initial challenges such as understanding the nuances of avocado farming, dealing with pests and diseases, and optimizing yields. The group of farmers with 10-20 years of experience in avocado farming is smaller, indicating fewer farmers with moderate experience. These farmers have likely accumulated considerable practical knowledge and have overcome initial learning curves. They might balance traditional practices with new techniques. They are likely to have stable yields and a good understanding of market dynamics. The largest group represented by farmers with more than 20 years of experience had extensive experience in avocado farming. They possess deep knowledge about local soil conditions, climate, pest management, and optimal farming practices. Their experience can contribute to high productivity and resilience against farming challenges. However, they might be more resistant to change and adopting new technologies, preferring traditional methods that have worked for them over the years.

Older farmers are more interested in tree planting because of their lengthened experience. Previous experiences, like farming, might influence a person's behavior for a long time (Iversen et al., 2016). The experience of the farmers has a positive relationship with tree planting because they know how to manage the trees (Garen et al., 2009). Experience can improve a person's personality and experience, as well as their capacity to handle risks and events that come with it (Hoff & Stiglitz, 2016). The results on the experience of the farmer in avocado farming were the basis for selecting the topic to be taught during the training session in the avocado innovation platform. Because these results showed the gap that the avocado farmers have in avocado production.

The presence of a substantial number of experienced farmers provides an opportunity for knowledge transfer. Experienced farmers can mentor those with less experience, sharing best practices and lessons learned. This study organized workshops and training sessions through the IP where experienced farmers shared their insights to enhance overall productivity and farming techniques. Balancing traditional knowledge with innovative practices was crucial for sustainable farming during the workshop. Experienced farmers' traditional knowledge was combined with new techniques to develop sustainable farming practices that are both productive and environmentally friendly. The IP encouraged a culture of continuous learning and adaptation that helped all farmers, regardless of experience level, to thrive in a changing avocado farming.

4.4.3 Spacing between avocado trees

The analyzed data shows that 53.1% of the farmers have 5-10 meters between their avocado trees, and 16.1% are planting their avocados at 5 meters. The results are presented in Figure 4.2.

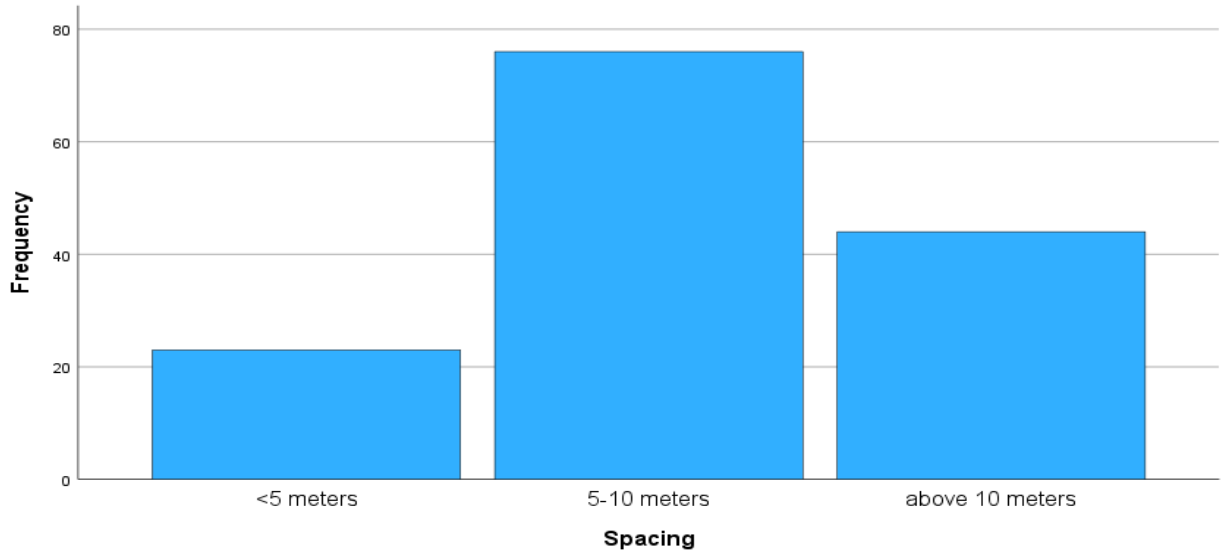

Figure 4.2: Spacing Between Avocado Trees

Spacing between avocado trees is very crucial because it affects the production quality and quantity**.** The farmers were asked to state the space that is between trees and to mention the importance of spacing. The majority of the farmers said the importance of spacing is to increase the yield and to allow light, watering, and nutrients. The distance between avocado plants was strongly correlated with their output. As tree height, canopy breadth, and tree spacing rose, so did the fruit output of individual trees (Biazin et al., 2018). According to earlier descriptions, grafting, pinching, pruning, and spacing can all have an impact on the structure of avocado trees (Snijder et al., 1999). Since the predicted size of the mature tree determines the proper spacing for the orchard's long-term productive life, spacing should be regarded as one of the most crucial factors when planting fruit orchards.

Some avocado farmers in Gisagara District were not using proper spacing in their avocado plantations. After the establishment of the avocado innovation platform, farmers were trained on different topics including proper spacing and planting density. Proper spacing and planting density ensure that each tree receives adequate sunlight, nutrients, and airflow. This

helps to prevent overcrowding, diseases, and stunted growth, ultimately leading to higher yields.

4.4.4 Avocado harvesting methods

The results on avocado harvesting methods used by smallholder farmers show that 93.7% of respondents used climbing on the tree. While the special harvesting tool (fruit picker) was used by 10% of the respondents. The frequency distribution of harvesting methods is presented in Table 4.10.

Table 4.10: Avocado Harvesting Methods

Harvesting methods	Frequency	Percent
Climbing on the tree	134	93.7
Hitting the tree	102	71.3
Shivering the branches	5	3.5
Special tool	15	10.5

Avocados are easily scratched, so careful harvesting method is very important to avoid injuries to the fruits. Harvesting methods were chosen as a parameter to measure a good market for avocado fruits because good harvesting methods help to maximize avocado yield and minimize fruit losses in terms of injuries. The harvesting methods of avocados include climbing on the tree, hitting the tree, shivering the branches, and the use of special tools or fruit pickers. Some of the harvesting methods can cause avocado losses and waste after harvesting due to damage (FAO, 2013). The use of proper harvesting methods can reduce post-harvest losses.

Climbing on the tree is used by the farmers where the fruits are free falling on the ground which damages the fruits and causes injuries and death incidences during harvesting period. Hitting the tree is a harvesting method used by avocado farmers where the fruit falls freely to the ground but this method damages the fruit as well as immature fruits which may fall and cause losses because of non-marketability. Avocado farmers in Gisagara District were using this method because the majority of them have the traditional variety of avocado trees which are very tall. Shivering the branches of the tree was also used by farmers where they shake the trees in order to harvest the fruits. For this method, there is free fall to the ground of the avocado fruits but it can damage the fruit at the highest level and both mature and immature fruits are harvested at the same time. The special harvesting tool (fruit picker) is another method that does not cause damage to the fruit because there is no free fall of the fruit and it helps to

select only the matured fruits and minimize the losses caused by injuries and harvesting unmatured fruits. Poor harvesting methods and poor handling of harvested fruits affect the quality of avocado and post-harvest life as well. During the discussion with the avocado farmers, they said that about 40% of avocado fruits are lost immediately during harvesting time and after harvesting due to poor harvesting methods. The members of the avocado innovation platform were trained on the proper harvesting method of avocado in order to minimize the losses and injuries during harvesting time.

In Ethiopia, traders have reported about 19% overall avocado loss due to mechanical damage. Post-harvest diseases, post-harvest insects, and physiological disturbances (Bantayehu et al., 2017). In Kenya, harvesting avocados without using the fruit picker contributes to a loss of approximately 7% of harvested fruit and an overall loss of 12-18% in exports by the time the fruit reaches Europe (Sharma & Soederberg, 2020). Harvesting methods affect the quality of avocado fruit. Avocado fruits with injuries, cracked, damaged, or bruised are not preferred on the market. The fruit cracks when it falls to the ground from the tree during harvest, causing the avocado growers to suffer their first significant losses. Compared to fruit harvested at normal maturity, fruit harvested too early or too late has a lower quality, is more prone to physiological disruptions, and has a shorter shelf life (Kader, 1999). The quality and anticipated shelf life of avocados are significantly influenced by the harvesting techniques employed (Kassim et al., 2013). Mechanical damage brought on by incorrect harvesting techniques limits the postharvest quality of avocados in general (Munhuweyi et al., 2020).

4.4.5 Training on avocado production and marketing

The majority (97.2%) of the respondents said that they had not attended any training on avocado which has several significant implications for their productivity, market access, and overall agricultural practices. The main reason said by the farmers include that they had not received any invitation to attend training on avocados and they also said if it is possible to get an opportunity for attending training on avocado production and marketing, they will actively participate in the training. About (2.8%) of the farmers had received training on seedlings, spacing and plantation, and harvesting methods and they found out that training was very useful and it could be better if they received more training. The training was organized by TUBURA (One Acre fund project). Training on avocado production and marketing attended by the farmer affects the agronomic practices used by the farmer due to the knowledge and skills the farmer received from such trainings. The farmers who received trainings grow more avocado trees and they participate more in export markets and local markets because they have more information

(Amare et al., 2019). This study assisted the smallholder avocado farmers in attending trainings on avocado production and marketing through the established avocado innovation platform in Gisagara District of Rwanda. The avocado innovation platform was established in Gisagara District in order to fill the gap that avocado farmers were having in avocado production and marketing including the lack of crucial knowledge about optimal avocado farming practices, such as soil preparation, pest and disease management, pruning, irrigation, fertilization techniques, information on market trends, quality standards, and how to meet the requirements of different buyers, including processors and exporters. All these gaps can lead to lower productivity and higher susceptibility to crop diseases and pests, meeting market standards, limiting their access to more lucrative markets, and confining them to local markets with lower prices, ultimately affecting their income and livelihoods. Through the IP, the avocado farmers were trained on modern farming techniques, pest and disease management, post-harvest handling, and market access strategies.

4.4.6 Frequency of contact between farmers and extension agents

The findings show that 86.7% of farmers had not been in contact with the extension agents. The frequency of farmers in contact with extension agents is presented in Table 4.11.

Table 4.11: Frequency of Farmers' Contact with Extension Agents

Frequency of visits	Frequency of farmers	Percent of farmers
No visits	124	86.7
Weekly	1	0.7
Monthly	9	6.3
Quarterly	6	4.2
Annually	3	2.1
Total	**143**	**100**

The farmers who had been in contact with the extension agent said that they were discussing other crops, not avocado crops. The frequency of farmers in contact with extension agents has a significant contribution to the adoption of agriculture practices (Nkonki-Mandleni et al., 2022). Farmers that interact with extension agents are more equipped to employ cutting-edge techniques and contemporary technologies (Knowler & Bradshaw, 2007). Farmers have a better understanding of optimal practices through regular interactions with extension personnel. The farmers who received training grow more avocado trees and they participate

more in export markets and local markets because they have more information (Amare et al., 2019).

4.5 Avocado Marketing

The Avocado marketing studied in Gisagara District was the market outlet for the avocado fruits in Gisagara District, income from avocado, and avocado varieties preferred by the farmers. These were studied because they may affect the marketability of the avocado fruits and the livelihood of the avocado farmers as well.

4.5.1 Market outlet for avocado fruits

Data on market outlets of the avocado fruits from the study location show that 79.7% of the farmers sold their produce to the local market and only 0.7% of the farmers sold their avocados to the processors or exporters. The result showed the outlets to include neighbors, local markets, collectors, traders, processors, and exporters as presented in Table 4.12.

Table 4.12: Market Outlet for the Avocado Fruit

Market outlet	Frequency	Percent
Neighbors	78	54.5
Local market	114	79.7
Collectors	67	46.9
Traders	8	5.6
Processors	1	0.7
Exporters	1	0.7

Market outlets are very important for the avocado farmers for this is where they can sell off their produce. In order to get the premium price for the avocado fruits, they must be a good market outlet. The majority of the sampled avocado farmers sell their produce to the local market, this indicates that the local market is the most accessible market to the farmer, but it offers a low price. The avocado farmers in Gisagara district were getting low prices because of the lack of information and lack of linkage to the processors and exporters who can provide a high price. This indicates limited participation in higher-value market chains, which might be due to farmers lacking the knowledge or resources to engage with processors and exporters, including understanding export requirements or accessing these markets, another reason is the limited connections and networks with processors and exporters might hinder farmers from

accessing these potentially more lucrative markets, the processors and exporters often require higher quality and specific standards that local farmers may not meet. Avocado exports out of Rwanda are low as smallholder farmers are not inclined to grow *Hass* or *Fuerte* avocado varieties required by international markets *Fuerte* and *Hass* are the most popular avocadoes preferred for export purposes (Dreher & Davenport, 2013). Avocado farming communities need information on marketing (George et al., 2018). The main challenges faced by smallholder farmers include access to the market, unstable prices, and access to information on marketing (Ayenew, 2023, Gatare et al., 2017). Interventions such as training, and forming an avocado innovation platform could help farmers improve their product quality and access higher-value markets. To enhance market diversification, an avocado innovation platform was established in order to improve farmers' access to broader markets, both domestic and international, the IP helped in meeting export standards, provided training, and facilitated market linkages.

4.5.2 Income from avocado

The income category of below 100,000 Rwf annually accounted for 81% of the respondents, whereas those earning above 300,000 Rwf accounted for 2.1% of the respondents. Respondents were asked to indicate their income from selling avocado fruits per year. The results are presented in Table 4.13.

Table 4.13: Income from Avocado Earned by Smallholder Avocado Farmers

Average income Rwf	Frequency	Percent
Below 100000	117	81.8
100000-200000	17	11.9
200001-300000	6	4.2
Above 300000	3	2.1

Avocado growing by the farmers in Gisagara District provides households with income. The income a farmer earns is very important because it determines what investments the farmer can make. Avocado farming is not generating sufficient income for smallholder farmers due to the low quality of produce. The avocado farmers in the study area are selling their produce to the local markets only that offer the low price. Smallholder farmers might have limited access to high-quality seeds, fertilizers, and proper farming techniques, resulting in low yields. Low

productivity directly impacts income as farmers have less produce to sell. The smallholder farmers also sell their avocados in local markets, which may offer lower prices compared to larger, more competitive markets. Limited access to broader markets, including international ones, restricts their ability to get better prices for their produce. The international markets for agricultural commodities offer good prices but require good quality as well compared to the local markets in developing countries (Amare et al., 2019). Targeting these markets could increase the income and improve the livelihood of the farmers (Ramírez & Morales, 2019).

Improved market linkages, such as innovation platforms, cooperatives, and farmer associations, can assist farmers in accessing larger, more profitable markets. The avocado innovation platform was established to facilitate connections with processors and exporters, resulting in increased income. This was accomplished by providing training on best farming practices, pest and disease management, and efficient use of inputs, all of which contributed to improved productivity and produce quality.

4.6 Challenges and Opportunities to Produce Quality Avocadoes for Local and Export Markets

This section on presents results, interpretation of results and discussions of the challenges and opportunities of Avocado value chain quality production of fruits in Gisagara District. The identified agenda were then used in developing the Avocado Innovation Platform (AIP) for use in co-learning, partnership building and co-innovation.

The type and level of challenges affecting Avocado growing and the opportunities available to the farmers in Gisagara District were assessed by use of two instruments: a Focus Group Discussion guide (Appendix C and a household questionnaire for farmers (Appendix A). The FGD were used to identify the challenges and opportunities, while the farmers questionnaire was used to triangulate the information and rate the identified challenges and opportunities (Creswell & Creswell, 2023; Kumar 2011). The farmers then ranked the challenges and opportunities based on a five-point rating scale (1-5), where 1 indicated the lowest ranking and 5 the highest ranking as demonstrated by Creswell & Creswell (2013). The data was analysed using descriptive statistics (means, standard deviations) with a mean of 2.5 as the benchmark. The 2.5 mark was used to accept the challenges and opportunities denitrified for the Avocado production and marketing in Gisagara District.

4.6.1 Challenges and Opportunities in Production of Quality Avocados in Gisangara District

The smallholder Avocado farmers were asked to identify the different challenges and opportunities that they face in the participation in the Avocado value chain. The participants were then asked to rank each of the items identified by the smallholder Avocado farmers based on the severity of the challenge using a 5-point rating scale with responses options measuring a range from the lowest to the highest. as follows:

1=Very Low challenge or opportunity, 2=Low challenge or opportunity, 3= Moderate challenge or opportunity, 4=High challenge or opportunity, and 5=Very High challenge or opportunity. The results of the identification and ranking of the challenges and opportunities are shown in Table 4.14.

Table 4.14: Descriptive Statistics for the Level of Challenges and Opportunities Facing Avocado Farmers in Producing Quality Avocados for Export in Gisagara District

		SHF Rating in Terms of the Level of Challenges		
No	**Statements on the Level of Challenge and Opportunities for the Avocado farmers**	**Total**	**Mean**	**Std. Dev**
1	No access to land for avocado growing	603	4.21	.723
2	Obtaining quality avocado seedlings	589	4.12	.764
3	Access to inputs of avocado production (fertilizer, water and chemicals)	527	3.68	.808
4	Pests and diseases affecting avocado seedlings and fruits	525	3.67	.969
5	Inadequate fertility in the soil for avocados	494	3.45	.802
6	Lack of skills and knowledge in good avocado production practices by Farmers	472	3.30	.760
7	Lack of farmer to farmer learning and exchange of idea related to avocado productions	413	2.88	.823
8	Limited extension services for avocado	392	2.74	1011

n=143

The smallholder avocado farmers identified eight (8) different types of challenges (Table 4.17) affecting the production of quality avocados in Gisagara District for the local and export market. The challenges were arranged in their level of severity, the highest being lack

of access to land for avocado growing, (*M*=4.21, *SD*=.72) and the one with the lowest level of severity was limited extension services for Avocado farmers (*M*=2.74, *SD*= 1.01).

All these challenges affect the quality of fruit in the market, both for the domestic market and for export. It therefore implied that the avocado farmers in Gisagara District need training on good farming practices for avocado crops, training on marketing avocado produce, training on how to get quality avocado seedlings and their location, and training on pest and disease management in avocado plantation. These results influenced the study to establish an avocado innovation platform where various actors in the avocado value chain came together to discuss the challenges on the avocado crop and find the solutions to these challenges. Challenges facing smallholder farmers in Africa include a lack of markets, poor product quality, and high transaction costs (Delgado & Siamwalla, 1997). Other challenges faced by the farmers include inadequate farmer skills and knowledge of production, and pest and diseases (Bekele, 2016). The lack of information and coordination among avocado farmers was also reported as the challenge of avocado marketing in Hawaii (Krishnakumar et al., 2009).

Access to the market is said by the majority of farmers in the study area to be a major challenge in avocado production. Challenges include lack of good market, lack of information, low purchase price offered by the middlemen and collectors, lack of standardized agreement on selling prices, and the losses they get when they sell the whole tree with the middlemen, they use to harvest all avocado fruits mature, immature fruits and remove all flowers, they just overhasty the fruits because of unappropriated harvesting tools they use. Low prices and lack of market information have been reported as the main marketing problems faced by Kenyan avocado growers in the Trans-Nzoia District (Omolo et al., 2011).

One of the difficulties in producing avocados, according to the farmers in the area of the study, is the restricted access to production inputs. The production inputs were a challenge due to the cost of farm inputs based on the capability of the farmer. This could be the reason why most of the farmers are not interested in adding fertilizers to the avocado crop. It has also been stated that avocado producers in the Philippines exploit limited agricultural input as a production limitation (FAO, 2000). It has been reported that the inadequate use of fertilizer in avocado farming was the reason for reduced crop yield and quality among Philippine avocado growers (Juma et al., 2019). Researchers claim that insufficient availability of agricultural inputs limits the amount of fruits and vegetables that can be produced. Limited access to agricultural input was also reported as a constraint among tomato farmers in Tanzania (Mutayoba & Ngaruko, 2018). Researchers have reported that limited access to agricultural inputs limits potato and bean production in Tanzania (Mayala, 2014).

Obtaining high-quality seedlings was reported as a challenge for avocado production by farmers in the study area the avocado farmers were using any seedling they got without considering the source of that seedling which led to low-quality avocado produce that could not meet the standard of export purpose. The results are in line with those conducted by Gaspard et al. (2021) on the economic analysis of factors affecting avocado production, profitability, and sustainability in Rwanda; where they found that getting good quality avocado seedlings was a challenge to the farmers. But this will change through the mission of RAB where they facilitate the farmers to get good quality avocado seedlings that can fit the local and export markets.

Research done in Cyprus shows that there is a significant difference between the yield of grafted oranges (Georgiou & Gregoriou, 1999). The same result was observed in the study conducted in Israel where, there was a significant difference in the yield of grafted tree of *Hass* avocado (Haberman et al., 2020). The quality of the seedlings has also been reported to play an important role in determining fruit size in avocados (Mickelbart et al., 2007). There were effects of good-quality seedlings on avocado yield and fruit weight (Cohen et al., 2022). The quality of the seedlings Plays a role in determining the size of the mango fruit (Avilán et al., 1997). A study conducted in Israel showed significant differences in the yield of grafted *Hass* avocado trees (Lazare et al., 2021).

Knowledge about good farming practices of avocado was also ranked highly (*M*=3.30, *SD*=.760) by the farmers of Gisagara District to be the challenge of avocado production because of limited extension on avocado crop which was also ranked highly by the agencies (*M*= 2.74, *SD*=1.011). Most extension staff are not interested in avocado production, so they cannot properly guide farmers, they are focusing on other crops rather than avocado as reported by the farmers. There is a need to train the farmers on good agricultural practices regarding avocado crop in order to boost the quality and quantity of avocado fruits produced by the smallholder farmers in the area of the study, this could be done through the establishment of an avocado innovation platform in Gisagara District. The lack of technical and scientific knowledge information among farmers related to the correct implementation of agronomical practices has been identified as the main challenge that results in low-quality and quantity avocados that are not preferred in the international markets (Ramírez-Gil, 2018). Lack of agricultural extension support for avocado growers was reported as the major challenge in avocado farming in Ethiopia (Shumeta, 2010). where there were no extension services provided to avocado farmers in the southwestern part of Ethiopia. Limited extension support service was also reported as a limiting factor that affects the production of tomatoes in Tanzania (Mutayoba & Ngaruko,

2018). They found that while the number of advisors tasked with assisting farmers in each village in the Morogoro region was sufficient, the agents did not have sufficient power to do the job. Extension services for Philippine avocado growers were dissatisfied due to the lack of technical knowledge about avocados by extension officers, who were mainly deployed to staple food crops (FAO, 2000).

Pests and diseases were identified as challenges for avocado cultivation by farmers in the study area. Avocado pests and diseases can directly impact the avocado industry in the form of reduced sales, property damage, and increased management costs (Evans & Jonathan Crane, 2011). Ignoring diseases and pests can even lead to a 50% reduction in avocado production and its market value makes farmers reluctant to continue production (Evans & Jonathan Crane, 2011). Anthracnose is reported as a problem affecting avocado production and quality in Kenya (Wasilwa et al., 2007). The disease has caused the loss of more than 60% of Kenya's avocado production during the long rain seasons. Root rot has been reported as a challenge to avocado production that has eliminated commercial avocado production in many parts of Latin America and is the main challenge limiting production in Australia, California, and South Africa (Ploetz et al., 2002).

4.6.2 Constraints in avocado marketing in Gisagara District

The small holder Avocado farmers for the Avocado Innovation Platform were asked to identify the different constraints experienced by the stakeholders during the marketing of Avocado fruits locally and abroad. The participants were then asked to rank each of the items identified by the small holder Avocado farmers based on the severity of the constraint using a 5-point rating scale with responses options measuring a range from the lowest to the highest. as follows:

1=Very Low constraints, 2=Low constraints, 3= Moderate constraints, 4=High constraints, and 5=Very High constraints. The results of the identification and ranking of the constraints are shown in Table 4.15.

Table 4.15: Descriptive Statistics for the Level of Constraints in Avocado Marketing by Small holder Avocado Farmers in Gisagara District

No	Statements on the Level of Constraints in Marketing by the Small holder Avocado Farmers	Rating in Terms of the Level of Marketing Constraints		
		Total	Mean	Std. Dev
1	Low quality of produce (Avocado fruits)	595	4.16	.718
2	Low prices for Avocado fruits in the market	568	3.97	.795
3	Unavailability of markets for Avocado fruits	507	3.54	.909
4	Lack of market information on Avocados	505	3.53	.998
5	Difficulties in storing the Avocado fruits	463	3.23	.863
6	Post-harvest fruit loses	448	3.13	.827
7	Lack of proper transport to markets for fruits	391	2.73	.863
8	Lack of proper organization of Avocado farmers	366	2.56	.931
9	Lack of connection (linked) to Avocado markets	366	2.56	.939

n=143

The smallholder Avocado farmers identified nine (9) different types of Avocado marketing constraints (Table 4.15) in Gisagara District, for the local and export market. The constraints were arranged in their level of severity, the highest being low quality of Avocado fruits (*M*=4.16, *SD*=.71) and the one with the lowest level of severity was lack of connection to Avocado markets (*M*=2.56, *SD*=.93).

Avocado farmers who are not well organized was ranked highly (*M*=2.56, *SD*=.93) by the respondents in the area of the study. This study assisted the farmers in organizing them by establishing an avocado innovation platform in their district that will help them market their avocado produce. The establishment of the avocado innovation platform included different actors along the avocado value chain where they came together to identify the challenges that are in avocado production and marketing and find solutions together to overcome those challenges.

The unavailability of markets was highly ranked (*M*=3.54, *SD*=.90) by the respondents as a constraint to avocado marketing. This involved a lack of information regarding the market and low prices set by middlemen. This challenge was addressed through the formation of collective marketing of the fruits by smallholders. Collective marketing of avocados comprises farmers forming a group. It enables them to increase the price negotiation power, incomes, and

access to inputs and technologies. Collective marketing of avocados has assumed importance in the context of agri-food system transformation; inadequate information on price, demand, and market trends; contractual and procurement systems; and as a response to safety standards of food exports. Collective groups usually have intermediaries prepare for them contract farming agreements with avocado exporters/buyers based on fruit quality.

Market unavailability contributes to post-harvest losses and low profitability for avocado growers in the study area. This problem was rated highly (M=3.13, SD=.83) by of the smallholder avocado farmers. Post-harvest losses are a constraint in avocado marketing due to the short shelf life of avocado commodity and difficulties in storage. Limited shelf life has been reported to have an impact on the avocado trade in Kenya (Omolo et al., 2011) and Vietnam (GTZ, 2005).

Lack of proper transport to the market affected the marketing of avocado in Gisagara District. It was rated as a moderate (M=2.73, SD=.86) constrain by the smallholder farmers in Gisagara District. The roads in the district that connect the farmers to markets are not well maintained and, in some areas, they are inaccessible. The roads are not tarmacked and are very slippery during the rainy season. The farmers either carry their produce on their heads or use bicycles, when carrying avocado fruits to the markets. Inadequate transportation to the market leads to fruit damage and increased post-harvest losses in the study area. About 5% of avocado losses in Kenya are reportedly due to inadequate transportation to market (World Economic Forum, 2014). Poor transportation means was also one of the constraints of avocado marketing (FAO, 2000).

Low prices and lack of market information are reported as the biggest marketing problems facing Kenyan avocado growers in the Trans Nuzoia district (Omolo et al., 2011). Access and control over the market were reported among Ethiopian avocado farmers that the demand for avocados in their region is low and they have received low prices for their products as they are vulnerable to price negotiations due to high cash demand and short shelf life of the fruit (Shumeta, 2010). Low payments and unstable trading conditions are reported to affect small avocado farmers whose yields are insufficient to cover transportation costs to other markets in Colombia (Serrano & Brooks, 2019). The challenges faced by smallholder farmers in Africa are the lack of markets the poor quality of their products and information on the market price (Delgado & Siamwalla, 1997). Low prices, information sharing, price determination, inadequate marketing extension services, and lack of linkages to the market and market access were reported as the main challenges faced by Rwandan farmers (Mutago, 2022; Nahayo et al, 2017; Mbitsemunda & Karangwa, 2017; Innocent et al, 2018; Mubirigi et al,

2016). Smallholder farmers in developing countries face unbelievable challenges in marketing their farm produce. Lack of market information, involvement among middlemen, and thus price determination, and lack of transportation facilities are the main challenges facing smallholders in many developing regions (Tardif-Douglin, 2009; Baffes & Haniotis, 2016). There were many challenges in avocado production and marketing in Gisagara District, Rwanda, there was a need to find innovative solution. The baseline results recommended the formation of the Avocado Innovation Platform as a vehicle for promoting a multi-stakeholder for the reason that the famers mentioned they are lacking of organization in order to improve the avocado production and marketing, that recommend the formation of the Avocado Innovation Platform. This study had developed avocado innovation that involved different actors along avocado value chain, where they came together to identify the challenges and opportunities that are in avocado production and marketing in order to minimize the challenge and constraints and maximize the opportunities and profits.

4.7 Avocado Value Chain Stakeholders and Their Roles in Production and Marketing

Stakeholder analysis can be described as a stepwise process comprising identification of stakeholders, analyzing and describing them, their interests and resources, and prioritizing and classifying stakeholders according to their salience. Stakeholder analysis helps to identify the role of each stakeholder. After the identification of the stakeholders, the interests of each stakeholder were identified in relation to the problems being addressed by the platform. The relative priority that the platform should give to each stakeholder was to be worked out. The stakeholders identified included input suppliers, avocado smallholder farmers, collectors/traders, processors, exporters, researchers, and extension agents.

4.7.1 Stakeholder analysis

A stakeholder analysis was done to determine the key actors who will have a significant influence on the success of the avocado innovation platform and to provide intervention in avocado production and marketing in Gisagara District. Stakeholder analysis is a process that assists in determining the interests of all parties involved in a project before it starts, possible conflicts or risks that could jeopardize the endeavor, opportunities and connections that different participating groups could make at different phases, and stakeholder engagement tactics. According to their degrees of involvement, interest, and influence in the project, stakeholders can be grouped using stakeholder analysis, which also helps determine the most effective ways to include and communicate with each stakeholder group (Varvasovszky, 2000). During the data collection process, participatory tools such as the Actor Interaction Analysis

were employed (matrix). Table 4.16 presents the matrix of the avocado value chain in Gisagara District.

Table 4.16: Matrix of Avocado Value Chain Actors in Gisagara District

Stakeholders	Attributes	Interests	Resources	Input in the IP
Avocado smallholder farmers	Avocado farmers Main decision makers	Key producers of avocado	Land Labor	Primary to implementation of the innovation platform outputs
Gisagara District agronomist	Primary local partner	Extension service provider	Agronomical capacity	Knowledge dissemination
Rwanda Agriculture Board	facilitators	Propagation of certified avocado seedlings	High quality Avocado seedlings Technical input	Supply of high-quality Avocado seedlings
Sector agronomist	Facilitators and local partners	Extension service provider	Technical capacity provider	Mobilizing the community on the Avocado innovation platform, Dissemination of information
Collectors	Facilitators	Purchase, transport, and sell avocado produce	Cash, market, and means of transportation	Enable avocado farmers to access the market
National Agricultural Export Development Board	Facilitators	Find global markets	Advice and business tools related to export	Provide trusted markets

Inputs suppliers	Facilitators	Sells of avocado input	Farm inputs	Supply of appropriate inputs required by avocado farming
Traders	Facilitators	Buy and sell avocado produce	Cash and market premise	Link producers to consumers, Search market for avocado produce
Processors	Facilitators	Value addition to avocado produce	Processing facility for avocado produce	Contract farmers to supply avocado produce
Exporters	facilitators	Export avocado produce	Means of export capacity	Contract farmers to supply avocado produce

4.7.2 Role of stakeholders in avocado production and marketing

The term value chain refers to the entire set of operations needed to take a product or service from its inception through the various stages of manufacture, delivery, and disposal after usage (Zamora, 2016). Value chain analysis is becoming more and more popular due to its emphasis on locating possibilities and significant chain bottlenecks as well as its capacity to find market-based solutions that boost competitiveness (Donald, 2009). Value chain analysis makes clear the linkages between the many actors in the chain, exposes restrictions along the chain, and reveals connections between producers and markets. The avocado value chain in Gisagara District was examined in this study. It aimed to comprehend the actual situation on the ground in order to help local actors develop plans for integrating smallholder avocado growers into the chain and strengthening ties between avocado growers and other value chain participants in order to boost output and profits. The stakeholders comprise input suppliers, avocado smallholder farmers, collectors, traders, processors, exporters, researchers, and extension agents.

4.7.2.1 Avocado input suppliers

The majority of the smallholder avocado farmers (66.4%) identified their own farm seed as their source of avocado seedlings. Table 4.17 shows the source of seedlings by the smallholder farmers in the study area.

Table 4.17: Source of Avocado Seedlings

Source of avocado seedlings	Frequency	Percent
Local nurseries	56	39.2
RAB	18	12.6
TUBURA	14	9.8
Own farm seed	95	66.4
Elsewhere	11	7.7

The avocado value chain in Gisagara District began with the input supply, which mainly focused on the supply of avocado seedlings. Own farm seed was identified by the majority of the smallholder avocado farmers (66.4%) as the main source of avocado seedlings but they are not properly grafted, there is a need to provide training to the farmers on avocado grafting and to avail the good quality of avocado seedlings. Other farmers identified the local nursery as the source of avocado seedlings. RAB, TUBURA, and elsewhere. The good sources of quality avocado seedlings in Gisagara District are RAB and TUBURA. The farmer should plant the seedlings from certified nurseries for several reasons including risk management, short maturity, high-yield avocado varieties, and quality assurance. The challenges related to the avocado seedlings cited by tree nursery growers were the lack of a modern irrigation system, lack of training, insufficient capital, limited market information, lack of labor with technical knowledge, and market scarcity. The quality of avocado seedlings has been reported to play a significant role in determining the quality and size of avocado fruit (Mickelbart et al., 2007). The good quality of seedlings affects avocado yield and fruit weight (Cohen et al., 2022). The quality of the seedlings Plays a role in determining the size of the avocado and mango fruit (Avilán et al., 1997). The yield of avocado trees is influenced by the type of seedlings planted (Lazare et al., 2021). And therefore, avocado farmers need information on quality seedlings.

4.7.2.2 Smallholder avocado farmers

These are the most important actors in the avocado value chain involved in avocado production. In Gisagara District avocado production is an important crop that generates a good

income for the growers. It is practiced by smallholder farmers who mainly intercrop avocado with other crops. The average production is less than 1000kg per year. In addition, farmers are facing pests and diseases which reduce the quantity and quality of avocado fruits. The major pests and diseases reported by the farmers were falling of immature fruit and flowers, aphids on fruits and trees, drying of leaves, there is some powder inside the fruits, ants, worms inside the avocado fruits, white power on the stem of the tree, stone in the fruits, rotting of the fruit, trees drying from the top (buds) of the tree up to the bottom (roots), insects, premature fruits with a changed color, termites, small snow in the avocado fruits, drying of branches, insects feeding on the leaves of avocado trees. All those pests and diseases of avocado trees require proper management for the farmers.

Access to quality avocado seedlings was a major challenge. Farmers cited the unavailability of good-quality avocado seedlings when they are needed. Post-harvest losses occur during harvesting time due to inappropriate harvesting tools that cause the breaking of avocado fruits and the removal of immature fruits. Lack of good varieties that can be stored for long periods without damage. In addition to generating foreign exchange, avocado fruits are a reliable source of revenue for producers (NAEB, 2015). A study in Kenya shows that *Hass* and *Fuerte* varieties are better because of disease resistance, and pests, higher oil content, and higher capacity to stay for long without being damaged and yield a better price than the local varieties (Amare et al., 2019). *Hass* and *Fuerte* are the best varieties which have a long shelf life with a less post-harvest losses (MINAGRI, 2012). The proper harvesting methods for avocados play an important role in quality and the expected shelf life (Kassim et al., 2013). Some of the harvesting methods can affect the life span of avocado fruits due to damages (FAO, 2013). The use of proper harvesting methods can reduce significantly post-harvest losses.

4.7.2.3 Collectors/Traders

Avocado marketing was the second party involved in the avocado value chain. Middlemen and collectors/traders were the players in the avocado marketing industry. Farmers cited poor avocado prices, a lack of organization among avocado growers, a lack of market knowledge, a lack of quality varieties, and a lack of market connections as barriers to avocado marketing. The market determines the price of avocados. The buyers and sellers do not formally collaborate in setting the price. The degree of supply and demand in the market determines the prices. There was no active cooperative, platform, or group of avocado producers in Gisagara District, according to conversations with the farmers. As a result, avocado middlemen who paid poor prices were able to take advantage of farmers in Gisagara

District. The farmers were unable to negotiate greater pricing since they did not improve their marketing.

Because of the poor roads, collectors who ride bicycles to deliver avocados from the farm to the markets encounter difficulties with mud during the wet seasons. The main challenge cited by the traders was inadequate storage facilities that caused losses. The traders faced losses due to the low-quality available avocados, high temperatures occurring in the ripping place, overstaying of the fruits due to the quantity and quality of avocados, and lack of storage maintenance skills. Avocado fruits have a short shelf life that causes post-harvest losses due to rotting. Other challenges cited by the traders in avocado marketing are buying a high quantity of fresh immature avocados that do not taste well and are not preferred after ripping and take a long time to rip. The main source of avocado fruits for the traders are middlemen and the farmers, most of the time collectors are the middlemen. The Gisagara farmers sell avocado fruits to the middlemen and the local markets that offer a low price because farmers are not able to search for the good markets and they are not linked to the good market as well. The price paid depends on the taste of the avocado, the first take a sample and eat it once they find that is not sweet, they don't pay for it. Therefore, the farmer should grow good-quality avocados, which will generate more income for them. The price of avocado varies from 100 Rwf to 500 Rwf. The supermarkets buy and sell avocado fruits. The supermarkets buy avocados at a very good price based on the quality of avocados.

4.7.2.4 Processors

Avocado processing represents another segment of the avocado value chain. There were three companies engaged in avocado processing in the country that include: Avocare company which produces an edible oil called Extra Virgin avocado oil where they are using *fuerte* and *hass* avocado varieties. Holly Trust Ltd is another company that produces the oil from avocado called Kaso avocado oil, it is an edible oil and can be used for hair and skin care as well. Sanit Wing is an avocado company operating in Burera District that produces different products made from avocado fruits including soap, liquid soap, oil, and other different oils that are being used in other industries. Lucent Group Ltd is a company operating in Huye district, this district is a neighboring district of Gisagara District. Lucent Group Ltd produces oil for human consumption that is made from avocado. It will be easier for avocado farmers to have a partnership with Lucent Group Ltd as it is not far from the study area so they can make a contract with avocado farmers of Gisagara district with negotiated prices.

The most preferred avocado varieties for processing were *Hass*, *Fuerte*, and *Ettinger* because of their high oil content and good storage capacity. The avocado processor company processed avocado fruits into cooking oil, soap, shampoo made from avocado, hair care oil, liquid soap, oil used for salad, and skin care oil. Lack of organization among avocado farmers affected the supply chain of avocados both in quality and quantity. The use of untrusted seedlings by the farmers led to low-quality avocados which could not be used by the avocado processors. Organizing farmers into the Avocado Innovation Platform brought a positive change in the whole value chain of the commodity. There was an agreement that the processors would be buying avocados from the members of the platform.

4.7.2.5 Exporters

The export of avocados from Rwanda is increasing day to day. Due to their storage capacity, *Hass* and *Fuerte* are the most popular types exported from Rwanda. The main destinations of avocados from Rwanda are Dubai, France, the Netherlands, and the Middle East. The exporters were buying avocados from the middlemen; there were so long channels of middlemen between avocado farmers and exporters. This happened because there was no active group, cooperative, or platform of avocado farmers operating in Gisagara District. Due to the lack of formal cooperation between buyers and sellers in the price-setting process, avocado growers in the study area were getting the low price imposed by the middlemen. The degree of supply and demand in the market determines the prices. As a result, farmers in Gisagara District were vulnerable to being taken advantage of by avocado middlemen who offered poor prices, according to conversations with the farmers. There was a lack of bargaining power by the avocado farmers because the farmers were not well organized. After the establishment of the avocado innovation platform in Gisagara, the exports were buying the avocado fruits from the farmers without the involvement of the middlemen.

4.7.2.6 Researchers

The role of the researchers in the Avocado Innovation Platform was to initiate the IP and provide the necessary innovative technologies and technical knowledge needed to improve productivity and access to market information to make the IP profitable and attractive. The researchers were from the University of Rwanda - College of Agriculture, Animal Sciences and Veterinary Medicine. Other researchers were from the Rwanda Agriculture and Animal Resources Development Board. The avocado farmers were trained on the value chain of avocado crops.

4.7.2.7 Extension agents

The extension officers were another important actor in the avocado value chain where they had to act as mediators between other stakeholders of the avocado value chain and they had to communicate every action of the platform to all members of the platform. The development of relationships and communication between partners aids in guiding the entire IP system toward a shared objective. Extension agents assist in spreading inventions and making sure they are used and acknowledged in return. Extension officers involved four sector agronomists and one agronomist in charge of cash crops.

4.7.2.8 Avocado consumers

Another final chain that could not be ignored in the avocado value chain was the consumers of avocado, which consisted of hotels, restaurants, canteens, and households. The consumers could get avocado fruits from farmers, markets, supermarkets, or through the processors. The selected consumers received avocado fruits from different areas. Two different hotels sampled for the interview got avocado from traders at a negotiated price but both insisted on good quality avocado fruits. Even though the avocado fruits were available all over the year, they are complaining about the poor harvesting methods of the farmers and the low quality of avocado. The preferred varieties for consumers were the ones with less water.

4.8 Multistakeholder Network Features That Could Promote High-Quality Avocado Production

A range of networking strategies are necessary for the avocado innovation platform to be sustainable in order to improve connections between the many stakeholders throughout the avocado value chain. To increase the platform's capability, actors in the avocado value chain were led through a brainstorming session. Through the interactive process of brainstorming, platform users debate a problem and reach a consensus. The facilitator of the event started by giving the attendees an overview of the platform for producing and marketing avocados. After then, the group was split up into mixed subgroups. Every small group talks about a certain subject and documents what they learn on a flipchart. The leader of each subgroup presented their ideas to the attendees during the plenary session for their validation and approval. Crucial decisions and events that shaped the innovation process; stakeholder interaction within innovation networks; platform sustainability; local awareness of AIP and its effects on the community; obstacles to interaction and how to overcome them; expectations of the platform benefits of AIP; perception of actors; and the sustained ability of stakeholders to interact and

to recognize and address opportunities for the avocado value chain were among the common themes.

4.8.1 The net-map toolbox analysis

Links between actors were assessed using the net-map toolkit according to influence, resource sharing, and information exchange. When there are numerous stakeholders and influencers on the outcome, the net-map toolbox is a participatory tool that aids a target group of people in clarifying, discussing, and identifying situations that could be improved (Schiffer & Waale, 2014). It is a social analysis method that helps people comprehend, depict, and enhance situations where various actors affect outcomes through mapping and debate (Schiffer & Hauck, 2007). Through the creation of the map, individuals and groups were able to articulate their own perspectives on the current avocado situation in the Gisagara District, facilitate discussion, and enable participants to develop a personalized perspective of the stakeholders involved with the avocado value chain.

The net-map toolbox represents the structure of the situation. Actors and their power relationships, influences of different actors, connections between actors, and goals of different actors. Improve the way people work together to achieve common goals. Toolboxes help to understand complex systems and problems by visualizing situations (FAO, 2018). The net-map toolbox allowed the Avocado Innovation Platform to clarify roles and power relationships between actors. It also identifies strengths and weaknesses in the network that need to be addressed.

Farmer representatives, researchers, extension service providers, processors, merchants, collectors, input suppliers, and exporters were among the AIP members who contributed to the creation of the net-map toolset. Arrows were used to show the connections between the actors. By connecting the actors, it becomes evident whose roles on the platform each actor played and which actors provided and received information, guidance, and commands. The net-map toolbox in Figure 4.3 displays the actors that are part of the platform as well as the connections between them in terms of information sharing, advising, and command exchange. It offered a framework for operation that could be adjusted over time in response to suggestions and modifications.

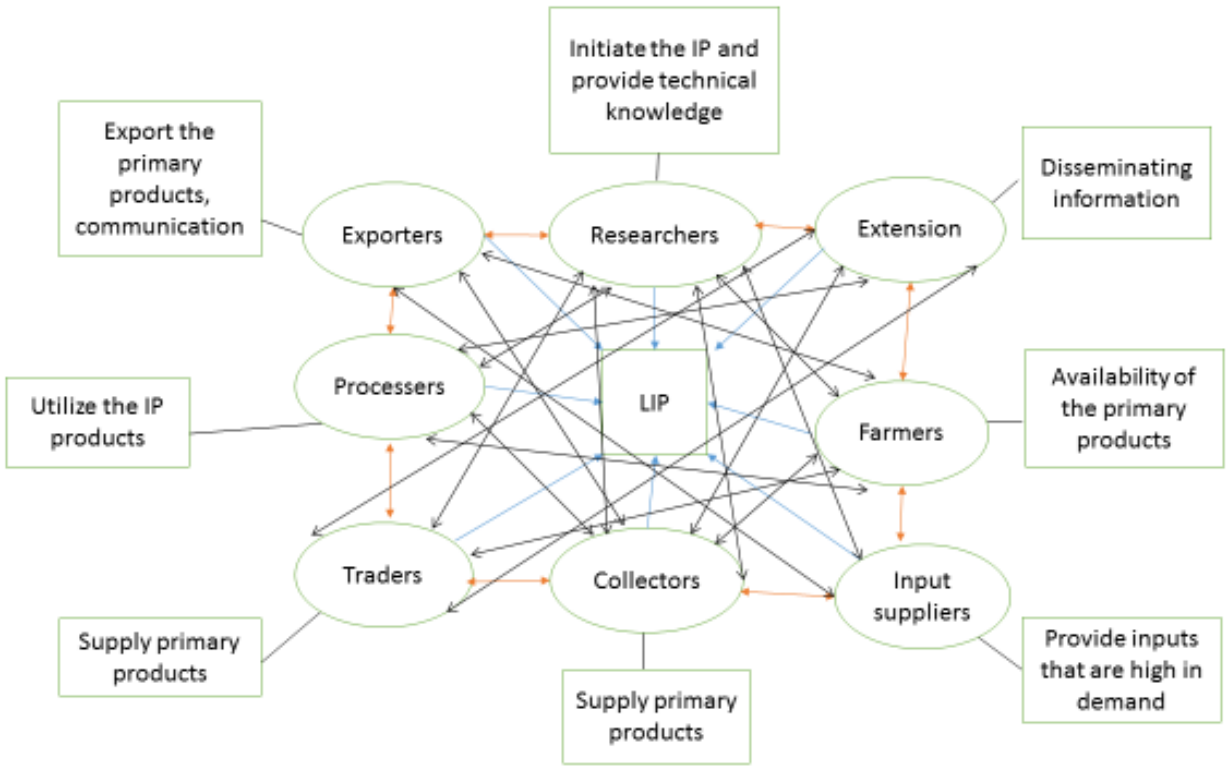

Figure 4.3: The Network Between the Stakeholders of the Avocado Innovation Platform

There was no connection between processors and farmers before the formulation of AIP, after the establishment of the avocado innovation platform avocado farmers are able to sell their produce to the avocado processor companies. The processors' representatives invited AIP officials to discuss with their management a contract to allow farmers to supply avocados.

There was no linkage between exporters and farmers but after the development of AIP, the exporters invited AIP representatives to organize meetings and discuss how they can have a contract with the avocado farmers. The participants were informed that the *Hass* and *Fuertes* varieties are the only ones preferred in the international markets.

Traders had a great deal of influence in determining the price of avocados. The lack of official organization among avocado farmers has led to low prices for avocados. Therefore, it was found that good governance in avocado marketing requires farmers to be involved in both contract farming and group marketing. The extension officers have great power and influence. Therefore, they have to continue mobilization on the sustainable interaction between the stakeholders of the avocado value chain. To analyze the multi-stakeholders, and their patterns of interactions and collaborations within the IP, a multi-stakeholder interaction matrix and a stakeholder network will be set up respectively. Table 4.18 presents the interaction between stakeholders. The * symbol indicates the interactions between the stakeholders.

Table 4.18: Multistakeholder Interaction Matrix and a Stakeholder Network

Interaction	Input supplier	Farmers	Collector	Traders	Processers	Exporters	Researchers	Extension agents
Input supplier		*	*	*	*	*	*	*
Farmers	*		*	*	*	*	*	*
Collector	*	*		*	*	*	*	*
Traders	*	*	*		*	*	*	*
Processers	*	*	*	*		*	*	*
Exporters	*	*	*	*	*		*	*
Researchers	*	*	*	*	*	*		*
Extension agents	*	*	*	*	*	*	*	

4.8.2 Ownership and maintaining the avocado innovation platform

The avocado innovation platform network formation and care requires the full commitment of active stakeholders to achieve the objectives. Maintaining an avocado innovation platform can be expensive. There must be a budget to maintain the network and a certain and sustainable source of funding to organize group activities, while the members of the platform must pay part of their own costs. A concerted effort should be made to create local ownership and leadership in the Avocado Innovation Platform. The recognition and background support of local leaders is crucial. Organizations that benefit most from a cohesive AIP should take every measure to ensure that the network stays strong.

4.8.3 Improved stakeholder networking and collaboration

Stakeholder networks have been strengthened by the players in the avocado value chain to encourage ongoing engagement and communication between platform users. All parties involved in the avocado value chain were involved from the beginning of the study process, which made it possible to use interdisciplinary methods. In addition to creating the ideal conditions for results dissemination, application, and practical implementation, it guarantees

optimal knowledge integration and reciprocal learning. Additionally, it enables stakeholders to spot mistakes in current linkages and collaborate to fix them.

The Avocado Innovation Platform's leadership is essential in establishing connections with the data and resources required to run the platform. Additionally, effective leadership has stoked trust among Avocado Innovation Platform members and even encouraged non-members to embrace the platform's recommended initiatives. By uniting avocado stakeholders, the Avocado Innovation Platform's leadership allows them to concentrate on a single objective, preventing overlap, competition, and duplication for optimal resource allocation. The Avocado Innovation Platform's strategy is to foster a sense of ownership over the platform's outcomes and guarantee their sustained utilization.

4.9 Establishment of Avocado Innovation Platform

This study suggested avocado innovation platforms as ways to facilitate multi-stakeholder involvement in tackling issues pertaining to the cultivation of avocado crops in the research region and limitations associated with avocado produce marketing. The Avocado Innovation Platform was created, bringing together many important players who have a significant impact on the Gisagara District's avocado value chain. Only when research is integrated into the vast network of connections and procedures that assist in forming and implementing ideas can it foster creativity (Gildemacher & Mur, 2013). The establishment of the Avocado Innovation Platform in Gisagara District covered two core processes including the process of Avocado Innovation Platform formulation and activities carried out in the AIP.

4.9.1 Formulation of avocado innovation platform

The process of AIP formation involved, assessing the avocado value chain stakeholders and their roles, fixing the multi-stakeholder network features, and constitution of the AIP membership, and the identification of the problem, and building capacity through training smallholder farmers on avocado production and marketing.

To introduce the project in the research region and to identify and register all actors in all sectors of the avocado value chain, an initial workshop was organized. Farmers, suppliers of inputs, merchants and collectors, processors, exporters, researchers, and extended service providers were among the participants. Stakeholder connections were made, roles were clarified, and common requirements were found. The facilitator of the avocado innovation platform was impartial, objective, and able to collaborate with everyone. To overcome obstacles and seize possibilities, the facilitator led discussions and encouraged group problem analysis among the participants. The facilitator's responsibilities included establishing the

innovation platform, identifying problems, facilitating and advocating for institutional change, managing meetings, managing communication, handling power and conflict, and keeping an eye on, documenting, and reporting.

The AIP network made it easier to monitor and assess the innovation process, as well as to generate and share knowledge about avocado production and marketing. Presentations, trainings, field trips, and demonstrations were used to accomplish this. Participatory forums were used to engage farmers and AIP stakeholders in order to gain insight on both general knowledge and farmer experiences. Strengthening platform ownership and ensuring ongoing platform use were the goals of the AIP method.

The platform aimed to increase avocado production and improve the marketing arrangement of the crop in targeted areas, improve information lows along the value chain, reduce post-harvest losses, and impart farmers to be more market-oriented. The president, vice president, secretary, and four advisors made up the elected committee that oversaw the Avocado Innovation Platform. The innovation platform's structured decision-making process comprised determining, delegating, prioritizing, and discussing responsibilities in order to reach a consensus.

4.9.2 Constituting the avocado innovation platform membership

Based on the results of avocado value chain analysis and stakeholder analysis, the avocado innovation platform consisting of 60 members was formed. Intentional sampling was used to select 40 small avocado producers, 5 input suppliers, 5 traders/buyers, 2 processors, 2 exporters and 6 extension agents to participate in setting up the avocado innovation platform.

4.9.3 Activities carried out in the AIP

Avocado innovation platform activities include assigning responsibilities to stakeholders, identifying the team leaders, and assessing linkages between stakeholders.

4.9.3.1 Assigning responsibilities to stakeholders

In order to allocate tasks to members based on their abilities, the avocado innovation platform workshop was designed to consider their requirements, interests, and ambitions. As indicated in Table 4.19, responsibilities were delegated according to each stakeholder's relative interests.

Table 4.19: Responsibilities of the Stakeholders

Action	Responsibility
Availability of quality avocado seedlings	Rwanda Agriculture Board and local tree nursery growers, TUBURA
Production of quality avocado	Avocado farmers
Reduce the cost of inputs.	Sector and District agronomists and input suppliers
Linkages to good local markets	Sector and District agronomists and Processors
Access to the global markets	National Agricultural Export Development Board and exporters.

4.9.3.2 Identification of team leaders

Elections were held democratically to determine the leaders of the AIP, after which roles were clarified. The role of the president is to convene and chair meetings. The vice president was in charge of resource mobilization. The secretary is the person who oversees the archives, minutes, and all project documents. The treasurer had to take care of the finances. The role of Advisors was to provide advice where it is required. The final role of the AIP committee is to ensure the sustainability of the platform.

4.9.3.2 Identification of the problems in avocado value chain

Farmers were chosen through a purposive selection technique to take part in the problem tree analysis for problem identification. This is a tool for conducting situational analysis that involves participation. By determining the underlying causes and their most significant impacts, problem tree analysis assists stakeholders in developing a realistic overview and awareness of the issue. In order to meet the actual needs of the beneficiaries, it offers a visual depiction of the primary issues, their causes and consequences, and a solution strategy (Popa & Moraru, 2019).

Using a flip chart, the problem tree analysis was completed in a group discussion with 40 farmers, 3 researchers, and 4 extension agents. Confirming that avocado production and marketing are the primary issues to be examined was the first step in the process. The issue was written in the middle of the flip chart, which served as the tree's trunk. The committee then

determined the primary sources of the primary issue, which serve as the tree's roots. After that, the group determined the primary repercussions or impacts of the issue, which turned into the tree's branches. As elements were rearranged and reorganized, there was a great deal of constructive conversation.

Later, each difficulty was transformed into a positive needed outcome, transforming the problem tree into an objective tree. The intended change an active Avocado Innovation Platform was brought about by transforming the underlying issues into underlying solutions. The core problems were the low quality and quantity of avocado produce and poor avocado marketing. The farmer groups cited the major causes of low quality and quantity of avocado produce in Gisagara District these include limited extension services related to avocado production, lack of good quality seedlings, management of pests & diseases in avocado farming, poor soil fertility due to soil erosion and soil degradation, lack of knowledge about good farming practices related to avocado. The effects of that problem led to low income, food insecurity, and low productivity (Figure 4.4).

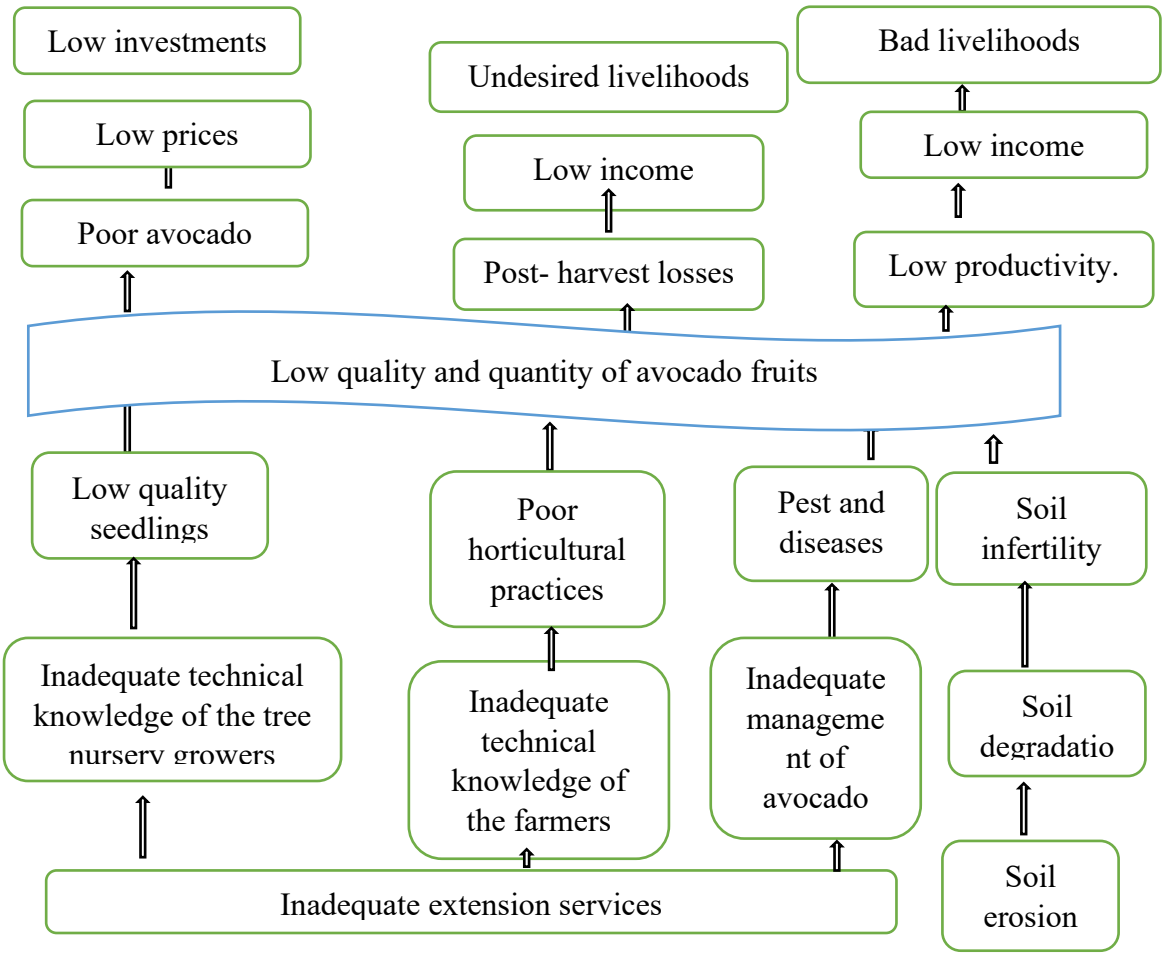

Figure 4.4: Problem Tree- Low Quality and Quantity of Avocado Fruits

The farmer groups also cited the major causes of poor avocado marketing including lack of access to the good market, low market price, lack of market information, and not being connected to the market. The effects of that problem led to post-harvest losses, low income, food insecurity, lack of investment, unemployment, and undesired livelihoods (Figure 4.5).

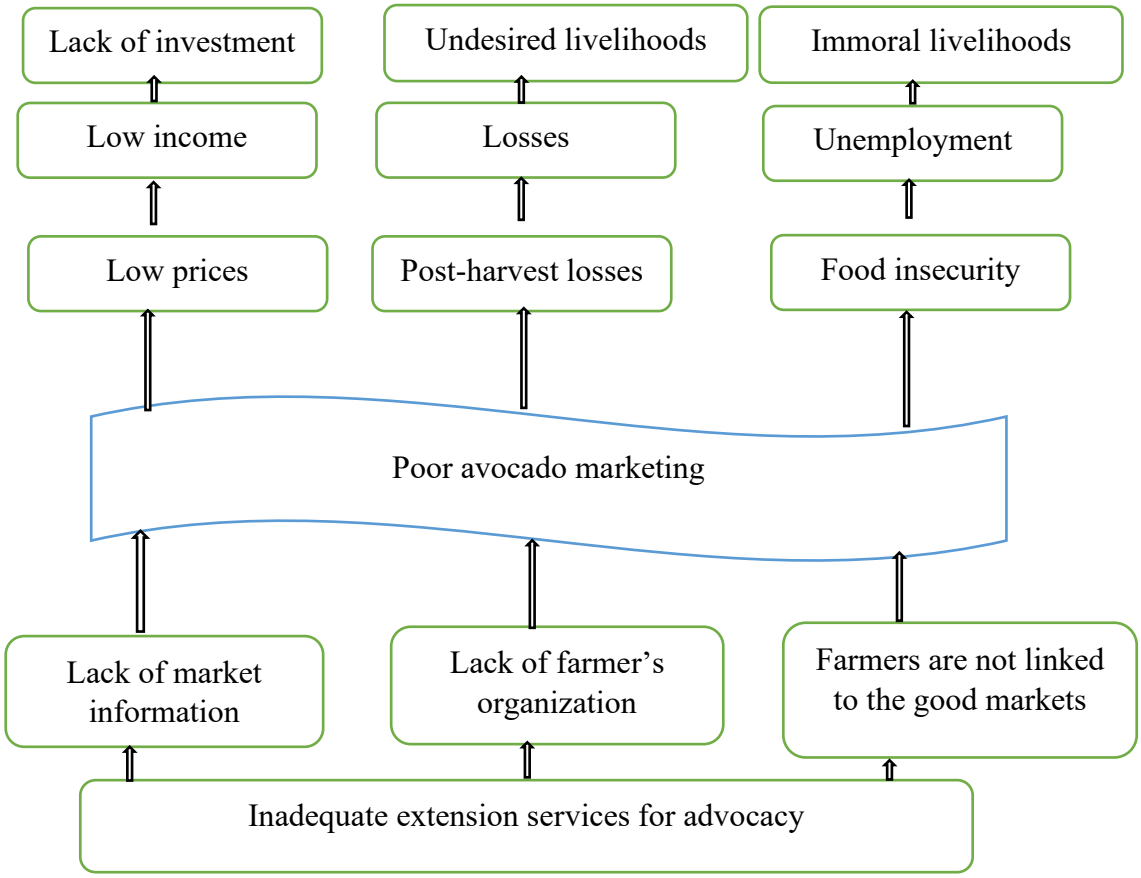

Figure 4.5: Poor Avocado Marketing

The problem tree was transformed into an objective tree that recommends solutions to the mentioned problems (Figure 4.6). The key high points in the objective tree included access to adequate extension services, adoption of soil conservation measures, and the use of good horticultural practices. The ultimate aim was avocado innovation platform necessary for facilitating the information flow on avocado production and marketing.

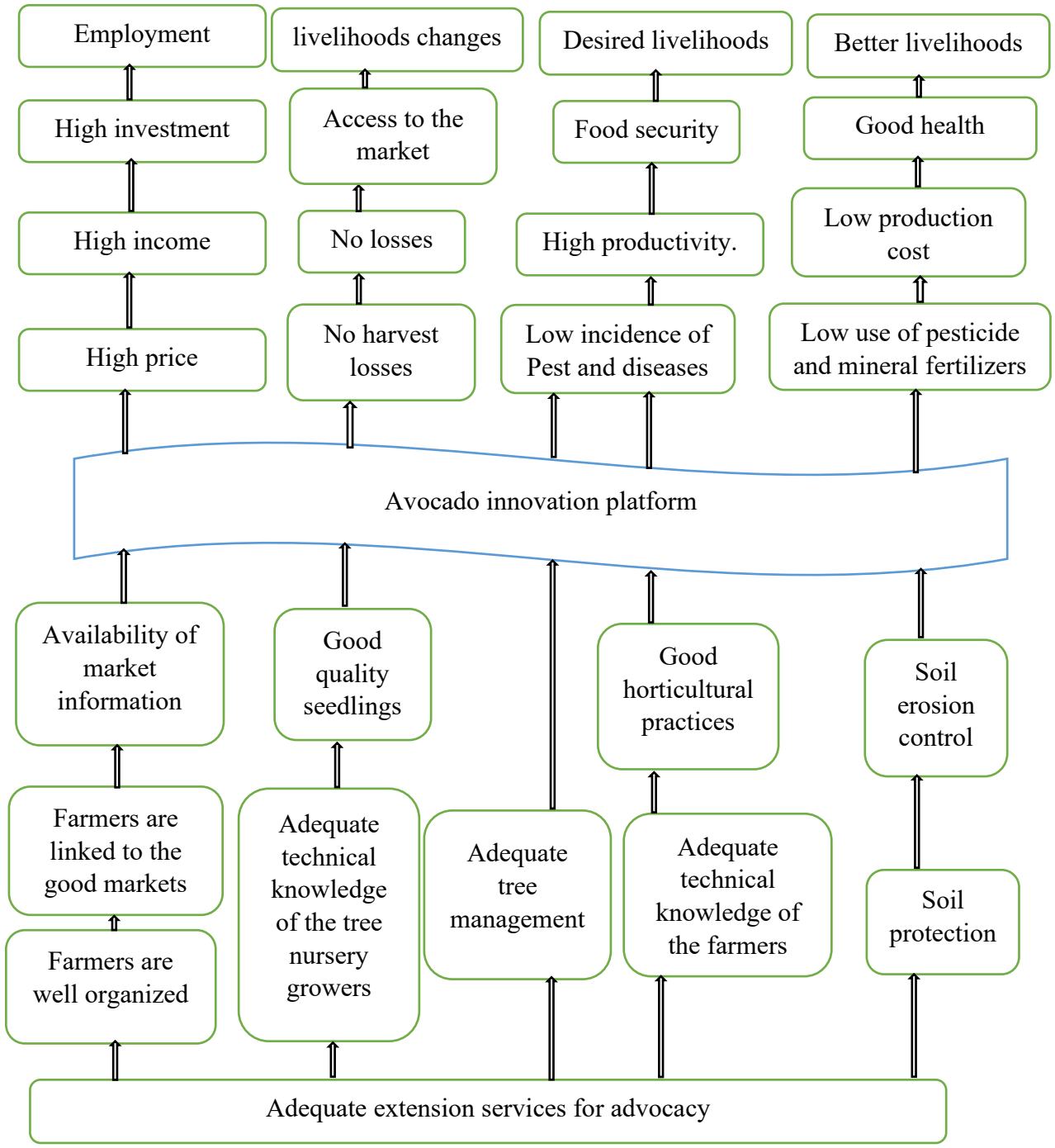

Figure 4.6: Objective Tree -Establishment of Avocado Innovation Platform

4.9.4 Capacity building activities conducted by the Avocado Innovation Platform

Activities carried out by the AIP during capacity building included training avocado farmers, field visits, and demonstrations. The farmers' trainings were held in the four targeted sectors of Gisagara district. Forty avocado farmers participated in the training activities. The topics covered during the training included varieties of avocado, avocado grafting techniques,

land preparation, irrigation, fertilization, pruning, pest and diseases, harvesting and post-harvest handling techniques, avocado tree management, and marketing of the produce.

Field visits were made in order to observe the household implementation of avocado tree management. This was necessary to assess whether the demonstration was having an impact. Households were also monitored for avocado harvesting techniques. It became clear that the farmers had applied the recommendations from the training. These demonstration sites acted as the center of learning where knowledge was generated and disseminated through action and reflection. Other stakeholders also had the opportunity to present their ideas for avocado production and marketing interventions. Participatory Action Research (PAR) was used involving avocado farmers, Extension officers, processors, exporters, and researchers. The study realized that quality avocados for domestic and export markets need to be underpinned by quality avocado seedlings and market links.

4.9.4.1 Enhanced access to quality avocado seedlings

Inadequate quality avocado seedlings were identified by the study as the main challenge to quality avocados for local and international markets, where the source of seedlings was dominated by untrusted sources. This study organized training for farmers on quality avocado seedlings including grafting techniques, harvesting and post-harvest management, and disease control. Building the capacity of farmers on avocado seedlings enabled avocado farmers to produce quality seedlings independently and they can be sold to the other farmers in Gisagara District or neighboring districts. Hence, all these pieces of training were supported by actors who are involved in horticulture including the Rwanda Agriculture Board, Local agronomists, and the University of Rwanda – College of Agriculture, Animal Sciences, and Veterinary Medicine.

The smallholder avocado farmers of Gisagara District were also trained on grafting techniques of avocado seedlings (Plate 1). Grafting is an age-old method that is frequently employed in agriculture to improve crops. A bud or branch from one plant, known as a scion, and the roots of another plant, known as the rootstock, are used to join two suitable plants in this method (Ahsan et al., 2019). Grafting offers a twin plant method to boost orchard yield in fruit trees such as avocado. Typically, rootstocks with enhanced disease resistance and yield enhancement are grafted onto scions with excellent yield and quality (De Villiers & Ernst, 2015). Grafting is a more efficient method of propagation for obtaining higher quality seedlings in terms of production and disease resistance. Scion grafting onto a seedling rootstock is mostly used in the commercial propagation of avocado trees (Reyes-Herrera et al., 2020). Grafting is

commonly used to combine highly productive clonal scions with adaptable seedling rootstocks. In order to create a distinct tree phenotype, this mechanism suggests that several genomes interact (Zhang et al., 2014).

Avocados are commonly propagated by grafting, which mainly increases orchard output by shortening the period to tree productivity. Additionally, it permits the use of rootstocks and scions that have been specially chosen for increased commercial acceptance and productivity (Ahsan et al., 2019). Avocado rootstocks can be grown from seeds or mature tree cuttings. However, using mature scion material speeds up economic return and early maturity. Bimolecular communication and nutrient transport between the root and shoot, a crucial system to sustain the growth and survival of both organs, depend on the union mending sufficiently for grafting to be successful (Bhogale et al., 2014).

***Plate 1**: Farmers with seedlings grafted by themselves*

4.9.4.2 Effect of good agronomical practices on avocado trees

Smallholder avocado farmers of Gisagara District were trained on agronomical practices required by avocado crops. These practices included land preparation, irrigation, fertilization, pruning, pest and diseases, harvesting, post-harvest handling techniques, and avocado tree management.

Regarding land preparation, avocado producers received training that emphasized the importance of meticulous land preparation for avocado production. The farmer must remove all grass and weeds from the property, as well as stump and plough it. The farmers also learned about tree propagation, and they now know that grafting or budding scions of favorable cultivars onto seedlings or rootstocks is how avocado trees are propagated. Although avocados

can be produced from seeds, the quality and potential production of the fruit will vary greatly. Avocado trees that have been grafted or budded often bear fruit between the ages of three and five, whereas seedlings typically take five to seven years.

Avocado farmers of Gisagara District gain knowledge on pollination of avocado trees. Pollinating avocado blooms is necessary before the fruit sets. Even in cases where a variety is self-fertile, pollination necessitates the movement of pollen from a male flower to the stigma of a female bloom since flowers are either male or female. Even Hass, which is commonly seen as being extremely self-fertile, produces more when pollen originates from a different type. For Hass, Ettinger is an especially effective pollinator. Insects are typically responsible for pollination. It is advised to keep honey bee hives in or close to the orchard because honey bees have been identified as the most significant pollinators.

Smallholder farmers were also trained on how avocado trees need mulching. In order to preserve and preserve the soil until the trees can provide shade, it is preferable to plant a cover crop in the early years of an orchard. If at all feasible, the area surrounding the tree's base should be covered with organic mulch and clear of grass and other weeds.

Avocado growers have received training on the value of pruning avocado trees, and they know that it is best to prune in the first few years to promote numerous frameworks branching and lateral growth. All branches coming from below the grafting joint must be removed in order to continuously inhibit sucker growth and strengthen this tree's shape. These shoots do not belong to the grafted cultivar; instead, they grow from the rootstock. The market favors larger fruits, but when a tree produces a large number of developing fruits, the fruits are typically smaller. If some of the developing fruits are removed (thinned out), the desired heavier avocados will typically result.

Avocado farmers were also trained on the role of fertilizers on the avocado crop because before training farmers thought that it was not necessary to apply fertilizer on avocado trees. Because their roots are prone to burning, young trees require extremely careful fertilization. If a good fertile plot is selected for planting, avocados can absorb and use sufficient amounts of critical materials without much fertilization. Nonetheless, it is typical to apply 50 kg of manure per tree annually.

The farmers were further trained on weeding avocado plantations. Weeds should be kept out of avocado orchards. It is best to cultivate shallowly because it will harm roots. It is possible to prevent weed development and preserve soil moisture by mulching with grasses and leaves. To control weed growth, weedicide can be used once a year. Training the farmers on the role of irrigation to avocado crops was also done. During extended dry spells, irrigation

improves crop production and plant development. Moisture stress can affect avocados. During flowering, fruit set, and fruit development, there are critical phases of moisture demand. Fruit grew larger and had more oil when it was irrigated every three weeks, which also caused early maturity. Water is administered every ten days during a dry spell.

Avocado farmers of Gisagara District acquired knowledge and skills in the management of pests and diseases which can cause up to 60% of the loss. These include *Phytophthora ceamomic,* Anthracnose *(Colletotrichum gloeosporioides),* Cercospora fruit spot *(Pseudocercospora purpurea),* Scab caused by *Sphaceloma perseae,* Scale insects, Fruit flies **(***Bactrocera invadens, Ceratitis spp.*).

Members of the avocado IP also received training on harvesting and post-harvest. In order to minimize postharvest losses and avoid picking immature or overmatured fruit, maturity indices are crucial while harvesting avocados. Fruit that is harvested too soon ripens insufficiently and is therefore of low quality. Fruit must be gathered without mechanical injury, since this can degrade its aesthetic appeal and serve as a gateway for postharvest viruses that cause deterioration during storage and transit.

4.9.4.3 Assessment of management practices of avocado trees at the household level

Training activities on avocado production were accompanied by continuous monitoring to determine the benefit of measures jointly developed by researchers and farmers. Workshops and field visits were held regularly to discuss innovations and their impact on the farm level and reflected within the platform. Farmers put into practice the knowledge gained from the demonstration plots and saw a significant positive change in the performance of the avocado trees. The observation was used to monitor the implementation of management practices at the household level.

The involvement of farmers as key members of the Avocado Innovation Platform in research through their active participation in the demonstration generally led to the implementation of management practices including pruning of the avocado trees, mulching, fertilizer application, and irrigation of the avocado trees when it is necessary. Four focus group discussions were held with the innovating farmers in order to carry out training on the management practices of avocado trees.

4.9.4.4 Training smallholder farmers on access to avocado market

In order to increase avocado fruit revenue at both domestic and international markets, the study concentrated on enhancing farmers' marketing skills through the Avocado Innovation

Platform. The lack of market information, low market price, unavailability of markets, avocado farmers are not well organized, and avocado farmers are not connected to the market were the key issues in Gisagara District. Avocado producers must have access to market data in order to sell their produce in high-priced domestic and foreign markets. Through the Avocado innovation platform intervention, members of the platform started marketing their avocados as a group and advising other avocado farmers to join the platform. This empowered the avocado farmers to gain bargaining power and get better prices for their avocado produce.

Numerous strategies, such as collective action through farmer organizations and cooperatives, have been put forth to enhance the chances of small farmers in agricultural markets (Devaux et al., 2009). In order to address the issues smallholder avocado farmers experience in the production and marketing of avocados, this study suggested creating an avocado innovation platform. The avocado innovation platform improved information access and gave smallholder avocado producers more negotiating leverage.

4.9.4.5 Description of the intervention

After conducting a baseline survey on avocado production and marketing in Gisagara District, where avocado farmers identified their challenges in avocado production and constraints in avocado marketing. These included: Avocado farmers are not well organized was mentioned as the major constraint in avocado marketing, lack of market information, unavailability of markets, and low market price.

The avocado innovation platform aimed to increase the availability of quality seedlings for local and export markets, reduce post-harvest losses resulting from unaspirated harvesting methods and inadequate storage capacity, it also helps in the management of pests and diseases, connecting the avocado farmers to the markets with the good prices, to support the sustainability of the platform.

For the avocado innovation platform strategy to be implemented effectively, particular efforts must be made to increase stakeholders' ability to carry out their assigned responsibilities. The Innovation Platform was established as a multi-stakeholder strategy to encourage cooperation and interaction among the various stakeholders of the platform, and capacity building of smallholder farmers through providing training to avocado farmers. Table 4.20 shows the summary of the avocado innovation platform outputs.

4.9.4.6 Summary of Avocado Innovation Platform outputs

The outputs from the avocado innovation platform were summarized as presented in Table 4.20.

Table 4.20: Summary of Avocado Innovation Platform Outputs

Input	Outputs
Facilitating the establishment of the platform	Various stakeholders along the avocado value chain participated in the platform. The avocado innovation platform has been launched.
Evaluation of platform members' priorities and needs	Needs and priorities of the various stakeholders known
Transparent election of the leaders of the platform	notes were taken and recorded
Training on management of the innovation platform	The training was conducted and notes were taken
Training farmers on avocado production and marketing	Based on an evaluation of opportunities and needs, appropriate technologies and processes were found. enhanced ability of farmers to use recommended agronomic methods and high-quality seedlings
Enhancing the linkages between avocado farmers, inputs suppliers, traders, collectors, processors, and exporters	The interactions among different actors along the avocado value chain were enhanced.
Technical training of extension, farmers, and farm demonstration	Enhanced capability of extension workers to provide adequate services and information related to avocado production and marketing

The avocado innovation platform was launched (Plate 2), and Innovation platform members arranged successive meetings. Decisions of meetings were communicated to the members of the platform. During platform meetings, the avocado stakeholders validated the challenges and opportunities and agreed to work together in order to achieve innovative solutions leading to high-quality avocado production, reduced post-harvest losses of avocado,

availability of good quality avocado seedlings, and access to all information needed by the stakeholders of the platform.

***Plate 2**: Smallholder farmers in Gisagara District attended the avocado innovation platform*

4.10 Evaluation of the Contribution of the Avocado Innovation Platform on the Production and Marketing of Avocadoes in Gisagara District

The evaluation consisted of the following: (i) network quality between the members of the Avocado Innovation Platform, (ii) level of interaction and linkages formed, (iii) capacity building of the actors, (iv) assessing the knowledge and skill acquisition by the Avocado Innovation Platform team. The results of the evaluation were compared with the baseline situation that was conducted before the establishment of the innovation platform. A structured questionnaire was used to evaluate the avocado innovation platform based on the network quality, capacity building of farmers, and knowledge gained by the smallholder avocado production and marketing. These were the key features of the avocado innovation platform identified by this study as the independent variables.

4.10.1 Network quality between the members of the avocado innovation platform

The AIP members attended the group meetings twice a month that suggests a strong level of engagement and commitment to the platform. It likely indicates that these participants find value in regular interactions due to the dynamic nature of the discussions, the need for continuous updates, and the importance of staying closely connected with ongoing innovations and collaborations. These regular meetings allow farmers to interact with advisory service

providers, researchers, and other stakeholders. The avocado farmers were interested in attending the meeting regularly because they were gaining knowledge and skills in avocado production and marketing and it was a very good opportunity for the farmers to meet with the potential stakeholders who are involved in the value chain of avocado crops. Before the formulation of the avocado innovation platform, there was no interaction among the stakeholders. The transition from no interaction to a structured avocado innovation platform marks a pivotal shift towards a more collaborative, efficient, and innovative industry. The benefits of such a platform are manifold, from enhanced communication and problem-solving to accelerated innovation and market growth. Group meetings can be an effective way to sensitize large numbers of people to improved technologies in a short period of time and stimulate general motivation for local agriculture and rural development (FAO, 2019a). These regular meetings influenced the extent of respondents' interaction, 70.7% of AIP members rate their engagement as high or very high as shown in Figure 4.7.

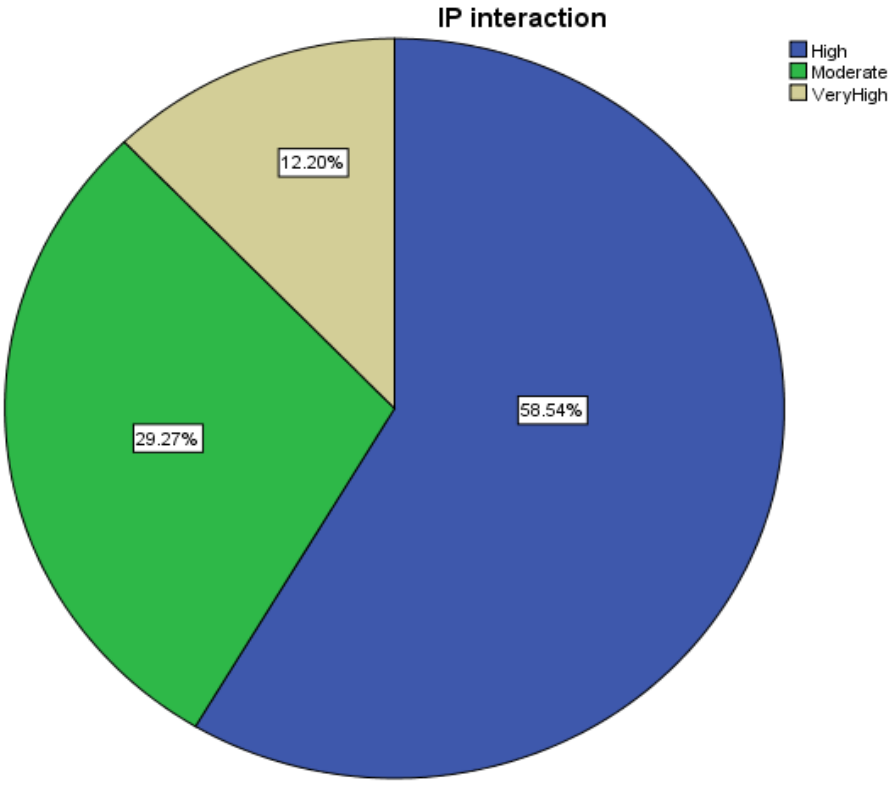

Figure 4.7: Level of Interaction of Respondents

The majority of AIP members rate their level of interaction as high or very high, this high interaction allows members to share their knowledge and skills and work together to achieve team goals. Before the establishment of the avocado innovation platform, the absence of interaction among stakeholders likely presented several challenges and missed opportunities

for the avocado industry. The creation of such a platform represents a significant shift towards collaboration and coordinated efforts. Through regular meetings and close interactions, farmers have access to essential knowledge about avocado production and marketing from researchers, extension officers, and other actors in the chain value of avocado crops. The establishment of an IP helps the agricultural innovation system by building interaction between different actors and facilitating institutional change (Davies et al., 2018). Social networks increase the efficiency of society by enabling coordinated action and achievement of goals that cannot be achieved on an individual level. This approach builds on established connections between networks (Adekunle & Fatunbi, 2012).

4.10.2 Capacity building of farmers on avocado production and marketing

The Avocado Innovation Platform assessed the methods that were used in building the capacity of the group in terms of their usefulness in strengthening the capacity of the farmer. The group assessed the three main methods (group, demonstrations, and farm visits) and the results of their assessment are summarized in Table 4.21.

Table 4.21: Assessment of the Strength of the Methods Used in Capacity Building During the AIP Activities

IP activities	VH %	H %	M %	L %	VL %
Group training	12.2	61.0	24.7	1	1
Demonstration	59.4	16.1	23.5	1	0
Farm visits	23.3	31.3	26.3	12.4	6.7

N=40 *Key: VH- very high, H- high, M- medium, L- low, VL- very low.

The results of the AIP assessment (Table 4.21) show that demonstrations (75.5%) and group training (73.2%) were highly ranked as the best methods used to strengthen the capacity of the smallholder farmers in Avocado production and marketing. AIP observed that the method of using demonstrations provided a hands-on, practical approach to learning. Farmers were able to see the techniques and technologies in action, which helped in understanding and retention. Group training provided an opportunity for farmers to discuss common challenges and share solutions among the members of the platform, and farm visits allowed farmers to see real-life applications of techniques and practices in a working farm environment. All those methods were most effective in building farmers' ability to access information about avocado

production and marketing where avocado farmers gained practical knowledge and skills that they were immediately applied to their own farming practices. This leads to improved productivity and efficiency. Demonstrations, group training, and farm visits were used to ensure that the smallholder farmers were well equipped and acquired the necessary knowledge on avocado production and marketing and they need to continue using the good practices. The smallholder avocado farmers were trained on good horticultural practices and ways of reducing postharvest losses. The farmers said that:

We did more farm visits to see how we could take care of avocado trees through the avocado innovation platform. Now we are using good agricultural practices on our avocado trees and we have started to see the signs of good produce.

Group training allowed us to learn from one another and to share our experiences, it was very helpful because now I know my colleagues who have avocados as a business if I get any challenge, I just ask and get quick feedback through the avocado innovation platform.

The avocado innovation platform helped us a lot because before the platform I was not approaching agronomists to enquire about something related to avocado, I was just searching the information related to other crops such as maize, rice, beans, and so on, but now I am getting any assistance regarding avocado.

Demonstrations are conducted by instructors who physically demonstrate the application of agricultural techniques and convey the benefits of adopting methods already used in other areas of agriculture (Nally & Brooks, 2018). It serves as a platform for knowledge transfer on applied research results in agricultural practice. Demonstration was used in training farmers on avocado grafting where the avocado farmers were learning by doing. Farmers attending training that use demonstrations are more likely to adopt the new technology (Cafer & Rikoon, 2018). A study on the accessibility and effectiveness of extension services on capacity building of smallholder farmers indicated that training, farm visits, and demonstrations were effective extension methods that helped to improve farming techniques (Manyakanyaka et al., 2022). Group training and farm visits are effective extension methods (Moaba, 2016).

4.10.3 Level of AIP actors' knowledge and skills on avocado production and marketing in Gisagara District at the start of the activities

The current level of Knowledge and skills on Avocado production and marketing of the AIP actors in Gisagara District was assessed by the use of a questionnaire filled by the participants before the start of the AIP process (Pretest). The variable, level of knowledge and

skills for the AIP actors was operationalized as a multi-indicator index (Babbie, 2014). The indicators were identified and selected to reflect proficiency in the production and marketing of Avocados. The full list of the 29 indicators used are shown in section III of the AIP actors' questionnaire (Appendix D).

The participants were then asked to self-rate their level of knowledge and skill acquisition by relating it to their theoretical and practical competence in performing the different techniques or activities contained in this list of indicators. Table 4.22 shows the 29 indicators of the index categorised into a summarised list, it includes: varieties, seedling management, soil management, tree management, water application, harvesting, storage, transporting, marketing activities, pests, and diseases.

The rating of the extent of skill acquisition was based on a 6-point rating scale (0 to 5 points), where 0 indicated no knowledge or skill, 1 very low level of knowledge and skill, 2 low level of knowledge and skill, 3 moderate level of knowledge and skill, 4 high level of knowledge and skill and 5 very high level of knowledge and skill. The scores for the individual indicators were summed up and averaged to give the index. The descriptive statistics for the index are given in Table 4.22.

Table 4.22: Descriptive Statistics of AIP Participants Pretest Rating of Their Knowledge and Skills in Avocado Production and Marketing Before the Start of the AIP Process in Gisagara District

	Indicators of Production and	**AIP Rating of Knowledge and Skill (0-5)**		
No	**Marketing of Avocados**	**Total**	**Mean**	**SD**
	Production of Avocados			
1	Avocado Varieties	174	2.67	.965
2	Timeline in acquisition	131	2.01	1.05
	Avocado Seedling Management			
3	Vendors and location of source	140	2.16	1.24
4	Grafting of seedlings	160	2.46	1.16
5	Planting	150	2.30	1.06
6	Tree spacing	156	2.40	1.23
7	Size of pits	157	2.41	1.15
	Watering of Avocado plants			
8	Amount of water	151	2.32	1.23
9	Water application techniques	158	2.43	1.15

	Soil Management			
10	Fertilizer type and application	163	2.50	1.09
11	Compost making and application	163	2.50	1.09
	Avocado Tree management			
12	Grafting	141	2.16	.961
13	Pruning of branches	158	2.43	1.04
14	Harvesting of fruits	169	2.60	1.16
15	Post-harvest storage	156	2.40	1.01
	Avocado Pests			
16	Type of pests (recognition)	169	2.60	1.10
17	Effects on plants	168	2.58	1.01
18	Identification of pests (number)	168	2.58	1.01
19	Control and management	166	2.56	1.04
	Avocado Diseases			
20	Types	161	2.47	1.11
21	Effects on fruits	116	1.74	1.11
22	Control and management	111	1.70	1.01
	Marketing of Avocados			
23	Vendors (outlets)	109	1.67	1.01
24	Collective action groups	124	1.90	1.19
25	Market information	155	2.38	1.29
26	Access to good prices	152	2.33	1.21
27	Link to processor	120	1.84	1.09
28	Link to exporters	128	1.96	1.04
29	Transport	120	1.84	1.21
	Index of Knowledge and Skill on Avocado Production and Marketing for the AIP Actors	**149.31**	**2.29**	**.682**

Mean 2.29± .08, Median 2.20, Mode 1.0, SD .682, Min 1, Max 4.0

The level of knowledge and skill on Avocado production and marketing of the AIP participants was found to be of moderate level (*M*=2.29. *SD*=.682) on a scale of 0 to 5 (0= No skill acquired and 5=Very High level of skill acquisition) and ranged between 1 and 4. The reliability of the index using Cronbach alpha was found to be (α=.806). The index was grouped

into six categories (0=No skill, 0.1-1.0=very low, 1.01-2=low, 2.01-3.0=medium, 3.01-4.0 high and 4.01-5 very High) and a chi-square test for the equality of categories for the index was performed and the results are shown in Table 4.23.

Table 4.23: Chi-square Test for Equality of Categories for the Index of Knowledge and Skills in Production and Marketing of Avocados by AIP Actors in Gisagara District

Category	Description	Observed N	Expected N	Residual	Statistics
1.0-2.0	Low	23	16.3	6.8	χ^2=31.923
2.01-3.0	Medium	31	16.3	14.8	*df*=3
3.01-4.0	High	9	16.3	-7.2	*p*=.001
4.01-5	Very High	3	16.3	-14.2	
Total		**65**			

The chi-square test (Table 4.23) revealed statistically (*p*=.001) significant differences among the different categories of the index of knowledge and skill acquisition in Avocado production and marketing. The category of medium (2.01-3.0) of the index was found to be statistically significantly (χ^2=31.92, *df*=3, *p*= .001) higher than the other categories, indicating that the majority of the AIP participants' knowledge and skill on Avocado production and marketing was in the medium level category.

4.10.4 Assessment of the level of acquired knowledge and skills on avocado production and marketing from the participation in the AIP

The knowledge and skills gained on Avocado production and marketing by the AIP participants during the capacity building process was assessed by the use of a questionnaire that was given to the participants at the end of the AIP process (Post-test). The variable, level of knowledge and skills for the AIP actors was developed as a multi-indicator index (Babbie, 2014).

The indicators were identified and selected to reflect proficiency in the production and marketing of Avocados. The participants were then asked to self-rate their current level of Knowledge and skills acquisition by relating it to their theoretical and practical competence in performing the different techniques or activities contained in this list of indicators. Table 4.24 shows the 29 indicators of the index categorised into a summarised list, it includes: varieties,

seedling management, soil management, tree management, water application, harvesting, storage, transporting, Marketing activities, pests, and diseases.

The rating of the extent of skill acquisition was based on a 6-point rating scale (0 to 5 points), where 0 indicated no knowledge or skill, 1 very low level of knowledge and skill, 2 low level of knowledge and skill, 3 moderate level of knowledge and skill, 4 high level of knowledge and skill and 5 very high level of knowledge and skill. The scores for the individual indicators were summed up and averaged to give the index. The descriptive statistics for the index are given in Table 4.24.

Table 4.24: Descriptive Statistics of AIP Participants Post-test Rating of Their Knowledge and Skills in Avocado Production and Marketing After the AIP Process in Gisagara District

	Indicators of Production and	**AIP Rating of Knowledge and Skill (0-5)**		
No	**Marketing of Avocados**	**Total**	**Mean**	**SD**
	Production of Avocados			
1	Avocado Varieties	289	4.13	.863
2	Timeline in acquisition	294	4.36	.944
	Avocado Seedling Management			
3	Vendors and location of source	282	4.33	.843
4	Grafting of seedlings	275	4.23	1.16
5	Planting	275	4.23	1.16
6	Tree spacing	282	4.33	.843
7	Size of pits	271	4.16	.876
	Watering of Avocado plants			
8	Amount of water	269	4.13	.881
9	Water application techniques	269	4.13	.881
	Soil Management			
10	Fertilizer type and application	269	4.13	.881
11	Compost making and application	269	4.13	.881
	Avocado Tree management			
12	Grafting	280	4.31	1.02
13	Pruning of branches	282	4.33	.956
14	Harvesting of fruits	270	4.15	.883
15	Post-harvest storage	275	4.23	1.01
	Avocado Pests			

16	Type of pests (recognition)	277	4.26	.940
17	Effects on plants	269	4.13	.881
18	Identification of pests (number)	265	4.07	.957
19	Control and management	269	4.13	.881
	Avocado Diseases			
20	Types	269	4.13	.881
21	Effects on fruits	288	4.43	.918
22	Control and management	298	4.58	.768
	Marketing of Avocados			
23	Vendors (outlets)	298	4.58	.768
24	Collective action groups	289	4.44	.810
25	Market information	279	4.29	.861
26	Access to good prices	282	4.33	.871
27	Link to processor	292	4.49	.812
28	Link to exporters	292	4.49	.812
29	Transport	289	4.44	.810
	Index of Knowledge and Skill on Avocado Production and Marketing for the AIP Actors	**278.03**	**4.27**	**.595**

Mean 4.27± .07, Median 4.44, Mode 4.86, SD .595, Min 2.66, Max 5.0

The level of acquired knowledge and skills on Avocado production and marketing after participating in the AIP was found to be very high than the level of knowledge and skills before the AIP (*M*=4.27. *SD*=.595) on a scale of 0 to 5 (0= No knowledge and skill acquired and 5=Very High level of knowledge and skill acquisition) and ranged between 2.66 and 5.0. The reliability of the index using Cronbach alpha was found to be (α=.806).

The index was grouped into six categories (0=No skill, 0.1-1.0=very low, 1.01-2=low, 2.01-3.0=medium, 3.01-4.0 high and 4.01-5 very High) and a chi-square test for the equality of categories for the index was performed and the results are shown in Table 4.25.

Table 4.25: Chi-square Test for Equality of Categories for the Index of Knowledge and Skills in Production and Marketing of Avocados by AIP Actors in Gisagara District

Category	Description	Observed N	Expected N	Residual	Statistics
2.01-3.0	Medium	1	21.7	-20.7	χ^2=42.86
3.01-4.0	High	20	21.7	-1.7	*df*=2
4.01-5	Very High	44	21.7	22.3	*p*=.001
Total		**65**			

The chi-square test (Table 4.28) revealed statistically (*p*=.001) significant differences among the different categories of the index of knowledge and skill acquisition in Avocado production and marketing. The category of very high (4.01-5.0) of the index was found to be statistically significantly (χ^2=42.86, *df*=2, *p*= .001) higher than the other categories, indicating that the majority of the AIP participants' level of knowledge and skill on Avocado production and marketing was in the very high-level category.

4.10.5 The contribution of avocado innovation platform in enhancing the acquisition of knowledge and skills in avocado production and marketing to AIP actors in Gisagara District

The contribution of the Avocado innovation platform in enhancing the acquisition of knowledge and skills by Famers in Avocado production and marketing in Gisagara District was assessed by comparing the level of knowledge and skills before the start of the AIP process and at the end of the process (a pretest-posttest procedure).

The means of the level of knowledge and skills before the AIP process and after the AIP process were compared using the Paired sample *t*-test. The means from the pre-test and posttest were used to compare the level of AIP contribution to the production and marketing of Avocado in Gisagara District, the two means are given in Table 4.26.

Table 4.26: Mean Comparisons for Pre-test and Post-test Means

Level of AIP participants' Knowledge and Skill in Avocado Production and Marketing	Mean	Standard Deviation	Std. Error Mean
Before AIP process (Pre-test)	2.29	.682	.084
After AIP process (Post-test)	4.27	.595	.073

n=65

The results (Table 4.26) show mean comparison for the Pre-test and Post-test data. The level of knowledge and skills acquired by the AIP participants during the process of capacity building was higher (*M*=4.27, *SD*=.59) when compared to the level than when they started the AIP process (*M*=2.29, *SD*=.68). A paired sample *t*-test was then performed to determine whether the mean differences were statistically significantly different from each other and the results are shown in Table 4.27.

Table 4.27: Results for the Paired Sample T-test

Mean differences	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference		*t*	*df*	*p*
			Lower	Upper			
-1.980	1.176	.145	-2.271	-1.688	-13.573	64	.001

The level of knowledge and skills acquired by the participants during the AIP process was found to be significantly higher statistically (*t*=-13.57, *df*=64, *p* <.001).

The current results show that there is a big change in the achievement of the training provided to the IP members. Knowing where to source quality seedlings is crucial for ensuring healthy and productive avocado trees. This knowledge helped farmers select the best varieties suited for both local and export markets, enhancing their market potential. Effective irrigation practices are vital for optimal growth and productivity of avocado trees. Teaching farmers about efficient irrigation methods led to better water management. Educating farmers on the correct use of fertilizers led to improved soil health and increased avocado yields. Knowing the best harvesting methods was essential for minimizing damage to the fruit, reducing post-harvest losses, and ensuring it reached the market in good condition. Training in this area helped farmers maintain the quality of their produce. Educating farmers on proper harvesting techniques was crucial for maintaining avocado quality and reducing post-harvest losses.

The knowledge imparted through the innovation platform equipped avocado farmers with the skills and information necessary to optimize their farming practices, enhance productivity, and improve the quality of their produce. The comprehensive and practical nature of this training ensured that farmers were better prepared to meet market demands and achieve sustainable growth.

The focus of this study was to use participatory action research to bring together groups of people with various backgrounds, specialties, and interests in the production and marketing of avocados, such as farmers, traders, processors, and researchers, in order to give them a place

to learn, act, and transform. activity research's ultimate goal is to bring about social change through a particular activity. Members of a community or group who are trying to change their circumstances work with an action researcher. Thus, an agenda for social change that reflects the idea of combining information to define a problem in order to solve it is the focus of action research (Macdonald, 2015).

Literature studies report that the innovation platform has a positive impact on the agriculture value chain. A study in Burkina Faso (Cullen &Tucker, 2014), value-chain stakeholders taking part in an innovation platform jointly planned activities, which directly led to the observed gains in crop and livestock production. A research conducted in Malawi found that 82.8% of participating families said that their household's food security had improved as a result of innovation platform activities, indicating that food security had grown as a platform impact (Makate & Mango, 2017). During the avocado innovation platform training the farmers learned the grafting techniques to solve the problem of lacking the seedlings.

Educating farmers on sourcing the best seedlings is essential for improving crop yields and quality. MSPs helped to improve seed systems. By learning how to act in concert, participants in an innovation platform in Benin enhanced the seed system, increasing smallholder growers' production and profits (Vissoh et al., 2017). Group marketing was not there because the avocado farmers in the area of the study were not organized and networking was not easy. Transporting avocado produce to the market became easier because of group marketing. The formulation of IP helped the smallholder avocado farmers overcome all the challenges faced by the farmers before its establishment. Most members benefited significantly from access to market information. This includes data on market trends, pricing, demand, and supply, which helps farmers make informed decisions about production and sales. Group marketing allowed farmers to pool their resources and sell collectively, often leading to better bargaining power and reduced costs. This collective approach helped smallholder farmers compete more effectively in the market. It improved market linkages and negotiation strategies as well. Encouraging collective action among farmers led to better market outcomes, as it enhanced their negotiating power and market presence. The connections with exporters opened up international markets for farmers, offering opportunities for higher income and growth. This also encouraged farmers to meet higher quality and safety standards required for export. AIP facilitated building strong networks and linkages with different stakeholders, including exporters, processors, and other stakeholders, which was essential for creating market opportunities and improving the competitiveness of farmers.

an IP is a forum for collaboration where agricultural stakeholders identify problems and provide solutions (Kilelu et al., 2013). Innovation platforms (Ips) are thought to incorporate pertinent stakeholders in order to have a greater influence (Schut et al., 2018).

CHAPTER FIVE
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1. Introduction

This chapter gives conclusions from the findings of the study The chapter also looks at the implications of the results and how they contribute to avocado production and marketing. Finally, recommendations are drawn from the findings of the study that can help improve avocado farming and marketing which will in turn help farmers improve their income and livelihoods.

5.2 Summary of the Findings

Avocado (*Persea americana*) has become an important high-value crop in Rwanda due to its nutritional benefits, local and global market demand, and potential to improve farmers' income. However, smallholder farmers in Gisagara District often lack technical knowledge for effective orchard management. This research aims to fill this gap by exploring innovative practices and knowledge-sharing platforms. This study investigated how innovation platforms enhanced knowledge and skills among smallholder avocado farmers in Gisagara District. It identifies best practices, challenges, and opportunities for sustainable avocado production.

Most existing studies on avocado focus on production and export, without integrating value chain stakeholders or building farmer' capacity in production and marketing. This study addressed this gap by evaluating the effectiveness of an interactive multistakeholder platform to improve both production and marketing aspects. The goal of this study was to develop an innovation platform for building the capacity of smallholder farmers in avocado production and marketing in Gisagara District, Rwanda. The study aimed to achieve five objectives including determining the challenges and opportunities to produce quality avocado fruits for local and export markets in Gisagara District, Rwanda; assessing the avocado value chain stakeholders and their roles in avocado production and marketing in Gisagara District, Rwanda; determining the multi-stakeholder network features that could effectively promote high-quality avocado production in Gisagara District, Rwanda; establishing an innovation platform for enhanced avocado production and marketing in Gisagara District, Rwanda; and determining the effect of the avocado innovation platform on avocado production and marketing in Gisagara District, Rwanda.

The study employed participatory action research and survey research designs. The accessible population was 22143 households. A simple random sampling method was used to select 143 farmers to participate in the survey. A purposeful sampling method was used to

select the sectors in Gisagara District. A questionnaire schedule with closed and open-ended questions was used to collect data from household heads. Focus group discussions were used to get information from the key informants including six extension staff, four input suppliers, six traders, two processors, and two exporters. The household survey instruments were validated by the experts in the Department of Agricultural Education and Extension. Thirty farmers from Gatare Sector of Nyamagabe District were randomly selected for a pilot survey to pre-test the survey instruments and their reliability. Cronbach's alpha was used to measure the instrument's internal consistency and a reliability coefficient of 0.7 or higher was accepted. The data was analyzed using the Statistical Package for Social Science (SPSS). Quantitative and qualitative tests were used to analyze data. Analyzed data was presented descriptively using frequency, percentages, and means. Thematic analysis was used in qualitative data.

The main avocado varieties planted by smallholder farmers in Gisagara District were *Reed*, *Hass*, *Simmonds*, and *Fuerte*. The main challenges faced by the smallholder farmers in avocado production were getting quality seedlings, knowledge about good farming practices, pests and diseases, and access to production inputs, all these challenges affect the quality of fruit in the market, both for the domestic market and for export. The findings revealed that the quantity of *Hass* and *Fuerte* varieties grown in Gisagara District is not enough for local and international markets, there is a need to promote *Hass* and *Fuerte* varieties which are preferred by the international market. The major challenges faced by avocado farmers in Gisagara District are the lack of market information, low market price, the unavailability of markets, poor transport to the market, farmers are not connected to the market, avocado farmers are not well organized, post-harvest losses due to the short shelf life of avocado and difficulties in the storage capacity of the farmers.

After conducting a baseline survey on avocado production and marketing in Gisagara District, where avocado farmers identified their challenges in avocado production and constraints in avocado marketing. The Avocado Innovation Platform was established to find solutions to the problems encountered by smallholder farmers in avocado production and avocado marketing. The AIP also aimed to build the capacity of smallholder farmers in avocado production and marketing. The specific interventions of the establishment of the Avocado Innovation Platform were to assess the avocado value chain stakeholders and their roles in avocado production and marketing, encourage the features of multi-stakeholder networks that could successfully promote high-quality avocado production to address sector limitations and opportunities, and promote involvement in avocado innovation platform.

The avocado innovation platform brought together different actors along the avocado value chain who had not previously collaborated, to jointly address particular restrictions and opportunities in avocado production and marketing. The avocado innovation platform also intended to increase the availability of quality seedlings for local and export markets, reduce post-harvest losses resulting from unaspirated harvesting methods and inadequate storage capacity, help in the management of pests and diseases, and connect the avocado farmers to the markets with the good prices to support the sustainability of the avocado innovation platform. Effective implementation of the avocado innovation platform approach involved specific efforts to strengthen the capacity of stakeholders to perform their respective roles. Innovation Platform was set up as a multi-stakeholder approach to promote collaboration and interaction among the various stakeholders of the platform, and capacity building of smallholder farmers through providing training to avocado farmers.

The end-line survey was conducted to assess changes brought about by the capacity building of smallholder avocado farmers on farming practices to overcome the challenges in avocado production and marketing. The end-line survey had reflective items to allow IP members to think back and compare their knowledge, skills, and experiences before and after participation in the IP while focusing on study objectives and research questions. The level of knowledge and skills before the AIP process and after the AIP process using the Paired sample *t*-test. The means from the pre-test and posttest were used to compare the level of AIP contribution to the production and marketing of Avocado in Gisagara District. The results on mean comparison for the Pre-test and Post-test data shows that the level of knowledge and skills acquired by the AIP participants during the process of capacity building was higher when compared to the level than when they started the AIP process. A paired sample *t*-test was then performed to determine whether the mean differences were statistically significantly different from each other. The level of knowledge and skills acquired by the participants during the AIP process was found to be significantly higher statistically. The study found that innovation platforms significantly improved farmers' knowledge of pruning, grafting, pest management, post-harvest handling, and market access.

The study findings provided useful information among the avocado value chain actors on avocado production and marketing particularly in Gisagara District, and Rwanda in general. Farmers can adopt identified best practices including the use of certified seedlings, post-harvest management and organic pest control to boost productivity and fruit quality this will help farmers to diversify income, enhance household nutrition, and reduce poverty.

5.2 Conclusions

The study concludes that:

i. The main challenges faced by the smallholder avocado farmers were getting quality seedlings, knowledge about good farming practices, pests, and diseases, access to production inputs, lack of market information, low market price, avocado farmers are not well organized, and post-harvest losses. These challenges lead to low production both in quality and quantity. However, there are significant opportunities to improve avocado production, including the growing demand for avocados in local and export markets, potential for value addition includes processing and the government support.

ii. The avocado value chain stakeholders were identified and they are able to play their roles in avocado production and marketing.

iii. Multi-stakeholder networks were encouraged to promote high-quality avocado production, address sector limitations and challenges, and find opportunities to promote involvement in the avocado innovation platform.

iv. An interactive avocado innovation platform built the capacity of smallholder farmers and found solutions to the problems encountered by smallholder farmers in avocado production and avocado marketing.

v. The avocado innovation platform has increased the availability of quality seedlings for local and export markets, reduced post-harvest losses, and the management of pests and diseases, provided market information, and then connected the avocado farmers to the markets with good prices.

5.3. Recommendations

The following recommendations are made from the study conclusions.

i. The Government of Rwanda should strengthen agricultural extension services, invest in farmer training on good agronomic practices, and expand access to improved planting materials and affordable inputs. To enhance productivity and competitiveness, policies should promote irrigation infrastructure, post-harvest handling facilities. Furthermore, creating favorable market linkages, providing timely market information, and supporting farmer organization will empower smallholders to increase production and incomes.

ii. A coordinated effort involving all stakeholders is essential to transform the avocado farming sector into a more profitable and sustainable industry. This can be achieved through collaboration among the stakeholders of the platform.

iii. Members of AIP should hold regular coordination meetings to plan activities, share knowledge, and address challenges collectively to ensure sustainable collaboration between the stakeholders of the avocado innovation platform its sustainability.

iv. Gisagara District should support the continuity of the established Avocado Innovation Platform in Gisagara District.

v. The study also recommends scaling up the avocado innovation platform in other districts of the country. This should be done through the Ministry of Agriculture and Animal Resources.

5.4 Suggestions for Further Research

Based on the findings, this study identified the following gaps for further research:

i. Longitudinal evaluation of income and yield changes among the members of avocado innovation platform.

ii. Explore digital platforms for linking farmers to markets and extension services.

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APPENDICES

Appendix A: Questionnaire for Avocado Farmers

The enumerator first introduced herself, then she asked the respondents if is willing to participate in the survey. If yes, she introduced the topic.

This study is aimed to empower smallholder farmers in avocados production and marketing through the establishment of an innovation platform to help the farmer to produce quality avocado for local and international markets. Your answers are very important to this study and will not be used for any purpose other than this study.

Section A: socio-economic background of the respondents

Please, answer the following questions about yourself.

I. Identification of respondents

District: ……..

Sector: ……

Cell: ……

Village: ……

1. Respondent's gender
   i. Male ☐
   ii. Female ☐
2. Age of the respondent
   i. below 30 ☐
   ii. 30-39 ☐
   iii. 40-50 ☐
   iv. Above 50 ☐
3. Level of education of the respondent
   i. No formal education [ ]
   ii. Primary [ ]
   iii. Secondary [ ]
   iv. College Diploma [ ]
   v. University [ ]
4. Size of the family
   i. 1-3 members [ ]
   ii. 4-7 members [ ]
   iii. Above 8 members [ ]

5. Farm size (Hectares)
   i. Less than 0.25 ha
   ii. 0.25-0.50 ha
   iii. 0.51-0.75 ha
   iv. 0.76- 1 ha
6. Type of farming: 1. □ Mainly for home consumption
   2. □ Mainly for market
7. Affiliation to a social organization:
   1. No
   2. □ Farmer group (specify) …… ……...
   3. □ Cooperative (specify) ……...
   4. □ IP (specify) ……...
   5. Farmer Field school (FFS) (specify) …….
   6. VSLA (Ikimina) (specify) …….

II. Avocado Production

8. How many avocado trees do you have on your farm? ……
9. How many seasons per year do you harvest avocado? …….
10. Average production per year (kg): ……...kg

    Eg: how many sacs (imifuka) ……sacs or basin (ibase): …….. bassin

    1 sacs (imifuka) = ……. Kg sacs (imifuka) or 1 basin (ibase)= ……kg

    < 1000Kg ☐ 1001-2000kg ☐ 2001-3000kg ☐ 3001-4000kg ☐

    >4000kg ☐

11. Avocado yield per Tree

    Eg: how many sacs (imifuka) ……sacs or basin (ibase): ……... bassin

    1 sacs (imifuka) = ……...Kg sacs (imifuka) or 1 basin (ibase)= ……kg

    < 500Kg ☐ 501-1000kg ☐ 1001-1500kg ☐ 1501-2000kg ☐

    >2000kg ☐

12. what are the varieties of avocado trees do you have on your farm?
    i. Fuerte ☐
    ii. Haas ☐
    iii. Nabal ☐
    iv. Ettinger ☐
    v. Reed ☐

vi. Simmonds ☐

vii. Pinkerton ☐

viii. Bacon ☐

ix. others ☐ (Specify)……

13. Where did you source the avocado seedlings?

i. From tree nursery growers; ☐

ii. From RAB certified seedlings supplier; ☐

iii. TUBURA ☐

iv. Own farm seed; ☐

v. Elsewhere (specify) ……. ☐

14. Are you experiencing any pest or diseases on your avocado trees?

15. If yes, what are the major avocado pest and diseases in this area?

……

……

……

16. How do you manage the avocado pest and diseases?

……

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……

17. What is the avocado plantation system?

i. Intercropping ☐

ii. Monocroping ☐

iii. Others (specify) …….

18. Agronomic practices applied on avocado

i. Application Pruning ☐

ii. Application Irrigation in dry season ☐

iii. Application Mulching ☐

iv. Application of fertilizers ☐

v. Others (specify) …… ☐

III. Avocado marketing

19. Are you on contract farming?

Yes ☐ No ☐

20. Average sales per year: ……kg

Eg: how many sacs (imifuka) ……sacs or basin (ibase): ……... bassin

1 sacs (imifuka) = ……...Kg sacs (imifuka) or 1 basin (ibase)= …….kg

≤ 1000Kg ☐ 1001-2000kg ☐ 2001-3000kg ☐ 3001-4000kg ☐

4001-5000kg ☐ >5000kg ☐

21. Where do you sell your avocado?

i. Neighbor ☐
ii. Local market ☐
iii. Collectors ☐
iv. Traders ☐
v. Processors ☐
vi. Exporter ☐
vii. Other ☐ (Specify)……

22. Which method is more profitable in selling your avocado and why?

i. Neighbor ☐
ii. Local market ☐
iii. Collectors ☐
iv. Traders ☐
v. Processors ☐
vi. Exporter ☐
vii. Other ☐ (Specify)……

23. Avarage avocado income (Rwf).

i. <100000
ii. 100000-200000
iii. 200000-300000
iv. >300000

24. Which variety has a better market price?

i. Fuerte ☐
ii. Haas ☐
iii. Nabal ☐
iv. Ettinger ☐
v. Reed ☐
vi. Simmonds ☐
vii. Pinkerton ☐
viii. Bacon ☐
ix. Others ☐ (Specify) ……

25. What is the type of transport do you use?

i. Head
ii. Bicycles
iii. Vehicles
iv. Others ☐ (Specify) ……

26. Which variety do you prefer to grow and why? …….
……..

27. Do you know avocado varieties that are highly recommended to grow for the markets purpose? ☐YES ☐NO

28. If YES, please list them down

1. ……
2. ……
3. …….
4. ……..
5. …….

IV. Knowledge, skills, and practices have you developed to improve your avocado production.

29. Do you belong to any avocado group, cooperative or platform?

Yes ☐ No ☐

30. If no, what is the reason behind?

i. We have no group ☐
ii. I do not have time ☐
iii. It is not helping ☐
iv. Other …….

31. What is your experience in avocado farming?

<10 years ☐
10-20 years ☐
> 20 years ☐

32. Did you apply fertilizer on your avocado trees? ☐YES ☐NO

33. If yes, Which kind of fertilizers do you use on your farm?

Organic manure ☐
Inorganic fertilizer ☐
Both ☐

34. How did you plant your avocado seedlings in terms of spacing?

i. < 5 meters ☐

ii. 5-10 meters ☐

iii. Above 10 meters ☐

35. Why is the required spacing so important?

i. Correct spacing increases yield ☐

ii. helps to maintain the number of plants required in the field ☐

iii. facilitates plant growth and reduces the spread of diseases ☐

iv. allows light, watering, and nutrients ☐

36. What tools do you use to harvest avocado?

i. By scaling on the tree and picking ripe fruits ☐

ii. By hitting the tree using long stick ☐

iii. By shivering the branches of the trees ☐

iv. Using special harvesting tool ☐

v. Others ☐ (specify) …….

37. What do you do to safely pack and store your avocado for a long time*?*

i. ……..

ii. ……

iii. ……

iv. ……..

38. Have you ever got training on avocado farming? ☐YES ☐ NO

39. If yes, what are the topic covered?

i. ……..

ii. ……..

iii. ……

iv. ……

40. How often extension agents from the District or Sector visiting you?

1.Weekly ☐

2. Monthly ☐

3. Quaterly ☐

4. Annually ☐

41. Do you have access to market information and links for your avocado? ☐ YES ☐ NO

42. If yes, How do you get this information

i. Radio ☐

ii. TV ☐

iii. Phone ☐

iv. Farmers ☐

v. Extension officers ☐

vi. Umuganda ☐

vii. Other ☐ (specify) …….

V. The challenges and opportunities for the production of quality avocadoes for local and export markets.

31. Please, rate the following challenges you personally experiencing in your avocado farm enterprise, using 1. Strongly Agree (SA) 2. Agree (A) 3. Undecided (U) 4. Disagree (D) 5. Strongly Disagree (SD)

	Challenges	SA	A	U	D	SD
1.	Access to land					
2.	Getting quality seedlings					
3.	Access to production inputs					
4.	Pest & diseases					
5.	Inadequate soil fertility					
6.	Access and control over the market					
7.	Knowledge about good farming practices					
8.	Lack of time to join fellow farmers and exchange ideas					
9.	Limited extension services					
10.	Other (specify)……					

32. What strategies do you have in your hands that help you or will help you to address the challenges and advance your farm enterprise?

……

……

……

33. Indicate your general opinion about the listed constraints to avocado marketing using the following key:

1. Strongly Agree (SA) 2. Agree (A) 3. Undecided (U) 4. Disagree (D) 5. Strongly Disagree (SD)

Constraint to avocado marketing	SA	A	U	D	SD
Low quality of produce					
Low market price					
Unavailability of markets					
Lack of market information					
Difficulties in storage					
Post harvest losses					
Poor transport to the market					
Avocado farmers are not well organized					
Not connected to market					
Others (specify) ……. …….					

34. What the opportunities that are linked to the production avocado?

Opportunities	Yes	No
Availability of market	□	□
Availability of quality seedlings	□	□
Easy access to production inputs	□	□
Attending trainings on avocado	□	□
Others	□	□

END – THANK YOU

Appendix B: Focus Group Discussion Guide/ Key Informant Checklists for Avocado Value Chain Actors

1. Input suppliers

i. Where is your source of inputs?

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ii. What are the available avocado varieties?

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iii. What are your sources of avocado?

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iv. Which avocado variety is most demanded by farmers?

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v. Are you able to meet the farmers 'demands? Yes ☐ No ☐

vi. What are your challenges and opportunities as an avocado seedling suppler?

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vii. What is your role in avocado production and marketing?

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2. Collectors / Traders

i. What are the preferred avocado varieties?

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ii. What are the available avocado varieties?

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iii. What are your sources of avocado?

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iv. Are your sources of avocado reliable throughout the year? Yes ☐ No ☐

v. If not reliable, which months of the year do you have deficiencies?

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vi. What are the market outlets for your avocado?

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vii. Are you able to meet the demand for avocadoes for your market outlets?

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viii. What factors do you consider when you negotiate prices with people who sell avocadoes to you?

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ix. What factors do you consider when you negotiate prices with people who buy avocadoes from you?

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x. What is your role in avocado production and marketing?

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xi. What are your challenges and opportunities that are in avocado production and marketing?

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xii. How do avocado prices vary?

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xiii. When selling avocadoes do you receive higher prices for avocadoes of higher quality

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xiv. What quality attributes of avocadoes receive the best prices?

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xv. Are you able to obtain avocadoes with the desired quality attributes?

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xvi. What is the source of avocadoes with the desired quality attributes?

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xvii. On average, for how long do you store your avocadoes before selling?

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xviii. Do you experience avocadoes storage losses? Yes ☐ No ☐

xix. If yes, what are the major causes of avocadoes storage losses?

(both in terms of quality and quantity) …….....

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3. Exporters

i. What is your source of avocado?

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ii. Which avocado varieties do you prefer? Why?

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iii. Are avocadoes available throughout the year? Yes ☐ No ☐

iv. If not, which months do you have a deficit?

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v. What quality attributes do you consider when buying avocadoes?

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vi. Are you willing to pay more for higher-quality avocadoes? Yes ☐ No ☐

vii. Would you be interested in buying avocadoes from smallholder farmers on a Contractual ☐is? Yes N☐

viii. How do you store avocadoes? …….....

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ix. Do you have any challenges with avocado storage?

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x. What is your role in avocado production and marketing?

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xi. What are your challenges and opportunities that are in avocado production and marketing?

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4. Processors

i. What are your sources of avocado?

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ii. Do you prefer specific avocado varieties? Why? Yes ☐ No ☐

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iii. Are you willing to pay higher prices for better-quality avocadoes? Yes ☐ No ☐ Why

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iv. How do avocado buying prices vary?

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v. Would you be interested in buying avocadoes from smallholder farmers on a Contractual b☐s? Yes ☐ No

Why? ……
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vi. What is your role in avocado production and marketing?

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vii. What are your challenges and opportunities that are in avocado production and marketing?

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5. Extension officers

i. Which avocado seed varieties are in this area?
ii. Are there any avocado seed varieties that are preferred by the farmers?
iii. Do the farmers meet the demand for local and international markets?
iv. What are the avocado's challenges and opportunities in Rwanda?
v. What are the effects of avocado challenges along the avocado value chain in Rwanda?
vi. How do avocado farmers and stakeholders in the avocadoes value chain share their knowledge, experiences, and challenges?
vii. Is there a policy framework for avocado production and marketing that has been established to mitigate avocado challenges in Rwanda?
viii. What specific interventions have been done to address avocado challenges?
ix. What have you done or should be done to avoid avocado challenges in Rwanda?
x. Is there any innovation platform or forum of avocado in the District? Which one?
xi. What is the importance of promoting avocado production across the District?
xii. What is your role in avocado production and marketing?

THANK YOU

Appendix C: Innovation Platform Evaluation Tool

Introduction

The purpose of this survey is to evaluate the innovation platform for avocado production and marketing in Gisagara District, Rwanda. Your honest answers are very vital to this study, will be treated with utmost confidentiality and will not be used for any purpose other than this study.

Section A: socio-economic background of the respondents

Please, answer the following questions about yourself.

Identification of respondents

District: ……..

Sector: ……

Cell: ……

Village: ……

1. Respondent's gender
   i. Male ☐
   ii. Female ☐
2. Level of education of the respondent
   i. Illiterate [ ]
   ii. Primary [ ]
   iii. Secondary [ ]
   iv. Diploma college [ ]
   v. University [ ]
3. Size of the household ----------
4. Farm size (Hectares) ----------
5. Type of farming: 1. □ Mainly for home consumption
   2. □ Mainly for market
6. Affiliation to a social organization: 1. □ Farmer group
   2. □ Cooperative
   3. □ IP
7. Cultivated area (ha) for avocado: ……ha
8. Total production per year (tons): ……...tons
9. Total sales per year: ……tons

Section B: Evaluation of an Innovation Platform

10. Network Quality

i. What is the level of attendance to scheduled meetings by IP members?

1. once per month 2. Twice per month 3. Once per two months

ii. To what extent do the members of IP interact at individual level?

1. Very low 2. Low 3. Moderate 4. High 5. Very high

iii. capacity building of farmer

1. demonstration 2. Farm visits 3. Group training

12. Knowledge dissemination

Rate the IP on the level of knowledge dissemination using the following key.

1. Very Low 2. Low 3. Moderate 4. High 5. Very High

Section C: Avocado production and marketing

13. Knowledge acquired on avocado production

Please indicate the level of knowledge you have acquired on the listed avocado production through the IP training.

avocado production	Level of knowledge				
	Very low	Low	Moderate	High	Very high
Location of quality avocado seedlings for the export purpose					
Irrigation					
Avocado diseases and pest control					
Use of fertilizer					
Pruning					
Best method for harvesting avocado					
Post -harvest handering					
Mulching					
Others (specify)					

14. Access to avocado seedlings

Please rate your level of access to avocado seedlings using the listed criteria

Avocado seedlings	Level of access				
	Very low	Low	Moderate	High	Very high
Availability of good quality avocado seedlings					
Access to variety of choice					
Affordability of avocado seedlings					
Timeliness of acquiring avocado seedlings					
Others (specify)					

15. Knowledge acquired on avocado marketing

Please rate your level of access to the market using the listed criteria.

Avocado marketing	Level of access				
	Very low	Low	Moderate	High	Very high
Market information					
Transport to the market					
Group marketing					
Linkage to consumers					
Linkage to processors					
Linkage to exporters					
Others (specify)					

avocado production and marketing	Level of knowledge				
	Very low	Low	Moderate	High	Very high
Avocado varieties					
Timeline in acquisition					
Avocado seedling management					
Vendors and location of source					
Grafting of seedlings					
Planting					

Tree spacing					
Size of pits					
Amount of water					
Water application techniques					
Fertilizer type and application					
Compost making and application					
Mulching					
Pruning of branches					
Harvesting of avocado fruits					
Post -harvest handering					
Type of pests recognition					
Effects on plants					
Control and management					
Vendors outlets					
Collective action groups					
Market information					
Access to good prices					
Link to processor					
Link to exporters					
transport					

THANK YOU

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Appendix D: Data Outputs

Thematic analysis

1. Data Familiarization

Nature of the challenges mentioned by respondents include:

- **Challenges in Production**: Pest & diseases challenge, Inadequate soil fertility challenge, Access to production inputs challenge.
- **Challenges in Marketing**: Low market price csrt, Unavailability of markets csrt, Poor transport to the market csrt.
- **Other Challenges**: Community responsibilities chlg, Limited extension services chlg.

2. Initial Coding

Identify specific challenges mentioned by respondents and assign codes to them.

Code	**Data**
Pest and diseases	aphids, white powder, insects, premature falling of fruits
Low market prices	Low market price csrt, bad price
Lack of market access	Unavailability of markets csrt, not connected to market csrt
Poor transport infrastructure	Poor transport to the market csrt, difficulties in storage
Limited extension services	Limited extension services chlg, lack of training
Inadequate inputs	Access to production inputs challenge, lack of fertilizers
Soil fertility issues	Inadequate soil fertility challenge, poor soil quality
High domestic responsibilities	Many domestic responsibilities challenge
Post-harvest losses	Post harvest losses csrt, rotting of fruits
Lack of organized farmer groups	Avocado farmers are not well organized csrt
Climate-related challenges	Drought, falling of unmatured fruits

3. Theme Development

Theme	Codes Included	Description
Production Challenges	Pest and diseases, soil fertility, inadequate inputs, climate-related challenges	Issues directly affecting avocado cultivation and yield.
Marketing Challenges	Low market prices, lack of market access, poor transport, post-harvest losses	Barriers to selling avocados profitably.
Institutional Challenges	Limited extension services, lack of organized farmer groups	Weak support systems for farmers.
Socio-Economic Challenges	High domestic responsibilities, financial constraints	Personal and economic hurdles faced by farmers.
Infrastructure Challenges	Poor storage facilities, lack of irrigation, inadequate roads	Physical barriers to production and marketing.

4. Theme Analysis

I. **Production Challenges**:

   i. **Pest and Diseases**: Frequently cited (e.g., aphids, insects, premature fruit drop). Farmers lack knowledge/pesticides to manage these.

   ii. **Soil Fertility**: Declining soil quality affects yields. Few farmers use fertilizers effectively.

   iii. **Input Access**: High cost or unavailability of quality seedlings, fertilizers, and pesticides.

II. **Marketing Challenges**:

   i. **Low Prices**: Farmers sell at low prices due to lack of bargaining power or market information.

   ii. **Market Access**: Dependence on local traders/collectors; few links to exporters or processors.

   iii. **Post-Harvest Losses**: Poor storage (e.g., lack of cold rooms) leads to spoilage.

III. **Institutional Challenges**:

i. **Extension Services**: Limited training on modern farming techniques or pest management.

ii. **Farmer Organization**: Most farmers are not part of groups/cooperatives, reducing collective bargaining power.

IV. **Socio-Economic Challenges**:

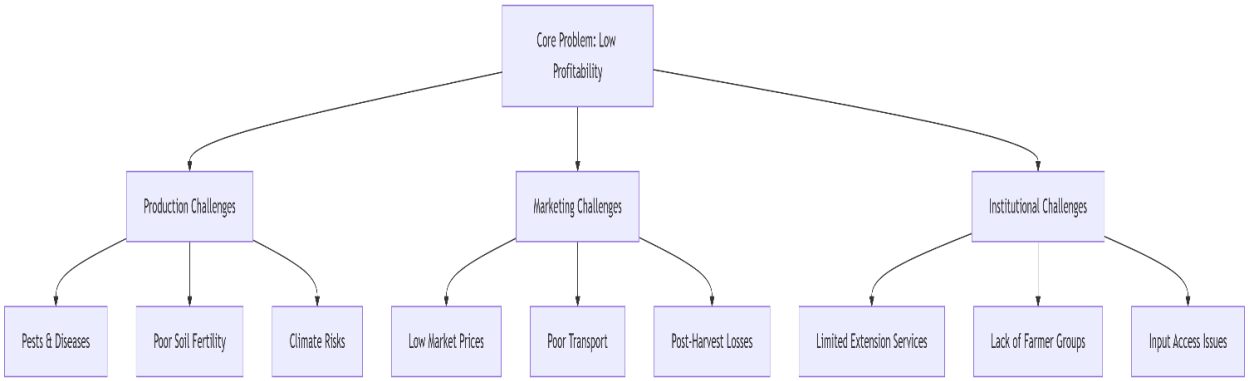
i. **Domestic Burdens**: Especially for female farmers, household duties limit time for farming.

ii. **Financial Constraints**: Inability to invest in inputs or irrigation.

V. **Infrastructure Challenges**:

i. **Transport**: Poor roads increase costs and reduce market access.

ii. **Storage**: Lack of facilities leads to post-harvest losses.



Analysis of Key Informants Data on Avocado Production and Marketing

1. **Input Suppliers**

I. **Key Inputs**: Grafting materials, seeds, and seedlings (sourced from RAB, farmers, and markets).

II. **Challenges**:

i. Limited capital and market access.

ii. Grafting material shortages.

III. **Opportunities**:

i. High demand for seedlings (especially Hass and Fuerte).

ii. Income generation through nursery businesses.

IV. **Role**: Supply seedlings and provide technical support.

2. **Extension Officers**

I. **Preferred Varieties**: Hass and Fuerte are the most preferred due to market demand and adaptability.

II. **Challenges**:

i. Poor seed quality and limited extension skills.

ii. Market access issues and low production capacity.

III. **Opportunities**:

i. Government support (e.g., free seedlings, nurseries).

ii. Training programs (e.g., Farmer Field Schools, Twigire Muhinzi).

IV. **Role**: Mobilization, technical support, and farmer training.

3. **Traders**

I. **Preferred Varieties**: Hass, Fuerte, and Reed dominate due to quality and shelf life.

II. **Challenges**:

i. Short storage life and rapid spoilage.

ii. Price negotiation difficulties based on quality/quantity.

III. **Opportunities**:

i. Stable income source.

ii. Direct farmer connections ensure quality supply.

IV. **Market Outlets**: Farmers to consumers, with prices ranging from 50–300 RWF/kg.

V. **Storage Issues**: Losses due to heat, poor handling, and overstay (1–3 days max).

4. **Exporters**

I. **Preferred Varieties**: Hass, Fuerte, and Ettinger (meet export standards).

II. **Quality Focus**: Green color, no blemishes, proper fertilization.

III. **Challenges**:

i. Seasonal availability (peak: March–September).

ii. High logistics costs (cold storage, transport).

vi. **Opportunities**:

i. Growing global demand.

vii. **Role**: Exporting and training farmers on quality standards.

5. Processors

I. **Preferred Varieties**: Hass and Fuerte (high oil content for processing).

II. **Challenges**:

i. Inconsistent supply and poor-quality fruits.

ii. Limited processing infrastructure.

III. **Opportunities**:

i. Value addition (e.g., oils, processed products).

IV. **Role**: Procuring avocados, processing, and supplying seedlings.

6. Cross-Cutting Insights

I. **Varieties**: Hass and Fuerte are universally preferred for their marketability and quality.

II. **Challenges**:

i. **Supply Chain**: Storage limitations, seasonal gaps, and poor-quality inputs.

ii. **Market Access**: Price volatility and lack of coordination among stakeholders.

III. **Opportunities**:

i. **Policy Support**: Government initiatives (e.g., free seedlings, nurseries).

IV. **Recommendations**:

i. Improve cold storage and transport infrastructure.

ii. Enhance training on quality standards and grafting techniques.

iii. Establish innovation platforms to connect farmers with markets.

Appendix E: Copy of the Research Permit

REPUBLIC OF RWANDA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Kigali, 23rd August 2023
N°: NCST/482/425/2023

Ms. Marie Chantal ZANINKA
National ID N°: 1198770111903096

Dear Ms. Marie Chantal,

RE: Approval to Conduct Research in Rwanda

I am pleased to inform you that your request to conduct research in Rwanda entitled: **"Building the Capacity of Smallholder Farmers in Avocado Production and Marketing in Gisagara District, Rwanda."**, has been approved under research permit **No: NCST/482/425/2023**.

This permission only covers research activities specifically related to the provided research project title, and project proposal submitted to the National Council for Science and Technology (NCST) for the period from **23rd August 2023** to **22nd August 2024**.

The research will be carried out under the affiliation of the **University of Rwanda, College of Agriculture, Animal Sciences and Veterinary Medicine (UR-CAVM)** under the supervision of **Prof. Jean NDUWAMUNGU (+250788484777)**, Deputy Dean SFBC/CAVM, and will take place in Southern province.

As a requirement, you will be **required to prepare a power point presentation of your results, and present at NCST Stakeholders Scientific Conference and submit both the progress and final reports** after completion of your research activities to the NCST, UR-CAVM, and Governor of Southern Province.

I wish you success in your research.

Dr. Eugene MUTIMURA
Executive Secretary

CC:
- Hon. Governor of Southern Province
- Principal UR-CAVM
- Prof. Jean NDUWAMUNGU, Supervisor of the study

Grand Pension Plaza Building, 13th Floor, P.O. Box 2285 Kigali-Rwanda,
E-Mail: info@ncst.gov.rw Web Site:www.ncst.gov.rw

Appendix F: Publication 1: Contribution of an Avocado Innovation Platform to Knowledge and Skills in Gisagara District, Rwanda.

Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 23 Number 3 (July 2024) pp. 51 - 63

ISSN 1119-745

CONTRIBUTION OF AN AVOCADO INNOVATION PLATFORM TO KNOWLEDGE AND SKILLS IN GISAGARA DISTRICT, RWANDA

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ABSTRACT

The avocado fruit has an essential role in human health, due to its nutritional value. Despite the importance of the avocado crop in Rwanda, there is still inadequate avocado yield that can fetch good prices in the local and international markets. Moreover, there is little knowledge among farmers on avocado quality and varieties. To address those challenges the avocado innovation platform (AIP) was established to build the capacity of farmers in avocado production and marketing. This study set out to assess the contribution of the established AIP on knowledge and skills in Gisagara District, Rwanda. The study employed survey research designs. Data was gathered from 40 members of AIP farmers and 25 other stakeholders that include extension staff, inputs supplies, exporters, researchers and processors using a questionnaire schedule. Data was analyzed using percentages, Likert scale ratings, t-test, and chi-square with SPSS software. The level of knowledge and skills acquired by the AIP participants during the process of capacity building was higher (M = 4.27, SD = 0.59) when compared to the level than when they started the AIP process (M = 2.29, SD = 0.68). A paired sample t-test shows that the level of knowledge and skills acquired by the participants during the AIP process was found to be significantly higher statistically (t = –13.57, df = 64, p < 0.001). The study shows that the established AIP has greatly facilitated access to quality avocado seedlings and market access for its members. Therefore, it is worthwhile to recommend the continuity of the established of AIP in Gisagara District.

Key words: capacity building; avocado innovation platform; interaction; networking; multistakeholder platform

Appendix G: **Publication 2: Analysis of Challenges Faced by Smallholder Farmers in Avocado Production in Gisagara District, Rwanda.**

Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 23 Number 3 (July 2024) pp. 64 - 73

ISSN 1119-745

ANALYSIS OF CHALLENGES FACED BY SMALLHOLDER FARMERS IN AVOCADO PRODUCTION IN GISAGARA DISTRICT, RWANDA

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ABSTRACT

Avocado is a multipurpose perennial fruit that has been grown for its flavor, nutritional value, and socioeconomic benefit in Rwanda and other parts of the world. Despite the importance of the avocado crop in Rwanda, there is an inadequate avocado yield that can fetch good prices in the local and international markets. Therefore, the purpose of this study was to analyse the challenges faced by smallholder farmers in avocados production in Gisagara District, Rwanda. This study used a survey research design. Data were collected from 143 avocado farmers using closed- and open-ended questionnaires, Focus Group Discussion (FGD) and key informant interview. Data were analyzed using the Statistical Package for Social Science version 30. Frequency, percentages, Likert scale, means and standard deviation were used to analyze the data. Findings revealed that the main challenges affecting avocado production include limited access to quality seedlings, inadequate knowledge about good farming practices, ineffective access to production inputs, and pests and diseases. Availability of quality avocado seedlings is requisite to quality avocado fruits for local and international markets. The study findings provided useful information among the avocado value chain actors on the challenges faced by smallholder farmers in avocado production in Gisagara District, and Rwanda in general. The study recommends the establishment of an avocado innovation platform where different actors along the avocado value chain can come together to find out the innovative solutions to these challenges.

Key words: avocado value chain, challenges, production, and smallholder farmers

Appendix H: Training Material

AVOCADO FARMING TRAINING MANUAL




TRAINING

1. Avocado Crop

Avocado (Persea americana) belongs to the "Lauraceae" family. It is a plant that originated in Central and South America. In Rwanda, it grows in all districts of the country, but especially in the south. Imported avocados began to arrive in Rwanda in 1972, brought by ISAR. Avocados are rich in protein, potassium, vitamins B1, B2, B6, C, D and E. Avocado oil is cholesterol-free and fights heart disease and cancer. Avocados are also used in the pharmaceutical, cosmetic and soap industries. The peels and industrial waste are used to make animal feed. Avocado farming brings farmers a lot of money, especially varieties like Hass and Fuerte, which are popular in the international market. The best planting distance is 7 m x 7 m. If you use this distance, 204 trees will be planted per hectare. The yield per hectare can reach 40 tons per year.

2. Avocado Varieties in Rwanda

In Rwanda, there are many varieties; but three can be grown anywhere: Hass, Fuerte and Ettinger because they can withstand altitudes between 2000 m and 2500 m. The remaining varieties available in RAB include those that can withstand altitudes below 2000 m, these varieties are choquette, collinson, simpson, booth 7 and booth 8. The Hass variety can produce up to 120 kg per tree after seven years of planting. This variety is also the most popular in the international market because its fruits are high in oil and can last a long time after being harvested without spoiling. This variety is followed by the Fuerte variety in popularity and high oil content, Fuerte is the one that produces the most compared to Hass because it can reach 180 kg per tree per year after seven years of planting.

3. Avocado Farming Locations

Avocado grows best in areas with deep, aerated soil, sufficient fertilizer, and loamy soil that is not waterlogged or has no groundwater near the roots because it can cause the roots to rot and the tree to dry out. It prefers soil with a pH of 5.5 to 6.5 and an altitude of 2000 m or slightly above; this shows how avocado can grow in many different areas in Rwanda. It prefers areas with moderate rainfall (1000 - 1200 mm) per year, but it should not be less than 750mm. For it to grow well and produce sufficient yields, the required temperature is 12.8 - 28.3 degrees (oC).

4. Preparing Seedlings

It is best to start avocado seeding in December - January because this is when the traditional avocados are ripe and the seeds are easily available. This also ensures that the seedlings will be ready for transplanting (September - October).

i. Raising seedlings to be transplanted
ii. The greenhouse is built according to the following dimensions:
iii. Width of the greenhouse: 1 m – 1.2 m,
iv. Height of the greenhouse: 10 m – 12 m,
v. Distance between greenhouses: 80 cm – 100 cm,
vi. The planting holes should be 1.8 – 2.00 m apart,
vii. Dig a hole 50 cm deep,
viii. Plant the trees so that the greenhouse is 1.30 – 1.50 m apart

The seedbed should have trees, boards (or bars) on the sides for planting, The seedbed should also be covered to reduce the sun (the surface should not be made of grass or have seeds growing on it). For covering, a shadenet (sunscreen) can be used that reduces the light by 35%.

5. Grafting

The work of raising seedlings for transplanting is carried out as follows

Selecting traditional avocado trees with well-ripened and disease-free avocados. The seeds are removed from avocados that have been cut from the trees after being picked for burning: it is not advisable to use the seeds that have been picked because they are diseased. Once the seeds have been removed from the avocados, they are placed in clean water, then dried (in a place out of direct sunlight). Before transplanting, the seeds are soaked in water containing a fungicide (e.g. copper oxychloride) for about 10 minutes and then spread out in a designated area to dry. Planting is done in good, loose soil that contains sufficient fertilizer, and is not in a swamp. The seedlings are built, covered, and planted in rows. The rows are separated by 10 cm; in the rows, the seeds are close together, covered with a thin layer of soil and a little straw, and watered frequently as long as it does not rain. Pots with a diameter of 20 cm and a height of 20 cm are used (larger pots are better, although they are more expensive); if the pots are covered, they are perforated to allow water to drain. The pots are filled with a mixture of good soil: well-rotted manure and sand in a ratio of 3:1:1. After one and a half to two months, the seedlings in the nursery have sprouted. At this time, the sprout is 5-10 cm tall and is still attached to the seeds. 3 Remove the sprouted seedling, cut the root 3-5 cm from the seedling to allow new roots to grow, and place it in the prepared pots.

Transplanting is done 2–3 months after being transferred to the pots, the seedlings are 30 - 40 cm tall, about the size of a pencil, and the leaves and stem have already developed The red color has changed to green. There are many ways to graft avocados, but the most commonly used method is grafting on the head, because it gives the highest percentage of grafting. Grafting on the head is done by taking the grafted plant, removing the head, cutting between the soft and hard parts, and cutting the head in the middle to 3-4 cm. After that, they cut the grafting branch (the grafting branch) on both sides, insert it into the cut seedling, and tie it with a small piece of cloth so that the entire wound is covered. This is followed by covering the grafted branch with a special bag. The grafting branch used is the head or branch of the desired avocado tree variety (which produces good, abundant and delicious fruit). A good sapling has 2-3 eyes and is between 6-10 cm long. The thickness of the sapling is the same as that of the

cuttings it is being planted in so that it will take root well. Saplings from trees have been inspected and certified by an authorized agency, RAB.

6. Care of the Seedlings After Growing

Three weeks after germination, when the first leaves begin to open, the bag covering the branch is removed. It is important to regularly cut off the shoots that grow below the germination site. The seedling is ready to be planted in the field when the leaves have turned green; it has been 3-4 months since germination. The bag tied to the wound should be removed after it has healed so that it does not suffocate the seedling as it grows. The bag is removed at least after 3 months.

7. General Tasks for Caring for Seedlings in the Greenhouse

Watering: It is best to water whenever it is not raining. Watering should be done in the morning. It is not good to water in the evening because water stays on the leaves and can cause diseases to multiply quickly and root diseases to multiply quickly.

Mulching: This is done to loosen the soil in the seedlings so that water can penetrate well. Weeding: Weeds growing in the seedlings should be removed while they are still visible.

Removing weeds: All branches growing below the place where they were planted should be removed regularly.

Transplanting seedlings and cutting off the root that has grown beyond the seedling: This is done so that the seedlings do not take root in the soil and this will make it difficult to transplant them into the field. You should transplant or shake the seedlings after each month to prevent the root from penetrating the soil.

Spraying: Avocado seedlings are prone to various diseases. These include: root rot, anthracnose, and others. The most common pests are thrips, mites, etc. It is therefore necessary to spray pesticides in the orchard. To combat diseases, spray the following pesticides in turn: copper-containing pesticides (Examples: Gitenge, Komando, Funguran, Nordox), sulfur-containing pesticides (Examples: Thiovit, Miovit, Thiogil, Ramsulfur), carbendazim-containing pesticides (Examples: Rodazim, Megazim, Goldazim). To combat pests, spray the following pesticides in turn: abamectin-containing pesticides (Examples: Dudu abamectin, Romectin, Glider), acetameprid-containing pesticides (Examples: Aster extrem, Dudu acetameprid), lambda-cyhalothrin-containing pesticides (Examples: Lamdex, Lamdaline), alpha-cypermethrin-containing pesticides (Examples: Kiboko).

Hardening of seedlings: To make the seedlings strong and able to take root in the field, it is necessary to harden them by gradually reducing the amount of water they receive in the nursery and gradually reducing the amount of shade. This should be done about a month before they are planted in the field.

7. Field Preparation and Planting

Farm preparation is done by plowing the field to a depth of 30 cm, removing tree roots, stones and weeds. This is followed by marking out the areas in the field where avocado trees will be planted, and setting stakes.

For seedlings that have sprouted, the distance between trees and between rows is 5 m if no other crops are planned to be planted or 6 m to 7 m if you plan to grow other crops.

Pits are dug 60-100 cm wide and 60-100 cm deep (these measurements vary depending on the soil conditions). The topsoil is placed on one side, which is then mixed with compost, this is done at least a week before planting.

At least two buckets (25-50 kg) of well-rotted compost are placed in each pit. The amount of fertilizer that goes into the hole is determined by the soil in which it is going to be planted. Avocados are planted at the beginning of the rainy season from late September to November.

During planting, the soil is removed, leaving the soil around the roots so that the seedlings can take root well. After planting, they lightly press the soil around the planted seedling to make it firm. During planting, you should fill the soil a little and press it down, avoiding water standing near the stem when the seedlings are still young because this can cause root diseases.

8. Removing the Stem Used by the Stem

When the stem has started to produce new shoots and the wound has healed well, it is a sign that the stem that connected the stem to the stem can be removed. To remove the stem, a razor is used, taking care not to injure the tree. It is best to remove the mulch in time because if it is left too late, it will penetrate the roots and suffocate and even break them.

9. Replacement of Dead Seeds

Seeds that have not taken root are replaced early so that they can grow together with the others. When replacing, well-grown seedlings are used and this is done taking into account the availability of water.

10. Maintenance, Watering

Once avocados are planted, it is important to take good care of them by loosening them, loosening them so that water can penetrate the soil well. It is important to mulch around the tree using well-dried grass. It is not advisable to water the tree too close to the trunk (leave a distance of 20 cm from the trunk) as this increases the risk of attracting weeds and encourages soil-borne diseases.

11. Watering

It is necessary to water when the trees are still young during the dry season. Watering helps the trees to grow well and produce good yields when there has been little rain. Avocados are vulnerable to lack of rain, they need a lot of water during the flowering, fruiting and fruit development stages.

Watering once every 3 weeks has been shown to help the trees mature faster and the ripe fruits to be larger and have more oil. During the hot season, it is best to water at least every 10 days. Note: In areas with frequent rain and high sun, it is best to water young seedlings twice a week, and once a week for established seedlings.

The amount of water needed per tree varies depending on the stage of growth, soil type, local climate, and growing season. It is best to water the trees well. It is best to water early in the morning before the sun gets too hot.

12. Inspecting the Plant

It is important to inspect avocado trees frequently so that any problems can be identified and addressed early. When inspecting, pay attention to the following: mold in the soil near the tree, diseases and pests on the leaves, discoloration of the leaves, etc. During the inspection, it is also checked whether the trees are still in good condition and can be pruned and if they have any suckers removed. It is good if one constantly changes the route, he/she takes to inspect the field.

13. Pruning

Pruning the branches of the trees in the first years after planting is necessary to ensure that they can grow and have many branches. All branches that grow below the point where they were grafted are removed regularly. The avocado tree should not be allowed to have branches lower than 50 - 70 cm from the ground. This is done before the tree begins to bear fruit.

Once the trees have grown, pruning aims to obtain fruits of a certain size, quality and number. At this time, the focus is on removing unwanted branches, broken and diseased ones and reducing the length of those touching the ground.

14. Fertilizing Trees

Edible fruit trees need fertilizer, especially compost; at the time of planting, the farmer places 25-50 kg of compost per tree in the hole. From the time the trees are one year old, each tree is fertilized with 500 g of NPK 17-17-17 every year. When the trees are 3 years old, 30 kg of compost and 1 kg of NPK 17-17-17 per tree per year are applied. The fertilizer intended for one tree is applied in two stages (October and February).

15. Harvesting and Handling the Harvest

The first harvest begins three years after the tree is planted, but the yield increases every year. Depending on the type of avocado, it can be harvested twice a year, between July and August and between December and February. It is important to avoid damaging the avocado when harvesting; also avoid dropping it in the container you are harvesting it in (lay it down carefully). The harvested avocados are immediately placed in the shade.

Average yield per avocado tree (e.g. Hass)

Year	3	4	5	6	7	8	9	10
Number of fruits per tree	60	180	240	320	480	540	650	650
Yield per tree (kg)	15	45	60	80	120	135	163	163

One kilo of avocado contains 3-4 avocados

16. Major Diseases and Pests of Avocado

Diseases / Pests	**Symptoms Prevention**	**control**	**Dosage of the product in 20 liters of water**
(Avocado root rot)	In waterlogged soil, avocados can be affected by this	Plant in a water-resistant area, use fungicides such as copper oxychloride/hydroxide, Metalaxyl, Mancozeb.	50 g of solution in 20 L of water

	disease, at any age of the tree. Affected trees begin to lose their vitality, lose their leaves and fail to produce fruit. The leaves turn pale and yellow, the branches become sunburned and gradually dry up. The roots turn black and rot, and the tree dies prematurely.	Reduce watering when trees with root rot are observed.	
Anthracnose  	This disease is caused by a fungus. The leaves are the first to show symptoms, with brown spots that later turn brown, leaving the tree looking like it has been	This disease spreads most during the rainy season. It is best to plant seeds that are free from the fungus that causes this disease. Propagating avocados using disease-free cuttings. Cleaning the field, cutting branches and removing suckers from the tree to allow light to penetrate well. Removing fallen fruit.	Carbendazim (20-25ml), Copper hydroxide/ oxychloride(40-60g), chlorothalonil (30-40ml) Sulphur(50g)

	cut. If the tree is severely affected, the young fruit will turn brown. If the fruit is affected and matures, the fungus will remain hidden inside the fruit until it ripens. It is a post-harvest disease. The disease is characterized by indented spots that look like rot, and the rot can even penetrate deep into the edible part. The fungus usually lives on fallen fruit that has rotted or fallen leaves.	Using disease-free seedlings. Applying chemicals such as Carbendazim (Rodazim), Copper hydroxide, Copper oxychloride, sulfur and Chlorothalonil in turn.	
Scab	This disease is caused by a	Cleaning the field, cutting back branches and	50 g for copper 20 ml for

 	fungus. This fungus attacks young leaves and fruits. Infected fruits develop spots on the skin that look like small, round, light brown spots or scales. On leaves, they are most common on the upper surface of the leaf and are concentrated along the veins. The skin of the fruit cracks, and the cracks rot. It mainly affects varieties with thin, thin skins.	removing weeds from the tree to allow light to penetrate better, Picking up fallen avocados from the field, Applying fungicides such as Copper oxychloride/hydroxide, carbendazim or chlorothalonil.	carbendazim 40-60 g for chlorotharonil
SERICOSPORIOUS 	The disease is caused by a fungus. This disease is a problem for	Apply pesticides such as Copper oxychloride/hydroxide, carbendazim or chlorothalonil during	50 g for copper 20 ml for carbendazim 40-60 g for chlorotharonil

	the quality of the fruit. The severity of this disease varies depending on the growing season, and can cause a yield reduction of up to 60%. The fungus that causes it usually affects the fruit and leaves, the affected fruit has yellow spots or spots on the skin of the fruit and leaves, these spots gradually turn into red spots, harden and crack. The disease spreads more during the rainy season or when there is high humidity	flowering, fruit set and after harvest. Grow avocados in the field to prevent rot. Clean the field, trim branches and remove weeds from the tree to allow light to penetrate well.	

	in the avocado field.		
Thrips  	Adult thrips are a common sight on avocados, appearing dark brown or black, while juvenile thrips are yellow. These thrips are spread by farmers' tools and clothing. Thrips usually attack the crop during the dry season, where they lay eggs on leaves, which hatch into larvae that feed on the leaves, leaving a trail of leaves. Thrips can transmit a virus called tospovirus, which causes leaves to turn yellow and	Regularly inspect the field, Weed the field to remove weeds, Leave sufficient distance between plants, Apply chemicals such as: Lambdacyhalothrin, Imidachloprid (confidor), Astemepride (Aster extrim), cypermethrin, Prophenofos+Cypermethrin (Rocket), Buprofezin (Calibre), Indoxacarb (Protector)	20 mL of drug to 20 L of water. Dosage: 20-30ml/20l of milk Indoxacarb: 10-20ml/20l of milk

	dry. Thrips are often found on the tips of branches, in the flower and on the stems.		
Amblypelta lutescens&A. nitida 	Both adult and juvenile beetles bite into the fruit and suck out the water. Varieties with thin, thin skins such as Fuerte are most susceptible to this problem. Young fruits are damaged by these beetles and fall off. Mature fruits remain on the tree after being damaged by the beetles and show the following symptoms: Wounds that ooze water and	Visit the field, especially from flowering to harvest. Check for feeding areas or if young fruit are being harvested. Prune trees to reduce the number of hiding places for the beetles, which are easier to treat. Choose varieties that are resistant to the beetle, especially those with tough skins like Hass. Remove other plants that may be a breeding ground for the beetles near the avocados.	

	turn into a white powder when they dry. The fruit cracks where the beetles have eaten, creating a star-shaped wound. Wounds caused by these beetles are a source of fungal rot. The areas where the beetles have eaten are not visible on the outside, but are visible inside the fruit when it is ripe, especially on varieties with thick skins such as Hass. The areas where the beetles have bitten off harden and look like small		

	stones that are visible under the skin.		