FACTORS INFLUENCING FARMERS' ADOPTION OF IRRIGATION WATER MANAGEMENT PRACTICES AND TECHNOLOGIES ALONG THE NG'ARENG'IRO RIVER IN LAIKIPIA COUNTY, KENYA

Justus Mutavi Mutiso

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DECLARATION

I declare that this document and the research it describes are my original work and they have not been presented in any other University for academic work.

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Justus Mutavi Mutiso

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Supervisor's Declaration

This research was conducted under our supervision and is submitted with our approval as University supervisors.

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Dr. Mark Ndunda Mutinda

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Dr. Julius Kioko Nzeve, PhD.

AFRICA NAZARENE UNIVERSITY,

NAIROBI, KENYA

DEDICATION

This thesis is lovingly dedicated to my wife, Felistas who has supported and encouraged me through all the challenges of graduate work and life. And to my children, Selestine, Joshua and Anniversary who have instilled in me a renewed passion for life.

ACKNOWLEDGEMENT

To begin with, I want to thank the Almighty God for the guidance, mercy and strength He has granted me throughout the entire period. I also want to thank my supervisors Dr. Mark Ndunda Mutinda and Dr. Julius Kioko Nzeve for their effort in guiding me in developing this research proposal and writing the thesis. Not forgetting the entire fraternity of Africa Nazarene University.

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ABSTRACT

This research assessed the influence of factors influencing farmers' adoption of irrigation water management practices and technologies (IWMPT) along the Ng'areng'iro river in Lamuria sub-location, Laikipia County. The specific objectives of this research were to assess: (i) the influence of farmer's socio-economic factors (age, gender, income, education level) on the adoption of IWMPT (ii). Influence of farmers attitude on the adoption of IWMPT, (iii) influence of farmers knowledge on water use efficiency on the adoption of IWMPT, (iv) influence of farmers collective action on the adoption of IWMPT, and (v) influence of land size owned by the farmers on the adoption of water management practices and technologies by farmers. This study adopted an *ex-post facto* research design. The target population for this study was 2,600 households owning land within 2 km of the Ng'areng'iro river. A sample population of 333 households were randomly selected. Data were analyzed using descriptive and inferential statistics in a Statistical Package for the Social Sciences (IBM SPSS version 26). Farmer's adoption of irrigation water management practices and technologies was rated as being between 8 and 21, with a mean of 10.3±.07 (SD 1.36). The adoption of irrigation water management practices and technologies were statistically ($p< 0.05$) influenced by household socio-economic factors, specifically age (β= - 0.240, $p< .001$), income per month (β= 0.174, $p< 0.001$), and household number (β=0.170, p=0.002). Farmers attitude had statistically positive significant influence (β=0.287, $p< 0.001$) on adoption. The knowledge gained by the farmers on water use efficiency had a significant (β= 0.826, $p< 0.001$) influence on the adoption. Farmer's participation in collective action statistically (β= 0.815, $p< 0.001$) influenced the adoption process. The size of the irrigated plot owned by the farmers had positive statistically significant (β= 0.840, $p< 0.001$) influence on the adoption. The study recommended a development and implementation of an integrated water management plan that will involve all the stakeholders (government agencies dealing with water, extension and crops, and famers).and incorporate all the resources land, soil water and crops. The activities that will be catered by the plan will include farmer training, development of collective action groups, acquisition of needed technology, crop management, water use efficiency, crop husbandry and marketing of crops. The study will provide policy makers information and empirical evidence on the factors affecting the adoption of efficient water management practices and technologies by the farmers along the Ng'areng'iro river, Lamuria location, Laikipia county.

DEFINITION OF TERMS

Adaptation: According to Smit and Wandel (2006) and Füssel (2007), “adaptation” refers to “the processes, actions or outcomes in the system including households, community, groups, Sectors, regions and country to make the system more able to cope with, manage or adjust to Change some conditions, stress, hazards, risks and opportunities”.

Adoption: Adoption refers to the act of taking something on as your own as well as embracing ideas, habits among others

Collective Action: This is a behavior or action of a group of individuals working towards a common goal.

Livelihood: It refers to the means of securing the basic necessities e.g. Food, water, shelter and clothing

Option: It is the opportunity or ability to choose something between two or more things

Population: “Population” refers to an “entire group of individuals, events or objects having common observable characteristics”. (Mugenda & Mugenda, 2003).

Productivity: Productivity is a ratio between the output volume and the volume of inputs; it measures how efficiently production inputs, such as labor and capital are being used in an economy to produce a given level of output

ABBREVIATION AND ACRONYMS

CBNRM: Community Based Natural Resource Management

CG: Common Good

CPR: Common Pool Resource

IWMI: International Water Management Institute

IWMPT: Irrigation Water management Practices and Technology

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The study assessed the factors influencing farmer's adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Laikipia county, Kenya. The independent factors that formed the basis of this study were: the farmer's socio-economic factors (age, gender, income, education level), farmers attitude, farmers knowledge on water use efficiency, farmers collective action, and land size. The dependent variable was adoption of irrigation water management practices and technologies. This section of the thesis covered the following sub-sections: background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, scope of the study, delimitation, limitations, assumptions of the study, theoretical framework and conceptual framework.

1.2 Background of the Study

Agriculture continues to play a vital role in the Kenyan economy. According to the economic reports published by the World Bank in 2004 (|World Bank, 2004), agriculture contributes to more than 30 % of the gross development income, with more than half of the Kenyan population involved in agriculture in one way or another (Thompson & Pretty, 2006). Of this population, more than half of the required agricultural produce relies heavily on rainfed agriculture. In the past few years, there has been continued decrease in the rainfall in the region. Sporadic rainfall arising from climatic changes have led to food shortages and decreased productivity in subsistence farming. With increased food deficits, attention is now shifting to areas where agricultural production has been low for a while; Laikipia is included in such areas

(GOK, 2008). According to Kiage, Liu, Walker, Lam and Huh, (2007) land degradation in the region and low soil moisture is often compounded by the increasing amounts of sporadic rainfall which are known to cause increased soil erosion.

The Government and stakeholders involved in agriculture have increased their attempts in trying to curb and resolve majority of the challenges facing the agricultural sub-sector. In the past, such efforts have been directed towards land degradation; however, Tiffen, Mortimore, & Gichuki (1994) have highlighted the need for increased water management efforts. Several projects and policies are directed at finding a lasting solution towards the decreasing availability of water for plants, animals and homestead use. The Kenyan government through the Ministry of agriculture and Livestock in collaboration with the ministry of water and energy have created extension offices, whose main efforts are directed at passing new technologies and management efforts to the community as well as educating the farmers on the how and benefits of suing such technologies. This is to be in line with the country's vision 2030, which stipulates the increase of irrigated land in ASAL by 404,800 ha by 2017 (GOK, 2008).

Water resources such as streams, rivers, lakes, and aquifers are examples of common natural resource and as such, water presents a unique management challenge in which resource ownership and allocation are difficult to control (Burke, 2001; Quinn, Huby, Kiwasila, & Lovett, 2007). With common resources in general, users incur individual benefits and collective costs (Burke, 2001). Collective costs such as degradation and depletion occur when common resources are left unmanaged. Management of the common water resource is important in ensuring the sustainability of a vital life source for individuals and their livelihoods.

Water can be regarded as a common pool resource (in case of a ground water aquifer) or as a common good (in case of water quality issues). The behavior of farmers, who are both water users and polluters, is likely to be different in the common pool and common good case. The distinction between water as a common good and as a common pool resource is that the former is non-excludable and non-rival, while the latter is non-excludable and rival. How the farmer views the issue may change his/her decisions regarding water use and his/her expectations of the behavior of others (Burke, 2001).

Globally more than 300 million hectares of land used for agriculture rely on irrigated water for the same. Agriculture continues to be the largest human activity, drawing use of more than 70% of water. Fereres and Soriano (2006) highlight that the demand for agricultural water will increase by at least more than 5% in the next decade. This will in turn affect the cost and increase inefficiency of water supply. In sub-Saharan Africa, agriculture contributes to at least 30% of the GDP, 15% of the GDP in Kenya and provides 51% of employment in the country. However, the demand for water continues increasing even as the population increases and the demand for food continues increases.

Sustainable water management practices are now requiring a shift towards a more community participatory approach. The millennium development goals define the availability and access to clean water as one of the goals for each government. Biamah (2005) cites that non-governmental organizations as well as religious organizations have become the target for policy makers and extension officers in an attempt to bring water management technologies nearer to the community. NGO's and churches target the poorest in the communities with the aim of encouraging them to adopt modern water management techniques and technologies through the provision of education, technological inputs such as tanks and gutters and provision of loans to the community. Whereas some focus by the developmental organizations focuses more on supplying inputs as well as training, others help the farmers to form self-help groups so that they can gain access to training, capital and labor that is required to actively participate in water management.

The policy objective for the ministry of water and agriculture is self-sufficiency in access to and use of water by small scale farmers. As such, Kipkorir, Raes, & Massawe (2002) point out the ministries have come together with researchers and formulated water practices that are suitable for each agro-ecological zone. Such practices are designed simply to improve productivity not just in the farms but also ensure a healthier population in the country. Clasen and Cairncross (2004) state that Laikipia boasts a number of projects born from the environmental conservation view point which are now structured and re-designed to address the growing water shortage and problems. Despite being surrounded by several natural water sources, in addition to enjoying a fair amount of rainfall though sporadic, the region continues to endure diminishing access to water within the households. Kijne, Barker & Molden (2003). further points out that the lack of access to water and its resources has caused decreased development in the region, due to decreased productivity, low access to education and continued loss of animals to lack of water.

Despite all the efforts by the government and other NGO’s in providing water management technology and practices to the local communities, the adoption rate in Laikipia continues to be much lower in comparison to other regions in the country

(Barron, Rockström, & Gichuki, 1999). The process of adjusting to the new technologies and practices has proven to be quite a challenge. Some early adopters have often fallen short of maintaining the same standards following such challenges. Adoption to modern technologies on water use measures are important to help people as well as communities to better face local extreme conditions and associated changes to livelihood. In this case, therefore, adaptation has the potential contribution to reduction in negative impacts and realize positive effects to avoid the misuse of water and unnecessary labor force (Kiage et al. 2007).

1.3 Statement of the Problem

The water from the Ng'areng'iro river is a great resource for the farmers owning land next to it for it is a source of permanent water supply, which can be used to irrigate the soil and grow crops that can provide the owners food and income to enhance their economic wellbeing. According to Fraiture, Giordano, and Liao (2008)., The government and non-governmental organizations have been committed to bringing the community together in order to efficiently manage the water resources and to ensure increased agricultural output within the region through the use of irrigation to grow high value crops throughout the year and but with little success. At present, the farmers are not fully benefitting from the water resource due to improper use of the water leading to low crop production and inefficient use of the water resource. Many factors can be associated with this problem, they include: lack of awareness of efficient water use by farmers, poor crop husbandry, poor attitudes of the farmers towards irrigation technology, socio-economic characteristics of the farmers, and lack of collective action among the farmers. This study assesses the factors that cause the farmers not to adopt the use of efficient irrigation water management practices and technologies that are associated with high crop production and efficient use of water.

1.4 Purpose of the Study

The purpose of this study was to analyse the factors influencing farmer's adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Laikipia county, Kenya

1.5 Objectives of the Study

The specific objectives of the study were:

(i) To assess the influence of farmers' socio-economic factors (age, gender, income, education level) on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County,

(ii) To determine the influence of farmers' attitude on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County,

(iii) To explore the influence of f farmers' knowledge on water use efficiency on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County,

(iv) To investigate the influence of farmers' collective action on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County,

(v) To determine the influence of land size owned by the farmer on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

1.6 Research Questions

(i) What is the influence of farmers' socio-economic factors on their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

(ii) How does farmers' attitude influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

(iii) Does the farmers' knowledge influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

(iv) Do farmers' collective action influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

(v) How does the size of land owned by the farmer influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

1.7 Significance of the Study

Several studies have been carried out in other areas of Laikipia and Upper Ewaso Ng'iro Basin, but little information is available to the people living along Ng'areng'iro river in the locality of Lamuria. This research, therefore, intends to identify how the community addresses the issue of water use and the advantages of adaptation options to modern technologies in water use. It also intends to provide necessary, accurate and timely information for the efficient management of the water resources so as to improve crop production and enhance farmer's livelihood.

1.8 Scope of the Study

According to Simon & Goes (2013), the scope of the study are the parameters under which the study operated. The geographical boundary for this research and data collection was in Lamuria location, Laikipia East constituency. The study was carried out for the purposes of improving water management practices which are intended to restore and boost productivity of existing agricultural production.

1.9 Delimitation

Delimitations are those characteristics under the researcher's control that limit the scope of the study (Simon, 2011). There are many other factors that reduce productivity, for example, Land resource and land use system: Farm size is a foremost component of agricultural production. The farm size is an indicator of land availability. It also affects the efficiency of resource allocation and productivity. However, this study mainly focused on the factors influencing the adoption of water management technologies on farming.

1.10 Limitations of the Study

Conducting field research comes with certain challenges that can arise unexpectedly. In the recent years, Laikipia County has been on the spot due cattle rustling. Lamuria is an area where common language for the locals is "kikuyu" (the local tribal dialect) which also pauses another challenge. The use of translators in the field was a necessary component of this research, and in the event that a challenge of insecurity occur, the researcher was conducted the nearby government security personnel for escort during the research process.

1.11 Assumption of the Study

The study assumed that the participants were transparent and truthfully answered the questions directed to them.

1.12 Theoretical Framework

The study was informed by two theories related to use and management of water resources by the communities, they include: irrigation management transfer and participatory irrigation management.

1.12.1 Irrigation Management Transfer

Development authorities and government agencies developed irrigation management transfer in the early 1970's. The theory was informed by the increasing development of technologies and management practices which were not taking root in communities despite their advantages. Coupled with this, experts had noted the possibility of a decrease in the availability of water for agriculture, which was predicted to be more severe in the coming years. According to Schaible and Aillery (2007) irrigation water management transfer can only be achieved if:

(i) Farmers are able to acquire in depth knowledge on the process of application and use of irrigation management. Without proper in depth knowledge and understanding, farmers remain unwilling to invest and commit to the process of irrigation management. The farmers tend to hesitate due to lack of resources, capital and poor understanding of the technical knowledge that comes with irrigation management. Community development experts are often prone to forcing farmers to adopt new technologies, using incentives to direct farmers to new management practices with little training and knowledge transfer.

(ii) Farmers are able to derive lessons and provide feedback on the management practices. Government and development agencies often introduce practices which in essence have bene structured and developed from simple theory. While in theory the practice could be beneficial in terms of enhancing farmer production while at the same time conserving water, the same may not be practically applicable and relevant. A proper learning process which includes feedback allows the farmer to generate a wider understanding and ownership of the management practice. Farmers are also able to address the challenges they are encountering with the application process leading to reduced frustration and higher commitment to the practice.

1.12.2 Participatory Irrigation Management

Participatory irrigation management refers to the inclusion of the irrigation users that is, the farmers in the irrigation management system. It advocates not for consultation with farmers or tertiary management of the system but the actual involvement of framers who possess traditional and cultural knowledge. Traditional knowledge is a cumulative body of knowledge, know-how, practices and representations maintained and developed by people with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, spirituality and world-view. (ICSU, 2002). In fact, the dynamism of management is influenced by various factors, including technology, population growth, and education level for the people to adopt different situations.

This theory suggests that participation has some distinct comparative advantages. Farmers are more likely to develop an applicable and sustainable form of irrigation management which is built on the fact that they have intimate knowledge of their fellow users and the land practices of the community.

1.13 Conceptual Framework

This study will make an assessment of the usage of water as an important issue for water resource management. Water use for humans has quality requirements. For instance, drinking water must be free of pathogens and toxins to ensure good public health. Water used for irrigation may not have as strict water quality requirements, but the absence of water quality standards may result in incidents by which pathogens are transferred to humans through vegetables irrigated with polluted water.

The study conceptualizes that the adoption of irrigation water management practices and technologies by farmers along the Ng'areng'iro river, in Lamuria location, Laikipia County. The irrigation water management practices and technologies would include the following: provision of a water storage structure (either a plastic lined dam or a weir dam), protection of the riparian land (the are next to the river banks), protection of the spring or water catchment area, use of efficient irrigation methods such as drip irrigation, crop husbandry within the irrigated area, and efficient energy use (Chuchird, Sasaki, & Abe, 2017). The independent variable will be the factors that affect the adoption of the irrigation water management practices these include: socioeconomic characteristics of the farmers (these are indicated by the age, education level, gender, income levels and household numbers), attitude of the farmers, farmer's knowledge of irrigation practices and technology and collective action. The whole relationship can be intervened by government policies regarding water use and management.

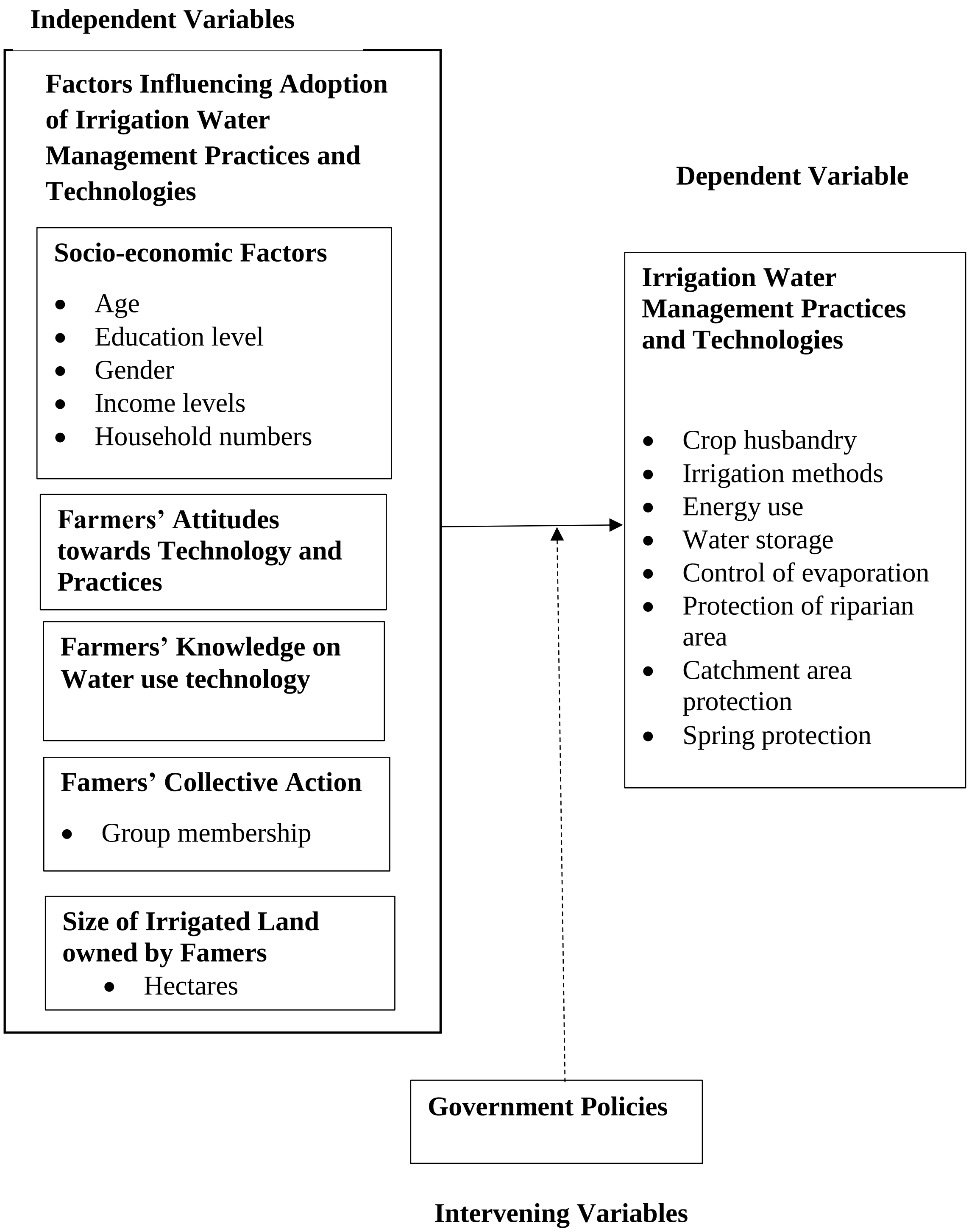

Figure 1.1: Conceptual Framework of Relationship between the factors influencing farmers adoption of irrigation water management and technologies along Ng'areng'iro river, in Lamuria location, Laikipia County.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter deals with the theoretical and empirical review of literature related to irrigation water management, the sub topics include: (i) irrigation water management techniques, (ii) influence of farmers socioeconomic factors on irrigation water management, (iii) farmers knowledge and awareness on water management technologies, (iv) farmers collective action on water use and management, (v) summary of literature review, and (vi) research gaps.

2.2. Irrigation Water Management Techniques

2.2.1. Crop Production

Agriculture takes up at least 70 % of the fresh water usage across the globe today. Mati (2006) states that as the world population continues to grow significantly, making the demand for water to be very high. Molden (2013) in his research found that a fifth of the world's population is likely to face severe water scarcity in the next decade. With this in mind, the global society has been overly focused on ensuring that farmers adopt water management techniques in an effort to save the environment. Historically, irrigation has continued to play a crucial part in enhancing and increasing farm productivity. Irrigated crops tend to yield a much higher product than those that are not irrigated. According to Siebert and Doll (2010) irrigation is especially useful in areas where the process of evaporation coupled with that of transpiration exceeds the annual precipitation. Irrigated agriculture is now facing renewed interest, as farmers are called upon to demonstrate efficient water use. However, as Tanner and Sinclair (2003) concludes, there is a contextual difference in what farmers consider to be efficient water usage and what is agreed upon by scientists and development agencies. For majority of the farmers, irrigation management success is determined by production per acreage rather than by reduction of water used in the farm.

2.2.2. Irrigation Methods

The practices of irrigation management are an important element of increasing crop production. According to Cetin and Bilgel (2002) irrigation methods are plentiful and each provides distinct advantages to the farmer in terms of technological knowledge that is needed, resources needed and ease of use. Onder *et al.* (2005) in their study focused on identifying the various methods of irrigation that are applicable for traditional farmers. He identified the following types of irrigation:

Furrow systems: in this system, farmers dig up small, shallow channels. This system is most ideal for farms that are built on a slope. Furrows are designed to be specifically fit for the design and scope of the farm, either straight or carved. The general idea is to ensure that the water is guided directly to parts of the farm that need it; saving on both time and enhancing the efficiency of the irrigation systems.

Border check systems: as shown by Valipour and Sefidkouhi (2015) this system is rarely applied in developing nations mainly because of the costly maintenance and the design of the system itself. Generally, farmers are required to build paddocks of land which they then border off with ridges that are designed to direct the water.

Central pivot systems: in this system a central pie is mounted and towers are mounted 2-4 meters above the ground. Water pumped through the central pipe is then adequately distributed across the farm through the water towers. The system provides a distinct advantage to the farmer in that it is easy to set up and also it increases the speed of water distribution.

Low flow irrigation systems: according to Ali (2011) these are commonly known as drip or trickle systems. They are ideal for areas where the availability of water may not be as steady as required. Frequent small amounts of water are applied directly to the soil through small systems of strategically placed holes. Water is directed immediately to the root avoiding the possibility of high evaporation and percolation of water. This is found to be a highly efficient system of irrigation; however it also requires technical knowledge and much time to set up.

2.2.3. Energy Use

Farmers and authorities have applied the use of various technological advances, continued research and applied a variety of methods to address the delicate balance between water use and energy efficiency. Hamidat et al. (2003) indicates that traditional methods of irrigation management have overly focused on water efficiency only, without much consideration for energy use. The benefits of irrigation modernization include: water efficiency, productivity and improved operations. However, this also translates to increased energy use. It is therefore necessary to analyze the energy efficiency of the various irrigation methods available to the farmers.

2.2.4. Water Storage

Water harvesting and storage plays a key role in improving the potential of rain fed agriculture and crop production. Water storage enables farmers to have access to water when it is scarce. Three categories of small scale storage are available, soil moisture storage, ground water storage and surface storage. Hussain et al. (2011) defines soil water storage as the amount of water that is stored within the vicinity of the root. Soil water storage allows the farmer to determine how much water to apply to the plants and at what durations. This allows for water efficiency where water applied is actually needed and adequately used to bring out the health of the plant. Plants can only extract a small portion of water, and the rest is often led to waste depleting necessary root nutrients from the plant. On the other hand, McCartney et al. (2019) indicate that ground water storage refers to where large amounts of water are stored within the ground. The water that is in storage is also remaining in movement but due to the nature of storage system, such movement is quite slow. The farmers access the water saturation level, which is imbedded in rock, and then channel rainfall water into the storage constructed there within. The result is that there is always a large amount of water which can then be pumped for irrigation purposes as well as supporting other farm and domestic water needs. Finally, surface water storage, in farms is often characterized by small depressions which gather large amounts of water, which are then stored for future use. During the rainy seasons such depressions may fill and even overflow, however in the dry seasons the water volume decreases significantly and at the same time is drawn through soil moisture into the farms.

2.2.5. Control of Evaporation

Crops, flora and Fauna can only make use of water when it is in liquid form. Evaporation transforms the required water (liquid) into vapor form (which cannot be absorbed into the plant). As per Vines (1962) majority of the farmers especially those relying on water harvest and storage to meet their water needs often have to contend with the problem of evaporation. According to him, water evaporation can be minimized by reducing the surface area of reservoir storage. The surface area, where a large amount of water congregates leads to a large amount of evaporation. The same can also be reduced by introducing mechanical covers which are designed to limit the exposure of the water. However, Saggai et al. (2014) counters that the most effective means of reducing evaporation is creation of thin oil surfaces. If the fill of oil remains intact, evaporation is not only reduced it is ultimately successfully curtailed. The effectiveness of usage after such covering is not fully desirable which in turn means that though evaporation has been curtailed, productivity of the farmer is viably affected.

2.2.6. Protection of Riparian Areas

A riparian area is the area between the river and the land, a zone that is recognized for emitting steam and vapor which then feeds natural vegetation which in turn protect the health of the river. In this study, Ng'areng'iro river in Laikipia has been selected simply because it has a waning riparian zone. The health of this zone has been of interest to environmentalists and development agencies since it determines the availability of future water for farming and agriculture. According to Hood and Naiman (2000) it is important to note that without a healthy riparian area, it would be difficult for the farmers to collect excessive water as well as release the same during the rainy seasons. Riparian vegetation and areas fall under the protection of both the government and the community. Surprisingly, this is the one area where the community plays a more than 80% role in establishing control. For example, Sabo et al. (2005) highlights simple activities such as establishing a clear boundary for the riparian vegetation, so that human activity does not intrude into such area and enhancing clean water activities in such areas may seem like simple steps yet they continuously protect the riparian environment.

2.2.7 Catchment Area Protection

Protection of catchment areas is vital both environmentally and economically. Jakeman and Letcher (2003) indicate that catchment areas are protected simply because they ensure constant water supply and maintain the high quality of water received by the farmers. There is constant need to ensure high protection of catchment areas, matter which has drawn government attention. The most viable means of pricing catchment areas is ensuring zero human encroachment since the catchment environment in itself is quite delicate. However, Lockwood (2000) notes that lax rules, constant corruption and high population have led to increased encroachment in catchment area. This in turn has decreased the water supply and quality of water received by the farmers. This study suggests that such protection can be improved by including and highlighting the role that farmers play in consequential protection of catchment areas.

2.2.8. Spring Protection

Water coming directly from the surface provides two distinct advantages for the farmer that is; one the one hand it improves the quality of water received by the farmer and on the other it requires low resource investment by the farmer. Warner et al. (2000) as such, the farmer needs to continuously protect the water and especially the spring source. This is done by ensuring that the spring source is not contaminated by the surface water. Such contamination will reduce the quality and could lead to blockage of the source. On the other hand, Jakeman and Letcher (2003) indicates that pit latrines which are common in traditional farms often interrupt the flow of water and could lead to easy blockage, coupled with a lack of fencing around the area. Even with all these facts, majority of the farmers often ignore the value of spring protection, and this is often due to the lack of knowledge on the value that such springs have in ensuring the quality of the farm.

Rockström, Karlberg, Wani, Barron, Hatibu, Oweis, & Qiang (2010) conclude from their study that in Africa and especially in Kenya, women are the main water users and therefore managers of these vital resources. Focus, should be given as he recommends towards training women on proper water use and management techniques. Such training is focused on ensuring that the community is able to avoid a global water crisis and ensure stable food production.

2.3 Influence of Farmers Socioeconomic Factors on Water Management Practices and Technologies

According to Pahl-Wostl (2007) one of the main potential barriers to the adoption of water technologies is the socio-economic in nature. Socio-economics speak of the educational background, income and access to information for the community. Allan (2005) concurs indicating that often it has been falsely assumed that cultural barriers are the only issue that the water technologies have to contend with when it comes to adoption. However, even where individuals are willing and have noted by themselves the value of water technologies, the issue lies in the ability to maintain and initiate the use of water technologies. Archer et al. (2010) underscores the lack of credit especially where capital to purchase equipment and training for the use of water technologies is required. The higher the initial cost of purchasing equipment is, the more likely that farmers will be less inclined to purchase and initiate the use of water technologies. The focus should be directed at more affordable approaches that do not require the community to go out of the way in terms of adoption. Technology in itself however often requires a much higher investment thus making adoption quite difficult.

Kalbus et al. (2012) in their study highlighted the need for higher education as a foundation for the adoption of water technologies. Education provides an ideal foundation for the understanding of the value of water technologies. It is important for the individuals to understand the importance of water management for the future generations as well as sustainability of water access. However, as with any technical aspect, it is difficult for community members with low levels of education to understand such value. In addition Schlüter et al. (2010) concurs that the most important aspect of water technologies is the right use. Without proper use, the effect of water technologies would not be significant and thus would draw fewer benefits for the community. Higher educated individuals are often more willing to take the risks associated with water management technologies as well as adopt new methods of water consumption use and conservation.

Sidibé (2005) coordinated the farm size with the initial decision for farmers to participate in adoption of water technologies. He found that farmers with larger farms were often more willing to experiment and successfully implement the use of technologies. This is in line with the possibility of increasing productivity as well as the empirical evidence that supports the increase of capital that comes with larger farms. However, Zalidis et al. (2002) cautions that such evidence can is skewed at best and often influenced by other factors that render farm size insignificant. Whatever the case, the socio-economic factors are the most significant factors influencing adoption. There is therefore need to gather evidence with regard to how each factor influences adoption of water technologies and thus recommendations on how to address the socio-economic challenges that limit adoption of ideal water management technologies.

2.4. Farmers Attitude towards Irrigation Water Technologies and Practices

Khalkheili and Zamani (2009) state that attitude plays a crucial role in determining the adoption of any form of technology. Attitude of the adopters in itself lays the foundation for adoption or non-adoption. While many other aspects maybe easy to alter and change and thus improve the rate of adoption, attitude remains quite difficult to change even for the most experienced fieldworkers. Maleksaeidi *et al*. (2018) highlights that when it comes to irrigation technology attitude especially with regard to the economics of irrigation and detrimental impact to the value of the environment, care must be taken to encourage adoption. Torkamani and Shajari (2008) continue to state that change into the use of irrigation technology may itself be marred with challenges both economical and environmental. During the first years production within the farm may vary and the fruits of the change may not be immediately visible. Farmers who have had negative attitudes towards such technology are therefore likely to abandon projects before they have taken root. In fact, based on this there are farmers who may not even be drawn or interested in making the changes. This is especially the case with the aging farmers, whose faith is based on traditional irrigation systems. For such farmers, change is not only unnecessary, it is simply a new way to increase costs in the farming production system and traditional ways remain much cheaper and more reliable (Bagheri and Ghorbani 2018). This is not to say that attitudes are set in stone and cannot be changed. There are tools such as the use of traditional elders, use of sample plots and farms and introduction of small changes rather than huge immediate changes that can in turn be used to alter attitudes of farmers and encourage participation in modernising irrigation technology

2.5 Farmers' Knowledge on Water Management Technologies and Practices

Geerts and Raes (2009) found that farmers asked to state new forms of water management technologies were unable to do so. This is simply because they were unaware of such technologies in existence. Awareness is determined by access to the information and the understanding of the value of the information. Awareness is the first step towards any form of adoption. Farmers need to be aware of the existence of water management technologies and the benefits that accrue from the adoption of such technologies. Roe et al. (2005) cites that in the first attempt in improving awareness come in the form of extension services. Extension officers are the first and most crucial resource with regard to disseminating the information that is needed to the farmers. Manjunatha et al. (2013) in their study highlighted that the largest number of adopters in agricultural technologies and new forms of agriculture, which is 55.8% of the population had interacted with extension officers.

Awareness increases not just the possibility but also the rate of adoption among small scale farmers. No one can adopt what they do not know about. Further as shown by Becu et al. (2003) knowledge and awareness on their own level increases the level of efficiency and use of water management technologies. Knowledge allows the farmers to identify their challenges they are facing together. There are situations where the farmers are not aware of their own challenges and thus are not aware of the need for change. Set of actions can only be highlighted and actively pursued when understanding has been reached. To increase the level of community participation, community members must be aware of their challenges and the available solutions that they can access. The second aspect of awareness as Lubell (2004) includes identifying the best possible solution. The solution should not only actively resolve the problems but also include benefits that are sustainable over a period of time. When it comes to water management often the solutions available are short term at best. Traditional solutions to water shortage have often failed in resolving the problem, however when the community is not aware of the possibility of the advantages of the same solutions in the long term they are less likely to adopt the new systems opting instead to remain with the old traditional systems which are not as effective. Studies that have been conducted measuring levels of adoption but lacking the aspect of awareness are limited. On the one hand, adoption rates without consideration of awareness may give a false positive where the researchers focus on an ideal respondent population. On the other hand, there is also the possibility under-estimation that arises from false adoption rates.

2.6 Collective Action on Irrigation Water Use and Management

The ability of Laikipia's water supply to adjust successfully to changing climatic conditions as well as increasing population lies in collective action. According to Mosse (2003) collective action is the answer to approaching shared risk as well as addressing the vulnerability for the many community members. Collective action leads to a process of shared beliefs, shared interests and responsibilities which in turn lead to shared benefits. Action (2006) defines collective action as coordinated engagement of the various individuals within a group of shared beliefs and more specifically working towards achieving a specific objective. Collective action is both a resource and an invitation to take action in terms of reducing vulnerability. Benvenisti (1996) continues to elaborate that through collective action, individuals are given the first invitation to resolve a similar challenge which they are facing. Having recognized the similarity of their challenges, the individual community members therefore bring together their resources in order to allow the individuals to find an elaborate and ideal way to resolve the problem.

Meinzen-Dick et al. (2002) studied collective action in Baringo and Kitui, where it has been quite successful. Having noted the problem of water, the women involved in self-help groups through the help of the PARIMA project undertook collective action. They mainly focused on watershed education and provision of water harvesting tools. Over time as shown by this project, participation in collective action led to more sustainable access to clean water and ideal water management techniques. Lubell et al. (2002) indicate that water management techniques and technology have been hard to adopt and maintain in unilateral actions and decisions.

The call for increased community participation in the same actions means that the community members are to be called towards collective action. Collective action has the advantage of ensuring that the community not only remains aware of the vulnerability cause by inadequate availability and supply of good quality water; but also ensures that the community retains the social license in ensuring that the valuable resource is used properly and uttermost responsibility is maintained thereby bringing about permanent change. Since catchments often have a broader social norms that may minimize the quality of life of individuals within the community either through real water challenges and problems or through perceived privilege, the only real solution with substantive results can only be found in the community with ideal collective action. Despite these theoretical probabilities, there is little evidence that exists scientifically supporting such claims. Much of the work on collective action has been directed at socio-economic general boundaries, with the problem of water shortage and availability taking a back seat.

2.7 Size of Irrigated Land Owned by Farmers

Although there have been various studies conducted on the factors and issues that influence adoption of technology among farmers, the size of land has only recently become highlighted as one of those factors. When it comes to irrigation, few have considered the elements of farm size as influencing both the attitude and the economics of adoption. Tamburino *et al.* (2020) found that while small scale farmers were often more willing to learn and increase production in their farms, they were often much slower in terms of investment in irrigation technology. They suggested that this was simply a game of economics, where small scale farmers lacked the resources and income needed to invest in the irrigation technology. Large scale farmers on the other hand, are often seeking ways to minimise the water usage and increase productivity. They are therefore much more willing to adopt the new forms of technology. Namara, Nagar, and Upadhyay, (2007) together with Khanpae and Karani (2015), however suggest that the issue of farm size goes beyond simple economics and well into psychological attitudes. In his study, he found that small scale farmers often feel that they are making much less use of the water resource. They determine that individually their water usage cannot in any case affect the level and quality of the water source. Instead such blame should be placed on large scale farmers. Therefore, it should be the responsibility of the large farm owners to adopt the various water management technologies. The issue of land size and irrigation technology adoption remains slightly unclear and contested, with limited data available to reach an acceptable conclusion.

2.8 Summary of the Reviewed Literature

Climate change as well as global population increase; have greatly affected global water resources (Vorosmarty et al., 2000) including both direct and indirect impacts on water availability (Rao et al., 2007). Modern agricultural techniques can improve not only adaptation to water use strategies, but also mitigation to climate change. Therefore, it means that, the relationship between mitigation and adaptation in agriculture is critical for farmers (Smith, 2009).

According to Smit and Wandel (2006) and Füssel (2007), adaptation refers to processes, actions or outcomes in the system including households, community, groups, sectors, regions and country to make the system more able to cope with, manage or adjust to change some conditions, stress, hazards, risks and opportunities. According to IPCC (2007), adaptation therefore, means the adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects; which moderates harm or exploits beneficial opportunities.

A research on assessment of impacts of climate change cannot be separated with adaptation option study and vice versa. Therefore, the integrated assessment approach will be applied in this study. Results of assessment of impacts of climate change on livelihood as well as farming system will be used as basic data for setting up scenario of climate change, giving adaptation strategies in the future and improving shortcomings of current adaptation strategies.

2.9 Knowledge Gap

A farming system is a unit consisting of human groups and the resources that they manage in its environment; involving the direct production of plant and animal products. Farming system is a system in which a combination with interrelated farming and household activities are inter-dependent and interacting with each other to achieve household goals (Dixon et al., 2001). This research will set the process of assessing and examining the community's strengths, weaknesses, assets, gaps, and needs to determine which issues should be addressed, existing resources to address identified gaps, and the best course of action to address those identified needs (ibid).

Agricultural productivity heavily depends on environmental conditions such as water quantity and quality, soil fertility, climate conditions and the natural environment. As governments and development organizations look towards local users for more effective and sustainable water management, it is important to understand how local people can be brought together to address common general need such as water scarcity (Meinzen-Dick et al., 2002; Meinzen-Dick et al., 2004). A major critique of CBNRM is that the degree of success varies widely across cases (ibid). The streams and underground sources of water in Lamuria represent a common resource for the local people. Common resources are characterized by individual benefits and collective costs (Burke, 2001). If not managed properly, individual users have the potential to degrade and deplete the resource.

Water scarcity is a phenomenon that many communities are now experiencing, not only in Lamuria but in the whole country and the African continent at large (IWMI, 2007). This research proposal is therefore, intended to provide a reliable information on water use adaptation options for the purpose of future water management that can significantly contribute to addressing water scarcity by improving access and controlling water usage.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter introduces an in depth coverage of the study area, research design, study population and sample, data collection procedures, data analysis and presentation techniques that will be used in the study. The chapter discusses the methods that were employed in this research.

3.2 Research Design

This study adopted a descriptive research design. According to Cooper and Schindler (2000), the research objectives that are fulfilled by a descriptive study include descriptions of phenomena or characteristics associated with a particular population, estimates of the proportions of a population that have these characteristics and a discovery of associations among different variables. Questions were asked to describe the relationship between collective action and other related concepts: water access and usage, common community issues and levels of interaction.

3.3 Research Site

This research was carried out in Lamuria. Lamuria is located within Laikipia East Constituency, Laikipia County in central Kenya, and it is situated on a plateau northwest of Mount Kenya within the Ewaso Ng'iro North catchment basin, and it lies within latitudes 0° 11'0" S and 36° 52' 0" E. The average temperature is 16.6^{o} c and precipitation: 818mm. it receives an average rainfall of 370mm Annually (UN WWAP, 2006b). The location of the area on a map of Kenya is shown in Figure 3.1.

This study was carried out in Lamuria sub location, Laikipia County. Lamuria is located within Laikipia East District, Laikipia County in central Kenya. Situated on a plateau northwest of Mount Kenya within the Ewaso Ng'iro North catchment basin, and it lies within latitudes 0° 11'0" S and 36° 52' 0" E.

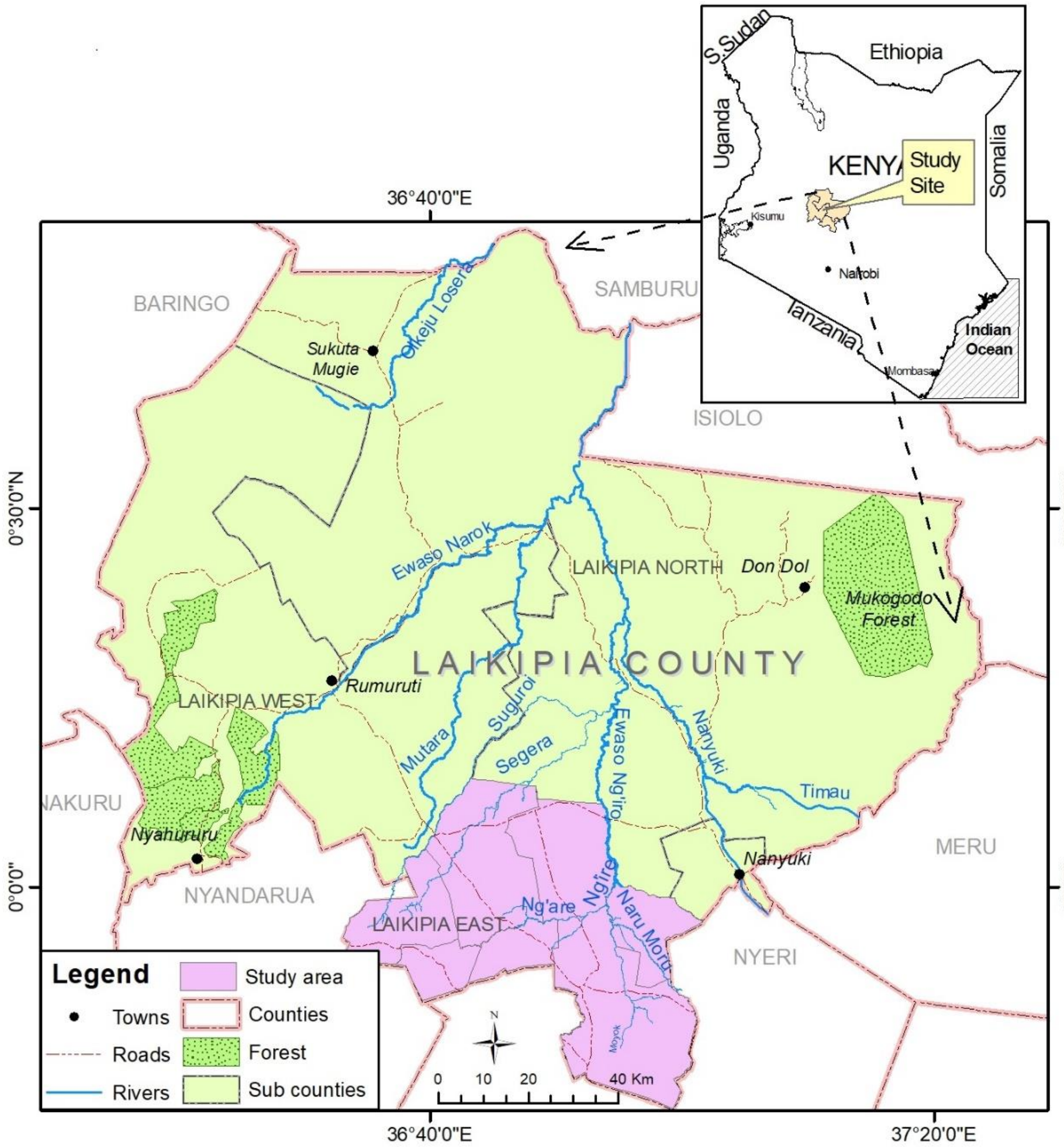

Figure 3.1: General Site Location Map of Lamuria, Laikipia County

This area was chosen for study because of two main reasons. The first is that the area has a high population of farmers who generally rely on irrigation to produce food. The main source of water for farming is the Ng'areng'iro river. The second river is that the river volume has been decreasing for the past decade. Despite constant efforts by the government to alter the same, few efforts have been recognized. The two factors correlate in a manner that provides a rich data environment, for information that is vital in understanding the value of irrigation management.

3.4 Target Population

Target Population refers to an 'Entire' group of individuals, events or objects having common observable characteristics (Mugenda & Mugenda, 2003). The overall population of Lamuria location is 418,118 people and a household population of 96,700. The farmers owning land within the locality of the river are estimated to be 26,000 and they were targeted by the study.

3.5 Study Sample

3.5.1 Sampling Procedure

Stratified random sampling was used to select the sample for the study. The total sample was determined to be 333 and was divided into two strata, the left and the right of the river. The two groups of the farmers were identified from the chief's records in Lamuria sub-county and a list of the farmer who have plots on the right hand side of the river and the ones with plots on the left hand of the river were created. Then using a *table of random numbers* the sample was randomly selected from the two lists.

3.5.2 Study Sample Size

The sampling frame consisted of farmers owning or renting plots on both sides of the river to a maximum of 2 km width from the river. It is estimated that the sampling frame will consist of 2,500 small scale farmers. The sample size required was calculated using the formula described by Krejcie and Morgan (1970) and Kathuri and Pals (1993):

$$n = \frac{\chi^2 * N * P(1-P)}{(ME^2 * (N-1)) + (\chi^2 * P(1-P))}$$

Where:

n = The required sample size, given by the following:

χ^2 = The table value of chi square for one degree of freedom relative to the desired level of confidence which was 0.95. [The chi-square value used was 3.841].

N = The population within the study area [2,500]

P = The population proportion [assumed to be 0.50], as this magnitude yields the maximum possible sample size required.

ME = desired margin of error (expressed as a proportion). This is the degree of accuracy as reflected by the amount of error that can be tolerated in the fluctuation of a sample proportion about the population **P**. The value of d was taken as 0.05, which is equal to plus or minus 1.96σp. $\boldsymbol{ME^2}$= [0.05^2 =0.0025]

n = 333

Based on the population of the farmers owning farms with the 2 km width of the river on both sides (2,500) and the above formula the required sample size was 333 farmers. The sample population was stratified into two to create a group of 166 farmers selected at random from the right hand side of the river and another one of 166 framers from the left hand side of the river.

3.6 Data Collection Procedures

An introduction letter was obtained from the Board of Post graduate studies at Africa Nazarene University. The introductory letter was used to obtain a research permit from the National Council for Science, Technology and Innovation (NACOSTI) within the Ministry of Higher Education, Science and Technology. The researcher visited Lamuria the site of the study to familiarise with the situation, seek permission to make inquiries from the farmers and obtain a list of the farmer owning or renting plots from the Chiefs office.

The study comprised both primary and secondary data. The primary data was collected through administration of structured questionnaire, while the secondary data was collected from diverse sources of documents or electronically stored information, relevant text books, magazines, journals, circulars, reports and earlier empirical research (Orodho, 2003). Questionnaires were used here because of its ability to gather data faster over larger area and also because of its ability to uphold confidentiality of the information required. (Kothari, 2008).

3.6.1 Data Collection Instruments

The study utilized one research instrument a structured household survey questionnaire (Appendix A). The questionnaire consisted of section about the participants' characteristics, the independent variables and the dependent variable. To determine the factors influencing the adoption of irrigation water management technologies on farming in Lamuria location along the Ng'areng'iro river, in Laikipia County, the researcher prepared a survey questionnaire and a set of guide questions for the intended respondents. A questionnaires has the advantage of being cheap and easy to administer and results in suitable data for analysis as designed by the researcher (Mugenda & Mugenda, 2003).

The questionnaires consisted of various parts. Part 'A' consisting of statements seeking information on respondents' background. This is necessary in describing respondents' particulars in the study. The other parts from 'B' were designed in a way that all objectives of the study were fully covered as indicated in appendix A. The questionnaires were administered by the researcher with the help of trained enumerators.

3.6.2 Pilot Testing of Research Instrument

Prior to the actual study, a pre-test study was carried out. A pilot survey is a replica and rehearsal of the main survey. According to Kothari (2008) a pilot study brings to the light the weaknesses, if any, of the questionnaires and also the survey technique, and thereby improvements can be made. The benchmark for reliability was based on Cronbach's Coefficient Alpha with value 0.7 as the minimum which is mostly used when the research being carried out has multiple measures of a concept (Tavakol & Dennick, 2011). In this study, the questionnaire was pilot-tested among thirty respondents before being revised and administered to the entire study group.

3.6.3 Instrument Reliability

A pilot study was conducted on 30 randomly selected farmers to pretest the study instruments, this group of farmers did not form the part of the main study to avoid bias. Borg and Gall (1989) recommend that the minimum sample size of a pre-test should be 20-30 respondents.The data was used to determine the reliability of the instruments using Cronbach's alpha. Reliability of an instrument is the degree of consistency with which it measures a variable (Mugenda & Mugenda, 1999). Cronbach's alpha coefficient of 0.7 and above were found to be acceptable for the proposed study. The results of the pilot study then helped in restructuring of the questionnaires by incorporating the missing information, omitting irrelevant questions and paraphrasing questions that appear ambiguous to the respondents (Mutai, 2000).

3.6.4 Instrument Validity

Construct validity is a criteria that is commonly used to evaluate the rigor of empirically based, social science research (Creswell, 2009).To ensure validity, and this research investigated and established measures of the individual variables. Variables and indicators were developed and linked to previous research studies on water use management on firming. The validity of data collection was addressed by triangulating the data through multiple data sources and collection methods.

3.6.5 Data Collection Procedures

The questionnaires were administered by the researcher after the respondents were explained the need for the data and their right to privacy. Prior to data collection, the respondents were informed of the purpose of the study and assured of confidentiality of information provided in order to promote their free and honest participation in the study. An atmosphere conducive to all the respondents was created by the researcher, to enable them open up and answer the questions asked truthfully.

3.7 Data Processing and Analysis

The unit for analysis was the individual farmers owning or renting land along the Ng'areng'iro river, in Laikipia County because it involves the investigation of opinions of individual household and families on the issues of irrigation water management practices and technologies on farming activities.

Data was analysed using both descriptive and inferential statistics within the Statistical Package for the Social Sciences (IBM SPSS version 26). Descriptive analysis included the use of frequency tables, charts, measures of central tendency and dispersion (means, modes, median, variance and standard deviation and cross tabulation of categorical variables).

Inferential statistics were also be used to determine the relationship between variables and to test the research questions. Inferential statistics included linear regression analysis to determine the influence of the independent on the dependent variables (Mugenda & Mugenda, 1999). The factors to be considered by the study include independent variables(X) and dependent variable (Y).The regression equation was determined as:

$Y= \beta_0+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+\alpha$

Where Y is the dependent variable (irrigation water management practices and technologies), β_0 is the regression coefficient, β_1, β_2, β_3 and β_4 are the slopes of the regression equation, X_1 socioeconomic factors, X_2 farmers attitudes, X_3 is farmers knowledge, X_4 is collective action while α is an error term normally distributed about a mean of 0 and for purposes of computation, the α will be assumed to be 0. The equation was solved by use of a statistical model using SPSS. This generated a quantitative report from this analysis using inferential statistics. Data collected from the Focus Group Discussions was analysed by use of narratives. The summary of the analytical procedures that were used are given in Table 1.

3.8 Legal and Ethical Considerations

According to Gliner & Morgan (2009), ethical and legal consideration are activities designed to test research hypothesis and allows conclusion to be drawn and eventually developed to contribute to generalized expressed statements. The researcher therefore, maintained confidentiality of information involved in the research, as well as assuring respondents about confidentiality of all the information given out.

In order to complete a legal requirement of all academic research within the country, the researcher applied for and obtained a research permit from NACOSTI. The permit obtained is dated, () and is attached in the appendices.

Table 3.1: Summary of the Analytical Procedures

Study Questions	Variables Involved	Statistical Methods
Q_1: What is the influence of farmer's socio-economic factors on their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?	Independent: farmers socioeconomics Dependent: water management practices and technologies	Descriptive statistics, linear regression analysis
$Q_{2:}$ How does farmer's attitude influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?	Independent: farmer's attitude Dependent: water management practices and technologies	Descriptive statistics, linear regression analysis
Q_3: How does the farmer's knowledge influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?	Independent: farmers knowledge, Dependent: water management practices and technologies	Descriptive statistics, linear regression analysis.
Q_4: Does farmer's collective action influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia	Independent: collective action. Dependent: water management practices and technologies	Descriptive statistics, linear regression.
Q_5: Does the size of land owned by the farmer influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County	Independent: Land size. Dependent: water management practices and technologies	Descriptive statistics, linear regression.

CHAPTER FOUR

DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents results and their interpretation on the factors influencing farmer adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County. The chapter is divided into the following sections: (i) characteristics of the farmers in Lamuria location, (ii) Characteristics of the farming system along the Ng'areng'iro river in Lamuria location, (iii) influence of farmers socioeconomic characteristics on adoption of irrigation management practices and technologies, (iv) influence of farmers attitude on adoption of irrigation management practices and technologies, (v) influence of farmers knowledge on farmers adoption of irrigation management practices and technologies (vi) influence of farmers collective action on farmers adoption of irrigation management practices and technologies.

4.2 Characteristics of the Farmers in Lamuria Location

Four attributes of the households in the study area, which were considered important to this study are discussed in this section, they include: Ethnic communities in the study area, Age of the respondents, sex of the respondents, marital status, and Educational level.

4.2.1 Sex of the Respondents

The sex of the respondents was noted and the data was summarized and presented in Table 4.1.

Table 4.1: Sex of Respondents

Sex of Farmers	Frequency	Percent
Male	247	73.5
Female	89	26.5
Total	336	100.0

The majority (73.5 %) of the respondents were male, while 26.5 % were females.

4.2.2 Marital Status of the Respondents

The respondents were asked to state their marital status and the data was recorded and analysed. The frequency distribution is given in Table 4.2.

Table 4.2: Distribution of the Respondents by Marital Status

Marital Status	Frequency	Percent
Single	47	13.9
Married	236	70.3
Divorced/Separated	5	1.5
Widowed	48	14.3
Total	336	100.0

The majority (70.3 %) of the respondents are married. One of the importance aspects of the rural culture is marriage. Only married individuals are carried and regarded positively by the community.

4.2.1. Age of Farmers

The farmers were asked to state the year they were born as per their identity card and chiefs records. The information was analysed by determining the age from their year of birth. The results were then categorized into six categories and the descriptive statistics and frequency distribution are presented in Table 4.3.

Table 4.3: Age Distribution of the Farmers

Age Category (Years)	Frequency	Percent
30-35	17	5.0
36-41	64	19.0
42-47	109	32.5
48-53	90	26.9
54-60	34	10.1
61 and Above	22	6.5
Total	**336**	**100.0**

Mean 44.6.± .36, Median 43, Mode 38, Std. dev 6.74, minimum 32, and max 64

The mean age of respondents was found to be 44.6 years and the age ranged between 32 and 64 years.

4.2.2 Level of Formal Education Attained by Household Heads

The farmers were asked to state their highest level of formal education they had attained, the responses are summarized in Table 4.4.

Table 4.4: Formal Education Level Attained by the Respondents

Level of Formal Education	Frequency	Percent
Illiterate	42	12.5
Primary	154	45.8
Secondary	89	26.4
College	35	10.4
Degree	16	4.9
Total	**336**	**100.0**

Analyzed data showed that a majority of the respondents, 45.8 % had attained the primary level of formal education, with at least 25.8% attaining secondary level of education. Even fewer that is, 12.5 % had not attended any formal type of schooling and only 10.4 % have transitioned to college and 4.9 % to universities. This concurs with the information found in many national surveys such as the integrated household living conditions survey. The high number of primary school leavers can be attributed to the free primary education programme initiated by the government.

4.3.2 Monthly Income of the Farmers

The farmers were asked to state the income they received per month from all the sources available to them. The frequency distribution and descriptive statistics of the farmer's income are given in Table 4.5.

Table 4.5: Monthly Income of Farmers

Income Category	Frequency	Percent
Below 5,000	29	8.6
5,001-10,000	184	54.8
10,001-15,000	79	23.5
15,001-20,000	24	7.1
20,001-25,000	17	6.0
Above 25,001	3	.9
Total	336	100.0

Mean 10,085±307, median 9,200, mode 5,638, std dev. 4,140, minimum 4,140, maximum 50,000

The majority (54.8 %) of the farmers received monthly incomes of between 5,000 and 10,000 and 8.6 % of the farmers had income levels of below 5,000 per month. These income levels were deemed to be small to cater for the welfare of the households and the farm activities.

4.2.1 Number of People Living in the Household

The number of people living in the household was determined and analysed and the results are given in Table 4.6.

Table 4.6: Number of People in the Farmers Household

Number	Frequency	Percent
2.00	15	4.5
3.00	51	15.2
4.00	72	21.4
5.00	82	24.4
6.00	65	19.3
7.00	39	11.6
8.00	12	3.6
Total	336	100.0

Mean 5±08, median 5, mode 5, standard deviation 1.48, minimum 2, maximum 8

The number of people living in the household is related to the number work force in the family as these members provide the much needed labor in the irrigation plots. The mean number of people in the household was 5 and varied between 2 and 8.

4.3 Characteristics of the Farming System along the Ng'areng'iro River in Lamuria Location

The farming system practised by the farmers along the Ng'areng'iro river was determined and is explained here under the following sections: (i) farming experience, (ii) type of crop grown, and (iii) land size.

4.3.1. Farming Experience

The farmers were asked to state the number of years they had been farming o their irrigation plots. The information was analysed and the frequency distribution and descriptive statistics are given in Table 4.7.

Table 4.7: Number of Years in Farming

Years of Farming	Frequency	Percentage
0-5	61	18.3
6-10	116	34.8
11-15	87	26.1
16-20	46	13.8
Above 20	23	6.9
Total	333	100.0

Majority (53.1 %) of the farmers have been participating in farming for less than 10 years, which makes them modern farmers. Only 6.9% of the respondents have been farming for more than 20 years.

4.3.2 Type of Crops Grown by Farmers under Irrigation

The farmers grew a mixture of crops under irrigation. The information was analysed in terms of the type of crop, land size under a particular crop, and its production. The results of the analysis are given in a multiple response Table 4.8.

Table 4.8: Types of Crops Grown under Irrigation and their Production

Farm Crop	Size (ha)	Average Production (bags)	Production per ha (Kg)
Onions	1.30	3.7	2.84
Chillies	0.52	1.79	3.44
Kales (Sukuma)	0.64	5.28	8.28
Tomatoes	0.47	2.75	5.85
French beans	0.77	2.28	2.96

n=336

Five different types of crops are grown under irrigation, they included onions, chilies, kales, tomatoes and French beans. The acreage on onions is the highest in the scheme as they are easy to grow and market.

Land Size Owned By the Farmers in the Irrigation System

The farmers were asked to the total area of land they owned within the irrigation scheme. The data was then analysed and the descriptive statistics and frequency distributions are given in Table 4.9.

Table 4.9: Land Size Owned by Farmers in the Irrigation System in Lamuria Location

Land size in ha	Frequency	Percent	Cumulative Percent
.40	5	1.5	1.5
.81	29	8.6	10.1
1.01	1	.3	10.4
1.21	54	16.1	26.5
1.62	40	11.9	38.4
1.82	2	.6	39.0
1.86	2	.6	39.6
1.90	1	.3	39.9
1.94	1	.3	40.2
2.02	39	11.6	51.8
2.43	42	12.5	64.3
2.63	3	.9	65.2
2.83	52	15.5	80.7
3.16	1	.3	81.0
3.20	1	.3	81.3
3.24	21	6.3	87.5
3.64	4	1.2	88.7
4.05	2	.6	89.3
4.45	6	1.8	91.1
4.86	4	1.2	92.3
5.26	11	3.3	95.5
5.67	8	2.4	97.9
6.07	7	2.1	100.0
Total	**336**	**100.0**	

Mean 2.3±.07, median 2, mode 1.2, std. dev. 1.2, minimum.4, maximum 6

The mean land size owned by the farmers within the irrigation system is 2.3 ha, and varied between 0.4 ha and 6 ha. The majority (64.3 %) of the farmers had land sizes that were below 2.43 ha. Land that can be irrigated is a prime resource in the location.

4.4 Farmers Adoption of Irrigation Water Management Practices and Technologies in Lamuria Location, Laikipia County

Farmers' adoption of irrigation water management practices and technologies in Lamuria location, Laikipia County was the dependent variable used in this study. The variable was defined as the act of taking something on as your own as well as embracing ideas, habits among others. The variable was operationalized as the number of irrigation water management practices and technologies undertaken by an individual farmer.

The level of adoption was determined by combining five different indicators to form an index. The index comprised of five different indicators, which included: (i) crop husbandry techniques used by the farmer; this included use of certified seeds, fertilizer application, and right spacing of the crops, (ii) water use practices and technologies; type of irrigation used, type of energy used, availability of storage facilities, (iii) control of water seepage in conveyance structures; flood protection, lining of ponds and canals, (iv) protection of riparian; protection of riparian erosion, protection of riparian area from animals, protection of plantation. The respondents were asked to state the different practices and technologies they were engaged in, the responses were coded on a 0,1 scale or dummy variables. These fourteen (14) items indicators were then summed together to form the index of farmers adoption of irrigation water management practices and technologies. The frequency distribution and descriptive statistics of the resulting index is given in Table 4.10.

Table 4.10: Frequency Distribution of the Index of Farmer Adoption of Irrigation Management Practices and Technology

Scale	Frequency	Percent
8.00	11	3.3
9.00	88	26.2
10.00	89	26.5
11.00	105	31.3
12.00	38	11.3
13.00	3	.9
21.00	2	.6
Total	**336**	**100.0**

Mean 10.3±.07, median 10, mode 11, std. deviation 1.36, minimum 8, maximum 21

The index of the level of farmer's adoption of irrigation management practices and technologies ranged between 8 and 21. The index of the level of adoption was then divided into six categories as follows: 1 =very low, 2 =low, 3 =moderate, 4 = high, 5= very high and 6 extremely high levels of farmer's adoption. A Chi-square test was performed to determine the equality of the groups. Based on this categorization, the scores for the index of the level of farmer's adoption were distributed as shown in Table 4.11.

Table 4.11: Chi-square Test for Equality of the Categories of Level of farmers Adoption in Lamuria Location, Laikipia County

Scale category	Level of Adoption	Observed N	Expected N	Residual	Statistics
1.00	Very Low	11	56.0	-45.0	χ^2= 167.21
2.00	Low	88	56.0	32.0	df= 5
3.00	Moderate	88	56.0	32.0	*p*= .001
4.00	High	105	56.0	49.0	
5.00	Very High	39	56.0	-17.0	
6.00	Extremely High	5	56.0	-51.0	
Total		**336**			

The chi-square test indicates that the majority of the farmers had a score for level of adoption of irrigation management practices and technologies that was termed as high. These results were found to be statistically significant (χ^2 167.21, df 5, p .001).

4.5 Influence of Farmers Socioeconomic Characteristics on Adoption of Irrigation Water Management Practices and Technologies

The first objective of this study was to assess the influence of farmer's socio-economic characteristics (age, household number or workforce, income, education level) on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

4.5.1 Socioeconomic Characteristics of the Famers Lamuria Location, Laikipia County

The independent variable socioeconomic characteristic of the farmers included four personal characteristics of the farmers that were important to the irrigation farming system along the Ng'areng'iro river, in Lamuria location, Laikipia County. These characteristics are discussed at length in sections 4.2 and 4.3 of this thesis. The variables include: (i) age of the farmer, (ii) highest education level, (iii) monthly income, and (iv) household number or workforce.

4.5.2 Determining Influence of Socioeconomic Characteristics on Farmers Adoption of Irrigation Management Practices and Technologies

The first research question of this study, tested whether socioeconomic characteristics had a significant influence on the level of farmers adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Laikipia County. The research question was stated as:

Q_1: Is there a statistical significant influence of socioeconomic characteristics on farmer's adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Laikipia

The study question was answered using multiple linear regression model. The dependent variable was the index of farmer's adoption of irrigation water management practices and technologies and the independent variables were the four socioeconomic characteristics: age of the farmer, highest education level, monthly income, and household number or workforce. The results of the multiple regression model are presented in Table 4.12.

Table 4.12: Regression Model Summary for Socioeconomic Characteristics and Farmers Adoption of Irrigation Water Management Practices and Technologies

R	R Square	Adjusted R Square	Std. Error of the Estimate
.420[a]	.276	.266	1.25190

a. predictors: (constant), household numbers, highest academic , income per month, age

The model indicates an adjusted R^2 value of 0.226; this means that the independent variable socioeconomic characteristics explained approximately 27 %of the variation in dependent adoption of irrigation water management practices and technologies. The *F* test for the regression model is shown in Table 4.13.

Table 4.13: *F* Test for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p*
Regression	110.436	4	27.609	17.616	.001[b]
Residual	515.624	329	1.567		
Total	626.060	333			

a. Dependent Variable: index of farmer's adoption
b. Predictors: (Constant), household numbers, highest academic, income per month, age

The overall regression equation was found to be significant (*F* 4, 329) = 17.61, *p*=.001). The regression coefficients of the model showing the *beta*, *t* statistics and the tolerance levels (*VIF*) is shown in Table 4.14.

Table 4.14: Regression Coefficients for Socioeconomic Characteristics and Farmers Adoption of Irrigation Water Management Practices and Technologies

	Unstandardized Coefficients		**Standardized Coefficients**			**Collinearity Statistics**
	B	**Std. Error**	***Beta***	***t***	***p***	**VIF**
(Constant)	12.852	.904		14.214	.001	
Age	-.049	.011	-.240	-4.354	.001	1.071
Highest Academic	.240	.140	.091	-1.711	.008	.888
Income per Month	3.980	.000	.174	3.361	.001	.934
Household Numbers	.156	.049	.170	3.190	.002	.886

a. Dependent Variable: Index of farmer's adoption

The regression analysis indicates positive significant influences between highest academic level (*β*=-.091, *p*=.008), income per month (*β*=-.174, *p*=.001) and household number (*β*=-.170, *p*=.002) on farmer adoption of irrigation water management practices and technologies. Negative significant influence were found to exist between age of the farmer (*β*= --.240, *p*=.001) and the dependent variable.

Socioeconomic characteristics (age, academic qualifications, income, and household numbers) of the farmers have statistical significance influence on the adoption of irrigation water management practices and technologies.

4.6 Influence of Farmer's Attitude on Adoption of Irrigation Water Management Practices and Technologies

The second objective of this study was to assess the influence of farmer's attitude on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County. The objective was stated as follows:

To determine the influence of farmer's attitude on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

4.6.1 Farmers' Attitude towards Water Management Practices and Technology

The independent variable, farmer's attitude towards irrigation water technology and management practices was operationalized as an index that combined responses from thirteen statements contained in Table 16. The farmers were asked to state their agreement or disagreement of these statements on a scale of 1 to 5. The scale ranged from 1 indicating Strongly Disagree to 5 indicating Strongly Agree. The responses were then summed up to form the index and a mean score obtained for each statement. The mean scores for each statement and the grand score for all the statements are shown in Table 4.15.

Table 4.15: Mean Scores of Farmers' Responses to their Attitude towards Water Management Practices and Technologies

No	Water Management Practices and Technologies	Mean	SD
1	Having a pond for water storage	3.34	1.252
2	Having plastic lining for ponds and water canals	2.84	1.437
3	Use of dripline irrigation	3.16	1.104
4	Providing piped water to the homestead	3.79	0.934
5	Protecting the riparian area	3.55	0.957
6	Use of engine and pump for irrigation	2.21	1.267
7	Protecting the water source	3.61	0.929
8	Planting high value crops	3.42	0.151
9	Importance of crop husbandry	3.29	1.058
10	Formation of collective action groups to aid in water use and management	2.86	1.224
11	Spend money to purchase equipment to manage water	2.34	1.161
12	Protection from flooding	3.66	0.962
13	Increase crop production using crop husbandry techniques (spacing, crop, fertilizer,)	3.55	1.239
	Mean score for the index of Farmers attitude towards water management practices	**2.74**	**1.398**

The index of farmers attitude was categorized into five categories as follows: Very Poor (20-30), Poor (31-40), Medium (41-50) Good (51-60) and Very Good (Above 61). The frequency distribution of the categories and the descriptive statistics for the index are shown in Table 4.16.

Table 4.16: Frequency Distribution and Descriptive Statistics for the Index of Farmers Attitude towards Water Management Practices and Technologies in Laikipia County

Category	Description	Frequency	Percent
20-30	Very Poor	67	19.9
31-40	Poor	119	35.4
41-50	Medium	53	15.8
51-60	Good	92	27.4
Above 61	Very Good	5	1.5
Total		336	100.0

Mean 41±.58, median 39, mode 28, standard deviation 10.7, min 21, max 62

A chi-square test for the equality of the categories was performed and the results are presented in Table 4.17.

Table 4.17: Chi-square Test for Equality of the Categories of Farmers Attitude towards Water Management Practices and Technologies in Laikipia County

	Description	Observed N	Expected N	Residual	Statistics
20-30	Very Poor	67	67.2	-.2	χ^2= 109.65
31-40	Poor	119	67.2	51.8	*df* =4
41-50	Medium	53	67.2	-14.2	*p*=.001
51-60	Good	92	67.2	24.8	
Above 61	Very Good	5	67.2	-62.2	
Total		**336**			

The results of the chi-square test (Table 4.17) indicate that the farmers attitude category of Low was significantly higher statistically (χ^2= 109.65, *df* =4, *p* =.001) than the other categories. This implied that the farmers who had a Poor attitude towards the water management practices and technologies were significantly higher than the other categories.

4.6.2 Influence of Farmers Attitude towards the Adoption of Water Management Practices and Technologies in Laikipia County

The second research question of this study, sought to determine whether farmers attitude influence the adaption of water management practices and technologies. The research question was stated as:

How does farmer's attitude influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

The study question was answered by determining the relationship between farmer's attitude and the adoption of irrigation water management practices and technologies using simple linear regression model. The dependent variable was the adoption of irrigation water management practices and technologies by farmers and the independent variable was the farmer's attitude. The results of the regression model are presented in Table 4.18.

Table 4.18: Regression Model Summary for Farmers Attitude and Adoption of Water Management Practices and Technologies

R	R Square	Adjusted R Square	Std. Error of the Estimate
.287[a]	.235	.232	1.34592

a. Predictors: (Constant), farmer's attitude

The model indicates an adjusted R^2 value of 0.235; this means that the independent variable farmer's attitude explained approximately 24 % of the variation in dependent variable adoption of water management practices and technologies. The *F* test for the regression model is shown in Table 4.19.

Table 4.19: *F* Test for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p*
Regression	21.997	1	21.997	12.143	.001[b]
Residual	605.039	334	1.811		
Total	**627.036**	**335**			

a. Dependent Variable: index of adoption total
b. Predictors: (Constant), farmer's attitude

The overall regression equation was found to be significant (F (1, 334) = 12.14, p=.001). The regression coefficients of the model showing the *beta, t* statistics and the tolerance levels (*VIF*) is shown in Table 4.20.

Table 4.20: Regression Coefficients for Farmer Attitude and Adoption

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics
	B	**Std. Error**	***Beta***	***t***	***p.***	***VIF***
(Constant)	9.312	.294		31.698	.000	
Farmers Attitude	.024	.007	.287	3.485	.001	1.000

The regression analysis indicates that farmers attitude has a positive significant contribution (*β*=-.287, *p*=.001) to the adoption of water management practices and technology by farmers in Laikipia County. It was concluded that farmer's attitude significantly contributed to the adoption of water management practices and technologies by farmers.

4.7 Influence of Farmers' Knowledge on the Adoption of Irrigation Water Management Practices and Technologies

This section deals with the third objective of the study, which was stated as follows:

To explore the influence of famers' knowledge on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

4.7.1 Farmers Knowledge on Irrigated Water Management Practices and Technologies

Farmer's knowledge on irrigated water management practices and technologies was operationalized as an index that combined farmer's responses on the level of knowledge and understanding of the thirteen different irrigated water management practices and technologies. The farmers self-rated their level of knowledge of the thirteen listed items on a 5-point, with 1 representing Very Low level of knowledge on the item and 5- indicating a Very High level of knowledge on the item, the results are on Table 4.21.

Table 4.21: Indicators of Farmers knowledge on Irrigation Water Management Practices and Technologies

No	Water Management Practices and Technologies		
1	Having a pond for water storage	1.46	1.01
2	Having plastic lining for ponds and water canals	1.09	0.957
3	Use of dripline irrigation	1.42	0.907
4	Providing piped water to the homestead	2.04	1.109
5	Protecting the riparian area	1.95	1.072
6	Use of engine and pump for irrigation	0.94	1.116
7	Protecting the water source	1.68	1.222
8	Planting high value crops	2.04	1.007
9	Importance of crop husbandry	1.91	1.029
10	Formation of collective action groups to aid in water use and management	2.08	1.026
11	Spend money to purchase equipment to manage water	1.61	0.880
12	Protection from flooding	1.61	1.05
13	Increase crop production using crop husbandry techniques (spacing, crop, fertilizer)	1.27	1.109

The responses were then added together to form an index of farmer's knowledge, whose frequency distribution and descriptive statistics are shown in Table 4.22.

Table 4.22: Frequency Distribution and Descriptive Statistics of the Index of Farmers Knowledge on Irrigated Water Management Practices and Technologies

	Frequency	Percent
Below 20	22	6.5
21-30	74	22.0
31-40	48	14.3
41-50	49	14.6
51-60	27	8.0
61-70	33	9.8
71-80	39	11.6
81-90	15	4.5
91-100	10	3.0
Above 101	19	5.7
Total	**336**	**100.0**

Mean 52.6±1.55, median 45, mode 30, std. dev. 28.5, min 16, max 142

The results of Table 4.22 show that the index of farmer's knowledge had a mean of 56.2, median of 45 and a mode of 30 and ranged between 16 and 142. The index varied a lot among the farmers with a standard deviation of 28.5, this can be attributed to the different types and levels of training the farmers had undergone. A chi-square test for the equality of the categories was performed and the results are presented in Table 4.23.

Table 4.23: Chi-square Test for Equality of the Categories of Farmers Knowledge on Water Management Practices and Technologies in Laikipia County

Category	Observed N	Expected N	Residual	Statistics
Below 20	22	33.6	-11.6	χ^2= 101.20
21-30	74	33.6	40.4	*df*=9
31-40	48	33.6	14.4	*p*=.001
41-50	49	33.6	15.4	
51-60	27	33.6	-6.6	
61-70	33	33.6	-.6	
71-80	39	33.6	5.4	
81-90	15	33.6	-18.6	
91-100	10	33.6	-23.6	
Above 101	19	33.6	-14.6	
Total	**336**			

The results of the chi-square test (Table 4.23) indicate that farmers knowledge category of between 21 and 30 was significantly higher statistically (χ^2= 109.65, *df* =4, *p* =.001) than the other categories. This implies that the farmers who had a low knowledge towards the water management practices and technologies were significantly higher than the other categories.

4.7.2 Influence of Farmers Knowledge on the Adoption of Water Management Practices and Technologies in Laikipia County

The third research question of this study, sought to determine whether farmers knowledge had an influence the adaption of water management practices and technologies. The research question was stated as:

How does the farmer's knowledge influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County?

The study question was answered by determining the relationship between farmer's knowledge and the adoption of irrigation water management practices and technologies using simple linear regression model. The dependent variable was the adoption of irrigation water management practices and technologies by farmers and the independent variable was the farmer's knowledge. The results of the regression model are presented in Table 4.24.

Table 4.24: Regression Model Summary for Farmers Knowledge and Adoption of Water Management Practices and Technologies

R	R Square	Adjusted R Square	Std. Error of the Estimate
.826[a]	.682	.681	.77311

a. Predictors: (Constant), farmer's knowledge

The model indicates an adjusted R^2 value of 0.681; this means that the independent variable farmer's knowledge explained approximately 68 % of the variation in dependent variable adoption of water management practices and technologies. The *F* test for the regression model is shown in Table 4.25.

Table 4.25: *F* Test for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p*
Regression	427.405	1	427.405	715.089	.001[b]
Residual	199.630	334	.598		
Total	627.036	335			

a. Dependent Variable: index of adoption
b. Predictors: (Constant), farmer's knowledge

The overall regression equation was found to be significant (F (1, 334) = 715.08, p=.001). The regression coefficients of the model showing the *beta, t* statistics and the tolerance levels (*VIF*) is shown in Table 4.26.

Table 4.26: Regression Coefficients for Farmer Knowledge and Adoption

	Unstandardized Coefficients		**Standardized Coefficients**			**Collinearity Statistics**
	B	**Std. Error**	***Beta***	***t***	***p.***	***VIF***
(Constant)	8.220	.089		92.795	.001	
Knowledge	.040	.001	.826	26.741	.001	1.000

The regression analysis indicates that farmers knowledge has a positive significant contribution (β=-.826, p=.001) to the adoption of water management practices and technology by farmers in Laikipia County. It was concluded that farmer's knowledge significantly contributed to the adoption of water management practices and technologies by farmers.

4.8 Influence of Famers Collective Action on Adoption of Irrigation Water Management Practices and Technologies

The fourth objective of this study was to investigate the influence of collective action on the uptake of irrigation water management practices and technologies by farmers along the Ng'areng'iro river, in Lamuria location, Laikipia County.

4.8.1 Farmers Collective Action

The independent variable collective action by farmers within the Ng'areng'iro river irrigation system in Lamuria location, Laikipia County used in this study has been defined as: the behavior or action of a group of individuals working towards a common goal. For this study collective action by farmers was operationalized as the membership of farmers in water related groups and active participation in the group activities dealing with water management practices and technologies. Farmer participation in group activities included the following: (i) cleaning of water canals and intakes, (ii) payment of membership dues, (iii) management of the catchment areas, (iv) communal ownership of water resources (machinery and equipment), (v) adherence to water irrigation schedule, (vi) maintenance of water storage structures, (vii) marketing of farm produce collectively, (viii) attendance to group awareness meetings, (ix) planning of water systems. The respondents were asked to state a yes or no depending on whether they undertook one of the activities. The information was then coded into a dummy variable or 0, 1 variable. The information was summed up to form an index of collective action of individual farmers. The descriptive statistics and the frequency distribution of the index of collective action by farmer in Lamuria location are given in Table 4.27.

Table 4.27: Level of Collective Action by Framers in Lamuria Location, Laikipia County

Level of Collective Action	Frequency	Percent
1.00	22	6.5
2.00	74	22.0
3.00	48	14.3
4.00	49	14.6
5.00	27	8.0
6.00	33	9.8
7.00	39	11.6
8.00	15	4.5
9.00	10	3.0
10.00	19	5.7
Total	336	100.0

Mean 4.5±.13, median 4, mode 2, standard deviation 2.52, minimum 1, maximum 10

The level of farmer’s collective action index had a mean of 4.5. The minimum level was one (1) indicating very low level of participation in collective action activities, while the maximum was ten (10) indicating a very high level of farmer participation in collective action activities. The levels of collective action by farmers in Lamuria were analysed using the Chi-square test to determine the equality of the different categories of the levels of collective action and the results are given in Table 4.28.

Table 4.28: Chi-square Test for Equality of the Categories of Level of Group Participation in Water management Practices and technologies in Laikipia County

Scale	Observed N	Expected N	Residual	Statistics
1.00	22	33.6	-11.6	χ^2= 101.20
2.00	74	33.6	40.4	*df*=9
3.00	48	33.6	14.4	*p*= 001
4.00	49	33.6	15.4	
5.00	27	33.6	-6.6	
6.00	33	33.6	-.6	
7.00	39	33.6	5.4	
8.00	15	33.6	-18.6	
9.00	10	33.6	-23.6	
10.00	19	33.6	-14.6	
Total	**336**			

The chi-square test indicates that the majority of the farmers had a score for level of participation in collective action activities that was termed as Low with a level of two (2). These results were found to be statistically significant (χ^2 101.20, *df* 9, *p* .001).

4.8.2 Influence of Collective Action on Farmers Adoption of Irrigation Water Management Practices and Technology

The fourth research question of this study, tested whether collective action by farmers had a significant influence on the level of farmers adoption of irrigation water management practices and technologies in Laikipia County. The research question was stated as:

Is there a statistically significant influence of collective action on farmers adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location in Laikipia County?

The study question was answered using simple linear regression model. The dependent variable was the level of farmers adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County and the independent variable was the level of Farmers collective action. The results of the regression model are presented in Table 4.29.

Table 4.29: Regression Model Summary for Collective Action and Farmers Adoption

R	R Square	Adjusted R Square	Std. Error of the Estimate
.815[a]	.664	.663	.79370

The model indicates an adjusted R^2 value of 0.663; this means that the independent variable collective action explained approximately 66 % of the variation in dependent variable Farmers adoption. The *F* test for the regression model is shown in Table 4.30.

Table 4.30: *F* Test for the Regression Testing the Fit of the Model

	Sum of Squares	*df*	Mean Square	*F*	*p*
Regression	416.628	1	416.628	661.354	.001[b]
Residual	210.407	334	.630		
Total	627.036	335			

The results show an overall regression equation that was significant

(F (1, 334) = 661.35, p=.001). The regression coefficients of the model showing the *Beta, t* statistics and the tolerance levels (*VIF*) is shown in Table 4.31.

Table 4.31: Regression Coefficients for Collective Action and Farmers Adoption

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics
	B	Std. Error	*Beta*	*t*	*p*	*VIF*
(Constant)	8.312	.089		93.674	.001	
Collective Action	.441	.017	.815	25.717	.001	1.000

The regression analysis indicates that the level of farmers collective action had a positive significant influence (*β*=-.815, *p*=.001) on farmers adoption of irrigation water management practices and technologies. The level of farmer's adoption of irrigation water management practices and technologies was significantly increased by the increase in collective action activities.

4.9 Land size and Farmers Adoption of Irrigation Water Management Practices and Technologies

The fifth objective of this study endeavored to determine the influence of the size of land owned by the famer on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location in Laikipia County?

4.9.1 Irrigated Land Size Owned by Farmers

Land size was operationalized as the area under cultivation using irrigation water from the Ng'areng'iro river in Lamuria location in Laikipia County. The frequency distribution of the land size categories owned by the farmers and the descriptive statistics are shown in Table 4.32.

Table 4.32: Irrigated Land Size Owned by Farmers

Land size Categories in ha	Frequency	Percent
.01-1	34	10.1
1.01-2	101	30.1
2.01-3	136	40.5
3.01-4	27	8.0
4.01-5	12	3.6
5.01-6	26	7.7
Total	**336**	**100.0**

Mean 2.3, median 2, mode 1.2, standard deviation 1.29, minimum .40, maximum 6.

4.9.2 Influence of Land size on Farmers Adoption of Irrigation Water Management Practices and Technologies

The fifth research question of this study, tested whether the size of irrigated land owned by farmers had a significant influence on the level of farmers adoption of irrigation water management practices and technologies in Laikipia County. The research question was stated as:

Does the size of land owned by the farmer influence their adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

The study question was answered using simple linear regression model. The dependent variable was the level of farmers adoption of irrigation water management practices and technologies along the Ng'areng'iro river in Lamuria location, Laikipia County and the independent variable was the size of irrigated land owned by the farmer. The results of the regression model are presented in Table 4.33.

Table 4.33: Regression Model Summary for Land Size and Farmers Adoption

R	R Square	Adjusted R Square	Std. Error of the Estimate
.840[a]	.706	.705	.74307

The model indicates an adjusted R^2 value of 0.705; this means that the independent variable irrigated land size explained approximately 71 % of the variation in dependent variable Farmers adoption. The *F* test for the regression model is shown in Table 4.34.

Table 4.34: *F* Test for the Regression Testing the Fit of the Model

	Sum of Squares	***df***	**Mean Square**	***F***	***p***
Regression	442.617	1	442.617	801.625	.001[b]
Residual	184.418	334	.552		
Total	627.036	335			

The results show an overall regression equation that was significant

(*F* (1, 334) = 801.62, *p*=.001). The regression coefficients of the model showing the *Beta*, *t* statistics and the tolerance levels (*VIF*) is shown in Table 4.35.

Table 4.35: Regression Coefficients for Land Size and Farmers Adoption

	Unstandardized Coefficients		**Standardized Coefficients**			**Collinearity Statistics**
	B	**Std. Error**	***Beta***	***t***	***p***	***VIF***
(Constant)	8.203	.085		97.035	.001	
Land Size	.360	.013	.840	28.313	.001	1.000

The regression analysis indicates that the size of irrigated land owned by farmers had a positive significant influence (*β*=-.840, *p*=.001) on farmers adoption of irrigation water management practices and technologies. The size of land owned by farmers influenced their adoption of irrigation water management practices and technologies.

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter consists of five sections, which include; the discussion, conclusion, recommendation and recommendation for further research.

5.2 Discussion

The study findings for this study are discussed based on the specific objectives stated in section 1.4 of this thesis.

5.2.1 Influence of Farmers' Socio-economic Factors (Age, Gender, Income and Education level) on the Adoption of Irrigation Water Management Practices and Technologies along Ng'areng'iro river

The relationship between the socio-economic factors and the adoption of irrigation of water management practices and technologies was found to be statistical significant. The highest academic level of household heads, household income per month and household number had positive significant influences on the farmer's adoption of irrigation water management practices and technologies, while negative significant influences were found between farmer's age and the adoption of practices.

Majority of the decision making within the community whether on land use or on land use practices is often determined by the mea. While women provide labor and often make small decisions within the homestead, investment in irrigation and other farm practices can only be carried out with the assistance and in fact under direction of the men. Where a husband is missing, decisions are transferred to sons, fathers and brothers who assist in providing what is considered ideal decision making (Bjornlund 2002).

What is of concern is that women are often more recipient to change and training that could help in building a sustainable production foundation.

Age of respondents: The majority (83.4 %) of the farmers were below 53 years, Adeoti (2008) in his study found that the younger generation in Kenya, below the age of 30 often frowns on agriculture especially where such farms are located in rural areas instead, they seek out formal employment as a preference. Agriculture and farming is highly sought by individuals who are middle aged, nearing the age of retirement as they seek a secondary source of income. However, the younger population are often the first and most willing to adopt changes and take up new roles. They are more experimental and often seek higher production with minimal labor. They also understand the basics of environmental protection. They are therefore more likely to adopt irrigation practices. On the other hand, the older generation seem to be rooted in tradition and customs. They often have no interest in changing their traditional systems. Namara et al. (2007) in his study found that where older generations have made changes in farming practices, it is often following the urging and direction of younger more educated children. In majority of the cases however, the older generation farmers are often only willing to make minimal change where forced to.

Level of education: the data showed that the highest level of education common among the respondents (45.8%) is completion of primary school education, closely followed by 26.4% secondary school leavers. Genius *et al.* (2014) indicates that education level is an important factor in irrigation adoption. This is mainly because the farmers need to understand the basic technology as well as the importance of such investment. Education is globally considered a vital tool for combating poverty. The adoption of improved agricultural technologies and embracing of new development projects are significantly affected by educational attainment. The irrigation farmers' level of education is an important factor that determines their ability to understand policies or programmes that affect farming (Adesina and Ouattara, 2000). According to Umar (2016), this category of literate farmers will probably be more productive because their level of education will enable them to make inquiries as regards new innovations in farming. Due to their level of education and exposure, their farm produce could be much better compared to others with lower levels of education. Also, other colleagues could go to them for advice and information because they are among the early adopters of innovation since they are highly education.

5.2.2 Influence of Famers Attitude on the Adoption of Irrigation Water Management Practices and Technologies along the Ng'areng'iro River

The farmers attitude towards the irrigation project was found to have a positive statistical significant influence on the adoption of irrigation water management practices and technologies along the Ng'areng'iro River.

The data showed that the farmers who had a Poor attitude towards the water management practices and technologies were significantly higher than the other categories. According to Khanpae et al. (2020) poor attitudes towards water management can be born out of the belief that water is readily available especially where the community is settled near a water source. Even as the levels of water in the river begin to diminish, the focus is not on managing water use but rather on ensuring maximum usage. This according to Ostrom (1990) forms the basis of the tragedy of the commons. The tragedy of the commons occurs when a community own a resource that they must use together. Everyone seeks to get maximal benefits from the resource. everyone also assumes that every other person is maximizing their profit from the use of the resource. The problem is that no one really concerns themselves with caring for and maintaining the quality of the resource. This poor attitude causes individuals to develop a poor attitude towards water management technologies. Kulshreshtha and Brown (2003) suggest that adopters' attitude, particularly with respect to economic and environmental effects of irrigation, were significant determinants of their decision to proceed with adoption of irrigation, and have a role to play in adoption of irrigation over and above that explained by socio-economic characteristics. These results suggest that negative perceptions with respect to economics of irrigation and those related to its detrimental impacts on environmental quality, particularly through soil salinity, may be significant deterrents for adoption of irrigation. For majority of the famer's new irrigation technologies seem to be an extra cost which they cannot afford, and to many remains unnecessary as well as difficult to maintain. Further. Farmers often have the attitude that small changes effected in their individual farms have no significant influence in the water and soil quality. For the extension officers, the biggest challenge encountered in their daily farm visits is the attitudes of the farmers which seem to have vested and lack any possibility of change.

5.2.3 Influence of Famers Knowledge on Water Use Efficiency on the Adoption of Irrigation Water Management Practices and Technologies along the Ng'areng'iro River

Farmer's knowledge on water use efficiency was found to have a positive statistically significant influence on the adoption of irrigation water management practices and technologies.

In irrigation, Water Use Efficiency (WUE) represents the ratio between effective water use and actual water withdrawal. It characterizes, in a specific process, how effective is the use of water. Efficiency is scale and process dependent. Along a canal, the conveyance efficiency is the ratio between the volume of water at delivery points and inflow at entrance. At field level, effective water use is the water transpired by the crop and some other special requirements (land preparation, salt leaching). Runoff, deep percolation and evaporation from bare soil or standing water in paddy fields, are losses. The results of the chi-square test (Table 4.23) indicate that farmers knowledge category of between 21 and 30 was significantly higher statistically (χ^2= 109.65, *df* =4, *p* =.001) than the other categories. This implies that the farmers who had a low knowledge towards the water management practices and technologies were significantly higher than the other categories. Whittlesey (2003) provides a two pronged explanation to what maybe the reason behind this. First, there are few extension officers who take the time to understand and explain the process of water use efficiency in a manner that the farmers understand. This means that the farmer remains in a state where they do not understand both how and why they should adopt new water use techniques. Secondly, because of the low level of education among farmers, water use efficiency methods such as pond building often seem like an unnecessary expense. The challenge comes in understanding the basic importance of the development of an efficient water use system.

Karami (2006) studied both adopters and non-adopters in farming techniques. He found that knowledge, or rather previous knowledge however basic played a crucial role in advancing the adoption of various techniques. With basic knowledge, farmers are more comfortable in seeking more information and also show more willingness to learn and adopt new techniques. Where previous knowledge is non-existent even the most basic of techniques can in itself seem to be too difficult and complex and therefore fall on the realm on unmanageable. Tuberosa et al. (2007) further indicates that it is important for all new technology to be introduced on the basis or building on the concepts of previous behavior and traditional knowledge. This makes it seem more approachable and easier to understand which in turn ensures a higher success rate-. When farmer believe they can understand the concepts of the technology they are more likely to develop a positive attitude towards the same. They are also willing to invest time and resources in learning more about the technology since they have a belief that in the end they will understand all premises.

5.2.4 Influence of Farmers Collective Action on the Adoption of Irrigation Water Management Practices and Technologies along the Ng'areng'iro River

Farmer's involvement in collective action groups and activities had a positive significant influence on the adoption of irrigation water management practices and technologies.

Even though, different authors agreed on the argument that collective action can solve the problem in common pool resource management, there are different argumentations and approaches on its implementation (Ostrom, 1990). And there are different determinant factors which are affects its accomplishment. Incentives or benefits which materialize from the common resource and coercions, and the level and type of participation of water users in irrigation system activities are some of the potential determinants for the sustainability of the system management by performing collective action. Sustainable collective action often requires two main elements: willingness to participate and willingness to invest in the process of action.

Collective action is the state where farmers identify a need within the community, in this case scarcity of water and bring together their efforts to find ways in which to govern and control resources so that they can reap maximum benefits and resolve their need. According to Parthasarathy and Chopde (2000) and Meinzen-Dick et al. (2002) as settlements have increased and farming activities intensified along the river bed, water resources have become scarcer. The river volume continues to decrease causing farmers to either engage in drastic measures to harvest water or in turn invest in alternative sources. The problem of water scarcity can be addressed by providing governing rules for water users and establishing roles of maintenance, through collective action. However, Marshall (2013) indicates that collective action in itself requires voluntary commitment. Community members and individuals must not only be willing to engage in action but also incur the costs that come with participation and maintain the same for a period of time. Knox et al. (2009) further states that since the water availability in a system is limited by the capacity of diversion from the river flow, it is exhaustible through overexploitation. Thus, abuse by farmers in upper streams creates a negative externality for downstream farmers. Yet, no incentive mechanism exists to prevent an individual user from abusing water because water take-in to his/her field cannot be metered and, hence, is not chargeable in proportion to his/her consumption. It is costly to organize actions to save water (by such means as rotating water supply among users) or to augment water supply (by such means as removing silts and cutting weeds in canals) because everyone is tempted to free ride on others' conservation activities.

5.2.5 Influence of Land Size Owned by the Farmers on the Adoption of Irrigation Water Management Practices and Technologies along the Ng'areng'iro River

Irrigated land size owned by farmers was found to have a statistical significant influence on farmer's adoption of irrigation water management practices and technologies. This could be attributed to the assumption that such farmers are often more willing to invest in new technologies that may decrease effort and enhance productivity in their farms. Mendola (2007) in his study found that farmers with large tracts of land and longer ownership, were more willing to invest in long term care and maintenance of common resources. This is mainly because, a large percentage of their income would be affected by the probability of water scarcity and loss of farm produce. Further, such farmers were often more directed towards commercial farming, thereby more willing to take risks to enhance their own farm productivity. Production yield often increases with every new irrigation technology that is introduced, leading to the belief that large tract farmers are more likely to be enthusiastic about irrigation.

Churchid et al. (2017) further notes that reasons behind the positive correlation maybe more psychological than economic. The study makes the suggestion, that small scale farmers often feel that their water consumption is much lower in comparison to large scale farmers. They feel that the large scale farmers benefit more from the use of the common water resource. As such, they feel that not only are they not likely to benefit from adopting irrigation techniques, they may in turn increase the benefit for large scale farmers. In addition, they may carry the assumption that small scale farming has little to no effect on the water volume and quality. The small scale farmers may therefore feel that the investment in irrigation technology is unnecessary and unwarranted, and should be undertaken only by the large scale farmers who benefit more from the resource.

5.3 Summary of Main Findings

The relationship between the socio-economic factors and the adoption of irrigation of water management practices and technologies was found to be statistically significant. The highest academic level of households, household income per month and household number had positive significant influences on the farmer’s adoption of irrigation water management practices and technologies, while negative significant influences were found between farmer’s age and the adoption of practices.

The farmers attitude towards the irrigation project was found to have a positive statistically significant influence on the adoption of irrigation water management practices and technologies along the Ng’areng’iro River.

Farmer’s knowledge on water use efficiency was found to have a positive statistically significant influence on the adoption of irrigation water management practices and technologies.

Farmer’s involvement in collective action groups and activities had a positive significant influence on the adoption of irrigation water management practices and technologies.

Irrigated land size owned by farmers was found to have a statistically significant influence on farmer's adoption of irrigation water management practices and technologies.

5.4 Conclusions

The following conclusions were made from the study objectives:

First objective; Farmer's socio-economic factors (age, gender, income, education level) had statistical significant influence on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

Second objective; Farmers' attitude towards the irrigation project had statistical significant influence on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

Third objective; Farmer's knowledge on water use efficiency had statistical significant influence on the adoption of irrigation water management practices and technologies

Fourth objective; Famers collective action had statistical significant influence on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

Fifth objective: Irrigated land size owned by the farmers was found to have statistical significant influence on the adoption of irrigation water management practices and technologies along the Ng'areng'iro river, in Lamuria location, Laikipia County.

5.5 Recommendations

An integrated irrigation water management plan for the Ng'areng'iro river, in Lamuria location, Laikipia County will need to be drawn and its application be co-ordinated by a government agencies involved in water and crop production in partnership with the community or the Water Resources Users Association (WRUA), the plan will involve the following policy measures:

(i) Creation of collective action groups that will supervise the cleaning of the main canal and regulate sediment deposition and canal erosion

(ii) Water supply management plan to cover all the irrigation plots in a synchronized manner. A time table for water distribution can be made in line with the crop water requirement as per accepted standards.

(iii) The collective action groups can be used in purchasing of equipment by combining their resources and training farmers on how to efficiently use them

(iv) A programme of training farmers using one of the extension practical approaches such as farmer to farmer or extension officers to farmers (or other relevant approaches) to enhance farmer's knowledge on water use efficiency.

(v) Crop management programme, where the farmers will be encouraged to choose the right crops, grow, market them effectively.

(vi) Have Public-Private Partnerships (PPP) to provide farmers with finances at affordable rates to enable them develop good irrigation management practices on their farms. The increased incomes derived from the farms or agroecosystems from the increase in environmental services (especially water quantity and quality due to the implementation of these measures will provide the farmers with extra income to repay the loans and also improve on the household financial capital,

(vii) The plan will involve integration of practices (water, crops, soil, and plot) to create a combined set of sustainable land and water intensification practices. The combining of the technologies will provide a more intense programme as the practices will complement one another.

The management practices and technologies to be adopted will be selected from the following irrigation water management list, which is not exhaustive:
river bank protection, controlling water abstraction, controlling sand harvesting in the river, pollution control, canal management, soil and water conservation, water application to crops, application of fertilizers to crops, choice of crops, marketing of crops, land preparation, irrigation furrows.

5.6 Recommendations for Further Studies

The following are recommended to be done for further research within the Ng'areng'iro river irrigation scheme:

(a). Determine the economics of all activities and practices undertaken by the farmers to ascertain their viability and their impact on the wellbeing of the people.

(b). Determine farmer's needs and requirements in terms of knowledge and capacity for improving on the water management efficiency.

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APPENDICES

Appendix A: Questionnaire for Farmers

Introduction

My name is **Justus Mutiso**: A Master of Science student from Africa Nazarene University. I am conducting a research study entitled ***"Factors Influencing the Adoption of Irrigation Water Management Practices and Technologies by Farmers along the Ng'areng'iro River In Laikipia County, Kenya"*** You have been identified and selected for this study. The purpose of this questionnaire is to request you to participate in this study by providing the information sought. The information obtained will be strictly for academic purpose and shall be treated with utmost confidentiality.

Instructions

Please answer all questions appropriately and tick (☑) *all that apply*

Part I: Demographic Information

Age: ______________________

Section A: Bio Data

i) Personal Identification

Name…..…………………………………………………………………….

Cell phone No: ………………………………………………………….

Age……………………………………………………………………

Gender …………………………………………………………..

Ethnic Community………………………………………………………………….

Title ………………………………………………………………………..

Occupation……………………………………………………………….

ii) Highest academic qualification attained **(tick appropriately)**

Ph.D. /Master's degree /Bachelor's degree/ Diploma/ secondary/ primary/ did not go to school/ Other (specify)…………………………………………………………

iii) Income sources: Farming (Yes/No); Formal employment (Yes/No); Business (Yes/No); Labourer (kibarua) (Yes/No); Remittances (Yes/No); _______________

iv) Income per month _________________________________

v) Do you have finances to purchase irrigation equipment: (Yes/No)

vi) Household numbers ____________________

vii) Distance to your homestead (km) ___________________

Section B: Farming system

(i) Number of years' experience in farming activities (please state the appropriate number of years) _____________

(ii) Which year did you start farming at the river ___________________

(iii) Size of your farm _________________________

(iv) Area currently farming on ______________

(v) Farm ownership (Own/Rented/ Borrowed/ an empty plot)

(vi) Crops grown under irrigation:

Crop	Acreage	Average production	Where marketed
Onion			
Chilies			
Sukuma			
Tomatoes			
French beans			
Maize			
Beans			

Section C: Crop husbandry techniques used

(i) Right spacing of crop on farm: (Yes/No)

(ii) Fertilizer application: (Yes/No)

(iii) Use of certified seeds: (Yes/No)

Section E: Collective Action Groups

(i) Membership to group (Yes/No)

(ii) Number of groups you are a member ______________________

(iii) Name of groups ______________________________________

(iv) Group activities: irrigation activities (….) marketing of crops ( ); transport provision ( ); loans ( ); merry go round ( ); burial ( ); other name them __________________________________

(v) Any WRUA (Water Resource Use Association) in the area (Yes/No)

(vi) Name of WRUA ________________________

(vii) Member of the WRUA (Yes/No)

(viii)

Section F: Irrigation Water Use Efficiency

(i) Type of irrigation system used: drip ( ); furrow ( ); sprinklers ( ); flooding ( ); water can use ( ); other name them ____

(ii) Energy use: gravity ( ); diesel engine and pump ( ); foot pump ( ); solar ( ); petrol engine and pump ( ); other name them ____

(iii) Availability of storage facility: (Yes/No)

(iv) Type of water storage facility __________________________________

(v) Protection from flooding on the farm: (Yes/No),

(vi) Method used in flood protection ____________________

(vii) Protection of water from seepage and evaporation:

Lining of the canals (Yes/No),

Lined ponds/dams (Yes/No)

Protection of riparian area (area next to the river banks)

(i) Protection of riparian area from erosion: (Yes/No)

(ii) Protection of the riparian area from animals: (Yes/No)

(iii) Planting of protection vegetation cover: (Yes/No)

Section G: Attitude towards irrigation water management practices and techniques

Agree or disagree with the following statements related to water use management, using the following rating scale:

1=Strongly Disagree, 2=Disagree; 3=Moderately Agree; 4=Agree; 5=Strongly Agree.

Water management practices and technologies	**Rating**				
	1	**2**	**3**	**4**	**5**
Having a pond for water storage					
Having plastic lining for ponds and water canals					
Use of dripline irrigation					
Providing piped water to the homestead					
Protecting the riparian area					
Use of engine and pump for irrigation					
Protecting the water source					
Planting high value crops					
Importance of crop husbandry					
Formation of groups to aid in water use and management					
Spend money to purchase equipment to manage water					
Protection from flooding					
Increase crop production using crop husbandry techniques (spacing, crop, fertilizer,)					

Section H: Knowledge on water management technology and practices

(i) Are you trained in water use management practices: (Yes/No)

(ii) Where were you trained: (Yes/No)

(iii) Length of training: (Yes/No)

(iv) Have you visited other farmers undertaking irrigation agriculture: (Yes/No)

(v) Gauge your level of knowledge on the following practices related to irrigation water management on a scale of 0 to 5 (0= no knowledge, 4 =high knowledge)

Water management practices and technologies	**Rating**				
	0	**1**	**2**	**3**	**4**
Making ponds for water storage					
Putting plastic lining for ponds and water canals					
Use of dripline irrigation					
Piping water to homes and farms					
Protecting the riparian area					
Use of engine and pump for irrigation					
Protecting the water source					
high value crops					
knowledge of crop irrigation					
Formation of groups					
Cost of purchasing equipment to manage water					
Protection from flooding					
crop husbandry techniques (spacing, crop, fertilizer)					
Location of the pumps					

Appendix B: NACOSTI Letter

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/18/46444/25761**

Date: **9th October, 2018**

Justus Mutavi Mutiso
Africa Nazarene University
P.O. Box 53067-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of the factors influencing the adoption of irrigation water management practices and technologies by farmers along the Ngarengiro River in Lakipia County Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Laikipia County** for the period ending **9th October, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Laikipia County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Laikipia County.

The County Director of Education
Laikipia County.

Appendix C: NACOSTI Permit

THIS IS TO CERTIFY THAT:
MR. JUSTUS MUTAVI MUTISO
of AFRICA NAZARINE UNIVERSITY ,
0-200 Nairobi ,has been permitted to
conduct research in Laikipia County

on the topic: ASSESSMENT OF THE FACTORS INFLUENCING THE ADOPTION OF IRRIGATION WATER MANAGEMENT PRACTICES AND TECHNOLOGIES BY FARMERS ALONG THE NGARENGIRO RIVER IN LAKIPIA COUNTY KENYA

for the period ending:
9th October,2019

Applicant's
Signature

Permit No : NACOSTI/P/18/46444/25761
Date Of Issue : 9th October,2018
Fee Recieved :Ksh 1000

Director General
National Commission for Science,
Technology & Innovation

Appendix D: Field photos

The *Ng'areng'iro River* and irrigation plots next to the river

An irrigation plot belonging to a famer and using water Ng'areng'iro River

A farm plot located on the sloping part of the river bank. A wrong paractice

The water pump house. The pump removes water from the river and directs it to the farmer plots

The Ng’areng’iro river banks, showing erosion on the banks

A Farmer plot along the Ng’areng’iro River. Vegetables and maize in the background