INFLUENCE OF AGROFORESTRY ON LIVELIHOODS FOR SMALLHOLDER FARMERS IN SOLIO SETTLEMENT SCHEME IN LAIKIPIA COUNTY, KENYA

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A Thesis Submitted to the School of Science and Technology in Partial Fulfillment for the Requirements of the Conferment of Masters of Science Degree in Agriculture and Rural Development of Kenya Methodist University

October, 2022

DECLARATION

Declaration

This thesis is my original work and has never been submitted for a degree at another university.

Signature…… Date……/……/2022

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Recommendation

This thesis has been submitted for examination with our approval as the university supervisor.

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DEDICATION

Dedicated to my partner-Jimmy Irungu, my children Jeremy Keru and Jamila Nyawira. My Parents, siblings and Nancy Odunga for their unending support throughout my study.

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ABSTRACT

Agroforestry adoption has shown potential in providing better environment benefits, food and energy, and enterprise development. Nevertheless, the agroforestry adoption is hindered by numerous factors among them, unreliable rainfall, lack of resources and lack of enough land space. The purpose of this research was to determine how agroforestry affects livelihoods of small holder farmers in the recently established Solio Settlement Scheme. The specific research objectives were three: to determine the environmental benefits of agroforestry to the small holder farmers in Solio Settlement Scheme, to measure food and energy diversification associated with agroforestry adoption small holder farmers in Solio Settlement Scheme and to assess the benefits of agroforestry adoption to enterprise development in Solio Settlement Scheme. The study distributed questionnaires 368 farmers who provided numerical data for statistical analysis. Descriptive and inferential statistics were conducted by use of SPSS to answer the research questions. Results were further presented by use frequency tables. During the entire investigation the researcher adhered to the relevant research ethics. The study established that 92.6% of the Solio Settlement Scheme practice agroforestry. Majority of the respondents moderately agreed that practicing agroforestry resulted to environmental benefits as indicated by the mean of 3.09 and standard deviation of 0.25. It was also found that many of the respondents moderately agreed that agroforestry is the source of food and energy diversification as depicted by the mean of 3.15 and standard deviation of 0.49. It was further established that 97% of the respondents agreed that agroforestry created enterprise development. The correlation results indicated that there exist a positive and significant association between environmental benefits and livelihoods of small scale farmers adopting agroforestry ($r = .636^{**}$ p= .0005). The study deduced that food and energy diversification had a positive and significant association with livelihood of small scale farmers adopting agroforestry ($r = .725^{**}$, p=.0005). The study further established that enterprise development had a positive and significant association with livelihood of small scale farmers adopting agroforestry ($r = .789^{**}$, p= .0005). The study concluded that farmers are capable of providing an adequate food diet for all household members throughout the year after implementing agroforestry through increased crop production. It also noted that agroforestry adoption reduced scheme temperature, soil erosion, water runoff, water floods, and wind speed while also providing habitat for a variety of animals. It further concluded that adoption of agroforestry has resulted in the establishment of numerous businesses. The study recommended that households need to plant agroforestry trees species that can conserve and restore ecological ecosystems. Agroforestry was established to be effective in supporting crop diversification because of the stable and favorable conditions there. Farmers ought to be trained on biogas production, organic manure preparation, bee keeping and tree nursery commercial practices by extension officers. The national government in conjunction with Laikipia County Government, Kenya forest services and Solio Settlement Scheme local leaders can organize agroforestry awareness trainings pertaining the importance agroforestry and how it should be undertaken.

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ABBREVIATION

M	:	Mean
MEA	:	Millennium Ecosystem Assessment
CGL	:	County Government of Laikipia
NGO	:	Non-Governmental Organizations
P-Value	:	Probability value
SD	:	Standard Deviation
SPSS	:	Statistical Package for Social Sciences
UN	:	United Nations
WB	:	World Bank

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Agroforestry is the intentional pairing of trees with crop plants and/or livestock in predetermined space arrangements and sequences, resulting in a variety of interactions (Coelho, 2017). Agroforestry is the technique of attempting to integrate and manage a consortium of forest and agricultural resources on the same area, with farmers planting trees on their farms, pasturelands, and homesteads (Kinyili, 2021; Peveri, 2021; Wanjira & Muriuki, 2020). Agroforestry, according to Shidiki et al. (2020), can be a spatial arrangement of plants and animals with simultaneous forest integration or a time-sequence where trees and shrubs are planted on a fallow to improve fertility.

Agroforestry has long been associated with sustainable livelihoods, sound land management, and long-term growth (Asaaga & Malhi, 2020; Tiwari, 2017). These include the availability of a variety of things for usage (Temu, 2013) such as energy in the form of firewood, building materials in the form of posts and timber, food in the form of farm-grown beans and maize, fruits, and medicinal natural herbs (Sharma & Singh, 2016; Wafuke, 2012).According to a study by Muir (2021), other non-timber items, such as wax and honey from bees, safe to eat fruits, nutritious insects, vegetables, herbal cures, brooms, and fibers, can be generated through agroforestry. Trees and shrubs provide several benefits, including capturing carbon from the atmosphere, tapping nutrients and water deep into the earth, supplying feed for cattle, producing microclimates, and offering aesthetic value (Uphoff, 2013; Recha et al., 2014). Furthermore, the bulk of wild animals rely on trees and shrubs for shelter and food (Mojo & Alebachew, 2014).

Small holder farmers and rural households around the world are being encouraged to use agroforestry to offer food security, diversify revenue through tree seedlings, firewood sales, and surplus food crop sales, and restore natural systems (Leach & Mearns, 2013; Carsan, 2012).

Following that, various international organizations, including the United Nations (UN) and the World Bank (WB), as well as governments and non-governmental organizations (NGOs), have contributed resources to encourage people to adopt agroforestry in tropical areas where conditions are favorable (Miller et al., 2017).

Globally, agroforestry has been moderately embraced in India, according to Sahoo and Majid (2020) the forest cover is 24.1% of the entire geographical land of the Indian nation. Agroforestry has been associated with this progressive forest cover recorded India. The conservation and management of forest has been strengthened through policy framework geared to protection of water systems. Agroforest accounts 72% of the fuel demand mainly sourced from small and medium timber, it also accounts 60-80% of raw material of pulp paper. Dhyani, et al. (2013) noted that agroforestry improved that fertility, provide fodder, produce tree fruits and expand wood fuel supply. Several research finding from different agro climatic condition in the India have indicated that financial returns generated vary from one area to another, nonetheless financial returns from unfertilized lands have been slightly low compared to fertilized firms. Government task force report (2001) pointed out that diversification of agriculture by other land use systems like forestry, animal husbandry, horticulture and fisheries etc., also has been envisaged, to make it more lucrative and ecologically sustainable.

In United States 75% of the productive assets are owned by the small scale farmer and most of them practice agroforestry as way of enhancing environmental conservation and boasting livelihoods among small scale holders (Valdivia et al., 2010). Gardener et al. (2000) remarked

that diversification has been manifested across small scale land owners practicing agroforestry and traditional crops are widely grown and also indigenous livestock are reared. Most of the agroforestry activities are practiced are alley cropping, windbreaks, forested riparian buffers and forest farming (Gold et al., 2000). These practices are beneficial in the long run incomes, stream, environmental and scenic beauty.

In Colombia Cacao agroforestry system is the most prevalent mode agroforestry because it favors Cacao crop grown by small scale farmers with differing production practices dependent upon climate, soils and household needs (Abbott et al. 2018). Cerda et al. (2014) pointed out that this system of agroforestry is associated with complex multi species cropping system where cacaos trees are associated with both temporary and permanent crops and woody trees. However, productivity of Cacao agroforestry is considered low and potential of harvesting timber is low (Abbott et al. 2018). On the other hand, Silvopastoral systems is alternative system adopted to bridge the gaps of Cacao agroforestry system, it is used in managing cattle ranches (Jose & Dollinger, 2019), and traditional have a high environmental impact but characterized by low productivity and deeply rooted on social economic background and supported by cultural conformity.

Regionally, in South Africa 40% of the population reside in the rural areas (department of forest and agriculture report, 2012). Most of the population in the rural areas has embraced agroforestry farming and this practice has been integrated with modern technology (Zerihun, 2021). There has been pressing need for promoting small scale holder agriculture to improve livelihoods to ensure food security. Agroforestry has been adopted in those rural areas to boast agriculture and this practice has been considered environmental friendly. Although agroforestry has been seen

globally as way of fostering agriculture and enhancing livelihoods, little has been embraced in the case of South Africa (Alao et al., 2013).

Agroforestry has been practiced in Nigeria over years based on a certain criteria known as systems, Amonum et al. (2009) pointed out that these systems exist in different places and they are unique, diverse and complex and thus calls for categorization into groups based on their common features. However, there are three basic elements managed across all agroforestry units which are comprised of Agrisilviculture, Silvopastora and Agrosilvopastoral. Agroforestry has been adopted more as agricultural by small scale holders' farmers contrary to being handmaiden for forestry. Agroforestry is critically for soil improvement and conservation (Snyder & Cullen, 2014). Agroforestry in most parts of Nigeria has been practiced to yield both wood and food and also to catapult conservation and rehabilitations of ecosystems. Many of the researchers from Nigeria have considered agroforestry as a solution to developed problems and understanding of indigenous trees system could immensely assist in solving emerging problems (Leakey, 2012).

Agroforestry was once poorly understood and adopted established in East Africa, according to Brown et al. (2018), with farmers participating in the activities always being less than 8% but has been increasing since the new millennium for instance smallholders in Ethiopia use various agroforestry practices based on socioeconomic and biophysical conditions, which have livelihood implications (Madalcho & Tefera, 2016; Alambo, 2020). Agroforestry is associated with several benefits which include atmosphere, tapping nutrients and water deep from the ground, providing fodder for livestock, creating a microclimate, and aesthetic purposes (Uphoff, 2013; Recha et al., 2014). Some of the common land use reasons carried out by these smallholder farmers include the deliberate preservation of naturally occurring trees on farmlands, the provision of incomes, the prevention of soil erosion, which results in a reduction in inorganic

fertilizer usage, and ecological systems (Iiyama et al., 2017). However, due to rising fuel wood demand and degradation of nearby forests, agricultural intensification, the growing popularity of exotic tree species that provide greater economic benefits to farmers, and the fact that land proclamations do not specify clear instructions for farmers on how to manage and conserve indigenous trees, the practice of agroforestry is declining in many agricultural landscapes in Ethiopia (Amare et al., 2019; Elagib & Al-Saidi, 2020).

Over the years, Kenya has used a variety of agroforestry techniques. The *shamba system* is the oldest, and it allows peasants to farm in state-owned forests and woodlands in exchange for care for the trees and bushes. Farmers are allowed to engage in agriculture during the early stages of afforestation or re-afforestation under the Plantation Establishment and Livelihood Improvement Scheme (PELIS), but they must stop once the canopies have covered the underlying vegetation (Chabeda-Barthe & Haller, 2018; Wanjira & Muriuki, 2020; Achungo, 2015). Farmers, on the other hand, plant trees and bushes on their farms in addition to growing crops and raising livestock (Njue et al., 2004).

Agroforestry, according to Kenyan experts, has the potential to provide economic, social, and environmental benefits by addressing household income, fuel, food supply, and environmental concerns if it is integrated at the household level (Catherine, 2021). There have been numerous campaigns in Kenya to direct and encourage farmers to adopt agroforestry practices in their farmland (Maina, 2020) and notably, agroforestry is being adopted in Kenya, with various designs, in private small-scale and government-owned farms for multiple objectives such as food, energy, and environmental benefits, including climate change mitigation (Sharma et al., 2016; Renzahoet al., 2017). However, due to a variety of factors, Kenya's rate of agroforestry

adoption remains low. As a result of agroforestry's low acceptance rate, several proposals have been offered to promote its use in various parts of the country (Kimaro, 2019; Bisong & Larwanou, 2019). Some of the proposals include adoption of climate smart agriculture to improve bio-geochemical interaction within landscape which reduces the competition of natural resources.

Solio Settlement Scheme is a brand-new program that began operations in 2009 (Gakuru, 2017). The project area is classified as semi-arid because it is located in the shadow of Mount Kenya and receives 550-900mm of annual rainfall. Until the squatters from central Kenya were transferred there, before then the area was not inhabited. The County Government of Laikipia (CGL, 2020) has made significant headway in restoring the area through tree and shrub planting. The agroforestry trees species that were grown by the county government; *Comiphoraafricana, Euphorbia tirucalli, Dovyalis caffra (kei apple), Moringa oleifera, Psidiumguajava and Erythrina abyssinica.* According to CGL, residents are also interested in raising livestock and growing vegetables. As a result, this is an excellent location for building human-environment interaction, notably in the fields of agriculture and tree planting. Because smallholder farmers make up the bulk of the population, agroforestry has a huge potential for them. This is because agroforestry uses small parcels of land to create a wide range of products and services (Muschle, 2016). Via order to boost smallholder farmers' livelihoods, economic development, and resilience, the Laikipia county administration has attempted to promote the use of agroforestry in the Solio Settlement Scheme (Laikipia County Development report, 2020). However, there has been very little effort to evaluate the trade-off between agroforestry adoption and its effects on the livelihoods of these Solio Settlement Scheme small holder farmers. According to Benjamin (2018), income expansion, ecosystem advantages, increased productivity due to reduced

inorganic fertilizer use, and diversity of food and energy products are all common pronounced livelihood components recognized in agroforestry adoption. Unfortunately, studies on the impact of agroforestry adoption on livelihoods are scarce. This research looked at how agroforestry adoption impacted on small holder farmers' livelihoods in the Solio Settlement Scheme, with a focus on environment, food and energy diversification, and enterprise development, as well as how these benefits acted as a catalyst to sustain agroforestry adoption in the ranch.

1.2. Problem Statement

Farmers who use agroforestry benefit from greater environmental change, income, food, and energy diversification. New resettlement programs aimed at supporting people to acquire land result to different rural development benefits like income generation, infrastructure growth (roads), industrialization and optimal land utilization. Additionally, environmental conservation has resulted to increased food production and enhancement of livelihoods among habitants of Solio settlement scheme.

In all Kenya’s agricultural areas, efforts are being made to increase agroforestry's role in delivering ecosystem services, improving livelihoods, and lowering use of inorganic fertilizer as environmental consciousness among small scale farmers grows. Further, there is a growing body of research that suggests that agroforestry contributes to development of enterprises, increased food and energy output, and mitigating the effects of climate change. Despite the existing knowledge and awareness of the benefits of agroforestry, recent studies show that even when farmers adopt agroforestry, they still face challenges in sustaining their livelihoods. This begs the question of the practicality of agroforestry in sustaining livelihoods. In order to have better knowledge of how agroforestry affects the lives and livelihoods of smallholder farmers, it's critical to evaluate the farmers’ attitudes and experiences. Furthermore, farmers must understand

the benefits of agroforestry before they can adopt it on their farms. This study sought to determine the influence of agroforestry adoption on the livelihoods of smallholder farmers in Solio Settlement Scheme in Laikipia County.

1.3 General Objectives

The study determined the impacts of agroforestry adoption on the livelihoods of small holder farmers in the Solio Settlement Scheme in Laikipia County.

The study was guided by three specific objectives:

i. To determine the environmental benefits of agroforestry to the small holder farmers in Solio Settlement Scheme.
ii. To measure food and energy diversification associated with agroforestry adoption small holder farmers in Solio Settlement Scheme.
iii. To assess the benefits of agroforestry adoption to enterprise development in Solio Settlement Scheme.

1.4. Research Questions

i. What are the environmental benefits that results from agroforestry adoption in Solio Settlement Scheme?
ii. Has the agroforestry provided food and energy diversification to the small holder farmers in Solio Settlement Scheme?
iii. What are the benefits of agroforestry adoption to enterprise development in Solio Settlement Scheme?

1.5 Significance and Justification of the Study

The findings of this study would provide insights on the impacts of incorporating agroforestry into settlement projects. Farmers would be notified about the degrees of diversification of their household earnings from honey extraction, tree nursery business, crop sales, energy in the form of firewood, and sales of building posts and timber. Furthermore, farmers would benefit from the study by understanding how the trees they planted serve to improve the overall landscape, improve food security, increase output, and overall livelihood sustainability.

The findings of this study would be particularly valuable to the Laikipia County Government and other climate change partners since they would inform the contributions those smallholder farmers who practice agroforestry would benefit. They would use this document as a guide when developing a policy that will lead to the reclamation of other degraded areas, thereby boosting their productivity and enhancing their food output.

The study would motivate other academics to perform additional research on the impact of agroforestry adoption on livelihood of smallholder farmers of resettlement schemes across the board and nationalism as well as other concerns aroused and suggested under further research recommendations section in chapter five. The majority of those residing in the Solio resettlement plan came from roadside camps and other informal settlements (CGL, 2020). As a result, these people must make use of the available resources (land and water) to improve their lives. Because the region is semi-arid, agroforestry is a viable option for them. Studies on the impact of agroforestry on smallholder farmers have highlighted the social, economic, and environmental benefits (Kinyili & Ndunda, 2021). However, little has been done to identify the unique impacts of agroforestry adoption on the livelihood of smallholder farmers in the newly established ranch system in Laikipia County, resulting in a knowledge gap. As a result, it is reasonable to expect

that this study would provide pertinent information about the impacts of agroforestry adoption on smallholder farmers in Solio Settlement Scheme.

1.6 Scope of the Study

The research was conducted at the Solio Settlement Scheme, in Tigithi ward which is located in the shadow of Mt Kenya and is characterized by 550-900mm annual rainfall, thereby making it a semiarid environment. The Solio Settlement Scheme is divided into seven villages namely; Furaha, Rehema, Bahati, Tetu, Mathingira, Makandamia, and Baraka. The researcher chose this Solio Settlement Scheme plan since the land was dry and initially had almost no trees when the residents were relocated to it in 2012. This initial situation has changed over the last twelve years and the area has experienced an increase in the tree cover and overall vegetation type. As a result, the small holder farmers in this scheme are in an excellent position to highlight the benefits they have received through adoption of agroforestry on their farms.

1.7 Study Limitations

The focus of this research was on the Solio Settlement Scheme in Laikipia County. The study's drawbacks included the fact that the characteristics of smallholder farmers in the Solio Settlement Scheme would not have been distinguished from other smallholder farmers, and thus the study's findings in terms of agroforestry adoption might not be generalizable to other counties. In addition, the type of agroforestry tree species varies from region to region based on ecological conditions presenting contextual limitation. In terms of conceptual limitation, there are numerous benefits of agroforestry However; this study was limited to environmental benefits, food and energy benefits and enterprise development.

1.8 Assumptions of the Study

During the research, the researcher made the following assumptions:

i. Respondents would be able to openly express their thoughts and feelings about the study variables.
ii. That the farmers would objectively provide accurate and truthful answers to the questions.
iii. Variables not employed in this study had no significant bearing on the results.

1.9 Operational Definition of Terms

Agroforestry: This is referred to a simultaneous integration of trees, cultivatable crops, and livestock in fields (Jose et al., 2012).

Ecosystem services: In the context of this study, "ecosystem services" refers to the benefits received from the use of agricultural practices (Ziter & Turner, 2018).

Enterprise development: In the context of this research, enterprise development means the process of investing time and resources in agroforestry in order for farmers to establish and discover a way out of poverty thereby improving their living standards.

Income: Financial or material gain derived from agroforestry adoption by small holder farmers

Livelihoods: Livelihoods are the circumstances in which the majority of people live and are able to meet their basic necessities (Dinku, 2018).

Scheme: A scheme is a plan for promoting rural development by establishing farmers in impoverished areas with the goal of increasing their income (Awulachew, 2019).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses prior research on the effects of agroforestry adoption on small-holder farmers' livelihoods. It also explores pertinent empirical reviews on the impact of agroforestry to the lives of smallholder farmers, as well as the conceptual framework, operational framework, and research gaps.

2.2 Adoption of Agroforestry and Livelihoods

Agroforestry is practiced by smallholder farmers worldwide with the primary purpose of increasing indoor food, energy, and revenue (Mume & Workalemahu, 2021). Farmers in Latin and Central America replicated the floral diversity of tropical forests by planting crops with a range of growth types (Altieri et al., 2015). According to Dagar and Tewari (2016), agroforestry was conducted in Asia through a complex system of shifting cropping, with some trees purposefully left standing to create a partial shade for new foliage to emerge before the rice growing season ended.

In Africa, Amonum and Bada (2019) discovered an extensive mixture of herbaceous plants and trees in Katsina State, Nigeria, whereas in Malawi (Coulibaly et al., 2017) discovered crops were cultivated in combination with tree species to produce food and timber. These examples from across the globe demonstrate that previous households were more concerned with food production and the integration of trees into farms for other purposes. Agroforestry rarely reaches 9% of farmland in the majority of countries (Kamoto et al., 2021). Thus, agroforestry productivity in numerous countries continues to be insufficient to make a sustainable

contribution or to meet the general population's need for trees and their associated goods (Sharma & Sharma, 2017). As a result, the majority of agroforestry is always abandoned in favor of other food cropping systems (Muschler, 2016).

According to studies, the proclivity for agroforestry development in Kenya has always been associated with a strong demand for food, energy, and medicine, as well as the possibility to produce money through the sale of firewood, seedlings, poles, and timber (Jerneck & Olsson, 2013).

Smallholder farmers in Kenya and Ethiopia use agroforestry to provide timber and poles for construction, according to another study by (Kinyili et al., 2020; Catherine, 2021; Jha et al., 2021). As a result, agroforestry is considered as a means of diversifying production, mitigating the risk of global warming, and reducing inorganic fertilizer use, all of which contribute to augmenting limited household incomes (Kinyili & Ndunda, 2021) as well as relieving strain on natural forests (Lin, 2014). However, it is disputed if these aims have been realized in many developing countries. According to Nyaga et al. (2015), roughly 1.2 million Kenyans practice some type of agroforestry on their farms and in rural communities. While these farming communities have long practiced agroforestry, there is a dearth of awareness about agroforestry's contribution to their livelihoods, economic development, and environmental advantages (Meijer et al., 2015). Smallholder farmers in Kenya utilize agroforestry because it is a cost-effective method of simultaneously growing trees, crops, and rearing cattle (Benjamin & Sauer, 2018).

2.3 Practice of Agroforestry

Agroforestry practices range from traditional to modern (Zerihun, 2021). Agroforestry is classified into eight categories in distinct temperate and tropical regions based on its nature, complexity, and function (Sultana & Bari, 2021). First, it is the role of homestead gardens.

Homestead gardens are techniques that involve the arranging of a variety of trees, crops, and possibly livestock in an intimate, multistory configuration (Kumar, 2015). Second, the term "agroforestry" refers to crops grown on mountain slopes prior to the formation of forest plantations (Dhakal & Rai, 2020). Thirdly, improved fallow refers to rapid-growth woody plants, preferably leguminous, that are planted during shifting agriculture's fallow phase (Nair et al., 2021). The fourth is agricultural and plantation crop synthesis, which comprises multistory tree crop combinations, shade trees and crops (Sultana & Bari, 2021; Nimbolkar, 2016). Fifth, multipurpose trees are fruit and other trees planted randomly or deliberately in cropland or pasture to provide fruit, fuel wood, fodder, and timber on farms and rangelands, among other services (Zerihun, 2020).

The sixth agroforestry practice is mixing trees with fodder and livestock production, such as grazing in existing forests, using trees to create live fences around pastures, or providing shade and erosion control, a practice dubbed' silvopasture' agroforestry (Nair et al., 2021; Elevitch et al., 2018). Seventh, windbreaks and shelterbelts are rows of trees planted and managed around farms and fields as part of agriculture or livestock production in order to protect crops, cattle, and soil from natural dangers such as wind, heavy rain, waves, or flooding (Nair, 2012; Bhardwaj et al., 2017). Finally, alley cropping is the cultivation of fast-growing, typically leguminous woody species in single or grouped rows that are mulched into agricultural production lanes to add organic matter and nutrients and/or gathered for a variety of purposes, including animal fodder (Boinot et al., 2019).

At the global, regional, and local levels, efforts have been made to characterize the environmental benefits of agroforestry adoption. According to Kremen (2020), agroforestry benefits both adopters and non-adopters significantly through carbon sequestration, soil and

water management, and habitat for pollinating insect and mammal species. Attaining these benefits will considerably boost food security, livelihoods, and poverty reduction, all which humans rely on ecosystems to provide (Currier & Robinson, 2018; Quandt et al., 2019). Several studies, however, have discovered that the environmental benefits of agroforestry tend to provide only a marginal level of subsistence for smallholder farmers and/or prevent communities or households from falling into poverty, rather than actively contributing to a household's continuous improvement (Francis et al., 2015; Chemarum, 2016).

As a result of these advantages, the Millennium Ecosystem Assessment (MEA) proposes that ecosystems be preserved in order to continue benefiting humans (Congreve & Cross, 2019). However, it is the concept's extension to agroforestry that has sparked considerable research interest, as it describes the benefits humans derive from agroforestry as an ecosystem (Noordwijk, 2021). Most of the anecdotal evidence supporting ecosystem service benefits comes from developing countries, where populations rely heavily on natural ecosystems without appreciating the true benefits, due to their proximity to forest ecosystems and reliance on subsistence agriculture (Meijer et al., 2015; Benjamin &Sauer, 2018).

In Kenya, few studies have been conducted on the merits of agroforestry and this has been attributed to inadequacy of governance will from respective stakeholders (Quandt, 2018). According to Bishaw et al. (2013), Kenya lacks a comprehensive understanding of the role of agroforestry in increasing biodiversity, improving soil fertility, minimizing erosion, improving hydrological regimes, and sequestering atmospheric carbon. By assessing and combining such crucial data into decision-making, more informed judgments on natural capital for human well-being and livelihood can be made to guide management activities and policies targeted at achieving a varied range of environmental advantages.

Climate change, frequent droughts, depletion of natural resources, and reduced agricultural output have aggravated the situation in most areas in the world, resulting in high poverty rates (Syano et al., 2016). Agroforestry, which involves planting trees on farms and in agricultural landscapes, has recently been regarded as a strategy of earning revenue and lowering production costs in terms of soil quality (Syano et al., 2016). Agroforestry has been acknowledged for its enhanced economic return, which has a substantial impact on rural incomes (Kinyili et al., 2020). The economic benefits of agroforestry have maintained an incomprehensible level of interest among research communities, particularly in impoverished nations (Kinyili, 2021). Agroforestry is currently being employed by many smallholder farmers in Africa (Awazi & Tchamba, 2019; Amare et al., 2019; Quandt et al., 2017). (Nkonya et al., 2016; Meijer et al., 2015). The idea of managing trees with crops and cattle on the same land is seen as a possible revenue source (Mbowet al., 2014).

Smallholder tree planting reduces other options (Van Der et al., 2020; Benjamin & Sauer, 2018). As a result, smallholder tree nursery businesses strive to maximize productivity and ultimately tree yields, hence increasing profits. Smallholder tree nursery businesses have fixed costs for land, buildings, heavy equipment, and machinery, as well as land levies (Kinyili, 2021). Variable expenses like fertilizers, seedlings, labor, transportation, and pesticide purchases, as well as other operating overheads such as power, must also be addressed. As a result, the revenue generated by these smallholder farmers' tree nursery enterprises is extremely reliant on input costs. Smallholder farmers also sell firewood, honey, and cattle folders (Kinyili & Ndunda, 2021).

Agroforestry also helps slow land deterioration and improve soil productivity, quality, and sustainability (Roy, 2016). As a result, a lot is known about how agroforestry affects soil

properties. Although agroforestry advocates claim the principal benefit is reduced inorganic fertilizer use, the debate continues about which soil qualities are improved. Agroforestry improves soil chemical, physical, and biological properties, enhancing crop and tree output (Muchane et al., 2020). Most of the soil's biological task-fulfillment potential can be determined by increasing output. Agroforestry plants and bushes promote soil fertility by fixing atmospheric nitrogen (N2) (Lorenz & Lal, 2014). The root system accumulation and litter fall of agroforestry trees help concentrate nutrients in the soil (León & Osorio, 2014).

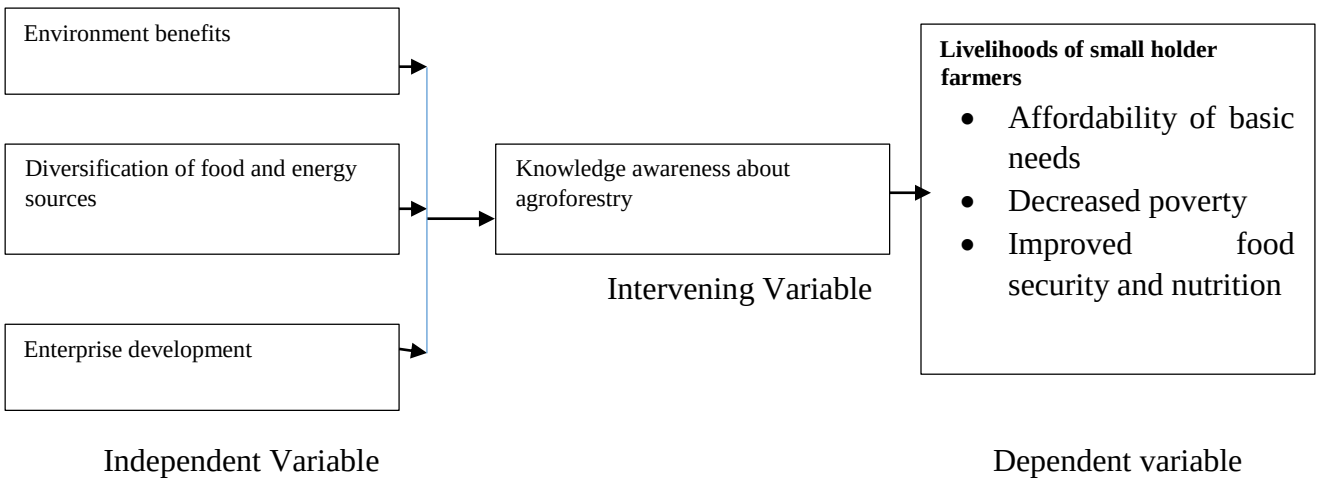
Agroforestry's principal benefits are often linked to its impact on soil quality (Muchane et al., 2020). The cover function of agroforestry reduces the impacts of rainfall and wind on soil aggregates (Jnr, 2014). Numerous studies have shown that agroforestry improves soil physical properties (Dollinger & Jose, 2018; Muchaneet al., 2020) Trees have shown to improve water infiltration and soil moisture, raising soil moisture, boosting water infiltration, minimizing inorganic fertilizer use, and enhancing water dynamics are all closely related to soil quality and agroforestry (Kuyah et al., 2019). Soil biodiversity and microbial biomass protection (Kumar & Babalad, 2018). Soil qualities can be improved by agroforestry practices in Sub-Saharan Africa (Beauty & Singh, 2019; Anyango et al., 2020). Numerous scholars have investigated and documented the benefits associated with diverse agroforestry adoption schemes, each with its own unique socioeconomic and livelihood implications (Meijer et al., 2015). However, research on the benefits of agroforestry to enterprise development to livelihood is scant.

2.4 Conceptual Framework

Gichungu and Oloko (2015) and Kiminza and Were (2016) postulate that conceptual framework is a diagrammatic and methodical representation that shows the relationship between dependent variables and independent variables. In this study, the independent variable was the impacts of agroforestry adoption identified under the study (Environmental benefits, diversification of food and energy and enterprise development) whereas the dependent variable was the livelihoods of smallholder farmers in Solio Settlement Scheme in Laikipia County as identified by indicators shown in Figure 2.1.

Figure 2.1

Conceptual framework

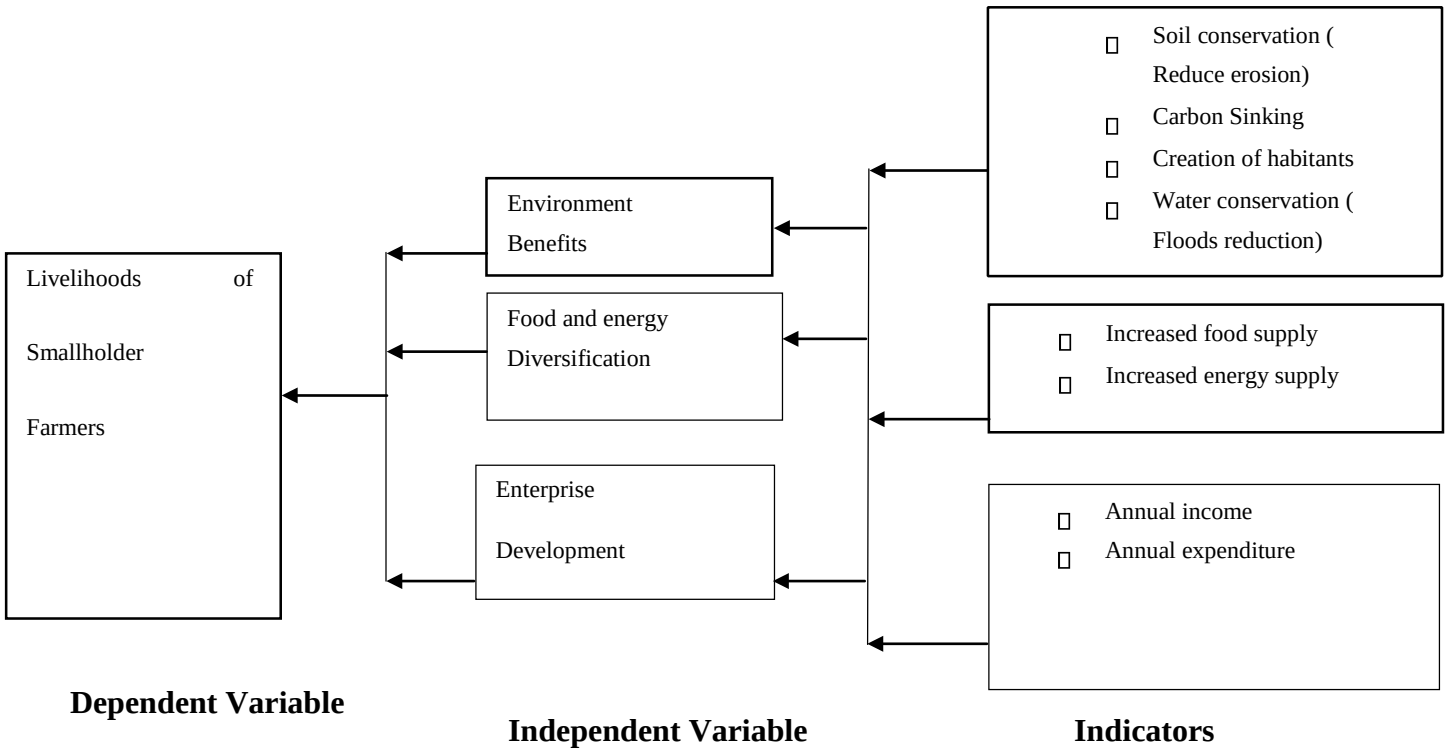


2.5 Operationalization Framework

Operational framework is an arrangement of variables that the researcher operationalized in order to accomplish the study objectively (Tobi & Kampen, 2018). Figure 2 Operationalization of key variables

Figure 2.2

Operationalization of variables



2.6 Research Gap

Agroforestry is clearly gaining popularity in African countries (Mwase et al., 2015). However, little research has evaluated the combined socioeconomic and environmental benefits of agroforestry adoption. Concerning reduction in inorganic fertilizer use, it is well established that agroforestry delivers a variety of benefits to adopters (Ospina, 2017; Jose & Udawatta, 2021) but little research has examined benefits in terms of output growth. Numerous researches indicates that agroforestry produces items that smallholder farmers can sell directly to enhance their livelihoods; yet, studies on the income generated by agroforestry have received scant attention in the Solio Settlement Scheme project and throughout Kenya. Finally, multiple studies have

demonstrated that agroforestry benefits smallholder farmers' food and energy security (Amare et al., 2019). Such research, however, is scarce in Kenya, and it is unknown whether or not agroforestry has diversified food and energy sources in the Solio Settlement Scheme since its inception. As a result, this research would be necessary to assist close this knowledge gap.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The tools and procedures that were employed to accomplish the research objectives are described in this chapter. It defines the study design, pre-testing procedures, the target population, the sampling frame, the desired sample size, the sampling process, the data collection methods, and the pretesting procedures. Additionally, it explored the procedures of data management, statistical measurement models, data processing and analysis methodologies, and presentation.

3.2 Study Design

A research design is a strategy for answering the research questions using empirical data the term research design' refers to both the whole process (including research methodology) and the research design structure (Rahi, 2017; Wing et al., 2018). This study employed the descriptive research design because its aim was to accurately and systematically describe the situation of target population in the study area. According to Lucas (2018), survey research is a self-report study that collects quantitative data by using samples drawn from a target population, in these small scale farmers in the study area. This research strategy was regarded to be appropriate since it allows the researcher to generalize findings from samples to the target population and to characterize "what exists" in terms of variables or circumstances in a situation. Descriptive research design is appropriate in obtaining information to systematically describe a phenomenon, situation, or population. More specifically, it helps answer the what, when, where, and how questions regarding the research problem, rather than the why.

The primary reason for using descriptive research methodology is that the study problem is well-defined, and the researcher wants to perform field surveys by travelling to the target group to explain particular qualities depending on their own perception of the issue (Creswell, 2013; Da Silva, 2017). Hence, this method was suitable for assessing the influence of adopting agroforestry on the livelihoods of smallholder farmers in the Solio settlement in Tigithi Ward, Laikipia County.

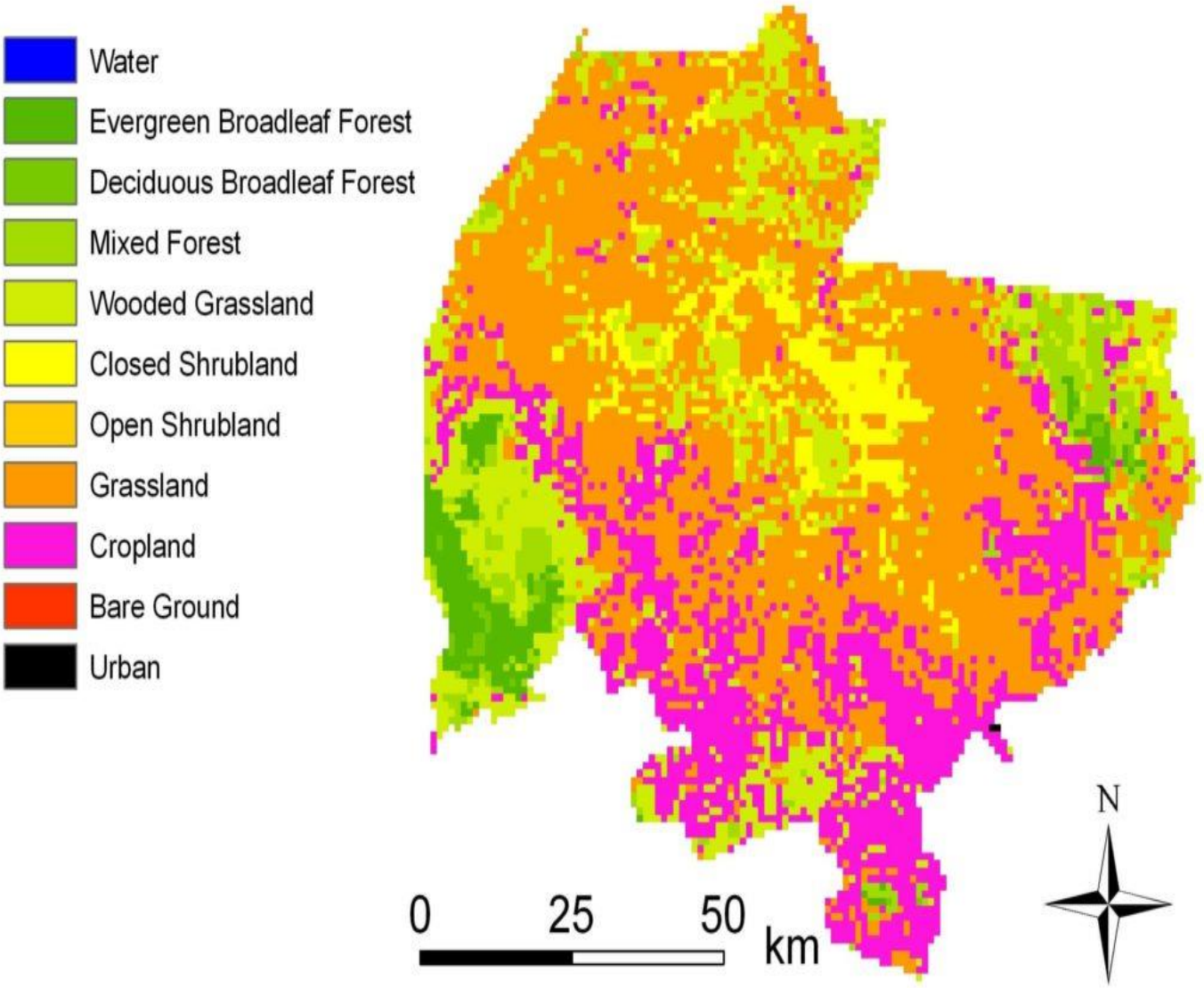
In order to seek answers to the research questions, questionnairres were admistered to the farmers to learn how agroforestry adoption had benefited the farmers. The household surveys also quantified the roles of farmer-managed agroforestry interventions on farmers' economic status (Erbaugh & Oldekop, 2018).

3.2.1 Study Area

Solio Settlement Scheme is a brand-new program that began operations in 2009 (Gakuru, 2017). The Figure 3.1 shows the map of the study area.

Figure 3.1

Map of Solio Settlement Scheme



The project area is classified as semi-arid because it is located in the shadow of Mount Kenya and receives 550-900mm of annual rainfall and lies Until the squatters from central Kenya were transferred there, before then the area was not inhabited. The County Government of Laikipia (CGL, 2020) has made significant headway in restoring the area through tree and shrub planting. The annual average temperatures of Solio Settlement Scheme are 22 degrees Celsius, and normally hot, dry and windy. Loamy-clayey soil types are dominant is the settlement scheme. The County Government of Laikipia in conjunction with other stakeholders like Upper Tana Nairobi Water Trust Fund, SACDEP and Moving Mountains have made significant progress in reforming the Solio Settlement Scheme. The agroforestry trees species promoted by the Solio Settlement Scheme include; *Acacia xanthophlea (murera), Croton megalocarpus (Mukinduri), Fraxinus pennysylivanica (Miiria), Grevillea robusta (Mukima) and Olea africana (Mutamaiyu).*

3.3 Target Population and study area

According to Etikan et al. (2016), the Target population of a study is the total number of participants. Additionally, Stacks (2016) defines "target populations" as "individuals, events, or records that contain the desired attributes and may provide answers to the measurement questions." Pandey (2021) contributes to prior research by confirming that the target population refers to the group of persons, objects, or stuff from which samples are taken for analysis. In 2007 the Kenyan Government purchased through the Settlement Trustee Fund approximately 15,000 acres from Solio Settlement Scheme. Most of the land acquired lies within Laikipia County. A smaller portion lies within the Nyeri County. There are currently 4,600 households in this area of study.

Table 3.1

Target population

Area	Population
Solio East Settlement Scheme	1200
Solio West Settlement Scheme	3400
Total	4600

3.4 Sampling Frame

The sampling frame is the range of sampling units in the survey (Taherdoost, 2016). A sample frame contains elements in the population from which a sample unit will be taken (Neuman, 2016). The study adopted the list of currently registered small holder farmers by the county government of Laikipia and the Upper Tana Nairobi Water Fund.

3.4.1 Sampling Methods, Sampling Design and Sample Size

This section describes the procedures for selecting the study subjects from the target population. Sampling is the process of selecting a representative sample or segment of a population in order to ascertain the population's characteristics, as stated by (Alvi, 2016).

Sharma (2017) defines a sample as a group of units drawn from the target population to reflect the complete population. Additionally, Porto (2015) defines a sample as a subset of a population that enables a researcher to gather data and make predictions about the population using statistical inference in a descriptive survey (Pandey, 2021; Makar, & Rubin, 2018). Generally, the higher the sample size, the more likely the variable scores will be reflective of the population scores (Sharma, 2017; Etikan & Bala, 2017).

The researcher used Sloven's method to determine the sample size for the investigation.

$$n=N / (1+Ne2$$

Where, n = desired sample size N= target population size e =the level of precision adopted

$$4600 / (1+4600(0.05)2=4600/(1+11.5)=368$$

Therefore, the study sampled 368 small holder farmers were engaged in the research using stratified random sampling. A stratified random sample is one obtained by dividing the population elements into mutually exclusive, non-overlapping groups of sample units called strata, then selecting a simple random sample from within each stratum (stratum is singular for strata). Every potential sample unit must be assigned to only one stratum and no units can be excluded. Solio Settlement Scheme consists of two areas; Solio East Settlement Scheme and Solio West Settlement Scheme. Table 3.2 presents the distribution of target population within each stratum.

Table 3.2

Sample size distribution

Area	Population	Sample computation	Sample size
Solio East Settlement Scheme	1200	1200/4600*368	96
Solio West Settlement Scheme	3400	3400/4600*368	272
Total	4600		368

3.5 Tools for Data Collection

Semi structured questionnaire was used to collect primary data (Sileyew, 2019). According to Odhiambo et al. (2020), a questionnaire is a document comprised of a set of questions printed or typed in a predetermined order on a form or collection of forms. A structured questionnaire was used since it is an efficient way to collect data in a short amount of time and at a lower cost than other data collecting methods (Sintema, 2020).

The questionnaire was designed in accordance with the study objectives and research questions (Boateng, 2018) where it had closed-ended questions to fundamentally steer the participants to the vital response choices and open-ended questions to allow the respondents to express their opinions and views in a more pragmatic manner (Ragab & Arisha, 2018). Furthermore, the questionnaire included sections or questions in the form of Likert scales to assess the level of agreement of responses among the respondents (Anjum, 2020). The researcher, in collaboration with five research enumerators, administered questionnaires to gather data by visiting the target households.

3.6 Data Collection Procedures

Before beginning the data collection process, a written authorization was obtained from the appropriate authorities (Bryman, 2021). The researcher provided the respondents a brief overview of the study's purpose in relation to the research objectives and assured the participants of the confidentiality of the information that they would submit. The collected data was first evaluated for completeness and consistency before statistical analysis was conducted. A letter from the university research department and national commission of science, technology and innovation (NACOSTI) will be sought to grant the researcher permission to collect data from the respective respondents' households.

3.7 Pretesting of Research Instruments

Preliminary testing was carried out to establish the validity and reliability of data collection tools, as well as to become familiar with the questionnaire administration method, prior to the real data collection (Gray, 2021; Althubaiti, 2016). Twelve small-holder farmers from Village Five Mathingira of Solio were chosen to take part in the pilot trial. Pilot data was used to improve the research tool through elimination of errors and simplifying the research tool so that it became easier for the respondents to answer questions concisely. Pilot results were also used to gauge the logistical arrangements the researcher will confront during the actual data collection. To avoid data duplication, pilot study participants were not resampled to participate in the main study (Gennaro & de Bruin, 2020) and also pilot data was not used in the final analysis because of its nature where it was still considered error prone and improvement was needed.

3.8 Instrument Validity

It has been established that the validity of an instrument evaluates an instrument's relevance to the study's purpose(s) and research question (Heale & Twycross, 2015; Taber, 2018). The researcher examined three different ideas of content validation: construct-related validation, criterion validation, and method validation (Mohajan, 2017; Clark & Watson, 2016). An extracted construct's square root average variance must be greater than the correlations between the construct and the other constructs for the construct to be valid (Asmelash & Kumar, 2019).

3.9 Reliability

Transparency reduces bias and ensures neutrality and credibility (Singh, 2014; Hair et al., 2021). Reliability is the consistency of scores obtained by the same person taking the exam at different times, under different settings, or by different raters (Baotenget al., 2018; Mueller & Knapp, 2019). Internal consistency is defined by Knupfer and McLellan (2013) as the degree of correlation between items of a single instrument, whether in separate halves of the test or within a single subject or content (Watson, 2019).

It was necessary for the researcher to apply the Cronbach's coefficient alpha in order to analyze the internal consistency of Likert scale scores and to assess the reliability of the measurements (Feng &Yamat, 2019; Gupta & Bashir, 2018). Cronbach's coefficient alpha has a scale value between -1 and +1, with an alpha level of 0.70 or higher being considered satisfactory (Peterson & Kim, 2013; Peters, 2014).

A reliability test was performed to determine the dependability of the data collection instruments. Cronbach's coefficient Alpha which measures internal consistency of the instrument was conducted using SPSS window version 25. Results are shown in Table 3.3.

Table 3.3

Reliability Statistic

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	Comment
.963	.963	34	Dependable

The findings in Table 3.3 indicate a Cronbach's Coefficient Alpha value of 0.963. Cronbach Alpha coefficient of 0.7 and above is termed as reliable and satisfactory results (Ingle & Mahesh, 2020). Hence, the constructs in the questionnaire were considered reliable for statistical analysis.

3.10 Data Processing and Analysis

Data exploration (Editing, coding, classification, and tabulation) was conducted so as to the raw for statistical analysis (Kothari, 2009; Sharma, 2018). Data screening and cleaning followed data entry. Frehiwot (2020) recommends tabulating acquired data in order to identify and check for errors, violations, incompleteness, misclassification, and gaps in the information gathered from the respondents, as well as to identify and correct errors.

To achieve the study's aims, data were analyzed using Statistical Package for Social Sciences (SPSS) version 25. Tiwariet al. (2018) defines data analysis as the act of organizing, structuring for decision making or drawing conclusions, reducing data to manageable size, producing summaries, looking for patterns and applying inferential statistical tools.

Correlation analysis, and paired samples T-test was used to examine statistically significant difference between and among respondents concerning measured environmental advantages, food and energy diversification and enterprise development deriving from agroforestry practice.

3.11 Normality Testing

Normality is determined by the Shapiro Wilk test, which does not need multiple graphs to be drawn (Gargiulo, 2020). The normality of the residual distribution was checked using the Shapiro Wilk test (Khatun, 2021). The numerical data on dependent variable gotten were found to be normally distributed hence; the researcher used non parametric techniques (Spearman Rank Correlation) for data analysis (Sedgwick, 2014).

3.12 Ethics Considerations

The researcher ensured ethical conduct while carrying the study. Thus, our research was guided by the following ethical guidelines:

Reliable study: This study focused entirely on the identified research questions. As a result, the study's results would be compatible with the questions posed and the data. Furthermore, research ethics mandates that the procedures applied be closely related to the study objectives (Robinson, 2021). Therefore, we were primarily seeking to get replies that would allow us to develop a reliable study on the impacts of agroforestry adoption on the livelihood of small-holder farmers in the Solio Settlement Scheme.

Consent and Voluntary Participation: This study was guided by the reality that no farmer would be forced to reply to the concerns we are addressing, and each farmer is only required to respond with his or her own agreement. The respondent and the researcher agreed on participation before actual data collection.

Confidentiality: Given that we are conducting research on resettlement schemes that target smallholder farmers who may be concerned about being relocated from their lucky farms, the researcher stated unequivocally that there must be a level of confidentiality established with whoever is providing us with the information to ensure they are safe.

The Covid-19 protocol: To ensure that the subjects are not exposed to covid-19 hazards, the researcher followed the health protocols established by the Ministry of Health (Bosire et al., 2021). We focused on the risk-benefit ratio, which specifies that no study should endanger the participants' lives (Silali, 2021).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings in accordance with the study objectives. The results are also interpreted and discussed with reference to what other researchers found as reported in chapter two. The main goal of this study was to assess the impact of the agroforestry adoption on livelihood of smallholder farmers in Solio Settlement Scheme. The chapter begins by presenting the response rate as well as reliability results of all constructs. The chapter further presents descriptive statistics analysis results of respondent profile and study variable data. Diagnostic tests, paired-samples t-test analysis, and correlation analysis results are presented. Further, the findings, where necessary, are visualized using frequency tables.

4.2 Response Rate

A total of 368 questionnaires were to be administered to smallholder farmers in Solio Settlement Scheme participate in the study. 351 respondents participated in the study, which represents a return rate of 95% return response. This response rate concurs with stipulations by Mugenda and Mugenda (2003) and Wang and Cheng (2020) that response rate above 70% is representative of the population from which samples are drawn. Hence, adequate responses were sampled indicated in Table 4.1. The high response rate was mainly attributed to by the engagement of chiefs and lead farmers who communicated with other farmers prior to the day of the data collection.

Table 4.1

Respondents' response rate

Questionnaires	Response	Non-response	Comment
368	95%	5%	Representative the population

4.3 Demographic Information of the Respondents

This section gives a description of background information of the respondents.

4.3.1 Age Distribution of the respondents

Table 4.2

Age Distribution of the respondents

Response	Frequency	Percent
29 and below years	74	21.1
(30 - 39) years	69	19.7
(40 - 49) years	70	19.9
(50 - 59) years	68	19.4
(60 and above) years	70	19.9
Total	351	100.0

The age distribution of respondents was analyzed and presented in table 4.2; mean age =46.31 years, with a standard deviation of 14.67 years. The present findings indicate that most adopters of agroforestry in Solio Settlement Scheme are aged 46 or older, with much smaller variances. Consequently, it appears that elderly individuals adopt agroforestry practices in the study area. The findings are consistent with the study findings of Jha et al. (2021) who in their study on

factors influencing the adoption of agroforestry by smallholder farmer households from Morogoro and Dodoma, Tanzania‖ found that, agroforestry is predominantly practiced by old smallholder farmers who own land and have the financial means to purchase necessary inputs. In contrast to the average mean, young people under the age of 29 were seen participating in agroforestry in the Solio Settlement Scheme plan during the survey (N=74, 21%). This could be linked to youth unemployment in formal industries, as indicated by numerous studies in Philippines (Tacbalan, 2021), Nigeria (Osikabor & Oyelami, 2022), Kenya (Molon, 2020).

4.3.2 Gender Distribution

The study sought to establish the gender composition of the respondents and results are summarized in Table 4.3.

Table 4.3

Gender Representation

Response	Frequency	Percentage (%)
Male	183	52.1
Female	168	47.9
Total	351	100.0

The results showed that 52.1% of respondents were male, compared to 47.9% of females, indicating that there were more male agroforestry adopters in Solio. These results were at odds with numerous other agroforestry studies undertaken in the past, which discovered that land used for farming and tree planting is primarily owned by men (Koech, 2020; Kansiime et al., 2021). The difference in agroforestry adoption between men and women appears to be caused by social norms and settlement practices, which shows that women have begun to manage farms (Karuga, 2022). The societal standards may also depict a situation in which most men spend their time

away from farms, whether they are working, running their own businesses, or seeking for ways to get income to support their families (Kinyili, 2021; Sachs, 2019). The statistics cannot show whether women have any power over the agroforestry trees that are present on their farms because the study did not investigate the issue of family structure and responsibilities.

4.3.3 Marital status of the respondents

The study sought marital status of respondent and the findings presented in Table 4.4.

Table 4.4

Marital status responses

Response	Frequency	Percent
Divorced	11	3.1
Married	252	71.8
Single	42	12.0
Widowed	46	13.1
Total	351	100.0

The study deduced that majority of the respondents are married (N=252, 71.8%). This finding was expected as was reviewed in many agroforestry related studies that at the age of 45 years, most people are already in their homes as married couples and engaged in economic activities to support their families (Pike et al., 2018).

4.3.4 Level of Education of the respondents

The researcher described the level of education of the respondents and the results presented in Table 4.5.

Table 4.5

Level of Education

Response	Frequency	Percent
None	40	11.4
Primary	135	38.5
Secondary	139	39.6
College	33	9.4
University graduate	4	1.1
Total	351	100.0

Most farmers were educated through the primary level (N=135, 38.5%) and the secondary level (N=139, 39.6%) according to the data. Only (N=40, 11%) of the respondents with no educational background were reported. In addition, 10.5% (N=37) of the population had finished postsecondary education. Due to the importance of education in agroforestry operations, it was crucial for the researcher to determine how respondents comprehended the phenomenon under investigation. Due to the lack of school fees to continue to tertiary levels of education, the bulk of the rural population frequently attends school up to the primary or secondary level before leaving out to look for work and earn a living (Fafunwa & Aisiku, 2022). Further, according to other research, most Kenyan smallholder farmers in the agroforestry sector frequently abandon their studies prior to receiving their primary certification in order to focus on farming activities (Sousa et al., 2020; Quandt, 2021). Hence, the study findings support the earlier agroforestry results. The proportion of participants in the current study who reported having no formal

education is similarly consistent with past findings (Nyairo, 2020). From the analysis, even though the Solio Settlement Scheme has a low literacy rate, agroforestry adoption is observed to be very high.

4.3.5 Household Member Size

The study further described household size of agroforestry adopters in the Solio Settlement Scheme, and the results are displayed in Table 4.6.

Table 4.6

Household member's size category

Household classes	Frequency	Percent
(2 and below) HH members	80	22.8
(3 - 5) HH members	74	21.1
(6- 8) HH members	95	27.1
(9-10) HH members	62	17.7
(11 and above) HH member	40	11.4
Total	351	100.0

The average number of household members was 4.7, with a standard deviation of 1.74 and a range of 11 members. The study revealed that the distribution of household member size varied greatly amongst categories, with most smallholder farmers having households with 6-8 family members, demonstrating that most smallholder farmers had a sizable household. The findings are consistent with those of Sisay (2021) who discovered that agroforestry adopters have averaged household member sizes, ranging from 6 to 10 family members, as compared to agroforestry non-adopter smallholder farmers (Liliane, 2021).

4.3.6 Family Land Size

The respondents were asked to state their size of land under agroforestry. The results are provided in Table 4.7.

Table 4.7

Land sizes in acres

Response	Frequency	Percentage
(3 & below) Acres	126	35.9
(4-7) Acres	212	60.4
(8 and above) Acres	13	3.7
Total	351	100.0

The average land size was 2.98 acres, with the majority having land sizes ranging from 4 to 7 acres (N=212, 60.4 %), followed by those reporting property sizes of 3 and less acres (N=126, 35.9 %). Only 3.7 percent (N=13) of those surveyed had 8 or more acres of land. Small-scale farmers often have land sizes ranging from 4-7 acres as well as less than 3 acres. Nonetheless, the study expected similar findings as was done under small-holder farmers in Solio Settlement Scheme, and therefore the study agrees with most reported findings in most agroecosystems in Kenya and globally at large (Kitonga et al., 2020; Musafiri et al., 2022; Amare & Darr, 2020; Dhakal & Rai, 2020).

4.3.7 Enterprises Practiced in Solio Settlement Scheme

Table 4.8

Enterprises practiced in Solio Settlement Scheme

Response	Frequency	Percent
Both Crops and Livestock	255	72.6
Crops	83	23.6
Livestock	5	1.4
Other	8	2.3
Total	351	100.0

Table 4.8 displays the agroforestry enterprises that the respondents were engaged in. Most respondents (N=255, 73%) used both crops and livestock, whereas 24% (N=83) of farmers solely used crops, and only 1.4% (N=5) of respondents kept livestock. This suggests that farmers in the study area engage in a significant amount of mixed agroforestry. This supports research by Ahmad et al. (2021) which showed that smallholder farmers prefer to raise crops and animals on the same plot of land in agro ecosystems to increase their income and food supply. However, according to other researchers, most Kenyan smallholder farmers in the agroforestry sector frequently abandon their studies prior to receiving their primary certification in order to focus on farming activities.

4.3.8 Land Allocated for Tree Planting

The study sought to determine the scope of agroforestry practiced by most of the farmers. The respondents were asked to state if they have allocated land specifically for tree planting as shown in Table 4.9.

Table 4.9

Land Allocation

Response	Frequency	Percent
No	26	7.4
Yes	325	92.6
Total	351	100.0

The findings in table 4.9 indicate that majority of respondents allocated land for tree planting, commonly planted tree species included Grevillearobusta, Crotonmegalocarpus, Mexicanash, fruit trees and Oleaafricana. However, a small proportion recorded to have not allocated land for tree planting. This confirmed that smallholder farmers' uptake of the agroforestry practice in Solio Settlement Scheme is very high. Further, the study explored the main factors that made some farmers not to adopt tree planting in their yards. The study established that lack of consistent rainfall (N=11, 3.1%), lack of resources (N=13, 3.7%) and insufficient land to grow crops and trees were the main reasons for not allocating land for trees as presented in table 4.9. The findings concurred with Ullah et al. (2022) study, that established that, there several factors limiting agroforestry adopter not to adopt tree planting in their lands and among them; lack of reliable rainfall and lack of access to quality tree seedlings, lack of finance and limited land for other farming activities (Jha et al., 2021).

Table 4.10

Reasons for not Adopting Tree Planting

Primary reason for not allocating land for planting trees	Frequency	Percent
	325	92.6
Lack of consistent rainfall	11	3.1

lack of resources	13	3.7
lack of enough land to grow crops and trees	2	.6
Total	351	100.0

4.4 Environmental benefits on Agroforestry

Descriptive statistic results for the study variables are provided in this section. The specific descriptive statistics included are frequency, percentage, mean and standard deviation. The first objective of the study was to determine the environmental benefits of agroforestry adoption to smallholder farmers in Solio Settlement scheme. The items measuring the notion on environmental benefits were rated by the respondents; Soil conservation highly attributed to by reduced soil erosion, the creation of inhabitants/ecosystems, and water regulation as a result of reduced events of flooding were used to measure the environmental benefits variable. The Likert scale used was as follows: 1=Very Small Extent (VSE), 2=Small Extent (SE), 3=Moderate (M), 4=Large Extent (LE) and 5=Very Large Extent (VLE).

Table 4.11

Summaries on Descriptive Results on Environment Benefits

STATEMENTS	Very small extent	Small Extent	Moderate	Large Extent	Very Large Extent	Total	Mean	S D
Due to agroforestry, the Scheme's high temperature has decreased.	3%	2%	16%	54%	25%	100%	3.09	1.44
Soil Erosion has reduced	2%	1%	8%	66%	23%	100%	1.93	1.53
Agroforestry has resulted in an increase in water infiltration, which has resulted in a decrease in water runoff.	1%	1%	35%	48%	15%	100%	3.26	1.54
Agroforestry decreases wind speed, which has a negative influence on	2%	1%	35%	40%	22%	100%	3.19	1.53
Agroforestry has resulted in the creation of ecosystems that provide home for a variety of	2%	7%	27%	41%	23%	100%	3.24	1.64

STATEMENTS	Very small extent	Small Extent	Moderate	Large Extent	Very	STATEMENTS	Very small extent	Small Extent
Species. As a result of trees, water floods have been decreased, demonstrating the value of	1%	1%	32%	48%	18%	100%	3.20	1.49
Species. As a result of trees, water floods have been decreased, demonstrating the value of	1%	1%	32%	48%	18%	100%	3.20	1.49
AGGREGATE							3.09	0.25

The findings in table 4.11 demonstrated a high mean of 3.09 (M>3.0) and a low standard deviation of 0.25. This indicates that most respondents measured environmental benefits with the indicators or items. For instance, most respondents (M=3.74, S D=1.22) remarked that, following the adoption of agroforestry, there has been consistent rain patterns (48 percent). Further, majority of the respondents agreed to a large extent that; Due to agroforestry, the scheme's high temperature has decreased (54%); Soil Erosion has reduced (66%); Agroforestry has resulted in an increase in water infiltration, which has resulted in a decrease in water runoff (48%); Agroforestry decreases wind speed, which has a negative influence on water evaporation (40%); Agroforestry has resulted in the creation of ecosystems that provide home for a variety of species (41%); As a result of trees, water floods have decreased, demonstrating the value of agroforestry (48%). Thus, majority of respondents, to a large extent agreed that agroforestry adoption resulted to positive environmental benefits.

4.5 Measurement of Food and Energy Diversification Associated with Agroforestry Adoption to Smallholder Farmers

The second objective of the study was to measure impact of agroforestry on food and energy diversification. The variable was operationalized by food and energy supply. Eight constructs were used to measure the food and energy expansion. The scale used was as follows: 1 -Strongly disagree (SD) 2- Disagree (D) 3- Neutral (N) 4-Agree (A) 5-Strongly Agree (SA). The descriptive results are shown in Table 4.12.

Table 4.12

Food and Energy Diversification

STATEMENT	SD				SA			
		Disagree	**Medium**	**Agree**		**Total**	**Mean**	**Std. Deviation**
Agroforestry has enabled me to provide food	2%	61%	18%	5%	14%	100%	3.09	1.83
Due to my agroforestry adoption, I am able to offer an adequate food diet	1%	3%	17%	10%	69%	100%	3.20	1.93
Crop production increased as a result of the adoption of agroforestry	2%	6%	32%	46%	15%	100%	3.26	1.73
Energy diversified as a resultof agroforestry adoption	0%	2%	21%	49%	27%	100%	3.19	1.18
Prior to agroforestry, I was unable to obtain an adequate supply of cooking energy from fuel wood.	2%	2%	20%	53%	23%	100%	3.24	1.28
Due to agroforestry adoption,I am able to obtain affordable and sufficient energ	1%	2%	21%	47%	29%	100%	3.20	1.22
Largely, Food supply has expanded	2%	1 %	16 %	64%	17%	100%	3.74	1.46
Essentially, Food supply has expanded	2%	1 %	36 %	44%	18%	100%	3.15	0.29
Aggregate							3.15	0.49

The results in table 4.12 show a mean value of 3.15 and standard deviation of 0.49. The mean of 3.15 signifies moderate responses in relation to food and energy diversification. The low standard deviation showed that there are minimal variations in the respondent's scores regarding food and energy diversification. This is because there are no discrepancies in the characteristics of the smallholder farmers. The findings further, report that, majority of respondents agreed that agroforestry adoption has impacted smallholder farmers by diversifying food and energy. In particular, they noted that; after agroforestry adoption, they are able to provide an adequate food diet for all home members throughout the year (69%, M= 3.2); crop production increased as a result of the adoption of agroforestry (46%, M=3.26); Energy diversified as a result of agroforestry adoption (49, M=3.19); adequate supply of cooking energy from fuel wood was realized (53%, M=3.24); Largely, food supply expanded as a result of agroforestry adoption (64%, M=3.2); To many smallholder farmers, disagreed that, they were not capable of providing an adequate food diet for all home members throughout the year prior to adopting agroforestry (64%, M=3.09).

Further, the study sought ways in which agroforestry in Solio Settlement Scheme has impacted on food and energy supply. The results are presented in Table 4.13.

Table 4.13

Ways Agroforestry Impacted on Food and Energy

Ways Agroforestry Impacted on Food and Energy	Frequency	Percent
Negatively	6	1.7
Positively	336	95.7
Not Aware	9	2.6
Total	351	100.0

During the study, the researchers found that farmers accrued livelihood benefits from agroforestry

Practices through food and energy diversification (N=336, 95.7%). The findings concurred to other past research works on adoption of agroforestry (Nzilu, 2015; Maluki et al., 2016; Nakuru & Makori, 2017; Oloyede & Ayinde, 2016; Ashiagbor et al., 2018).

Figure 4.1

Capsicum Production

A farmer tending to capsicum in the farm illustrating food diversification.

4.6 Benefits of Agroforestry Adoption to Enterprise Development

The study sought to establish whether the farmers agree that agroforestry creates enterprises and results from the data gotten are presented in Table 4.14.

Table 4.14

Responses on whether Agroforestry Creates Enterprises

Agroforestry Creates Enterprises	Frequency	Percent
No	12	3.0
Yes	339	97.0
Total	351	100.0

From the analysis, majority of the smallholder farmers agreed that agroforestry adoption resulted in enterprise development (N=339, 97%) while only 3% of the respondent noted that agroforestry has no benefit of creating enterprises. However, the study did not establish further the premise of this. Majority of the respondent noted that, firewood sales (N=156, 44%) is the main primary sources of income followed by sales of surplus food crops (N=96, 27%) as indicated in table 4.15. These findings concur with those of Cheboiwo et al. (2018) who found that, agroforestry enables farmers to start income generating activities through products like bee honey, selling, tree nursery, sales of food, timber, posts, rafters and firewood. Further, the study sought the main projects that are primary sources of revenue.

Table 4.15

Sources of Income

Primary source of income	Frequency	Percentage
Sales of surplus food crops	96	27.4
Fuelwoods sales	156	44.4
Honey extraction	14	4.0
Sales of timbers and building posts	51	14.5
Tree nursery business	34	9.7
Total	351	100.0

4.7 Enterprise Development

The third objective of the study was to determine impact of agroforestry on enterprise development. The respondents were asked to rate sentiments on enterprise development which covered aspects on annual income, annual expenditure and improved soil quality which will enhance crop productivity. The scale used was as follows: 1 -Strongly disagree (SD) 2- Disagree (D) 3- Neutral (N) 4-Agree (A) 5-Strongly Agree (SA). The descriptive results are shown in Table 4.16.

Table 4.16

Enterprise Development

Statement	Strongly Disagree	disagree	Neutral	agree	Strongly Agree	Total	Mean	std. deviation
Agroforestry generates income	10%	2%	22%	65%	1%	100%	2.6	2.2
Agroforestry is beneficial to the livelihoods	2%	2%	23%	51%	21%	100%	2.1	1.7
Reduced fertilizer uses in the farm	2%	16%	18%	52%	12%	100%	2.6	2.3
Reduced purchase of artificial fertilizer	1%	17%	10%	51%	21%	100%	2.6	2.3
Many small holder farmers operate agroforestry	1%	0%	21%	60%	18%	100%	2.2	1.8
Agroforestry has improved my income	1%	1%	34%	49%	15%	100%	2.2	1.8
I used a considerable quantity of inorganic fertilizers on my farm	1%	4%	16%	64%	15%	100%	2.4	2.0
My expenditure on artificial fertilizer decreased.	2%	15%	41%	31%	11%	100%	2.6	2.3
Increased soil fertility								
Aggregate score	1%	5%	33%	47%	14%	100%	2.4	2.0
							2.4	0.2

The analysis results in table 4.16 shows a mean value of 2.4 and standard deviation of .2. The low SD indicates that there were minimal variations in the respondent's scores. This is because there are no discrepancies in the characteristics of the smallholder farmers. The findings further, report that, majority of responded agreed that agroforestry adoption has impacted positively in

developing enterprises for them. They noted that; Agroforestry generated income (65%). 51% of the respondents attested that Agroforestry is beneficial to their livelihood. Similarly, more than half of them agreed that agroforestry helped in reducing artificial fertilizer that was applied before agroforestry adoption. Majority of the smallholder farmers agreed that they operate agroforestry in Solio Settlement Scheme; this is informed by the good and profitable way of life brought by agroforestry which have shown signs of improvement income (49%).

Figure 4.2

Beehives

Bee keeping for business enterprise in Solio Settlement Scheme

Figure 4.3

Tree nursery

The tree nursery is a source of income for farmers in Solio

4.8 Livelihood of Small Farmers in Solio Settlement Scheme

The researcher sought to find whether agroforestry enhanced the livelihoods of small scale farmers in the Solio Settlement Scheme. The results are presented in Table 4.17.

Table 4.17

Impact of Agroforestry on Farmers' Livelihood

Has agroforestry enhanced livelihood?	Frequency	Valid Percent	Cumulative Percent
Yes	307	87.5	87.5
No	44	12.5	100.0
Total	351	100.0	

The results in table 4.17 above shows that livelihood of smallholder farmers has been enhanced by use of agroforestry (N=307, 87.5%). Only 12.5% (n=44) of the respondents felt that agroforestry has not enhanced their livelihood. The findings concur with Kinyili (2021) in Machakos and Jha et al. (2021) in Tanzania, who in their studies, found that, livelihood among agroforestry adopters was better those agroforestry non-adopters in Nakuru.

Further, the respondents were asked to rate statements on the dependent variable, which was their livelihood. This variable was measured using various items that covered issues on affordability of basic needs, poverty and optimal environment. The scale used was as follows: Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA). The descriptive results are shown in Table 4.1

Table 4.18

Livelihood of Farmers

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total	Mean	Std. dev
The decreasedscheme's temperatures have improvedmy livelihood	3%	2%	23%	54%	19%	100%	3.2	1.5
Reduction ofsoil erosion due to agroforestryadoption	1%	2%	18%	63%	16%	100%	3.1	1.3
Decreased waterrunoff accrued from agroforestry hasimproved mylivelihood	0%	7%	19%	59%	15%	100%	3.2	1.5
Trees have reduced windspeed that hasresult to betterlives	0%	5%	15%	54%	26%	100%	3.0	1.2
Consistent rainfall due to agroforestry hasimproved small farmer's lives in Solio scheme	0%	13%	10%	61%	16%	100%	3.4	1.8
Adequate foodsupply due to agroforestry adoption has improved mylivelihood	1%	1%	29%	55%	14%	100%	3.6	1.3
Adequate energysupply due to agroforestry adoption has improved mylivelihood	1%	3%	27%	55%	14%	100%	3.2	1.5
Income generated fromagroforestry improved mylivelihood	1%	7%	14%	66%	13%	100%	2.4	2.0
Reduced purchase ofartificial fertilizer savesmy resources	1%	11%	40%	36%	12%	100%	3.5	1.9
Enterprises developed fromagroforestry (tree nursery,honey harvesting, selling offuelwood, salesof timber and building poles) has improved my livelihood	1%	3%	4%	36%	57%	100%	2.4	2.0
							3.2	0.3

From the analyses, majority of the respondents agreed that; The decreased scheme‘s temperature has improved my livelihood (54%); Reduction of soil erosion due to agroforestry adoption has improved my livelihood as a small farmer (63%); Decreased water runoff accrued from agroforestry has improved my livelihood (59%); Trees have reduced wind speed that has resulted to better lives (54%); consistent rainfall pattern due to agroforestry has improved small farmer‘s livelihood in Solio Settlement Scheme (61%); Adequate food supply due to agroforestry adoption has improved my livelihood (55%); Adequate energy supply due to agroforestry adoption has improved my livelihood (55%); Income generated from agroforestry improved my livelihood (66%). While slightly less than half of the participants noted a moderate score on Reduced purchase of artificial fertilizer saves my resources hence improved livelihood (40%) and slightly more than half (57%) strongly agreed that Enterprises developed from agroforestry (tree nursery, honey harvesting, selling of fuel wood, sales of timber and building poles) has improved my livelihood.

4.9 Results on Diagnostic Tests

Diagnostic tests were conducted to ascertain that there were no violations of assumptions prior to statistical analysis and to avoid inaccurate estimations. The tests included normality test, multicollinearity test, heteroscedasticity test, scatterplot and auto-correlation test. Normality testing was done by use of the Shapiro-Wilk statistic. A significant result (Sig. value of less than .05) indicates the data is not normally distributed. In the case of non-normal, the data distribution violates the assumption of normality.

Table 4.19

Normality Test Shapiro-Wilk Statistics

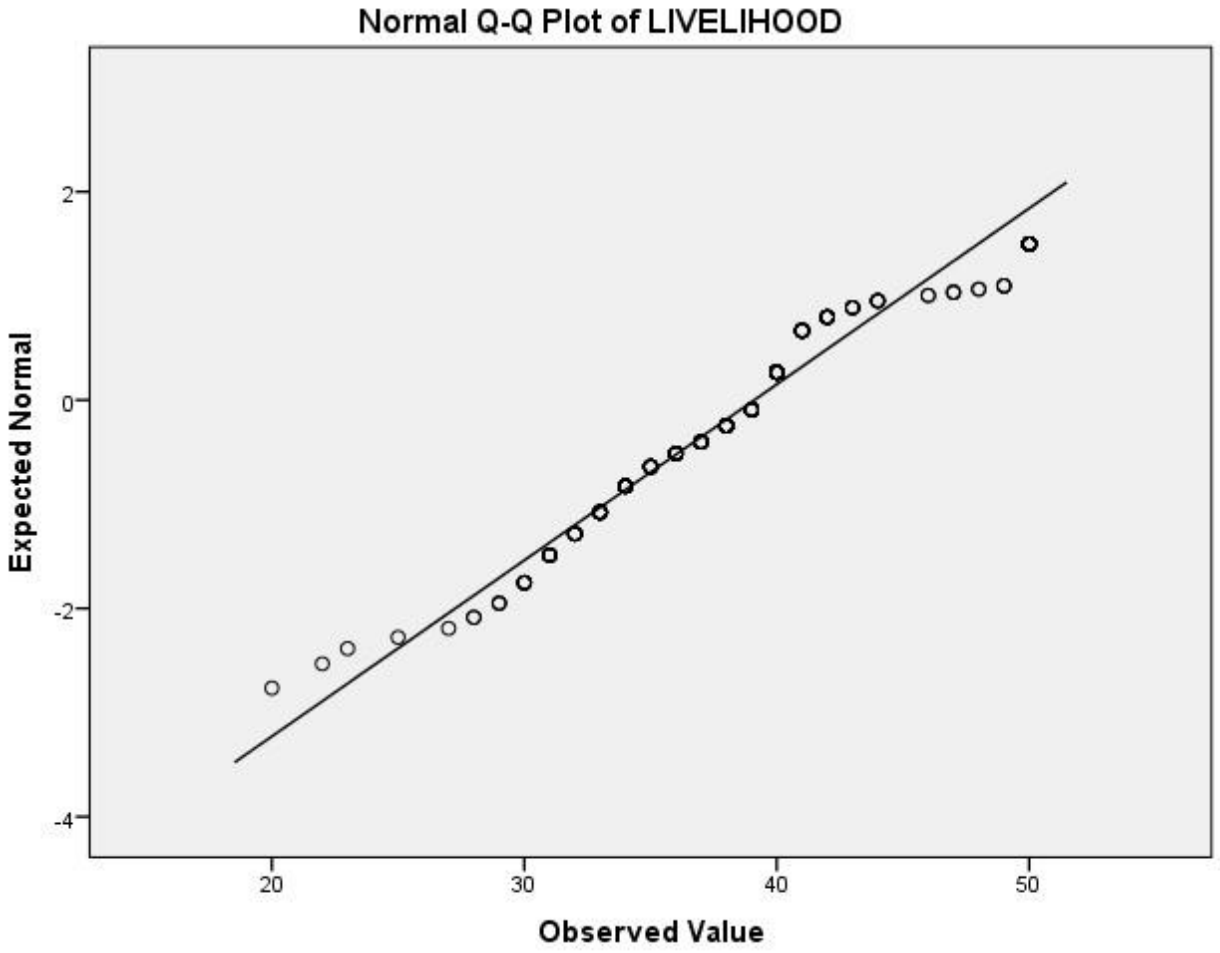
	Shapiro-Wilk Statistic	df	Sig.
Livelihood of small holder farmers (dependent variable)	.938	351	.195

The findings from Shapiro-Wilk statistic showed the scores on dependent variable are normally distributed (P> .05). That is, the population from which the samples were taken was normally distributed. The variance of the residuals about predicted scores should be the same for all predicted scores test for the researcher to conclude no problem with Homoscedasticity.

The graph of Normal P-P plots below demonstrates the distribution of scores on the dependent variable, revealing that no violation of assumption of homoscedasticity.

Figure 4.4

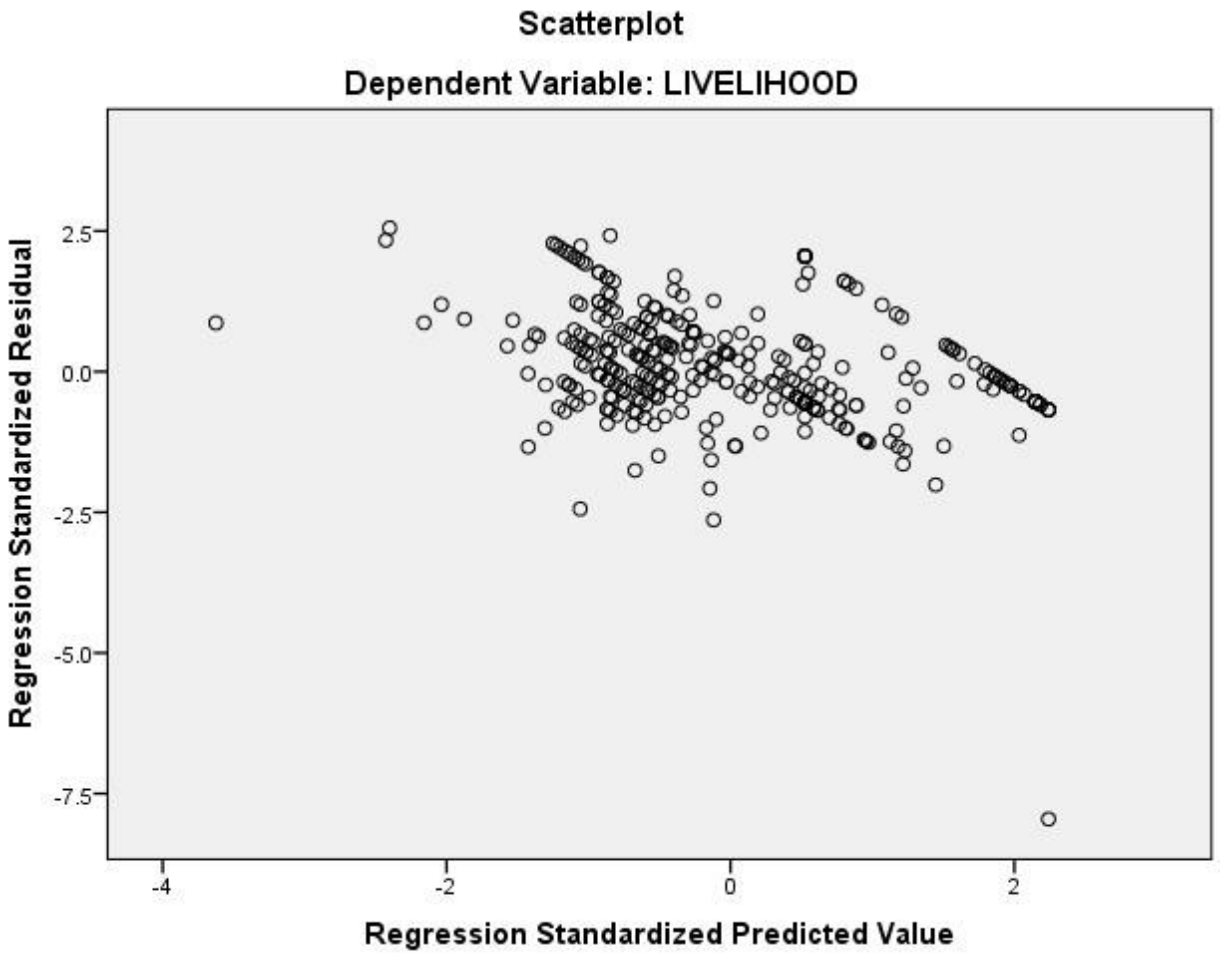
Homoscedasticity Test



Scatter plot was conducted to give an indication of relationship between dependent variable and independent variables.

Figure 4.5

Scatterplot



This was an indication of strong correlation. Hence, the plot guided the researcher to conduct the correlation analysis to explore the specific strength and direction of the relationship between the variables.

The study evaluated if there was significance difference in mean scores of expenditures on food, Building timber and post, Health, Education, Fuelwood, and Luxury and recreation of

smallholder farmers from the year 2012 (before agroforestry adoption) and year 2021 (after agroforestry adoption). Also, the overall expenditure was evaluated. The results are presented in Table 4.20

Table 4.20

Annual Financial Expenditure on Food

		Mean	N	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	Food expenditure 2012	95115.84	351	155025.142	8274.630			
	Food expenditure 2021	80545.17	351	69310.839	3699.539	1.848	350	.006

From the results in table 4.20 above, there was statistically significant difference in mean scores of expenditures on food before agroforestry adoption (2012) to after agroforestry adoption (2021); (at 95% confidence interval). Thus, there was significant decrease in expenditure on food before intervention (M= 95115.84, S. D= 155025.142) to after intervention (M=80545.17, S. D= 69310.839), t (350) = 1.848, calculated P-Value of 0.006<0.05. The mean decrease in food expenditure was 14570.670 with a 95% confidence interval ranging from 940.337 to 30081.676.

The eta squared statistic was calculated to explore the magnitude of the difference (strength of agroforestry adoption on food supply using the following formula.

Eta squared =

$$\frac{t^2}{t^2 + (N - 1)} \quad \text{.....4.1}$$

$$= 341.5104/353.415104$$

$$= 0.9$$

An Eta squared value of (.9) indicates a huge effect size. From the analysis, it is thus found that farmers spent more on food purchase in 2012 than in 2021. This confirms that, from agroforestry, more food is produced. This finding is supported by studies in Ethiopia by Amare et al. (2019) who found that, food production was significantly higher among adopters than non-adopters of agroforestry. Hence, adoption of agroforestry comes with benefits of more food access in the entire period of the year. However, this study did not categorize the main food produced by smallholder farmers practicing agroforestry.

Table 4.21

Annual Expenditure on Building Timber and Post

Type of Timber	Year	Mean	N	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair Building timber and post	2012	6313.68	351	14363.302	766.656			
Building timber and post	2021	5043.14	351	15379.850	820.916	1.814	350	.07

A paired-samples t-test was conducted to compare the expenditure scores on timber and post from investigation of before the adoption of agroforestry and after the adoption of agroforestry. There was not statistically significant difference in scores before the intervention (M = 6313.68, SD = 14363.302) and after adoption (M = 5043.14, SD = 15379.850; t (350) = 1.814, P. Value = .07; Sig. value (1-tailed) was greater than the specified Alpha value of .05). The mean decrease in expenditure was 1270.538 with a 95% confidence interval ranging from 106.691 to 2647.768. The eta squared statistic (.009) indicated a small effect.

Table 4.22

Expenditure on Education

		Mean	Std. Deviation	Std. Error Mean	T-test value	df	Sig. (2-tailed)
Pair 1	Education 2021	35813.42351	98818.333	5274.532			
	Education 2012	33022.08351	92520.714	4938.390	1.331	350	.001

A paired-samples t-test was conducted to compare the expenditure scores on education by smallholder farmers before the adoption of agroforestry and after the adoption of agroforestry. There was statistically significant difference in scores of before the adoption (M = 33022.08, SD = 92520.714) and after adoption (M = 35813.42, SD = 98818.333; t (350) = 1.331, P. Value = .001; Sig. value (2-tailed) was less than the traditional Alpha value of .05). The significance mean increase in expenditure was 2791.339 with a 95% confidence interval ranging from 1334.428 to 6917.106. The eta squared statistic calculated (.004) indicated a small effect. This implies that the annual expenditure on education were all significantly higher for the farmers

after agroforestry adoption (P < 0.05). This was due to the higher disposal income from agroforestry that enabled them spending more on education. This concurs with the finding that found the expenditure on basic needs like education is significantly higher for the agroforestry adopters than non-adopters (Mesike & Okwu-Abolo, 2022).

Table 4.23

Expenditure on Fuelwood

Description	Year	Mean	Std. Deviation	N	T-test	value df	Sig.(2tailed)
Pair Fuelwood	2012	6389.46	92520.714	351	10.5		0.04
Fuelwood	2021	6149.83	11176.793	351			

A paired-samples t-test was conducted to compare the expenditure scores on fuelwood by smallholder farmers before the adoption of agroforestry (2012) and after the adoption of agroforestry (2021). There was statistically significant difference in scores of before the adoption (M = 6389.46, SD = 92520.714) and after adoption (M = 6149.83, SD = 11176.793; t (350) = 105, P. Value = .04; Sig. value (2-tailed) was less than the traditional Alpha value (0 .05). The significance mean decrease in expenditure was 239.630 with a 95% confidence interval ranging from 415.141 to 894.400. The eta squared statistic calculated (.149) indicated a large effect. The expenditure on fuel wood by small holder farmers was smaller after adoption than before adoption. This was indicated to have been attributed to high production of these wood products among farmers and the fact that they do not no need to buy fuel wood for their daily cooking. From the analysis, it is noted that, farmers even sell surplus fuel wood to nearby hotels and community for income. Therefore, this study concurs with other studies since most of the

adopters have these agroforestry products (fuel wood) in their farms and hence they do not need to buy these products from outside their farms (Dhakal & Rai, 2020).

4.10 Energy Diversification

Farmers with livestock in the Solio settlement scheme adopted biogas as a means of cooking food so to reduce reliance on fuel wood.

Figure 4.6

Biogas generation unit

Biogas generation unit for fuel by a farmer in Solio settlement scheme

Figure 4.7

Biogas cooker

Biogas cooker used in one of the homes as a source of fuel for cooking by farmers in Solio Settlement Scheme

Figure 4.8

Stored Firewood

Homestead with stored firewood used for fuel underneath a water tank platform

Table 4.24

Luxury and Recreation

Luxury and recreation	Year	Mean	N	Std Deviation	Std Error Mean	t	df	Sig. (2-tailed)
Pair Luxury and	2021	3995.16	351	12487.590	666.538			
Luxury and recreation	2012	3628.06	351	11747.453	627.033	1.590	350	.113

A paired-samples t-test was conducted to compare the expenditure scores on luxury and recreation activities by smallholder farmers before the adoption of agroforestry and after the adoption of agroforestry. There was not statistically significant difference in scores of before the adoption (M = 3628.06, SD = 11747.453) and after adoption (M = 3995.16, SD = 12487.590; t (350) = 1.590, P. Value = .113; Sig. value (2-tailed) was greater than the traditional Alpha value of .05). The significance mean increase in expenditure was 367.094 with a 95% confidence interval ranging from -86.944 to 821.132 an indication that there was marginal improvement in access to leisure and luxury goods. It is observed that, most of the farmers after adopting agroforestry are able save the income and use it to purchase luxuries and recreation.

Table 4.25

Overall state of Expenditure after the Adoption of Agroforestry

Expenditure after adoption of Agroforestry	Year	Mean	N	Std. Deviation	t	df	Sig. (tailed)
Pair Total expenditure before adoption-	2012	140110.81	351	141377.334			
Total expenditure after adoption	2021	156809.08	351	199596.869	-2.084	350	.038

A paired-samples t-test was conducted to compare the overall level of expenditure after the adoption of agroforestry by smallholder farmers before the adoption of agroforestry and after the adoption of agroforestry. There was statistically significant difference in expenditure scores of before the adoption (M = 140110.81, SD = 141377.334) and after adoption (M = 156809.08, SD = 199596.869; t (350) = 2084, P. Value = .038; (Sig. value (2-tailed) less than the traditional Alpha value of .05). The significance mean increase in overall expenditure by farmers was 16698.265 with a 95% confidence interval ranging from 32453.436 to 943.094. The eta squared statistic calculated (.01) indicated a moderate effect. This concludes that the expenditure on food, building timber and posts, education, fuelwood, luxury and recreation was significantly higher after adoption of agroforestry ($P < 0.05$). This was due to the higher disposal income from agroforestry that enabled farmers save on food, from fuelwood and timber and post sales and in turn spend more on acquiring quality education, search for luxury and recreation as well as affording other foods product that they do not grow, build better houses. Search for luxury and recreation food, clothing, education and medicine (Kursky, 2020; William, 2018).

4.11 Correlation analysis Results

This section examines the underlying relationship between impacts of agroforestry adoption (environmental benefits, food and energy diversification and enterprise development and the livelihood of small holder farmers in the Solio Settlement Scheme. From the normality test, the scores on dependent variable were normally distributed hence the researcher applied parametric techniques to explore the underlying relationship between the variables. Pearson Moment-Product Correlation analysis was employed. In particular, he Pearson Bivariate correlation coefficient was utilized to calculate the correlation coefficients between the variables. Table 4.26 shows the results.

Table 4.26

Correlations Analysis Results

Variables	**Correlation**	**Livelihood**	**Environmental benefits**	**Energy and diversification**	**Enterprise development**
Livelihood	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	351			
Environmental Benefits	Pearson Correlation	.636**	1		
	Sig. (2-tailed)	.000			
	N	351	351		
Food and energ diversification	Pearson Correlation	.725**	.722**	1	
	Sig. (2-tailed)	.000	.000		
	N	351	351	351	
Enterprise development	Pearson Correlation	.789**	.727**	.811**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	351	351	351	351

**. Correlation is significant at the 0.01 level (2-tailed).

The findings in Table 4.26 revealed that all independent variables under investigation were positively and significantly correlated with livelihood and with each other (r =.636** p= .0005), Food and energy diversification (r= .725**, p=.0005) and Enterprise development (r=.789**, P= .0005) had strong-positive and statistically significant relationship with dependent variable (Livelihood of smallholder farmers). This implies that the livelihood of these smallholder farmers improved with improvement environment; increase in food and energy and with more enterprise creation. However, enterprise development improves lives of farmers in Solio Settlement Scheme than better environment and increment in food and energy.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The study was conducted to establish the influence of agroforestry adoption on the livelihoods of small holder farmers in the Solio Settlement Scheme in Laikipia County. Specifically, the study was guided by three study objectives that were to determine; the environmental benefits of agroforestry adoption on the livelihood of small holder farmers, the benefits of agroforestry adoption to enterprise development, and to measure food and energy diversification associated with agroforestry adoption to small scale farmers More so, the study variables were conceptualized and operationalized in order to accomplish the study objectively. Further, this chapter presents the summary of the findings, conclusion and recommendations of the study.

5.2 Summary of the Findings

This section provides the summary of the findings based on each study variables in a bridged format. The results summarized in this section are not hypothetical rather but based on the analysis of quantitative data acquired from smallholder farmers in Solio Settlement Scheme. The study used descriptive survey research approach to answer the research questions under the investigation. The study did statistical analysis from data gathered from 351 smallholder farmers in Solio Settlement Scheme through a structured survey questionnaire. Data was analyzed descriptively as well as by use of inferential statistics techniques.

It was found that agroforestry is predominantly carried out by female smallholder farmers aged 46 and older who own property and have the financial capacity to purchase necessary materials. Furthermore, most smallholder farmers are married people who have settled down to work on the

farm but have a low educational background. Most smallholder farmers, according to the survey, had large households of 6-8 family members and an average of 3 acres of land. To summarize, smallholder farmers use agricultural and livestock production to maximize crop and animal production, resulting in increased livelihood. Furthermore, the study found that income from crops, livestock, and tree resources, as well as total income of smallholder farmers, increased significantly following agroforestry adoption. Farmers' overall annual expenditure was shown to be greater after intervention than before intervention. However, before agroforestry, expenditures on food, fuelwood, timber, and posts were much higher. Conversely, after agroforestry adoption, farmers' expenditure on education, recreation, and luxury was much higher.

The study established that most of small holder farmers had averaged household member sizes, ranging from 6 to 8 family members. Further, the average land size among smallholder farmers was 2.98 acres, with the majority having land sizes ranging from 4 to 7 acres. It was observed that, farmers in the study area engage in a significant amount of agrosylvopastoral system (intergrated agroforestry with both crop and animal rearing in the same piece of land). Additionally, the analysis confirmed that smallholder farmers' uptake of the agroforestry practice in Solio Settlement Scheme is very high due to collaborated efforts by the farmers, government, faith based organizations and private stakeholders. However, lack of consistent rainfall, lack of resources as well as insufficient land to grow crops and trees were established as hindrances to agroforestry.

The first objective of this study was to determine the environmental benefits of agroforestry adoption accrued by smallholder farmers in Solio Settlement Scheme. The variable was operationalized by three pointers: Climate change, Creation of habitants/ecosystems and Water regulation. The cumulative responses of environment benefits of agroforestry adoption shown

high mean score of 3.09 (M>3.0) and a low standard deviation of 0.25 with majority of respondents measuring environmental benefits with the defined indicators. The variable had a correlation coefficient of; r =.636** P = .0005, hence there was strong-positive and statistically significant relationship between environment and livelihood of smallholder farmers.

The second objective of the study was to measure how agroforestry adoption helped farmers to diversify food. There was increased food security through crop diversification as households were able to plant different food crops all year round because of favorable weather conditions associated with agroforestry farming. The study found food and energy had an aggregate mean of 3.15, and standard deviation 0.49. Further, findings indicate agroforestry adoption positively impacted on food and energy; hence agroforestry adoption increased the production of food and energy in Solio. There was strong-positive and statistically significant relationship between food and energy, and livelihood of smallholder farmers (r= .725**, p=.0005).

The third study objective was to determine the benefits of agroforestry adoption to enterprise development. This variable had three indicators that were operationalized to measure the level of livelihood among smallholder farmers in Solio. They included annual income, annual expenditure and improved soil quality. The study found that, agroforestry has created different enterprises to smallholder farmers; among the enterprises created from agroforestry are income from firewood sales, surplus crop sales, sales of timbers and building materials like posts, honey extraction, and tree nursery business. It is from the study; therefore, it is found that, enterprise development variable had a cumulative mean of 2.4 and standard deviation of 0.2.

From the analysis of paired-samples T-Test conducted to evaluate the influence of agroforestry adoption in terms of enterprise development, the study found that there was statistically significance decrease in expenditure on food after agroforestry adoption with a 95% confidence

interval. Similarly, there was statistically significant decrease in fuel wood expenditure after the intervention while, there was not statistically significant difference in mean decrease in on timber and building posts expenditure with a 5% significance level. On the other hand, there was statistically significant increase in education as well as luxuries and recreation expenditures with a 95% confidence interval. Further, in general expenditure view, there was statistically significance mean increase in overall expenditure by farmers with a 95% confidence interval. Finally, the study found that, enterprise development had strong-positive and statistically significant relationship with Livelihood of smallholder farmers ($r=.789^{**}$, $p= .0005$).

The dependent variable was a measure of the livelihood of smallholder farmers. This variable was measured using various items, such as affordability of basic needs like food, water and shelter. The study established benefits from agroforestry in line to environment, food and energy and enterprise development. The cumulative mean was 3.2 and standard deviation of 0.3. Also, analysis found that, all independent variables under investigation; Environmental benefits ($r =.636^{**}$ $p= .0005$), Food and energy diversification ($r= .725^{**}$, $p=.0005$) and Enterprise development ($r=.789^{**}$, $P= .0005$) had strong-positive and statistically significant relationship with dependent variable (Livelihood of smallholder farmers).

5.3. Conclusion

Positive environmental advantages have flowed to smallholder farmers as a result of adoption of agroforestry, such as regular rainfall. Additionally, it can be proven that agroforestry adoption reduced scheme temperature, soil erosion, water runoff, water floods, and wind speed while also providing habitat for a variety of animals. According to the study, the better the environment, the better the farmers' livelihood.

Agroforestry diversified smallholder farmers' food and energy sources. According to the study, it is concluded that farmers are capable of providing an adequate food diet for all household members throughout the year after implementing agroforestry through increased crop production. After implementing agroforestry, farmers acquired affordable and sufficient energy from fuel wood. As a result, it is apparent that agroforestry enhanced food and fuel wood production. According to the findings of the study, there is a strong positive statistically significant association between food and energy and smallholder farmer livelihood; hence, smallholder farmer's livelihood increases with food and energy diversification.

Further, the study concluded that, adoption of agroforestry has resulted in the establishment of numerous businesses. The study revealed that after implementing agroforestry, farmers can save money on fuel wood sales, excess food crop sales, honey sales, timber sales, tree nursery business, and the expense of purchasing artificial fertilizers. As a result, agroforestry is a healthy way of life. According to the study, the more agroforestry develops enterprises for farmers, the better their living. As a result of the introduction of agroforestry in the Solio Settlement Scheme, farmers' livelihoods improved.

5.4 Study Recommendations

The study recommends that households need to plant agroforestry trees species that can conserve and restore ecological ecosystems. The tree species ought to be able to support the soil structure, enhance organic manure and regulate precipitation. The specific tree species to be planted incuded*; Acacia xanthophlea (murera), Croton megalocarpus (Mukinduri), Fraxinus pennysylivanica (Miiria), Grevillea robusta (Mukima) and Olea africana (Mutamaiyu).*

Agroforestry was established to be effective in supporting crop diversification because of the stable and favourable conditions there. The study recommends that households should diversify

the food crops they plant to enhance access to adequate and nutritious food for their Households. Ordinarily, the crops are supposed to be adaptive to the agroforestry environment. The food crop should include drought tolerant and short season crops like soybeans and pigeon peas, papaya, banana, mango, guava, and avocado.

It was found that agroforestry is important in driving enterprise development. Farmers ought to be trained on biogas production, organic mature preparation, bee keeping and tree nursery commercial practices by agroforestry extension officers. With this enterprise development activities the household living at Solio Settlement Scheme can generate income by selling biogas, organic mature, honey and tree seedlings.

5.5 Policy interventions

Based on the study's findings, the study suggests that the national government, county governments, and climate partners offer the necessary resources to assist farmers in adopting agroforestry. The national government in conjunction with county government, Kenya forest services and Solio Settlement Scheme local leaders can organize agroforestry awareness trainings pertaining the importance agroforestry and how it should be undertaken. The awareness trainings may be in the form of community meetings and other resourceful workshops.

The government should also adopt tree planting policy where every household is given target number of trees plant so that it can foster agroforestry. Farmers who will manage to plant the targeted number of trees are rewarded through established incentive program such as getting farm inputs at subsidized prices. The national and county governments need to create marketing destinations for agroforestry enterprise products like biogas, organic mature, honey and tree nursery seedlings.

5.6 Recommendations for Further study

The study recommends to the future researchers to further examine the importance of agroforestry. Previous studies have not exhaustively studied and quantified the merits of agroforestry. Agroforestry is associated with so many untapped benefits that researchers have not studied and this makes it difficult for the beneficiaries to derive. These benefits are of economic importance. Agroforestry is a key driver and interconnect to several economic activities. Benefits derived from agroforestry can directly affect farmers or indirectly affect the surrounding beneficiaries. Future researchers should look into the environmental benefit that can be tapped from agroforestry especially now the world is confronting the climate change rampaging effects. Agroforestry could be an ideal solution to the emerging environmental challenges and researchers need to find out. There has been no clear measurement matrix which can accurately determine the impact of agroforestry on individual livelihood.

Future researchers should consider investigating the correct measurement components of livelihood so that a harmonized and conclusive component measurement of livelihood could be attained. The future researchers should attempt to compare the benefits of agroforestry across all levels ranging from practice to the geographical regions. The future research should also consider assessing the performance of different agroforestry trees in different agro-ecological zones.

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APPENDICES

Appendix I: Introduction Letter

INTRODUCTION LETTER

Dear Respondent,

RE: ACADEMIC RESEARCH PROJECT

I am currently enrolled as a Master's student at Kenya Methodist University. I wish to do scholarly study on the effects of agroforestry adoption on the livelihood of smallholder farmers in Laikipia County's Solio Settlement Scheme. A questionnaire has been developed and will be used to collect pertinent data in order to answer the study's research objectives. The goal of this letter is to respectfully request your permission to collect information regarding this critical issue.

Please keep in mind that any information you provide will be held in strict confidence.

I will be really grateful for your participation.

Sincerely Yours,

Winfred Gathoni

Student

Appendix II: Introduction Letter from KeMU

Appendix III: Questionnaire

Instructions: Each set of questions has its own set of instructions. Please read them thoroughly as they differ from section to section. Certain questions require you to check the applicable or appropriate response, while others require you to rate your agreement (how strongly you agree or disagree); how frequent in agreement or how frequently you agree or disagree using a 5-point Likert scale.

The specific objectives of the study include; IV. To determine the environmental benefits of agroforestry adoption on the livelihood

To assess the benefits of agroforestry adoption to enterprise development VI.

To measure food and energy diversification associated with agroforestry adoption to smallholder farmers

SECTION ONE: GENERAL INFORMATION

1. Please tick your age _____ in years
2. What is your gender
   i. Male [ ]
   ii. Female [ ]
3. What is current marital status *(tick whichever applies*)

   Single [ ]

   Married [

   Widowed [ ]

   Divorced [ ]

   Other [ ]

4 What is your highest level of education completed? *(Tick the appropriate the one)*

None [ ]

Primary [ ]

Secondary [ ]

College [ ]

University graduate [ ]

5 What is your family size? _____ *(indicate actual number of household members)*

6 What is the size of your land in acres? _____ *(write in acres)*

7 Which enterprises do you have on your farm?

Crops

Livestock

Both (crops and livestock keeping)

Others

8 Have you allocated land for tree planting?

Yes ( )

No ( )

9 If you answered NO in question 8 above, explain the reason (s)

_____

SECTION TWO: STUDY VARIABLE

ENVIRONMENTAL BENEFITS OF AGROFORESTRY ADOPTION ON THE LIVELIHOOD OF THE SMALLHOLDER FARMERS

1. Please indicate the extent to which you agree with the following statement related to Environment effects of agroforestry adoption on the livelihood of the smallholder farmers (Use points on a scale of 1-5; Where; 1=Very Small Extent (VSE) 2= Small Extent (SE), 3=Moderate (M), 4= Large Extent (LE) and 5=Very Large Extent (VLE))

STATEMENT	VSE	SE	M	LE	VLE
Due to agroforestry, the scheme's high temperatures have decreased.					
Soil Erosion has reduced					
Agroforestry has resulted in an increase in water infiltration, which has resulted in a decrease in water runoff.					
Agroforestry decreases wind speed, which has a negative influence on water evaporation.					
Agroforestry has resulted in the creation of ecosystems that provide home for a variety of species.					
As a result of trees, water floods have been decreased, demonstrating the value of agroforestry.					
Following the establishment of agroforestry, consistent rainfall is seen.					

MEASUREMENT OF FOOD AND ENERGY DIVERSIFICATION ASSOCIATED WITH AGROFORESTRY ADOPTION TO SMALLHOLDER FARMERS

1. **Rate your agreement to these statements relating to impact of agroforestry on food and energy supply to small holder farmers in Solio Settlement Scheme** *(Use the 5-point Likert scale to circle one response appropriately)*

1 -Strongly disagree (SD) 2- Disagree (D) 3- Medium (N) 4-Agree (A) 5-Strongly Agree (SA)

STATEMENT	SD	A	M	D	SA
I am capable of providing an adequate food diet for all home members throughout the year prior to adopting agroforestry					
Due to my agroforestry adoption, I am able to offer an adequate food diet for all home members throughout the year.					
Crop production increased as a result of the adoption of agroforestry?					
Energy diversified as a result of agroforestry adoption					
Prior to agroforestry, I was unable to obtain an adequate supply of cooking energy from fuel wood.					
Due to agroforestry adoption, I am able to obtain affordable and sufficient energy from fuel wood.					
Largely, good supply has expanded greatly as a result of agroforestry adoption.					
Essentially, good supply has expanded substantially as a result of agroforestry adoption.					

2. In what ways has agroforestry impacted on your food and energy supply?

i. Negative [ ]

ii. Positively [ ]

iii. Not aware [ ]

BENEFITS OF AGROFORESTRY ADOPTION TO ENTERPRISE DEVELOPMENT

8. Do you agree that agroforestry as developed different enterprise that has impacted on the livelihood of small holder farmers in Solio Settlement Scheme?

i. Yes [ ] **ii.** No [ ]

9. Do you suggest that the revenue you get after adoption of agroforestry has increased or decreased?

i. Increased [ ] **ii.** Decreased [ ]

10. If you answered that revenue rose as a result of agroforestry adoption in question 9 above, please describe briefly how you believe this occurred. _____

_____

11. If your revenue grew as a result of agroforestry adoption, what is the primary source of revenue (what caused the increase)?

i. Firewood sales []

ii. Timber and post sales [] iii. Excess food harvests are sold []

iv. Honey

extraction []

v. Tree nursery business []

12. If you responded the revenue reduced following agroforestry adoption, identify the **PRIMARY** reason for the decline _____

13. Please provide an estimate of your annual expenditures on the following products between 2012 and 2021.

ITEM	**PRODUCT**	**ANNUAL EXPENDITURE IN 2012 (KSH)**	**ANNUAL EXPENCTURE IN 2021 (KSH)**
1	Food		
2	Building timber and post		
3	Health (to buy human medicine and animal treatment)		
	Education		
	Fuel wood		
	Luxury and recreation		

14. Do you believe your daily expenditures have increased or decreased as a result of the adoption of agroforestry?

i. Increased [ ] ii. Decreased [ ]

15. How much do you agree with the following statements about the benefits of agroforestry adoption for enterprise development in the Solio Settlement Scheme? (Use the 5-point Likert scale to tick one response appropriately) where;

1 -Strongly disagree (SD) 2- Disagree (D) 3- Neutral (N) 4-Agree (A) 5-Strongly Agree (SA)

STATEMENT	**SD**	**D**	**N**	**A**	**SA**
Agroforestry generates income for smallholder farmers hence it is worth adopting.					
Agroforestry is beneficial to the livelihoods of smallholder farmers					
Reduced fertilizer uses in the farm after agroforestry adoption					
Reduced purchase of artificial fertilizer					
Many small holder farmers operate agroforestry in this Solio Settlement Scheme since it is a good and profitable way of life					
Agroforestry has improved my income					
Prior to agroforestry, I used a considerable quantity of inorganic fertilizers on my farm to increase crop and tree productivity.					
After agroforestry adoption, the cost of purchasing artificial fertilizer decreased.					
Increased soil fertility has enabled me to purchase a comparatively minimal amount of fertilizer, resulting in enterprise development.					

16. In your opinion, has the adoption of agroforestry enhanced the livelihoods of smallholder farmers in the Solio Settlement Scheme?

i. Yes [ ] ii.

No [ ]

Thank you!

Appendix IV: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **411802**

Date of Issue: **07/June/2022**

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This is to Certify that Miss.. Winfred Gathoni Kirugumi of Kenya Methodist University, has been licensed to conduct research in Laikipia on the topic: Agro-Forestry Adoption on the Livelihoods of Small Holder Farmers in the Newly Settled Solio Ranch Scheme in Laikipia County for the period ending : 07/June/2023.

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