INFLUENCE OF SOCIOECONOMIC FACTORS AND EXTENSION SERVICES ON ADOPTION OF AGRICULTURAL WATER MANAGEMENT PRACTICES AMONG SMALLHOLDER FARMERS IN RONGAI SUB-COUNTY, NAKURU COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Master of Science Degree in Agricultural Extension of Egerton University

EGERTON UNIVERSITY

SEPTEMBER 2025

DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented for any award of diploma or degree in any other institution.

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Recommendation

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DEDICATION

I dedicate this thesis to my husband Mr. Paul Kahenya, daughters Jewel Muthoni, Joywell Wangare and Jaynell Mugure, and all my supportive friends who believe in my academic potential.

ACKNOWLEDGMENTS

I am deeply grateful to God for the gift of life and the abundant grace, which has sustained me throughout this journey without which reaching this remarkable milestone would not have been possible. My heartfelt appreciation goes to the Centre of Excellence in Sustainable Agricultural and Agribusiness Management (CESAAM), Egerton University, for awarding me the scholarship that made the completion of my studies a reality. I extend sincere thanks to my supervisors, Professor Fredrick Ngesa and Dr. Susan Mwaniki, for their unwavering support, guidance, and encouragement. I am also thankful to the entire Faculty of Education and Community Studies, as well as all lecturers in the Department of Agricultural Education and Extension, for their dedication in coursework delivery and their commitment during proposal and thesis defenses. I gratefully acknowledge the Ministry of Agriculture and Livestock Development, Rongai Sub-County, the extension officers, and the smallholder farmers who contributed to the data collection process. May the Almighty God richly bless each one of you for your invaluable role in the successful completion of my studies.

ABSTRACT

Water is a vital resource in agriculture, with its availability directly influencing crop yields and overall agricultural productivity. Much of Kenya falls within arid and semi-arid zones, where water scarcity poses a persistent challenge to farming. Rongai Sub-county in Nakuru County is one such semi-arid region. Over time, various agricultural strategies have been developed to address water shortages. This study specifically focused on the adoption of three Agricultural Water Management Practices (AWMPs): rainwater harvesting, irrigation, and the cultivation of drought resistant crops. The adoption of these practices varies and is influenced by several factors, particularly socioeconomic factors and access to agricultural extension services. This research investigated how farmers' education levels, income levels, and access to extension services affect the uptake of AWMPs by smallholder farmers in Rongai Sub-county. A cross-sectional survey design was employed, targeting a sample of 130 smallholder farmers selected from an accessible population of 6,230. Additionally, two ward extension officers from Visoi and Soin wards, along with an agricultural water officer, participated in the study. A proportionate sampling method was used for each ward, followed by simple random sampling to select individual farmers. Data were collected using structured questionnaires for the farmers and interview guides for the extension officers and agricultural water officer. Data analysis was conducted using SPSS Version 22. The results showed a low adoption rate of AWMPs in Rongai Sub-county, at only 35.8%. At a significance level of 0.05, binary regression analysis yielded p-values of 0.557 for education level, 0.033 for income level, and 0.024 for access to extension services. These results indicate that while income level and extension services significantly influence the adoption of AWMPs, education level does not have a statistically significant effect. Based on these findings, the study recommends that smallholder farmers diversify their income through off-farm activities to enhance financial resilience and facilitate the adoption of water management practices. Furthermore, the government of Kenya, in collaboration with other stakeholders, should strengthen extension service delivery by investing in training and recruiting more extension officers.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and semiarid Lands
AWMPS	Agricultural Water Management Practices
CESAAM	Centre of Excellence in Sustainable Agricultural and Agribusiness Management
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
ICRISAT	International Crops Research Institute for the Semiarid Tropics
ICT	Information and Communication Technology
KALRO	Kenya Agricultural and Livestock Research Organization
NACOSTI	National Commission for Science, Technology, and Innovation
NGOs	Non-governmental Organizations
REC	Research Ethics Committee
RWH	Rain Water Harvesting
SPSS	Statistical Package for Social Sciences
UNEP	United Nations Environmental Programme

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The amount of water consumed worldwide has been growing faster than population growth in the last century (Aivazidou, 2022). Water is a core element of sustainable agricultural development, particularly in enhancing agricultural productivity (Mutegi *et al.*, 2024). Some of Agricultural Water Management Practices (AWMPs) are drip irrigation, rainwater collection, sowing of drought-resistant crops, dry farming, sub-soiling, minimal tillage, cover crops, and compost and mulching (He *et al.*, 2021).

Water scarcity is a universal problem (Aivazidou, 2022). More than forty percent of the total water use in Europe is for farming. Other regions of Europe have experienced years of droughts, which have caused some countries like Spain and Italy to use drip irrigation to increase food output (Wordofa *et al.*, 2021). Some of the other AWMPs embraced in Europe are harvesting and storing water and planting drought-tolerant crops like grapes (Pataki *et al.*, 2023).

China, especially Northern China, faces the challenge of water scarcity. Approximately half of the total Chinese territory belongs to the region, and its share of the available water resources of the country as a whole does not exceed 20 percent (Aivazidou, 2022). Despite limited irrigated land, China has managed to produce more grain and is able feed part of the global population (Kang & Eltahir, 2019). The irrigated area is the largest in Northern China, with irrigation covering 14 million hectares in China. This irrigation process has led to the rise in crop production (Kang & Eltahir, 2019). In the same way, Israel is overcrowded, and more than fifty percent of its land is arid. It only gets rain during four months of the year, leading to scarcity of water. Even in a water-scarce area, it has already implemented AWMPs with the help of organic farming, pressure irrigation, and high-quality seeds, which have significantly increased food production and food security (Aivazidou, 2022).

African countries widely experience agricultural water challenges, soil degradation, and soil salinization that threaten small-scale farming (Liu *et al.*, 2024). As a case in point, in Malawi, drastic weather conditions like drought and floods are a menace to the country. These usually have very negative consequences on human lives, agriculture, infrastructure, and other important socioeconomic areas. An estimated 90 percent of export earnings in the country are spent in the farming sector and are the leading pillars of the national economy (Phiri & Velmurugan, 2024). Malawi is dependent on rain-fed agriculture in aspects of agricultural development. Throughout the years, drought has had adverse effects on agricultural production, diminishing the potential of the smallholder farmer and impacting the entire economy (Liu *et al*., 2024). Provided that farmers solely depend on rain-fed farming, the concept of sustainable food security, poverty reduction, and rural development will be impossible to achieve. In order to respond to such a water deficit, Malawi has intensified the required effort to ensure the introduction of irrigated agriculture, particularly among smallholder farmers (Phiri & Velmurugan, 2024).

Kenya is made up of arid and semiarid lands, also known as the ASALs, taking up 89 percent of the total country (Mutegi *et al*., 2024). The economy of Kenya revolves around agriculture, which sustains the consumption of sufficient food and employment resources for rural households. The issue of water scarcity has impacted this region incredibly, and it is going to maintain the scenario unless proper measures are taken (Waaswa *et al*., 2021). However, in certain sectors, Kenyan smallholder farmers have been made fruitful through the adoption of AWMPs, which include harvesting run-off water, irrigation, and organic farming (Mulwa *et al*., 2021).

In Eastern Kenya, smallholder farmers have yielded higher crops after adopting AWMPs by planting advanced high-quality and drought-tolerant cereals and legumes (Feyisa, 2020). At Yatta in Machakos County, farmers recorded high yields once they embraced water harvesting by using water pans to water crops. With the use of resilient crop varieties and water harvesting, food security within the broader County of Machakos has been attained (Mutegi *et al*., 2024). Farming communities regard the importance of the adoption of AWMPs. This is so as to encourage improved and efficient agricultural activities. Many factors may affect the adoption of AWMPs, such as demographic, institutional, political, and socioeconomic factors (Yang *et al*., 2023).

Demographic factors are characteristic of a population. These factors include age, race, ethnicity, gender, and sexual orientation (Atube *et al*., 2021). Institutional factors are defined as the right financial, legal, and social institutional framework. Various policies and actions catalyze political factors and include extension services, the availability of credit and marketing, crop insurance, research, and the labor market. They consist of the taxation systems, government policies, and leadership. Whether we live well depends on socioeconomic factors to a great extent (Feyisa, 2020). These influence the capability of making healthy choices. Income, level of education, land area, the availability of labor force, farm ownership, and farming experience are some of the socioeconomic characteristics that can precondition the adoption of AWMPs (Tatis Diaz *et al*., 2022).

The socioeconomic elements are important to the farmers since they directly influence their farming operations in terms of growth, sustainability, and profitability (Feyisa, 2020). Credit may depend on the income level of the farmer. Access to credit is needed to buy seeds, machines, fertilizers, and other vital inputs (Adams & Jumpah, 2021). Without access to financial resources, farmers may not be able to invest in the productivity of their farm (Tatis Diaz *et al*., 2022). Formal education also contributes to making farmers accessible to information and practical methods that will help them cope with emerging issues, sophisticated technologies, and advanced productivity (Feyisa, 2020).

A household's educational attainment exerts a decisive influence on adoption of modern agricultural technologies. Individuals who have completed higher levels of formal schooling are generally quicker to adopt these innovations, while households with only limited formal education do so less often (Feyisa, 2020). Equipped with higher education, farmers usually decode and implement agricultural knowledge more adeptly, even when the information is conveyed in their native languages (Wang *et al*., 2023). The local language can help with understanding, closer integration, and information retrieval (Khoza *et al*., 2019). Moreover, trained farmers in many cases pursue extra income-generating activities that allow them to embrace new agricultural activities in a comfortable way (Feyisa, 2020).

Adoption of modern farming technology is likely to be associated with the on-farm and off farm incomes of farmers (Feyisa, 2020). The reason is that off-farm income contributes to one of the major plans to deal with credit constraints experienced by smallholder farmers and enhance the capacity of farmers to purchase the technologies (Wordofa *et al*., 2021). Farmers have been known to find it difficult to afford agricultural technologies due to the price of the technologies. Consequently, the first trend is that farmers who enjoy a better income will more likely embrace modern technology in agriculture than those whose income is low (Bajaj *et al*., 2023).

Agricultural extension services are important in motivating farmers to adopt effective agrarian water management strategies (Feyisa, 2020). They serve as a link that allows closer cooperation among policymakers, research institutions, and farmers, who may open the way to finding the necessary capabilities and resources to put enhanced agricultural practice into practice (Nguyen *et al*., 2023). Extension services are pivotal in broadening the uptake of new technologies, supplying farmers with hands-on knowledge, technical expertise, and the necessary resources to make informed decisions (Gagoitsiwe & Keba, 2020). Such services mitigate the doubts about the efficacy of new practices and steer farmers toward appraising innovations. Hence, farmers who stay in regular contact with extension officers tend to adopt modern technologies more often, pointing to a strong positive correlation between extension availability and technology uptake (Feyisa, 2020).

Other factors may affect the adoption of agricultural water management practices (AWMPs). Among them are psychosocial factors such as opinions and beliefs alongside the availability of suitable technologies and infrastructure, prevailing climatic and environmental conditions, economics as well as policy-related drivers (Feyisa, 2020). Even so, this research concentrated on farmers' income, education level and access to extension services, as these factors are crucial to driving adoption behaviors (Gagoitsiwe & Keba, 2020).

Nakuru County emerges as one of Kenya's most noteworthy agricultural hubs. The area is deeply engaged in the production of staple crops that sustain household food security (Government of Kenya, 2019). The County also produces fruits and vegetables, positioning it as a multifaceted and highly productive agricultural domain (Gachie, 2020). Nakuru County is unable to produce much food despite its high potential, since water is scarce in some areas. The County is subjected to an average of 800 to 1000 mm of rain annually. Nevertheless, certain areas such as Rongai Sub-County, Gilgil, and Njoro Sub-County record annual rainfall levels as low as 500-800mm annually that fall below the average rainfall levels required to sustain agricultural production (Muturi, 2024).

Regardless of the situation, Nakuru County has made efforts in promoting the adoption of AWMPs. Under the project in Lare ward, Njoro Sub-County, smallholder farmers capture and store the rainwater to process irrigation (Kilimo News, 2020). According to Kilimo News (2020), also100 water pans have been built in Nessuit and Njoro wards in collaboration with the Nakuru county government and National Irrigation Authority in order to increase crop production during the dry seasons. Rongai Sub-County is one of those places in Nakuru that does not experience much rainfall annually. It has 5 wards, namely Menengai West, Soin, Visoi, Mosop, and Solai wards (Gachie, 2020). It has 26,804 smallholder farmers and 52,348 households. Rongai Sub-County occupies 988.1sq.km of land (Government of Kenya, 2019). The relatively dry climatic conditions experienced in Rongai have prompted the Kenyan government to make attempts to establish AWMPs, such as through the construction of 390 water pans, which can support irrigation in the region (Muturi, 2024). However, the adoption of AWMPs in the region remains low (Gachie, 2020).

1.2 Statement of the Problem

Water scarcity has been a persistent problem in several parts of Kenya, including Rongai Sub-County in Nakuru County. Despite this challenge, the uptake of Agricultural Water Management Practices (AWMPs) remains low, particularly among smallholder farmers. Limited agricultural productivity has been partly attributed to the poor adoption of these practices. In Rongai Sub-County, efforts have been made to encourage the implementation of AWMPs however, only a small proportion of smallholder farmers have embraced them. Furthermore, there has been no comprehensive research to ascertain the factors contributing to the varying levels of adoption of AWMPs in the area. This study, therefore, aimed to examine how selected socioeconomic factors, specifically education level ,income level, and the availability of extension services, influence the adoption of AWMPs, including rainwater harvesting, irrigation, and the use of drought-tolerant crops, among smallholder farmers in Rongai Sub-County, Nakuru County, Kenya.

1.3 Purpose of the Study

This study aimed to examine the impact of socioeconomic factors and extension services on the adoption of Agricultural Water Management Practices among smallholder farmers in Rongai Sub-County, Nakuru County, Kenya.

1.4 Objectives of the Study

The objectives of the study were;

i. To determine the influence of farmer's education level on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.
ii. To determine the influence of farmer's income level on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.
iii. To determine the influence of access to extension services on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.

1.5 Research Hypotheses

The following null hypotheses guided the study:

Ho1: There is no statistically significant influence of farmer's education level on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.

Ho2: There is no statistically significant influence of farmer's income level on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.

Ho3: There is no statistically significant influence of access to extension services on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya.

1.6 Significance of the Study

The study gave insights into the influence of selected socioeconomic factors and extension services on the adoption of AWMPs. This can respond to the problem of the adoption of AWMPs among smallholder farmers in Rongai Sub-County. The information can also assist in program development by extension service providers and community development agencies among the farmers, which is integral to the adoption of AWMPs. Government policymakers, such as the Ministry of Agriculture and Livestock Development, can also apply the information to improve the desired agricultural water management practices and diffusion strategies.

1.7 Scope of the Study

The study focused on smallholder farmers in Rongai Sub-County of Nakuru County. The research focused on how the selected socioeconomic and extension services influence the adoption of AWMPs. The selected factors were the farmer's education level, income level, and access to extension services. The AWMPs examined in this study were run-off rainwater harvesting, irrigation, and the use of drought-resistant crops.

1.8 Assumptions of the Study

The study relied on the premise that the information provided by smallholder farmers was accurate, even though most responses were based on memory rather than documented records.

1.9 Limitations of the Study

Language was a barrier, and some of the smallholder farmers were not conversant with English. However, the questions were translated into Kiswahili to help the farmers respond to the questions.

1.10 Definition of Terms

The following are critical words that were important in the study. The words were defined according to the literature and further operationalized according to the study.

Adoption: It is the cognitive process by which a person progresses from initially encountering a new concept to ultimately applying it and potentially using it again (Sahin, 2006). In this study, Adoption meant sustained use of AWMPs, which was classified as either high or low adoption.

Agricultural Water Management Practices: Are the strategies and techniques used to manage water resources efficiently in agricultural setting (Glória *et al*., 2020). These practices aim to optimize water use for crop production, enhance water conservation, and reduce water wastage while ensuring sustainable farming practices (Adeagbo *et al*., 2023). In this study, AWMPs refer to using water to provide crops with the amount of water they need to improve production. The study focused on rainwater harvesting, irrigation, and drought-resistant crops.

Education Level: The state of learning attained by a student or even a group of students, which is influenced by the developmental differences among students and the organization of the learning environment (Muturi, 2024). In this study, the education level refers to the highest or current level of formal education the farmer has attained.

Extension Services: The dissemination of scientific research and agricultural knowledge through farmer education and training programs (Chukwuone *et al.*, 2020). In this study, extension service was defined as any agrarian activity involving the exchange of information between extension workers and farmers to improve the agricultural and socioeconomic conditions of the farmers' lives. Its indicators were the number of extension services provided to smallholder farmers by extension service providers.

High Adoption: It is more significant than standard quantity, size, or intensity (Wordofa *et al.*, 2021). In the study, more than 50% of the adoption of agricultural water management practices was considered high.

Income: The total monetary earnings, assets, and other valuable transfers received over a specified period by individuals or entities as compensation for services, product sales, investment returns, pension distributions, gifts, and other sources (Feyisa, 2020). In this paper, income was gauged by the amount of money earned through the farm and off-farm activities.

Low Adoption: Refers to below average in amount, extent, or intensity (Chapa *et al.*, 2020). In the study, less than 50% of the adoption of AWMPs was considered low.

Practice: It is the practical application of an idea (Adeagbo *et al.*, 2023). In this study, practice was measured based on the adoption of AWMPs, specifically through harvesting rainwater, irrigating crops, and using drought-adaptive crops.

Smallholder Farmers: Farmers who farm land smaller than five acres (Nzuma & Ritho, 2019). The definition was applied for the study.

Socioeconomic Factors: These are elements that define people's status in society. These factors include income, education, farming experience, employment, and land ownership (Atube *et al.*, 2021). In the study, socioeconomic factors describe farmers based on their socioeconomic habits, including education level, income level, farming experience, and access to extension services. The study focused on farmers' education level and income level.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews existing literature on how selected socioeconomic factors and extension services influence the adoption of agricultural water management practices. The following sections have been discussed: 2.1 Introduction, 2.2 Impact of Water Scarcity in Agriculture, 2.3 Adoption of Agricultural Water Management Practices, 2.4 Impact of Socioeconomic Factors, Extension Services on the Adoption of AWMPs, 2.5 Determinants of Adoption of Agricultural Technologies among Smallholder Farmers, 2.6 The Theoretical Framework, and 2.7 The Conceptual Framework.

2.2 Impact of Water Scarcity on Agriculture

The past century experienced the growth in global water use more than twice as fast as that in population, and more arid regions are approaching a point beyond which it can be economically feasible to provide water service (He *et al.*, 2021). Water shortages have severe implications for world agriculture, touching almost every aspect of food stability, farming operations, and the economic system (Dinar *et al.*, 2019).

The major effects of water scarcity on agriculture are declining crop production and a lack of enough water supply, resulting in low output because crops need the necessary moisture in order to grow and yield, especially among crops such as rice, wheat, and maize, which are reactive to water stress (Liu *et al.*, 2023). Shortage of water not only strains crops but also livestock. Animals need water in order to hydrate, and crops need water to grow. With water shortage, the livestock farmers may be forced to pay more or even reduce the number of their herds, which can affect the chain of food supply of meat, milk, and fowl. Fisheries and aquaculture are also affected by water scarcity because the decreasing quality and availability of water can lower the number of fish or complicate the process of fish farming (Wisser *et al.*, 2024).

Lack of water also limits farmers from practicing low impact farming methods such as crop rotation, organic agriculture, and conservation tillage (Liu *et al.*, 2023). These sustainable farming methods are more efficient in terms of using water, but can be more resource or financially demanding, which most of the smallholder farmers cannot support (Dinar *et al.*, 2019). Water shortage represent the same problem in Europe; there is a high variation in water shortage issues in the region in terms of climate, topography, and water use. The most exposed countries in Southern Europe are Spain, Italy, Portugal, Greece, and sections of France in terms of vulnerability to a shortage of water. These regions are hot during the summer, and they have scarce water resources. As an example, Spain is extremely dependent on irrigation in agriculture, especially in its drier south, and consequently, is extremely vulnerable to droughts (Soares & Lima, 2022).

Middle Eastern countries have always been exposed to the serious implications of water conditions. Rapid population and instability in the area on the background of climate variability are more emergent and can cause a demand in estimated economic losses associated with climate-driven water scarcity projected at 6 to 14 percent Gross Domestic Product (GDP) by 2050 (Gabr, 2023). One of the countries that is a victim of semi-desert climatic conditions and a deficiency of fresh water sources is Egypt. The situation is predicted to continue and deteriorate over the years because of climate change and global warming (Mostafa *et al.*, 2021).

Rainfall in Egypt is extremely limited, with annual precipitation along the northwestern coast ranging from 192 mm in Alexandria to 102 mm in Al-Saloum and dropping to just 80 mm in Port Said, gradually increasing eastward. Despite these arid conditions, the government has successfully managed to sustain water availability. A key strategy has been the implementation of a national policy focused on recycling drainage water in the Nile Delta (Mostafa *et al.*, 2021). This policy promotes the reuse of agricultural drainage water by extracting it from main and branch drains, blending it with freshwater in central and branch canals, and supplementing supplies through the treatment and recycle of domestic and industrial wastewater (Gabr, 2023).

Sudan is one of the Eastern African nations experiencing ecological crises, such as water shortages and desertification. Life in Sudan is dependent on the widespread usage of water resources. Unemployment in the country stands at 80% of the job bearers, with only 97 percent of the water utilized in the agricultural sector (Nyika & Dinka, 2023). In partnership, there have been different attempts to alleviate the situation by developing other projects. The Wadi El Ku Integrated Catchment Management Project is a United Nations Environmental Program (UNEP) project funded by the European Union to accomplish its objective through practical action in conjunction with communities and the state government of North Darfur

(Ruzzante *et al.*, 2021). The main positive outcome of the project was better food security, livelihoods, and agricultural productivity (Nyika & Dinka, 2023). Moreover, the project contributed to the minimization of tensions between communities and the elimination of disagreements over the limited natural resources, especially those between pastoralists and crop farmers (Ruzzante *et al*., 2021).

Water shortage is an acute concern in Kenya that has broad implications for food security and farming, economic growth, population health, and social harmony. Many East African countries, including Kenya, are hampered by climate variability, population growth, and poor water management, among other factors. The effects of water scarcity in Kenya are especially high in arid and semiarid lands (ASALs) and heavily rain-based agricultural areas (Nyika & Dinka, 2023).

Kitui County is located in the lower eastern region of the Republic of Kenya, and it is one of the most water-limited counties in the nation (Mulwa *et al*., 2021). Rainfall in the County is erratic, and there is a seasonal drought, whereby water security is a major concern. Kitui is currently facing the problem of water insecurity, which can significantly impact agriculture, livelihoods, and the general well-being of the population (Government of Kenya, 2019). Nevertheless, different management practices are being executed to deal with these challenges. Along with nongovernmental organizations (NGOs), international communities and local community-based groups have adopted different water management strategies that aim to enhance water security in Kitui County (Mulwa *et al*., 2021). These tactics pay attention to making more water available, enhancing its efficient use, and addressing the improvement of water quality (Koehler *et al*., 2022).

Numerous homeowners in Kitui are advised to exploit rooftop rainwater harvesting mechanisms that will allow them to trap the rainwater when it rains and thus store rainwater during rainy seasons. Such water will be available for use in homes, irrigation, and to supply animals with water, especially when it is dry. Training and support are provided to ensure proper installation and maintenance (Mulwa *et al*., 2021). There are various water storage initiatives involving the creation of small-scale dams and pans (artificial water storage reservoirs) to store and contain rainwater. These are constructions that assist in supplying water in dry periods, both at home and on farms. A good example is the Kyamwilu dam and other water projects that are regarded as an important source of water in Kitui (Mwangi & Kariuki, 2019).

The County of Nakuru has been affected by drought and high temperatures, whereby, since 1981, the temperature has increased by 1 °C. This climatic volatility is a factor that leads to the low farm yields experienced by the farmers repeatedly (Waaswa *et al*., 2021). The problem of water shortage in the Rongai Sub-County of Nakuru County in Kenya is a major problem that is mainly influenced by the semiarid climate, seasonal rainfalls, and increasing water consumption owing to population increase and farming (Gachie, 2020). The Rongai area, which is in the southern region of Nakuru County, is mostly prone to water shortage, especially during the dry periods and the long droughts. Water resources management in Rongai Sub-County requires tackling immediate supply challenges while promoting sustainable water use practices to meet the population's needs, agriculture and local ecosystems (Talli, 2020).

Rainwater harvesting is one of the best resolutions in Rongai in encouraging rainwater harvesting on a household and community basis. Several households in Rongai have been urged to have a rainwater harvesting system that can collect and hold the rainwater captured during the rainy season (Gachie, 2020). The water is available for domestic use during dry spells, smaller-scale irrigation, and livestock. Dams and water pans: Small dams, water pans, and reservoirs have been important strategies used in the harvesting of rainstorms to store water in order to use it in farming activities and domestic purposes (Talli, 2020). Other projects, such as the Ngong Water Pan Construction efforts, have already been in use in areas nearby, and this may be extended in Rongai. Such reservoirs offer a reserve against dry periods through agriculture and home uses of water (Sitieney, 2023).

2.3 Adoption of Agricultural Water Management Practices

The increasing food demand worldwide has posed a serious challenge to the concept of sustainable agriculture as water availability decreases (Eyieyien & Ijomah, 2024).Water scarcity is anticipated to worsen due to the projected increase in the global population and the effects of climate change, such as higher temperatures and irregular rainfall patterns (Mandal *et al*., 2020).

Water as a resource is irreplaceable, and it can only be renewed when used reasonably. All forms of life, socioeconomic growth, and a healthy ecosystem require water (Mandal *et al*., 2020). The most important water-consuming activity in the world is agriculture, which consumes 70 percent of the total share of water withdrawals globally. The AWMPs involve a number of management practices, of which watershed, conveyance, and application are among the key practices (Eyieyien & Ijomah, 2024). The AWMPs interventions are capturing and storing water, drip irrigation, dry farming, drought-tolerant crop use, and organic farming (Aivazidou, 2022).

A comprehensive perspective on Agricultural Water Management Practices is essential, as sustainable and productive water management inherently involves addressing related factors such as climate change and variability, crop selection, animal nutrition, ecosystem preservation, and soil quality (Gloria *et al*., 2020). This holistic approach is important because AWMPs play a key role in mitigating water scarcity, enhancing food security and nutrition, and supporting a healthy ecosystem (Eyieyien & Ijomah, 2024).

The government of Kenya has already implemented different soil and water management processes, and activities undertaken include water harvesting, conservation, and management (Gachie, 2020). These practices enhance water retention in the soil profile by employing methods such as bench terraces, tied ridges, fallowing, contour fallows, mulching, crop rotation, mixed cropping, conservation tillage, and soil fertility improvement techniques (Gloria *et al*., 2020). In Kenya, field trials in the semiarid areas of the country revealed that water conservation methods can boost food production (Rotich *et al*., 2024).

The following are the AWMPs that the study focused on as commonly practiced in Rongai Sub-County:

2.3.1 Uptake of Rainwater Harvesting Technique

In the regions where the rates of rain are low, rainwater harvesting (RWH) methods frequently gain more popularity (Chapa *et al*., 2020). There are arid and semiarid (ASA) areas all over the world where there is less rainfall and rainy seasons are short. The common type of agriculture practiced in these areas is rain-fed agriculture, which is crop-based and relies on rainfall (Rotich *et al*., 2024). To address the issue of minimal annual precipitation and severe climatic emergencies, farmers have come up with a number of agricultural techniques and methods of rainwater harvesting (Tamagnone *et al*., 2020).

Floodwater harvesting is possible in large quantities during the rainy season. About 90 and 50 percent of the run-off of 4.6 and 10.8 billion cubic meters are measured within a season. The site where there is run-off water, structures should be built in a deep and appropriate location instead of wasting the run-off water. Such structures would facilitate any modifications in policy formation and executing the water resources to practice in irrigating the agricultural systems (Babker *et al*., 2020). The readiness and ability to harvest water that would have flooded off is a mitigation plan since the mere existence of water harvesting facilities or structures means that farmers are in a better position to mitigate the drought conditions by managing the supply of rainwater more intensely and effectively (Abd-Elaty *et al*., 2024).

Various water harvesting techniques, such as the development of water harvesting systems like zai pits, water pans, and shallow wells, have been applied in Kenya's arid and semiarid lands (Gloria *et al*., 2020). This is a way to exploit the scant amount of rain that they receive to stimulate crop and pasture growth (Ngetich *et al*., 2022). Such methods aim at preventing soil erosion and conserving water. The outcomes of such interventions are however, yet to be fully realized because of the low rate of adoption of such technologies by farmers (Luttta *et al*., 2020).

2.3.2 Adoption and Use of Irrigation Systems

In rain-fed farming, watershed management has widened water availability on a large scale and over a long duration. However, with appropriate irrigation management in such areas, one would end up using the available water appropriately (Mandal *et al*., 2020). Water is considered a scarce resource, a factor of production, and an appropriate economic factor for use in semiarid irrigated regions. However, the significant variability in irrigation performance highlights the need for improved management strategies to enhance the efficiency and long-term sustainability of irrigated agriculture (Malik & Dechmi, 2019).

Irrigation is of various varieties, which include surface irrigation, sprinkler irrigation, and drip irrigation (Wang *et al*., 2019). Surface irrigation usually involves the introduction of water at a point at the highest altitude and the distribution of the water by gravity run-off throughout the field (Mandal *et al*., 2020). This means the area is covered by overflow.

Water use efficiency can also be well enhanced through surface irrigation, as it ensures that water is directed to the crop root zone (Wang *et al*., 2019).

Sprinkler irrigation is pressurized irrigation where water can be applied on the surface of the soil through mechanical and hydraulic equipment that mimics nature in creating rain. Drip irrigation, however, entails a uniform flow of water, which is enabled to flow down slowly to the plant root; either above the surface of the ground or buried beneath the surface (Omran & Negm, 2020). The goal is to supply water straight to the plant roots while reducing losses from evaporation (Wang *et al*., 2019). Egypt employs a lot of drip irrigation. It is one of the most satisfactory irrigation systems because it conserves water, raises the amount and quality of crop production, reduces the issue of weeds, and makes it easy to apply fertilizers. In Sudan irrigation takes place in river basins in arid areas where other techniques besides gated irrigation are used, including spate irrigation to irrigate the nearby arable areas (Mandal *et al*., 2020).

Mwangi (2019) highlights that irrigation significantly contributes to improving the livelihoods of farming families by increasing crop production and raising household earnings. In Kenya, vegetable farmers in Kiambu have successfully conserved water and achieved higher crop production through the use of irrigation. This practice enables farmers to cultivate high-value crops, improve the quality of their produce, and intensify small-scale farming systems by encouraging the use of additional productivity-enhancing inputs. Furthermore, irrigation strengthens smallholder agriculture by making it more resilient to climate-related disruptions, thereby improving productivity, livelihoods, and overall food security (Gloria *et al*., 2020).

2.3.3 Adoption and cultivation of Drought-Resistant Crops

Abiotic stresses like drought, excessive salinity, and extreme temperatures can severely reduce crop yields by hindering plant growth and development. During water scarcity, plants activate various complex defense mechanisms to enhance their chances of survival (Zhu *et al*., 2019).

Drought-tolerant crops such as maize, cowpeas, sorghum, millet, beans, sweet potatoes, and rice, among others, have been bred to maturity using traditional plant breeding processes or biotechnology and continue growing and yielding despite a shortage of rain (Mandal *et al*., 2020). They have existed since the 20th century, yet over the past 20 years, the research concerning drought-tolerance crops has been expanding, and the focus has been put on staple crops, such as maize, rice, and wheat (Kebede *et al*., 2019). Farmers in Eastern Kenya are experiencing an increase in the production of crops and are gaining more income (Mulwa *et al*., 2021). They have distributed 1,000 tons of better-quality seeds of drought-tolerant cereals and legumes to more than 144,000 household farming units, covering more than 60,000 hectares of land (Ngetich *et al*., 2022).

2.4 Influence of Socioeconomic Factors and Extension Services on the Adoption of Agricultural Water Management Practices

Water is a crucial crop to farmers and a fundamental food component (Lutta *et al*., 2020). However, in most instances, rainfall is not sufficient to provide the required volume of water to facilitate the proper production of food. This, therefore, creates the necessity to preserve the available small amount of water. This is done through the various AWMPs that include the use of rainwater harvesting techniques, drip irrigation, and drought-resistant crops (Stavi *et al*., 2020).

Diverse communities are not willing to implement AWMPs, but some of them do accept it willingly (Eyieyien & Ijomah, 2024). According to research, use of AWMPs has largely been influenced by socioeconomic elements. In fact, a survey conducted in India on the influence of socioeconomic factors on the adoption of AWMPs by farmers showed that the level of education and the size of the farm determine the choice that various farmers adopt when applying different AWMPs (Stavi *et al*., 2020). This means that socioeconomic factors are significant and undisputable in affecting the use of AWMPs due to the limited water sources (Atube *et al*., 2021).

Socioeconomic factors influence both life expectancy and quality of life. A farmer's socioeconomic status plays a key role in determining the adoption of improved farming practices (Chimoita *et al*., 2019). Factors such as educational attainment, landholding size, farming experience, employment status, income level, and availability of labor all affect the uptake of agricultural technologies (Khoza *et al*., 2019).

Netherlands has performed remarkably well in Europe's agriculture and has some of the most fertile land in Europe. The socioeconomic aspects that have facilitated the Dutch being good farmers include land and extension services; this system of managing water has enabled the drainage of any excessive water and storage of it to serve the dry season (Stavi *et al*., 2020).

Successful AWMPs have resulted from the collaboration of farmers and the extension services, whereby water boards have continued to cooperate with farmers and extension services. Water boards in the Netherlands manage the pace of the flow and amount and quality of water (Ruzzante *et al*., 2021).

In Africa, there has been wide use of the AWMPs in specific regions, whereas there has been poor uptake of the AWMPs in other areas. Socioeconomic elements are some of the factors that influence the level of adoption (Feyisa, 2020). In Algeria, every farming activity is being done with irrigation, but it has been changing with the influence of capital. In the northern Algerian region, the drip irrigation used in industrial tomato farms brought the average weight of tomatoes up to 19 tons compared to 13 tons in 2019. As much as the growth in yield is a preferred output, the adoption of modern agriculture through drip irrigation comes with large volume pumps, which need a significant amount of money to install and maintain the irrigation system (Oulmane *et al*., 2022).

Kenya has realized the need to apply agricultural water management practices in developing sustainable agricultural practices in the country, especially due to the significant effects of climate change elements like frequent droughts (Waaswa *et al*., 2021). In order to mitigate these difficulties, farmers have implemented a number of AWMPs, such as harvesting rainwater and growing crops tolerant to drought, which makes them more resilient and leads to more sustainable production even in the more vulnerable areas (Ngetich *et al*., 2022).

Smallholder farmers in Yatta in Machakos County were able to achieve high farming yields after implementing water harvesting through the building of water pans to irrigate their farms (Ngetich *et al*., 2022). Stabilized food security in the greater Machakos County was achieved because the previously arid land became habitable. Education played a role in the adoption of water harvesting, whereby, people were trained so as to acquire the necessary skills to adopt the systems of water harvesting through establishing water pans (Mutegi *et al*., 2024). Training is essential in AWMPs since it enhances the uptake of technologies rapidly (Ngetich *et al*., 2022).

The Kenyan smallholder farmers are economically and socially challenged. Among the challenges are land tenure, animal diseases, farm and animal pests, poor access to suitable technologies, inability to obtain credit, and drought (Chimoita *et al*., 2019). One of the primary obstacles that smallholder farmers face is drought (Waaswa *et al*., 2021). Various mitigations have been instituted to address the challenge, and AWMPs are one of the mitigations instituted (Mwangi & Crewett, 2019). Specifically, AWMPs improve food security by preventing food insecurity due to bumper harvests of crops (Rotich *et al*., 2024).

While Agricultural Water Management Practices are successful in enhancing food production, their adoption is limited by various challenges, including socioeconomic constraints (Chimoita *et al*., 2019). All these dynamics affect the response of the farmer to AWMPs in terms of availing the means to make the adjustments, including capital and labor, and even the intelligence to implement new technologies (Feyisa, 2020). The socioeconomic factors that the study concentrated on are as follows:

2.4.1 Impact of Farmers' Education Level on Adoption of Agricultural Water Management Practices

The academic background of smallholder farmers is another typical and significant factor that determines the adoption behavior of smallholder farmers toward agricultural technology. Education is alterable, which transforms the knowledge, skills, and attitudes of the farmers (Tatis Diaz *et al*., 2022). It even improves the analytical and problem-solving ability of the farmers. Moreover, education allows for increasing the proficiency of decision-makers when they think critically and make proper utilization of information sources. According to research in Nigeria looking at factors affecting farmer adaptation to climate change, the well-educated farmers knew outlets in obtaining information and were more effective in assessing and interpreting information concerning new farming technologies such as AWMPs in comparison to the less educated or uneducated farmers (Hoa Le Dang *et al*., 2019).

Different studies have revealed that the level of education is a positive determinant of the embrace of technologies (Tatis Diaz *et al*., 2022). An example is a study that was conducted on determinants of the adoption of improved sorghum varieties in Somalia Region and Ethiopia, where it was indicated that farmers who are better educated have greater chances of adopting improved sorghum varieties as compared to their counterparts who have a lesser education level within the region studied (Feyisa, 2020). Levels of education improve the cognizance and judgment, and this can raise the likelihood of accepting the practices. The educated farmers can also increase their practical awareness and apprehension of an issue since they can understand a lot about their location and the food system (Lukurugu *et al*., 2022).

Agricultural production also relates to educational qualifications. Another study concluded that the farm output of co-operative farmers in Anambra state of Nigeria is influenced by socioeconomic factors, like level of education (Yang *et al*., 2023). It is noteworthy that education will have effect on the consumption of technology since new technologies allow one to comprehend the anticipated returns (Nzuma & Ritho, 2019).

2.4.2 Influence of Farmers' Income on uptake of Agricultural Water Management Practices

The earnings of smallholder farmers, from both agricultural and non-agricultural sources, play a crucial role in the uptake of new technologies (Asante *et al*., 2024). Earnings from non-farming activities have been found to positively impact the adoption of new technologies. This is mainly because off-farm income enables smallholder farmers to overcome financial limitations and obtain the resources they need (Atube *et al*., 2021). It is commonly noted that the pricing of the technologies often guides the attitude of the farmers towards paying for relevant agricultural technologies. Consequently, the more farmers have income, the higher their chances of accessing agricultural technologies are (Asante *et al.*, 2024).

Income from other sources will enable the farmers to have capital to acquire productivity enhancing inputs like improved seeds, fertilizers, and other resources required (Asante *et al*., 2024). Farmers who earn off-farm income tend to adopt more technologies and spend more on the inputs bought than the other groups (Nzuma & Ritho, 2019). Nevertheless, off-farm incomes have not been positively correlated with all the technologies. According to some studies, the employment of modern agricultural technologies has a negative correlation between off-farm and use of the modern innovations (Khoza *et al*., 2019).

2.4.3 Impact of Extension Services on uptake of Agricultural Water Management Practices

Extension services can be defined as the various activities that help deliver the information, guidance, and services required by farmers and families to enhance their knowledge, skills, experience, and increase their livelihoods through farming (Feyisa, 2020). Extension services are often described as a form of informal education with the potential to facilitate the sharing and dissemination of knowledge, which farmers can then translate into practical applications. (Hamdan Al-Zahrani *et al*., 2021).

Extension services are of two types: public and private. The government and parastatal organizations offer public extension services. The leading actors who offer private extension services are private firms and non-governmental organizations, co-operative unions of farmers, agricultural input marketers, and commercial extension practitioners. The quality of such services is more refined and takes less time to deploy than the services offered by the state (Mwololo *et al*., 2019).

Technology adoption is marked by access to extension services (Nguyen *et al*., 2023). The problem of the absence of formal education among farmers has a negative impact that could be avoided through extension services, leading to the adoption of technology. Therefore, the extension service provides the platform on which one can access essential information that facilitates the adoption of technology (Mwololo *et al*., 2019). In addition, the feedback obtained via the extension services reduces the ambiguity regarding the performance of a particular new technology. It contributes to favorably changing the estimation of adoption by a specific individual. Extension services function as a type of non-formal education that supports the dissemination and exchange of knowledge, enabling farmers to transform this information into practical use (Feyisa, 2020).

Some of the attributes that have led to technological development in the agricultural system of developing countries include extension services (Feyisa, 2020). Extension officers can easily identify challenges facing farmers, which will help in the development of technology and resolve the problems. It is a critical aspect that makes different farmers differ in the status of adoption. Nowadays, the extension system provides a lot of agricultural technology delivery (Atube *et al*., 2021).

Extension services enhance the capacity of farmers to make the best farming choices through the evaluation of new technologies and obtaining information regarding the technologies. Extension services also aim to change the behavioral patterns of farmers (Nguyen *et al*., 2023). The change in behavior, in its turn, would lead to improved farming decisions, including the uptake of high-yield technologies, which would achieve the satisfying results of increased land productivity, increased farm revenue, and improved household livelihoods (Mwololo *et al*., 2019). Extension services educate farmers on contemporary production techniques and disperse farming information to them. In addition, the farmers can join co-operatives that enable them to obtain production inputs with the assistance of the extension workers. Such services allow the process of adopting technology and raise productivity and earnings (Anang & Asante, 2020).

Farmers are required to get new practices, knowledge, and skills to develop their farming practices and other productive engagements (Mwololo *et al.*, 2019). In the process, positive attitudes towards farming, new practices, and extension will have developed in them, which will affect their behavior. The farmers will be equipped with the most recent information and schooling regarding agriculture through extension services to manage their farming activities better and offer them more technical abilities (Feyisa, 2020). It is also through extension services that adult farmers can acquire the required education and knowledge of the new agricultural practices. It is through this that farmers are able to make proper use of technology. They adopt technology and discuss it with other farmers, resulting in its intense adoption (Utami *et al.*, 2019).

Extension is not only confined to the technology of farming practices, management of the farmers is also included, so that they can relate well in their respective markets. They can also communicate effectively with the concerned individuals and receive improved and efficient markets. In addition, the use of modern technology blends with extension services, which leads to high productivity (Nguyen *et al.*, 2023). The extension services aid in lowering the cost of engaging in information exchange with the broader farming community (Feyisa, 2020). Farmers may demand extension services at any point; thus, their availability is paramount in situations where they have some dire issues and wish the extension agent to get involved in addressing those issues (Wordofa *et al.*, 2021).

Extension services can be offered in various ways, including individual and group approaches (Feyisa, 2020). The propagation of mass media provides the benefit of communicating with multiple actors simultaneously; nevertheless, the transfer of knowledge is primarily a domain of the agricultural extension agents. Such a mass media extension is done by sending information to the media sources in the form of newspapers, stories, pictures, and recorded interviews with the farmer or the extension service provider (Yang *et al.*, 2023). However, with the innovation of the internet and the subsequent ICT the hierarchies are reversing since it is a place where farmers and other experts can connect and provide agricultural information faster (Atube *et al.*, 2021).

Farmers are now able to share information through their mobile phones and internet-related applications to communicate with their colleagues at a distance that one could not even imagine a few years ago (Eyieyien & Ijomah, 2024). The rapidity of information dissemination and the multiplier of information to a large number of individuals is aided by the mass media extension. Nevertheless, it only reaches farmers who have the means of utilizing mass media (Omulo & Kumeh, 2020). Extension services supply farmers with ideas of new practices and guarantee access to better technologies. The introduction and uptake of better AWMPs can be influenced by extension services (Eyieyien & Ijomah, 2024).

2.5 Determinants of the Adoption of Agricultural Technologies among Smallholder Farmers

The concept of agricultural practices uptake refers to the extent to which farmers fully embrace new technologies over time, once they are fully informed about the technology and its potential benefits (Hamdan Al-Zahrani *et al*., 2021).Such technologies are created to raise crop production in farms, enhance farm product quality, raise the revenue of farmers, and warrant food security (Yin *et al*., 2022). Examples of AWMPs include some agricultural technologies such as rooftop farming, dew harvesting greenhouse, crop mapping drones, indoor farming devices, and farm mobile applications (Aivazidou, 2022).

According to Arslan (2020), there are a number of elements that contribute to adoption of technologies. These factors are socioeconomic factors, the socio-demographic factors, access to information, and the infrastructure. Certain factors encourage adoption, others hinder it, while some exert both positive and negative influences on the adoption process. Socio-demographic includes age, education, number of people in a family, and gender. Information access affects the adoption positively (Yang *et al*., 2023).

Access to detailed information about specific practices, as well as broader information on prices, market opportunities, and practical experience, is likely to enhance adoption by helping farmers understand the benefits of implementing the practice (Yin *et al*., 2022). Infrastructure can either affect adoption positively or negatively. An example is that adoption could be adversely affected by distance to markets or roads. In case the markets in which the modern technologies are present cannot be accessed, low adoption will occur due to a small number of farmers having access to the technologies (Yang *et al*., 2023).

The problems of the farmer or the functioning environment also limit the use of agricultural technologies. These challenges are psychosocial challenges, technology and infrastructure challenges, climatic and environmental issues, economic and policy issues. Psychosocial problems involve cases where farmers are not psychologically ready to do farming and agriculture. Conversely, technology and infrastructure challenges refer to the presence of bad roads, no means of storage, no transport, poor networking, and lack of computerized machines (Tatis Diaz *et al*., 2022). The climatic and environmental factors involve a lack of good soil and unfavorable weather conditions, which are characterized by floods and droughts. Lastly, under economic and policy concerns, one can mention such factors as the absence of money, poor access to credit, the absence of funds to acquire more advanced farm implements, shortage of labor, and high input costs, including fertilizers, seeds, and machinery. As observed, the adoption of agricultural technologies can be influenced by socioeconomic factors (Gagoitsiwe & Keba, 2020).

2.6 Theoretical Framework

This study was founded on the diffusion of innovation theory by Everett Rogers (Rogers, 2003). Rogers reasons that it is through diffusion that an innovation is applied in a social System. The theory tries to describe how, why, and at what speed new ideas and technology diffuse (Sahin, 2006). According to the theory, four primary factors influence the spread of a new idea: the innovation itself, the communication channels used, the passage of time, and the social system in which it occurs. Rogers also described technology adoption as a decision making process where an individual moves through several cognitive stages before choosing to embrace an innovation. This process involves acquiring information about the innovation, forming an opinion about it, deciding to adopt or reject it, implementing the new idea, and finally confirming the decision (Sahin, 2006).

The theory affirms that, innovation is judged for adoption when it can be tried out (trialability), the output can be observed (observability), it dominates other innovations or the present circumstance (relative advantage), it is not difficult to learn or use (complexity), and it fits in or is compatible with the circumstances into which it will be adopted (compatibility) (Sahin, 2006). Experts across various fields, including agriculture, have applied this theory to promote the uptake of innovative practices. For smallholder farmers, adopting improved agricultural methods largely depends on their ability to access and understand information about new techniques, as well as their ability to apply this knowledge in practice effectively (Dearing & Cox, 2018).

Although this theory is applicable in several disciplines, it has the limitation of assuming that farmers are rational actors who make adoption decisions independently (Dearing & Cox, 2018). However, adoption is often influenced by social dynamics, cultural context, and collective behavior. In agriculture, a farmer may not independently decide to adopt a new irrigation system solely based on personal factors but may be influenced by peer networks, community leaders, or local regulations. Socioeconomic factors can affect the trialability, observability, relative advantage, complexity, and compatibility of AWMPs. Therefore, introducing AWMPs with those elements can be used highly by trained smallholder farmers in Rongai Sub-County. The theory was therefore, appropriately applied in the study.

2.7 The Conceptual Framework

The conceptual framework outlines the approach used to study the selected socioeconomic factors and extension services. The study hypothesized that socioeconomic factors and extension services influence the adoption of agricultural water management practices (Fig. 1). Socioeconomic factors can affect the trialability, observability, relative advantage, complexity, and compatibility of AWMPs.

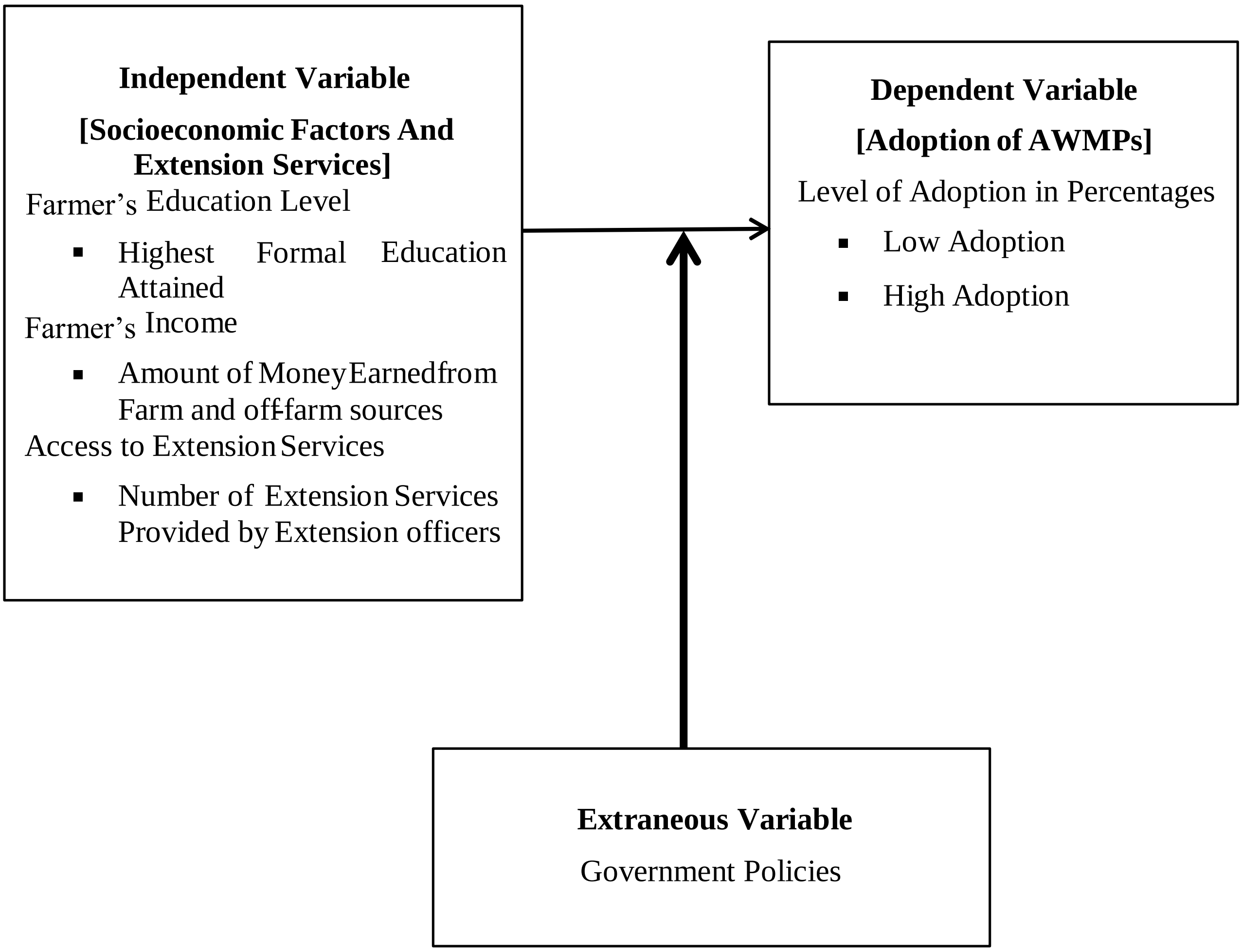
The independent variables were selected socioeconomic factors and extension services. The factors focused on were the farmer's education level, income level, and extension services. The farmer's education level was measured in terms of the highest formal education attained, income was measured in terms of the amount gotten from the farm and from other non - agricultural activities, and access to extension services was measured by the number of extension services provided by the extension officer, either physically or online.

The dependent variable was the adoption of AWMPs, while the extraneous variable is government policies such as the National Irrigation Policy and the National Food and Nutrition Security Policy. The policies may directly or indirectly affect the study, and the researcher has no control over them. Adoption of AWMPs was measured in percentage and classified as low adoption or high adoption. These percentages were calculated from

AWMPs farmers have adopted compared to the three AWMPs focused on in the study (Rainwater harvesting, irrigation, and use of drought-resistant crops). AWMPs were classified as low adoption if less than 50% and high if more than 50% (Figure 1).

Figure 1

Conceptual Framework of Influence of Socioeconomic factors and Extension services on the Adoption of Agricultural Water Management Practices



CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

The chapter discusses the approach adopted in conducting the research. It outlines the design of the study, its geographical scope, the population under consideration, sampling methods, the sample size, the instruments applied, and the procedures for gathering and analyzing data.

3.2 Research Design

The research was based on a cross-sectional survey design. Such a design is useful for descriptive studies and for generating hypotheses, as it allows data to be gathered from several variables at one time. It also makes it possible to use different tools, like questionnaires and interviews, to collect both numerical and descriptive data (Tomaszewski *et al*., 2020). Therefore, this design was chosen as the most suitable for the study.

3.3 Location of the Study

This research took place in Rongai Sub-County of Nakuru County, Kenya. Administratively, Rongai is divided into five wards, namely Soin, Solai, Mosop, Visoi, and Menengai West (Appendix C). Rongai Sub-County is approximately 988.1 square kilometers with a population of 199,906 people. Its population density is 202 square kilometers. Livestock keeping, crop cultivation, trade, and investments are the main economic activities in Rongai (Gachie, 2020).

Rongai Sub-County experiences variations in seasonal rainfall and is susceptible to droughts. The rainfall range is 500-800mm per annum, below average equated to the average rainfall of 800-1000 mm per annum. The Kenyan government has managed the situation; for example, extension service providers have created awareness of the importance of water harvesting during the rainy season. Consequently, some farmers have successfully constructed water pans to store water used to irrigate crops during the dry seasons (Mutegi *et al*., 2024). The study covered two wards, Soin and Visoi, as they experienced extremely low seasonal rainfall of 400- 600 mm per annum (Gachie, 2020).

3.4 Target Population

The research targeted 26,804 smallholder farmers in Rongai Sub-County, two Ward extension officers from the Visoi and Soin Wards, and the agricultural water officer. The accessible population was 6,230 smallholder farmers from Visoi Ward, 3,156, and Soin Ward, 3,074, since the two Wards experienced extremely low rainfall (Karinga, 2021).

3.5 Sampling Procedure and Sample Size

Visoi and Soin were purposively picked out of the five wards because they experience low seasonal rainfall that leads to inadequate water in the areas (Karinga, 2021). A proportionate sampling method was used to determine the number of respondents from purposively sampled wards. In contrast, a simple random sampling technique was used to obtain the respondents from the two wards. The study incorporated one hundred and thirty (130) smallholder farmers from the accessible population of 6,230 smallholder farmers within the study area in Rongai Sub-County. The following formula, as stated by Nassiuma (2000), was used to determine the appropriate sample size for the study:

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

$$\frac{6230x(0.21)^2}{(0.21)^2 + (6230-1)x(0.02)^2} = 108$$

n =the required sample size, N= the population within the Study area, C coefficient of variation, e= Standard error.

The sample was obtained using a coefficient of variation of 21% and a standard error of 2%. This is in line with the statement of Nassiuma (2000) that in the greater number of surveys there will be a coefficient variation found between 21%<=C<=30% and a standard error between 2%<=e<=5. The study expected 95 percent certainty (5 percent sampling error). The sample size was 108; however, following the recommendation of Kaur (2019), to account for non-responses, attrition, and to obtain a representative sample size, the researcher revised the sample size to 130, which is 20% of 108.

108*20/100=21.6

108+21.6=129.6

= 130

Therefore, the study incorporated 130 smallholder farmers and three key informants: two ward extension officers and the agricultural water officer. The total sample was 133. The two ward extension officers assisted in devising the sampling frame.

Table 1

Sample Size Distribution Summary (n=130)

Ward	Number of smallholder farmers	Proportion in percentage	Sample size
Visoi	3,156	50.66	66
Soin	3,074	49.34	64
Total	**6,230**	**100**	**130**

3.6 Instrumentation

To gather the necessary data, the research relied on two principal tools: a semi-structured questionnaire and an interview script. Because it proved an efficient means of handling large respondent groups, the questionnaire was administered to smallholder farmers. The tool adhered to the outlined objectives and divided its sections to cover each designated theme. Section A collected demographic information about the farmers, Section B investigated the impact of socioeconomic status and access to extension services, and Section C probed adoption of agricultural water management practices (Appendix A). Moreover, structured interviews administered via an interview guide (Appendix B) were performed with key informants, comprising two ward extension officers and the agricultural water officer from Rongai Sub County.

3.6.1 Validity

The validity of a research instrument denotes the level to which it accurately measures and depicts the constructs for which it was intended (Tomaszewski *et al*., 2020). The questionnaires and interview guides were examined by specialists from the Faculty of Education and Community Studies at Egerton University. By integrating their professional perspectives on both face and content validity, the instruments were refined, and their accuracy and suitability for the study were thereby strengthened.

3.6.2 Reliability

The reliability can be described as the consistency, stability, and replicability of the research instrument or a measurement over time (Tomaszewski *et al.*, 2020). Piloting the questionnaire enabled the study to estimate its reliability. Piloting involved 30 smallholder farmers in the Lare ward of Njoro Sub-County in Nakuru County. Lare Ward has climatic and agricultural characteristics similar to those of the Rongai Sub-County (Gachie, 2020). Thirty smallholder farmers were used during piloting. The Cronbach Alpha Scale was used to estimate the reliability of items. The questionnaire is reliable if it meets or exceeds the minimum reliability score of 0.70 (Tomaszewski *et al.*, 2020). If the reliability score is less than 0.70, the instrument is modified. The reliability score was 0.50, less than the minimum accepted score. A further triangulation test was conducted among five smallholder farmers from the thirty smallholder farmers in Lare to ascertain the instrument's reliability since most of the items generated qualitative data. The instrument was thereafter modified before data collection was done.

3.7 Data Collection Procedure

For verification, the research proposal was presented to the Board of Postgraduate Studies and the Research Ethics Committee (REC), both of Egerton University. Upon receiving a research authorization letter from the Board of Postgraduate Studies of Egerton University and a research permit from the National Commission for Science, Technology, and Innovation (NACOSTI), the researcher presented the research permit to the Nakuru County education office that allowed data collection. A research permit was also presented to the Rongai Sub-County agricultural office to seek permission to collect data. Visits to the smallholder farmers were arranged with Ward extension officers' assistance. The researcher then administered the questionnaire to the smallholder farmers and interviewed the two Ward extension officers and agricultural water officers from the Sub-County.

3.8 Data Analysis

The data was cleaned, coded, scored, and entered into SPSS (Statistical Package of Social Sciences) version 22. The 130 questionnaires after cleaning had 120 questionnaires filled and, thus, were taken as the basis upon which data analysis was done. The demographic elements of respondents were determined by using descriptive statistics. The test of binary logistic regression was applied to predict how socioeconomic factors and extension services influence the adoption of AWMPs. Binary Logistic regression gives the researcher freedom because the variables can be categorical or continuous, and it is also suitable for interpreting extensive data (Tomaszewski*et al.*, 2020). All tests of significance were computed at α=0.05 significance level. The Binary Logistic regression model that was used is:

$$y= ß0 + ß1X1 + ß2X2 + ß3X3 + \varepsilon.$$

Where: y Adoption of AWMPs (Dependent variables)

Indicators: 1. Low Adoption 2. High Adoption

ß0 = intercept, ß1, ß2, and ß3 = coefficient of determination

Xn = X1+X2+X3 (Independent variables);

X1= Farmer's level of education
Indicator:

Level of formal education attained

X2; Income Level:

Indicator:

Amount of money earned per month from on-farm and off-farm activities

X3=Extension services

Indicator: Number of extension services provided

3.9 Ethical Considerations

The research process adhered to ethical issues. A research permit was presented to the Rongai Sub-County Agricultural Office to seek data collection permission after verification by the Research Ethics Committee (REC) and the Board of Postgraduate Studies of Egerton University. Informed consent was obtained, and all the respondents were informed about the purpose of the research and the study procedures. Confidentiality was observed, and dignity and cultural values were considered. After the study, the findings were disseminated to the relevant stakeholders.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and discussions of this study that sought to establish the *"Influence of socio-economic factors and extension services on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Nakuru County, Kenya*."

The data obtained were discussed and measured based on the objectives and hypotheses of the study. The results are presented in six sections: Section 4.1 provides the introduction, Section 4.2 provides the demographic characteristics of the smallholder farmers, section 4.3 Adoption of AWMPs, section 4.4 elaborates on the results and discusses Objective One, section 4.5 highlights the results and discusses Objective Two, and Section 4.6 provides the results and discusses Objective Three.

4.2 Smallholder Farmers' Demographic Information

The research aimed to establish the demographic nature of smallholders. The items that were measured as demographic characteristics were gender, age, the size of the farm, the nature of the farming, and any training in agriculture.

4.2.1 Smallholder Farmers' Gender

According to Table 2 and Figure 2, 65.8% of smallholder farmers were male. Gender is a key element in the family decision-making process. Generally, male farmers have more land and capital and can access credit more quickly than their female counterparts (Gagoitsiwe & Keba, 2020). Previous studies have indicated that men typically hold more decision-making power in many cultures in agriculture. These cultural factors can influence which technologies are adopted and who decides their use (Peralta, 2022).

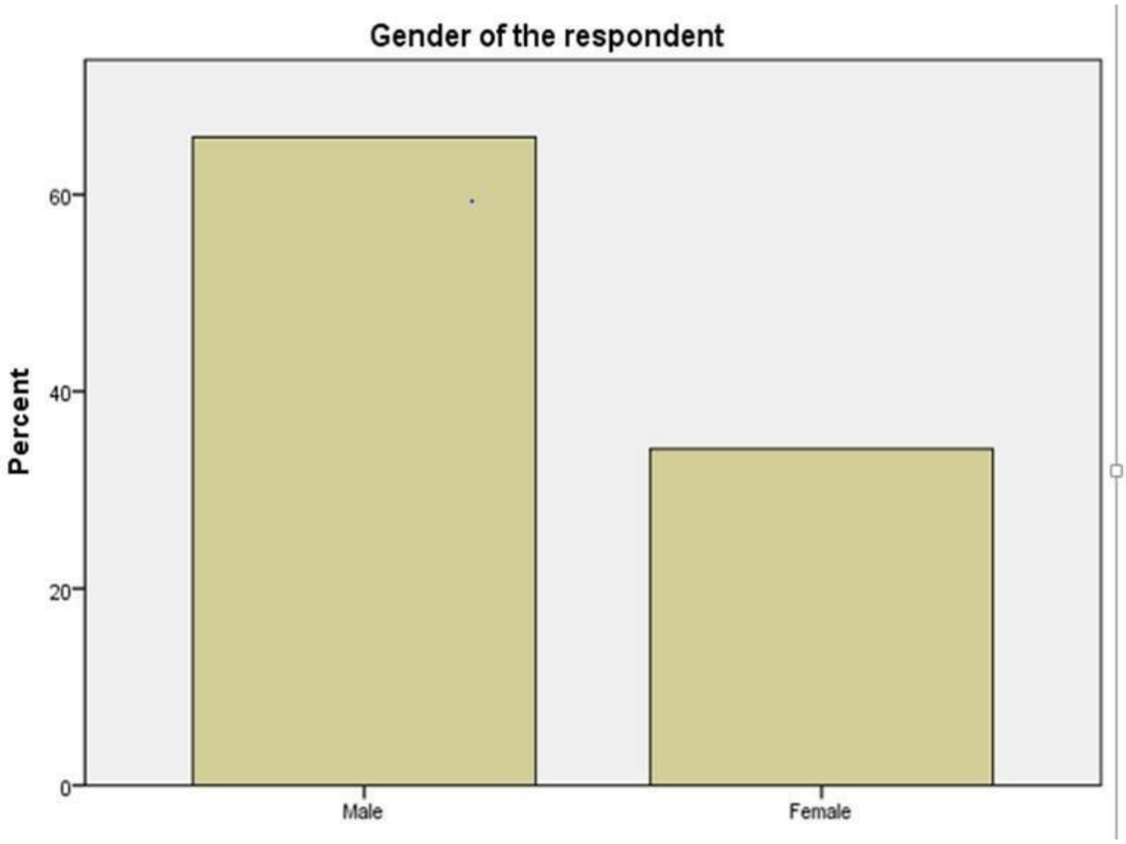
Table 2

Gender of Smallholder Farmers (n=120)

Gender	Frequency	Percent
Male	79	65.8
Female	41	34.2
Total	**120**	**100.0**

Figure 2

Smallholder Farmers' Gender



4.2.2 Smallholder Farmers' Age

Figure 3 and Table 3 indicates that the age bracket of 40-49 years was the largest at 29.2%, and the least was 18-30 years at 3.3%. It means that there were numerous middle-aged farmers. One of the main latent attributes of making a decision is age (Tomaszewski *et al*., 2020). Based on a study conducted in Ethiopia, age had a great impact on adopting the agricultural technology, in the view that the older the person, the highly likely they were to adopt agricultural technologies (Feyisa, 2020).

Farmers in their middle age tend to be more open to adopting new technologies and modern agricultural practices (Tomaszewski *et al*., 2020). They might have been taught more up-to-date farming knowledge, be better with technology, and be ready to try out new instruments and processes to advance efficiency (Moxley *et al*., 2022). Hence, middle-aged smallholder farmers are more likely to adopt AWMPs than younger and older farmers.

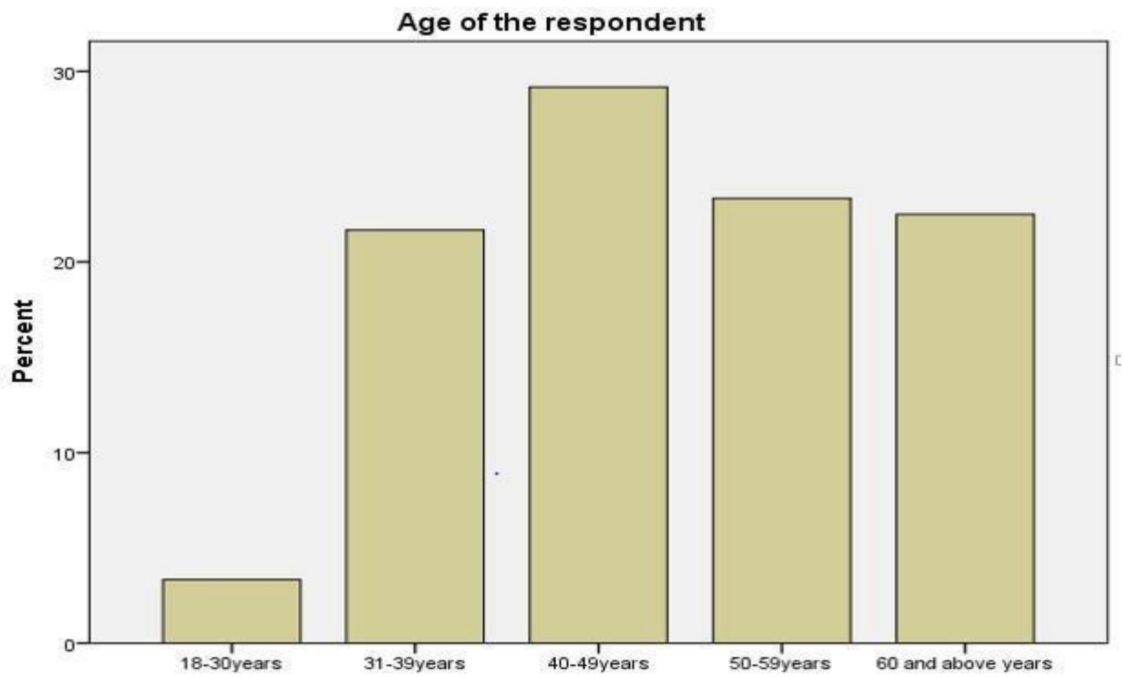
Table 3

Smallholder Farmers' Age (n=120)

Age	Frequency	Percent
18-30 years	4	3.3
31-39 years	26	21.7
40-49 years	35	29.2
50-59 years	28	23.3
60 years and above	27	22.5
Total	**120**	**100.0**

Figure 3

Smallholder Farmers' Age



4.2.3 Smallholder Farmers' Farm Size

Farm size and productivity vary across the world. Figure 4 and Table 4 indicates that the majority of the smallholder farmers' farm size is 1.1-2 acres at 31.7%, and a few farmers have farms of 3.1-4 acres at 9.2%. Land is one of the major resources of farm production, and it is important as well because it is the origin of all material wealth (Yang *et al*., 2023). The quantity and quality of farm wealth of a farmer are denoted by farm size, nature of soil, climate, and rainfall (Benimana *et al*., 2023). Table 4 is an illustration of farm sizes for smallholder farmers in Rongai Sub-County.

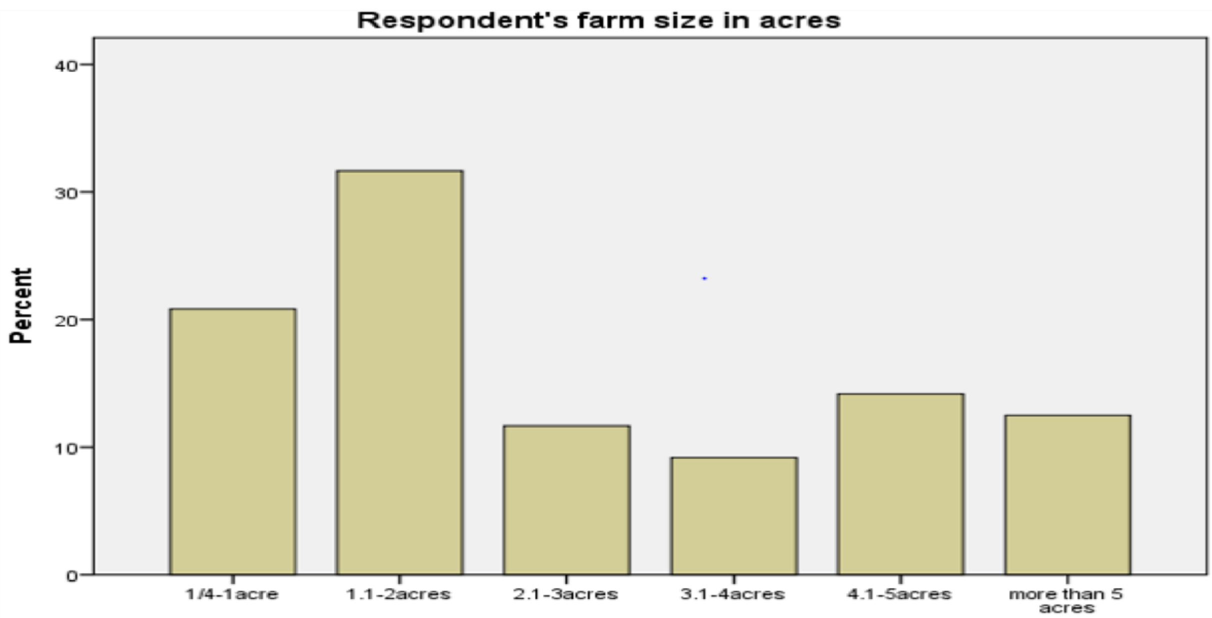
Table 4

Smallholder Farmers' Farm Sizes (n=120)

Farm size	Frequency	Percent
1/4-1acre	25	20.8
1.1-2acres	38	31.7
2.1-3acres	14	11.7
3.1-4acres	11	9.2
4.1-5acres	17	14.2
More than 5 acres	15	12.5
Total	**120**	**100.0**

Figure 4

Smallholder Farmers' Farm Size



In reference to farm size, as shown in studies, is that there is a certain correlation between the size of the farm and the farmer who has adopted the modern agricultural practices. Farmers with larger farms embrace more advanced farm activities than small-scale farmers, with a high probability of adopting less complex technologies (Ray *et al*., 2020). It tells us that numerous farmers might not take up technologies that entail huge farm areas, although they can carry out technologies like AWMPs (Yang *et al*., 2023).

In Rongai Sub-County, most smallholder farmers cultivate 1-2 acres of land, which may hinder their adoption of agricultural technologies that require much space. However, smallholder farmers can venture into less complicated agricultural technologies, such as drought-resistant crops, which may increase their production despite their limited farm sizes.

4.2.4 Smallholder Farmers' Type of Farming

Table 5 indicates that 75% of smallholder farmers practiced mixed farming, while a few, 25%, practiced crop production alone. Mixed farming can reduce the cost of production and increase yields. Table 5 provides an overview of the farming methods employed by smallholder farmers in Rongai Sub-County.

Table 5

Smallholder Farmers' Type of Farming (n=120)

Type of farming	Frequency	Percent
Crop production	30	25.0
Mixed farming	90	75.0
Total	**120**	**100.0**

Research shows that for farmers who practice crop production only, their earnings become dependent on the value of the crops (Yang *et al*., 2023). In addition, imperfect market situations and mismanagement of the demand and supply of crops also adversely affect the income from the crops. To manage this challenge, farmers are always encouraged to practice mixed farming as it provides better income and higher productivity (Ray *et al*., 2020).

Mixed farming provides a diversified source of income, which can reduce financial risks. Farmers with crops and livestock may be more financially stable and can invest in sustainable agricultural technologies (Ray *et al*., 2020). This makes them more likely to adopt innovations that promise to improve productivity. Smallholder farmers in Rongai Sub-

County are likely to earn more as they practice mixed farming, which may enable the farmers to adopt AWMPs more than those who practice crop farming only.

4.2.5 Training in Agriculture

Table 6 indicates that most farmers had training in agriculture at 59.2%, while 40.8 % did not have any training in agriculture. Training smallholder farmers is vital as it impacts knowledge and skills that farmers can apply to increase agricultural production (Nguyen *et al*., 2023).

Table 6

Training of Smallholder Farmers (n=120)

Training	Frequency	Percent
Trained	71	59.2
Not Trained	49	40.8
Total	**120**	**100.0**

Studies indicate that many farmers who receive training on specific areas in agriculture tend to have positive attitudes towards that area and generally improve agricultural production (Benimana *et al*., 2023). From the findings, most smallholder farmers had received training, increasing the likelihood of adopting AWMPs.

4.2.6 Specific Training for Smallholder Farmers

According to Table 7, most smallholder farmers were trained in crop production at 29.2 %, and only a few were trained in water conservation at 2.5%. This shows that many farmers were trained in the sector of crop production. Therefore, this may increase farm production in the area. Training farmers in different agricultural areas is important as it creates awareness concerning specific areas and introduces new production techniques (Tatis Diaz *et al*., 2022). Table 7 indicates the specific training smallholder farmers in Rongai have been trained on.

Table 7

Specific Training for Smallholder Farmers (n=120)

Specific Training	Frequency	Percent
No training	49	40.8
Crop production	35	29.2
Climate-smart agriculture	7	5.8
Animal production	26	21.7
Water conservation	3	2.5
Total	**120**	**100.0**

In China, studies show that training farmers, especially on crop production, may promote sustainable agriculture, leading to food security (Ule *et al*., 2023). Since only a few smallholder farmers in Rongai were trained in water conservation, this would suggest that the adoption of AWMPs in the area is generally low.

4.3 Adoption of Agricultural Water Management Practices

Agricultural Water Management Practices are the strategies and techniques used to efficiently and sustainably manage water resources in agricultural systems. These practices aim to optimize water use for crop irrigation, livestock, and other agricultural activities while minimizing waste and conserving water resources (Glória *et al*., 2020). This study focused on rainwater harvesting, irrigation, and drought-resistant crops. Adoption of AWMPs was coded and analyzed as: 1, Rainwater harvesting; 2, irrigation; and 3, use of drought-resistant crops. For each practice, the entries were scored as 1 for adopted and 0 for not adopted. The AWMPs' composite data scores were generated to determine the adoption of AWMPs.

The composite information shows the average results of the three AWMPs to evaluate whether the farmer has used them or not. The first procedure towards generating the composite data was to obtain the score of each of the Agricultural Water Management Practices. The process of adding up each score of the three practices became the second step, and the third action involved dividing the totals by the number of AWMPs, which is 3. The resultant gave composite data.

4.3.1 Adoption of Selected Agricultural Water Management Practices

Table 8 and Figure 5 show the adoption of the three AWMPs (rainwater harvesting, irrigation, and use of drought-resistant crops.

Table 8

Adoption of Agricultural Water Management Practices by Smallholder Farmers (n=120)

Agricultural Water Management Practices	**Adoption**	**F**	**(%)**
Rainwater harvesting	No	56	46.7
	Yes	64	53.3
Irrigation	No	88	73.3
	Yes	32	26.7
Drought-resistant crops	No	37	30.8
	Yes	83	69.2

Figure 5

Adoption of the Selected Agricultural Water Management Practices (n=120)

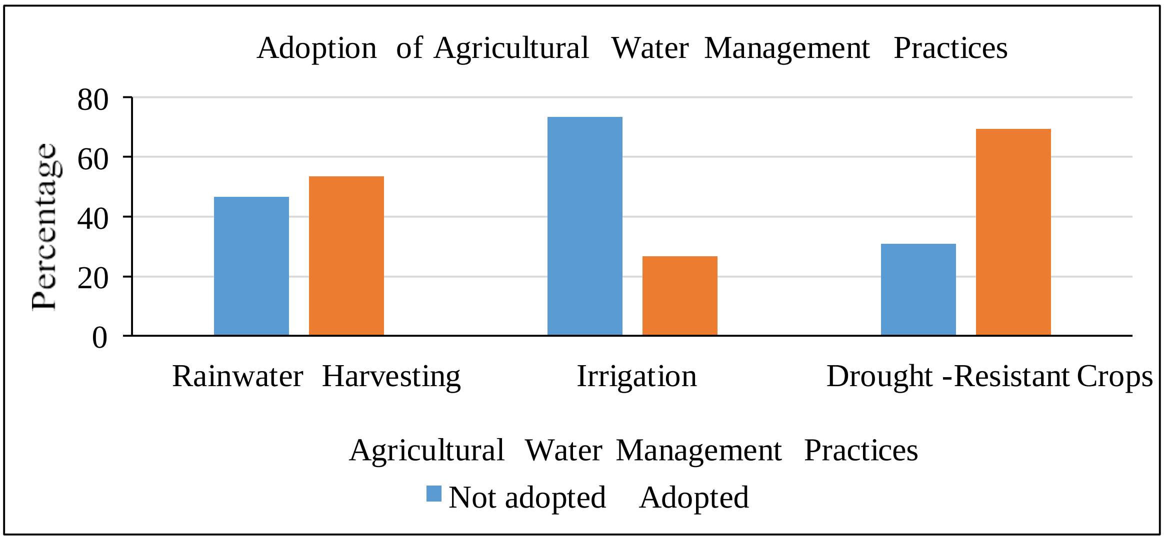


Figure 5 shows that adoption rates vary. The adoption rate of drought-resistant crops was high at 69.2%, rainwater harvesting at 53%, whereas irrigation methods were adopted at a far lower rate of 26.7%. The results point to the necessity of focused interventions to remove the obstacles preventing the adoption of AWMPs. The differences in adoption rates emphasize the importance of customizing training from extension services to particular practices according to the local environment. Targeted agricultural water management strategies play a vital role in promoting sustainable crop cultivation, maximizing water efficiency, and tackling issues associated with water shortages (Glória *et al*., 2020). These practices contribute to increased agricultural productivity while conserving water resources, protecting ecosystems, and strengthening the persistence of farming structures (TatisDiaz *et al*., 2022).

4.3.2 Average Adoption of Agricultural Water Management Practices

Optimizing smallholder farmers' adoption of AWMPs can increase crop yields and improve farm profitability (Wordofa *et al*., 2021). Table 9 illustrates the average adoption of AWMPs in Rongai Sub-County. The table is generated from composite data.

Table 9

Average Adoption of Agricultural Water Management Practices (n=120)

AWMPs Adoption	Frequency	Percent
No	77	64.2
Yes	43	35.8
Total	**120**	**100.0**

Table 9 notes that 35.8% of smallholder farmers have adopted AWMPs, whereas the majority (64.2%) has yet to do so. Consequently, this indicates that uptake of agricultural water management practices in Rongai Sub-County continues to be comparatively low. Previous studies show that the uptake of agricultural innovations by smallholder farmers is often influenced by a range of factors. (Wordofa *et al*., 2021). The factors are personal attributes, socio-economic elements, political factors, and institutional support (Feyisa, 2020).

4.3.3 Agricultural Water Management Practices Information Sources

Table 10 shows sources of information on AWMPs among smallholder farmers in Rongai Sub-County.

Table 10

Agricultural Water Management Practices Information Sources (n=120)

Source of Information	Frequency	Percent
Chief	16	13.3
Ward extension officer	59	49.2
Farm groups	18	15.0
Mass media	21	17.5
Internet	2	1.7
No information	4	3.3
Total	**120**	**100.0**

Smallholder farmers can get important news and knowledge of farming from various sources. Table 10 shows various sources of knowledge on AWMPs. Remarkably, 49.2% of the respondents cited ward extension officers as their primary source of AWMPs information. This percentage illustrates how important it is for local extension agencies to share knowledge and encourage smallholder farmers to practice sustainable water management techniques. Information is also disseminated via farm groups 15.0%, the media 17.5% and local leaders 13.3% to a lesser degree.

The significance of community-based channels in providing smallholder farmers with essential information on AWMPs is underscored by the internet's comparatively low effect of 1.7%. Collaboration among extension service providers is necessary in order to enhance the uptake of farming technologies effectively (Nguyen *et al*., 2023).

4.3.4 Training on Agricultural Water Management Practices

Table 11 shows the frequency of AWMPs trainings among smallholder farmers in Rongai Sub-County.

Table 11

Frequency of Agricultural Water Management Practices Trainings (n=120)

Number of Trainings	Frequency	Percent
Not at all	34	28.3
Once a year	15	12.5
Once a month	41	34.2
Twice a month	8	6.7
More than twice a month	21	17.5
Total	**120**	**100.0**

Table 11 reveals a heterogeneous environment concerning AWMPs training. At 28.3%, several respondents indicated they had received no training, indicating a knowledge dissemination gap that may prevent the implementation of efficient water management techniques. On the other hand, a sizable portion of participants receive training regularly, whereby 34.2% attend training once a month, and 17.5% attend more than twice a month. Training smallholders on AWMPs is key as it may encourage adopting the practices leading to improved agricultural productivity (Adams & Jumpah, 2021). This suggests a chance for focused training initiatives to close the knowledge gap among those without any training (Zakaria *et al*., 2020).

4.3.5 Use of Knowledge and Skills from AWMPs Trainings

Smallholder farmers who utilize the skills gained from various trainings are likely to improve their farm yields compared to those who do not utilize the skills they have (Adams & Jumpah, 2021). Table 12 shows the frequency of use of skills and knowledge from AWMPs trainings among smallholder farmers in Rongai sub-county.

Table 12

Frequency of Use of AWMPs Trainings Skills and Knowledge (n=120)

Use of Skills	Frequency	Percent
Not at all	46	38.3
Rarely	39	32.5
Often	22	18.3
Always	13	10.8
Total	**120**	**100.0**

Table 12 reveals varied utilization patterns of skills and knowledge acquired from training in AWMPs. 10.8 % of the smallholder farmers always utilized the skills they gained concerning agricultural water management practices, while a sizable portion of 38.3% did not utilize the skills. This suggests that smallholder farmers in Rongai are likely to get low yields. Since, without efficient water management practices, crops may suffer from either too little water (drought stress) or too much water (flooding) (Zakaria *et al*., 2020). Both can significantly reduce crop yields and make farming less predictable (Ha *et al*., 2023).

4.4 Farmer's Education Level and the Adoption of Agricultural Water Management Practices

Education level refers to the learning status a student or group achieves. It is affected by the developmental differences of the students and how the learning environment is structured (Muturi, 2024). In this study, education level was defined as the highest level of education attained or the current level of education if still in school. It was measured in terms of the highest formal education level the farmer has attained.

4.4.1 Smallholder Farmers' Level of Education

Smallholder farmers in Rongai Sub-County were requested to indicate their highest level of education, where the frequency was coded and measured as shown in Table 13 and Figure 6.

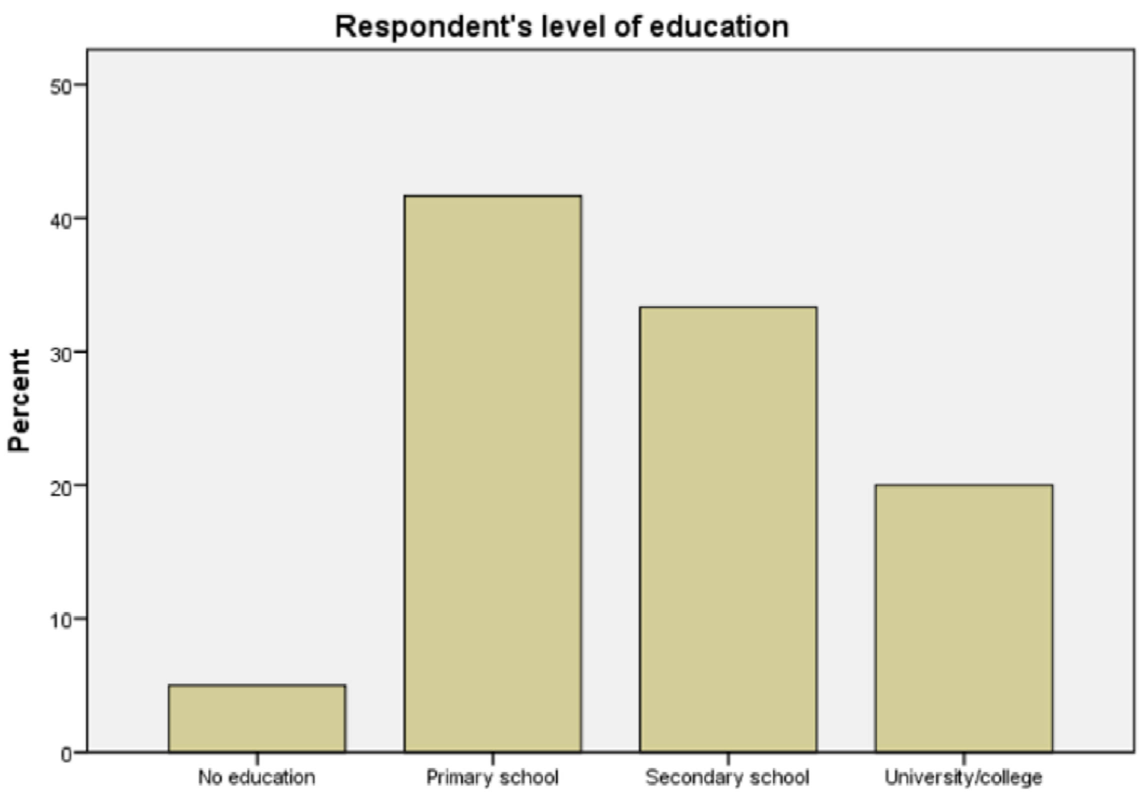
Table 13

Smallholder Farmers' Level of Formal Education (n=120)

Formal education level	Frequency	Percent
No education	6	5.0
Primary school	50	41.7
Secondary school	40	33.3
University/college	24	20.0
Total	**120**	**100.0**

Figure 6

Smallholder Farmers' Level of Formal Education



Majority of the smallholder farmers had primary school education as their highest formal education, at 41.7%, while 5% of the farmers had no education. Research has shown that education level and adoption of agricultural technology are positively correlated (Feyisa, 2020). In this study, many farmers were educated up to the primary level, which could increase their probability of adopting AWMPs.

A survey of forces underpinning the sustained adoption of farming technologies in developing nations highlights education as a key element (Feyisa, 2020). The results indicate that individuals who embrace new technologies early are usually better educated than those who adopt them later, with limited educational attainment and knowledge frequently discouraging technological uptake (Nguyen *et al.*, 2023). Along the same lines, Ethiopian research on agricultural technology uptake revealed a positive link between farmers' educational attainment and their willingness to adopt, highlighting education's decisive influence on use of sustainable farming practices (Adeagbo *et al.*, 2023).

Research has also shown that increasing the duration of formal education for farmers can enhance the adoption of sustainable agricultural practices (Belayneh, 2023). However, contrasting findings emerged from research conducted in China, which examined how different sources of knowledge influence farmers' uptake of environmentally friendly agricultural technologies. The study found that formal education alone does not significantly impact farmers' choices regarding the adoption of such technologies. Instead, it highlighted the importance of information received through public channels such as agricultural programs on the radio as a more influential factor (Wang *et al.*, 2023).

The farmer's education level is essential in adopting agricultural technology (Atube *et al.*, 2021). Nevertheless, in this study, academic background did not show any impact on the adoption of Agricultural Water Management Practices, and this could be associated with social norms. Farmers often adopt technologies based on social networks rather than individual formal education. Peer influence, social norms, and community-based learning can have a stronger impact on adoption than formal education (Adams & Jumpah, 2021).

4.4.2 Regression Analysis of the Influence of Education Level on Adoption of Agricultural Water Management Practices

H_O1 *There is no statistically significant influence of farmers' education level on smallholder farmers' adoption of agricultural water management practices in Rongai Sub-County, Kenya.*

To test the hypothesis, this study analyzed and documented the frequency of education levels in adopting agricultural water management practices. The frequency of education levels was coded and analyzed as follows: 1 for no education, 2 for Primary education, 3 for Secondary education, and 4 for University or college level. The findings of the statistical tests are presented in Table 14.

Table 14

Regression Analysis between Level of Education and Adoption of Agricultural Water Management Practices (n=120)

Variables in the Equation		B	S.E.	Wald	Df	Sig	Exp (B)
Step 1[a]	Education	.132	.225	.346	1	.557	1.141
	Constant	-.939	.639	2.161	1	.142	.391

a. Variable(s) entered on step 1: Education.

Table 14 generated a P value of .557 >.05, so the null hypothesis was accepted. This indicates that education level did not have a statistically significant influence on the adoption of agricultural water management practices. The insights of this research are similar to those of a study done in Northern Ghana on farming technologies and smallholder farmers' welfare in 2021, as it also concluded that the farmers' education level may not influence the adoption of agricultural technologies (Adams & Jumpah, 2021). This is so since some technologies are not complicated to practice, and some come as a collection of many technologies. Some farmers decide to adopt some technologies, leaving others, and this does not necessarily depend on the education level of the farmer (Tatis Diaz *et al*., 2022).

Further, previous research explained that a more significant academic background did not necessarily influence agricultural production processes. Many farmers rely heavily on practical, hands-on experience rather than formal education (Adams & Jumpah, 2021). For instance, a farmer with decades of experience in the field may understand crop management intuitively, even without formal schooling. If new technologies are not easily relatable to their current practices, education alone may not persuade them to adopt the technology (Tatis Diaz *et al*., 2022).

In Kenya, many farmers may prioritize traditional farming practices and cultural beliefs over new technologies, regardless of their level of education. Social networks, community practices, and peer effects often have a more significant role in decision-making than education alone. Adoption of new technologies also involves perceived risks, whether financial, operational, or cultural. If the technology is seen as risky or unproven, farmers may be slow to adopt it, even if they are educated (Muturi, 2024).

The results of this study, whereby education level does not influence the adoption of AWMPs, could be attributed to other factors. These include the training farmers have in agriculture, since results showed that many farmers had training in different areas of agriculture, and, therefore, the education level of the farmers did not affect the uptake of agricultural water management practices. Additionally, most of the farmers were between 40 and 49 years old, which could imply that they had experience in agriculture, which would help them decide whether to adopt AWMPs without necessarily being influenced by their education level.

4.5 Farmer's Income Level and the Adoption of Agricultural Water Management Practices

Income can be defined as the amount of money, goods, and other changes of value that individuals or institutions receive over a specified time as payment for a service, payment for a product, returns on investments, pension pay, and gifts, among others (Feyisa, 2020). This paper evaluated income as the amount of money received from farms and off-farm activities.

4.5.1 Smallholder Farmers' Income Level

The study required smallholder farmers to specify their sources of income, which included farming, off-farm activities, or a combination of both. The results are presented in Table 15.

Table 15

Farmers' Source of Income (n=120)

Source of Income	Frequency	Percent
Farming	54	45.0
Both farming and other activities	66	55.0
Off-farm activities only	0	0.0
Total	**120**	**100.0**

As Table 15 shows, 45% of farmers in Rongai Sub-County derived their livelihoods exclusively from farming, while the remaining 55% supplemented it with additional income-generating activities. Atube *et al*. (2021) likewise noted that the impacts of climate variability have spurred farmers to broaden their revenue streams as a strategy to lessen the financial losses incurred from adverse weather conditions. Taken together, the results suggest that many farmers are inclined to seek out multiple income streams as a strategy to strengthen their financial security and resilience.

Additional studies indicate that per capita income is a positive determinant of farmers' decisions to undertake adaptations (Kahenge *et al*., 2020). This can be an indication that diversifying farm land to other income-generating activities by farmers increases the chances of them adopting sustainable agricultural technologies such as AWMPs.

4.5.2 Smallholder Farmers' Income from Farm and Off-farm Activities

Land cultivation serves as the primary source of income for smallholder farmers in rural households, forming the backbone of their livelihoods and economic sustainability (Ngetich *et al*., 2022). Table 16 illustrates the income level of smallholder farmers in Rongai Sub-County from farming and other sources per year and monthly, respectively.

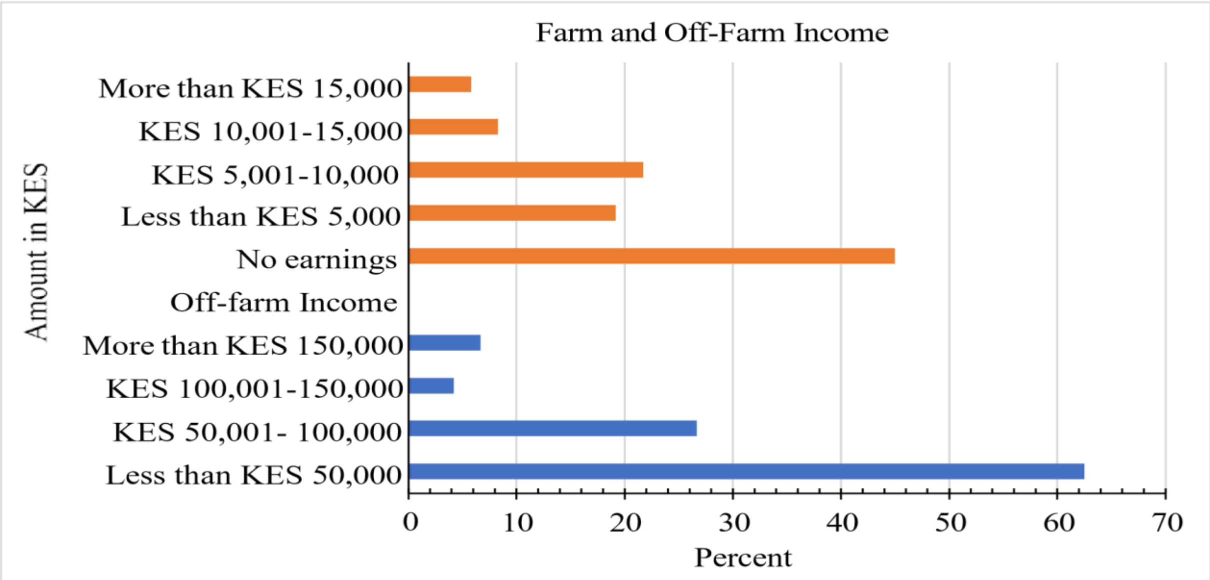
Table 16

Smallholder Farmers' Income Levels (n=120)

Farm Income		
Amount	**F**	**%**
Less than KES 50,000	75	62.5
KES 50,001- 100,000	32	26.7
KES 100,001-150,000	5	4.2
More than KES 150,000	8	6.7
Total	120	100.0
Off-Farm Income		
No earnings	54	45.0
Less than KES 5,000	23	19.2
KES 5,001-10,000	26	21.7
KES 10,001-15,000	10	8.3
More than KES 15,000	7	5.8
Total	**120**	**100.0**

Figure 7

Smallholder Farmers' Income Levels (n=120)



Results from Figure 7 indicate that many smallholder farmers earned less than Kshs 50,000 from their farms annually, indicating a potential financial obstacle for many smallholder farmers in Rongai Sub-County. These financial limitations in Rongai Sub-County are consistent with research highlighting that any farmers, especially smallholders, who have minimal access to premium quality seeds, fertilizers, and pesticides, inadequate irrigation, and outdated farming practices can contribute to lower productivity leading to lower income from farming and this may hinder adoption of modern agricultural practices such as AWMPs (Bajaj *et al*., 2023).

Many smallholder farmers did not have earnings from other sources, as indicated in Figure 7, highlighting how vulnerable some farmers who make farming their only source of income may be. Off-farm sources of revenue are important to farmers for several key reasons. It provides financial stability, enhances farm sustainability, and allows farmers to navigate better economic, environmental, and market challenges (TatisDiaz *et al*., 2022). While diversifying into non-farm pursuits is sometimes viewed as a risk management tactic, some farmers may be more vulnerable to financial instability if they do not get income from other sources, especially in drought-prone areas (Bajaj *et al*., 2023). This is consistent with the idea that smallholder agricultural systems are more resilient when they have a variety of revenue streams and a suitable position to adopt modern agricultural technologies that may require extra money (Nguyen *et al*., 2023).

4.5.3 Income Facilitating Uptake of Agricultural Water Management Practices

Off-farm economic activities and farm income help farmers overcome financial constraints regarding purchasing inputs and adopting agricultural technologies (TatisDiaz *et al*., 2022).

Table 17 presents farmers' views on whether income aids in adopting AWMPs:

Table 17

Income and Adoption of Agricultural Water Management Practices (n=120)

Adoption	**Frequency**	**Percent**
Yes	94	78.3
No	26	20.8
Total	**120**	**100.0**

Table 17 demonstrates that most smallholder farmers, at 78.3%, acknowledge that their income makes it easier to implement AWMPs, explaining that revenue streams are important in accelerating the adoption process. This assertion is consistent with views about adopting innovations, where financial resources are a major driver (Belayneh, 2023). Regardless of their financial difficulties, most farmers understand that revenue is crucial to removing obstacles to the implementation of AWMPs. Evidence from previous studies suggests that farmers in higher income brackets are more likely to implement innovative and sustainable farming techniques on their land (TatisDiaz *et al*., 2022).

4.5.4 Utilization of Earnings in the Adoption of Agricultural Water Management Practices

An understanding of farmers' priorities may be gained from the breakdown of how revenue is allocated to AWMPs adoption. Table 18 illustrates how income is utilized to adopt AWMPs in Rongai Sub-County.

Table 18

Income Use in the Adoption of Agricultural Water Management Practices (n=120)

Use of Income	Yes		No	
	F	**%**	**F**	**%**
Purchasing drought-resistant seeds	65	54.2	55	45.8
Purchasing water harvesting material and equipment	35	29.2	85	70.8
Irrigation	20	16.7	100	83.3

Table 18 indicates that purchasing drought-resistant seeds accounts for 54.2% of revenue, indicating a deliberate investment in resilient crops, a frequently advised strategy for areas with limited water resources (Lukurugu *et al.*, 2022). Funds were also allocated to irrigation at 16.7% and purchasing water harvesting materials at 29.2%. This demonstrates a practical use of financial resources to meet particular agricultural water management practices. Previous studies have highlighted that smallholder farmers prefer adopting agricultural technologies that are not expensive compared to complex and costly technologies such as irrigation (Feyisa, 2020). These findings may explain why only 16.7% of smallholder farmers in Rongai Sub-County utilized their income to adopt irrigation.

4.5.5 Regression Analysis of the Influence of Income Level on Adoption of Agricultural Water Management Practices

H_O2 There is no statistically significant influence of farmer's income level on adopting agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya”. To test the hypothesis, the study analyzed and documented the frequency of combined income in adopting agricultural water management practices. The frequency of income level was coded and analyzed as follows: Money earned from farming per year, 1 as less than Ksh 50, 000, 2 as Ksh 50,001-100, 000, 3, as Ksh 100,001-150,000 and 4 as more than Ksh 150,000. Money earned from other sources per month was coded as follows: no earnings, 2 as less than Ksh 5000, 3 as Ksh 500110, 000, 4 as Ksh 10,001-15,000, and 5 as more than Ksh 15,000.

To get the combined income, composite data was generated from the two sources of income (farming and other sources). Also, composite data for the three agricultural water management practices (rainwater harvesting, irrigation, and use of drought-resistant crops) were generated, as explained in section 4.3. A statistical analysis was applied to probe the association between household income and the uptake of agricultural water management practices. To evaluate this influence, we first examined adoption levels relative to combined income sources, and these findings are summarized in Table 19.

Table 19

Regression Analysis between Income Level and Adoption of Agricultural Water Management Practices (n=120)

Income Level	B	S.E	Wald	Df	Sig	Exp (B)
Smallholder farmer’s income	-.266	.125	4.561	1	0.033	.766
Constant	.141	.381	.137	1	.711	1.152

a. Variable(s) entered on step 1: Smallholder farmers' income level.

The reported p-value of 0.033 is lower than the significance level of 0.05 thereby rejecting null hypothesis in this study. The outcome, therefore, gives compelling evidence that household income plays a significant role in determining the adoption of agricultural water management practices. Statistical evidence highlights that income plays a central role in steering farmers' decisions to adopt AWMPs. The rejection of $\mathbf{H_O2}$ guided by the 0.033 value's significance at 5 percent level aligns with earlier work explaining that financial capacity is pivotal in determining farmers' readiness and capacity to adopt agricultural technologies (Feyisa, 2020).

In support of these findings, prior studies indicate that income is presumed to be directly related with the uptake of agricultural technologies. A range of contemporary farming technologies from advanced irrigation systems and machinery (tractors, plows) to precision agriculture tools entail considerable upfront investments. Farmers earning greater incomes are better positioned to finance these technologies or obtain credit to do so (Bajaj *et al*., 2023). A research carried out in Uganda on the factors driving smallholder farmers' adoption responses to climate change shows that, in the face of climate change, farmers with higher annual incomes from agriculture were more inclined to implement the adaptation strategies of using improved seeds and cultivating trees than their counterparts with lower farm earnings (Atube *et al*., 2021).

In Kenya, income plays a pivotal role in the adoption of modern farming technologies, as it is closely tied to various factors such as financial capacity, risk tolerance, access to resources, and market opportunities. A majority of Kenya's smallholder farmers rely chiefly on agriculture to support their livelihood. Given the predominance of smallholder farmers in Kenya, income disparity becomes a decisive factor in whether they adopt the available modern technologies or not adopt.

4.6 Extension Services and Adoption of Agricultural Water Management Practices

Extension services are defined as the transfer of scientific knowledge and research into farm practices via farmer education or training (Feyisa, 2020). In this study, the element of extension service was used to describe any involvement of agricultural practices that engaged extension workers and the farmers in an attempt to enhance the agricultural, economic, and social state of the farmer (Atube *et al*., 2021). It was quantified as the number of extension services provided by the extension officer.

4.6.1 Sources of Extension Services in Rongai Sub-County

Extension services are offered to farmers in different ways and from different sources, including public and private extension providers (Feyisa, 2020). The following are different sources of extension services in Rongai Sub-County.

Table 20

Sources of Extension Services in Rongai Sub-County (n=120)

Source of Extension Services	Yes	No	Percent	
National Government	6	114	5.0	95.0
County Government	69	51	57.5	41.7
Private organizations	51	69	42.5	57.5

Table 20 shows a notable disparity in the sources of extension services. Although 95% of farmers do not get national government extension services, there are higher levels of accessibility in county government and private organizations. These results indicate the need to support all extension service providers so that if smallholder farmers cannot access government services, they can comfortably access them from other sources. This aligns with previous research highlighting decentralized extension services' success in reaching and supporting smallholder farmers (Adams & Jumpah, 2021).

The availability of information via farming extension promotes the chances of adopting sustainable agricultural technologies since the farmers are subjected to new information and technical expertise. Thus, to enable farmers to adopt new farming technologies, arrangements to ensure that farmers receive information and support regularly should be enhanced (Atube *et al*., 2021).

4.6.2 Access to Extension Services in Rongai Sub-County

Extension services play important roles in helping smallholder farmers adopt farm technologies. The likelihood that the farmers will adopt the agricultural technologies increases to the extent to which they can access the extension services (Adeagbo *et al*., 2023). Table 21 shows the frequency of accessing extension services, and Figure 8 represents the frequency of accessing extension services in Rongai Sub-County.

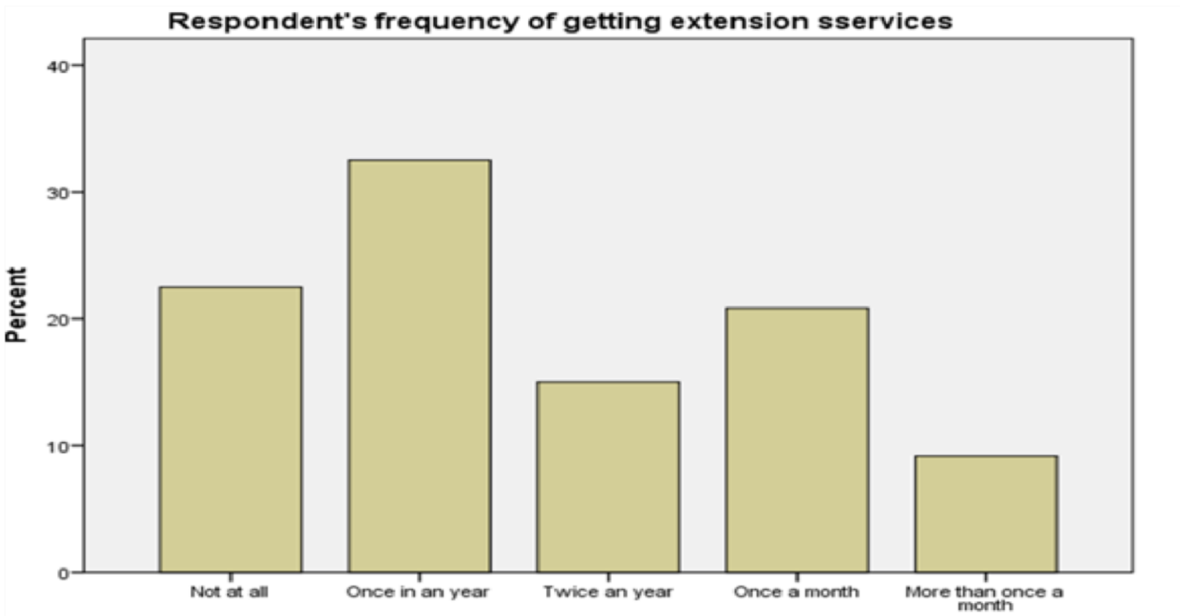
Table 21

Farmers' Frequency of Access to Extension Services (n=120)

Access to Extension services	Frequency	Percent
Not at all	27	22.5
Once a year	39	32.5
Twice a year	18	15.0
Once a month	25	20.8
More than once a month	11	9.2
Total	**120**	**100.0**

Figure 8

Farmers' Frequency of Access to Extension Services



In accordance with Figure 8, many smallholder farmers were able to access extension services at least once a year. 32.5% accessed extension services once a year, 15% twice a year, 20.8% once a month, 9.2 % more than once a month and 22.5% were not able to access extension services completely. The variation in the frequency of getting extension services highlights the need for more regular extension services.

Research clarifies that regular trainings from extension services providers, especially on farm demonstrations and credit access, also appear to have a favorable impact on the farmer's assimilation of different farming strategies. More so, the tendency towards the sustainable use of agricultural technologies is positively correlated with the frequency of contacts with extension services (Adeagbo *et al*., 2023).

Findings from a study carried out in Zambia, an African nation, demonstrate that the regularity of extension services is a primary factor behind the uptake of non-transgenic soybeans by smallholder farmers (Kahenge *et al*., 2020). The evidence points to the possibility that improving farmers' access to extension services, particularly by offering them more regularly, could be pivotal in driving adoption of improved agricultural practices (Adeagbo *et al*., 2023).

4.6.3 Regression Analysis of the Influence of Extension Services on the Adoption of Agricultural Water Management Practices

H_O3 There is no statistically significant influence of extension services on adoption of agricultural water management practices among smallholder farmers in Rongai Sub-County, Kenya. The study analyzed and documented the frequency of accessing extension services regarding the adoption of Agricultural Water Management Practices to test the hypothesis.

The frequency of accessing the extension services was coded and analyzed as follows: 1 not at all, 2 once a year, 3 twice a year, 4 once a month, and 5 more than once a month. The adoption of agricultural water management practices and the frequency of accessing extension services were used in statistics to determine the influence of extension services on adoption of agricultural water management practices among smallholder farmers in Rongai Sub County in Nakuru, Kenya. The results of the statistical test are presented in Table 22.

Table 22

Regression Analysis between Accessing Extension Services and Adoption of Agricultural Water Management Practices (n=120)

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1a	Frequency of accessing extension services	-.360	.160	5.100	1	.024	.698
	Constant	.328	.435	.569	1	.451	1.388

a. Variable(s) entered on step 1: Frequency of accessing extension services.

In this study, the null hypothesis was rejected owing to a p-value of 0.024 which is less than .05. Consequently, this analysis provides statistically strong evidence that access to extension services significantly affects the decision to adopt agricultural water-management practices. This finding is generally consistent with previous research indicating that more frequent interaction with extension services has a positive impact on farmers' choices to adopt agricultural technologies (Feyisa, 2020). In addition, extension services have been recognized as a pivotal catalyst in the uptake of technology. Extension agents perform a crucial function, informing farmers of the advantages, correct utilization, and accessibility of agricultural technologies, and by means of these services, innovators and technology users interact, enabling farmers to obtain the information needed for informed decisions (Yin *et al*., 2022).

Additional evidence for these results emerges from a Nigerian study analyzing the factors that shape cassava farmers' adoption of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)–supported technologies. The investigation indicates that interactions between farmers and extension service providers are pivotal, as extension agents convince and guide farmers to adopt the technologies at their disposal (Sanusi *et al*., 2021). Across Kenya, rural farmers continue to rely chiefly on extension services for their agricultural information. Extension agents supply guidance on advanced farming techniques, pest and disease control, the efficient use of fertilizers, the adoption of high-yielding seeds, and the practice of mechanized agriculture (Feyisa, 2020). These programs likewise act to narrow the information deficiency that farmers encounter when adopting agricultural technologies through demonstrations, organized field days, and peer-to-peer farmer exchanges (Mutegi *et al*., 2024).

Rongai Sub-County, extension service providers and agricultural water officers noted that both the smallholder farmers and extension service providers are willing to enhance the adoption of agricultural water management practices in the area. However, smallholder farmers can only afford drought-resistant seeds due to some elements, such as the high cost of constructing water pans, irrigation, and the porous soil in the area. Hence, the adoption rate remains low in the area. Support through disseminating funds from the national government would boost the adoption of the practices since smallholder farmers cannot afford them. Also, collaboration and linkages between the sub-county extension service providers and private service providers, such as community-based organizations, can improve the adoption of agricultural water management practices and develop innovations in agricultural water management.

The findings of this study may increase the rate of accessing extension services, especially with the current push for advocacy for demand-driven extension, unlike in the past when the extension service providers had to look for the farmers. Extension operations should be more frequent and comprehensive to optimize their impact on farmers' ability to adopt new technologies. These initiatives could result in better uptake of agricultural technologies such as AWMPs by smallholder farmers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The chapter gives a review of the significant findings of the research, presents the conclusions, and provides practical recommendations from the findings.

5.2 Summary of the Study

The research examined how specific socio-economic factors, along with extension services, influence the adoption of Agricultural Water Management Practices (AWMPs) among smallholder farmers in Rongai Sub-County, Nakuru County, Kenya. The study focused on three main aspects: farmers' levels of education, income level, and access of extension services. Results revealed that overall adoption of AWMPs in the region remains relatively low. Among the factors analyzed, only income levels and access to extension services were found to have an impact on the uptake of AWMPs.

5.3 Conclusions of the Study

This study examined the impact of socio-economic factors and extension services on the adoption of AWMPs. The study concluded that:

i.) Adoption of Agricultural Water Management Practices in Rongai Sub-County is low.

ii.) The education level of smallholder farmers does not statistically influence the adoption of Agricultural Water Management Practices in Rongai Sub-County.

iii.) The income level of smallholder farmer statistically influences the adoption of Agricultural Water Management Practices in Rongai Sub -County.

iv.) Access to extension services statistically influences the adoption of Agricultural Water Management Practices in Rongai Sub-County.

5.4 Recommendations for Practice

Based on the findings, the following recommendations were proposed for various stakeholders involved in agricultural development in Rongai Sub-County:

i.) National and County Governments should collaborate in constructing water pans and irrigation systems in the sub-counties, as this would increase the adoption of AWMPs in Rongai Sub-County.

ii.) Extension service providers should frequently train smallholder farmers on AWMPs regardless of the farmers' formal education level.

iii.) To improve smallholder farmers' financial capacity to adopt AWMPs, farmers should diversify their income sources.

iv.) The Government and NGOs should strengthen extension services by allocating resources and increasing staffing to enhance outreach and support for smallholder farmers. This initiative will create awareness among smallholder farmers about the benefits of AWMPs adoption.

5.5 Recommendations for Further Study

Although this study gives details of how socio-economic factors and extension services can influence the adoption of agricultural water management practices, there are opportunities for further research that include:

i.) Comprehensive assessment of the role of institutional and demographic factors in the adoption of certain Agricultural Water Management Practices, including rainwater harvesting, organic farming, and irrigation.

ii.) The impacts of growing water scarcity on domestic and agricultural production.

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APPENDICES

Appendix A: Questionnaire for Smallholder Farmers

Serial number:

____

Dear respondent,

I am Mercy Wagaitheri Mwangi, a student at Egerton University, pursuing a Master of Science in Agricultural Extension**. I am conducting research on the Influence of Socio-economic Factors and Extension Services on Adoption of Agricultural Water Management Practices among Smallholder Farmers in Rongai Sub-County, Nakuru, Kenya**. You have been selected as one of the respondents. Please respond to all questions honestly and clearly. The information you provide will be kept confidential and will only be used for the study. Thank you.

____

Mercy Wagaitheri Mwangi

LOCATION OF THE FARMER

Ward _______________________

Location________________________________

Key Words: Agricultural Water Management Practices (AWMPs)
These practices include rainwater harvesting, Irrigation, and the use of drought-resistant crops.

For example, the construction and use of water pans and the use of drought-resistant seeds such as Haraka 101, among others

SECTION A: DEMOGRAPHIC CHARACTERISTICS OF THE FARMER

Please use a tick to fill in (√) or fill in accordingly

1. What is your gender?

    a) Male [ ]

    b) Female [ ]

2. Which category includes your age?

a) 20-30 [ ]

b) 31-39[ ]

c) 40-49 [ ]

d) 50-59 [ ]

e) 60+ [ ]

3. What is the size of your farm in acres? ____________________________

SECTION B: SOCIO-ECONOMIC CHARACTERISTICS OF THE FARMER AND ACCESS TO EXTENSION SERVICES

Please use a tick to fill in (√) or fill in accordingly

4. What is your highest level of education?

a) No formal education [ ]

b) Primary [ ]

c) Secondary [ ]

d) Tertiary [ ]

e) Others

Specify____

5. Do you have any training in Agriculture?

a) Yes[ ]

b) No[ ]

6. If yes specify ____

7. What type of farming are you involved in?

a) Crop production[ ]

b) Livestock rearing[ ]

c) Both[ ]

8. Where do you get your money from?

a) On-farm income [ ]

b) Off-farm income [ ]

9. How much do you earn per year from your farm?

a) Less than KES 50,000.00[ ]

b) KES 50,001- KES 100,000.00[ ]

c) KES 100001- KES 150000.00 [ ]

d) More than KES 150,000.00 [ ]

10. How much do you earn per month from off-farm sources?

a) Less than KES 5,000.00[ ]
b) KES 5,001-10,000 .00[ ]

c) KES 10,001 -15000.00[ ]

d) KES more than 15,000 [ ]

11. Does your income influence your decision-making regarding using agricultural water management practices (rainwater harvesting, Irrigation, and drought-resistant crops)?

a) Yes [ ]

b) No [ ]

If yes, how has the money helped you use agricultural water management practices?

____

12. What are the sources of extension services in the Sub-County? (Tick all available)

a) National Government [ ]

b) County government[ ]

c) Cooperatives[ ]

d) NGOs [ ]

e) Community Groups[ ]

f) Others

Specify ____

13. How often do you access extension services?

a) Once a month [ ]

b) More than once a month [ ]

c) Twice an year[ ]

d) Once an year[ ]

e) Not at all

14. How do you utilize the information from extension services on your farm?

a) Crop production and Livestock production[ ]

b) Water conservation[ ]

c) Accessing sources of credit[ ]

d) Accessing sources of inputs[ ]

15. Do extension services help you make decisions on the use of agricultural water management practices?

a) Yes [ ]
b) No [ ]

If yes, how? _______

SECTION C: AGRICULTURAL WATER MANAGEMENT PRACTICES

(Rainwater harvesting, Irrigation, and use of drought-resistant crops
Please use a tick to fill in (√) or fill in accordingly

16. Which AWMPs are you practicing?

a) Rainwater harvesting [ ]

b) Irrigation [ ]

c) Use of drought-resistant crops [ ]

17. How many times have you been trained on AWMPs?

a) Once a month [ ]

b) Twice a month [ ]

c) More than twice a month [ ]

d) Once a year [ ]

e) Not at all [ ]

18. What are the methods of training used?

a) Farm visit [ ]

b) Field demonstration [ ]

c) Farmer field school [ ]

d) Group discussion [ ]

e) Others, please specify [ ]

19. How often do you use skills and knowledge from the training?

a) Always [ ]

b) Rarely [ ]

c) Not at all [ ]

THE END.THANK YOU!

Appendix B: Key Informants' Interview Guide

Dear respondent,

I am Mercy Wagaitheri Mwangi, a student at Egerton University, pursuing a Master of Science degree in Agricultural Extension. I am conducting research on the Influence of selected socio-economic factors and extension services on the adoption of Agricultural Water Management Practices in Rongai Sub-County. Please respond to all questions honestly and clearly. The information you provide will be kept confidential and will only be used for the study.

Questions

1. Do you advise smallholder farmers on Agricultural Water Management

Practices?

____

2. How often do you advise them? ____
3. In what areas of Agricultural Water Management Practices do you advise the farmers?

____

4. In what agricultural water management practice areas do you train the farmers?

____

5. In what areas do smallholder farmers consult on Agricultural Water Management Practices? ____
6. How often do farmers visit your offices or call to consult on Agricultural Water Management Practices________________________________
7. How does the government disseminate information on agricultural water management practices to smallholder farmers? ________________________________-

8. What is the current level of Agricultural Water Management Practices adoption in the Sub- County? _______-

____

9. What are the Agricultural Water Management Practices that smallholder farmers have adopted? ____

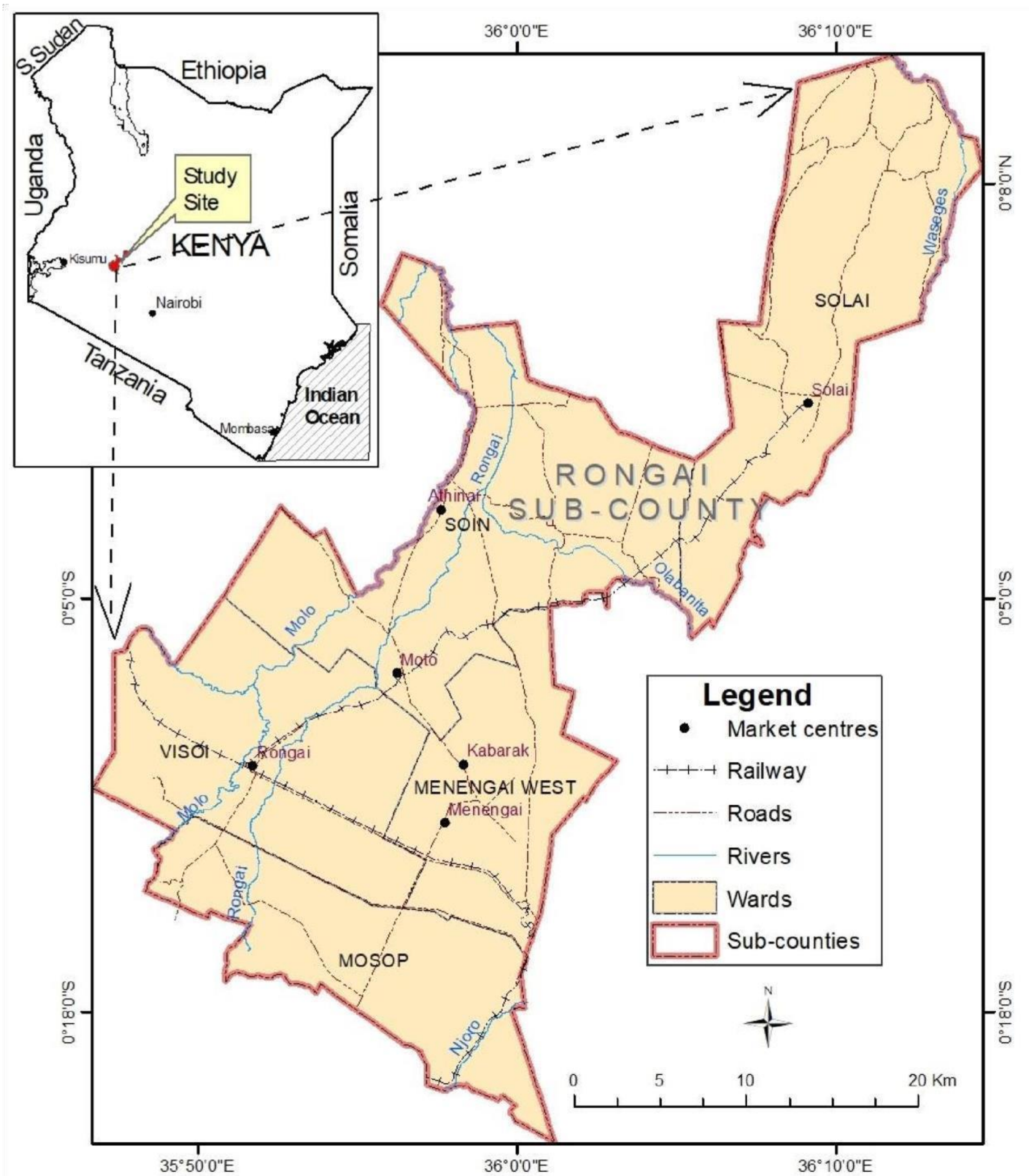
10. What factors might have contributed to the adoption rate of Agricultural Water Management

Practices in the sub-county? ___________________________________

11. How can the adoption of Agricultural Water Management Practices be improved?

____

Appendix C: Rongai Sub-County Map



Source: (Gachie, 2020)

Appendix D: Research Permit

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Ref No:**690026**

Date of Issue:**31/March/2023**

RESEARCH LICENSE

This is to Certify that Ms.. Mercy Wagaitheri Mwangi of Egerton University, has been licensed to conduct rese provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nakuru on the topic: INFLUENCE ECONOMIC FACTORS ON THE ADOPTION OF AGRICULTURAL WATER MANAGEMENT PRACTIC SMALLHOLDER FARMERS IN RONGAI SUB-COUNTY, NAKURU for the period ending : 31/March/2024.

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Appendix E: First Publication from Thesis

Asian Journal of Agricultural Extension, Economics & Sociology

Volume 42, Issue 4, Page 11-19, 2024; Article no.AJAEES.113734
ISSN: 2320-7027

To Determine the Influence of Farmer's Educational Level on Adoption of Agricultural Water Management Practices in Rongai Sub-county, Nakuru County, Kenya

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Authors' contributions

The study inception and design were contributions from all the authors. Author SMWM supervised author MWM during data collection while author FN supervised data analysis. The article was written, read and approved by the all authors.

Article Information

DOI: 10.9734/AJAEES/2024/v42i42391

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/113734

Original Research Article

Received: 18/12/2023
Accepted: 23/02/2024
Published: 04/03/2024

Appendix F: Second Publication from Thesis

Asian Journal of Agricultural Extension, Economics & Sociology

Volume 42, Issue 11, Page 321-329, 2024; Article no.AJAEES.124271
ISSN: 2320-7027

Influence of Farmer's Income Level on Adoption of Agricultural Water Management Practices among Smallholder Farmers in Rongai Sub-county, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajaees/2024/v42i112617

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/124271

Original Research Article

Received: 12/08/2024
Accepted: 14/10/2024
Published: 12/11/2024