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**DETERMINANTS OF THE UPTAKE OF AGRICULTURAL WATER MANAGEMENT
TECHNIQUES BY SMALL-HOLDER FARMERS IN ARID AND SEMI-ARID LANDS OF
KENYA: A CASE STUDY OF LAIKIPIA COUNTY**

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DECLARATION

This thesis report is my original work and has not been submitted for any degree award in any other university.

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CERTIFICATION

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DEDICATION

This thesis is dedicated to my dear parents Mr. Peter Maina and Mrs. Teresiah Wahu and my siblings Purity Watetu and Francis Mairu for their care and support during my thesis writing.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	: Agro-Ecological Zones
ASALs	: Arid and Semi-Arid Lands
CIDP	: County Integrated Development Plan
FAO	: Food and Agriculture Organization
FGDs	: Focus Group Discussions
HH	: Household Head
KALRO	: Kenya Agriculture and Livestock Research Institute
KES	: Kenyan Shilling
LAOP	: Laikipia Agricultural Observatory Platform
MMR	: Mixed Methods Research
SDGs	: Sustainable Development Goals
SPSS	: Statistical Package for the Social Scientist
SSA	: Sub-Saharan Africa
SWC	: Soil and Water Conservation

ABSTRACT

The study investigated the determinants of the uptake of agricultural water management techniques by small holder farmers in Laikipia County. A mixed methods research design was used with a sample of 100 farmers. Multi-stage sampling technique was used to select the respondents of qualitative data while purposive sampling was used to select respondents of quantitative data. Quantitative data was collected through structured questionnaires while qualitative data was collected through focus group discussions and key informant interviews. Analysis of quantitative data was done using Statistical Package for Social Sciences Version 26. Quantitative data was presented using descriptive and inferential statistics. Qualitative data was analyzed using NVivo software version 12 and presented in verbatim. The correlation analysis showed education ($\beta=4.293$), belonging to a farmer group ($\beta=2.895$), access to credit ($\beta=2.032$), access to extension ($\beta=2.696$) among other factors influenced the uptake of water management techniques positively. The study further identified opportunities available to enhance the uptake of water management techniques such as ground water exploitation, investing in e-extension to train farmers and intensifying surface runoff harvesting. The study recommends the allocation of more resources towards farmer education by the government, building of robust weather forecast systems by the meteorological department and creation of Public-Private Partnerships to provide farmers with credit at affordable rates in order to support those with financial constraints in investing in water management techniques.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Globally, agriculture is the largest consumer of water accounting for 70% of water use (Qin et al., 2018). According to (Chen et al., 2018), 80% of the cropland in the world is under rain-fed agriculture and it produces 60-70% of the world's food. Arid and Semi-Arid Lands (ASALs) occupy 40% of the landmass globally (Njoka et al., 2016). A land is classified as an ASAL based on its aridity levels. ASALs are characterised by low and erratic rainfall patterns and high levels of climatic variations (Paper, 2023). Agricultural productivity in ASALs is limited by shortage of water resources which is caused by irregular rainfall patterns. Global warming further exacerbates the water shortage problem (Chen et al., 2018). To overcome these shortcomings, farmers have had to adopt various water management techniques in ASALs such as Zai pits, mulching, furrow irrigation, cone gardens and drip irrigation. These techniques are aimed at increasing water use efficiency and enhancing agricultural productivity (Śpitalniak et al., 2019).

Agriculture is the primary source of livelihood for Sub-Saharan African inhabitants (Paper, 2023), with 75% coming from small-holder farmers. However, most of these farmers rely on unreliable rain-fed agriculture due to frequent droughts. To enhance resilience, protect livelihoods, and achieve food security, adaptation measures are necessary. Dryland agriculture is crucial for food security in Kenya. Water management techniques are essential during unpredictable rainfall, droughts, and floods, as heavy water losses occur from runoff (Filho, 2015). In Africa, ASALs occupy 55% of land (Paper, 2023). Plant productivity and growth in drylands is limited majorly by persistent droughts which results in inadequate soil moisture available for crop use (Vijaylakshmi et al., 2012). Research has shown that communities living in drylands are mostly affected by extreme climate change events and unless appropriate adaptation measures are practised, their vulnerability increases (Rao et al., 2011).

Water management techniques encourage the conservation of soil moisture and the efficient use of the available water. Various water management techniques have been developed in Kenya's ASALs. Through reducing the speed of runoff in sloppy terrains and encouraging infiltration, water management techniques also reduce soil erosion (Oweis, 2017). According to (Kassie et al., 2013), several soil water conservation technologies which have been promoted in rural areas of Sub-Saharan Africa have received low rates of adoption due to inadequate knowledge on their benefits and how to properly put them into use. This inadequate knowledge has been attributed to poor access to quality information regarding these technologies (Paper, 2023). Other studies have reported that adoption of technology is based on factors including but not limited to land use, age, land tenure, access to capital, education, size of family, access to labour and the profitability of adopting the technologies (Arslan, 2020).

Laikipia County, is one of the 29 counties in Kenya classified as an ASAL. Various agricultural water management technologies have been promoted in the county to mitigate drought and improve water availability and accessibility. However, low adoption rates by small-holder farmers hinder their full impact. This study aims to assess factors determining the uptake of water management techniques by

small-holder farmers in the county. The findings will inform policymakers, practitioners, and development partners on the best approaches to enhance water management techniques sustainability in Kenya's ASALs.

1.2 Statement of the problem

Water scarcity is one of the major challenges facing inhabitants of ASALs (Food and Agriculture Organisation, 2017). These areas are faced with inadequate and erratic rainfall patterns resulting in water shortages for animal, human and plant consumption. Water scarcity constraints agricultural production, threatens ecosystems and affects livelihoods of people relying on agriculture for survival. Water scarcity is also the major source of conflicts over water resources especially where residents rely on a common water source (Food and Agriculture Organisation, 2017). Climate change has exacerbated the water shortage problem with longer and more frequent droughts being experienced.

In an effort to control water scarcity which limits high agricultural productivity and promote dryland agriculture, the Government of Kenya together with its development partners have been promoting agricultural water management techniques such as Zai pits, mulching, furrow irrigation, cone gardens and drip irrigation in Laikipia County. Promotion of these techniques is aimed at supporting the country in achieving Sustainable Development Goal (SDG) 2 on zero hunger and SDG 3 on good health and well-being. Despite these efforts, uptake of these technologies by small holder farmers has remained low.

Development of water management techniques should go hand in hand with adoption in order for them to contribute to improved food security. An analysis of the determinants of uptake of water management techniques is an important link between technology generation and dissemination. However, little research has been done in Laikipia County on understanding how small-holder farmers gain knowledge of, adopt and implement water management strategies in their households. This research therefore aimed to fill these information and knowledge gaps. The findings of this research will provide guidance on the design of policies and programs which will foster uptake of water management techniques in Laikipia county and other ASAL counties.

1.3 Research objectives of the study

1.3.1 Main objective

The main objective of this study was to assess the factors determining the uptake of agricultural water management techniques by small-holder farmers in ASALs of Laikipia County, Kenya.

1.3.2 Specific objectives

- I. To examine the influence of socio-economic determinants on the uptake of agricultural water management techniques by small-holder farmers in Laikipia County.

- II. To determine how institutional factors influence uptake of agricultural water management techniques by small-holder farmers in Laikipia County.
- III. To identify opportunities in enhancing uptake of agricultural water management techniques by small-holder farmers in Laikipia County.

1.4 Research Questions

- I. What are the socio-economic determinants influencing the uptake of agricultural water management techniques by small-holder farmers in Laikipia County?
- II. How do institutional factors influence uptake of agricultural water management techniques by small-holder farmers in Laikipia County?
- III. What are the opportunities available in enhancing uptake of agricultural water management techniques by small-holder farmers in Laikipia County?

1.5 Relevance of the study

This study aimed to investigate the factors that influence uptake of agricultural water management techniques among small-holder farmers in Laikipia County. The research findings will generate new information and provide knowledge to help stakeholders in the water sector in the county to understand the adoption process of water management techniques. The findings will also be important to the Ministry of Water, Sanitation and Irrigation, National Irrigation Board and Ministry of Agriculture and Livestock in coming up with water management techniques tailored to the needs of the small holder farmers. Promoting agricultural water management in ASALs is an important contribution towards the achievement of SDG 2 on zero hunger, SDG 3 on good health and well-being and Kenya's Vision 2030 whose aim in agriculture is to boost food security by the year 2030. The study findings will also be useful for future scholars as a basis for further study in this research area.

1.6 Scope and limitations of study

This study focused on the uptake of water management techniques practiced by small holder farmers in Laikipia County as a means to address the water scarcity issues persistent in the county. Further, the study sought to examine the socio-economic and institutional factors influencing the uptake of water management techniques either positively or negatively. The study was limited to only the selected water management techniques yet there are a number of techniques that farmers in the area practice. Thirdly, all surveyed farms were based in Laikipia County and therefore future studies could assess how determinants of uptake of water management techniques change across cultural contexts. Lastly, past studies have identified other factors such as agro-ecological conditions which also influence adoption decisions. However, this study did not address such factors.

1.7 Assumptions of the study

The researcher assumed that the sampled population was a true representation of the study population. The researcher also made the assumption that the questionnaire return rate would be high enough to provide a true representation of the research area. Thirdly, the researcher assumed that the interviewees and respondents were honest in the answers they gave to help draw valid and reliable conclusions. Finally, it was also assumed that after the findings of this research will show the relevance of the study and information obtained will be useful in the future for further research in this topic.

1.8 Definition of terms

Access to credit- capability of consumers to acquire financial help for agricultural purposes which they pay with interest within a stated period.

Adoption- integrating a new technology into existing practises.

Arid lands-an area of land which receives rainfall of between 150 mm and 550 mm.

Semi-Arid lands-lands receiving precipitation below normal but not as low as arid lands.

Socio-economic-relationship between social and economic habits of a certain population.

Small-holder farmers-farmers who practise farming on a small scale and manage lands of less than 2.5 acres to 25 acres.

Water management techniques-structures used by farmers to reduce water wastage in their farms.

Uptake- the action of making use of something available.

CHAPER TWO: LITERATURE REVIEW

2.1 Introduction

In this section, past studies on the development of Kenya's agricultural policy on soil and water conservation, the various water management techniques being practised in ASALs and the determinants of the uptake of these techniques have been reviewed.

2.2 Kenya's agricultural policy on soil and water conservation

Kenya's agricultural policy development dates back from the pre-colonial era (before 1963). During this period, the development of agricultural policies was done to benefit the European settlers with little attention being given to the local farmers' interests. The laws resulted in the natives being forcefully evicted from their productive land and ownership given to the whites therefore marginalizing the locals. The Swynnerton plan which focused on farmer education, credit, land tenure, extension systems, and agricultural policy was introduced in 1954. For effective implementation of the agricultural policy, there was the establishment of extension and research divisions in the Department of Agriculture. Colonial administrators enforced compulsory soil and water conservation to the natives in order to deal with land degradation problems. This forceful enforcement caused negative attitudes towards soil and water conservation techniques among smallholder farmers. After the attainment of independence in Kenya in the year 1963, small holder land users felt free from the colonial rules which imposed soil and water conservation on them. This feeling of freedom resulted in the rejection of soil and water conservation measures in a period referred to as "lost years" (Mati, 2016). During the late 1980s-90s, soil and water conservation extension approaches were initiated with a focus on community mobilization. The Catchment approach was adopted to address soil and water conservation with a focus on catchments. The government then adopted farmer-centred approaches which shifted policy attention from an emphasis on the structural measures in place to addressing the farmer as a decision maker who controls what happens to their land. It came to the realization of the administration that these approaches ignored indigenous knowledge which already existed and the process through which farmers get to know about new practices and adopt them. This resulted in the promotion of indigenous technologies in soil and water conservation. (Mati, 2016)

2.3 Current policy on agricultural water management in Kenya

2.3.1 Kenya Agricultural Policy 2021

The Kenya Agricultural Policy of 2021 was developed in order to provide a structure for sustainable development in Kenya's agriculture sector following the requirements of the Constitution of Kenya, the Kenya Vision 2030, SDGs and other development goals at the national, regional and international level. It provides guidelines on the efficient utilisation of opportunities and resources in the sector and outlines the linkages between research, extension, irrigation and infrastructure (Republic of Kenya, 2021). As relates to water for agriculture and irrigation, the policy aims to promote the sustainable use and development of water resources for livestock, fisheries and crops. The national and county governments are tasked with the role of; providing a mechanism for investing in irrigation in order to increase agricultural production in the face of climate change, promoting integrated water resource management in livestock, fisheries and crop production, developing strategies to promote efficient water use through for instance recycling in livestock, fisheries and crop production and encouraging and enforcing the protection of water towers, wetlands, riparian lands and catchments to ensure safe water is available for sustainable crop, fisheries and livestock production (Republic of Kenya, 2021).

2.3.2 Laikipia County Integrated Development Plan

Laikipia County Integrated Development Plan (CIDP) outlines the county's development priorities, programs and strategies to be employed in the period 2023-2027 to facilitate integrated development for the residents of Laikipia. The agriculture sector in the county is governed by the Department of Agriculture, Livestock and Fisheries. The sector is divided into various sub sectors namely; Crops and Irrigation Development, Veterinary Services, Livestock Production and Fisheries Development. As regards irrigation infrastructure development, the CIDP outlines the following priorities; excavation of dams and household water pans, improvement of irrigation schemes, increasing farmer's capacities in water harvesting and storage facilities and provision of affordable drip kits and dam liners. To achieve this irrigation infrastructure development, the county aims to excavate/desilt 25 dams/pans, sink 75 boreholes, establish 10 irrigation schemes, install 5 drip kits and procure 750 dam liners between the period 2023-2027 (Tender, 2016).

2.4 Climatic conditions in Laikipia

Rainfall in Laikipia occurs in a bimodal pattern with long rains being experienced from March to May and short rains from the month of October to December. The average annual rainfall ranges between 635-1210 mm and temperature is between 9.8°C-24.48°C (Tender, 2016). A higher annual rainfall is recorded in areas located nearest to Mt. Kenya and Aberdares Ranges slopes. Between the year 2017 and 2021, the lowest average amount of rainfall of 635.9mm was recorded in

Doldol. During the same period, Nyahururu which receives the highest rainfall had an average of 1,210.9mm (Tender, 2016).

2.4.1 Ecological conditions of Laikipia

Laikipia is rich in rangelands, pastureland, wildlife, rivers, forests and other forms of landscapes. Arable land is 1,998.7km² which is 20.9 percent of the total land area while non-arable land is 7,511.5km² which represents 79.1 per cent of the total land area. Non-arable land is utilized for livestock rearing, wildlife, conservancy and mining. The major soil types are clay, sand and loam. In most parts of the plateau, the main soil is black cotton soil while dark reddish brown and rocky soils are found mainly on the hillsides. There are seven gazetted forest areas which total to about 580km² and 23 non-gazetted forests. The main gazetted natural forest is the Mukogodo Forest Reserve located in Laikipia North Sub-County which covers 30,189 Ha. The forest and surrounding ranches contribute largely to Laikipia-Samburu ecosystem which host Kenya's second highest density of wildlife (Tender, 2016).

2.4.2 Agro-ecological zones in Laikipia

Agro-Ecological Zones (AEZ) describe the division of a land into smaller units with similar attributes related to potential productivity, land suitability and environmental impact. Crop cultivation potential refers to the agronomically possible upper limit for production of different crops under given soil, terrain and agro-climatic conditions and specific agricultural input levels and management conditions.

Table 1: Agro-ecological zones for Laikipia County 2018-2022

Source: Laikipia County Statistical Abstract 2023

Zone	Description	Constituency/wards	Dominant enterprises
UH 2-3 (Upper Highland-Sub Humid)	<p>I. Rainfall is over 1000mm/year.</p> <p>II. The temperature ranges from 19°C to 25°C.</p> <p>III. Soils are well drained, fertile with a lot of humic materials.</p> <p>IV. Altitude is over 2100m ASL</p>	I. Laikipia West-Igwamiti and Githiga wards	Dairy farming, beans, irish potato, wheat, maize and fish farming.
Low Highlands (LH 1-5)	<p>I. Rainfall is erratic and ranges from 700-1000mm/year.</p> <p>II. Soils are moderately well drained and</p>	<p>I. Laikipia East-Ngobit, Umande, Nanyuki, Thingithu wards.</p> <p>II. Laikipia West-Igwamiti, Marmanet and</p>	Maize, wheat, dairy farming, beans, fish farming, sunflower, barley

	<p>III. contain less humic materials. Temperatures ranges from 15C to 25C. Altitude is between 1500-2100 M ASL</p>	Githiga wards.	
UM5 - UM6 (Upper Midlands Zones)	<p>I. Rainfall is erratic and ranges from 500mm-700mm/year.</p> <p>II. Soils are not well drained and contain less humic materials.</p> <p>III. Temperature ranges from 15C to 28C. High evaporation</p>	<p>I. Laikipia East-Nanyuki and Tigithi wards.</p> <p>II. Laikipia West-Rumuruti and Salama wards.</p> <p>III. Laikipia North-Mukogodo East, Seger</p>	Millet, beef farming, sorghum, hay.
LM3 - LM5 (Lower Midlands)	<p>I. Rainfall ranges from 400mm to 500mm /year.</p> <p>II. Temperature ranges from 15°C to over 28°C.</p> <p>III. Soils are shallow ,poor in fertility and have high evaporation rates.</p> <p>IV. Altitude is around 1500mm ASL.</p>	<p>I. Laikipia North-MukogodoWest , Mukogodo East, Segera, Sosian</p>	Ranching,beef farming and sisal

2.5 Major water management techniques applied in Laikipia

2.5.1 Zai pits

A 'Zai' refers to a hole which is dug into soil to capture precipitation, reduce runoff and evaporation of water in agricultural fields. It helps increase agricultural productivity (Muchai et al., 2020). The technology was initially practised in Burkina Faso and Mali (M.N. Danjuma* and S. Mohammed, 2015);(Partey et al., 2018).The technology has been used in growing crops such as millet, pigeon peas, sorghum ,millet and other drought resistant crops in ASALs. Zai's have 20-30 cm in diameter, 10-20 cm depth and spacing between the pits is usually 70-80 cm (Danso-Abbeam et al., 2019).

The farmers then add decomposed manure or residues from crops into the pit before covering. This organic matter helps to improve water infiltration and protect soil water from evaporating at a high rate (Danso-Abbeam et al., 2019).The Zai technology is used mainly in semi-arid lands which receive 300-800mm annual rainfall ,have slopes below 5% and soils are sandy/loamy .The pits are most suitable for lands with crusted soils, reduced penetrability, inadequate ventilation, hardpan formation limited plant root development and compaction. The digging of the pit encourages more water to penetrate the soil and traps runoff water (Osei Danquah, 2019).



Figure 1:Zai pits constructed in Laikipia

Source: Author's field work,2024

2.5.2 Drip irrigation

Drip irrigation refers to the slow application of water to a crop directly to the root zone through delivery equipment known as emitters. This is done under some pressure from a pumping source or through natural gravity head. This type of irrigation has the highest water application efficiency (Choudhary et al., 2010). The system has a number of advantages namely; increased application uniformity, preservation of the soil structure and reduced evaporation. By supplying the exact amount that a crop requires, the drip irrigation system reduces water wastage to a high level (Moin & Kamil, 2018). It is however costly to put up a drip irrigation system and a high level of skills and expertise is also required (Nakawuka et al., 2018).



Figure 2: Drip irrigation system in Laikipia

Source: Author's field work, 2024

2.5.3 Furrow irrigation

Furrow irrigation is a type of flood irrigation whereby water is directed through open narrow channels in order to deliver water to crops. Furrows refer to small channels that carry water down the land slope. As water moves along the slope, it infiltrates into the soil and reaches the crops. Usually, the crop is grown on ridges which are between the furrows. This irrigation method is suitable for crops which cannot stand water for a long period (Ambomsa, 2020). The application of water to the furrows is done through pipe siphons or temporary gaps made in the supply channel. The amount of time water is allowed to flow in the furrows is dependent on the infiltration rate of soil, rate of spread of water in soil and the amount of water needed to recharge the root zone. When compared to other surface irrigation methods, the furrow system is advantageous. This is because water in furrow gets into contact with only a half to a fifth of the land surface thereby reducing excessive evaporation of the water. The length, shape and spacing of furrows are dictated by available stream size, slope and type of soil. Other factors which may influence how a furrow system is designed include; irrigation depth, length of field and farming practice. Flat or gentle slopes (not exceeding 0.5%) are usually preferred for furrow irrigation (Waweru, 2013).



Figure 3: Furrows constructed in Laikipia

Source: Author's field work, 2024

2.5.4 Mulching

Mulching refers to the application of organic materials for example cut grass, straw, compost, grass clippings and leaves on the soil surface (Ranjan et al., 2017). It is an important water management technique since it plays a crucial role in the reduction of runoff and encouraging water infiltration into the soil .By conserving soil moisture, mulching helps to enhance crop water use efficiency and increase crop production (Kiboi et al., 2017). Mulching also prevents evaporation of soil moisture by preventing direct solar radiation from hitting the ground .By preventing evaporation, mulching helps to increase crop water use efficiency and therefore reducing the cost pf production (Ranjan et al., 2017).



Figure 4:Mulching in use in Laikipia

Source: Author's field work,2024

2.5.5 Cone gardens

A cone garden resembles the shape of a cone. It is constructed by compacting rings of soil together and using a strong polythene sheet to hold the soil into place. Each ring has a smaller diameter than the ring located below it (Kwena et al., 2023). Cone gardens encourage water efficiency since less water is required for watering plants. They are therefore a very good water management technique for use in water-stressed areas. Other advantages include the creation of more space for crop planting, ease to maintain during weeding and watering and the ability to diversify crops by growing different vegetables in different layers (Munywoki et al., 2022).



Figure 5: Cone Garden in Laikipia County

Source: Author's field work, 2024

2.6 Conceptual Framework

A conceptual framework is defined as a set of ideas which are interconnected or theories explaining how a phenomenon works. It provides an understanding of the causal patterns of related ideas, events, knowledge, concepts and activities. The conceptual framework below shows the relationship of the variables in the study. Independent variables include socio-economic and institutional factors while the dependent variable is the uptake of water management techniques.

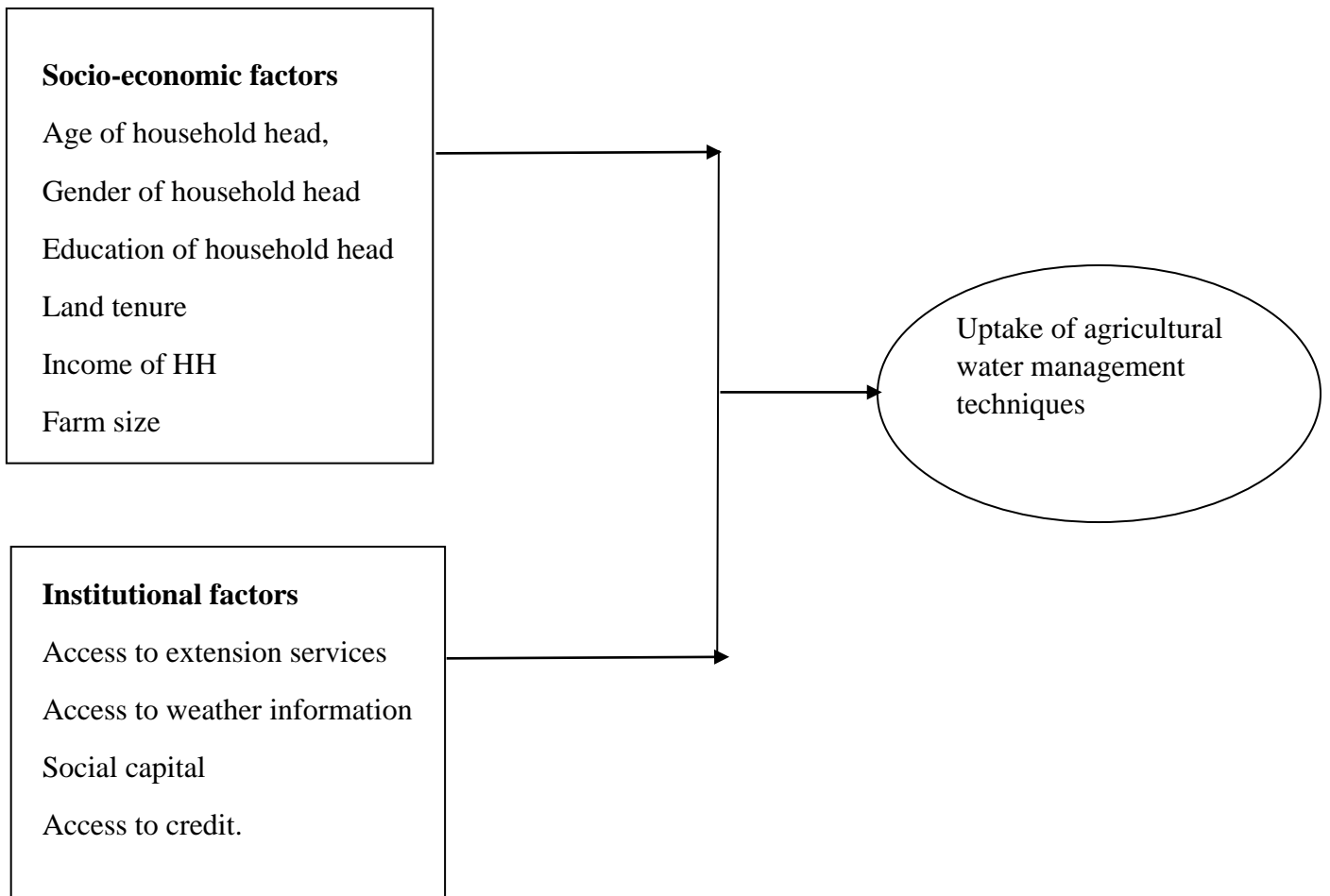


Figure 6:Conceptual Framework

Source: Author's construct,2024

2.7 Theoretical framework

2.7.1 Diffusion of innovation theory

This study was anchored on the Diffusion of Innovation Theory developed by Rogers 2003. Diffusion refers to the process through which an innovation gets communicated over time among members of a social system through various communication channels. Adoption is defined as integrating a new technology into existing practises (Loevinsohn et al., 2013). It is the mental process an individual goes through since hearing about a technology to finally utilising it. The process through which people adopt new innovations has been studied for many years and the diffusion of innovation theory has emerged as one of the most popular theories explaining the adoption process. It is because of this reason that the theory was adopted for this study. The theory states that the accessibility of information is the crucial variable ascertaining adoption decisions. Each participant of the social system undergoes a process involving 5 steps throughout the diffusion process. These steps are; knowledge whereby a person gets to know about an innovation and has an idea about its functioning. Having relevant information regarding a technology can persuade an individual to adopt it. Secondly, in the persuasion stage a person forms an attitude favourable or unfavourable towards the innovation. Decision is the third stage which involves a person engaging in activities which lead him/her towards adopting or rejecting the innovation. The fourth stage is implementation which involves a person putting the innovation into practise. Lastly, at the confirmation stage, a person evaluates the results from the innovation (Orr, 2003).

Adopters of an innovation are grouped into 5 categories based on the time they take to adopt a technology. These are (innovators, early adopters, early majority, late majority and laggards). Innovators enjoy taking risks and are excited by the potential benefits a new innovation may have therefore they are the first group of people to try a new innovation. The decisions taken by innovators at the implementation and confirmation stage are of value to other potential adopters. Secondly, early adopters make adoption decisions based on the decisions taken by innovators at the implementation and confirmation stage. This group mostly consists of opinion leaders who encourage others to adopt innovations if they have been effective for innovators. Thirdly, the early majority is composed of individuals who wait until most of their peers adopt the innovation in order for them to adopt. Next, the late majority is made up of people who adopt an innovation after the average member of the society does. Lastly, the laggards are the last adopters who are either traditional or isolated from the social system. The traditional people are suspicious of innovations and are often in close interaction with others with traditional values like them. Those that isolate themselves from the social system lack social interaction and therefore have less awareness about innovations (Orr, 2003). Several authors have used the diffusion of innovation theory to explain the adoption of agricultural innovation such as (Njenga et al., 2021), (Katumo, 2018), (Alcon et al., 2019) among others.

2.8 Socio-economic determinants of adoption of water management techniques

In previous studies, the most significant socio-economic factors that have been found to determine adoption decisions are age of household head, sex of household head, education of household head, land tenure, farm size and income.

2.8.1 Age of household head

A farmer's age may either have a positive or negative influence on adoption decisions of new technologies. Older farmers are more reluctant to risk taking therefore becoming less likely to adopt new technologies as compared to much younger farmers who are more open to taking risks (Karidjo et al., 2018). In a study conducted by (Huang et al., 2020) on adoption behaviour of soil and water conservation measures in China ,results revealed that age had a significant negative impact on the adoption of conservation measure. This was attributed to the labour-intensive nature of putting up these structures which makes it easier for young farmers to adopt as compared to their older counterparts who have less physical strength. Older farmers were also found to be slower in their acceptance of new knowledge and more resistant to adopting new techniques(Huang et al., 2020).In another study by (Mutua-mutuku, 2017) on the factors affecting smallholder farmers adoption of integrated soil fertility and water management practices in Machakos county ,Kenya results revealed that the youth and the elderly did not fully engage in farming. This could be attributed to the youth being attracted by other occupations and older farmers being more reluctant to taking risks.

2.8.2 Sex of household head

Sex has been shown to be a determinant in adoption of technologies decisions. In many communities in Africa, social barriers deprive women of the right to own property. This follows that they have fewer resources as compared to their male counterparts .A study conducted by (Tangonyire & Akuriba, 2021) on the socio-economic factors influencing farmers' specific adaptive strategies to climate change in Talensi district of the Upper East Region of Ghana revealed that women in the community were not allowed to own land .Due to this restriction to own land, the ability of female headed households to adopt technologies was limited . A study by (Amare & Simane, 2017) conducted in Ethiopia found that male headed households were more likely to adopt water management practices in their farms as compared to female headed households due to the substantial labour needed to construct these structures.Lastly,in a study on adoption of water conservation technologies in Tanzania, female headed households were found to be less likely to adopt technologies as compared to those which were male headed. This was due to the nature of technologies being labour intensive and time consuming. Females were found to spend more time on household activities rather than on installing these technologies in their farms (Kassie et al., 2013).

2.8.3 Education of household head

In past studies, education has been shown to be a major determinant of adoption of water management techniques. Households with educated members are able to access and understand relevant information to guide them in decision making. Farmers who are educated realise the need for knowledge regarding soil and water conservation techniques and therefore seek information as compared to less educated farmers (Mwungu et al., 2018).A study by (Amare & Simane, 2017) in Ethiopia revealed that education significantly increased the likelihood of small holder farmers adopting small-scale irrigation.

This is because, education helps farmers in their search and use of relevant information regarding water management in their farms.

Education was shown to expose the farmers to the potential benefits of practising irrigation therefore encouraging adoption. In another study on factors influencing conservation of green water for crop production in drylands of Kenya by (Anne et al., 2022) results revealed that majority of farmers had attained primary and secondary school education. More literate farmers adopted water management techniques as compared to those who had not attended school. Another research on smallholder adoption of sustainable land management technologies in Malawi also found education to be a major factor in determining adoption of technologies. Farmers with education at primary, secondary or higher level were found to be more likely to adopt technologies as compared to farmers with no education (Kansanga et al., 2021). Similarly, a study by (Mango et al., 2017) conducted in Southern Africa to investigate the awareness and adoption of land, soil and water conservation practices revealed that adopters of techniques had a higher level of education as compared to non-adopters. Lastly, (Zhang et al., 2019) in their study to determine adoption of irrigation water saving technologies in China also found an increase in the education status of farmers to increase the likelihood of adoption of technologies.

2.8.4 Land tenure

Land tenure refers to the existing property rights in a community. A secure land tenure may increase farmers' willingness to invest in water management technologies. The assurance of farmers that they have control over land in the long run enhances their adoption of techniques. Land can also be used as a collateral thus allowing farmers to easily access agricultural credit for investing in water management techniques. In this case, a farmer who owns land gets more motivated to adopt techniques since the land provides a means for them to access credit. A study by (Kpadonou et al., 2017) conducted to investigate the adoption of soil and water conservation technologies in West African Sahel showed a positive correlation between tenure security and the adoption of water conservation technologies by farmers. Farmers with no ownership of land were found to shy away from technologies that take long before gaining a return on their investment since they may not control the land long enough to gain the benefits. The lack of secure land rights for instance in cases where land is governed communally, farmers lack the economic incentives to invest in technology (Kassie et al., 2013). In another study by (Damtew Atnafe et al., 2015) on the assessment of the determinants of adopting techniques of soil and water conservation in Goromti Watershed, Western Ethiopia there was a positive correlation between tenure status and the adoption of soil and water conservation practices. The authors attributed this to the ability to control land providing greater motivation for investment in techniques since farmers will benefit from the techniques.

2.8.5 Income of household head

Previous studies have shown income of household head to be a key determinant in the adoption of water management techniques by farmers. Most soil and water management practices require a huge investment especially at the initial phase of installation while the economic returns are expected to be realised in the medium to long-term.

This investment requirement renders these techniques less accessible to farmers who are poorer . In a study by (Kpadonou et al., 2017) analysing the adoption of soil and water conservation technologies in West African Sahel ,the findings revealed that wealthier farmers were more likely to adopt the technologies as compared to poorer ones. Another study by (Belay et al., 2017) reported that the income of households had a positive effect on the adoption of water management technologies.(Challa & Tilahun, 2014) in their study on the determinants of the adoption of modern agricultural technology in Ethiopia found that the availability of non-farm income for households had a positive influence on the decisions of farmers to adopt technologies.

2.8.6 Farm size

In previous adoption studies farm size has been found to be a determinant of adoption of water management techniques by farmers. Owning a large farm and having a large crop acreage may likely increase the exposure to technologies which are more likely to be marketed to large farm owners .Farmers who own large pieces of land have a higher probability of adopting new technology since they can devote a piece of their land for trials as compared to those who own smaller pieces of land (Damtew Atnafe et al., 2015).A study conducted by (Darkwah et al., 2019) on the assessment of the determinants that influence the adoption of sustainable soil and water conservation practices in Techiman Municipality of Ghana revealed that there was a positive association between the size of a farm and the adoption of water conservation practices by farmers. This was attributed to the fact that farmers owning large farms have adequate financial resources to invest in technology adoption. Also, in case of failure of a technology, these large farm land owners have the ability to endure the resultant risks (Darkwah et al., 2019).In a study to investigate small holder adoption of soil and water conservation techniques in Ghana,(Abdallah et al., 2014) also found farm size to positively influence adoption decisions with farmers with a larger farm size adopting more soil and water conservation technologies .A similar study by (Mugonola et al., 2013) to assess the adoption of soil and water conservation technologies in the Rwizi catchment of South Western Uganda found that the likelihood of farmers to adopt soil and water conservation measures increased with an increase in size of land owned.(Huang et al., 2020) in their study on adoption behaviour of soil and water conservation measures in China found out that the size of land under cultivation had a positive impact on adoption of conservation techniques by farmers .They attributed this to the possibility of agriculture being a major source of income to the large farm owners and therefore the farmers had to give more attention towards techniques for soil and water conservation in an effort to increase water use efficiency which in turn reduces the production cost(Huang et al., 2020).

A study by (Asfaw & Neka, 2017) conducted in Ethiopia to determine factors affecting adoption of soil and water conservation practices however revealed contrary results by finding the increase in farm size to have a negative effect on adoption of SWC practices.The authors related this to most farmers owning large farms being old therefore lacking in access to labour to construct these conservation structures.

2.9 Institutional determinants of the adoption of water management techniques

Institutional factors have been found to have an influence on the adoption of water management techniques by small holder farmers in past studies. These factors include access to extension services, access to weather information, social capital and access to credit. The impact of these factors on adoption have been discussed below;

2.9.1 Access to extension services

There are different ways through which information regarding new technologies can be obtained. These are visiting demonstration fields, watching television or listening to radio, contact with agricultural extension officers, participating in training both formal or informal among others (Damtew Atnafe et al., 2015). Extension services provide important information to farmers regarding climate change, new agricultural water management techniques available in an area and increases the probability of farmers adopting farming practices which increase water use efficiency. Extension education has been found to be an important determinant in enhancing the increased adoption of water management practices (Mugonola et al., 2013). This is attributed to the fact that extension education provides relevant information regarding technologies helping farmers gain a better understanding on how the technologies are used, managed and their benefits. A study conducted by (Danso-Abbeam, 2022) to determine whether agricultural extension services promote adoption of soil and water conservation practices in Northern Ghana revealed that farmers who had access to extension services were more likely to adopt soil and water conservation practices as compared to those who did not interact with extension agents. In another study done by (Amare & Simane, 2017) in Ethiopia to assess the determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in the Muger Sub basin of the Upper Blue Nile basin the access to extension services to was found to have a positive correlation with adoption of irrigation practices by farmers. (Mango et al., 2017) similarly, in their study about factors that influence adoption of soil and water conservation techniques in Southern Africa concluded that farmers who had access to agricultural advice from extension officers were more likely to adopt techniques. Access to information improves the knowledge of farmers about new technologies and therefore influencing adoption. For instance in a study conducted by (Damtew Atnafe et al., 2015) on the determinants of adoption of soil and water conservation techniques in Western Ethiopia, 89.7% of adopters reported to have visited demonstration sites to learn about construction of structures. These findings are similar to (Zhang et al., 2019) research findings whereby more farmers who were adopters of water-saving irrigation technology in China reported to have participated in on-farm demonstrations before. Field demonstrations increased the likelihood of adoption of these water saving technologies by 31.5%.

2.9.2 Access to weather information

Smallholder farmers require climate related information during the different stages of agricultural production to aid them in adapting to climate variability and change. This information includes weather forecasts, cultivation practices and early warning signals. (ALHASSAN, 2019) in a study on farmers' choice of adaptation strategies to climate change and variability in arid region of Ghana reported that having better access to weather information positively influences decisions to adopt irrigation and other agricultural water management practices in response to climate change. Similarly,(Temesgen et al., 2014) found the access to weather information positively influenced farmer's decisions to adopt adaptation measures .In another study by (Belay et al., 2017) on the determinants of small holder farmers adaptation decisions to climate change in Ethiopia, the access to climate information was found to be an important variable. Results showed that farmers who had access to weather information had a higher probability of adopting soil and water conservation measures. (Atsiaya et al., 2019) in a study conducted on the responses to climate variability in Laikipia County reported that households with access to weather information were more likely to adopt risk reduction practices such as mulching on their farms. Finally,(Melka et al., 2015) conducted a study in Ethiopia which also found the access to weather information by farmers through social networks, local institutions and traditional knowledge to positively influence their adoption of mechanisms to cope with drought.

2.9.3 Social capital

Social capital which is built by belonging to a social group is a key factor that determines adoption of technology .A study conducted by (Amare & Simane, 2017) to investigate the determinants of small holder farmers decisions to adopt adaptation options to climate change in Ethiopia, showed a positive correlation between belonging to a social group and adoption of small-scale irrigation. This is because ,belonging to a social group encourages the exchange of information between farmers hence increasing awareness on water management technologies which farmers can use on their farm(Amare & Simane, 2017).In another study conducted in Tanzania ,belonging to a social group increased the likelihood of small -holder farmers adopting water conservation technologies .Social groups were found to highlight the benefits of water conservation and help farmers in managing the complexities which may occur during utilisation of technologies. This in turn improved the confidence levels farmers had in technologies therefore leading to adoption (Jha et al., 2019).Similarly,(Mango et al., 2017) in their study on adoption of soil and water management technologies in Southern Africa found group membership to significantly increase awareness and influence adoption of techniques. Farmers who were early adopters shared success stories about the techniques with other farmers in their group therefore encouraging them to also adopt.

2.9.4 Access to credit

The access to credit has been shown in several studies to be an important determinant in the adoption process of technologies (Temesgen et al., 2014). Having access to credit has been found to be a stimulator of adoption of technology by various authors. A study by (Amare & Simane, 2017) to investigate the determinants of smallholder farmers' decision to adopt adaptation options to climate change and variability in Ethiopia revealed that farmers with access to more financial resources are more likely to invest in irrigation and other water management practices in their farms. The provision of credit to farmers solves their financial constraints and allows them to adopt new technology or switch between technologies. Similarly, a study by (Temesgen et al., 2014) found the access to credit as having a positive effect on the intensification of irrigation by smallholder farmers in South Eastern Ethiopia. Lastly, a study conducted to investigate the factors affecting adoption of irrigation in Makueni County Kenya, revealed that all farmers who had adopted irrigation had access to credit and therefore concluded that the access to credit services has a positive influence on the adoption of technologies (Katumo, 2018).

CHAPTER THREE: METHODS AND MATERIALS

3.1 Introduction

This chapter explains the research methodology applied by the researcher to carry out the research. It includes the study area description, research design, target population, sampling technique used, instruments for data collection, validity of research instruments and ethical considerations taken into account during the study.

3.2 Study Area Description

Laikipia County borders Samburu County to the North, Nyeri County to the South East, Isiolo County to the North East, Meru County to the East, Nakuru County to the South West Nyandarua County and Baringo County to the West. It lies between latitude $0^{\circ}18'S$ $0^{\circ}51'N$ and longitude $36^{\circ}11'E$ $37^{\circ}24'E$. It is located on the leeward side of Mt. Kenya and Aberdare ranges. The county has 6 administrative sub-counties namely; Laikipia North, Laikipia West, Laikipia East, Laikipia Central, Nyahururu and Kirima (Tender, 2016). Laikipia County covers a land area of 9532.2 sq. km and is ranked the 15th largest county in Kenya by land size (Tender, 2016). According to the 2019 Kenya Population and Housing Census, the county had a total population of 518,560 people. The total number of households are 145,776 (KNBS, 2019).

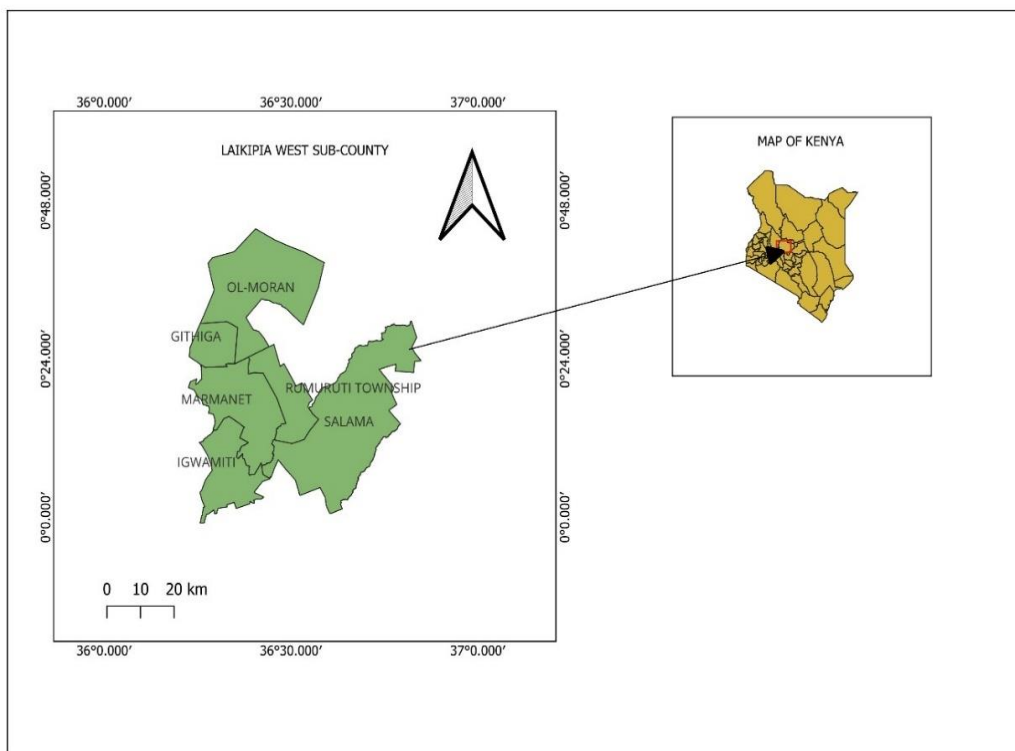


Figure 7: Map of study area (Author's construct, 2024)

3.3 Research Design

This study employed a mixed methods research (MMR) design which entails the collection, analysis, interpretation and reporting of both qualitative and quantitative data (Alatinga & Williams, 2019);(Dawadi et al., 2021).The research was conducted in a concurrent manner whereby qualitative and quantitative data were collected at the same time but analysed separately.The data were later merged to allow for comparison of the qualitative and quantitative results and to enhance an in-depth understanding of the research problem. The choice of the research design was based on its likelihood to provide a rich understanding of the research problem as compared to using only either qualitative or quantitative methods. The research design also has the ability to integrate multiple sources of data assisting in the study of complex problems (Dawadi et al., 2021). Lastly, the design allowed both qualitative and qualitative methods to complement each other such that the strengths of one method offsets the weakness of the other therefore helping the researcher to obtain more thorough conclusions (Clark & Clark, 2022).

3.4 Target Population

The target population for the study consisted of all the households in Laikipia West Sub County. According to the Laikipia County Statistics report (2022), there were 34,770 households in Laikipia West out of which 92 percent are small-holder farmer households. The target population therefore comprised of 31,988 small-holder farmer households.

3.5 Sample size and sampling Technique

3.5.1 Sampling Technique

A multi-stage sampling procedure was used to select the county, subcounty and farmers to be engaged in the research. Laikipia County was purposively selected since it is one of the 29 counties in Kenya classified as ASAL and there has been promotion of water management techniques by government and its development partners in an effort to promote dryland agriculture. In the second stage, Laikipia West sub-county was purposively selected from the 5 sub-counties in Laikipia since it has a high proportion of farmers as compared to the other sub-counties. Finally, proportionate random sampling was used to sample the 100 smallholder farmers who were engaged in the research. Purposive sampling was used to select participants of interviews and FGDs based on their knowledge about the process of selection and adoption of water management techniques by small holder farmers in Laikipia County. The 100 respondents were distributed proportionately in the six wards as shown in the Table 2 below.

Table 2: Sample distribution per ward

Ward	Sample size	Percentage (%)
Rumuruti	12	12.0
Olmoran	15	15.0
Igwamiti	16	16.0
Marmanet	20	20.0
Olmoran	19	19.0
Salama	18	18.0
Total	100	100

3.5.2 Sample size

To determine the sample size for the quantitative data, the following formula by Yamane 1967 (Naing, 2003) was used as given below:

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

Where: n is the sample size, N is the population size and e is the level of precision (10%).

$$n = \frac{31988}{1+31988(0.1^2)} = 100$$

Formula 1: Sample size calculation

The sample size for qualitative data was 6 key informants for interviews and 10 members per FGD. According to past research, a number of 4-6 key informants is recommended for interviews (Muellmann et al., 2021) . The number of members engaged in the FGDs was in line with the recommended number of 6-12 participants by researchers (Onwuegbuzie et al., 2009).

3.6 Data Collection Methods

3.6.1 Quantitative Data Collection

3.6.1.2 Survey

Questionnaires were used to collect primary data from the selected households. According to (Kothari, 2008) the questionnaire is the most suitable instrument due to its capacity to gather a lot of data in a sensibly speedy range of time. It has a guarantee of confidentiality of the information source through anonymous answering of questions while still ensuring standardization. (Kothari, 2008). The above reasons led to the picking of the questionnaire as a suitable data collection

instrument for this study. The questionnaire contained questions which were in line with the specific objectives of the study.

3.6.2 Qualitative Data Collection

3.6.2.1 Interviews

The researcher interviewed key informants comprising of officers from the Department of Agriculture, Livestock and Fisheries, Department of Water, Environment and Natural Resources, community leaders and extension officers. These institutions were chosen because they are involved in dissemination of knowledge on water management techniques in the county. Since they are involved with the community on a regular basis, it was expected that they are knowledgeable about the process of selection and adoption of water management techniques by small holder farmers.

3.6.2.2 Focus group discussions

Focus group discussions (FGD) were used to obtain information on water management techniques in use by small holder-farmers in Laikipia County and the motivating factors for adoption or non-adoption of these techniques. The participants of each FGD were chosen depending on their readiness to partake and their utilisation of water management techniques in their households. One-on-one discussions were used to obtain knowledge on issues related to water management techniques among small-holder farmers and to seek explanations for adoption behaviours in a way that would not have been clear if responding to direct questions. Focus groups comprised 10 members. Discussions were held at the convenience of participants and in a public space with a conducive environment. All discussions commenced with the facilitator appreciating the audience for availing themselves and explaining the purpose of the discussion. Ground rules were set and the participants allowed to freely interact.

3.7 Data Collection Instruments

3.7.1 Questionnaires

Questionnaires were administered to the head of household directly involved in water management. Data on farm size, education, income, age, land tenure access to credit, gender, access to extension services, access to weather information and belonging to a farmer group was collected.

3.7.2 Interview Guides

An interview guide was used to conduct interviews on 6 key informants and stakeholders involved in dissemination of water management techniques. The guide was designed containing open-ended questions in order to allow for an interactive interaction with the informants.

3.7.3 Focus Group Discussions Guide

A discussion guide was prepared to guide the focus group discussions. Participants were encouraged to freely express their opinion, respond to perspectives raised by other members and questions asked by the researcher. This enabled the researcher to collect a lot of information within a short time.

3.8 Data Analysis

Data analysis refers to the examination of raw data to establish facts. Data gathered from questionnaires was analysed using SPSS software version 26. Descriptive statistics such as frequency tables, percentages and correlation coefficients were used to describe results obtained from quantitative data. Qualitative data obtained from interviews and FGDs were coded and key themes developed using Nvivo software version 12.

3.8.1 Econometric Logit Model

A binary logistic regression was employed to evaluate the determinants of uptake of water management techniques. Binary logistic regression is a technique used in statistical analysis in cases where the probability of a dichotomous outcome for instance (adoption or non-adoption) is directly related to explanatory variables which are hypothesized to have an influence on the outcome (Neupane et al., 2002). This study fits the description above and for this reason, the logistic regression was applied. For this reason, the binary logistic regression model was used to TEST THE HYPOTHESIS of determining the uptake of water management techniques and to what extent.

The diffusion innovation theory states that adoption is binary and therefore a farmer either adopts(1) or rejects(0) an innovation (Weil, 2018). A binary variable refers to one where there are only two possible outcomes (Wilson & Lorenz, 2015). Diffusion refers to the communication process through which an innovation spreads within a social system. Adoption is the process that brings an individual to a decision of adopting or rejecting an innovation (Mehmood et al., 2016). Past studies have conceptualized choice as a binary variable where a farmer either chooses to use a certain technology or not (Belachew et al., 2020).

Many studies analyzing the determinants of choice have employed a wide range of econometric models in determining factors influencing choice decisions. For example, (Mango et al., 2017) employed the logit models to examine the factors that influenced farmer's knowledge and choice of land conservation strategies. Several other studies have also employed the logistic model to analyse the adoption of different technologies (Mugwe et al., 2009);(Muchai et al., 2020);(Kpadonou et al., 2017). These studies employed the model since it allows for a huge number of explanatory variables and has no assumptions of linearity and heteroskedasticity (Wilson & Lorenz, 2015). Heteroskedasticity refers to a condition whereby the variance of error in a regression model is not constant (Astivia & Zumbo, 2019). The presence of heteroskedasticity, can result in the coefficient standard errors being miscalculated (Astivia & Zumbo, 2019). The assumption of linearity states that for a model to be correctly specified, independent variables and the dependent variable have to share a linear relationship (Osborne & Waters, 2003).

The binary logistic regression model equation is expressed as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \dots + \beta_n X_n$$

Where:

Y = Uptake of water management techniques (categorical dependent variable: Yes =1, No= 0)

β = Beta coefficient

X₁ = Age (numerical independent variable: 30-40yrs=1, 40-50yrs=2, 50-60yrs=3, >60yrs=4)

X₂ = Education (categorical independent variable: primary school=1, secondary school, college= 3, university=4)

X₃ = Gender (categorical independent variable: Male=1, Female= 2)

X₄ = Income of HH (numerical independent variable: <KES50000=1, KES50000-100000=2, >KES100000=3)

X₅ = Type of land ownership (categorical independent variable: Private=1, Rented=2, Ancestral=3)

X₆ = Farm size (numerical independent variable: <2acres=1, 2-4acres=2, 4-6acres=3, >6acres=4)

X₆ = Social capital (categorical independent variable: Yes=1, No=2)

X₇ = Access to weather information (categorical independent variable: Yes=1, No=2)

X₈ = Access to credit (categorical independent variable: Yes=1, No=2)

X₉ = Access to extension services (categorical independent variable: Yes=1, No=2)

Formula 2: Binary logistic regression equation

3.9 Variable selection and hypotheses

3.9.1 Explanatory Variables and Hypotheses

The independent (explanatory) variables which are expected to determine the adoption decision of the farm households in this study are categorized into two. These are; socio-economic factors such as age of household head, education of household head, gender of household head, land tenure, farm size and income of household head which were hypothesized to influence the adoption of water management techniques significantly. Institutional factors include; access to extension services, access to weather information, social capital and access to credit. These are factors which promote or prevent uptake of water management techniques by farmers.

3.9.1.1 Socio-economic factors and their expected effects:

- I. Age of household head: The age of the farmer is expected to affect the decision to adopt water management techniques negatively.
- II. Gender of household head: The influence gender has on adoption decisions depends on the culture of a population. Most decisions on how to utilize land in Laikipia are made by male household heads. Male headed households are therefore hypothesized to adopt water management techniques more than female headed households.
- III. Education of household head: It is expected that farmers with more education are more knowledgeable and have the ability to interpret information regarding technologies more than those with less education. It is therefore hypothesized that more educated farmers are more likely to adopt water management techniques as compared to those with less education.
- IV. Land tenure: This defines the existing property rights in a certain community. Having secure land rights to land encourages farmers to invest in technologies and therefore farmers who own land are expected to adopt water management techniques when compared to those who farm on rented or communal land.
- V. Farm size: Farmers who own a large piece of land have space available for trials of new technology as compared to those owning small pieces of land. A large farm size is therefore hypothesized to have a positive influence on adoption decisions.
- VI. Income of HH: Income represents the amount of income (in KES) generated from money making activities by the HH. It is expected that a higher income will have a positive influence on adoption decisions since farmers have additional income to invest in water management techniques.

3.9.1.2 Institutional factors and their expected effects:

- I. Access to extension services: Extension services help the farmers to understand the importance of the water management in their farms. Farmers who have frequent contact with extension officers are hypothesized to adopt techniques more as compared to those with less or no access. This is a dummy variable with 1 representing farmers with access to extension agents and 0 if otherwise.
- II. Access to weather information: Farmers with access to weather information are able to plan ahead on the adaptation measures they will put in place to respond to climate change. Having access to weather information is therefore expected to positively influence adoption decisions of water management techniques.
- III. Social capital: Social capital is measured by belonging to a farmer group. Groups encourage the spread and exchange of information regarding technologies. It is therefore expected that belonging to farmer groups will have a positive influence on the decision to adopt water management techniques.

- IV. Access to credit: Since the installation and management of water management techniques is expensive, it is expected that farmers with access to credit adopt techniques than those who have no access to credit.

3.9.1.3 Ethical Considerations

In the course of this research, the following ethical issues were be taken into consideration in order to ensure the dignity of all participants was upheld;

- I. Official permission was sought from the area leaders before starting the research.
- II. Participation in the research was totally on a voluntary basis.
- III. Informed consent was sought from participants before being engaged in the research.
- IV. The objectives of the study were clearly explained to the respondents and an assurance given that the data will be used for academic purposes only.
- V. Confidentiality was upheld in dealing with the data obtained.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents analysis of results based on the three objectives of the study. These were: to examine the socio-economic determinants influencing the uptake of water management techniques by small-holder farmers in Laikipia County; to determine how institutional factors influence uptake of water management techniques by small-holder farmers in Laikipia County and to identify opportunities in enhancing uptake of water management techniques by small-holder farmers in Laikipia County.

4.2 Socio-Demographic Characteristics of the Respondents

This section discusses both social and demographic characteristics of the respondents based on their responses on questionnaires.

Table 3: Socio-demographic characteristics

		Frequency	Percent (%)
Age of HH (years)	30-40	14	14.0
	40-50	42	42.0
	50-60	31	31.0
	>60	13	13.0
Sex of HH	Male	78	78.0
	Female	22	22.0
Education of HH	Primary	29	29.0
	Secondary	41	41.0
	College	16	16.0
	University	14	14.0
Land tenure	Private	44	44.0
	Leased	26	26.0
	Ancestral	30	30.0
Income of HH (KES)	<50000	47	47.0
	50000-100000	40	40.0
	>100000	13	13.0
Farm size (acres)	<2.0	48	48.0
	2.0-4.0	34	34.0
	4.0-6.0	10	10.0
	>6.0	8	8.0

4.2.1 Age of household head

The study sought to find out the age brackets of the key respondents in Laikipia West Sub-County by asking them to state their age ranges. This was to help determine the age distribution for the respondents. The results are shown in Table 3 above.

4.2.2 Sex of household head

The study sought to find out the sex distribution among the key respondents in Laikipia County. The respondents were asked to indicate their gender as shown in table 3 above. A binary logistic regression analysis was later performed to assess if gender had any influence in the uptake of water management techniques.

4.2.3 Education of household head

The study sought to find out formal educational levels of the key respondents in Laikipia West Sub-County. The respondents were asked to state their formal educational levels as indicated in table 3 above. The findings show that majority of the respondents (41.0%) had attained basic education levels. Secondary school is considered the highest level of basic education in Kenya.

4.2.4 Land tenure

The study sought to find out the system of land rights among key respondents in Laikipia County. The findings are shown in table 3 above. A binary logistic regression analysis was then done to investigate if land tenure had any influence in the uptake of water management techniques.

4.2.5 Income of HH

The respondents were asked to indicate their income and the results are shown in table 3 above. A binary logistic regression analysis was then done to find out if the income of household head had any influence in the uptake of water management techniques.

4.2.6 Farm size

The respondents were asked to indicate the size of land under crop as indicated in table 3 above. A binary logistic regression analysis was then done to determine if the size of farm had any influence in the uptake of water management techniques.

4.3 Institutional factors

Table 4: Access to institutional factors by residents

		Frequency	Percent (%)
Access to extension	Yes	43	43.0
	No	57	57.0
Weather info access	Yes	59	59.0
	No	41	41.0
Social capital	Yes	58	58.0
	No	42	42.0
Access to credit	Yes	53	53.0
	No	47	47.0

4.3.1 Access to extension services

The study sought to find out the level of access to extension services by farmers in Laikipia County. The respondents were asked to indicate whether they have access to extension services as shown in table 4 above. Binary logistic regression analysis was later carried out to determine if access to extension services had any influence on the uptake of water management techniques.

4.3.2 Access to weather information

The study investigated the number of respondents with access to weather information as indicated in table 4 above. A binary logistic regression analysis was later carried out to find out whether having access to this information had any influence on their uptake of water management techniques.

4.3.3 Social capital

The study investigated sought to find out the proportion of key respondents who belonged to farmer group. The respondents were asked to indicate whether they belonged to a farmer group as shown in table 4 above. A binary logistic regression analysis was then done in order to assess if social capital had any influence in the uptake of water management techniques.

4.3.4 Access to credit

The study sought to find out the level of access to credit among the key respondents in Laikipia County. The respondents were asked to indicate whether they have access to credit as shown in table 4 above. A binary logistic regression analysis was later done to assess if access to credit had any influence in the uptake of water management techniques. Respondents reported that they sourced credit mainly from banks, Laikipia County Government Enterprise Fund, NGOs, farmer groups, family and friends.

4.4 Objective1: To examine the influence of socio-economic determinants on the uptake of water management techniques by small-holder farmers in Laikipia county.

4.4.1 Uptake of agricultural water management techniques

Table 5:Uptake of agricultural water management techniques

Uptake	Frequency	Percent (%)
No	33	33.0
Yes	67	67.0
Total	100	100

Results from the study revealed that majority of the respondents (67.0%) were practicing water management techniques while 33.0% did not practice any techniques. Under inferential statistics, a correlation analysis was performed to shown the strength of correlation between independent variables and uptake. A binary logistic regression analysis was then done to determine the factors that influence the uptake of these techniques as described below;

4.4.2 Correlation Analysis

Correlation analysis is done to examine the strength of correlation between two test variables. Correlation coefficients (r) measure the strength of association and can have values between -1 and $+1$. A correlation of 1 or -1 is an indication that the value of one variable can be determined by knowing the value of the other variable. The closer coefficients are to 1 , the stronger the association. A correlation value of 0 indicates that no relationship exists between two variables therefore knowing the value of one variable cannot help in the prediction of the value of the second variable. The correlation results showed that all the independent variables had a positive relationship with uptake of water management techniques except for age of household head and sex of household head. The results are shown in table 12 below. There is a positive relationship between education ($r = 0.200$; $p = 0.046$), income ($r = 0.358$; $p = 0.000$), land ownership ($r = 0.033$; $p = 0.746$), access to extension ($r = -0.371$; $p = 0.000$), belonging to a farmer group ($r = 0.291$, $p = 0.003$), access to credit ($r = 0.275$; $p = 0.006$), access to weather information ($r = -0.441$; $p = 0.000$), land size ($r = 0.247$, $p = 0.013$) and uptake of water management techniques. The results however revealed a negative association between age ($r = -0.382$; $p = 0.000$), sex ($r = -0.015$; $p = 0.881$) and uptake of water management techniques.

Correlations

Table 6: Correlation coefficients

	Sex	Age	Educ	Income	Land	Ext	Group	Credit	W.info	L.size	Uptake
Sex	1.00										
Age	-0.07	1.00									
Educ	.20*	-0.07	1.00								
Income	-0.09	-0.12	-0.04	1.00							
Land	-0.02	0.14	-0.03	-0.01	1.00						
Ext	0.04	.21*	-0.06	-0.13	0.16	1.00					
Group	-0.14	0.00	0.17	0.00	0.20	0.08	1.00				
Credit	0.03	-0.17	-0.18	0.00	-0.10	-.20*	-0.10	1.00			
W.info	-0.10	.20*	0.05	-0.03	0.02	.25*	0.13	-0.01	1.00		
L.size	.23*	0.03	0.16	-0.02	0.10	-0.05	-0.11	-0.10	-.29**	1.00	
Uptake	-0.015	-.382**	.200*	.358**	0.033	.371**	.291**	.275**	.441**	.247*	1
Sig. (2-tailed)	0.881	0.000	0.046	0.000	0.746	0.000	0.003	0.006	0.000	0.013	

*. Correlation is significant at the 0.05 level (2-tailed).

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

4.4.3 Binary logistic regression analysis

Regression analysis is performed to investigate the relationship between variables. Regression analysis is useful in ascertaining the effect one variable has upon another. The researcher undertook a binary logistic regression analysis to ascertain the influence of the independent variables (sex of HH, age of HH, education of HH, income of HH, type of land ownership, belonging to a farmer group, access to weather information, access to credit and access to extension) on the dependent variable (uptake of water management technologies). Binary regression is used when the dependent variable is dichotomous in nature.

4.4.3.1 Omnibus Tests of Model Coefficients

The omnibus tests of model coefficients table 7 below shows the goodness of fit of the current model (with explanatory variables included) as compared to the null model. A significance value of less than 0.05 is an indication that the current model performs better than the null model.

Table 7: Omnibus Test of Model Coefficients

	Chi-square	df	Sig.
Step	79.116	13	.000
Block	79.116	13	.000
Model	79.116	13	.000

4.4.3.2 Model Summary

Table 8 below shows the model summary. The value of R Square values give an approximation of how much the model explains variation in the outcome. The value of Nagelkerke R Square shown in the table below suggests that the model explains 74.7 % of the variation in the dependent variable.

Table 8: Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	52.676 ^a	.547	.747

4.4.3.3 Coefficients

Table 9 below shows the results of the binary logistic regression analysis. The B column indicates whether the independent variables have a positive or negative influence on the dependent variable. The Wald column is used to test the statistical significance of each independent variable. The Sig. column indicates the p value which if less than 0.05 which means that the independent variable is statistically significant.

Table 9: Binary logistic regression results for socio-economic factors

Model	B	S.E.	Wald	Sig.
Sex of HH	-.568	.975	.339	.560
Age of HH	-1.529	.595	6.614	.010
Education of HH	4.293	2.128	4.070	.044
Income of HH	1.984	.672	8.716	.003
Land ownership	1.467	1.081	1.843	.175
Land size	.597	.259	5.326	.021

a. Dependent Variable: Uptake of water management techniques

The age of household head was a significant factor that negatively influences uptake of water management techniques ($\beta = -1.529$, $p=0.010$). This implies that a unit increase in the age of household head is likely to reduce the uptake of techniques by 2 times. Findings from past researchers have revealed that older farmers are more rigid to risk taking and adopting new technologies. This finding correlates to those from research conducted by (Mutua-mutuku, 2017) and (Huang et al., 2020) who found age to have a significant negative impact on the adoption of water conservation measures.

The education of household head was a significant factor that positively influences uptake of water management techniques ($\beta = 4.293$, $p=0.044$). This implies that the uptake of techniques is likely to increase by 4 times when there is a unit increase in education of household head. This is because education helps farmers search and understand information regarding water management techniques. Educated farmers understand the need for water conservation and also seek for guidance from experts on the best techniques to utilize on their farms. This finding is consistent with those from studies done by (Anne et al., 2022), (Kansanga et al., 2021) and (Zhang et al., 2019) who found an increase in education to increase the likelihood of adoption of soil and water management technologies.

The income of household head was a significant factor that positively influences uptake of water management techniques ($\beta = 1.984$, $p=0.003$). This implies that the uptake of techniques is likely to increase by approximately 2 times when there is a unit increase in the income of household head. Investment in water management techniques requires monetary resources. Therefore, farmers who are wealthier have a high possibility of adopting techniques since they can afford to purchase materials required, install systems and pay for labor. This finding is consistent with those by (Belay et al., 2017), (Challa & Tilahun, 2014) and (Kpadonou et al., 2017).

The size of farm was a significant factor that positively influences uptake of water management techniques ($\beta = 0.597$, $p= 0.021$). This implies that a unit increase in the size of farm is likely to increase the uptake of water management techniques by 0.5 times. This finding is consistent with a research by (Abdallah et al., 2014), (Mugonola et al., 2013) and (Huang et al., 2020) who also found the increase in farm size to have a positive influence in the adoption of water conservation practices.

4.5 Objective 2: To determine how institutional factors influence uptake of water management techniques by small-holder farmers in Laikipia County

The study sought to investigate how institutional factors influence the uptake of water management techniques. This was investigated using a combination of both quantitative data from questionnaires and qualitative data gathered from interviews and FGDs.

4.5.1 Results from binary logistic regression analysis

Table 10: Binary logistic results for institutional factors

Model	B	S.E.	Wald	Sig
Belonging to a farmer group	2.895	.974	8.841	.003
Access to weather information	1.959	.945	4.294	.038
Access to credit	2.032	.965	4.438	.035
Access to extension	2.696	.987	7.464	.006

Access to weather information was a significant factor that positively influences uptake of water management techniques ($\beta = 1.959$, $p = 0.038$). This implies that the uptake of techniques is likely to increase 1.9 times with a unit increase in access to weather information. The finding is similar to studies by (ALHASSAN, 2019), (Atsiaya et al., 2019), (Melka et al., 2015) who found the access to weather information to positively influence uptake of water conservation technologies.

The access to credit was a significant factor that positively influences uptake of water management techniques ($\beta = 2.032$, $p = 0.035$). This implies that a unit increase in access to credit would result in the increase in uptake of water management techniques by 2 times. Having access to credit reduces financial constraints thereby enhancing the uptake of water management techniques. This finding is consistent with studies from (Temesgen et al., 2014), (Amare & Simane, 2017) and (Katumo, 2018) who found the access to credit to have a positive effect on the adoption of water conservation technologies.

The access to extension was a significant factor that positively influences uptake of water management techniques ($\beta = 2.696$, $p = 0.006$). This implies that farmers with access to extension were 2 times more likely to adopt water management techniques than those who did not have access to extension. Extension officers play a major role of disseminating information about technologies to farmers. Through this information, farmers have knowledge about benefits and application of technologies and therefore they are more encouraged to adopt technologies. This finding is similar to studies conducted by (Mugonola et al., 2013), (Danso-Abbeam, 2022) and (Mango et al., 2017) who found a positive correlation between the access to extension services and adoption of water conservation practices.

Belonging to a farmer group was a significant factor that positively influences uptake of water management techniques ($\beta= 2.895$, $p= 0.003$). This implies that a unit increase in membership to a farmer group would result in an increase in the uptake of techniques by approximately 3 times. During the research, some farmers also revealed that groups are an important source of credit and this improves their financial capability to invest in water management techniques. This result correlates to findings from (Mango et al., 2017),(Amare & Simane, 2017) and (Jha et al., 2019) whose findings revealed that belonging to a farmer group had a positive impact on the adoption of small-scale irrigation technologies.

4.5.2 Results from FGDs and interviews

Below is a summary of the findings gathered from FGDs and interviews regarding the influence of institutional factors on the uptake of water management techniques.

Most key informants were of the view that farmers who have contact with extension officers were more likely to uptake water management techniques since the officers spread knowledge about how to use techniques and offer farmers advise on the best practices to uptake. During the FGDs, most participants recognized the role extension play in disseminating relevant knowledge about water management techniques. One farmer remarked:

Most farmers in the area believe that tomatoes cannot be grown using drip irrigation rather planting basins since they require a lot of water to grow. With the right pipe size and double pipe installation, it is very possible. We couldn't have known this if it were not for the extension officers advise.

Having secure and rights was also viewed to encourage uptake of techniques since farmers feel more confident investing in land which they have control of. A key informant remarked:

Farmers who own land privately are more likely to invest in water management techniques since they feel secure about the land ownership. Those who have leased land or farm on ancestral land may not be fully motivated to invest in techniques since they do not know till when they can manage the land.

Belonging to farmer groups. Participants of FGDs noted that group gatherings are an important avenue where they exchange information about water management techniques. One participant noted:

It is through a group meeting that I learned about the current technology I use for water management from a fellow group member. I was able to gain the required information and know-how of how to utilise the technique in my farm.

Another respondent noted:

Farmer groups act as important sources of credit to members. In our farmer group, we have a table banking program whereby group members can get loans to engage in agriculture. These loans really encourage members to adopt water management techniques in their farms.

The availability of credit was also mentioned as a factor which influences the uptake of water management techniques through providing the much-needed funds to farmers to adopt the techniques. One farmer noted:

The provision of credit at subsidized interest rates by the county government has been one strategy employed by the leadership to support business owners. I have been a beneficiary of this loan and it greatly helped me invest in drip irrigation which I couldn't have afforded before.

Lastly, the access to weather information was also brought up as a factor that influences uptake of techniques. Key informants reported that farmers in Laikipia access weather information through mobile apps such as the Laikipia Agriculture Observatory Platform, Karlo Kaop Weather Platform and through the Kenya Meteorological Department. One informant remarked:

Since we introduced the Karlo Kaop Weather Platform to our farmers, they have reported that having access to weather information helps them in planning ahead on how to utilise their water based on the expected season.

4.6 Objective 3: To identify opportunities available in enhancing uptake of water management techniques by small-holder farmers in Laikipia County

Participants engaged in FGDs and interviews were asked to give their views on the opportunities available in enhancing uptake of water management techniques in Laikipia. Four key themes which emerged were: ground water exploitation, intensifying surface runoff harvesting, investing in e-extension to train farmers and investing in roof water harvesting.

Ground water exploitation. From the discussions, it emerged that the county government had invested in drilling few boreholes for residents and only few wealthy farmers could afford to drill their own boreholes for their farms. The participants reported that there is a lot of under-utilized ground water potential in the county. A farmer during the focus group discussions stated:

In Laikipia we have very fertile soils and warm climate which enhances fast crop growth. Our main problem is water scarcity. If the government invests in drilling more boreholes for communities, agriculture will thrive more here.

Intensifying surface runoff harvesting. Key informants engaged in interviews identified the methods used to harvest surface runoff by Laikipia residents as dams, water pans and tanks. They however noted that there are still some opportunities available in improving surface runoff harvesting such as the increase in use of dam liners on dams and water pans to prevent water seepage and also encouraging more farmers to practice harvesting in order to increase their water storage volumes.

Investing in e-extension to train farmers. With the increase in the use of social media, respondents highlighted that there are opportunities for more investment in e-extension to offer training to farmers on water management techniques via mobile applications and online platforms. One farmer during the FGDs noted:

Training farmers through e-extension will be advantageous to our county. The digital space, when used for training will offer more convenience as compared to traditional face to face training methods since one can learn at the comfort of their home. E-extension will also allow for faster information dissemination.

Investing in roof water harvesting. A key informant during an interview remarked:

The harvesting of rainwater from roof catchment is yet to be adopted fully by Laikipia residents which leads to huge losses in water during the rainy season. This method if widely used will help to substitute other water sources for use in agriculture.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study was conducted to assess the factors determining the uptake of agricultural water management techniques by small-holder farmers in ASALs of Laikipia County, Kenya. The specific objectives of the study were; to examine the influence of socio-economic determinants on the uptake of water management techniques by small-holder farmers in Laikipia County, to determine how institutional factors influence uptake of water management techniques by small-holder farmers in Laikipia County and to identify opportunities in enhancing uptake of water management techniques by small-holder farmers in Laikipia County.

The study examined the influence of socio-economic determinants on the uptake of agricultural water management techniques by small-holder farmers in Laikipia County. The results of the binary logistic model indicated that education of household head, income, land tenure and farm size had a positive influence on the uptake of water management techniques. In contrast sex and age of household head had a negative effect on the uptake of techniques.

Secondly, the study determined how institutional factors influence uptake of agricultural water management techniques by small-holder farmers in Laikipia County. Results of the binary logistic regression model indicated that social capital, access to credit, access to extension and weather information had a positive influence on the uptake of agricultural water management techniques. Findings from interviews and FGDs revealed that institutional factors influence the uptake of techniques in the following ways; Farmer groups and extension officers were found to encourage information spread of techniques thereby increasing the uptake of techniques. Secure land tenure was found to motivate farmers to invest in water management techniques. Access to weather information was found to help farmers plan ahead and thus increase their uptake of techniques. Lastly, access to credit was found to avail financial resources to support farmers in investing in water management techniques and therefore increasing uptake.

Lastly, the study identified opportunities available in enhancing uptake of agricultural water management techniques by small-holder farmers in Laikipia County. The findings revealed the following opportunities; intensifying surface runoff harvesting, investing in roof water harvesting, ground water exploitation and investing in e-extension to train farmers on agricultural water management techniques.

In conclusion, both socio-economic and institutional factors were found to influence the uptake of water management techniques among small-holder farmers in Laikipia. Since the adoption process has a socio-economic and institutional dimension, these factors need to be factored in during the design of policies related to dissemination of techniques in order to enhance the uptake of water management techniques in the county.

5.2 Recommendations

The government needs to allocate more resources towards farmer education through constant agricultural exhibitions, workshops and field demonstrations in order to improve their knowledge levels regarding water management techniques suitable for the county.

The meteorology department needs to build robust weather forecast systems in order to increase the accuracy of weather information. More accurate weather information will be essential in increasing the adaptive capacity of farmers to climate change.

The national and county government in collaboration with all stakeholders involved in agricultural water management should take advantage of the opportunities available in order to enhance the uptake of agricultural water management techniques in Laikipia.

Lastly, the study recommends the creation of Public-Private Partnerships to provide farmers with credit at affordable rates in order to support those with financial constraints in investing in water management techniques.

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CHAPTER SEVEN: APPENDIX

7.1 Questionnaire

LETTER OF TRANSMITTAL FOR DATA COLLECTION

January 2024.

Dear respondent:

I am a postgraduate student undertaking a Master of Science in Water Policy at the Pan African University Institute of Water and Energy Sciences. I am carrying out a study to investigate the **Determinants of The Uptake of Agricultural Water Management Techniques By Small-Holder Farmers In Arid And Semi-Arid Lands of Kenya, A Case Study of Laikipia County.**

The objectives of this study are;

- I. To examine the socio-economic determinants influencing the uptake of agricultural water management techniques by small-holder farmers in Laikipia County.
- II. To determine how institutional factors influence uptake of agricultural water management techniques by small-holder farmers in Laikipia County.
- III. To identify opportunities in enhancing uptake of agricultural water management techniques by small-holder farmers in Laikipia County.

I am using the attached questionnaire to collect information for the study. It is my kind request that you fill the questionnaire, providing the relevant information to facilitate the study. Please use the space provided to fill in the information required as objectively and honestly as possible. The information provided will be treated with strict confidentiality for the purpose of this study only.

Thank you.

Yours faithfully,



Susan Maina.

QUESTIONNAIRE NO:

Date:

Please tick the box :

I agree to take part in this research and that the information I will provide herein will be used for the purpose stated above

SECTION A: SOCIO-ECONOMIC INFORMATION

Instructions

Where choices are given, kindly tick next to the correct answer. Otherwise, where no options are given, write your answer in the spaces provided.

1) Sex of the household head	01=Male 02=Female 97=Other(specify)
2) How old are you?	
3) What is your highest level of education?	00=None 01=Primary 02=Secondary 03=College 04=University 97=Other(specify)
4) What is your income in Kenyan shillings (KES)?	
5) Does some percentage of your income go towards improving water management in your farm?	01=Yes 02=No

SECTION B: LAND OWNERSHIP AND UTILIZATION

Instructions

Where choices are given, kindly tick next to the correct answer. Otherwise, where no options are given, write your answer in the spaces provided.

1) What type of land ownership do you have?	01=Private property with title deed 02=Ancestral land 03=Leased
2) What area of land is under cultivation? (acres)	
3) Where do you source water for farming from?	
4) Do you practise any water management practises in your farm?	01=Yes 02=No
5) If YES, please tick which water management technique you practise?	01=Zai pits 02=Furrow irrigation 03=Mulching 04=Drip irrigation 05=Cone gardens 97=Other(specify)
6) Why did you decide to practise water management techniques in your farm?	
7) If NO. please specify why	01=Lack of knowledge of how to use technique 02=Too costly to practise 03=I do not see the need 97=Other(specify)
8) Have the water management techniques been of benefit to you?	01=Yes 02=No
9) If YES, please specify how	
10) If NO, please specify why	
11) What challenges do you face in utilising water management techniques in your farm?	

SECTION C: INSTITUTIONAL FACTORS

Instructions

Where choices are given, kindly tick next to the correct answer. Otherwise, where no options are given, write your answer in the spaces provided.

1) Do you have access to extension services?	01=Yes 02=No
2) If YES , what are the sources of extension services?	01=Government agents 02=Private entities 03=NGOs 97=Others(specify)
3) Do you receive training on agricultural water management techniques?	01=Yes 02=No
4) If YES , from what sources do you receive training on water management techniques?	01=Government extension officers 02=Researchers 03= Field days 04=Agricultural shows and exhibitions 05= Farmers trainings and workshops 06=Other farmers 08= Radio/ TV 09=Print media 97= Other (specify)
5) If YES , how is this training done?	
6) Do you belong to any farmer group?	01=Yes 02=No
7) If YES , what benefits do you derive from belonging to the farmer group?	01=Information on credit 02=General advice on farming 03=Information on water management techniques 04=Help in credit access 97=Others (specify)
8) Over the years, how has the weather in this area been?	
9) Have changes in weather affected you as a farmer?	01=Yes 02=No
10) If YES , how have the changes in weather patterns affected you as a farmer?	01=Drying up of water sources 02=Long drought spells 03=Declining agricultural productivity 04=Increased cost to access water 97=Others(specify)

11) Do you have access to information on changes in weather such as increases in temperature, seasonal rainfall variations, occurrence of drought etc?	01=Yes 02=No
12) If YES , which institution provides you with this information?	
13) Does access to weather related information have any influence on your uptake of water management techniques?	
14) Do you have access to agricultural credit?	01=Yes 02=No
15) If YES , how is the agricultural credit utilised?	
16) If NO , how can access to agricultural credit be improved?	
17) What suggestions would you give to the government and other stakeholders in order to improve the uptake of water management techniques in Laikipia?	

7.2 Interview Schedule For Key Informants

Respondent Title:

Date:

Please tick the box:

I agree to take part in this research and that the information I will provide herein will be used for the purpose stated above

- 1a) What experience do you have as an officer in agricultural water management? (years)
- b) Which other institutions are involved in agricultural water management in Laikipia County?
- c) Do institutional factors affect adoption of water management techniques in Laikipia county?
- d) If **YES**, which institutional factors affect adoption of water management techniques in Laikipia county?
2. How is agricultural water management carried out in this area?
3. Which programs have been put out by the national or county government to support agricultural water management in Laikipia county?
- 4a) How is capacity building done in your institution to train your officers on upcoming matters regarding agricultural water management?
- b) How often is this capacity building done?
5. How are agricultural field demonstrations of water management techniques done?
- 6a) What factors hinder the uptake of water management techniques by small holder farmers in this locality?
- b) As an institution, what role can you play to reduce the factors mentioned above?
7. Does the county government offer agricultural credit to farmers in Laikipia County?
- 8a) How do farmers access climate related information?
- b) What role does your organisation play in collecting and disseminating this information?
- c) What role do extension officers play in relaying this information to farmers?

9a) Does access to climate related information influence the uptake of water management techniques?

b) If **YES**, explain how access to climate related information influences the uptake of water management techniques?

c) If **NO**, explain why access to climate related information does not influence the uptake of water management techniques?

10.What opportunities are available for increasing the adoption of water management techniques in Laikipia?

11. What changes can you suggest to the national and county government to help enhance uptake of water management techniques in Laikipia?

7.3 Focus Group Discussions Guide

Date:

Please tick the box:

I agree to take part in this research and that the information I will provide herein will be used for the purpose stated above

1a) Do you belong to any farmer group?

b) If **YES**, how does belonging to a farmer group influence the uptake of agricultural water management practices?

2a) Do you have access to extension officers involved in agricultural water management?

b) If **YES**, what influence does access to extension officers have on uptake of agricultural water management practices?

c) If **NO**, what influence does having no access to extension officers have on uptake of agricultural water management practices?

3.How does access to credit influence the uptake of agricultural water management practices?

4.How does land tenure influence the uptake of agricultural water management practices?

5a) Do you have access to information on changes in weather?

b) If **YES**, how does having access to information on changes in weather influence your uptake of water management techniques you practise in your farm?

6a) What challenges have you encountered in practising water management in your farm?

b) What measures do you put in place to deal with these challenges?

7. What opportunities are available for enhancing the uptake of agricultural water management practices in Laikipia?

7.4 Work Plan

ACTIVITIES	OCT 2023	NOV 2023	DEC 2023	JAN 2024	FEB 2024	MARCH 2024	APRIL 2024
WEEKS	WEEK 1-4	WEEK 1-4	WEEK 1-4	WEEK 1-4	WEEK 1-4	WEEK 1-4	WEEK 1-4
Development of research topic and objectives	█						
Literature review	█	█	█	█	█	█	█
Writing and submission of research proposal	█	█					
Budget writing and submission		█					
Development of research tools		█	█				
Travel to home country			█				
Pre-visit to research area			█				
Submission of research tools for check of validity			█				
Data collection				█	█	█	
Data entry and analysis					█	█	
Thesis report writing					█	█	█
Travel back to Algeria							█
Final presentation of thesis							█

7.5 Photographs of the researcher during data collection





7.6 Budget

S/No.	Item	Unit	Quantity	Rate(\$)	Amount(\$)	Link to Research Activity**	Comment*** (For Evaluator Only)
(A) Materials and supplies							
1	Printing	Page	3000	0.06	200	For printing, scanning and binding my research instruments and the final thesis report.	
2	Binding	Set	10	5.00	50.00		
4	Scanning	Page	200	0.25	50.00		
5	Consumables(pens, pencils, note book, marker pens, manilla papers, cello tape)	Bulk	1	30	10.00		
6	Internet Recharge	Per month	4	50	200	For daily usage of internet for my research for downloading documents for literature review, communication with my supervisor and sending and receiving reports related to my study.	
7	Personal Protective Equipment	Bulk		50	50.00	Sanitizers, face masks, rainco	

						at and safety boots	
	Sub Total				560.00		
	(B)	Equipment					
1	Software package	Package	1	150	150.00	To purchase SPSS software for use in data analysis	
2	Software package	Package	1	170	170.00	To purchase NVIVO software for analysis of FGDs data	
3	Rental of one tape recorder for 30 days	Recorder	1	50	50.00	Tape rental to provide a complete and accurate record of the entire interviews and focus group discussion proceedings when conducting primary data collection for respondents including key administrators, community leaders, extension agents and farmers.	
4	Data set of registered small holder farmers by agricultural credit	Dataset	1	50	50	For examining the extent of	

	institutions					access to agricultural credit by small holder farmers	
5	128GB USB flash drive	Data set	1	20	20	For storing and transferring data collected during research	
Sub Total					440.00		
	(C)	Travel+ visa costs					
1	International travel	Round trip	1	1200	1200	Travel from Algeria to Kenya (Data collection Country)	
2	Field transportation	Per trip	4	75	300.00	The research requires travel to Laikipia County where field surveys will be conducted at different households where water management techniques are practised. This will involve collecting primary data on the factors that determine uptake of	

						water management techniques in the county. Travel distances from my living area to these destinations range between 300km to 500km.	
3	Airport taxi within Algeria	Per trip	2	50	100.00	Airport taxi to and from Tlemcen to Algiers	
4	Airport taxi within Kenya	Per trip	2	50	100.00	Expenditure to and from Jomo Kenyatta International Airport.	
	Sub Total				1700.00		
(D)	Contingencies (%) (reserve at least \$100 from which eventual bank transfer fees will be taken from				300.00	Cost from unexpected events that may arise during the research	
A	Materials and supplies	560.00					
B	Equipment	440.00					
C	Travel	1700.00					
D	Contingencies	300.00					
	Grand total	3000.00					

