IMPACT OF AGROFORESTRY TECHNOLOGIES ON LIVELIHOOD IMPROVEMENT AMONG SMALLHOLDER FARMERS IN SOUTHERN PROVINCE OF RWANDA

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DECLARATION

I, MUKUNDENTE Liliane declare that this thesis is my original work and has not been presented for award of degree and examination any other university or any other award.

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DEDICATION

Special dedications are reserved for Almighty God for the cares, protection, love, compassion and mercies on me. This work is dedicated to my lovely father NSABIWABO Jean Pierre and mother KANKINDI Marie Gorette whose words of encouragement and push for tenacity ring in my ears. I also dedicate this research to family of Rev. canon MASENGESHO Ephrem. I always appreciate all they have done in every day of my life. I dedicate this work and give special thanks to my best friend MUSABYIMANA Delphine.

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ABBREVIATIONS AND ACRONYMS

AFOLU	Agriculture Forestry and Land Use
FAO	Food Agriculture Organization
GHGs	Green House Gases
ICRAF	International Council for Research in Agroforestry
IPCC	Intergovernmental Panel on Climate Change
NRCAF	National Research Centre for Agro Forestry
TBEAs	Tree Based Ecosystem Approaches
UNEP	United Nations Environment Programme
UNFCC	United National Framework on Climate Change

ABSTRACT

The natural forest of Rwanda is under threat as a result of rising rural population and subsistence cultivation. As a result, the Rwanda Ministry of Agriculture has deployed agroforestry technologies in forest-dependent communities in order to reduce forest pressures and improve the livelihoods of local people. This study mainly focuses on the agroforestry practices adopted by smallholder farmers; assess socioeconomic and institutional factors that impact adoption of agroforestry and finally, evaluate the impression of adopting agroforestry practices on livelihood improvement of smallholder farmers in Southern Province of Rwanda. This study was carried out in four districts in southern province of Rwanda. A descriptive survey design was used in this study. Semi-structured questionnaires used to collect primary data from a sample of smallholder. The study used both quantitative and qualitative methods. Descriptive method of analysis was used to identify the different agroforestry technologies adopted by smallholder farmers in study area. A binary logit model used to assess the socioeconomic factors that influence the adoption of agroforestry in the study area. Propensity score matching model was used to determine the impact of agroforestry on livelihoods. The results of this study illustrated the different agroforestry practices adopted by the farmers in this area but the most farmers in study area had adopted boundary planting(68%) agroforestry followed by home garden(14%), alley cropping(11%) and scattered trees on farm(7%). Propensity score matching model demonstrated positive significant association between adoption of agroforestry and annual farmer income and consumption expenditure) of the respondents. Farmers adopted agroforestry had more annual income compare to non-adopters and also consumption expenditure of adopters was higher than consumption expenditure of non-adopter's farmers. Therefore, agroforestry adoption had a significant impact on the livelihood of most farmers and their households. Finally, Binary regression model showed no significant association between the adoption of agroforestry practices and respondent's age, gender, marital status, farming experience or income range of the respondents. On the other hand, there is a positive significant association between the adoption of agroforestry practices and household size as well as the farm size of the respondents, soil fertility and soil erosion. It is concluded that farmers with larger household size are more likely to adopt agroforestry practices than farmers with smaller household size and also shows that most of the farmers who were more likely to adopt agroforestry had a bigger land acreage for planting more trees.

CHAPTER ONE: INTRODUCTION

1.1 Background

Agroforestry is one of the most noticeable land-use systems across agro-ecological zones and landscapes in the world. With increased threats of climate change and food shortages and, concern in Agroforestry gathers its ability to meet different adaptation needs on-farm in other to achieve many roles in AFOLU (Agriculture Forestry and Land Use) associated mitigation pathways. Income from carbon, wood energy, assets, improved soil fertility; ecosystem services and enhancement of local climate conditions are all provided by agroforestry; in other to reduce human effects on natural forests.

Maximum of these effects have immediate local adaptation benefits when leading to global achievement to control concentrations of greenhouse gasses in atmosphere. (Mbow *et al*., 2014). Agroforestry has ability to recover soil fertility primarily by increasing soil organic matter and fixing leguminous trees with biological nitrogen. Farm trees also promote closer nutrient cycling than mono-cultivation systems and enrich the soil with nutrients and organic matter while enhancing proper soil structural relations(Lehmann *et al.,* 1998). Therefore, trees help to recover nutrients, maintain soil moisture and increase organic soil quality by tapping water and preventing nutrient leaching (Pouliot *et al.,* 2012; Duguma & Hager, 2011).

There are benefits of outstanding agroforestry technologies, such as fast growing fuel wood trees, native fruit trees that provide additional nutrition and revenue, trees that can supply medicinal plant products and trees that improve the soil (Molua, 2005). The interest of researching agroforestry in a changing climate stems from the benefits of agroforestry to produce farmers ' assets, mixed with opportunities to mitigate change of climate and advantage to promote sustainable production that improves quality of the diversity and resilience of agro-ecosystems.

Agroforestry in India adds to the Indian Agricultural Research Council's target of growing forest cover from the current 23% of the land size to 33%. The Greening India Task Force Report on Living Security and Sustainable Development suggests that 18 million hectares of rain-fed land and 10 million hectares of irrigated land

should be managed under agroforestry systems (Jose, 2009, Planning Commission 2001).

The International Panel on Climate Change (IPCC) Third Assessment Report on Climate Change (McCarthy *et al.*, 2001) has recognized the Agroforestry's ability to tackle multiple issues and provide a variety of scientific, environmental and socio-economic benefits. Estimates of the carbon sequestration potential of agroforestry systems range from 0.7-1.6 Gt (Trexler and Haugen, 1994) to 6.3 Gt (Brown *et al.,* 1996). Secondary environmental benefits comprise land tenure stability, increased farm income, food availability, biodiversity restoration and maintenance, conservation and maintenance of above and below-ground carbon storage capacity, and watershed hydrology and soil protection (Van Ardenne *et al*., 2003).

Plantings such as poplars (Populus spp.) and eucalyptus (Eucalyptus spp.) are well maintained and successful activity in India. On many farm properties in South Asia, quickly growing poplars are now many components of woodlots and shelter belts. Food-producing trees cultivated in systems of agroforestry will increase the economic security and the nutritional of poor people living in tropical countries (World Bank, 2006). Many Sub-Saharan African smallholder farmers practice agroforestry. Such systems influenced despite lasting for long times attempts to introduce annual crop monoculture production, which in Africa was far less successful than elsewhere (Djurfeldt *et al.,* 2005). Agroforestry has been shown to give farmers a number of advantages.

In many cases, for example, it can enhance soil fertility and boost farm household resilience by providing home consumption or additional products for sale (Thangataa and Hildebrand, 2012). The concept that farm trees provide livelihood advantage is not recent, and many farmers have adopted diversity-based approaches to adapting agriculture to change of climate (Nguyen *et al.,* 2013).

In view of persistent food shortages, predicted change of climate and increasing prices of agricultural contributions dependent on fossil fuel, agroforestry has newly experienced a surge in interest from development communities and research as a cost-effective means of improving food safety at the same time contributing to mitigation and adaptation of climate change (Hoang *et al.,* 2011). Consequently, agroforestry is

often absent from guidelines to ensure food safety in the context of climate variability (Beddington *et al.,* 2012), although many activities have been presented to provide advantages for rural development, buffer against climate fluctuations, help farmers to adapt and mitigate climate change (Thorlakson *et al.,* 2012). Several studies have shown that agroforestry practices can delay or reverse soil degradation, sequestrate carbon from secure livelihoods and atmosphere by providing environmental and economic benefits.

Besides that soil fertility, farmers run trees can also provide functions in addition to the products and ecosystem services that inspired farmers to conserve or plant trees (Skole *et al.,* 2013; Torquebiau *et al.,* 2009).

Agroforestry systems and forest plantations in Rwanda are the main sources of fuel wood used by many people. Nevertheless, agroforestry can be an efficient strategy for helping smallholder farmers adapt to change of climate. Agroforestry provides many benefits over other farming systems in assisting farmers to cope with the changes expected. Agroforestry helps to diversify production into a wider range of forestry and agricultural products, thus avoiding the increased climate variability predicted to result from climate change.

Agroforestry can also increase agricultural output products in wet and dry seasons by increasing soil porosity and using deep-rooted trees during drought periods and increasing soil aeration and evapotranspiration levels during wet season and also reducing runoff (Verchot *et al.,* 2007). Agroforestry also offers farmers with a means to diversify their farms by building materials, making firewood, fruits, and other tree products.

Rwanda needs more timberland assets to fulfill the expanding need for woody bioenergy and timber products (Rutunga *et al.,* 2007). Agroforestry has the potential to help solve this problem by providing farmers with access to multifunctional trees that can produce not only firewood or coal, but also timber and other wood products (Ndayambaje, 2005; Rutunga *et al.,* 2007). Eventually, by increasing water filtration and reducing soil erosion, agroforestry can increase water quantity and quality(Jose, 2009; Stainback and Masozera, 2010).

1.2 Problem Statement

The natural forest of Rwanda is under threat as a result of rising rural population and subsistence cultivation, which lead to deforestation as serious problem in Rwanda. As a result, each Rwandan household has only 0.65 hectares of appropriate farmland (Rutunga et al., 2007). Agriculture provides subsistence and income to the great majority of Rwandans, with agriculture accounting for nearly 95 percent of the population. Rwanda's climate is tropical, with adequate rain to support rain-fed agriculture, which accounts for 95 percent of the country's agricultural area (Kannan et al., 2010).

Crop productivity, on the other hand, is frequently harmed during the dry season and during droughts that occur on a regular basis. As a result, nearly half of Rwanda's agricultural land exhibits evidence of soil erosion, indicating a decrease in the land's ability to produce food and fiber.

According to the Rwandan Ministry of Agriculture and Animal Resources (2017), soil erosion results in a total soil loss of approximately 15 million metric tons per year, which is equivalent to losing the capacity to feed 40,000 people annually, leading to food insecurity and disturbance of rural farmers' livelihood. As a result, the Rwanda Ministry of Agriculture has deployed agroforestry technologies communities reliant on the forest in order to reduce forest pressures while also improving local people's lives. This new technology, however, has not been widely adopted in the country. Adopting agroforestry practices is critical to addressing the ongoing depletion of forest resources while also improving the livelihoods of farmers in communities. Southern Province is one of Rwanda's rural provinces with successful stories of agroforestry systems used in forest areas to increase food production and household income. However, no research has been conducted to determine the benefits of these agroforestry practices and how much they contribute to farmers' incomes and Rwanda's environment.

The goal of this research was to fill in the gaps in our understanding. This knowledge gaps by examining and understand the socio-economic, as well as institutional factors that influences farmers in the community to adopt agroforestry technologies and also to evaluate impact of agroforestry on livelihood of small hold's farmers.

1.3 Research Questions

In arrange to realize on the reason of the planned research investigated the following question:

In arrange to realize on the reason of the planned research investigated the following question:

1. What are the agroforestry practices adopted by the smallholder farmers in southern province of Rwanda?
2. How is the adoption of agroforestry practice influenced by socioeconomic, institutional and environmental factors in southern province of Rwanda?
3. Why is the adoption of agroforestry practices important for livelihoods of smallholder farmers?

1.4 Objectives of Study

General purpose of this research is to assess effect of agroforestry technology on livelihood improvement among the smallholder farmers in Southern province of Rwanda. This study had the following specific objectives:

1. To identify the agroforestry practices adopted by the farmers in Southern province.
2. To assess the socioeconomic, institutional and environmental factor that influences the farmers to adopt agroforestry.
3. To evaluate the impact of adopting agroforestry practices on livelihood of smallholder farmers

1.5 Research Hypotheses

H_1: Adoption of agroforestry technologies significantly affects the income and consumption expenditure of smallholder farmers in Southern province of Rwanda.

H_2: Socioeconomic, institutional, and environmental factors significantly influence the farmers to adopt agroforestry practices in Southern province of Rwanda.

1.6 Significance of Study

It gives experiences into commitment of agroforestry to the vocations of expansive and minimal household**.** The outcomes of this research is critical meanwhile it'll upgrade the government's endeavors within the battle against deforestation, increase agroforestry practices and catalyze their selection within the locale and outside, as well as participating to the restricted writing on the subject. The finding of this study can moreover offer assistance brings approach changes in both rural and woodland segments to improve economic development. Academicians and researches that have interest to know how agroforestry affect the farmers' livelihood will be used this research finding as source of literature.

1.7 Conceptual Framework

The conceptual framework could be developed by key variable of the research which is the intervening, independent, and dependent factors. This scheme indicates how these factors interrelate to attain the predictable result of agroforestry technology on livelihood improvement among smallholder farmers. Adoption of agroforestry was independent variable and livelihood of smallholder farmers was dependent variable. However, both independent and dependent variables are affected by extraneous variables such as government policies**,** Law and International agreements.

As demonstrated in (figure1.1). The decision to adopt agroforestry or not is thought to be influenced by socioeconomic, institutional, and environmental factors. Farmers that use agroforestry can expect their fields to be well-maintained and sustainable, resulting in higher yields and higher-quality produce, among other benefits. At the same time, adopters are considered to be profit-maximizing, thus high yields should lead to higher farm earnings, if prices are acceptable enough to cover the production costs, and this, in turn, should lead to higher household income Furthermore, because of the high stabilization of soil organic matter and increased soil water retention capacity, the effect of adoption will positively contribute to farmers' better livelihoods by allowing them to conserve water, soil fertility, and soil erosion control, resulting in high productivity.

Socio-economic factors considered for analysis were gender, age, income, farm size, farming experience and household size. Institutional factors were access to extension

services, access to credit, access to information, access to training and access to market. Lastly environmental factors were soil erosion, soil fertility, deforestation and reducing crop failure.

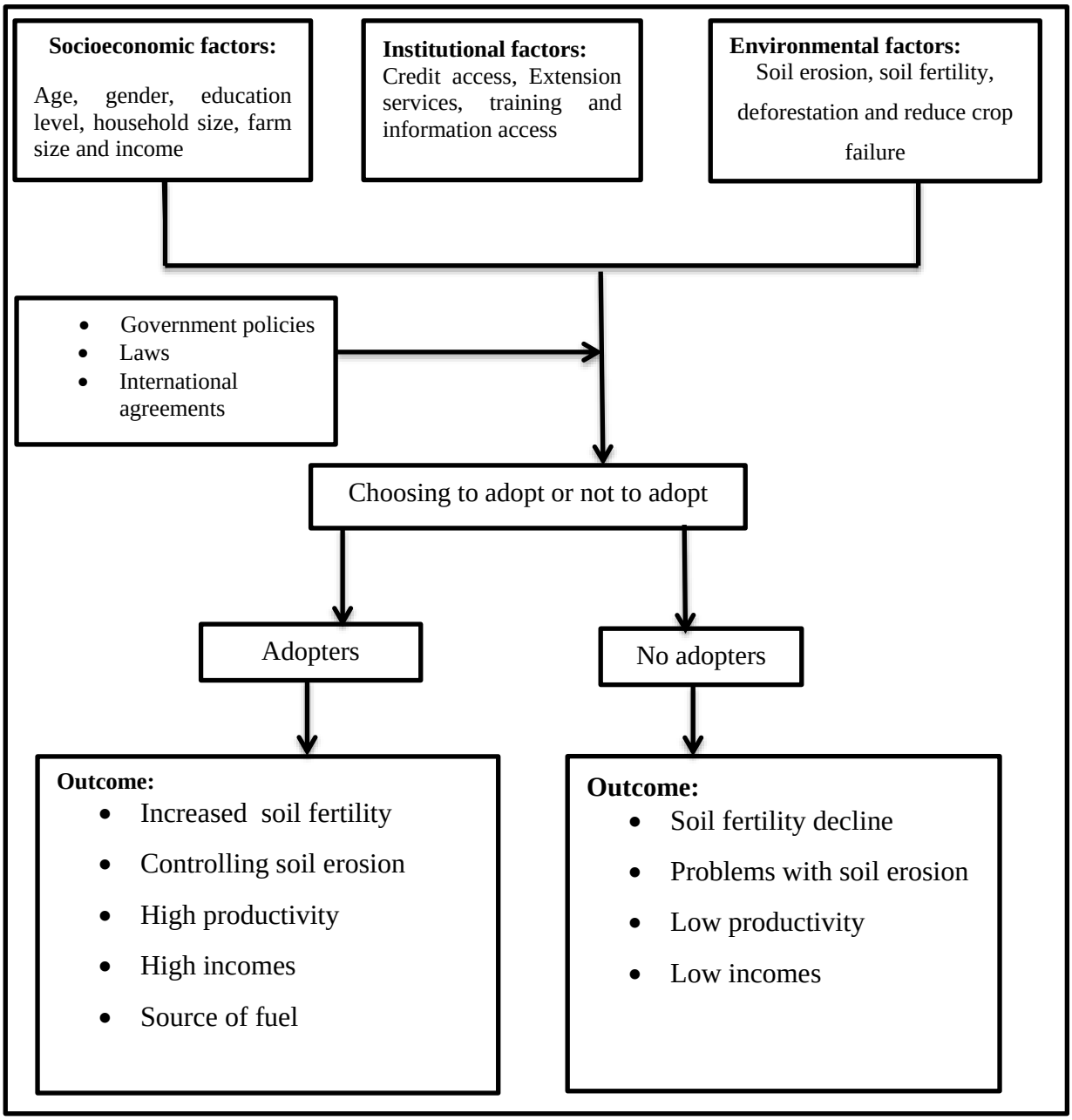

Figure 1 1: Conceptual Framework

1.8 Operational Definition of Key Terms

Agroforestry: International Centre for Research in Agroforestry (ICRAF) and the World agroforestry Centre (WAC) define the term agroforestry as a dynamic, environmentally sound natural resource management system that diversifies and sustains development through the incorporation of trees in farmland and rangeland for increased social, economic benefits and environmental to land users at all levels and Land-use system in which woody perennials are intentionally used in the same land-use unit as animals, agricultural crops or both in some sort of temporal sequence or spatial arrangement (Nair, 1993).

Household: It refers to a single person or a group of people who live and eat together and share common living arrangements, i.e. share expenses.

Household income: It refers to all income earned by all members of a family, in cash and in kind, in exchange for jobs or in return for investment in property, or income earned from other sources such as social benefits, pensions etc.

Climate change mitigation: Are any measures taken to completely reduce or eliminate long-term threats and hazards to human life and property from climate change (IPCC, 2001).

Climate change adaptation: Is natural or human mechanism in reaction to, or its impact on, real or anticipated climate stimuli that mitigate harm or exploit beneficial opportunities (UNFCC, 2010).

Socio-economic factors: These include labour, land tenure, loans, family size, farm size, gender ratio, education, dependency ratio, farm inputs, extension services, mechanization, distance, skills and crop types (Montambault and Alavalapati, 2005).

Agroforestry Adoption: Adoption happens when a farmer decides that agroforestry is the best course of action for meeting a certain requirement (Bozakbay 2005).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter opens with a review of the literature on climate change adaptation and farmers' livelihood in agroforestry systems conducted in Rwanda and elsewhere. The research begins with a review of world literature, followed by an examination of African literature, and lastly a discussion of Rwandan literature. The chapter also demonstrates how the study attempts to remedy gaps highlighted in empirical investigations conducted in various parts of the world.

2.2 Agro-forestry practices adopted by farmers

Agroforestry is defined as any land use in which trees, agricultural crops, and/or animals are mixed in a single production unit, either in a spatial combination or in a series. While agroforestry practice classification is as complicated as the systems themselves, multiple attempts have been undertaken to identify and name various systems. Examples include Simultaneous systems with direct interactions (e.g. alley cropping and multi-story gardens) and sequential or rotational systems (e.g. enhanced fallows and rotating woodlots) with indirect interactions or residual effects between trees and crops (Nair, 1993).

Agrosilvicultural (crops and trees, as in alley cropping, home gardens, etc.), silvopastoral (trees and animals, as in pastures), and agrosilvopastoral (crops, trees and animals as in zero grazing) are some of the agroforestry classifications. Agroforestry includes riparian strips and line planting (hedgerows, shelterbelts, and wind belts) that is characterized as trees outside of forests (Ares *et al.,* 2006, Long and Nair, 1999). Silvopastoral system can be found in the Mediterranean region (Eichhorn *et al.,* 2006). Forest farming is an agroforestry system that harvests non-woody forest products such as medicinal plants and mushrooms (Lange and Schippmann,1997; Lange, 1998) Bulgaria, Hungary, Albania, and Spain are examples of countries where this exists (Rigueiro-Rodriguez *et al.,*2009). This practice was also reported in America (Ares *et al.,* 2006) and (Bucagu *et al.,* 2013)Asia (Conklin, 1957), specifically in India in 1890 (Raghavan, 1960). When compared to any other region of equivalent size in the United States, the potential for combined wood, cattle, and wildlife production in the southern United States is unrivaled. There are more than 80

million hectares of forest land in the area, with around half of it suitable for livestock (Smith, 1950).

Agroforestry, on the other hand, is said to be an old tradition in Sub-Saharan Africa, where farmers intentionally keep and integrate trees into their crops (Bucagu *et al.,* 2013).

However, these agroforestry approaches have not been examined in the literature in terms of their contribution to farmers' livelihood, resulting in the discovered gap. According to the research, it is unclear if farmers' participation or non-participation in agroforestry methods contributed to the stated of their success.

2.3 Socio-economic factor that influence adoption of agroforestry

Socioeconomic concerns contribute to the human environment in which people live and perform. The selection criteria for the adoption of agroforestry system by farmers depend on a number of physical environmental conditions as well as socio-economic preconditions relating to the productive cultivation of perennial crops and particularly trees. Household and farm characteristics are socioeconomic factors that influence the adoption of agroforestry practices. Age, education level, gender, marital status, household size, years of farming experience, and annual farmer income are some of the household characteristics that can potentially influence adoption decisions. Farm variables such as farm size, soil fertility, soil erosion, and land slope can all influence adoption decisions.

2.3.1 Farm Size

Current et al.2005 who conducted study In Caribbean and Central American countries, farm size was found to be positively connected with agroforestry technology adoption decisions. Magugu et al.2018 carried out a study to identify socioeconomic factors influencing the adoption of agroforestry technology in Nyando, Kenya. The results reveal that farmers with larger farms were found to be more likely to use agroforestry techniques. One explanation is that larger farms can benefit from economies of scale by spreading the fixed cost of technology adoption over a greater area. A previous study by Deininger et al. (2008) reported that land size is substantially linked to a higher chance of investing in soil and water conservation activities, and that it more than doubles the expected number of hours spent on each

activity. For instance, Perz (2003) has indicated that, larger size of farming households could have a positive influence on employment of new technologies.

Maluki et al., (2016) carried out a survey targeting smallholder households in the semi-arid Makueni County, Kenya. The survey's goal was to find out which agroforestry practices were used and how widely they were used. Agroforestry adoption was found to be positively associated with the amount of the landholding (r^2 = 0.507). The larger land, the greater chance of investing in semi-arid agroforestry technology and the farmer's ability to plant in parts of the land deemed suitable without limits.

Nevertheless, studies conducted by Muhammed et al., (2012) in Northern part of Ghana indicated there was no important impact of the size of farming households on adoption of technologies for maize farming

2.3.2 Education Level

Obedy (2012), in a study conducted in Bungomo County, he discovered that the household head's level of education was statistically significant at 1% and had a positive impact on the adoption and intensity of new technology use. The decomposition results revealed a predicted total change of 4.26% in the number of hectares of farm land under agroforestry due to an increase in education level by one year. A one-year increase in education improves the likelihood of agroforestry adoption by 1.77 % and the intensity of usage of new agricultural methods increases by 2.49 % among adopters.

Another similar study has done by (Chukwuji *et al.*, 2006) found that the household leaders' levels of education were statistically significant and had a positive impact on new technology adoption.

According to Benjamin et al., 2020 who carried out study to identify socioeconomics factors influencing adoption of agroforestry among smallholder farmers in Arid and Semi-Arid Areas of Sub Saharan Africa? The study found that education was a key determinant, with those with a high level of education being 5.588 times more likely to adopt agroforestry than those with a low level of education. The majority of the adopters in this study had completed primary and secondary school.

Obeng and Weber (2014) conducted study by evaluating the socio-economic factors affecting agroforestry adoption by smallholder farmers in Ghana. The findings of that study state that education of farmers is negatively influencing them to adopt agroforestry practices at 5% level of significance. Less educated farmers were 54.5 % less likely to adopt agroforestry compared to farmers with formal education holding all other variables constant.

Nkamleu (2005) indicated that number of years of schooling has a direct association with choice decision processes in many instances. Place et al. (2003) also showed no influence of education on adoption of agroforestry practices in Kenya. Recent study by Mwangi and Kariuki (2015) has also reported a positive relationship between education and technology adoption.

Similarly, Akudugu et al., (2012) have noted in their research in the Bawku West District in Ghana that, educational levels of farming households are important determinant for adoption of technologies for enhancing farm productivity. Sood and Mitchell (2009) report that educated farmers are regarded as innovative or opinion leaders and are ready to take more risks than illiterate farmers.

2.3.3 Household Size

A study was undertaken to identify socio-economic and institutional drivers influencing agroforestry adoption in the ASALs (arid and semi-arid African areas) by (Benjamin M et al, .2020). They discovered that household size was 9.679 times more likely to influence agroforestry adoption, with the majority of agroforestry adopters coming from big households with 6-10 individuals. According to (Gido O.2012) who found that household size was statistically significant at 1% and positively influenced adoption and intensity of use of new agricultural practices.

Another study done by (Obeng and Weber. 2014) carried out a study in Ghana the aim of the survey was to analyze socio-economic factors affecting agroforestry adoption. The findings reveal that household labour measured by total household size positively influenced adoption of agroforestry at a statistically significant level of P > z value of 0.026.

Adeogun (2012) conducted research with the goal of determining the socioeconomic elements that influence the adoption of new agricultural technologies. The research was carried out in Borno State, Nigeria, in the Sahelian zone. A positive correlation between agroforestry and household size has been reported (r2 = 0.5039). According to the study's findings, 32.1 % of respondents had 9-12 individuals in their households. According to the findings, majority of the labor employed in small-scale farms comes from the household. However, the negative relationship between household and farmer participation in enhanced tree fallow and other intensive technologies has been indicated by (Franzels .1999) and also the study done by (Uisso and Masao 2016) they discovered no statistically significant link between household size and agroforestry adoption and practices.

2.2.4 Gender

Bernier *et al*. (2015) found that the household head's gender was positive and significant at 1%, indicating a link between higher demand for agricultural methods and gender. The findings found that male-headed families were more likely than female-headed households to have a higher demand for agricultural activities.

Gbegeh and Akubuilo (2012) similar findings were discovered, and it was revealed that in many parts of Africa, women are frequently denied property rights due to social constraints. As a result, they have fewer competencies and resources in terms of land management than men. A research that was carried out in the Bawku West District in Ghana has shown that, male-headed households are more likely to adopt and use new technologies in comparison to households led be females (Akudugu et al., 2012).

2.2.5 Age

According to Akudugu et al., 2012 and Boateng 2003 the younger farmers are seen to embrace modern technologies because of their level of education, their desires in taking-up potential risks, as well as the foreseeable long-run plans that they may have compared to the older generation.

Another study was done by Gbegeh and Akubuilo (2013) who claimed that there is a negative association between age and acceptance of improved agricultural methods, and that older people are less likely to adopt agricultural innovations. Elder farmers

have more agricultural experience and are better able to analyze the qualities of current technology than younger farmers, therefore they are more likely to adopt the practice. Older farmers, on the other hand, are more risk-averse and flexible than younger farmers, and hence have a lower likelihood of embracing new technologies (Adesina & Forson, 1995).

Similar study was done by Bernier *et al*. (2015) carried out the study to identify the socioeconomic, institutional, and environment aspects that influence agricultural practices. He observed that household age was connected negatively with higher demand for agricultural with a significance of 10%. This means that older farmers are less likely than younger farmers to implement many strategies. Old age factors such as the shorter-term planning horizon and energy loss, as well as risk prevention may lead to the negative effect of age on farming demand.

Another researcher called Challa & Tilahun (2014) farmers' age was found to have a favorable impact on the likelihood of adopting agriculture-related technologies, as it is linked to farming experience, which enhances abilities for better farming.

2.2.6 Access to credit

Bright (2017) starts that access to credit had a positive influence on the likelihood of increased demand for agricultural practices, which was statistically significant at 1%. A large increase in the amount of credit received resulted in the use of more agricultural methods. Credit expands farmers' financial resources, alleviates cash flow limitations, and allows them to purchase critical inputs.

Adekemi *et al*. (2016) argued that credit increases the farmers' economy to purchase improved seed, fertilizer and other Agricultural inputs. However, this is only as far as the profitability of the technology supersedes other investment alternatives available to the farmer. Beshir *et al.* (2012) highlighted that if households get sufficient credit, they are able to purchase trees improved seeds and fertilizers on time.

Benjamin et al., 2020 determined that at least 8.8% of adopters had access to credit, but none of the non-adopters had, access to credit was 10.686 times more likely to affect adoption. The availability and access to credit facilities for small-scale farmers

is another important determinant of farmers' behaviors and decisions in using new technologies and innovations (Boateng 2003).

2.2.7 Access to extension services

Obeng and Weber (2016) results showed access to extension information on tree planting positively associated with adoption of agroforestry but its effect in predicting the decision to adopt agroforestry is statistically not significant.

Gido *et al*. (2015) found that extension services are critical in assisting institutional systems that enable the distribution and diffusion of information among farmers, as well as the demonstration of benefits from new technology.

Akudugu *et al*. (2012) also argues that Extension assists farmers in understanding the importance of modern technology and improves the accuracy with which the technology package is implemented.

Bright (2017) who found in his study that extension service providers were statistically significant (at 1%), and were linked to higher demand for agricultural methods. Chija (2013) also found farmer's awareness and access to extension services as some of the most critical factors that enhance farmers' adoption of agroforestry in Kasulu district, Tanzania.

2.4 Impact of adopting agroforestry practices on livelihood of smallholder farmers

Agroforestry, as a science and practice, has the potential to address rising food insecurity by providing smallholders with a variety of benefits, including increased agricultural production, income, and employment opportunities, all of which improve rural living standards. Intense agricultural forestry surely has created investment and employment incentives to add farm revenue (Saigal *et al.,* 2002; Kareemulla *et al.,* 2003). Agroforestry is valuable because it provides a variety of macro- and micro-scale environmental services. This mitigates land loss on a macro scale by managing water erosion, soil erosion, recovering degraded land, and increasing agricultural productivity and irrigation (Wu and Zhu, 1997).

Agroforestry research has typically been demonstrated to promote farmer well-being and environmental health (Scherr *et al.,* 2002a). Agroforestry includes the deliberate use of trees in crop systems to improve farm production, provide services to the ecosystem and diversify sources of income. Nitrogen-fixing trees, for example, are frequently planted between rows of food crops to supplement limited nutrients and increase farm production. The usage and sale of tree crops such as fruit, fuel wood, and timber are also included in agroforestry processes (Nair, 1993). Trees provide farmland with wood products, as well as raw resources for rural industry, which produce jobs in rural areas (Current *et al.,* 1995). Also, agroforestry meets almost half of the demand of for both domestic wood and commercial requirements (Mbow *et al.,* 2014).

Regmi (2003) Studies how agroforestry has benefited farmers' rural livelihoods in Nepal's Dhading District. He interviewed with 42 households involved in the district's agroforestry practices and discovered that farmers understand the value of agroforestry in terms of increasing their incomes, increasing tree species diversity, and saving women time when collecting fodder and fuel wood.

India has the potential to protect valuable biodiversity and to contribute to local people's well-being (Quli, 2001). Individual farmers are encouraged to plant trees on their own farmland in order to meet the domestic needs of their families under agroforestry. Farmers are typically active in planting trees to provide shade for crops, wind shelters, and soil erosion prevention. Agroforestry initiatives in India involve the utilization of trees cultivated in plantations, community forestry, and a variety of other local forest management techniques (Pandey, 1998). It has been shown that small holdings of less than 2 ha with a combination of Acacia species and rice in the agroforestry system have a gain cost ratio of 1,47 and an internal return rate of 33% at an annual discount rate of 12% over a ten-year period (Singh and Pandey, 2011). According to the study done by Bhattacharya and Mishra (2003) in the Northeast Indian state of Meghalaya, an Agri-horticultural system based on Psidium spp. (guava) gave a 2.96 fold higher net return than a comparable system without trees.

Agri-horticultural agroforestry systems, for example farming systems including timbered forests and fruit trees, have the ability to raise the socio-economic condition

of farmers and contribute to the general development of the region. Dhyani *et al,* (2003) focused on the role of agroforestry products and environmental services in meeting the needs for subsistence and providing a basis for improving and sustainable social well-being.

Agroforestry is practiced in Rwanda, where trees and shrubs are grown on the same land unit with crops, either as linear formations, single trees, or woodlots. These trees supply goods including fuel wood, climbing bean stakes, feed, building poles, timber, fruit, and medicines, as well as services like soil fertility replenishment and soil conservation (Roose *et al.*, 1993). Increasing the use of agroforestry in multifunctional ecosystems will reduce the pressure on forests and protected areas (Khanal, 2011). Agroforestry offers a sustainable supply of tree products previously harvested from the forest, and increases the sustainability and profitability of local farming (Essa, 2004).

Agroforestry gives a feasible supply of tree items which were once in the past gathered from the woodland, as well as making strides the maintainability and efficiency of nearby farming (Gratty, 2004). Agroforestry is a more complex form of land management both economically and ecologically than other forestry or agricultural systems. This plays a major role in providing tangible and intangible benefits, tangible benefits such as job creation and increased farm profits, and intangible benefits include ecological restoration underlined in the various agroforestry systems (Rocheleau *et al.*, 2004).

2.5 Farmers' perceptions and adoption on agroforestry

According to (Saha, Sharmin, Biswas, & Ashaduzzaman, 2018) Van den Ban and Hawkins (1988), Perception is a mechanism in which people receive knowledge or stimulation from their environment to change their physiological consciousness. According to Rogers (2003), Adoption happens when a decision has been made by making full use of the new technology as the best way to address a need.

In Bangladesh (Saha, Sharmin, Biswas, & Ashaduzzaman, 2018) done study on farmers' perception and adoption in agroforestry practices showed that the many respondents within the area of study was well known the positive effect of agroforestry activities.

The farmers were aware of the economic and competitive advantages of agroforestry and had a positive attitude to these activities. Awareness of agroforestry activities suggested that competitive values (82.14%) were considered to be the most significant among most respondents. As they recognized agroforestry as a way to meet their essential fuel wood, fruit, food, timber and vegetables needs.

Likewise, a large proportion (73.80%) of farmers understood that the economic factors were the most relevant. This is because agroforestry has increased family income, incentives for jobs, and reduced farm expenditure. Some defensive functions of agroforestry, such as flood control, erosion control and soil protection were perceived by farmers. It is noteworthy that, according to respondents, it is difficult to practice agroforestry (17.85%) as a sign of lack of knowledge. In addition, some of the farmers surveyed (35.72%) said crop production would be decreased when trees were grown in the fields. Findings from this study indicated that an average significant percentage of farmers (64.28%) had adopted the practice of agroforestry, while 35.72 % had not adopted agroforestry.

According to (Nouman, Khan, Khan, & Farooq, 2007) who did the some study in in district Faisalabad of Pakistan Their results showed that 30,4% of respondents were willing to grow trees on their farmland, while 20,8%studied that the future of farmland trees is growing and that people are becoming conscious of planting trees on farmland. A majority of the respondents (57.6 %) expressed their opinion that trees should be planted to satisfy timber, fuel wood and fodder needs and requirements. The respondents (31.2%) needed some assistance in growing trees.

The study assessed adoption of agroforestry practices and farmers ' perception by Adedayo in Osun State, Nigeria, 2014 the study results showed divergent perceptions of agroforestry practice in the study area. In the Western Senatorial District of Osun, 10% of respondents felt that agroforestry is a scientific process that is difficult to practice, 62% felt that it could increase farm productivity, while 12% felt that the practice was not properly understood, while 16% felt that agroforestry was a common practice among the smallholders farmers.

At the highest percentage in the central senatorial district of Osun, 56% of respondents regarded agroforestry as an activity that can improve productivity, 19%

believed that it is a common practice among local farmers, 13% believed that agroforestry is a scientific practice that is difficult to practice, while 11% recognized agroforestry as a practice that is not well understood. In Osun west senatorial district, 76% of respondents were interested in Agroforestry practice, while 24% confirm that they never practiced agroforestry.

In Osun east, 80% of the respondents are participated in agroforestry practice while 20% have not adopted the practice. 72 percent of respondents were interested in Osun central compared to 28 percent, which suggested that they had never practiced agroforestry at any time of their farming experience. It means that a higher percentage of respondents in the study area are interested in agroforestry activity. This indicates that there is possibly a greater understanding among farmers in the study area of the potential of agroforestry system in increasing productivity per unit area.

Agroforestry, which involves incorporating trees into agricultural landscapes, allows Rwandan farmers to increase agricultural output by recycling nutrients, reducing erosion, increasing soil fertility, and producing wood and non-wood goods.

Agroforestry is in practice in the country for centuries (Nair, 1993, Habiyambere, 1999). Actually, Rwanda's agroforestry systems are dominated by a diverse range of exotic tree and shrub species that are suitable for the country's various agricultural systems.

In Rwanda, agroforestry is dominated by individual trees that are planted as lines (farm boundaries and contour lines), scattered trees on farmland and as small blocks (woodlots). Eucalyptus woodlots are among of the most commonly adopted agroforestry systems in Rwanda as it is estimated that at national level about 36-40% of farm owners keep them on their land (Ndayambaje *et al.* 2013).

2.6 Gaps in Literature Review

Many socio-economic studies in agroforestry have focused on perception and adoption in agroforestry practices (e.g., Saha *et al*., 2018; Adedayo, 2014; and Nouman *et al.*, 2007). Other major agroforestry studies have addressed its importance on soil fertility renovation and weed control (e.g. Nair, 2006; Motis, 2007; Bayala *et al.*, 2014; Ordonez *et al.*, 2014). Few studies have been conducted to investigate how

socioeconomic factors influence agroforestry adoption among smallholders in farming communities. In many locations there is often little quality and quantity information on socio-economic aspects affecting agroforestry.

However, there is limited literature on adoption of appropriate controlling practices and incorporation of those practices into rural livelihood structures (e.g., Liyama *et al.*, 2014; Klapwisk *et al.*, 2014; Namirembe *et al.*, 2014), there is little investigation on the adoption of agroforestry practice in specific (Jera and Ajayi, 2008; Pagiola *et al.*, 2008, 2007) and few articles have studied the adoption of agroforestry outside visible features (Calle *et al.*, 2009; Frey *et al.*, 2012; Hayes, 2012). Based on literature that have reviewed this are gaps we don't have enough literature on agroforestry and how it impacts livelihood of farmers in Rwanda and also we do not have information about the factor which influence acceptance of agroforestry.

Therefore, this study seeks to fill this literature gap by evaluating the impact of agroforestry on livelihood improvement among the smallholder farmers. Most previous research on this topic has focused on socioeconomic variables, presuming that these are the only factors that influence the advancement of agroforestry methods but they didn't talk about the environmental and institutional factors and how they influence agroforestry adoption. As a result, this study seeks to fill this gap by investigating how farmers' perceptions of environmental and institutional factors influence their decision to adopt or not adopt agroforestry technology.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area Characteristics

3.1.1 Location

Rwanda has five provinces: Kigali city, southern province, Northern, western and eastern are provinces. This study will be focused on southern province located at 2°19'60.0"S latitude and 29°40'00.0"E longitude.

3.1.2 Climate

The rainfall pattern is bimodal determines seasonality. The long rain is between March and May, short rain in October up to December. The monthly mean daily maximum temperature ranges from 28.5 ° C to 32 ° C (Rwanda meteorological, 2019).

3.1.3 Physiographic Features

The topography of southern province is generally hilly with deep water valley and this contributes to the regular flush flood that damage property and cause loss of life during rainy seasons and also provides soil erosion. The hilly Southern Province district was in the past synonymous with famine. Its poor soils coupled with poor farming methods combined to make the area one of the most unproductive parts of the country (Rwanda National Geography, 2018).

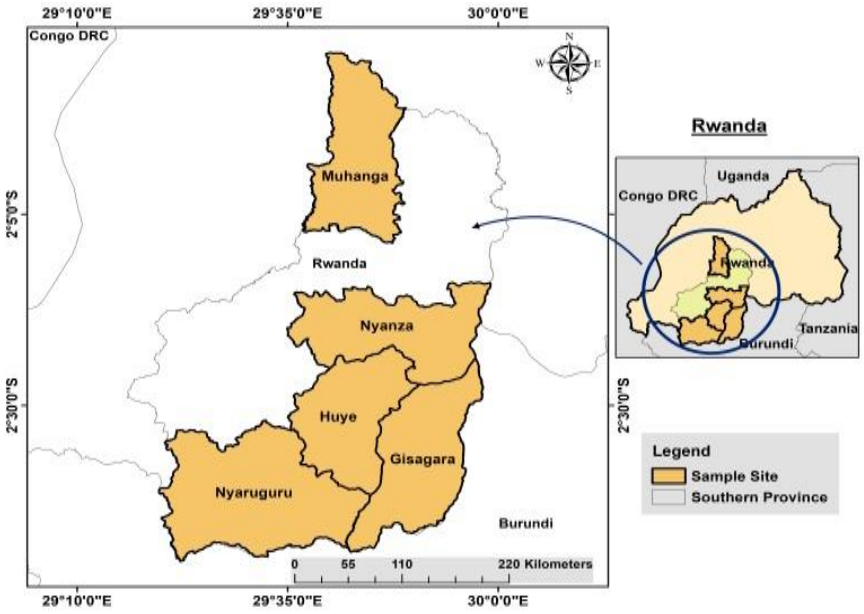

Figure 3.1: A map of Southern province with study area location

Source: *Researcher 2019*

3.1.4 Economic Activity

In the southern province, agriculture is the major economic activity. Consequently, the province has given priority to the growing of tea, coffee, wheat, Passion, Irish potatoes, processing of honey and livestock keeping. Same farmers' practices agriculture together with trees generated from wells and others don't practice such kind of agriculture (MINAGRI Report, 2018).

3.2 Study Design

The descriptive survey design used in this research to gather information by interviewing or administering a questionnaire to a sample of individuals (Orodho, 2003). This research was carried out in four (4) districts in southern province of Rwanda. This study used both quantitative and qualitative methods to allow the researcher to draw valid and reliable conclusions and recommendations regarding the effect of agroforestry on the livelihood of farmers

3.3 Target Population

The location of this study was chosen because the southern region is one of the areas in Rwanda with fruitful agroforestry stories to boost food production and increase household income. The destination population for this study comprise farmers which comprise of 6925, 1247 agroforestry adopters household and 4043 household of non-adopters of agroforestry will be the respondents from those districts located in southern provinces of Rwanda as shown in distribution table 3.1(ISAR report, 2015).

Table 3.1: Distribution table for householder population

No	District	**Adopters household Population**	**Non-adopters household Population**
1	NYANZA	209	1041
2	MUHANGA	230	1200
3	HUYE	428	672
4	GISAGARA	380	1130
	TOTAL	**1247**	**4043**

Source:*Researcher,2019*

3.4 Sampling Procedure

The study employed a stratified random sampling technique. In this technique, the analysis was done on element with strata, during stratified sampling, a random sample was used for each strata. Therefore, random sampling was taken to select 370 samples of adopters and 455 of non-adopters in four districts of southern province. Purposive sampling was employed to identify the key informants from the relevant agriculture office for each district.

3.5 Sample Size

To determine the sample from this study, simplified formula Yamane (cited in Kasunic 2005) was used to calculate sample sizes. This basic formula assumes a confidence level of 95 per cent and the maximum variance (p = 0.05).

The formula is

$$\mathbf{n} = \frac{N}{1+N.e^2} \quad (1)$$

Where:

- **n** is the sample size.
- **N** is the population size (209)
- e is the level of precision (0.05)

$\boldsymbol{n} = \frac{209}{1+209(0.05)^2} = \mathbf{68}$ Sample size of adopters for Nyanza District

Table 3.2: Sample size

No	District	Adopters	Non-adopters
1	NYANZA	60	91
2	MUHANGA	70	90
3	HUYE	81	87
4	GISAGARA	79	92
	TOTAL	**290**	**360**

Source:*Researcher,2019*

3.6 Research Instrument

In data collection the researcher used interview and questionnaires. The study used questionnaires which were self-administered as principal research instrument. This

study also utilized interview schedule as instrument to collect data from some respondents.

3.7 Data Collection Procedure

In collecting data, the researcher adopted primary and secondary data and the type of data expected to collect both qualitative and quantitative data.

3.7.1 Primary data

Primary data was obtained from the farmers and agricultures offices in each district through the questionnaire with structured questions and interview schedule with face to face and open ended interview.

3.7.2 Secondary data

Secondary data was obtained from the relevant authorities that deal with agriculture in each district and also other data were gathered from books, journals and the previous farmers' livelihood record from agricultures office of each district.

3.8 Data Analysis

We analyzed the data according to the objectives of study agroforestry practices adopted by the farmers in southern of Rwanda; we used descriptive method of analysis that includes the use of percentage table and frequency to know the performance. For analysis of agroforestry impact on farmers' livelihood propensity score matching was used and also binary logit regression model has been used to determine the factors affecting farmers adopting agroforestry.

3.8.1 Binary logistic regression model

It is statistical technique used to calculate the relationship between dependent variable and independent variables which accommodates two variables (binary). The binary logit regression estimates the possibility that a feature is present, or otherwise given the values of extraneous variables. If probability of adopting agroforestry practices is given by Y, then that for not adopting is given by 1-Y. The ratio referred to as the odds ratio can be expressed as$\frac{Y}{1-Y}$.

Taking the natural logarithm of the odds ratio gives the log of odds ratio, which can be estimated by the logit method. In the logit model, the log of the odd ratio is a linear function of the explanatory variables:

$\log(\frac{Y}{1-Y}) = \alpha + \beta_0 + \beta_1 X_1 + \cdots\cdots \beta_n X_n$ (2)

Where, β = coefficients to be estimated, x =explanatory variables, α = error term.

Following from the above, a farmer's choice to adopt agroforestry practices is given as a function of socio-demographic factors, agro-based characteristics and stated preferences for on-farm trees.

Decision to adopt agroforestry practices (Y) (Yes=1); (No =0). The adoption decision (dependent function) within the model framework is represented as follows:

$$\boldsymbol{Yi} = \alpha + \beta 1\, X1 + \beta 2\, X2 \cdots\cdots \beta n\, Xn \quad (3)$$

Where $\mathbf{Y_i}$ lies between 0 and 1 which is the predicted likelihood of adopting agroforestry practices adopting agroforestry practices is given as **β1, β2** ……**βn** for a unit increase in the independent variables and **X (1, 2 ,…. n)** are the independent socio-economic variables and **α** is the constant (error term) in the estimated model equation as indicated in equation1.

The final model of the decision to adopt agroforestry can therefore be estimated by equation below:

$$\mathbf{Y_1} = \alpha + \beta 1\, X1 + \beta 2\, X2 + \beta 3\, X3 + \beta 4\, X4 + \beta 5\, X5 + \beta 6\, X6 + \beta 7\, X7 + \beta 8\, X8 + \beta 9\, X9 + \beta 10\, X10 \quad (4)$$

Yi– the dependent variable (decision to adopt agroforestry practices)

X_1- gender of respondents

X_2- total annually income

X_3- education

X_4- respondents 'age

X_5- household size

X_6- farm size

X_7- farming experience

X_8-Acsess to credit service

X_9- Access to market

X_{10}- Access to extension services

3.8.2 Propensity score matching model

According to Rosenbaum and Rubin (1983, 1985) when adopters and non-adopters have similar characteristics their outcomes can be readily compared. We will allocate the clarifications into two clusters: treatment group, the farmers who are adopters into

agroforestry and the control group those who did not. In that case D=0 for control groups and D=1 for treated groups. Use **x** as variables that may impact the possibility of being allocated into the treated group. The propensity score model is a logit model with x as independent variables and D as the dependent variable.

$$P(x) = prob(D = \frac{1}{x}) = E(\frac{D}{x}) \quad (5)$$

Calculate the treatment effects: compare the products Y between the control and treated group, after matching

$$y = \begin{cases} Y1 \text{ if } D = 1 \\ \text{Y0 if D} = 0 \end{cases} \quad (6)$$

Average treatment effect (ATE) is the difference between the products of control and treated group. $D = \text{Y1} - \text{Y0}$

$$ATE = E(D) = E\left(\frac{Y1}{x}, D = 1\right) - E(\frac{Y0}{x}, D = 0) \quad (7)$$

3.9 Ethical Considerations

The research will regard the responders' security. The contributors were not expected to put their names on the questionnaire, because each questionnaire had a code number for reference. The members were guaranteed that data given was treated with privately and for the reason expecting as it were. They have too the flexibility to pull back from the research at any point or time.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter is about presenting the findings and data interpretation for the analysis. The data analyzed and interpreted were obtained through reporting, questionnaires and interviews. The data presented includes demographic information of the respondents. The chapter also presents discussion and results of the study according to its objectives.

Results were presented in tabular format whereby the tables show percentage. The binary logistic regression model was used to analyze the data to test whether socioeconomic, institutional, and environmental factors significantly influence the farmers to adopt agroforestry practices and Propensity score matching model which is used to evaluate the impact of adopting agroforestry practices on livelihood of smallholder farmers. To perform models, P-value of 0.05 was used to approve or disapprove whether there is relationship between independent and dependent variables. If the tabulated P-value is less than 0.05 it means that the relationship between variables is statistically significant if not the relationship between variables is not statistically significant. The study was carried out in selected four districts in Southern province of Rwanda. The respondents involved in this study were non-adopters and adopters of agroforestry farmers.

4.2 Description of the Population

This study was conducted in four selected districts in the province of Southern Rwanda. The respondents involved in this study were agroforestry farmers' adopters and non-adopters. Table 4.1 presented description of the variables used in the binary logit model and propensity score matching model.

Table 4.1: Description of variables used in binary logistic model and propensity score matching model

Variables	Description
Age	Age in years
Gender	Gender is 0 if the respondent is female and 1 is male
Level of education	Level is 0= No education, 1= Primary, 2=Secondary
House size	Number of people in the house
Farm size	Farm size in acres
Farming experience	Farming experience in years
Employment	Employment is 0 =No and 1= Yes
Agroforestry practices	Agroforestry practice is 0 = Adopters and 1 = Non adopters
Access to credit	Access is 0= No and 1=Yes
Annual farmer income	Income in Rwandan Francs (Rwfs) (1 US$=920Rwfs)
Consumption Expenditure	Consumption in Rwandan Francs(Rwfs)
Access to extension services	Extension service is 0=No and 1=Yes
Access to market	Access to market 0=No and 1= Yes
Marital status	Status is 0 if the respondent is single and is 1 otherwise

4.3 Demographic Characteristics of the Respondents

This section presents an overview of the socio-economic characteristics of the sample of farmers participating in the survey as well as the variables used in the analysis and how they are defined (Table 4.2). The demographic features provide the information about respondents' age, household size, farm size, farming experience as continuous data and employment, agroforestry practices, marital status, gender, education level as categorical data.

The results in Table 4.2 indicated that the Mean age of respondents was 45.88 years, the maximum age of the farmers was 70 years and minimum age of the farmers was 23years old. This indicated that the respondents were adult and enthusiastic, and were able to participate actively in agricultural activities. In addition, the younger age groups in the Rwandan community were students attending secondary and tertiary institutions. Table 4.2 also indicated that the Mean household size of the respondents was 5.44 house members with minimum of 1 person in the house and maximum of 11 people in the house. The result shows that the Mean farming experience of

respondents in this survey was 21.45 years with minimum of 1 year and maximum of 39 years' experience in farming.

The results demonstrated that Mean of farm size of the respondents was 22.67 acres with the minimum of 5 acres and maximum of 44 acres farming activities. The annual farm income from farming activities had mean of 127003.1Rwfs the minimum income was 50000Rwfs and maximum income was 750000Rwfs per year. The consumption expenditure of the farmers was 50000Rwfs as minimum money and maximum of 750000Rwfs with the Mean consumption expenditure of 115003.1Rwfs. The results indicated that the mean of farm size under agroforestry was 12.01 acres with the minimum of 1 acre and maximum of 20 acres farming trees and crops on the same land unit.

Table 4.2: Descriptive statistics for continuous socioeconomic characteristics

Variables	Mean	Std. Dev.	Min	Max
Age	45.88	10.56	23	70
Household size	5.44	2.66	1	11
Farming experience	21.45	9.27	1	39
Farm size	22.67	10.68	5	44
Annual farm income	127003.1	48538.2	50000	750000
Consumption expenditure	115003.1	47438.2	50000	750000
Farm under agroforestry	12.01	6.37	1	20

Source: *Field survey, 2019*

Table 4.3 indicates that out of the 100% respondents, 47.38% were males while 52.62% were females. This result indicated that the female farmers dominated relatively in the study.

Result for martial statuses shows that approximately 90.62% of the respondents were married and 9.38 were single. This shows that the majority of smallholder farmers were married in this study. This means that married people dominate agricultural production in which they employ family members as labor force.

The results of this survey demonstrated that 75.08 % were not employed and 24.92% were employed. This result shows that most smallholders' farmers do not have another occupation apart from farming activities.

In this study 44.62% of farmers practices agroforestry while 55.38% of the farmers do not practice agroforestry. This indicated that the non-adopters 'farmers dominated this study. The result illustrated that 54% of respondents in the survey had primary education, 27.08% had secondary education and 18.92% of respondents had no formal education. This result indicated that most smallholders' farmers have had primary education. This means that farmers without education need some form of informal education to improve their skills and ability to adopt new technologies, which will have a significant impact on their livelihood.

Table 4.3: Descriptive statistics for categorical socioeconomic characteristics

Variables	**Attribute**	**Percentage**
Gender	Male	47.38
	Female	52.62
Marital status	Single	9.38
	Married	90.62
Employed	Yes	24.92
	No	75.08
Agroforestry Adaptation	Adopters	44.62
	Non-adopters	55.38
Level of Education	No education	18.92
	Primary	54
	Secondary	27.08

Source: *Field survey, 2019*

4.4 Agroforestry Practices Adopted by the Farmers in Southern Province

4.4.1 Agroforestry practices adopted by the farmers

There are various types of agroforestry practices in Southern Province of Rwanda. The study area covers mainly the types of agroforestry practices adopted by the Rwandan smallholder farmers. Based on the sample studies in 4 districts of Southern province with interviews of 650 farmers, the various agroforestry systems practiced by the farmers are given in Table 4.3 and displayed in figure 4.1.

Table 4.4: Agroforestry practices adopted by the farmers

Agroforestry practices	**Percentage**
Alley cropping	11
Home garden	14
Boundary planting	68
Scattered trees on farm	7
Total	**100**

Source: *Field survey, 2019*

Figure 4.1 Shown 68% of the respondents had boundary planting agroforestry followed by 14% to home garden, 11% to alley cropping and 7% to scattered trees on farm. It may be noted that majority of the farmers (68%) were practicing boundary plantation. In Rwanda the farmers are planted young trees in their farms to avoid complications with the neighboring farmers. The trees also serve as a break in the wind to shield fields and crops from winds that damage crops. They are generally at boundary lines as well so they also set boundaries of the land and reducing the risk of erosion of top soil.

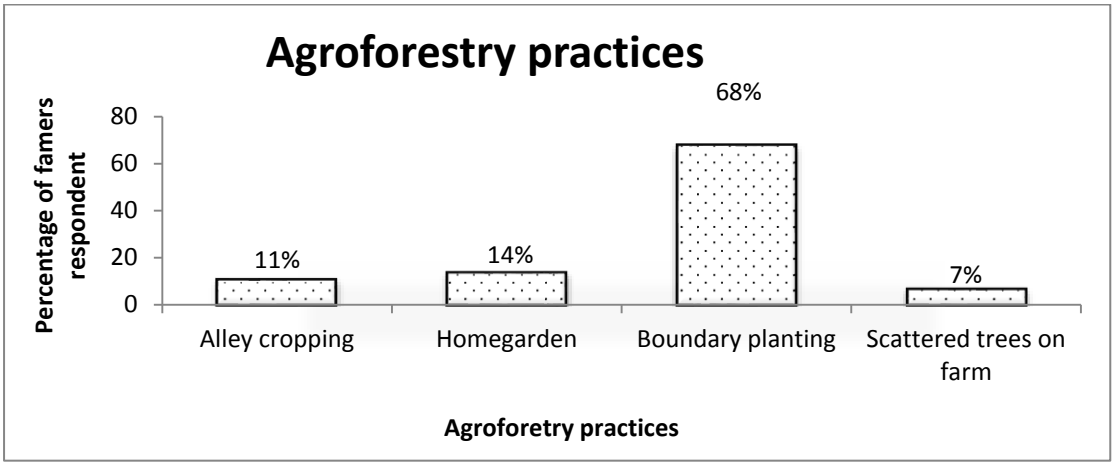

Figure 4.1: Agroforestry practices adopted by the farmers

Source: *Field survey, 2019*

4.4.2 Benefit from agroforestry

In this study, respondents were asked to identify the environmental benefits that agroforestry brings to the farmers. The farmers kept that these trees are planted to provide different uses such as fuel wood (18%), staking material (22%), constructional materials (7 %), grazing (5%), climate regulation (7%), soil erosion (14%), control of weed and pest (6%), reduction of crop failure (6%), improving soil fertility (7%), nutrient recycling (4%) and nitrogen fixation (5%). The responses from farmers on benefits of agroforestry are illustrated in below Table 4.5. Out of the total sample farmers, majority (22 %) have indicated that agroforestry is a source of staking material.

The study uncovered that the farmers either plant trees for extra benefit like constructional materials, staking materials, firewood, soil improvement, reduction of crop failure, control weed and pest and nutrient recycling (Table 4.5). This is in accordance with Adewusi (2006) who said farmers are planting or retaining trees on their farmland for soil improvement, environmental improvement, food, income and shade during the harsh weather.

Table 4.5: Benefit from agroforestry

Benefit from agroforestry	Percentages
Fuel wood	18
Staking material	22
Construction material	7
Grazing	5
Climate regulation	7
Soil erosion	14
Control weed and pest	6
Reduction of crop failure	6
Improving soil fertility	7
Nutrient recycling	4
Nitrogen fixation	4
Total	**100**

Source: *Field survey, 2019*

4.4.3 Agroforestry challenges for farmers

The result indicated that farmers who adopted agroforestry in this study area always face some challenges as shown in Table 4.6. According to the findings, a lack of input is the most significant barrier to farmers fully implementing agroforestry systems, followed by productivity.

Table 4.6: Agroforestry challenges for farmers

Agroforestry challenges	Percentage
Access to credit	8
Productivity	28
Lack of input	42
Access to market	5
Increase in product demand	18
Total	**100**

Source: *Field survey, 2019*

The result in Figure 4.2 shows the challenges of farmers who adopted agroforestry this result indicates 42% to input, 28% to productivity, 18% increase in product

demand, 8% access to credit and 5% access to market. Therefore, input and productivity are the most challenges faced by the farmers who adopted agroforestry practices.

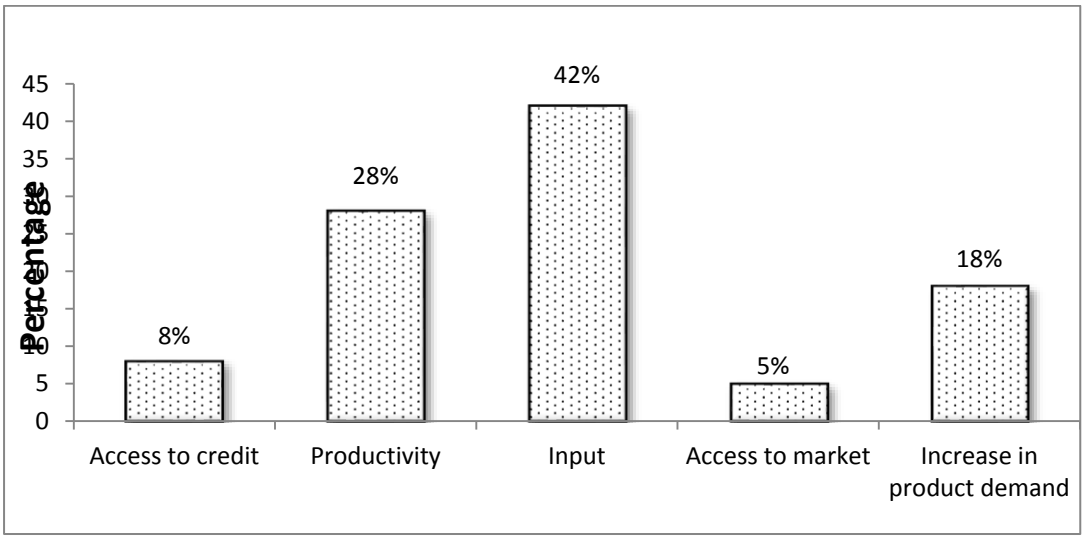

Figure 4.2: Agroforestry challenges for farmers

Source: *Field survey, 2019*

4.4.4 Agroforestry constraints for the farmers

According to the results from table 4.7, limited land was classified high (31.20%) among the limitations avoiding farmers from fully adopting agroforestry practices, followed by lack of capital (26.46%), lack of technical skills (14%), lack of viable seed (8.4%), lack of manpower (8%) and finally limited access to credit (5.6%).

The results in Table 4.7 show the problems faced by the farmers in adopting agroforestry where lack of capital and limited land was the major cause.

Table 4.7: Barriers faced by farmers in adoption of agroforestry

Agroforestry Constraints	Percentage
Lack of capital	26.46
Lack of viable seed	8.36
Lack of manpower	8.08
Inaccessible market	6.41
Limited access to credit	5.57
Limited land	31.20
Lack of technical skills	13.93
Total	**100**

Source: *Field survey 2019*

4.5 Socio-economic and institutional factors that influences the farmers to adopt agroforestry

Table 4.8 shows the estimated model which provides the coefficient, the T-test and P-value of 95 percent confidence interval. Fourteenth logit models based on socio-demographic features and institutional factors have been estimated to predict the probability of adopting agroforestry practices. Overall, two of the tenth independent variables included in the model had significant effects at 95 % confidence interval in explaining the decision to adopt agroforestry practices. The results of the estimated model showed the Pseudo r^2 as 0.3042. This indicates an improvement or 30.42 percentage change in the log likelihood between the null model and the full estimated model. The estimated log likelihood ratio was -134.51 and the chi-square test which indicates the difference in the degrees of freedom is given as 0.000, suggesting that our model as a whole fit significantly better than an empty model.

4.5.2 Socio-Economic Characteristics and Agroforestry Adoption

The results in Table 4.8 find that gender had a negative sign of predicting the adoption of agroforestry practices. Controlling for all other variables, women are more likely to adopt agroforestry practices by a factor of 1.500 than men. This effect is not statistically significant. With a unit increase in a farmers' age, the coefficient of adopting agroforestry is decreased by a factor of 1.005 controlling for all other variables. Several authors have had similar findings. Bernier *et al*. (2015) carried out

the study to identify the socioeconomic, institutional, and environmental-related factors that affect agricultural practices. At a 10% level of significance, he discovered that the age of the household was negatively associated with higher demand for agricultural practices and also Gbegeh and Akubuilo(2013) who claimed that there is a negative association between age and acceptance of improved agricultural methods, and that older people are less likely to adopt agricultural innovations..

Less educated farmers were 63.2 % less likely to adopt agroforestry compared to farmers with formal education holding all other variables constant. This effect was not statistically significant. Several authors have had similar findings. For example, Mathews *et al*., (1993) in their study of agroforestry adoption in Wellington County, Ontario reported no correlation of age and gender with the adoption of agroforestry. Place *et al.*, (2003) also showed no influence of education on adoption of agroforestry practices in Kenya. Obeng and Weber (2014) conducted study in Ghana and then the findings of that study state that education of farmers negatively influenced the adoption of agroforestry practices at 5% level of significance while Akudugu et al., (2012) have noted in their research in the Bawku West District in Ghana that, educational levels of farming households are important determinant for adoption of technologies for enhancing farm productivity.

Annual farmer income, education level, farming experience and age of farmers negatively affected the adoption of agroforestry practices at 5% level of significance. For a unit increase in annual farmer income, the coefficient of adopting agroforestry practices decreased by a factor of 1.00 controlling for all other variables. This is in agreement with study done by Obeng and Weber (2014) who found that Monthly income, education and age of farmers negatively influenced the adoption of agroforestry practices at 5% level of significance.

Years of farming experience indicated a somewhat positive influence on farmers' adoption decision but this was not statistically significant. With an increase in years of farming experience, the odds of adoption increased by a factor of 1.01, controlling for all other variables. Obeng and Weber (2014) found the similar results in their study carried out in Ghana.

Farm size and household size of farmers positively influenced the adoption of agroforestry practices at 95% confidence interval. Household labor measured by total household size positively influenced adoption of agroforestry at a statistically significant P-value of 0.000. For a unit increase in total household size, the coefficient of adopting agroforestry practices is increased by a factor of 1.40 controlling for all other variables. This is in agreement with Ayuya *et al.,* (2012) who concurs with the findings of this study by indicating that household size is significantly related to adoption of agroforestry technology. Large household size positively influences adoption of labor-demanding agricultural technologies since they have the ability to relax the labor limitations necessary in the course of introduction of new technologies. It is concluded that farmers with larger household size are further likely to adopt agroforestry practices than farmers with smaller household size.

An increase in farm size positively influenced adoption of agroforestry at a statistically significant P-value of 0.000. This shows that most of the farmers who were more likely to adopt agroforestry had a bigger acreage of land for planting more trees. From the findings, respondents' farm size is related to adoption rate of agroforestry; those with larger farm sizes are more likely to adopt agroforestry than those with small farm size. This is in agreement with several studies such as the study by Orisakwe and Agomuo (2011) who examined the socioeconomic factors of respondents practicing agroforestry and revealed that, farm size of the respondents had a positive relationship to levels of agroforestry adoption. He reported that an increase in respondents' farm size leads to an increase in adoption of agroforestry. A similar study by Kabwe *et al.,* (2009) reported a significant association between adoption of agroforestry and farm size. According to Geremew (2016) an increase of farm size by one hectare, increases the possibility of adopting agroforestry.

4.5.3 Institutional factors and Agroforestry Adoption

Access to credit, access to market and access to extension services of farmers negatively influenced the adoption of agroforestry practices at 5% level of significance. For a unit increase in access to credit, the coefficient of adopting agroforestry practices decreased by a factor of 1.190 controlling for all other variables. This result was contrary to the findings of Bright (2017) who starts that

access to financing had a beneficial impact on the likelihood of increased demand for agricultural methods and was statistically significant at 1%.

Access to market indicated a somewhat positive influence on farmers' adoption decision but this was not statistically significant. By increasing access to market, the coefficient of adoption increased by a factor of 0.482, controlling for all other variables.

For farmers with access to extension service, the coefficient of adoption increased by a factor of 2.059 compared to those with no access to extension service. Results from this study showed access to extension service on tree planting positively associated with adoption of agroforestry but its effect in predicting the decision to adopt agroforestry is statistically not significant. Similar study was done by Benjamin et al., 2020 found that access to extension services negatively influenced the probability of adopting agroforestry and also (Obeng and Weber(2016) results showed that access to extension information on tree planting positively associated with adoption of agroforestry but its effect in predicting the decision to adopt agroforestry is statistically not significant. Contrary Bright (2017) who discovered in his research that extension service providers were significant at 1% and were positively associated with higher requirements for agricultural practices.

4.5.4 ***Environmental factors and Agroforestry Adoption***

Results from Binary logistic regression show the relationship between environmental factors and adoption of agroforestry practices. The findings of this study indicate that deforestation and reduce crop failure have positive effect on adoption of agroforestry but the effect was not statistically significant.

The results also reveal that soil fertility and soil erosion are the factors that may influence smallholder's farmers in southern province at the 5% significance level. This effect was statistically significant. For a unit increase in soil fertility the coefficient of adopting agroforestry practices is increased by a factor of 1.43 controlling for all other variables. Because farming area becomes outdated for food production due to severe soil erosion, farmers prefer to dedicate their farmlands to cultivate trees that preserve land against future soil erosion and enhance soil fertility.

Other studies in different country such as Sub-Saharan Africa and Ethiopia (Djalilov et al., 2016), (Meijer et al., 2015) and (Gessesse et al., 2015) discovered that the presence of damaged farmland legitimized agroforestry plantations. The geographical location of southern province is generally hilly with deep water valley and this contributes to the regular flush flood that cause land degradation and also provides soil erosion. This implies very poor soils that have been significantly degraded by erosion. Land fragmentation as a result of agricultural expansion, combined with poor agricultural practices, has resulted in a severe depletion of available land.

Table 4.7: Logistic regression of the dependent variable on the independent variables

Adoption of Agroforestry	Coefficient	SE	T-test	**P-Value**
Socioeconomic factors				
Gender	1.50	0.48	1.24	0.21
Age (years)	1.01	0.03	0.15	0.88
Educational level	0.37	0.09	1.72	0.09
Household Size (persons)	1.40	0.41	5.05	0.00**
Farm Size (acres)	1.10	0.02	5.41	0.00**
Farming Experience (years)	1.01	0.04	0.16	0.87
Annual farmer income	1.00	0.00	1.57	0.12
Institutional factors				
Access to extension services	2.06	0.87	1.72	0.08
Credit access	1.19	0.49	0.43	0.67
Access to Market	0.48	0.20	-1.73	0.08
Environmental factors				
Soil fertility	1.43	0.44	5.09	0.003**
Reduce soil erosion	1.12	0.07	5.43	0.001**
Reduce deforestation	1.01	0.89	1.78	0.09
Reduce crop failure	1.02	0.03	1.34	0.01
Constant	0.00	0.00	-5.11	0.00**

Source: *Field survey 2019*

4.5.1 Marginal effect for the binary variables

Marginal effects inform us how a dependent variable (outcome) changes if a specific independent variable changes. The marginal effects for binary variables measure discrete change.

Table 4.8: Marginal effect of the dependent variable on independent variables

Adoption of Agroforestry	dy/dx	SE	T-test	P-Value
1.Socioeconomic factors				
Gender	.03	.48	0.58	0.21
Age (years)	.02	.05	1.93	0.88
Educational level	.07	.06	1.12	0.09
Household Size (persons)	.07	.01	6.15	0.00
Farm Size (acres)	.02	.002	9.26	0.00
Farming Experience (years)	.01	.01	-2.15	0.03
Annual farmer income	1.02	.03	1.57	0.12
2.Institutional factors				
Access to extension services	.17	.06	2.84	0.005
Access to credit	.02	.07	0.35	0.73
Employment	-.07	.09	-0.85	0.40
3.Environmental factors				
Soil fertility	.05	.01	7.02	0.003
Reduce soil erosion	.03	.04	6.34	0.00
Reduce deforestation	.18	.09	4.23	0.46
Reduce crop failure	1.12	.52	3.98	0.92

Source: *Research, 2019*

4.6 Impact of adopting agroforestry practices on livelihood of smallholder farmers

4.6.1 Annual income from crops

The farmers view on changing their household's annual income from the farming activities for both non-adopter and adopter's agroforestry farmers is presented in Table 4.10. The study considered the household yearly incomes that involve the money increased from the sales of both tree crops and food crops from the Agroforestry practices.

The results found in this study shows that annual farmer income was statistical significant evaluates for the average treatment effects on the treated (ATE). Propensity Score Matching demonstrates that implementing agroforestry practices boosts household income. This finding implies that households who use agroforestry technology are more likely to attain better livelihood outcomes than non-adopters. The increased level of income could help farmers meet certain household needs like affording medical bills and paying children's education fees. This indicates a significant impact on the livelihood of the households. These findings support the view that implementing agroforestry technologies can boost household income.

This result confirms observations by different authors (Rahman 2011; Hossain et al., 2005, Safa 2005; Hasanuzzaman et al., 2014; Rahman et al., 2007; Islam 2013) that the profit margins of agroforestry practitioners are higher than those of tree-free farmers. Adoption of agroforestry has led to higher income for families in the Philippines (Nepal (Regmi 2003 and Bugayong 2003). Therefore, adoption of agroforestry would be important to improve the farmer's income status and also improving the district's livelihood activities.

4.6.2. Consumption Expenditure

The farmer's household annual consumption expenditure for both non-adopters and adopters of agroforestry is presented in Table 4.10. The result for this study shows that consumption expenditure was statistically significant estimates for the average treatment effects on the treated (ATE). PSM show those who adopting agroforestry technologies consumed more money than non-adopters of agroforestry.

This implies that agroforestry could help them to secure access to food, able to afford school fees and learning materials for their children, clothes and medical treatment for the household members and also able to manage the comfortable living place. This had a positive impact on the livelihood of the farmers and their household and this is partly due to the fact that farmers can now use money that accrued from the sale of tree crops to purchase food items to supplement food in the household.

4.6.3 Progress out of poverty

The farmer's progress out of poverty for both non-adopters and adopters of agroforestry is presented in Table 4.10. The results found in this study shows that

progress out of poverty was statistical significant estimates for the average treatment effects on the treated (ATE). PSM shows that the use of agroforestry technology has a positive impact on domestic poverty. It can be concluded that Agroforestry adoption had a significant impact on the livelihood of most growers and their households.

Table 4.9: Average Treatment Effects (ATE) on the treated variable by Propensity Score Matching Model

Outcomes	**Coefficient.**	**SE**	**T- test**	**P-Value**
Annual farmer income	23163.27	5701.78	4.06	0.000**
Consumption Expenditure	-21440.18	3769.86	5.69	0.000**
Progress out of poverty	0.26	0.06	4.16	0.000**

Source: *Field survey 2019*

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides the summary of the findings, conclusion and recommendations based on the findings of the study. The chapter also outlines proposals for further studies

5.2 Summary of Findings

According to the study, most of the smallholder farmers were mainly non-adopters of agroforestry. It indicated that female farmers dominated relatively in the study. This study found that majority of smallholder's farmers in this area was married and also majority of them do not have another occupation apart from farming activities.

Most smallholders' farmers in this study have had primary education level. The most farmers in study area were adopted boundary planting as major practice of agroforestry. The study found that the input and productivity as major challenges of agroforestry adoption. Additionally, the study discovered that the majority of the trees planted were used for fuel wood and staking material.

Finally, this study found that household size, farmer size, soil fertility and soil erosion influence the farmers in Southern Province to adopt agroforestry practices. The findings reveal that the farmers who adopt agroforestry technologies are further likely to achieve better livelihood outcomes compared to non-adopters and also the result of this study found that those who adopting agroforestry technologies were consumed more money than non-adopters of agroforestry.

5.3 Conclusion

In terms of the type of agroforestry practiced, the study discovered that farmers in the study area use boundary planting.

Finally, the investigation found that the primary use of the trees they had planted was for firewood, leading them to pursue agroforestry in order to use the trees for fuel and stakes in the future. The study further concludes that smallholder farmers in Rwanda

were planted the trees in their farms to reduce the risk of top soil erosion and also to set boundaries of their lands.

The study sought to determine the socio-economic factors, institutional and environmental factors influencing smallholder farmers' decision to adopt agroforestry practices in Southern province of Rwanda. The key factors which had statistically significant influence on farmers' decision to adopt agroforestry practices were total household size, total farm size, soil erosion and soil fertility.

The study concluded that the size of farm had an influence on their decision to plant/not to plant trees. It further concluded that household size affect tree planting options among most smallholder farmers in many ways that include enough sources of labor and management. Farmers would also like to allocate their agricultural areas to cultivate trees that can protect the land from further soil erosion and increase soil fertility.

Impact of agroforestry on household livelihood of smallholder farmers as measured in terms of household income and consumption expenditure. Furthermore, the findings show that using agroforestry technologies raises household income and consumer expenditure significantly. The findings show that investing in land rehabilitation initiatives like agroforestry technologies is both economically and socially beneficial. The increased level of income could help farmers meet certain household needs like affording medical bills and paying children's education fees. The result has been established that Agroforestry innovations brings options for reducing poverty, improving food security and increase income and livelihood security of smallholder farmers in Southern province of Rwanda.

5.4 Recommendations

Interaction between farmer's and extension workers should be strengthened and the present extension services should be improved. Trainings should be imparted to farmers regarding different agroforestry system. The study proposes to raise awareness about the benefits of agroforestry practices and to provide technical assistance. The relevant government agencies should be encouraged the farmers in the areas to practice agroforestry so that they can benefit from crop yield of the crops and additional income from the sales of the tree products. Rwandan government also

should promote agroforestry for improved livelihood to increase the yield and productivity to smallholder farmers.

5.5 Area for further Research

Few studies have been carried out to examine how socio-economic factors affect agroforestry adoption among smallholders within farming communities. The available information regarding socioeconomic factors that affect agroforestry in many areas is often scanty in terms of quality and quantity. In this study Binary logit model was used to assess socio economic factor influence the farmers to adopt agroforestry but Binary logit model failed to provide statistically significant support to accept the influence of most of explanatory variables on farmers' adoption decision on agroforestry practice. Future research should be used another models to provide most of factors influence farmers to adopt agroforestry in order to increase household income, food security and welfare of smallholder farmers.

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APPENDICES

Appendix I: Questionnaire

THE IMPACT OF ADOPTING AGROFORESTRY TECHNOLOGIES ON LIVELIHOOD IMPROVEMENT AMONG SMALLHOLDER FARMERS IN SOUTHERN PROVINCE OF RWANDA

PREAMBLE

Dear Respondents,

I am MUKUNDENTE Liliane, Master's student at Kenyatta University (Reg.NO: N50EA/26073/2018) and I am doing a research on evaluating the impact of adopting agroforestry technologies on livelihood improvement among smallholder farmers in southern province, Rwanda.

The aim of this questionnaire is to collect information from smallholder farmers adopting and non-adopting agroforestry in order to evaluate the impact of adopting agroforestry techniques on livelihood improvement of those farmers. The information collected will be confidential and will not be used for any other purpose. The respondents are requested to be as honest as possible and also however you choose not participating or you may stop participating at any time without any negative effects.

Please endeavor to fill this questionnaire and turn back them to me and personal responses are recommended.

I am grateful to you for spending your time and accept to fill this questionnaire.

Thank you!

Yours sincerely,

MUKUNDENTE Liliane

GENERAL INFORMATION

Serial number: ……..

Date of the interview: ……. Time: ……..

Name of the Respondent: …… Cellphone Number: ……..

Name of the Enumerator: ……..…… Cellphone Number: ……

District: …… Sector: ……..

I. Demographic Information

1. Age: …….years
2. Gender: Male [ ] Female [ ]
3. Marital status: Single [ ] Married [ ]
4. Level of formal education:
   - No education [ ]
   - Primary Education [ ]
   - Secondary Education [ ]
   - Tertiary Education [ ]
   - University Education [ ]
5. Years of education: ……
6. Household size: …….
7. Employed: Yes [ ] No [ ]
8. Farm size: …….Acres
9. Farm under agroforestry: ……Acres
10. Farm Ownership rights: Private [ ] Communal [ ] Public [ ]
11. Farming experience: …….years
12. Annual farm income from crops: RWF……..
13. Annual farm income from trees: RWF…….
14. Annual farm income from livestock: RWF…….
15. Annual farm income from others, specify:

a. RWF……
b. RWF……
c. RWF……

d. RWF……

16. Annual off-farm income: RWF…….

17. Do you practice agroforestry? : Yes [ ] No [ ]

II. ADOPTERS QUESTION

i. Where did you get information of using agroforestry

Television [ ] workshop [ ] Social media [ ] training [ ] other [ ]

ii. Do you have access to extension services? Yes [ ] No [ ]

iii. Did you receive training on agroforestry? Yes [ ] No [ ]

iv. Do you have access to credit? Yes [ ] No [ ]

v. Do you have access to market of agroforestry product? Yes [ ] No [ ]

vi. For (v) if yes how fall is the market from your farming place in km? :…….

1. AGROFORESTRY PRACTICES

(Please select the main agroforestry techniques that you have adopted)

No	**Agroforestry practices**	√
1	Alley cropping	
2	homegarden	
3	Boundary planting	
4	improved flow	
5	scattered trees on farm	
6	woodlot	
7	Silvopasture	
8	Agrosilvopastoral	

1.2. What are the benefits from agroforestry?

No	**Services**	√
1	**Provision**	
	Fuel wood	
	Staking material	
	Constructional material	

	Grazing	
	Source of income	
2	**Regulating**	
	Climate regulation	
	Soil erosion control	
	control of weeds and pests	
3	**Supporting**	
	Reduction in crop failure	
	Improving of soil fertility	
	Nutrient recycling	
	Nitrogen fixation	
	Reduction of deforestation	
4	**Cultural**	
	Medicinal herbs	
	Aesthetic	
	Spiritual	

1.3. What are the Challenges affecting the adoption of agroforestry?

challenges	Yes	No
input		
Access to credit service		
Access to market		
Increase in product demand		
Productivity		

2. LIVELIHOOD OF FARMERS IN AGROFORESTRY

2.1. Income from agroforestry

a) How much money do you get from agroforestry per year in RWF? :…….

b) Please break down your income here:

i. Income from firewood: RWF……

ii. Income from charcoal burning: RWF…….

iii. Income from timber: RWF……

iv. Income from fruits: RWF……...

v. Income from oil: RWF…….

2.2. Consumption expenditures from agroforestry

a) How much money do you consume per year in Rwfs?: ……

b) Please break down your consumption here

i. Consumption for education: RWF……

ii. Consumption for food: RWF……..

iii. Consumption for accommodation: RWF……

iv. Consumption for insurance: RWF…….

v. Consumption for transport: RWF……..

vi. Consumption for clothes: RWF……

3.3. Progress out of poverty

No	**Indicator**	√
1	**How many of your children are in school?**	
	5	
	4 or 3	
	2	
	1	
	No children	
2	**What is the household's main source of drinking water?**	
	Hand pump, open well, closed well, pond, canal, river, stream, spring, other, or no data	
	Piped, motorized pump, or tube well	
3	**Does the household own a refrigerator or freezer?**	
	Yes	
	No	
4	**Does the household own a cooking stove?**	
	Yes	
	No	

5	**How many household members have salaried employment?**	√
	None	
	1	
	2 or more	
6	**Does the household own any type of land?**	
	Yes	
	No	
7	**Does the household own a scooter or motorcycle?**	
	Yes	
	No	
8	**Do you have your own television**	
	Yes	
	No	
9	**Does the household member get meal 3 times per day**	
	Yes	
	No	
10	**How many livestock do you have?**	
	None	
	1	
	2 or more	

III. NON ADOPTERS QUESTIONS

1. Are you aware about agroforestry?

Yes [ ] No [ ]

Note: if yes where do you get information about agroforestry?

Television [ ] Workshop [ ] Social media [ ] Training [ ]

Public lecturing [ ] other [ ]

2. Why are you not adopting agroforestry?

No	Constraints	√
1	Lack of capital	
2	Lack of qualified seed	
3	Lack of technical skills	
4	Lack of manpower	
5	Inaccessible market	
6	Limited access for credit	
8	Limited land	

3. Livelihood of farmers

3.1. Income from farming

a) How much money do you get from farming per year in RWF? :…….

b) Please break it down here:

i. Income from crops: RWF……..
ii. Income from livestock: RWF……

3.2. Consumption expenditures from agroforestry

a) How much money do you consume per year in Rwfs? :…….

b) Please break down your consumption here:

i. Consumption for education: RWF……
ii. Consumption for food: RWF……..
iii. Consumption for accommodation: RWF……
iv. Consumption for insurance: RWF…….
v. Consumption for transport: RWF……..
vi. Consumption for clothes: RWF……

3.3. Progress out of poverty

No	Indicator	√
1	**How many of your children are in school?**	
	5	
	4 or 3	
	2	
	1	
	No children	
2	**What is the household's main source of drinking water?**	
	Hand pump, open well, closed well, pond, canal, river, stream, spring, other, or no data	
	Piped, motorized pump, or tube well	
3	**Does the household own a refrigerator or freezer?**	
	Yes	
	No	
4	**Does the household own a cooking stove?**	
	Yes	
	No	
5	**How many household members have salaried employment?**	√
	None	
	1	
	2 or more	
6	**Does the household own any type of land?**	
	Yes	
	No	
7	**Does the household own a scooter or motorcycle?**	
	Yes	
	No	
8	**Do you have your own television**	
	Yes	
	No	

9	**Does the household member get meal 3 times per day**	
	Yes	
	No	
10	**How many livestock do you have?**	
	None	
	1	
	2 or more	

INTERVIEW GUIDE

The questionnaire by virtue of its nature may not have allowed for exhaustive and in-depth answer to the research questions; therefore personal (oral) interview was also conducted because some farmers were illiterate and the questions had to be translated into local languages. The result of personal interview will be used to supplement the information provided by the respondents.

1. AGROFORESTRY PRACTICES

1. **a)** Are the farmers participating in agroforestry practices?

Yes [ ] No [ ]

b) Do u identify agroforestry practices being employed in southern province?

……

……

……

2. **a)** Do u use different species of trees in you agroforestry practices?

Yes [ ] No [ ]

b) If yes, what kind of trees species and which tree species that is most frequently patronized by the farmers?

……

……

……

2. LIVELIHOOD OF FARMERS

1. a) Agroforestry agriculture can improve the farmer livelihood

Yes [ ] No [ ]

b) In which way the agroforestry make farmers livelihood improved?

……

……

……

2. a) Is agroforestry bringing the environmental benefit in southern province?

Yes [ ] No [ ]

b) Which environmental benefit indicates by the agroforestry?

……

……

……

3. a) Is there any challenge affecting the adoption of agroforestry?

Yes [ ] No [ ]

b) If yes, which challenge affecting the farmers to adopt agroforestry and which suggestion to those challenges?

Appendix II: Research Budget

EXPENSES DESCRPTION	BUDGET ($US)	BUDGET (KSH)
Stationary		
Photocopying	150	15170
Printing and Binding	100	10113.02
Subtotal	**250**	**25283.02**
Transport and Communication		
Phone calls	50	5056.51
Internet	100	10113.02
Transport (Sample Collection)	350	35395.57
Transport (During data collection)	300	30339.06
Subtotal	**800**	**80904.16**
Other Expenses		
Research Assistant Allowance (3)	200.00 ×5	101130.3
Accommodations	1500	151698
Sound record for interview data	500	50566
Photo camera	1000	101130.2
Computer laptop	650	65735.8
Subtotal	**4650**	**404528**
GRAND TOTAL	**5700**	**576452.4**

1 USD = 101.1302 KES as at 19 April 2019 (https://www.exchangerates.org.uk/Dollars-to-Kenyan-Shillings-currency-conversion-page.html).

Appendix III: Research Authorization

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Our Ref: N50EA/26073/2018 **DATE:** 27th September, 2019

Director General,
National Commission for Science, Technology
and Innovation
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MS. MUKUNDENTE LILIANE – REG. NO. N50EA/26073/18

I write to introduce Ms. Mukundente Liliane who is a Postgraduate Student of this University. She is registered for M.Env.Sc. degree programme in the **Department of Environmental Science & Education.**

Ms. Mukundente intends to conduct research for a M.Env.Sc. thesis Proposal entitled, **"Impacts of Agroforestry Technologies on Livelihood Improvement among Smallholder Farmers in Southern Province of Rwanda."**

Any assistance given will be highly appreciated.

Yours faithfully,

KENYATTA UNIVERSITY OFFICE OF DEAN 27 SEP 2019 GRADUATE SCHOOL P.O. Box 43844-00100 NAIROBI

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

JG/cww

Appendix IV: Research Permit

REPUBLIC OF RWANDA

Nyanza, ku wa 30/09/2019
N° 117/07.02

SOUTHERN PROVINCE
BP 41 NYANZA
TEL 252533385 FAX 252 533380
E-mail: south@southernprovince.gov.rw

Mrs. MUKUNDENTE Liliane
Tel: 0788792789

RE: Your letter requesting the permission to conduct academic Research

Mrs. MUKUNDENTE Liliane,

Reference is made to your letter requesting the permission to conduct academic research entitled **"Impacts of Agroforestry Technologies on Livelihood Improvement among Smallholder Farmers in Southern Province of Rwanda."**

You are informed that your request to conduct academic research in Nyanza, Huye, Ruhango and Muhanga Districts is accepted. This is for the interest of academic research only, and you will share with us results from your research.

Good luck.

MUSHAIJA Geoffrey
Executive Secretary
Southern Province
Tel:+250 788462645

CG Emmanuel K. GASANA
Governor of Southern Province

CC:

-Mayors of Nyanza, Huye, Ruhango and Muhanga Districts
SOUTH PROVINCE

Dukorane Umurava, Dutere Imbere- Serving the Community Faster, Smarter and Excellence