CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Farmer's Motivations to Adopt Sustainable Innovations in Rwanda

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled **Farmer's motivations to adopt Sustainable innovations in Rwanda** independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references.

In Prague 13 April 2022

Winnie Batamuliza

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Abstract

The agricultural sector must be sustainable to reach its full potential. However, there are numerous obstacles to Rwandan agriculture’s long-term viability, including soil degradation, poor soil fertility and lower yields. The thesis determines the motivational behaviour of farmers in adopting sustainable agriculture innovations. It further assesses the influence of factors on farmers' decisions for using sustainable innovations. A survey of 50 farmers from Abakorana Murava Cooperative uses a structured questionnaire. The results indicated that 94% of respondents highlighted market availability as a motivation for introducing innovations in agriculture. Market demand, profit expectation, access to finance and input availability contribute to adopting sustainable innovations. Ensuring that conservation efforts are efficient and sustainable can be achieved by supporting research and development in sustainable technologies and providing incentives to encourage adoption.

Keywords: Attitude, innovation, motivation, perception, smallholders, Rwanda

Contents

List of the abbreviations used in the thesis

MINAGRI - Ministry of Agriculture and Animal Resources

RAB - Rwanda Agriculture and Animal Resources Development Board

CIP - Crop Intensification Program

LMP - Livestock Master Plan

ISAR - Rwanda Agricultural Institute

TPB - Theory of Planned Behaviour

SAP - Sustainable Agricultural Practices

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1 Introduction

Agriculture is one of the main sectors of the economy and has a significant impact on the natural environment (Lamek et al., 2016). Agriculture is the backbone of the Rwandan economy, accounting for 34 percent of the national GDP and employing more than 80% of the population. The achievement of Vision 2020, the Millennium Development Goals and the Strategy for Economic Development and Poverty Alleviation is highly dependent on agriculture. The sector faces various challenges, most notably that the system has an extensive global margin. Rwanda has one of the most densely populated areas in Africa; smallholder farming, with an average area of 0.7 ha per household (Minagri, 2009).

Intensive agricultural production requires the use of more industrial inputs (i.e., mineral fertilizers and crop protection products) and their inefficiency or overuse, which can pose a severe threat to the environment, for example, soil quality, biodiversity, and animal welfare (Amani & Rodriguez-Eugenio, 2018). In animal husbandry, high amounts of natural fertilizers are rich in nitrogen and phosphorus, which, if misused and stored, can be a source of pollution, especially water pollution (Thortorn, 2010).

Numerous studies indicate the need to plan for the economy, including agriculture, according to the principles of sustainable development (Majewski, 2008). Natural resources are scarce, particularly non-renewable (Siebrecht, 2020). Sustainable agriculture produces abundant food without depleting the earth’s resources or polluting the environment. The sustainability of agriculture is based on the idea that we must meet current needs without compromising the ability of future generations to meet their needs. As a result, long-term management of natural and human resources is as important as short-term economic benefits (Altieri & Nicholls, 2012). Other environmental factors vandalism of agricultural activities includes improper compost management, gaseous and dusty material from excessive farming or animal husbandry to air, and improper waste management (Ogbuewu, 2012). It can be concluded that the level of negative impact on agriculture's environmental production depends on the type of farm and production system (Batalla, 2015).

Land management and natural resources, including the conservation or improvement of these resources and their use in ways that allow them to grow in the future and in terms of animal welfare, should be of management consideration (Thornton, 2010). Long-term sustainability of the agro-ecosystem is impossible without the knowledge, technical skills, and skilled work required to behave responsibly. As agriculture evolves continuously and in a particular context, sustainability requires a diverse and flexible knowledge base that includes formal, experimental research and local farmers' knowledge. Community structures supporting the farmer and scientific education, encouraging innovation, and researchers' cooperation can improve agricultural productivity and long-term sustainability (Brodt, 2011).

Motivation is not simply a matter of motivating oneself; it also includes elements that guide and maintain these goal-directed actions (although such motives are rarely seen directly). As a result, we often must consider why people act the way they do. What exactly lies behind the motives? (Carsrud & Brännback, 2011).

Farmers' natural preferences, market considerations, cultural and socio-economic factors contribute to their adoption of sustainable technologies. Despite the growing interest in sustainable agriculture and the increasing number of projects and policies to promote these processes in many countries, there has been little evaluation of a series of motivation-outcome, that is, how positively motivated factors encourage discovery and how these incentives to work (Valeria, 2021).

It is not easy to understand how farmers behave in conservation. Creating a complete picture of the motives and processes that contribute to SAP acquisition is why there is a need to understand the economic and social dynamics that influence farmers' desire to adopt innovations. Sustainable techniques play an essential role in increasing farm productivity, strengthening food security, improving economic growth, improving soil fertility, reducing the risk of drought and water scarcity, soil erosion, and maintaining biodiversity and agro-ecosystem sustainability (Adnan et al., 2018).

2 Literature Review

2.1. Agriculture in Rwanda

The agricultural sector accounts for 33% of the national GDP. Rwanda's GDP has risen by 7 percent since 2014. Tea and coffee are the leading exporters, and agriculture is considered the mainstay of the economy on a subsistence basis as the entire population produces about 70%, and the labour market contributes. Agriculture is an essential component of Rwanda's national growth plan, vision 2050. Government plans to close the agricultural sector to include commercial agriculture and fully commercialized Agro-processing and technology-focused by 2050 (Yongabo, 2021).

The Rwandan agricultural sector remains the backbone of the Rwandan economy in terms of employment and income generation for many families (NISR, 2013). The country is plagued by population growth (albeit slower), declining agricultural land size, inadequate agricultural technology, and soil erosion resulting in declining fertility, over-cultivation, and limited use of agricultural resources. These problems are exacerbated by insufficient expansion, land redistribution, incomplete financial markets, and poor rural infrastructure (Bizoza et al., 2007). Therefore, the Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda, through its operational agency, the Rwanda Agricultural Board (RAB), launched 2007 a program to strengthen the crops (CIP) to address those issues, avoid their dependence on rain-fed agriculture and to ensure food security and independence (Kathiresan, 2012).

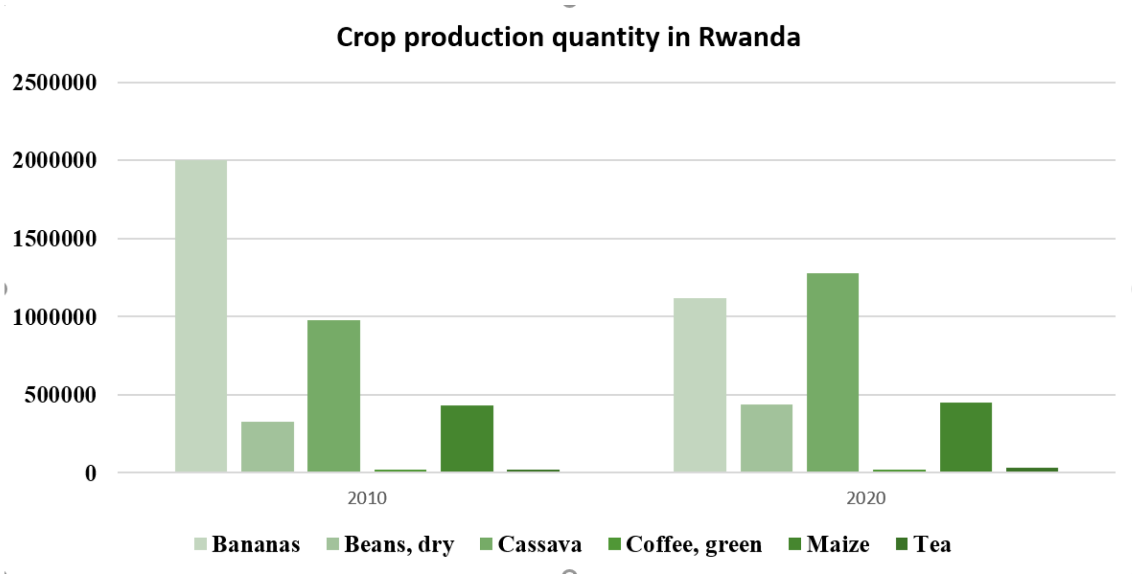

Figure 1. Crop production quantity in Rwanda (FAOSTAT 2020)

The government's crop intensification program (CIP) included subsidies such as improved seed and inorganic fertilisers available through the national agriculture extension system and the land consolidation policy, which increased land cultivation as co-operatives and associations are credited with the increased production. Furthermore (MINAGRI, 2020)

Rwanda's fields are particularly prone to soil erosion due to its steep and mountainous terrain, weak soils and a high concentration of 1156 mm rainfall concentrated during the rainy season. According to an international assessment, Rwanda was one of the 22 countries most affected by landslides. Based on previous studies, the most common soil erosion, and other land-related problems, especially in Rwanda, are due to unsustainable agricultural practices and land management due to overcrowding (Fidele, 2016).

2.2. Rwanda Climate

The climate of Rwanda, Rwanda has a tropical highland climate with moderate temperatures to those of the equatorial countries due to its high altitude. The average annual temperature varies from 16 ° C to 20 ° C, with no significant differences. It is raining heavily, but it can be not very clear. In the highlands of the Congo-Nile plateau, the average temperature varies between 15 ° C and 17 ° C and rainfall are very high (Hara et al., 2022).

The country is divided into four climate zones: the eastern plains, the central plateau, the highlands, and the districts surrounding Lake Kivu. The eastern plains receive 700 to 1,100 mm of annual rainfall, with mean annual temperatures ranging from 20 to 22 degrees celsius. The mean yearly temperature in the central plateau region is between 18°C and 20°C, with rainfall ranging from 1,100 to 1,300 mm. The Congo-Nile Ridge and the volcanic ranges of Birunga get between 1,300 and 1,600 mm of annual rainfall, with annual mean temperatures ranging from 10 to 18 degrees Celsius. Annual rainfall in the Lake Kivu and Bugarama plains ranges from 1,200 to 1,500 mm, with mean yearly temperatures ranging from 18 to 22 degrees Celsius. The country has four climatic zones. The long rainy season runs from March to May, and the short rainy season runs from September to November, whilst the long dry season lasts from June to August, and the short dry season lasts from December to February. The annual rainfall is 1,170 mm. Precipitation occurs throughout the year in Rwanda, with the heaviest amounts falling between September and May (Rwanda climatology 2020)

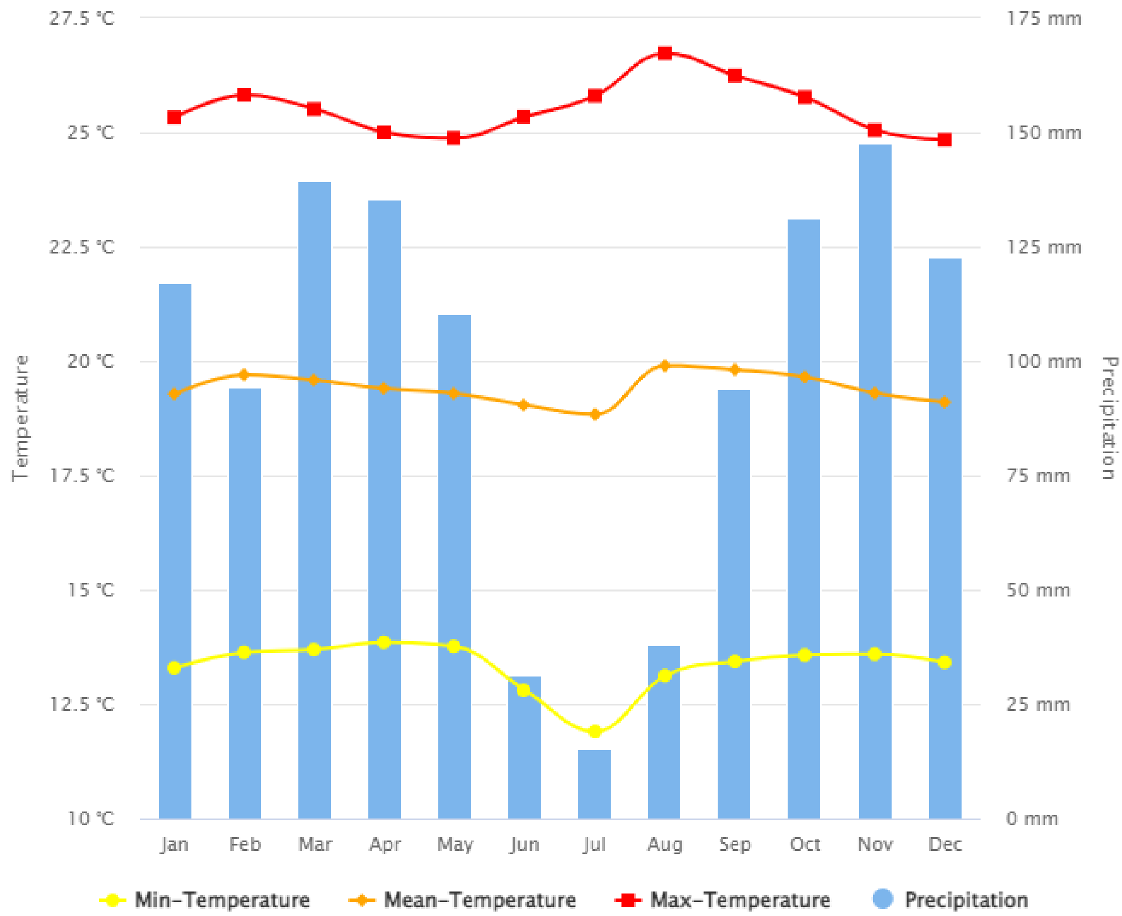

Figure 2. Monthly average temperature in Rwanda (Rwanda climatology 1991-2020)

The Rwandan government's goal is to work hard to increase crop production and all agricultural activities as a critical factor in the country's economic growth. Improving and managing soil quality is an essential account of sustainable agriculture. Agricultural processes can improve and protect the quality of the soil. The common belief among sustainable agricultural experts is that "healthy" soils are an essential part of sustainability; healthy soil will develop good crops with good yields with more vigour and less risk of pests (Kassie et al., 2013). The government's annual budget expenditure on sector assistance is essential but is expected to recover over time. A significant shift in its focus is required on agricultural policy away from the single farming approach and towards this one which allows farmers to adapt to changing conditions at the local level (Miklyaev, 2020).

Crop management practices that reduce soil quality are common, with plenty of water, fertilizer, pesticides, and farming power to sustain the harvest. In sustainable systems, the soil is seen as a soft and viable material to be protected. It must be protected and nurtured to ensure long-term productivity and sustainability. Protective measures, replacing crops, compost, and manure, improve soil productivity and reduce tillage while maintaining soil cover (Mekonen & Tesfahunegn, 2011).

Livestock Master Planning (LMP) presents improved biology, nutrition, and health programs for investment interventions and associated policy support to help achieve Rwanda's growth. The program and policies to increase efficiency and overall productivity in critical areas of the beef development program, red beef, milk, poultry, and livestock pig price chains (Shapiro et al., 2015). Under the recommended level of investment, the increase in the production of red meat in cattle, sheep, and goats from 2017 to 2022 was 32%, 33% and 50%, respectively. The GDP contribution of red meat from cattle to all areas and programs in Rwanda increased to 19% (Shapiro et al., 2017).

In analysing this diversity, especially agricultural systems are considered. Agricultural activities worldwide are creating growing concerns about their impact on the environment. The most expensive agricultural model widespread in the West has revealed the environmental limits. However, the various effects of agricultural production on the environment can also be seen depending on product type. Other factors will be involved in the production of plants and other animals. Pig production will have a different impact on the environment than cattle production (Berry et al., 2006)

From an economic point of view, the most important are industrial production systems characterized by high density, high volume, and concentration. Farms can carry out the industrial process with no arable land (e.g., commercial pig production food). Such overcrowding creates many environmental problems related to waste management, compost, and odourless. For example, liquid manure is very dangerous in groundwater and surface water rivers. Excessive amounts of fertilizer contain a large portion of water, such as liquid manure and slurry, which interferes with the visible features of the soil (Askarov et al., 2019).

2.3. Sustainable Agriculture Innovations

Sustainable agricultural practices allow for the efficient use of natural resources, reduce the environmental impact of agriculture, and increase resilience to climate change and diversity. Crop rotation, improved crop diversity, cover crop use, tillage and mitigation systems, integrated pest management, livestock and crop integration, sustainable agroforestry methods, and precision farming are just a few examples. Our food production systems are unsustainable, but the good news is that many aspiring farmers and scientists are using new, sustainable, social, and environmental farming systems. Sustainable farming methods are suitable for all farms as they produce a variety of fuels, food, and textiles. A sustainable farming system increases productivity while minimizing environmental damage through new science-based methods (Migiro, 2021).

A variety of sustainable agricultural practices Pesticides, chemical fertilizers, and other chemical additives are widely used in industrial agriculture. However, due to the negative aspects of this approach, there has been a modest movement in recent years toward the adoption of sustainable farming practices (Migiro, 2021). Rotating crops involves planting various crops in a particular area at certain times. Crop rotation helps maintain or improve soil health while preserving or increasing agrarian productivity over time (Shah et al., 2021). Cover crops are plants that are cultivated to cover the soil. Cover plants control soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, animal diversity, and animals in an agricultural ecosystem system that is controlled and man-made (Adetunji et al., 2020). Reducing tillage is a way to reduce soil erosion by leaving agricultural or ethnic waste on the ground rather than dumping or compacting it into the soil. Farmers save money on machinery, fuel, labour, and time by ploughing less (Pelosi et al., 2014).

Other sustainable innovations include integrated pest management methods - Although pesticides help control pests and agricultural production, overuse of certain pesticides results in several pest resistance. Plants attract various insects, birds and other species; some small animals can eat insects that damage plants. To help control pests, the farmer may release valuable insects such as lacewings and ladybugs on the farm. Planting trees near the farm will attract birds that will live in nests and even eat insects, thus reducing the number of insects (Karuppuchamy & Venugopal, 2016).

Hydroponics and Aquaponics, a sustainable farming method or garden, allow you to produce fish and vegetables in the same system. Fish waste is converted into nitrates, plants use it as fertilizer, and plants filter and purify the fish's water. Aquaponics is an independent, well-balanced environment. Insects and soil-borne diseases that damage monoculture crops have been reduced to land use. Because the subsoil can be disinfected and reused between plants, hydroponics can effectively control pests and diseases carried by the soil by eliminating plant and soil contact (Somerville, 2014).

Polyculture farming involves planting a variety of plants in one place. These types are often complementary, allowing a wide range of assets to be produced in one place while making full use of available resources. High biodiversity makes the system extremely resilient to climate change, supports healthy food, and utilizes natural processes to maintain soil fertility. Because of these benefits, collective farming has been the best agricultural strategy. Co-crop production is still typical in developing countries, even though it has been eliminated in industrialized countries (Ghazali et al., 2016). Permaculture is a core ethical and strategic plan based on sustainable agriculture, land reform, water conservation, and waste management. The main goal is to apply the permaculture principles to enable people to become their producers and move away from being loyal consumers (Newman & Jennings, 2012).

2.4. Farmer's Attitude, Perception & Motivation

Attitude refers to 'human testing of any psychological object'. Information objects is based on three common categories of information: cognitive information, emotional information, and information about past behaviours (Allen et al., 2003). Attitude is a tendency to act in a certain way. A state of readiness influences a person to act in a particular manner (Rahman et al., 1999). Therefore, agricultural assessments can lead to adequate definition and predictability of farmers' economic behaviour and use in conservation and environmental issues, focusing on the influence of climate change as predictors of conservation behaviour (Dimara & Skuras, 1999). Attitude is understood as a learned tendency to continuously be positive or negative (Schiffman & Kanuk, 1997). In addition, attitudes are positively motivated; they move a person to a specific behaviour or turn away from another (Giraldi, 2005).

Attitudes may change, and when they do, a new approach may replace the old one, but it does not exclude the existing one (Wilson et al., 2000). According to this model of dual attitudes, at the same time, people may have different attitudes toward something in the same area, which may express a vague or abnormal attitude and a clear one (Ajzen, 2001). Emphasizing this view, Schiffman and Kanuk (1997) emphasize that attitudes are consistent with the behaviour they display. A specific situation can cause people to behave in a way that is not in line with their mood (Giraldi, 2005).

According to Ajzen J (2001), attitudes are characterized by other factors such as stability over time, endurance, and the ability to predict behaviour. These factors are closely related in composition, gender, age and race, highlighting that attitude is a cohesive structure. The author points out that the power of perspectives can vary over a person's life cycle with great force throughout life. Strong relationships are associated with the most accessible beliefs, and when mental strength is assessed with specific meanings, they show a greater tendency to resist change (Ajzen, 2001).

Previous studies have found positive relationships between farmers' attitudes, ideas, and socio-economic levels concerning and participation in environmental programs (Jordan et al., 2005). Baynard and Jolly (2007) found that the perceptions of grain farmers about the risk of environmental degradation were a factor in shaping their mental states, as well as, indirectly, and their natural actions. Barreiro-Hurle et al., (2008) and Jordan (2005) found that high social capital levels positively affected farmers' perceptions and ideas for participating in environmental programs. Social money is defined as a sense of empathy and moral responsibility for other people or groups, known as "doing the right thing" (Jordan, 2005). Similarly, several certified growers of sustainable floriculture state their reason for embracing sustainable practices as "the right thing to do" and their responsibility as business owners.

However, the Theory of Planned Behaviour (TPB) states that attitudes alone are not sufficient to predict behaviour because social pressures and perceived difficulty in acting are also essential factors (Hattam, 2006). TPB was based on two studies in which positive attitudes alone were negative predictors of biological acceptance of organic farming and the impact of environmental attitudes on environmental behaviours (Hattam, 2006; Kaiser et al., 1999).

Hattam (2006) found that avocado growers who saw their ability to adopt an organic production system significantly impacted their goals. Farmers who had negative views of their skills were less likely to adopt sustainable practices, even though they understood its importance and had environmental concerns (Hattam, 2006). As a result, farmers with negative attitudes and perceptions about sustainability, their skills or low social incomes may be less likely to adopt sustainable practices.

The Collins Essential English Dictionary (2006) has defined perception as insight or intuition and a way of viewing. Farmers' decisions to use new agricultural technologies instead of other (old) technologies are based on complexity (Elizabeth et al., 2011). Their research concluded that it is more likely that the farmer's attitude and ideas will influence the successful adoption of ecosystems. However, farmers' perceptions of compliance with sustainable practices and their farming systems emerged as the best predictions for adopting such practices (Sheikh et al., 2003) found that attitudes toward technology and communication with extension agents were the main factors influencing the acceptance of the non-planting practice. Therefore, there is a need to find out farmers' views about using the selected sustainable agricultural technologies.

Motivation is a process that initiates, directs, and maintains goal-oriented behaviour. Motivation involves the biological, emotional, social, and cognitive power that unlocks behaviour. In everyday use, motivation" is often used to describe why a person does something. It is a force that drives human actions (Senay et al., 2010). Farmer's inspiration recognizes three basic individual psychological needs for independence, ability, and communication, forming the basis on which inspiration is built. Independent behaviour "is voluntary when a person fully approves of the actions they participate in, and the values expressed by the actions. So, people are more independent when they act following their real interests or values and inclusive desires". Competence demonstrates the importance of being competent and knowledgeable about the tasks performed and maintaining those skills and knowledge of the person in practice. Communication shows the need for people to connect with others in the community and be aware that others love, care for, accept, and support their actions and behaviour (Hoffmann et al., 2007).

Motivation for certain behaviours can range from external control based on an external topic to internal motivation. There are two types of external motivation: external motivation is governed by external motives and is associated with external law, reward (e.g., subsistence) or punishment (e.g., for good health or fertile soil in principle or value. In the case of the adoption of an invention, other internal behaviour is expected to lead to higher acceptance opportunities, more substantial persistence of the applied invention and better quality of the initiated invention. (Hirst et al., 2009).

2.5. Adoption Influencing Factors

Achieving environmental sustainability in agriculture requires properly managing the ecosystems and resources that farmers rely on, which can deliver valuable public goods, especially ecosystem services. Farmers generally must do more work or allocate more resources, and they do so in response to specific incentives offered by laws and market conditions and local and national government assistance and public-private partnerships (Bommarco et al., 2013). Sustainable measures may include reducing the use of potentially environmentally friendly materials or switching to more widely available resources while maintaining agricultural competitiveness and economic viability. Public finances, personal efficiency, training, and resources play an essential role in adopting sustainable innovations (Renwick et al., 2013).

Agricultural production and yield is the most crucial indicator of a farmer's success as it symbolizes the outcome of all agricultural workers and the resources placed on crop development on their farms (Angelsen, 2010). Agro-ecological problems such as soil erosion and property flow are most likely on high-rise farms. The presence of such environmental issues puts agricultural production at risk. Another problem for long-term farms is conserving soil quality while still using it (Kukal & Irmak, 2018). Farmer's Associations and Co-operatives, including informal sources (e.g., other farmers) and official sources of information, are used to disseminate information. To grasp this idea, where information is essential, farmers must believe that they can access specific sources, understand the information, and use sustainable innovations (Garibaldi et al., 2011).

Labour intensive, the size of a large home indicates improved management capabilities. (Bruwer, 2013). The size of the farm can be used as a representative of wealth: large farms benefit from a high level of the economy, increased productivity, and increased farm income.

Financial backups are for getting a loan and a mortgage. Farmers have better investment potential and lower risks if their financial knowledge improves (Niroula & Thapa, 2005). Practices for managing natural resources - Similarly, the land you own will be managed more efficiently than the leased land and passed on to the offspring. Although it is difficult to capture all aspects of the farm, the farm region is used to show the region's diversity in the quality of natural resources (Sahrawat et al., 2010).

Social capital is built within the framework of the development of the Rural Agricultural Producers' Coalition, operated by members and enables participants to work effectively to achieve shared goals. Co-management contributes significantly to the development of co-operative, organizational and operational levels. In addition, it assists union members in obtaining product certifications such as certificates and improving the lives of co-operatives by overcoming market failures, reducing transaction costs, solving information asymmetry problems, and adopting new technologies (Biresaw, 2019)

Tropical livestock units owned by the family raise the possibility of using sustainable technologies. The positive contribution of livestock to due to increased availability of animal manure, allowing farmers to use farm-saving equipment such as direct-seeking, reduce hard work in erosion control activities such as collecting stones, and better access to animal manure (Hoag, 2018). In addition, households with more animals are more likely to earn extra money by selling livestock and livestock products. The funds can be used to buy better seeds and other related items.

Gender is a crucial phase of social segregation and refers to the social and economic, political, and cultural factors that affect both men and women (World Bank et al. 2008). There are gender gaps in access, control, and ownership of resources such as land, livestock, and water; technical assets; and inequality of staff contributions and decision-making skills regarding agricultural production and processes. These gaps indicate that gender issues will impact the adoption of soil land management (Villamore et al., 2014).

Previous studies have examined the role of age and operation size on adoption. Three studies found that an increase negatively influenced the adoption of new practices, such as conservation programs and organic production in the grower's age, yet positively influenced by education levels (Hattam, 2006).

Older farmers were less likely to adopt new conservation and organic practices unless they involved minimal labour and did not need new investments in capital or knowledge (Barreiro-Hurle et al., 2008; Hattam, 2006). Education - Recent participation in training courses is associated with a direct acquisition. Those landowners who attended most training courses were more likely to apply the procedures than those with less education. Agriculture education at the intermediate and higher levels continues to play a critical role in rural development and long-term agricultural production. Outstanding agricultural research and the use of well-trained human resources can result in significant production gains, this can only be achieved if timely agriculture education is provided to various groups and levels, as well as a good partnership between a country's education, training, and agriculture policies (Gazi et al., 2009).

3. Aims of the Thesis

The main aim of the thesis is to investigate what motivate and drive farmers to implement sustainable innovations.

The specific objectives

1. To explore the use of sustainable agriculture innovations among smallholder farmers.
2. To investigate the farmer’s motivation for the implementation of agricultural innovations.
3. To identify the drivers for farmers’ to use sustainable agricultural innovations.

4. Methodology

3.1. Study Area

The study area highlighted in a red circle (Figure 1) is the Gisagara district in the Southern province, with a population of 307,000 in 680 km^2 (260 sq. mi). Gisagara district’s temperate climate features a series of irregular seasons that range from rainy to dry: Season A, which runs from September through December, is marked by heavy rainfall, especially in December. Season B begins in January with much rain, during April has much rain and concludes in June. Season C is the dry season that starts in July and ends in September.

The average annual temperature hovers around 20 degrees and yearly precipitation of about 1200 mm. Agriculture is the main activity of the households in Gisagara District. Agriculture employs 84.6 percent of the working population, 24.5 percent are agricultural wage workers, and 60.1 percent are self-employed farmers). Non-farm wage workers account for only 15.4 percent of the workforce. (Gisagara District Development 2018).

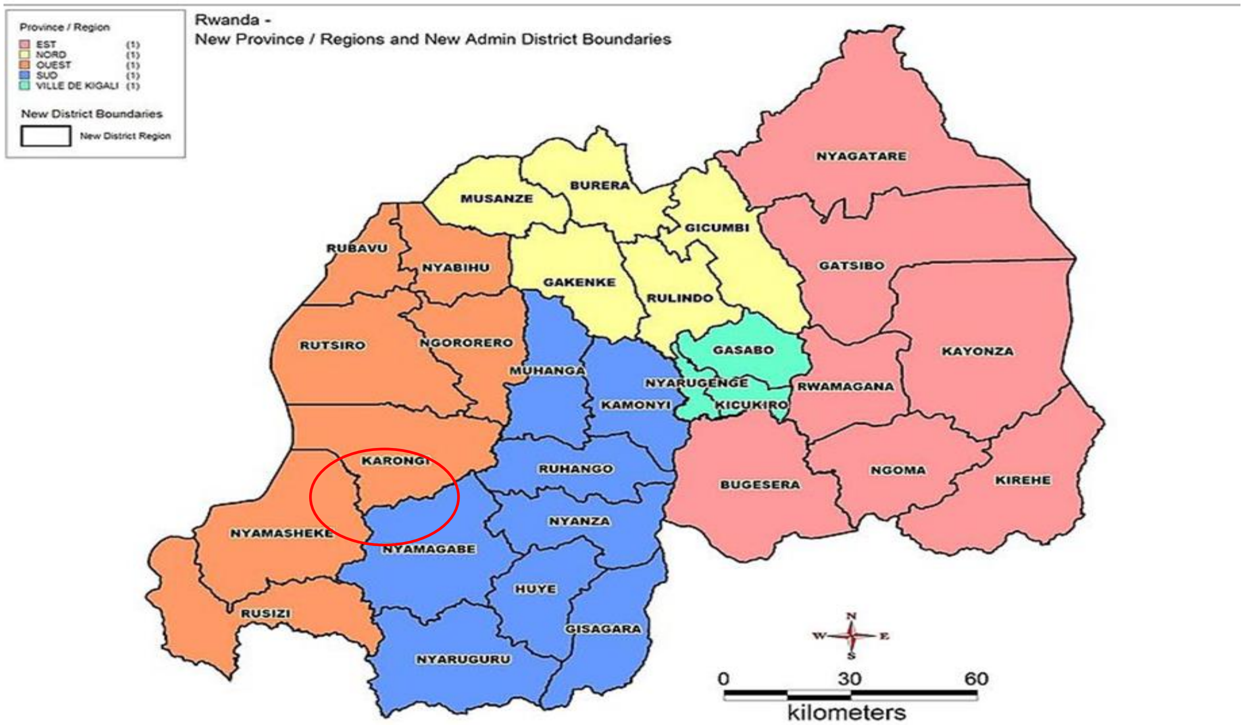

Figure 3 Study area

The data were collected using a soft copy of the questionnaire from Abakorana Murava co-operative with over 1600 members. Respondents were house heads who are members of the co-operative who were both female and male. The sample size for the study was fifty (50) respondents. The survey was conducted through a structured questionnaire. The questionnaire contains demographic questions, farmers' perceptions, and farmers' decisions to use sustainable innovations.

The literature overview is based on data collected from the relevant published articles from scientific journals on the Web of Science, Scopus, government institutions sources reports and other agricultural organizations such as the international Agriculture Institute, Food and Agriculture Organization, World Bank, International Institute of Tropical Agriculture and World Food Program. The data was analysed by using descriptive statistics.

4. Results and Discussion

4.1. Demography characteristics

Out of 50 respondents, there are 27 male and 23 female respondents. From the analysis, 32% of respondents are above 51, while 26% are aged between 41 and 50. The study proved that youths engaged in agriculture, where the lowest percentage of 18 respondents belonged to 21-30 and 31-40, and only 6% of respondents were aged below 20. Youth have considerable limitations to engaging in agriculture, such as demographic changes, technological changes, the introduction of new raw materials, the development of new infrastructure and market systems, and the non-agricultural sector through macroeconomic, trade, and sector policies. Other external factors include the development of input and output markets, the strengthening of ownership and land ownership, the improvement of market regulations, and the changing importance of cultural and social factors that influence consumer preferences, production, and markets. Changes in opportunities and constraints, changes in agricultural climate conditions, and increased or decreased risks associated with production and marketing. Internal factors include donations of farmers' resources such as land, human capital, and labour (Babu et al., 2021).

40% of respondents completed their studies till primary and secondary, while 14% studied till tertiary, and 6% of respondents were not educated. Some respondents have access to credit facilities from financial institutions. This study confirmed that skilled labour is needed to manage and conserve natural resources. Education improves agricultural productivity mainly through improvement. The technical efficiency adopted here is farmers' ability to make better decisions regarding input to make better and economically rational decisions (Eric et al., 2014).

As per the survey, 76% of respondents cultivate crops, and 24% use a mixed. In Rwanda, farmers are restricted from growing certain crops during the planting season; non-compliant farmers are often marginalized and do not have access to government benefits such as improved seeds and subsidies, and this distinguishes between the highest yields and the most grown crops (Miklyaev et al., 2021).

Table 1. Demographic characteristics

Gender		**Frequency**	**Percent**
	Male	27	54
	Female	23	46
Age			
		Frequency	Percent
	Below 20	3	6
	21-30	9	18
	31-40	9	18
	41-50	13	26
	51 & above	16	32
Level of education			
		Frequency	Percent
	Non	3	6
	Primary	20	40
	Secondary	20	40
	Tertiary	7	14
	Farming systems		
	Crops	38	76
	Mixed	12	24

4.2. Sustainable Agricultural Innovations

Crop rotation is one of the most used practices by respondents for farming. 20% of respondents said that they do not use any practices in agriculture. 16% of respondents use improved seed varieties training while doing farming. Soil health enhancement is one of the primary resources that this conservation agriculture management system aims to achieve.

The foundation for enhancing farm productivity is improving and sustaining soil health. Soil health is the ability of the soil to continue to operate as a vital living ecosystem that supports plants, animals, and humans. Therefore, Thierfelder et al. (2012) confirmed that crop rotation benefits from increasing water infiltration, soil structure, and biological activity in the soil.

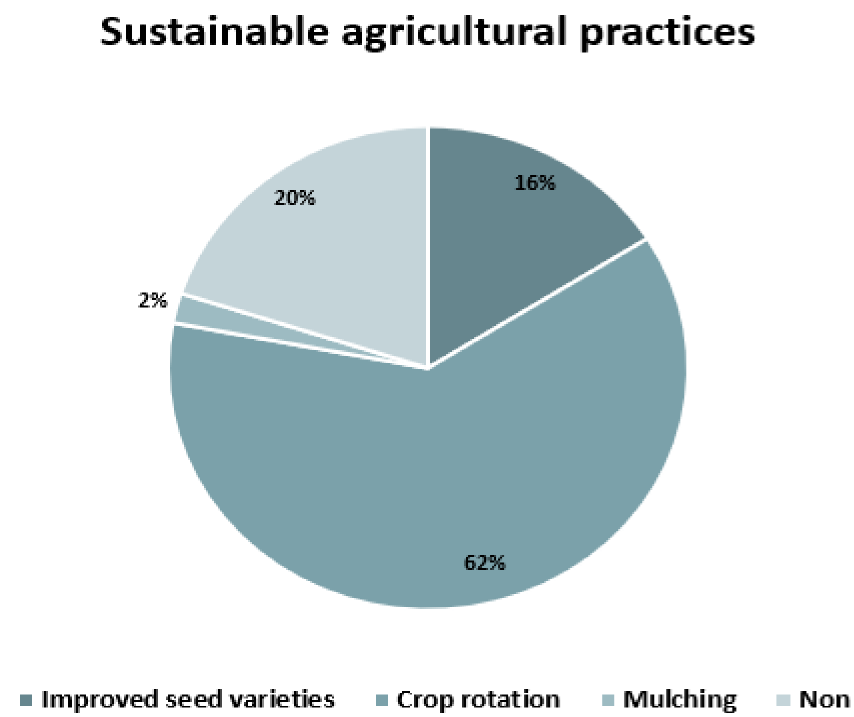

Figure 4 Sustainable Innovations

4.3. Motivation for sustainable agriculture innovation

As shown in Figure 4 below, up to 92% of respondents strongly agreed and said that the application of cow dung and compost increases soil fertility, and again 92% of respondents strongly agreed that technology should be used as best as possible to increase the efficiency of agriculture production. 82% of respondents strongly agreed with the statement that sustainable innovations are helpful to protect the environment. In comparison, 62% of respondents strongly agreed with the statement as they believe that modern agriculture is a major cause of ecological problems and must be modified to become ecologically sound. 78% of respondents strongly agreed and said that sustainable agriculture practices are beneficial to agriculture.

About 88% of respondents strongly agreed that technologies are essential for natural resource management & improved land productivity. In contrast, 86% of respondents strongly agreed with the statement as they think that skills and knowledge in soil and water conservation technologies will help in effective farming.

Out of 50 respondents, 86% of respondents strongly agreed and said that the only way to mitigate the effects of climate change is through sustainable intensification. Yields are enhanced without adverse environmental impact and the cultivation of new land, according to the definition of sustainable intensification. In this sense, the phrase refers to a vision of what must be accomplished rather than a description of current production systems, whether high-input conventional farming, smallholder agriculture, or organic alternatives (Garnet & Charles 2012).

This study investigated what motivates farmers to adopt SAP. Most of them said that technology attracts them most to meet food and fibre, which can only depend on the adopted technologies. Up to 62% of respondents strongly agreed that they are likely to consider technology as a part of social responsibility in their community. Technology as Smart farming is a management idea that combines current technology with agricultural production to boost quantity and quality. Smart farming entails the incorporation of information and communication technology into agrarian machinery, sensors, actuators, and network equipment, current technological discoveries demonstrate that discovering and developing new technologies is a long-term process, and common sense tells us that technology will enable Sustainable Agriculture (Santiteerakul et al., 2020).

About 80% of respondents believe that natural resource conservation gives them a sense of satisfaction. Intensive agricultural production areas require large amounts of freshwater worldwide, and agriculture uses the most water; hence irrigation is the most water-intensive activity. As a significant surface and groundwater contamination source, water availability and agricultural production techniques impact water quality. Soil health, also known as soil quality, refers to the soil's ability to continue to operate as a vibrant living ecosystem that supports plants, animals, and humans.

The cornerstone for constructing sustainable farming systems to serve the world with food and fibre is maintaining and cultivating healthy soils that provide various functions that assist both agriculture and the environment. Furthermore, from small vegetable growers to huge row-crop producers, all farmers benefit from good soils (Beker et al., 2017).

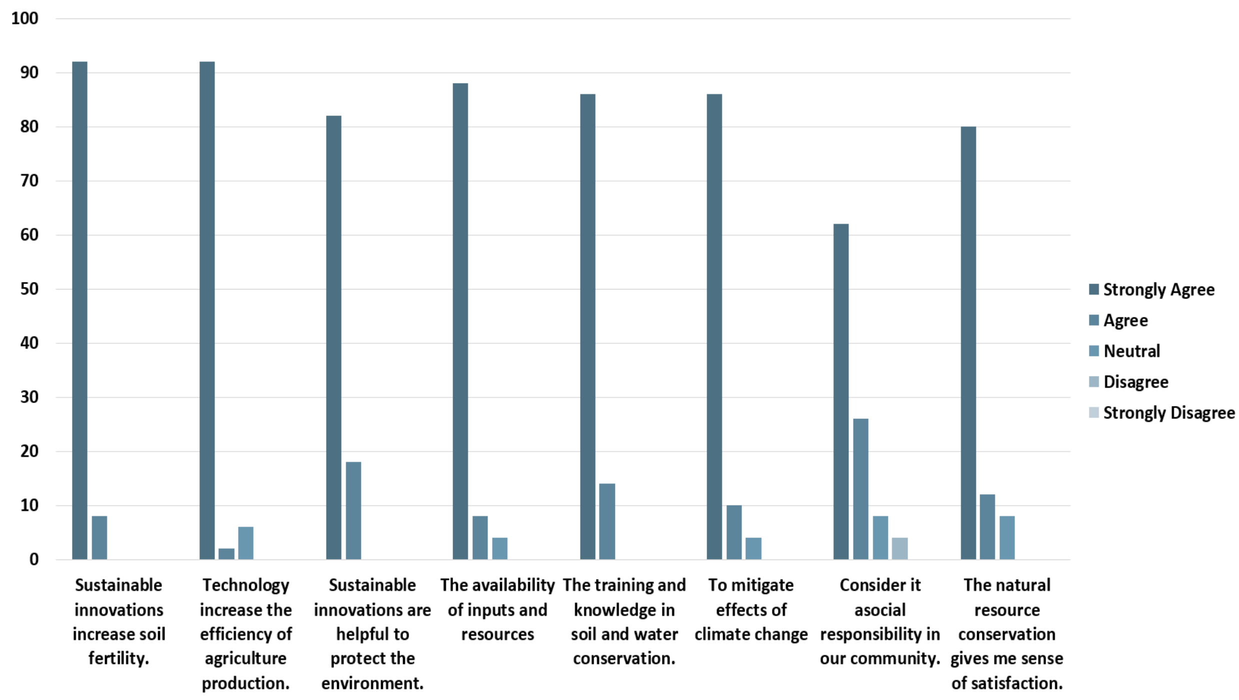

Figure 5 Motivations for using Innovations

4.4. Drivers of Farmers using Sustainable Innovations

94% of respondents strongly agreed with the statement that market availability affects their adoption of sustainable agriculture practices. The power of the market has driven the development of many SAPs methods through demand from developed countries, consumers for more critical food safety and food quality assurance. In addition to farm practices, good manufacturing practices are essential for downstream businesses to ensure the integrity of product attributes protected by SAPs programs. Many developing nations' marketing and supply chain infrastructures have inadequate capacity for differentiating SAPs produce to prevent full traceability and identity preservation of SAPs output (Hoobs , 2003).

80% of respondents strongly agreed and said that market demand influences the adoption of sustainable agriculture practices. Up to 80% of the respondents also insisted that land ownership strongly influences the adoption of sustainable agriculture. Practices.

According to 70% of respondents, technical training influences their adoption of sustainable agriculture practices, and 10% of respondents agreed with the statement. The analysis of this study proved that profit expectation is the fundamental economic factor that influences farmers in adopting agricultural practices. As confirmed by Elton & Johan et al., (2013), farmers do not only count on their crops or animal products. There can be an additional income from livestock composed of manure that can be sold with the possibility to be used as the analysis of this study proved that 92% of respondent believed that use of cow dung increase soil fertility

Profit expectation is the central critical economic factor influencing the adoption of sustainable agriculture practices, of which 90% of respondents strongly agreed. 80% of respondents strongly agreed that access to loans and input availability influences their adoption of sustainable agriculture practices. 84% of respondents strongly agreed that prices on the market influence their adoption of sustainable agriculture practices.

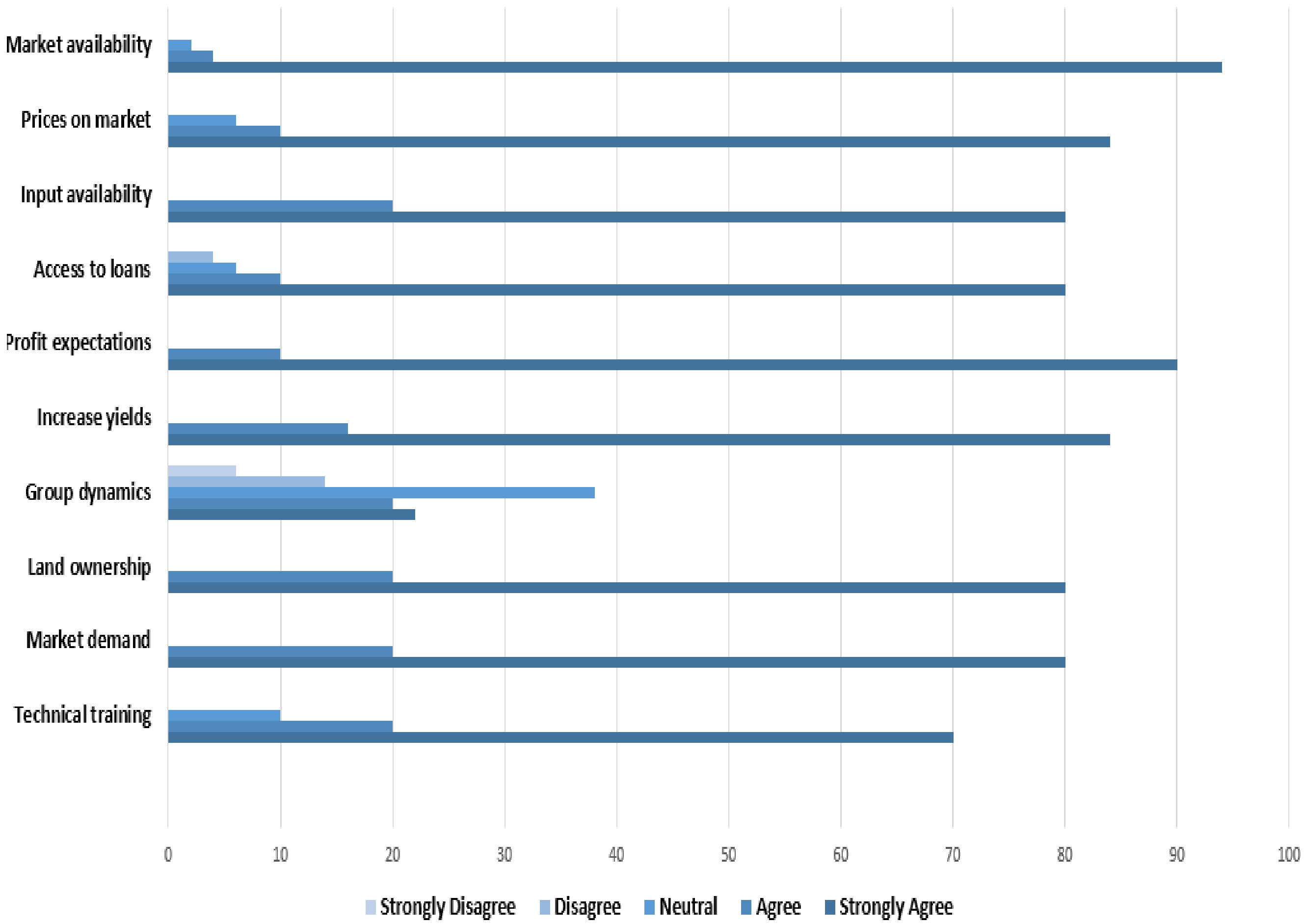

Figure 6. Drivers of the adoption of agricultural innovations

5. Conclusions

The main aim of the thesis is to investigate the behavioural motivate and drives farmers to implement sustainable innovations. The findings indicate that 92 percent of respondents strongly believe that applying cow dung and compost to soil improves fertility, favouring them to minimise inorganic fertilizers. A more significant percentage of farmers strongly agreed that innovations should be employed to promote agricultural output efficiency as much as feasible. Farmers are influenced by market demand and land ownership in adopting sustainable innovations in social factors. Besides this, profit expectation is one of the significant critical economic factors that influence the adoption of sustainable innovations. The farmers firmly believe that sustainable innovations help maintain the long-term productivity of the farming system. Moreover, they get motivated by technology that meets the climatic challenges in the agriculture sector. Adoption of soil and water conservation technologies will be beneficial for agricultural projects.

With the availability and proliferation of modern technologies, including smart devices, their greater "intelligence," autonomous behavior, and connectivity, agriculture and rural areas are changing and will continue to change dramatically. Farmers on the one hand must be supported throughout the process to adopt innovations. Many farmers may find it difficult to keep up with tecknology. As a result, having objective advisory services in place with sufficient of a good understanding about what agriculture innovation is about to bring on their tables is important.

To be globally competitive, Rwanda and other poor developing countries must stimulate creativity and innovation as a means of expanding production and adding value to agricultural products. Building farmers' and communities' capacity to discover and develop market possibilities, as well as experiment via the use of creative participatory methodologies, is crucial for developing a long-term collective capacity for innovation and new alternatives.

6. References

Adetunji, A, T, Ncube, B, Mulidzi, R., & Lewu, F. B. (2020). Management impact and benefit of cover crops on soil quality: A review. Soil and Tillage Research, 204, 104717.

Adnan, N, Nordin, S. M, Rahman, I., & Noor, A. (2018). The effects of knowledge transfer on farmers decision making toward sustainable agriculture practices: In view of green fertilizer technology. World Journal of Science, Technology and Sustainable Development.

Alam, G. M, Hoque, K. E, Khalifa, M. T. B., Siraj, S. B., & Ghani, M. F. B. A. (2009). The role of agriculture education and training on agriculture economics and national development of Bangladesh. African Journal of Agricultural Research, 4(12), 1334-1350

Aldy, J. E., Hrubovcak, J, & Vasavada, U. (1998). The role of technology in sustaining agriculture and the environment. Ecological Economics, 26(1), 81-96.

Allen, C.T., R.A. Machleit, S.S. Kleine and A.S. Notani, 2003. A place for emotion in attitude models. J. Bus. Res, 56(1): 1-6.

Alonge, A.J. and R.A. Martin, 1995. Assessment of the adoption of sustainable agriculture practices: Implications for agricultural education. Journal of Agricultural Education. 3(3): 34-42.

Altieri, M. A., & Nicholls, C. I. (2012). Agroecology scaling up for food sovereignty and resiliency. In Sustainable agriculture reviews (pp. 1-29). Springer, Dordrecht.

Amani, O, Unai, P, Russell, N.P. Biodiversity Conservation and Productivity in Intensive Agricultural Systems. J. Agric. Econ. 2007, 58, 308–329.

Angelsen, A. (2010). Policies for reduced deforestation and their impact on agricultural production. Proceedings of the national Academy of Sciences, 107(46), 19639-19644.

Askarov, A. A, Stovba, E. V, & Askarova, A. A. (2019, May). Ecological and economic evaluation of using arable land in the Republic of Bashkortostan. In IOP Conference Series: Earth and Environmental Science (Vol. 274, No. 1, p. 012095). IOP Publishing.

Assael H (1995) Consumer Behaviour and Marketing Action, South-Western College Publishing, Cincinnati, p. 718. Schiffman LG, Kanuk LL (1997) Consumer Behaviour, Prentice Hall, p. 672.

at 107th EAAE Seminar, Seville, Spain, 29 Jan. to 1 Feb. 2008. 12 June 2008. <http://purl.umn.edu/6458>.

Babu, S. C, Franzel, S, Davis, K. E., & Srivastava, N. (2021). Drivers of youth engagement in agriculture: Insights from Guatemala, Niger, Nigeria, Rwanda, and Uganda (Vol. 2010). Intl Food Policy Res Inst.

Baker, B. H, Omer, A. R, Oldham, L. S., & Burger, L. M. (2017). Natural Resource Conservation in Agriculture. Mississipi, MS, USA: Mississippi State University Extension.

Barreiro-Hurle, J, M. Espinosa-Goded, and P. Dupraz. 2008. Does intensity of change matter? Factors affecting adoption in two agri-environmental schemes. Presented

Batalla, I, Knudsen, M.T, Mogensen, L, Hierro, Ó, Del Pinto, M.; Hermansen, J.E. Carbon footprint of milk from sheep farming systems in Northern Spain including soil carbon sequestration in grasslands. J. Clean. Prod. 2015, 104, 121–129.

Baynard, B. & Jolly, C.M. 2007 Environmental perceptions and behavioural change in hillside farmers: The case of Haiti J. Caribbean Agro-. Econ. Soc. 7 122 138.

Bizoza A R, Ortmann G, Lyne M C. 2007. Determinants of the potato yield in Gikongoro Province, Rwanda. Africa Insight, 37, 1969–1985.

Bommarco, R., Kleijn, D, & Potts, S. G. (2013). Ecological intensification: harnessing ecosystem services for food security. Trends in ecology & evolution, 28(4), 230-238.

Bos, J.F.F.P, De Haan, J, Sukkel, W.; Schils, R.L.M. Energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. NJAS Wagening. J. Life Sci. 2014, 68, 61–70.

Brodt, S, Six, J, Feenstra, G., Ingels, C. & Campbell, D (2011). Sustainable Agriculture, Nature Education Knowledge, 3(10):1.

Brownson, R. C, Colditz, G. A, & Proctor, E. K. (Eds.). (2017). Dissemination and implementation research in health: translating science to practice. Oxford University Press.

Byiringiro F, Reardon T. 1996. Farm productivity in Rwanda: Effects of farm size, erosion and soil conservation investments. Agricultural Economics, 15, 127-136.

Carsrud, A, & Brännback, M. (2011). Entrepreneurial motivations: what do we still need to know? Journal of small business management, 49(1), 9-26.

CIE (2001). Indicators Within a Decision Framework: Social, Economic Institutional Indicators for Sustainable Management of the Rangelands. Report for the National Land & Water Resources Audit, Canberra.

Clark, M. L, Aide, T. M, Grau, H. R., & Riner, G. (2010). A scalable approach to mapping annual land cover at 250 m using MODIS time series data: A case study in the Dry Chaco ecoregion of South America. Remote Sensing of Environment, 114(11), 2816-2832.

Climatology, R. (2021). Current Climate. World bank.

Curtis, A, MacKay, J, Van Nouhuys, M. Lockwood, M, Byron, I, & Graham, M. (2000). Exploring landholderwillingness & capacity to manage dryland salinity: TheGoulburn Broken Catchment. Albury: JohnstoneCentre, Charles Sturt University.

D'Souza, G, D. Cyphers, and T. Phipps. 1993. Factors affecting the adoption of sustainable agricultural practices. Agr. Resource Econ. Rev. 22:159–165.

Diaz-Chavez, R, Mutimba, S., Watson, H., Rodriguez-Sanchez, S, & Nguer, M. (2010). Mapping Food and Bioenergy in Africa. A report prepared on behalf of FARA. Forum for Agricultural Research in Africa. Ghana. ERA-ARD, SROs, FARA, 3.

Food and Agriculture Organization of the United Nations. FAOSTAT Statistical Data base, Rwanda crop production quantity 1991-2020

Dimara, E. and D. Skuras, 1999. Importance and need for rural development instruments under the CAP: A survey of farmers' attitudes in marginal areas of Greece. J. Agr. Econ, 50(2): 304-315.

Garibaldi, L. A, Aizen, M. A, Klein, A. M, Cunningham, S. A, & Harder, L. D. (2011). Global growth and stability of agricultural yield decrease with pollinator dependence. Proceedings of the National Academy of Sciences, 108(14), 5909-5914.

Garnett, T, & Godfray, C. (2012). Sustainable intensification in agriculture. Navigating a course through competing food system priorities. Food climate research network and the Oxford Martin programme on the future of food, University of Oxford, UK, 51.

Ghazali, A, Asmah, S, Syafiq, M, Yahya, M. S, Aziz, N, Tan, L. P, & Azhar, B. (2016). Effects of monoculture and polyculture farming in oil palm smallholdings on terrestrial arthropod diversity. Journal of Asia-Pacific Entomology, 19(2), 415-421.

Haberkorn, G., Hugo, G, Fisher, M, & Aylward, R. (1999). Country Matters: Social Atlas of Rural & Regional Australia. Bureau of Rural Sciences, Canberra. http://www.affa.gov.au/docs/rural_science/social_science/atlas.html

Haga, K. Animal Waste Problems and Their Solution from the Technological Point of View in Japan. JARQ 1998, 32, 203–210.

Hara, S. M, Faverín, C, Villagra, E. S, Easdale, M. H, & Tittonell, P. (2022). Exploring drivers and levels of technology adoption for ecological intensification of pastoral systems in north Patagonia drylands. Agriculture, Ecosystems & Environment, 324, 107704.

Hattam, C. 2006. Adopting organic agriculture: An investigation using the Theory of Planned Behaviour. Poster presented at Intl. Assn of Agr. Econ. Conference, Gold Coast, Australia, 12–18 Aug. 2006. 2 Mar. 2008. <http://purl.umn.edu/25269>.

Hirst, G., Van Dick, R, & Van Knippenberg, D. (2009). A social identity perspective on leadership and employee creativity. Journal of Organizational Behaviour: The International Journal of Industrial, Occupational and Organizational Psychology and Behaviour, 30(7), 963-982.

Hobbs, J. E. (2003). Incentives for the Adoption of Good Agricultural Practices (GAPs). Food and Agriculture Organization, 1.

Hoffmann, V, Probst, K, & Christinck, A. (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? Agriculture and human values, 24(3), 355-368.

Jordan, J.L. 2005 Farmer's choice of using sustainable agricultural practices: A social capital approach Presented at the Southern Agr. Econ. Assn. Annu. Mtg Little Rock, AR 6–8 Feb. 2005 12 June 2008.

Karuppuchamy, P, & Venugopal, S. (2016). Integrated pest management. In Ecofriendly pest management for food security (pp. 651-684). Academic Press.

Kassie, M, Jaleta, M, Shiferaw, B, Mmbando, F. & Mekuria, M. (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. Technological forecasting and social change, 80(3), 525-540.

Kathiresan A. 2012. Farm land use consolidation in Rwanda. In: Assessment from the Perspectives of Agriculture Sector. Ministry of Agriculture and Animal Resources, Kigali, Rwanda.

Kathiresan, A. (2011). Strategies for sustainable crop intensification in Rwanda. Shifting focus from producing enough to producing surplus, 1-59.

Kukal, M. S, & Irmak, S. (2018). Climate-driven crop yield and yield variability and climate change impacts on the US Great Plains agricultural production. Scientific reports, 8(1), 1-18.

Lal, R. Soils and food sufficiency. A review. Agron. Sustain. Dev. 2009, 29, 113–133. Hole, D.G, Perkins, A.J.; Wilson, J.D, Alexander, I.H, Grice, P.V, Evans, A.D. Does organic farming benefit biodiversity? Biol. Conserv. 2005, 122, 113–130. Garnett, T, Appleby, M.C, Balmford, A., Bateman, I.J, Benton, T.G.; Bloomer, P.; Burlingame, B, Dawkins, M, Dolan, L, Fraser, D, et al. Sustainable intensification in agriculture: Premises and policies. Science 2013, 341, 33–34.

Lamek, N, Lanhai, L, Alphonse, K, Fidele, K., Christophe, M, Felix, N, Enan, M.N. Agricultural impact on environment and counter measures in Rwanda. Afr. J. Agric. Res. 2016, 11, 2205–2212.

Maiyaki, A. A. (2010). Zimbabwes agricultural industry. African Journal of Business Management, 4(19), 4159-4166.

Majewski, E. Trwały rozwój i trwałe rolnictwo. Teoria i praktyka gospodarstw rolnych—Sustainable Development and Sustainable Agriculture. In Theory and Practice of Agricultural Farms; SGGW Publishing: Warsaw, Poland, 2008.

Markus, H.R. and Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. Psychological Review, 98(2), 224-253.

McKenzie, F. C, & Williams, J. (2015). Sustainable food production: constraints, challenges, and choices by 2050. Food Security, 7(2), 221-233.

Mekonen, K, & Tesfahunegn, G. B. (2011). Impact assessment of soil and water conservation measures at Medego watershed in Tigray, northern Ethiopia. Maejo International Journal of Science and Technology, 5(3), 312.

Metz, B., Davidson, O, Swart, R, & Pan, J. (Eds.). (2001). Climate change 2001: mitigation: contribution of Working Group III to the third assessment report of the Intergovernmental Panel on Climate Change (Vol. 3). Cambridge university press.

MINAGRI (Ministry of Agriculture and Animal Resources) (2009) Strategic plan for the trans-formation of agriculture in Rwanda – Phase II (PSTA II). Final report, Kigali

Mittal, S, Gandhi, S, & Tripathi, G. (2010). Socio-economic impact of mobile phones on Indian agriculture (No. 246). Working paper.

Negatu, W. and A. Parikh, 1999. The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda of Ethiopia. Agricultural Economics, 21: 205-216

Newman, P., & Jennings, I. (2012). Cities as sustainable ecosystems: principles and practices. Island Press.

Niassy, S, Ekesi, S, Migiro, L, & Otieno, W. (Eds.). (2020). Sustainable management of invasive pests in Africa . Springer International Publishing.

Niroula, G. S, & Thapa, G. B. (2005). Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land use policy, 22(4), 358-372.

NISR (National Institute of Statistics of Rwanda). 2013. Seasonal Agricultural Survey Report. Ministry of Finance and Economic Planning, Kigali, Rwanda.

Ogbuewu, I.P, Odoemenam, V.U, Omede, A.A, Durunna, C.S, Emenalom, O.O, Uchegbu, M.C, Okoli, I.C, Iloeje, M.U. Livestock waste and its impact on the environment. Sci. J. Rev. 2012, 1, 17–32.

Opio, C, Gerber, P, Mottet, A, Falcucci, A, Tempio, G, MacLeod, M, Vellinga, T.; Henderson, B, Steinfeld, H. Greenhouse Gas Emissions from Ruminant Supply Chains–A Global Life Cycle Assessment; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2013.

Pelosi, C, Pey, B, Hedde, M, Caro, G, Capowiez, Y, Guernion, M, & Cluzeau, D. (2014). Reducing tillage in cultivated fields increases earthworm functional diversity. Applied Soil Ecology, 83, 79-87.

Piñeiro, V, Arias, J, Dürr, J, Elverdin, P., Ibáñez, AM, Kinengyere, A & Torero, M. (2020). A scoping review on incentives for the adoption of sustainable agricultural practices and their outcomes. Nature Sustainability, 3 (10), 809-820.

Ragodoo, N. J. (2009). CSR as a tool to fight against poverty: the case of Mauritius. Social Responsibility Journal.

Rahman, M.Z, H. Mikuni and M.M. Rahman, 1999. Towards sustainable farming development: The attitude of farmers in a selected area of Shimane Prefecture, Japan. J. Sustain. Agr, 14(4): 19-33.

Randell, S. (2014). Sustainable Rural Development in Rwanda: The Importance of a Focus onWomen in Agriculture. International Journal of Agricultural Extension, 107-119.

Renwick, D. W., Redman, T., & Maguire, S. (2013). Green human resource management: A review and research agenda. International journal of management reviews, 15(1), 1-14.

Rodríguez-Eugenio, N; McLaughlin, M.; Pennock, D. Soil Pollution: A Hidden Reality; FAO: Rome, Italy, 2018; p. 142.

Sahrawat, K. L, Wani, S. P., Pathak, P, & Rego, T. J. (2010). Managing natural resources of watersheds in the semi-arid tropics for improved soil and water quality: A review. Agricultural Water Management, 97(3), 375-381.

Santiteerakul, S, Sopadang, A, Yaibuathet Tippayawong, K., & Tamvimol, K. (2020). The role of smart technology in sustainable agriculture: A case study of wangree plant factory. Sustainability, 12(11), 4640.

Senay, I, Albarracín, D, & Noguchi, K. (2010). Motivating goal-directed behavior through introspective self-talk: The role of the interrogative form of simple future tense. Psychological Science, 21(4), 499-504.

Shah, K. K, Modi, B, Pandey, H. P, Subedi, A., Aryal, G, Pandey, M., & Shrestha, J. (2021). Diversified crop rotation: an approach for sustainable agriculture production. Advances in Agriculture, 2021.

Shapiro, B. I, Gebru, G, Desta, S, & Nigussie, K. (2017). Rwanda livestock master plan.

Shapiro, B. I, Gebru, G, Desta, S, Negassa, A, Negussie, K, Aboset, G, & Mechal, H. (2015). Ethiopia livestock master plan: Roadmaps for growth and transformation.

Sheikh, A.D, T. Rehman and C.M. Yates, 2003. Logit models for identifying the factors that influence the uptake of new ‘no-tillage’ technologies by farmers in the rice- wheat and the cotton-wheat farming systems of Pakistan’s Punjab. Agricultural Systems 75: 79 - 95.

Siebrecht, N. Sustainable Agriculture and Its Implementation Gap—Overcoming Obstacles to Implementation. Sustainability 2020, 12, 3853. Foley, J.A, Ramankutty, N, Brauman, K.A, Cassidy, E.S, Gerber, J.S, Johnston, M, Zaks, D.P.M. Solutions for a cultivated planet. Nature 2011, 478, 337–342.

Smathers, W.M.Jr. 1982. Farmers attitudes: In L.A. Christensen and L. Miranowski (Eds). Perceptions, attitudes and risks: Overlooked variables in formulating public policy on soil and water conservation and water quality. Staff Report (AGES 820129). U.S. Department of Agriculture, Georgia.

Tey, Y. S. (2013). The adoption of sustainable agricultural practices: an integrative approach for Malaysian vegetable farmers (Doctoral dissertation).

The World Bank and Food and Agriculture Organization and International Fund for Agricultural Development. 2008. Gender in Agriculture Sourcebook. World Bank

Thierfelder, C, Cheesman, S, & Rusinamhodzi, L. (2012). A comparative analysis of conservation agricultural systems: Benefits and challenges of rotations and intercropping in Zimbabwe. Field crops research, 137 , 237-250.

Thornton, P. K. (2010). Livestock production: recent trends, future prospects. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1554), 2853-2867.

Thornton, P.K. Livestock production: Recent trends, prospects. Philos. Trans. R. Soc. B Biol. Sci. 2010, 365, 2853–2867.

Van Eerdewijk, A, Wong, F, Vaast, C, Newton, J. and Tyszler, M. 2017. White paper: a conceptual model of women and girls' empowerment.

Vanlauwe et al. (eds.), Challenges and Opportunities for AgriculturalIntensification of the Humid Highland Systems of Sub-Saharan Africa, DOI 10.1007/978-3-319-07662-1_6, ©Springer International Publishing Switzerland 2014.

Woldeselassie, T. (2015). Climate change impact assessment on runoff potential in upper awash basin: A case study of legendaria-dire catchment.

Wolka, K. (2014). Effect of soil and water conservation measures and challenges for its adoption: Ethiopia in focus. Journal of Environmental science and Technology, 7(4), 185-199.

Yongabo, P, & Göktepe-Hultén, D. (2021). Emergence of an agriculture innovation system in Rwanda: Stakeholders and policies as points of departure. Industry and Higher Education, 35(5), 581-597.

Appendix 1: Questionnaire

Farmer's Motivation to adopt sustainable agriculture innovations in Rwanda

Dear Sir/Madam, I am a student from Czech university. I will be very thankful if you can spare 5 minutes from your valuable time to answer the questionnaire which will help me to know about Farmer's Motivations adoption of sustainable agricultural practices in Rwanda. Please answer all the question honestly and without any forced influence.

Disclaimer: This questionnaire is prepared for the purpose of research project. The information will be kept confidential and will not be used for any other purpose than project.

1. Name *

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2. Gender *

- Male
- Female

3. Age *

- Below 20
- 21-30
- 31-40
- 41-50
- 51 & above

4. Level of education *

- Non
- Primary
- Secondary
- Tertiary
- Other:

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5. Are you a member of a farmer's co-operative?

- Yes
- No

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6. Do you have access to credit facilities from financial institutions?

- Yes
- No

---

7. How is the land ownership of your land?

- Customary /Traditional land
- Private land

8. No. of years farming experience __________

9. Household size __________

10. What is the size of your farm in hectares? ___________

11. What type of farming system do you practice?

- Crops
- Animal
- Mixed

12. Which major types of crops do you cultivate?

- Maize
- Beans
- Soybeans
- Groundnuts
- Cowpeas
- Beans
- Sorghum
- Tobacco
- Vegetables
- Other

13. Which of the following practices do you use in farming?

- Reduced tillage methods
- Improved seed varieties
- Crop rotation
- Mulching
- Non
- Other

14. What is the major reason for using the method of sustainable agriculture practices?

- Soil protection
- Increase in crop yields
- Reduced labour demands
- Biodiversity
- Reduction in cost
- Reduce pollution

15. Rank the following social factors influencing the adoption of sustainable agriculture practices by you? (Scale - Strongly Agree, Agree, Neutral, Disagree & Strongly Disagree)

- Personal decision
- Group leader
- Technical training
- Cultural norms
- Religious beliefs
- Market demand
- Land ownership
- Group dynamics

16. Which of the following economic factors influence you the most in adoption of the sustainable agriculture practices? (Scale - Strongly Agree, Agree, Neutral, Disagree & Strongly Disagree)

- Increase yields
- Profit expectations
- Access to loans
- Input availability
- Cash at hand
- Prices on market
- Market availability

- Social trust
- Youth and women involvement
- Group negotiations

17. Given below are some statements regarding attitude towards adoption of sustainable agriculture practices, you are requested to state your degree of agreement/disagreement on each of the statements as mentioned below on a 5-point scale?

Statements	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Application of cow dung and compost increase soil fertility.					
Technology should be used as best as possible to increase efficiency of agricultural production.					
Sustainable agriculture practices are useful to protect the environment.					
Crop rotation improves soil texture.					
Farmers should be informed to use sustainable agricultural practices.					
Sustainable agriculture is useful to maintain long-term					

productivity of farming system.					
Modern agriculture is a major cause of ecological problems and must be greatly modified to become ecologically sound.					
Sustainable agriculture practices are beneficial to agriculture.					

18. Given below are some statements regarding motivation towards adoption of sustainable agriculture practices, you are requested to state your degree of agreement/disagreement on each of the statements as mentioned below on a 5-point scale?

Statements	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
The technologies are important for natural resource management & improved land productivity.					
The skills and knowledge in soil and water conservation technologies.					
The project and government allow the community to choose type of technology to adopt in the community.					

The use of technologies for sustainable production and for the future of my children.					
The only way to mitigate effects of climate change is through sustainable intensification.					
Adopting soil and water conservation technologies is the condition to benefit from project inputs.					
The natural resource conservation gives me sense of satisfaction.					
Consider technologies as part of social responsibility in our community.					