An assessment of Integrated Water Resource Management (IWRM) Approach for Reducing Food Insecurity in Drylands: A case of Kikuu River Sub-Sub-catchment, Makueni County, Kenya

By

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C50/77700/2017

A Project paper submitted in partial fulfillment of the requirements for the Degree of Masters of Arts in Environmental Planning and Management, Department of Geography and Environmental Studies of the University of Nairobi.

May 2017

DECLARATION

I declare that this research project is my own original work and has never been presented for award of a degree in any other institution.

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DEDICATION

This project is dedicated to my dear parents, brothers and sisters for being there for me all the time.

ACKNOWLEDGEMENT

I wish to extend my sincere thanks to my supervisors, Dr. Wambua and Dr. Kithiia for their invaluable comments, constructive criticisms and scholarly guidance that enabled me to undertake and complete this work. I am also profoundly indebted to the University of Nairobi for the opportunity to undertake my Masters course at the Department of Geography and Environmental Studies.

I am grateful to the household respondents at Kikuu river Sub-catchment and the key informant respondents at Makueni County government, WRMA, NEMA and the water sector CSOS for their willingness to participate in giving information in the entire period of my data collection. I would like to thank my field assistants and my academic mentors for their unconditional support towards the completion of my studies.

I cannot forget to thank my dear parents for molding and taking care of me from the time I was born. I recognize the role they played in my upbringing and provision. Indeed, without their support I would not have made it to this level. My gratitude also goes to my brothers and sisters, colleagues and friends for their unwavering support and encouragement throughout my studies.

Above all, I would like to thank God for his unfailing love, unlimited provision and sustainability.

LIST OF ACRONYMS

CSOs: Civil Society Organizations

CBO: Community Based Organization

CESPAD: Centre For Social Planning and Adminstrative Development

FAO: Food and Agricultural Organization of the United Nations

GIS: Geographical Information Systems

GOK: Government of Kenya

GWP: Global Water Partnership

HDI: Human Development Index

IWRM: Integrated Water Resource Management

LRA Long Rains Assessment Report

MWI: Ministry of Water and Environment

MUAC: Mid Upper Arm Circumference

MDGs: Millennium Development Goals

MWI: Ministry of water and Irrigation

NDMA: National Drought and Management Authority

NEMA: National Environmental Management Authority

WRMA: Water Resources Management Authority

WLNET: Water and Livelihood Network

WRUAs: Water Resource Users Associations

SCAMP: Sub Sub-catchment management Plan

SDGs: Sustainable Development Goals

SLM: Sustainable Land Management

SWC: Soil and Water Conservation

TARDA: Tana Athi River Development Authority

UN: United Nations

UNEP: United Nations environmental Development

UNDP: United Nations Development Programme

USAID: United States Agency for International Development

ABSTRACT

This research focused on assessment of effects of integrated water resource management on household food production. The key area of the study was Kikuu River Sub-catchment in Nzaui-Kalamba ward of Makueni County Kenya. The main aim was to investigate the effects of integrated water resource management on food security in drylands. Specifically, the research aimed at determining the local water resource management approaches in Makueni County and their contribution to food security. It also aimed at exploring the level of adoption of IWRM approach for environmental conservation and its effect on household food productivity and livelihood and investigate the Irrigation efficient methods used by the farmers in Kikuu River for irrigated farming and improved household food production. To address the study objectives, both primary and secondary data was collected and analyzed. Structured open-ended questionnaires and key informant interviews were used to collect primary data from households and key informants to get their views on adoption of IWRM and water efficient irrigation methods and their effects on food security and livelihood of farmers and other benefits to dry lands community. The study applied qualitative and quantitative data collection methods. Primary data was collected from a sample of 99 households drawn from 16400 households of Kikuu River Sub-catchment by use of an open-ended questionnaire. A Simple random sampling method was used to recruit the study respondents. Secondary data was obtained from official government reports, water sector and livelihood CSO reports and academic journals. The data collected was analyzed both using descriptive statistics such as the mean, percentages and elaborated in tables and graphs. The data was analyzed by use of Chi-square inferential statistics technique and tested at the 95 % confidence level (α=0.05)

The adoption of water irrigation efficient methods such as basin/Zypit and terraces promoted livelihood and household food production. Sustainable best practices that included conservation of riparian land, construction of the rain water harvesting structures and local conservation techniques such as the construction of terraces helped increase food production and livelihood of the community in the study area. The study also indicated that sustainable best practices improved farmers livelihoods as they could practice both commercial and subsistence agriculture. The null hypothesis was rejected since the research established that the statistical/calculated value was greater than the critical value. The calculated value was 45.99 while the critical value was 31.41. Therefore, the alternative hypothesis was adopted, and the

researcher concluded that there is a significant relationship between the adoption of IWRM and household farm produce. Therefore, the approach can be replicated in the other parts of the county and various river Sub-catchments in Kenya. The Study came up with the following Key recommendations; Water Regulatory Authority (WRA) previously known as WRMA in Water Act 2002 to engage with the relevant stakeholders towards Practice of Basin approach/IWRM in water management through forming and strengthening WRUAs in various Sub-catchments of Kenya. Water sector CSOs to invest in community rainwater harvesting structures and construct sand dams along Kikuu River to increase household water supply for domestic use and Irrigated farming so as to reduce the impact of food insecurity and improve the community livelihood.

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1.0 CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter sets out the overall study about Integrated Water Resource Management for food security in dry lands. A background of the study is discussed followed by brief discussion of the problem statement of the project. Study objectives and questions are also given. Finally, the justification, scope and definition of terms that are mainly used in the project are given.

1.2 Background of the Study

United Nations Organization defines food security as adequate and safe food supply at the household level (United Nations, 2010). Parameters of Food Security includes; Availability, the degree of access to services and stability of prices and supply of food products (FAO, 2012).

Food security has been an essential concern for global development and poverty reduction (Vink, 2012). Glopolis, (2013) noted that food security concept has changed from availability to accessibility. It is also expected that increase in population shall rise from 7 to 9 billion rising the number of food-insecure people (Rayfuse & Weisfelt, 2012).

Food security is a fundamental human need and a principal indicator of physical well-being (Patel, *et al.*, 2012). The economic performance can be increased by addressing drought and famine challenges. However, unequal management of natural resources has made the poor hungry (Jenkins & Scanlan, 2001). For instance, highest Global Hunger Index that were experienced in South Asia (IFPRI, 2012). In Sub-Saharan region, one person in four experience chronic hunger (Grebmer, *et al.*, 2010) and Africa is experiencing the highest number of food emergencies (FAO, 2006).

Despite the enormous progress, even today, about 800million people live in extreme poverty and hunger (Chu, 2009). UN, (2015) noted that over 160 million children have the low height for their age due to food insecurity and above 40 percent of the people in sub-Saharan Africa are affected by extreme poverty. About 44% of Kenyans are undernourished and experience high child mortality rate resulting from iron-deficiency, and lack of other important vitamins (FAO, 2012). In reality, Kenya is food insecure as a result of environmental degradation, climate change and overdependence on rain-fed agriculture (Rutten & Aarts, 2013).

Water is a key driver of efficient farm productivity, economic and social well-being of the least developed nations (World Bank, 2010). It helps ensure the protection of water, environment and other ecosystem assets (Stirzaker & CSIRO, 2010). Due to competition for water uses, leaders in the government other private partners, have to make good decisions on water allocation (Gumede, 2009). Policy makers should ensure equitable supplies to the ever-increasing demands of water for irrigated farming and other domestic use (Ganoulis, *et.al,* 2013). Shift from rain-fed agriculture to irrigated farming to feed the rapidly growing population has further increased the stress on water resources (World Environmental Congress, & Starrett, 2009). The traditional fragmented water management approach is no longer viable hence the call for a more holistic and coordinated approach (Perret, 2012).

Integrated Water Resources Management (IWRM) is an approach that is accepted globally for an equitable and sustainable use of water and other natural assets (Roy *et. al.* 2009). It is an empirical concept which concerns the inclusion of grass root partners in water management (World Bank, 2010). The IWRM idea was operationalized after Agenda 21 and the global summit concerning sustainable growth that was held in 1992 (In Paron, *et.al,* 2009).

The Kenyan water sector has undergone substantial changes and development in the past 15 years and, given the necessary adjustment to the new dispensation of devolved government (FAO, 2014). The National Water Policy 1999, the Water Act 2002 introduced a clear separation of water regulatory and service roles. This included the establishment of the Water Resources Management Authority (WRMA) at the national level and its regional and sub-regional offices (Water Act, 2002).

For participation of users and their empowerment, the law also provided for the formation of Water Resource User Associations (WRUAs). The WRUA Development Cycle (WDC, 2014) defines WRUA as an Association of Water Users and partners who have and voluntarily associated for the purpose of cooperatively managing and using a shared water source.

With the formation and enforcement of the Constitution of Kenya (COK) 2010 that puts more emphasis on public participation, further structural changes have been suggested, and efforts have been made to align the water sector with COK 2010. In this line, a draft National Water Policy was developed in 2012. To give effect to this, Water Act 2016 has been participatory

prepared and enactment. Section 27 of the Water Act 2016 clearly stipulates the mandate and activities of WRUAs. WRUAs have since become a pivotal stakeholder engagement mechanism in WRM in Kenya, with a role of water resource management at the sub-Sub-catchment level.

The water Act 2016 gives a clear structure of water management in that, the water Resource management remains a national government role through Water Regulatory Authority (WRA) previously known as WRMA and WRUAs are given the mandate to manage water Resource at Sub-catchment level. On the other hand, water services have been devolved and remain County government role (Water Act, 2016). Therefore, the researcher adopted the concept of IWRM strategy that ensures holistic and coordinated management of water, land and related resources for sustainable growth (GWP, 2004).

1.3. Research Problem Statement

Uncontrolled harvest of natural assets/ resources that include forest, sand, and land in the study area has resulted to severe land degradation and poor food production hence food insecurity in Makueni County. The households in Kikuu river sub-catchment mainly depend on rain-fed food production and overexploitation of sand and forest (Van Steenburgen & Tuinhof, 2010).

They keep livestock on their land that is not sustainable because they also rely on rain-fed fodder for the animals. In this light, there is need to invest in water for food and contribute to the Sustainable Development Goals (SDGs) (United Nations, 2010).

Merreyet, *et al.,* (2005) argue that improved water resources management can improve rural livelihoods. The water resources management and food security nexus is not clear in Makueni County (Mupangwa, *et al.,* 2008). Water resources management discussions have been done but no attention on its link with food security in the study area. This calls for the need to understand water resources management and food security nexus in Kikuu Sub-catchment Makueni County. Advocates of Integrated Water Resource Management such as the Global Water Partnership suggest that IWRM framework provide socio, economic and ecological benefits (GWP, 2000).

However, it is necessary to meditate and question, Is IWRM able to improve food production? Global water Partnership, 2013 did a technical research paper on IWRM and food security in

India and China. The paper reports that IWRM has been of great importance in improving agriculture and food production in India and China. This study, therefore, aimed at understanding the role of various stakeholders in the conservation of water and environment in Kikuu River sub- catchment and IWRM –food security nexus in Kikuu sub-catchment.

1.4 Objectives of the Study

The study focused on one general objective and three specific objectives as discussed in the following sub-sections.

1.4.1 General Objective

To examine IWRM approach and its contribution to food security and livelihood in dry lands, a case of Kikuu River Sub-Sub-catchment in Makueni County.

1.4.2. Research Specific Objectives

The specific objectives were:

1 To explore the level of adoption of IWRM approach for environmental conservation and its contribution to household food security.

2 To determine the local water conservation approaches in the study area and their contribution to food security.

3 To investigate the Irrigation efficient methods used by the farmers in Kikuu River for irrigated farming and their contribution to food security.

1.5 Study Key questions

The research aimed at improving the water resources management –food security nexus. The key research questions were:

1. Is the adoption of IWRM an efficient approach for reducing food insecurity in dry-lands?
2. What are some of the local conservation practices in Kikuu River Sub-catchment and their effect on food production?
3. What are the irrigation water efficient methods applied by the agribusiness farmers at the Kikuu River Sub-catchment and their contribution to food security?

1.6 Study Hypothesis

The study was based on the following Null and Alternate Hypothesis:

H0: There is no relationship between the adoption of IWRM and household food security.

H1: There is a relationship between the adoption of Integrated Water Resource management and food security at household level.

1.7. Justification of the Study

Dry land areas are complex, and this complexity requires that critical attention is paid to specific system attributes such as rainfall and land. In this regard, developers should always take into account environmental, social and historical contexts. Complexity is at the heart of challenges facing water development in drylands as well as the poor conditions of climate change (African Development Bank, 2011). Development partners and governments have taken an overly simplified view of water resources development. They have prioritized the delivery of the resource over the impact and on land, environment and the livelihoods systems (GWP, 2013). The results of this study aimed at assisting the agricultural sector to adequately address household resource constraints, reduce vulnerability and enhance agricultural productivity and economic growth. In the long-term, these improvements co to the achievement of not just Kenya Vision 2030 goals, but also the SDG on Eradication of Poverty and Hunger, Provision of clean water, safe environment and Promotion of community livelihood.

1.8. Scope of the Study

This study focused on IWRM for food security in Kikuu sub-catchment. The choice of the research area was informed by the fact that, Makueni County performs poorly on food production hence food insecure (KNBS and UNICEF, 2009). The rapid population growth has increased demand for food hence exceeding the supply (GOK, 2016). The households depend on natural resources such as sand harvesting and timber for provision of food to their families that led to degradation of riparian land and overdependence on rain-fed agriculture (WLNET, 2012). However, success stories have been reported on the conservation activities in Kikuu River Sub-catchment in the County. Project reports by CESPAD argue that the management of the Sub-

catchment is inclusive of several stakeholders, and the community takes the lead (CESPAD, 2015).

The study was designed to emphasize IWRM approach for environmental management and improve the current situation of food security in dry lands of Kenya.

1.9 Definitions of Operational Study Concepts

Agriculture: The cultivation of soil for crops and livestock keeping for food provision (Mahendra, 2010).

Dry land: A land with dry, often sandy soil, limited water and rainfall. Drylands are known by their scarcity of water FAO, 2000. They are zones with minimal evaporation and precipitation (UNCCD, 2000). In this study, the researcher applied the definition of dry land as an area with limited water resources and Hyper Arid. This definition helps understand how IWRM can be used to address food insecurity in the areas with limited rainfall and water resources in Kenya.

Integrated Water Resource Management (IWRM): Is a holistic process for a coordinated management of water, and related resources sustainably (GWP, 2003). It is about promoting equitable access and efficiency for sustainable utilization of water (Moriarty, *et al.*, 2004). This study applied the definition by GWP, 2003 and investigated how coordinated water and related resources management helped to improve food production in the water scarce areas. The researcher sought to understand the actors involved in water management at Kikuu sub-catchment, conservation methods adopted and the food production resulting from the application of holistic approach in water management.

Food security: The state when people have access to sufficient and nutritious food (FAO, 2012).

Household: Entails people in the same house and share meals (Pereira, 2012).

Sustainable Land Management (SLM): Utilization of land resources, for the production of food (Suzuki, *et.al*, 2016).

Soil and Water Conservation (SWC): activities that enhance a productive capacity of an area affected by degradation (Harris & Brown, 2009). Some of the water conservation techniques discussed in the study include Zypit or Basin construction which is a shallow pit that acts as rain-

water harvesting structure. The study applies the definition of Zypit as rain water harvesting structure and a method used by farmers at the study area to increase food productivity (Suzuki, et.al, 2016).

Livelihood: Concerns the means, assets and activities required for a living (Kabubo, 2010).

Water Resources Users Association (WRUA): Group of water user's representatives at the sub-catchment level and mandated with the function of WRM as per the Water Act 2016.

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section discusses food insecurity globally, in Africa as a continent and Kenya. It focuses on the causes of food insecurity, coping and mitigation strategies. It also looks at the Makueni County status of food security. The literature thematic discussions are given in both theoretical and empirical perspective. The chapter also provides a critical discussion on Integrated Water Resources Management and irrigation for enhanced food production in drylands. The theoretical and conceptual framework that links the study problem statement, objectives and research variables are explained in this section. The research has also analyzed the literature reviewed and highlighted the main study gaps that informed the research design and questions. A clear discussion on how the gaps have been addressed in the study is discussed. As the chapter ends, the researcher summarizes the key topics of the desk review and the literature findings. The researcher depended on internet scholarly materials, journals, government and nongovernmental organization reports and books.

2.2 Global Food Insecurity

Despite growing attention in the food production the world household food insecurity continues to worsen (Project Concern International, 2009). A myriad of factors has been responsible for the continuing global food insecurity. One factor is the rise in prices of the world staple foods (wheat, rice, and corn). Another factor is poverty and estimated 100 million people have fallen into poverty. For instance, in 2007 Afghanistan households were spending 75% of their income on food (World Bank, 2008). Dependence on imports influences the global food insecurity. A case in point is Haiti where over 80% of staple rice is imported. The result of it is that over half of the country's population is undernourished, and 24% of children suffer chronic malnutrition (Batjes, 2011).

Moreover, global warming has influenced food insecurity challenge. El-ninos and La- ninas hamper good crop production in Latin America and the Sub-Saharan Africa. Droughts caused by La-ninas have led to food insecurity especially in Ethiopia where 7 million people are food insecure and 10 million prone to drought (World Bank, 2008). Other factors that lead to household food insecurity include the shift to more non-agricultural technology, politics,

environmental degradation, insecurity and high population growth. Several consequences of global household food insecurity have manifested themselves (Grebmer, *et al*., 2010). Each year, 10% of Burundi's population requires food aid (FAO, 2008). Another consequence is poor health status exemplified in Benin whereby almost a quarter of children below five years are underweight (FAO, 2010). There are also increased malnutrition rates globally as in 2004 the global malnutrition was 15%, (WHO, 2004).

Food insecurity is a world problem as nearly 30% of the world's population was reported to suffer from malnutrition (Guha, Acharya& Davis, 2007). Insufficient sustainable growth cause hunger, hence poor economy. Several global initiatives put a spotlight on the problem of persistence of world hunger (UN, 2015). The 1996 world food summit (WFS) of UN member countries set the goal of reducing hungry to 50% globally by 2015. This goal meant moving from the estimated 818 million hungry in 1990 (benchmark period for the WFS) to 410 million by 2015. However, only South America, and the Caribbean almost attained the MDG target (FAO, 2015). Without good progress in solving hunger problem, achieving other MDGs such as poverty and health were difficult (FAO, 2005).

Unless more food, energy and fresh water are available by 2030, poverty will remain a challenge to the least developed nations (Grebmer, *et al.*, 2010). A key challenge to food provision is climate change that should be addressed (FAO, 2008). This would incorporate reduction of greenhouse gases and conserving biodiversity (UN, 2015).

Managing the agro-ecosystems and their interaction with natural ecosystems is thus not only important now, but will also become increasingly important for food security and environmental management (GWP, 2012). Agriculture cause approximately 19–29% of global greenhouse gas emissions and deforestation globally (UNEP, 2007). Reducing emissions from agriculture is possible through adoption of climate resilient agriculture and adopting the mitigation plans (FAO, 2012). The key to environmental success is to address the drivers of deforestation and degradation in Agriculture (UNEP, 2007). There exist a gap on the report by UNEP, UN, FAO and academicians such as (Grebmer, *et al.,* 2010) about food insecurity at the global level. The researcher noted that there is no clear linkage between IWRM and food security (UN, 2015). The scholars give the broad discussion on the status and causes of food insecurity in the world but, they fail to explain how IWRM can help solve the problem. The concern of food insecurity

in the world has also not been linked with the environment. Hence the researcher addresses the gap by investigating the link between environment and water resources management for household food production.

2.3 Food Insecurity in Africa

Various countries in Africa have experienced the devastating effects of household food insecurity. For instance, Cameroon in West Africa, Egypt in Northern Africa, Ethiopia in the Eastern Africa and South Africa in the Southern Africa (FAO, 2012). Egypt produces half of its demand for wheat and the country is exposed to the escalating food prices due to its wheat imports. It is classified as the number one importer of the produce in the world (Hove & Twomlow, 2006). The country also has a high population growth rate of 2% per annum. Moreover, the desert terrain of the Sahara limits crop production (FAO, 2008).

UNEP (2007) noted that African nations are facing a challenge of food insecurity due to poor land management and environmental conservation. The limited rains, as well as climate change, is affecting the productivity of households in the continent (UN, 2015). Also, the continent is experiencing water scarcity as most of the Sub-catchments are being degraded and affecting the agricultural sector for food security (FAO, 2012).

Reports by FAO and UN indicate that the problem of food insecurity is critical in Africa. The continent is developing and experiences a great impact of climate change and water scarcity. However, the reports do not give information on how the challenge of water scarcity and food insecurity is being addressed. In this concern, the study on IWRM and food security comes in to investigate the importance of IWRM in household food production. The researcher is introducing an approach that could be used in the dry lands and water scarce parts of Africa in reducing the emerging issue of food insecurity and increased poverty.

2.4. Food Insecurity in Kenya

NDMA, (2016) noted that nationally, food security was gradually declining because food supply to the markets was low and market demand was very high. The dwindling supplies were reported to result from below-average 2016 crop production that was experienced in both the long and short rain harvests. It also resulted from reduced regional imports from neighboring countries

that also experienced below-average production. FEWS NET, (2016) estimated that 2016 long rain maize production was about 2.6 million metric tons, which was around 10 percent below the past five-year average rains.

An analysis of wholesale maize prices across the major urban consumption markets of Nairobi, Mombasa, Kisumu, and Eldoret revealed that between October 2016 and January 2017, prices had increased by up to 10 percent. January wholesale prices increased by 18 percent above the 2012/16 average prices (NDMA, 2016).

A total of 2.6 million people were found to be food insecure and needed urgent humanitarian assistance (Republic of Kenya, 2016). Food insecurity in Kenya is caused by various factors that include poor policies, environmental degradation, and poor land use.

2.5.1. Government Agricultural Policies

In the first two decades of independence (1963-1983), the government of Kenya invested heavily in agriculture policies towards making Kenya food self-sufficient (Meinzen, 2007). The initiative proved a failure for Kenya food production (FAO, 2012). Market liberalization was too fast and not linked with other policies creating farmer confusion and a loss of investor confidence (Mumma, 2007). Lack of input by the private sector resulted in food shortages and declining nutritional status for Kenyans (FAO, 2008).

The lack of coherent land policies and poor coordination of major stakeholders limit the potential support of policies (Kiteme & Gikonyo, 2002). Dependency on donor funds for the vital research necessary to better inform policy makers and those responsible for implementation further weakens policy implementation in Kenya (Pearson, 2012).

2.5.2. Poor Knowledge of agricultural best practices

The acknowledgment of the link between women's empowerment and improved household food security (Mumma, 2007). Improving women's education is important policy instrument Kenya can use to increase agricultural productivity (UN, 2015).

Lack of education causes poor agricultural development and food insecurity in third world countries (Economic Review of Agriculture, 2009). Education contributes significantly to sustained rural income growth (Oniango, 2010) and increases the ability of farmers to utilize

resources efficiently (Rajaonarison, 2014). Knowledge promotes quality relationship between technology inputs and agricultural outputs (Meinzen, 2007).

The Ministry of Agriculture recognizes the use of agricultural training for its youth through various Rural Youth Agricultural Programs (Pearson, 2012). Youth is defined in Kenya as the population aged between 18 to 35 years (GOK, 2010). This age group comprises 62% of the total Kenyan population, and more than half reside in the rural settings (KNBS, 2009). An agricultural curriculum that combines basic content with local farming practices becomes relevant to learners of all ages (Pearson, 2012). Parents are happy to adopt new ideas brought home by their children as opposed to strangers. As a result, schools become community learning centers for education and social activities for adults as well (DFID, 2000). The process of learning becomes socially imbedded for all generations and encourages long-term changes in behavior that improve food security (Rajaonarison, 2014).

2.5.3 Climate change and Food production

Framed by the complexities of climate change and population growth, there is no question that human society faces considerable risks and challenges (Maalim, 2010). The United Nations Environment Programme (UNEP) recognizes that climate change is one of the major challenges of our time and is threatening food security (UNEP, 2010).

A review of the impacts of climate change on food security indicated that there is a challenge in availability, access; stability and utilization of the house hold food in Kenya (Schouten, 2009). The study also concluded that climate change would negatively accentuate existing levels of food insecurity, and the adverse impacts fall disproportionately on the poor.

Kenya has been experiencing unprecedented food insecurity due to climate change caused by environmental degradation and inadequate rainfall (Lawrence, 2014). The decrease in agricultural growth in Kenya has had a poor impact on the food security status in the country (Dan, 2006). In 2009, about 51% of Kenya's population lacked access to adequate food and the little that was available was of poor nutritional value (Ramin & McMichael, 2009).

The government reports and journal analyzed give various causes of food insecurity in Kenya. For example, (Meinzen, 2007) states that poor government policies and legislation result in reduced food production. Meinzen says that there exist conflicts between the policies hence

increased the level of food insecurity. This study has a gap in that; there is no data about how the policies in agriculture and water resources can be harmonized in an integrated manner for efficient water resource management and food production. The researcher addressed the gap by investigating the actors' involvement in water resource management at the study area hence mapping the stakeholders and their contribution to effective water resource management and food security. The study would help influence policy makers and embrace the idea of stakeholder engagement in water resource management for food security.

Oniango, 2010 and UN 2015 also discuss the lack of knowledge in agricultural best practices as a cause of food insecurity of Kenya. The UNDP report and Oniongo's findings also do not explain how the knowledge gap can be addressed to solve food insecurity. Data on actors in integrated water resource management for food security has not been provided. The researcher linked the farm production data, water resource management and environmental conservation to food security. The knowledge would influence policy makers to harmonize and integrate environmental and agricultural legislations for improved food production. UNEP (2010) and Schouten journal (2009) argue that; environmental degradation and climate change are main factors that lead to food insecurity in Kenya. This literature does not consider IWRM as a solution to the environmental degradation, climate change mitigation and a long-term solution to food insecurity. The researcher generated data on how the practice of IWRM in dry lands can increase household agricultural productivity.

2.5.4. Environmental Degradation and Food Production

As outlined by FAO and UN (2011), business as usual, with some marginal adjustments, is not enough for the protection of natural resources and food production for the growing global population. The report noted that 25 percent of the world's farmland is highly degraded due to uncontrolled harvesting of natural resources that include trees and sand. Human activities such as charcoal burning, clearance of land for settlement and tree logging is causing loss of biodiversity hence the lack of water for domestic use and irrigated agriculture.

Although nature is very forgiving, it is not indefinitely, and persistent abuse of the natural assets leads to uncontrolled degradation. Unfortunately, the environment has been abused in many parts of Africa and other least developed nations. The rapidly increasing people and livestock have taken population densities beyond the land's carrying capacity (UNEP and FAO, 2010).

UNEP, 2010 noted that every settled land of Africa is prone to environmental degradation of one sort or another. Several regions of the continent suffer from multiple forms of environmental degradation that has resulted in desertification and detrimental impact on food and agricultural productivity and production. Around 84 per cent of the total arable land in Africa has serious fertility limitations due to land degradation, and 47 percent of it is too dry for productive rain-fed agriculture (FAO, 2011). Africa's soil resources are the most fragile and sensitive to unwise use. (UNEP, 2011).

Like conflict, drought desertification and environmental degradation have a debilitating effect on the poorest communities (FAO, 2012). The rural poor in environmentally fragile areas are victims and unwilling architects of soil degradation. Staple-food producers working on marginal soils have to sacrifice the future for the present as they clear trees and mining soil to provide a livelihood (FAO and UNEP, 2010).

2.6 Makueni County food security situation

NDMA, 2016 reported that Maize production was at 42 percent decrease of long-term average; cowpeas at 74 percent decrease in comparison to the long-term average and 79 percent decrease in green grams productivity (COK, 2013). The nutritional status of children was poor as depicted by Mid Upper Arm Circumference (MUAC) trend compared to long-term averages (Makueni County, 2013). This is an indication that the County experiences challenges in the provision of household food and sustainable livelihood to the population. There exists a gap on the reports in that a nexus on food security and the environment has not been well addressed. This project seeks to investigate how the challenge of food insecurity in the county can be solved through the IWRM approach.

2.7 Strategies towards Food Security in Kenya

The challenge of food insecurity is affecting most of the Kenyan population (Meinzen, 2007). This sub-section discusses the various strategies that are practiced in Kenya towards food security and World transformation agenda number two on Zero hunger.

2.7.1 Sustainable Agriculture

Sustainable agriculture emphasizes social and human capital for food security (Chambers & Conway, 1992). Sustainable Agriculture (SA) promotes clean water, wildlife conservation, flood protection, and landscape quality (Moriarty, *et al.*, 2010). Non-food contributions of SA include on-farm biodiversity, groundwater recharge, urban to rural migration, and social cohesion (Haggblade, 2004). SA is based on the belief in peoples` capacity to work together to solve common management (Van & Tuinhof, 2010). Past agricultural policies have for the most part been non-participatory in nature, discounting traditional farming practices and knowledge (Rutten & Aarts, 2013).

A primary strategy of SA is human resource development, calling for an upgrade in agricultural training, especially the farmers training centers that fall under the Ministry of Agriculture (Bwalya, & Friedrich, 2002). Even though the GOK has identified several sustainability strategies, sustainable agricultural practices have yet to have the political base for widespread implementation (Thenya, 2013). The emphasis is based on soil and water conservation practices, zero or minimum tillage, better-input utilization, use of green manures or cover crops, use of Integrated Pest Management (IPM) resulting in the minimum need for pesticides, and its overall emphasis on creating a large public good with better stewardship of the land. This holds much promise for Kenyan agricultural output and overall food security (Asiago & Akello, 2014).

2.7.2. Water Resources Management

Kenya and many other developing countries have traditionally focused on demand and supply driven approaches in water. From post-colonial times water resources developed through several schemes the expanding agriculture and urban settlements (GWP, 2004). It also helped reduce food crisis of the 1950s and 1960s and improved the quality of life for the poor (Saravanan, *et al.,* 2009). The downside of the old supply-driven approach has resulted in a technically focused donor-driven water strategies which have required constant subsidies.

For about the last 12 years a concept called Integrated Water Resource Management (IWRM) has been growing in popularity as an approach that sustainably manages water resources (Moriarty, *et.al*, 2010). It is seen as the global solution to water management problems, as it accounts for interests in water conservation and use, as well as key political, legal, administrative, economic, environmental, social and cultural aspects.

The reviewed reports and journals on approaches to food security in Kenya discuss how sustainable agriculture has been integrated into food production and improvement of livelihood. Sustainable agriculture is a way of ensuring food production in Kenya (Morarty, *et al.,* 2010). However, the scholars and the GWP reports do not clearly show the link between IWRM and food security. In other words, the IWRM food security nexus is lacking. This study, therefore, addresses the gap through an assessment of the water-efficient irrigation methods and adoption of IWRM for food security.

2.8 The Integrated Water Resource Management IWRM

The IWRM concept has been defined by GWP (Global Water Partnership) as a process which ensures the coordinated management of water and related natural resources for the sustainability of ecosystems and human being (GWP, 2003).IWRM is about integrated and joined-up management. It is about promoting equitable access and efficiency for the greatest benefit for the greatest number of people, to achieve more sustainable utilization of water, including for a better environment (Moriarty, *et al.,* 2004).

IWRM is a process of assignment of functions to water systems, the setting of norms, enforcement (policing) and management. It includes gathering information, analysis of physical and socioeconomic processes, weighing of interests and decision making related to availability, development, and use of water resources (Hofwegen & Jaspers, 1999). IWRM involves the coordinated planning and management of land, water, and other environmental resources for their equitable, efficient and sustainable use (Calder, 1999). IWRM is a package of solutions, and as the word integrated implies, these solutions share an important relationship with each other (Moriarty, *et al.,* 2004). The study focuses on investigating the aspect of IWRM as defined by GWP, 2003 as a coordinated water management approach for improved food production and livelihood.

2.8.1. The Evolution of IWRM

In 1996 the World Bank, the United Nations Development Program (UNDP) and the Swedish International Development Agency created the Global Water Partnership (GWP). The GWP initiative is based on promoting and implementing integrated water resources management (GWP, 2004).

By the time of the 2nd World Water Forum in The Hague (2000), the global Summit on Sustainable Development in Johannesburg held on (2002) and the 3rd World Water Forum in Kyoto (2003), the GWP was well underway, promoting its work to willing ears. All three conferences served to move water up the political agenda. At the 2nd World Water Forum, this was the explicit aim of the conference.

2.8.2. IWRM Guiding Principles and Concepts

It is agreed that the concept of Integrated Water Resource Management (IWRM) is a result of an Earth Summit conference held in Dublin in (1992). During the summit, four basic principles were ratified regarding sustainable water conservation. Therefore, these principles were called the Dublin Principles, rather than the IWRM Principles. The Conference report sets out recommendations for action at local, national and international levels, based on four guiding principles (GWP, 2004).

Principle number one that says fresh water is a finite, vulnerable and important resource to sustain life and environment. Effective management of water that links land and water uses across the whole of a Sub-catchment area as well as the groundwater aquifer is essential.

Principle number two is important and argues that effective water development and management should be based on a participatory approach that involves users and policy-makers at all levels. Principle number three concerns gender mainstreaming in water management. It highlights that women play a central part in the provision, management, and safeguarding water resources.

Principle number four gives water economic value in all its competing uses and says that water should be recognized as an economic good. Therefore, protecting water as an economic good helps in achieving equitable use, and conservation of water resources.

Water is a basic need, and access to minimum quantities of safe water (20 liters per person per day should be everyone's right (African development bank, 2011). Lack of safe drinking water, sanitation, and irrigation is directly related to poverty and poor health (GWP, 2004). In developing countries, the poor pay high prices for water, but these costs are often hidden (Wagayehu, 2003).

For example, households spend about 1% of their income on water; on the other hand, in Onitsha, Nigeria, the poor spend as much as 18% of their income on water (Rutten, 2013). The application of economic principles to the allocation of water is acceptable and provides a simple tool for the development of water services in a more efficient direction. However, water should not be treated as a market-oriented commodity when it comes to domestic use for very basic needs (GWP, 2004) particularly for people in extreme poverty.

2.8.3. Importance of IWRM

Risk Promotion

GWP has successfully promoted water as a global risk through the IWRM paradigm that is now widely accepted as conventional wisdom, and the principles have been widely accepted by power structures; international and national governmental and non-governmental institutions (GWP, 2004).

Political Promotion

The link between poverty and concept of sustainable development was made at the Stockholm Conference (2012) and the link between poverty and sustainable development and water made at Dublin and Rio (1992). The role of the GWP has been politically promoting these links as well as the policy solution (IWRM) to governmental and non-governmental institutions (Moriarty, *et al.*, 2004).

There is growing belief that while this global crisis is founded on a mixture of various development factors, such as population growth and increasing resource demand, at the heart of the water crisis is poor management or governance (Adeola, 2010). IWRM is being hailed as the answer to all the world's water problems - providing that the holistic approach can be put into effective action (Moriarty, *et al.*, 2004).

Furthermore, it is also perceived as a way to build up the political system's capacity to identify and solve environmental problems (Watson, 2007). For example, lending for water resource development accounted for about 16% of all World Bank lending over the past decade (World Bank, 2004). They demand an accountable form of governance structure for them to work with

i.e. promote their policies and receive a return on the money they invest. In turn, their money (as well as from other donors and investors) is regarded as essential for development by poorer countries.

Policy approach

The policy of IWRM has broad appeal as it combines administrative rationalist (bureaucracy), democratic pragmatism and economic rationalist (market) approach, which are the three ideal ways human beings have found to coordinate efforts to solve environmental problems (Dormant, et al., 2007). Administrative rationalists believe that environmental problems should be left to the experts; the fact that River Sub-catchment areas can cover thousands of square kilometers means that there is an obvious and substantial requirement regarding scientific experts to provide an educated overview and officials to provide expert administration.

Democratic pragmatists believe that environmental problems should be left to the people; the fact that IWRM involves full public participation at the lowest appropriate level throughout the project process gives democracy a major role. This approach is widely recognized as critical for project durability, partly because it can be well suited and adapted to traditional forms of governance in developing countries. Economic rationalists believe that environmental problems should be left to the market. They are therefore very pleased to see water and its supply recognized a shaving an economic value.

The review of Global water partnership reports and empirical studies show that IWRM is very important in risk management and governance of water resources. The concept borrows from Dublin principles 1992 that water is an economic good, has gender consideration, water is a finite good and involves participatory approach. This reviewed literature has gaps in that; it does not give information on how the approach can be used to solve the problem of food insecurity in dry lands. It provides information on how the IWRM approach is important for effective water management as well as land and natural resource conservation.

This study thus focuses on the definition of IWRM as outlined by GWP 2004 as a process that promotes the coordinated development and management of water, land and related resources to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of ecosystems. The study also looks at the IWRM as an

integrated and joined up management of water resources that involves all actors promoting participatory and inclusive water governance.

2.8.4. IWRM and Food Security Nexus

The least developed countries face a challenge in meeting the increasing need for food and water. The challenge of climate change has made rain-fed agriculture unreliable hence effective adaptation strategies on land, water and food production is vital (Asiago & Akello, 2014). In this light, a coordinated effort to minimize trade-offs and maximizes synergies in the water and food production sector is encouraged. However, third world countries fail to apply the IWRM approach that helps improve water management food produce synergy. For example, South Asia follows a sectorial approach that does not consider the interconnections among the two sectors (Adeola, 2010).

As discussed by GWP 2013, to Promote IWRM the decision makers should put water and agriculture very close. The management of the two sectors should be coordinated and start from sub-catchments, basins, and integrate trans boundary water resource conservation. Development of strategies on how water resources can be shared through integration and promote vision programs on shared water is critical. Research, knowledge management and capacity building of different water actors within agricultural and water sectors are essential for effective water-food security nexus (GWP, 2013).

2.9. Irrigation and Food production

UNEP (2010) indicated that the world is growing drier with time and farmers need to mitigate the changes. Rain-fed agriculture is increasingly unreliable especially in the Se-arid areas where the issue is more about getting little water than it is about managing the water resources. Farmers all around the globe are quickly adopting irrigated agriculture as a guard against uncertainties such as the amount and distribution of rain (Meinzen, 2007). In Asia, irrigated agriculture has widely been a magic bullet which has transformed the regions from net food importers to food exporters (GWP, 2013).

Irrigation in Kenya is applied as one of the strategies that can be used to boost agricultural productivity in the country (FAO, 2012). European Social Simulation Association 2012 argued that farmers in Kenya practice irrigated agriculture and applies various irrigation methods that

include flood irrigation where water enters the land uncontrollably. Border irrigation is another irrigation method and includes water getting into the irrigation place as one controlled sheet of water that reduces the loss of water. The Kenyan farmers also use furrow irrigation method that includes water being directed to shallow channels.

The association noted that sprinkler irrigation is another method that is used in the areas for irrigated farming in Kenya. It involves distributing the water through pipelines under the pressure and use of various types of sprinkler that spray the water into the crops. European Social Simulation Association, 2012 also noted that drip irrigation is applied in Kenya and allows application of water to each plant through one or more emitters. ASAL and water scarce areas are more suitable for this type of irrigation as it allows application of water without loss (Simon.*et.al,* 2012)

Other irrigation methods require a high amount of water hence drip irrigation is the formidable tool against food challenge, and has been applied by desert countries such as Israel to feed the world (Margolis et.al, 2015). In this light, the researcher sought to understand the efficient irrigation methods adopted in Kikuu sub-catchment and holistically link with IWRM for improved food production in the study area.

2.10 Summary of Literature

The literature reviewed concerns the status of food security globally, in Africa as a continent, Kenyan food security and the status of food security in Makueni County. The data reviewed indicates that food insecurity is a critical problem that is affecting the whole world. World Bank report 2008 shows that around 75% households in the world spend their income in buying food. Most of the countries affected by climate change and communities depend on rain-fed agriculture for household food production. African countries such as Ghana also lack food and around 19% of children at Cameroon are underweight with increased child mortality rate as reviewed from UN, 2015 report.

The concern of food insecurity is also evident in Kenya affecting almost the 47 counties. The United Nations Human Development information of 2007/2008 noted that nearly 24% of Kenyans are poor and lack nutrient food supply and access. The literature review also outlines the causes of food insecurity in Kenya and some of the approaches used to address the challenge

in Kenya. Sustainable agriculture has been discussed as a major method towards food security. The Concept of IWRM has also been critically analyzed in the literature review.

It incorporates the Dublin principles for water conservation, livelihood improvement, and supply of safe and clean water. The key gap in the literature is the lack of clear link of IWRM-food security nexus. The studies and reports reviewed do not show how IWRM can be used as an approach towards the reduction of food insecurity in the drylands. This study, therefore, sorts to understand the link between IWRM and food security. The researcher focused on how holistic conservation of land and water resources can improve farm household production in drylands focusing on Makueni County.

2.11 Gaps from Literature Review

A lot has been done on factors promoting adoption of soil and water conservation technologies, dissemination of soil and water conservation technologies. In Kenya, the studies on SWC technologies deals mainly with the spread of soil and water conservation technologies, factors of adoption of soil and water conservation technologies, cost-benefits of terraces and the role of the sustainable agriculture in improving soil properties and the impact of soil erosion and land degradation on agricultural productivity. Despite these previous studies, the country still needs more research and data on Natural resource conservation and food security in the ASAL and Semi- arid Counties in the country. This study, therefore, worked on addressing the gap by assessing the level of IWRM adoption and water efficient technologies applied in the study area. The researcher examined the effects of IWRM and the water efficient technologies on the livelihoods and household food production of dry lands or water scarce population and their benefits as well as their environmental impacts in the study area.

2.12 Theoretical Framework

Soil and water conservation technologies have always occupied a central role in solutions to land degradation problems. This started as early as the 1930s when colonial governments became concerned with land degradation issues (Swift, 1996). More recently, as rapidly growing populations in Africa have become a concern in the international arena, soil and water conservation technologies are seen as the means through which to obtain the necessary increase

in agricultural production without degrading the land (Valentina & David, 2000). Some theories have been used to explain the focus of using IWRM and water efficient technologies.

2.12.1 Theory of ecosystem services by Esther Boserup (1965)

Ecosystem services refer to the benefits people get from ecosystems and include provisioning, regulating, and cultural services. With this model, humans may affect the ecosystem services by anthropogenic activities (Millennium Ecosystem Assessment, 2003). Therefore, human interventions have increased food provisioning services through the spread of technologies (Belay, 2014). In an ecosystem, both the production of services from each area and the flows of materials between areas must be assessed. Any change in an ecosystem may affect the all ecosystem services (Adeola, 2010). Agricultural production, for example, can be maintained through the addition of fertilizers and through new crop varieties, new advanced agricultural technologies even while the productive potential of the ecosystem is degraded through soil erosion. These include provisioning services, regulating, cultural and supporting services that maintain the conditions for life on Earth.

2.12.2 Land-use theory by David Ricardo (1772-1823)

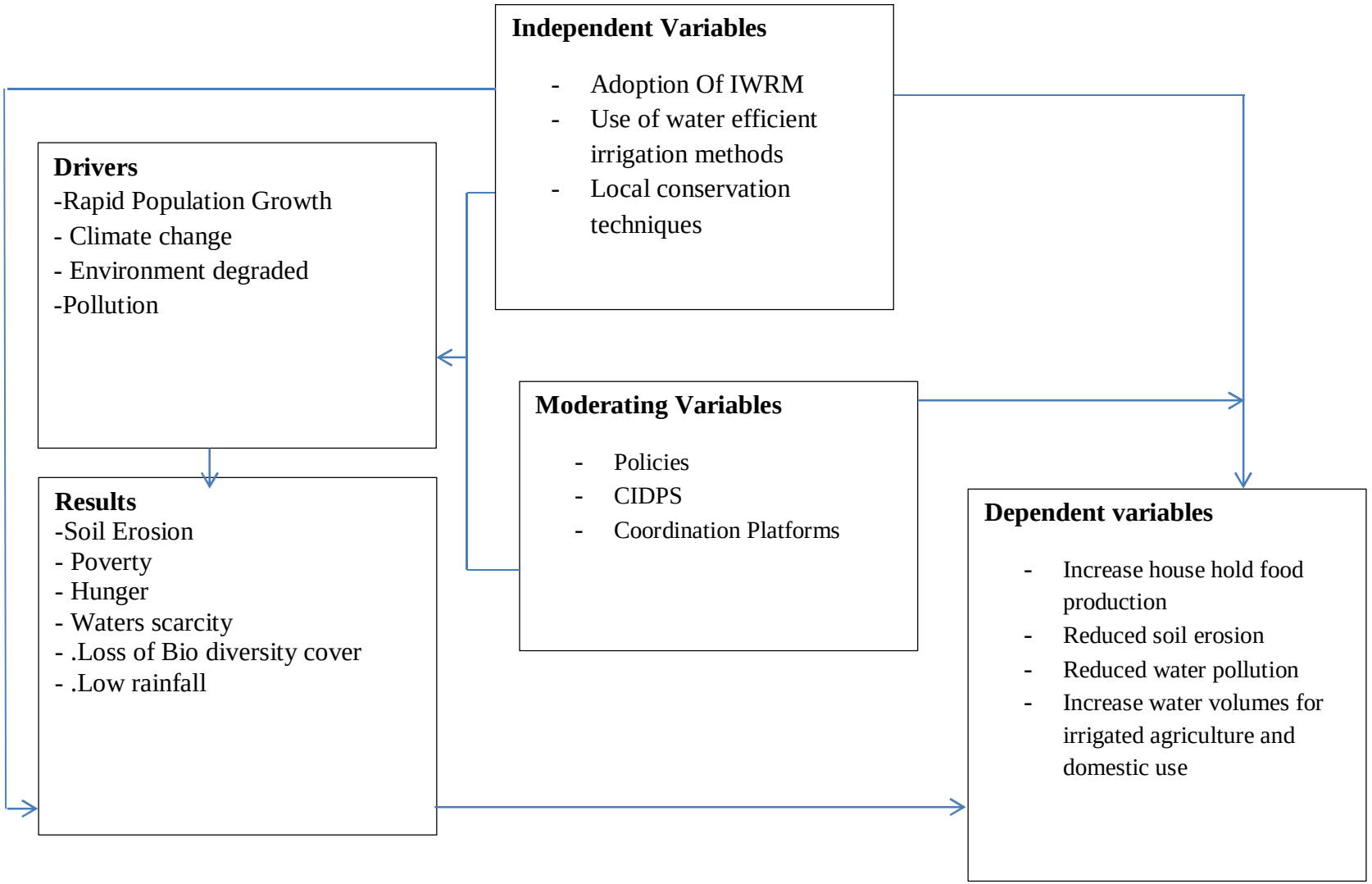
According to Wood et al., (2000), destruction of habitat and loss of plant species diversity form direct and indirect driving forces. These include changing land use system through cultivating land and expansion of agriculture in areas used for grazing (Bandara, 2008). Settlement expansion at the expense of agriculture and grazing land is encountered hence carrying capacity of the land is decreased. The study adopted land Use theory that was advanced by David 1772-1823. According to Wood, *et al* (2000), the underlying factors for changing resources use patterns include cultural perception of the local communities on forests and biodiversity. These responses result into improved natural resources use and management.

This study adopted land use theory considering that, demographics and socioeconomic change have a consequence on land use. Human population affects land use through production, recreation and consumption behaviors. To meet the food security aim and protect the environment, various technologies are introduced and promoted through various smallholders farming systems. The use of these water efficient technologies leads to agricultural productivity, soil erosion decrease and environmental protection. The research entails investigation of the Conservation best practices and Integrated Water Resource management as an approach of land

management for food security and improved livelihood. The study seeks to understand the actors involved in water and related management in Kikuu River Sub-catchment as well as the role of policy makers and various development partners in the management of the Sub-catchment

2.13 Conceptual Framework

The adoption of IWRM and water efficient technologies could be presented in the DPSIR relationship framework along with ecosystem services and sustainable livelihood. Therefore, DPSIR Framework as indicated in Figure 1 in association with Sustainable Livelihoods and Ecosystem Services was used to help carry out an integrated analysis of irrigation and Water Management technologies in Kikuu River Sub-catchment in Makueni County.



Legend: → **Influencing the variables**

Figure 2.1 Conceptual Framework

Source: Researcher, 2016

The study independent variables are the initiatives or the approaches adopted by the community, the National and County government, Development partners and policy makers towards effective change and positive impact on Water resource, land and related natural asset management. Adoption of IWRM which is a Basin approach that is coordinated and inclusive in water and land management is the key independent variable considered in this research. The researcher also considers Local conservation techniques practiced in the study area as a means of changing the status of the Sub-catchment and the community in Kikuu River Sub-catchment.

Water efficient irrigation methods are also elaborated as a response to the problem of water scarcity and food insecurity in the study area. Therefore, for sustainable livelihoods and food security, stakeholders perform different responses to control the state as well as promoting the impacts of the adoption of these actions (independent variables). Therefore, as indicated in the conceptual framework, the independent variables in collaboration with the intervening variables influence the dependent variables. Through the water act 2016 and the County regulations the community and relevant stakeholders adopt and practice IWRM, local sustainable best practices and water efficient irrigation techniques for food security. The water act gives community mandate to user groups referred to as Water Resources Users Association that manage water resources at Sub Sub-catchment level. The study thus applies this conceptual framework to understand and clearly discuss the IWRM food security nexus.

3.0 CHAPTER THREE: STUDY AREA

3.1 Introduction

This chapter focuses on the scope of the study. It discusses the County geographic and demographic data in general. The chapter outlines the climatic condition of Kikuu river sub catchment and the source of the river. The quality of water from Kikuu river, land use and the population of the sub catchment is briefly discussed. A and maps of the study area drawn.

3.2 Makueni County

Makueni County lies in the arid and semi-arid zones of the eastern region of Kenya whose major physical features include the volcanic Chyulu Hills which lie along the southwest border of Makueni County in Kibwezi west, Mbooni Hills in Mbooni Constituency and Kilungu and Iuani Hills in Kaiti Constituency. Mbooni Hills rise to 1,900m above sea level. (Makueni County CIDP, 2013) The County terrain is low-lying from 600m above sea level in Tsavo at the southern end. In the year 2012, the projected population was 922,183 consisting of 449,036 males and 473,147 females. This is an increase from 884,253 persons (107930 person increase) according to the 2009 Kenya National Population and Housing Census.

The County covers an area of 8,034.7 Km2 and borders several counties which include Kajiado to the West, Taita-Taveta to the South, Kitui to the East and Machakos to the North. It lies between Latitude 1º 35´ and 3o 00 South and Longitude 37º10´ and 38º 30´East (Makueni County CIDP, 2013).The County is currently divided into six Sub-counties that include Kaiti, Makueni, Kibwezi East, Kibwezi West Mbooni and Kilome. Makueni County is also divided into 9 districts; Makueni, Kilungu, Mukaa, Kibwezi, Kathonzweni, Makindu, Mbooni East, Mbooni West and Nzaui and 30 wards (Makueni County CIDP, 2013).

3.3 Kikuu River Sub-catchment

Kikuu River Sub-catchment is a main perennial River and originates from Mwaani, Makuli and Mbitini hills. The River Sub-catchment is located within the Athi River Sub-catchment in the Nzaui-Kikuu management unit. The Sub-catchment flows from Makuli and Nzaui hills down to Kikuu River and drains to Athi River. The area is sloppy with most of the drainage flowing towards Kikuu River. The whole River Sub-catchment covers approximately 129 square kilometers and cuts across Matulani, Kwa Mutumia, Kalima, Kawala, Ndovea, Ivila, Kathiani, Kyoa,

Kyangwasi, Iuluka, Ngangani, Kimia, Nthwani, Muthwani, Maviaume, among other villages in Makueni sub-county of Makueni County. The County has a semi-arid climate and does not receive adequate rainfall. The vegetation types consist of both natural and artificial vegetation (WRMA, 2012).

3.3.1 Climatic Characteristics

Rainfall in the Sub-catchment area is largely erratic and bi-modal which is largely influenced by altitude and varies from 300mm–700mm per year during the long rain season of March–May and short rains season of November-December. The temperature ranges from 15ºC in the higher areas to 32ºC at the lower areas. Kikuu sub- Sub-catchment lies within the semi-arid climatic zone. It lies in ecological zone LM3-LM5 (WRMA, 2012).

3.3.2 Water Quality

Water is of poor quality as both humans and animals take water from the shallow wells and dams directly and hence polluting the waters. For example, cattle and human bath drink water or wash clothes directly from the River. People within the Sub Sub-catchment depend on the perennial River, springs; water pans/earth dams and shallow wells for water supply. During the household study, it was observed that the livestock and people take water direct from the River. Women make some wells and wash the clothes in the River polluting water and make it unfit for consumption by downstream users. Some of the farmers have encroached the Riverbanks polluting the water through chemicals used in the farms and soil erosion.

3.3.3 Land use

Most land-use activities that contribute to the economic well-being of the area are focused on agriculture and commerce. It involves livestock rearing and small peasant farming as well as irrigation agriculture. Therefore, there is the need for water that can be used for agriculture and provision of fodder for the livestock. The small peasant farmers practice agriculture for food production and employment. The excess food produced through rain-fed agriculture and irrigation is sold in the local market for the livelihood of the community. Water is an economic product in the study area. Vendors sell water to the local market and the households far from the River by use of donkey and bicycle. Water is also used for commercial irrigation farming (WRMA, 2012).

3.3.4 Population

The Sub-catchment has approximately 82,000 people and 16,400 households (CIDP, 2013) distributed within the Sub Sub-catchment. The study population was the households that live along Kikuu River Sub-catchment in Nzaui Ward Makueni County. The water is increasingly becoming scarce, and IWRM approach was necessary to restore the water levels, satisfy competing demanding of water and ensure sufficiently is sustained even for the future generation. Therefore, the high population is high and requires a coordinated water management approach (IWRM) to avail water for irrigated farming that would help reduce the problem of food insecurity in the study area. Every person in the community including women, youth, men and individuals with disability need to be included and take part in water resource management for livelihood and food produce (WRMA, 2012).

3.4 Maps of for the Study Area

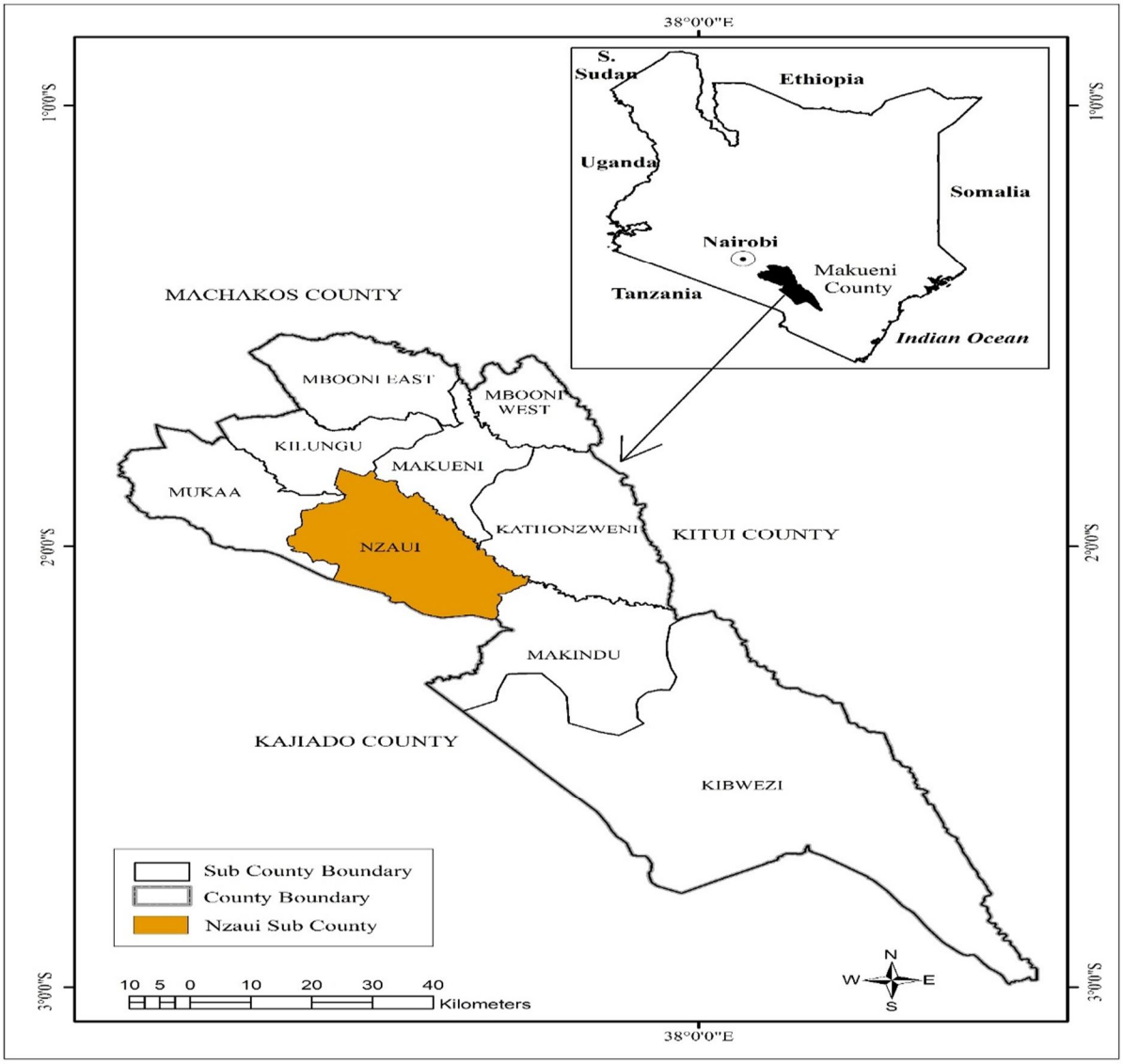


Figure 3.1: Administration map of Kenya and Location of Nzaui in Makueni

Source: Kenya National Survey, 2009

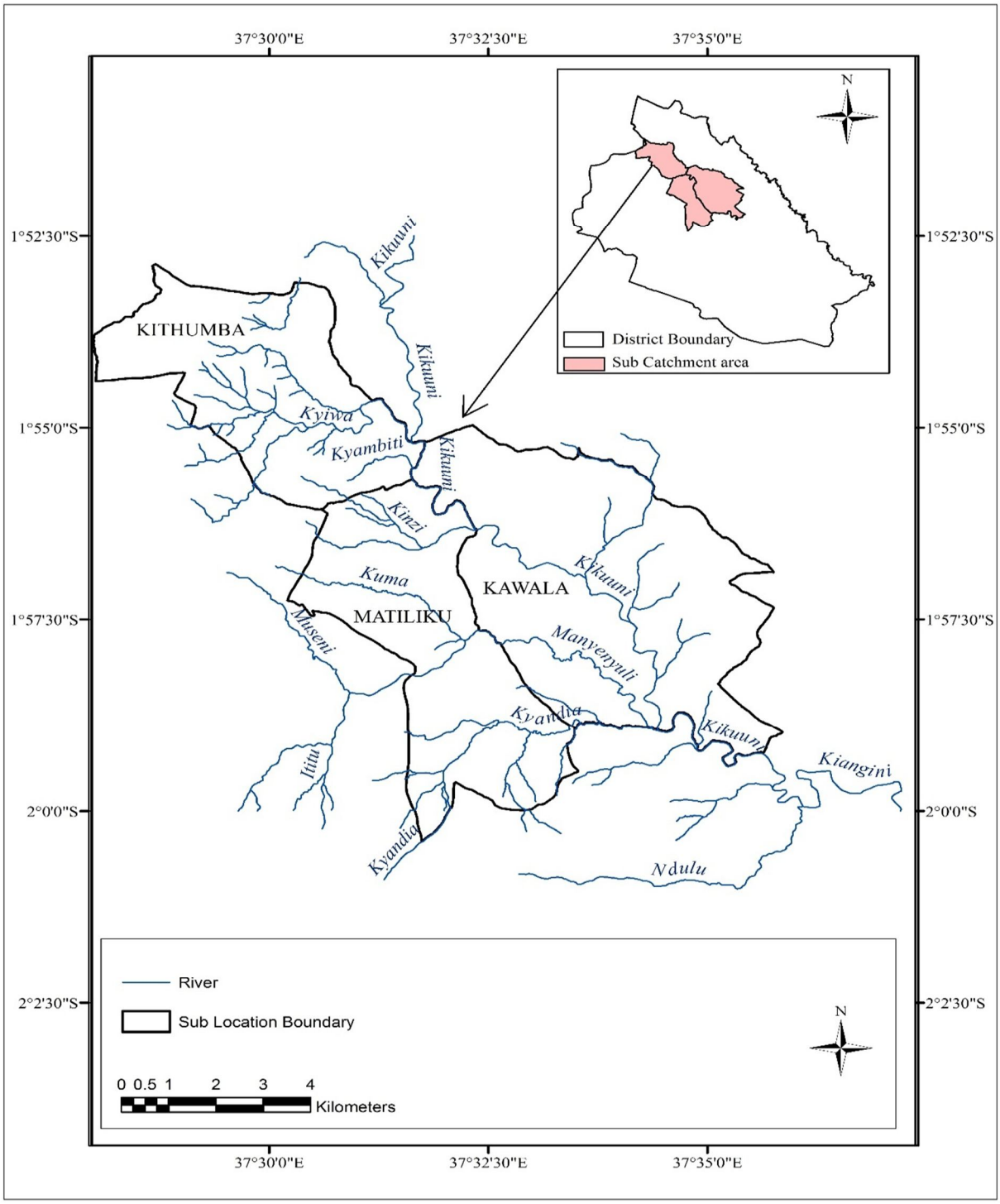


Figure 3.2: Kikuu River Sub-catchment and its tributaries

Source: Kenya National Survey, 2009

As indicated in Figure 3.2, Kikuu River originates from the North Western part of Nzaui Kalamba ward in Makueni County. The Sub-catchment is fed by springs and forests at Muaani hills. It joins Muooni River at the South Eastern part of the ward which then drains the water to Athi River. Therefore, the Sub-catchment is important in that it increases water for the second largest River in Kenya. Kikuu River is seasonal with an area of 129 square Kilometres as established and length of 60 Km. It's estimated to have 50 Cubic meters per second during the rainy season and declines to 10 Cubic meters per second during the dry season (WRMA, 2016).

4.0 CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

This chapter description of the research design that the study employed, sampling procedure, sample selection and strategies that were used for data collection and analysis. The tools used to collect data such as open-ended questionnaire, interview schedule, and a Camera. A formula on arriving at the study sample and hypothesis testing or data analysis statistical technique are illustrated in the chapter. The researcher has also given a justification of the choice of study design and data collection methodology.

4.2 Research design

The study focused on factors of sustainability and management as a means of identifying integrated water resource management and food security. In this light, this research work strived to present the research design which sought to investigate the study question. This research aimed at achieving a more complex and fuller explanation of the impact of Integrated Water Resource Management and food security. The researcher used Survey design that included face to face discussion of household questionnaires and key informant interview schedule. The study, therefore, adopted both qualitative and quantitative data collection techniques.

4.3 Target Population

The Population is a set of entities concerning which statistical inference are to be drawn often based on a random sampling taken from the population. It also refers to a set of potential measurement or value including not only cases observed but also those that are potentially observable (Yin, 2009).

The study was conducted in Kikuu River Sub-catchment. It has approximately 82,000 people and comprised of 16,400 households within Kikuu River Sub Sub-catchment. The County administrators that included the Nzaui Kilili Ward administrators and County officers in the department of water and agriculture also formed the target study population. National Government environment and water agency officials in the River Sub-catchment provided key informant responses. They included NEMA and WRMA officers at the ground and regional offices; Water sector and food security CSOS such as CESPAD, African Sand Dam Foundation, TARDA, and

INADES gave informed data on the field and area of study. Therefore, the basic units of analysis were the households within and used water from Kikuu river sub-catchment.

4.4 Sampling Technique

Sampling is defined as the process used in statistical analysis in which a predetermined number of observations was taken from a larger population. It is noted the methodology used to sample from a larger population has to depend on the type of analysis being performed and includes random sampling, systematic sampling, and observational sampling. The sample data should be representative of the whole population (Denscombe, 1998).This study employed two main sampling strategies; probability and non-probability sampling.

4.4.1. Probability sampling

Probability sampling is a sampling technique where the samples were formed in a way that all the individuals in the population had equal chances of being selected. Simple random sampling was used because it is highly representative of the population and helps eliminate bias that would arise during data collection. It also simplifies data interpretation and analysis of result and has sufficient external validity (Yin, 2009).

The simple random sampling was applied for selection of households with the aim of collecting quantitative data through the administration of open-ended questionnaires.

4.4.2. Nonprobability sampling

Non-probability sampling is a technique where the odds of any member being selected for a sample cannot be calculated, and the samples are gathered in a process that does not give all the persons in the population have equal chances of being selected.

The researcher adopted purposive sampling method to select key informant interviewees that are well informed with water management and food security in the study area. The key informant interviewees recruited included, water sector civil organizations that had initiatives in the study area, sector institutions and the county government line ministries.

4.5 Sample size

The study had a sample size of 99 households that lived within the sub-catchment. This sample focused on the household's heads. The ninety-nine (99) households were determined through the

(Nasuirma, 2000) model of determining the sample size when a researcher knows the total population size of the study area. *The Nasuirma model*

$$n= \{NC_v^2\}/ \{C_v^2+ (N-1)\ e^2\}: \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(Eqn. 1)}$$

Where: N = is the target population

Cv = is coefficient of variation

e = is tolerance at desired level of confidence

For this study:

Cv = 0.5

e = 0.05.

Therefore: $n= \{NC_v^2\}/ \{C_v^2+ (N-1)\ e^2\}$

$n= 16{,}400\ (0.5^2)/\ 0.5^2+ (16{,}400\ -1)\ 0.05^2$

$n = 4100/41.25$

$n= 99.39$

The sample size therefore was (n) 99

4.6. Nature and sources of data

This section gives the type of data collected and includes both qualitative and quantitative data, primary as well as secondary information gathered.

4.6.1. Primary data

Primary data was collected through administration of household questionnaires and semi-structured interview schedules. The household questionnaires were used on the head of each household that was sampled while semi-structured interviews were conducted with key informants. Data that was gathered from the household concerned the household general demographic characteristics; land use and stakeholder's River Sub-catchment utilization, River conservation efforts, and community-led water management initiatives, role, and responsibility of the stakeholders in water management and food security. The questionnaire provided a high degree of data standardization and adoption of generalized information amongst any population in dry parts of Kenya. The key informants were asked questions that required attention and clarity on some issues that were not fully addressed through the questionnaires about to IWRM and household food production in drylands.

4.6.2. Secondary data

Secondary data was acquired from the central government agencies such as NDMA, NEMA, and WRMA reports, County Government Integrated plans, and baseline studies on water and agriculture, Water sector, and food security or livelihood CSOs reports and any other relevant literature. For example, data on soils, hydrology, and climate was obtained from the State of Environment report for the district in NEMA office. Data on the demographic characteristics of the area was obtained from the Kenya National Bureau of Statistics whereas relevant reports on community involvement in the conservation were gathered from the Makueni WRUA Council reports and WRUA chairman at the Makueni County government headquarters.

Special reference to provisions of relevant policies and laws were used. The relevant policies included: Current National water act 2016, The Kenya Vision 2030, Current National Spatial Plan and The Sustainable Development Goals (SDGs).Information was also generated from the Constitution of Kenya (2010), The Land Act (2012).

The information sought here helped the researcher to know what the existing and proposed policy and legal framework provided regarding agricultural land use conversions and how the policies and laws are likely to influence agricultural land use and water conservation.

4.7. Data Collection Methods

This section provides the information on how the data is gathered and includes a brief discussion about the instruments or tools that were used to collect the research data.

4.7.1 Direct Observation

Observation items included watching events, people or situations to see the trends or attributes of anthropogenic activities in the study area. Specifically, the key aspects that were observed included water irrigation methods, the type of crops grown, the size of land and rain water harvesting structures if any and the livelihood strategies such as farming and business. The researcher also observed the distance of the farm from the River. Any farmer whose farm is at least 2Km from the River was taken as a respondent cultivating close to the River. On the other hand, a farmer who cultivated above 2 Km from the riparian area was categorized as a respondent far from the River.

4.7.2 Questionnaire surveys

Open-ended structured questionnaires were prepared and administered as one of the tools to collect data so as to give in-depth information. They were administered under the sampling procedure described in section 4.3. For each homestead that was selected, the head of the family answered the questionnaire since the authority of resource use is vested on the head. In the absence of the head that could be wife or husband, the eldest child would be considered for questionnaire administration. The information collected was divided into three (3) categories: This being, General information of the respondents, Land use and Irrigation for food security and the Sustainable water and related natural asset management which included IWRM and other local management techniques at Kikuu River Sub-catchment. If the fifth household totally lacked respondent, the researcher would administer the questionnaire to the sixth household.

4.7.3 Photography

Photography is the art, science, and practice of making durable images by recording light, either electronically using an image sensor. Photography was used to capture information to validate some aspects of the study like activities taking place around Kikuu River Sub-catchment. The researcher took photographs of the crops grown, conservation activities at the River such as Napier grass grown, construction of sand dams, terracing, and basin irrigation methods.

4.7.4 Key Informants Interviews

Key informant interviews are an in-depth discussion with people who have knowledge on the topic or key issues of the study. The purpose of key informant discussions is to gather data from a wide range of people including community leaders, professionals, or residents who have first-hand knowledge about the area of discussion. Specifically, the key informant interviews were administered to Water and Livelihood Network a national CSO that worked with Kikuu Sub-catchment community on water efficient technologies.

They were also administered with Centre for Social Planning and Administrative Development another national NGO that trained Kikuu River Sub-catchment WRUAs on IWRM and agriculture, the County government minister for water and environment, NDMA officer at Makueni County government, NEMA, WRMA, KFS officers working at the study area and Makueni WRUA Council CBO chairman.

The interviews were conducted at the Makueni County offices where NEMA, TARDA, NDMA, WRUAs, Sand Conservation and Utilization Authority, Ministry of Agriculture, Ministry of water, environment, and irrigation are located. The CSO interviews were conducted at their offices while WRMA interview was done via email. A structured interview schedule was used for every officer in their respective office. Key informants in the study were very helpful in getting some first-hand information on the utilization and management of Kikuu River Sub-catchment.

4.8. Method of Data Presentation and Analysis

The results after analysis were presented in tables and bar graphs. According to (Yin, 2009), data analysis is the process of inspecting, cleaning, transforming and modeling of data with the aim of getting information, suggested conclusion and supporting decision making. He noted that data analysis has multiple facets and approaches encompassing diverse techniques under a variety of names in the different business, science, and social science domain. Data analysis seeks to answer the research questions and assist in determining the trends and relationships among variables. Descriptive and analytical techniques were used to discuss the field data following the objectives of the study.

The purpose of data analysis is to determine whether some hypotheses are extremely unlikely given observed data. Chi-square statistical test method was also used in the study for the hypothesis testing. Application of the appropriate statistics helps the researcher to decide if the difference between the two groups' scores is big enough to represent a true rather than a chance difference. Choice of appropriate statistical techniques was determined to a great extent by the research design, hypothesis, and the kind of data that was collected. The descriptive statistics helped the researcher to describe many pieces of data. The major types of statistics included measures of central tendency, percentages, pie charts and bar graphs that supported the data analysis.

The Chi-square (x^2) was computed using the following formula:

$$\chi^2 = \Sigma (O-E)^2/E \quad \text{.....(Eqn. 2).}$$

Where: O – Observed frequency E

– Expected frequency

$(O-E)^2$ – Sum of the squares of the differences between

observed and Expected frequencies.

The χ^2calculated was compared with χ^2critical at a significance level of 0.05 and degrees of freedom which was determined as follows:

Degrees of freedom (df) = (r – 1) (c –1)

Where:

r: number of rows c: number of columns

The variables used in the hypothesis testing were the household farm produce and the best practices adopted in the conservation of the River Sub-catchment. The researcher worked on cross tabulation of the best practices (IWRM) adoption and farm produce. This was to test the hypothesis that: There is no relationship between the adoption of Integrated Water Resource management (IWRM) and farm household food security. The Null hypothesis (H_0) was rejected where χ^2calculated was greater than χ^2critical and the alternative hypothesis (H_1) that: There is a relationship between the adoption of Integrated Water resource management and farm household food security was adopted.

4.9. Study Limitation

During the study the researcher experienced the following challenges that were mitigated for efficient research process:

- Some household heads would not know the precise size of their farms that called for estimation and request for support from the spouse or observation by the researcher.
- Some head of the family were not free to share their views on the topic because of the lack of information hence the researcher adopted a simple concept of sustainable water management rather than the technical IWRM concept during the administration of the questionnaire.
- Time, cost and location factors were also major difficulties in completion of research. However, to overcome the limitations and maintain the effectiveness of research work sincere effort were put. Three assistants were recruited to reduce the limitation of time and use of a motorcycle helped the researcher to reach the interior parts of the study area.

5.0 CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the data and analytical interpretation of the field findings. It depicts the results on household and area characteristics, land use and irrigated farming for food security as well as the sustainable water management approaches and its impact on household food security.

5.2. Characteristics of Respondents and Their Properties

The study was conducted on households whose farms are located in the River Sub-catchment (close and far from the River). The respondents whose farms were at least 2 Km from the River were classified as close while those with land above 2Km from the River were categorized as far from Kikuu River. The respondents practiced both subsistence and commercial types of farming. They kept livestock for food and provision of organic farm manure and grew crops that include cereals, fruits, and vegetables.

Additionally, the farming system in the study area was characterized by rain-fed agriculture as well as irrigation. The main crops grown in the study area were maize, beans, vegetables, Irish and sweet potatoes, banana, cassava, oranges, lemons, and mangoes. On the other hand, the most abundant domestic animals were: cattle, goats, sheep, and poultry.

5.2.1 Respondents' Occupation

The study indicated that 76% of the households sampled were farmers and relied on natural resources for their basic needs. The researcher established that 7% were business persons and relied on local farm produce for their business supply, while 7% (n=7) were casual laborers in the farms or vendors of water by use of a bicycle or donkey to the local market residents.

Furthermore, the research indicated that only 8% were civil servants and less only 1% were unemployed and dependent on their relatives. With a high percentage of the respondents being farmers, it is clear that farming is the main source of livelihood in the study area. Although the land is characterized by water scarcity and little amounts of rainfall, the households apply diverse soil and water conservation practices. Application of sustainable best practice in water conservation has helped the households to increase their farm productivity and improve

through farming. It was noted that the respondents combine farming with other occupations such as teaching and business. The area is food secure because there are alternative livelihood strategies and water availability has multiplied their ways of livelihood. These findings compare with a study by Luca (2010) on the livelihood strategies in Kenya. Luca noted that application of alternative livelihoods in the Asal regions helps improve food security status of the communities in the vulnerable environments.

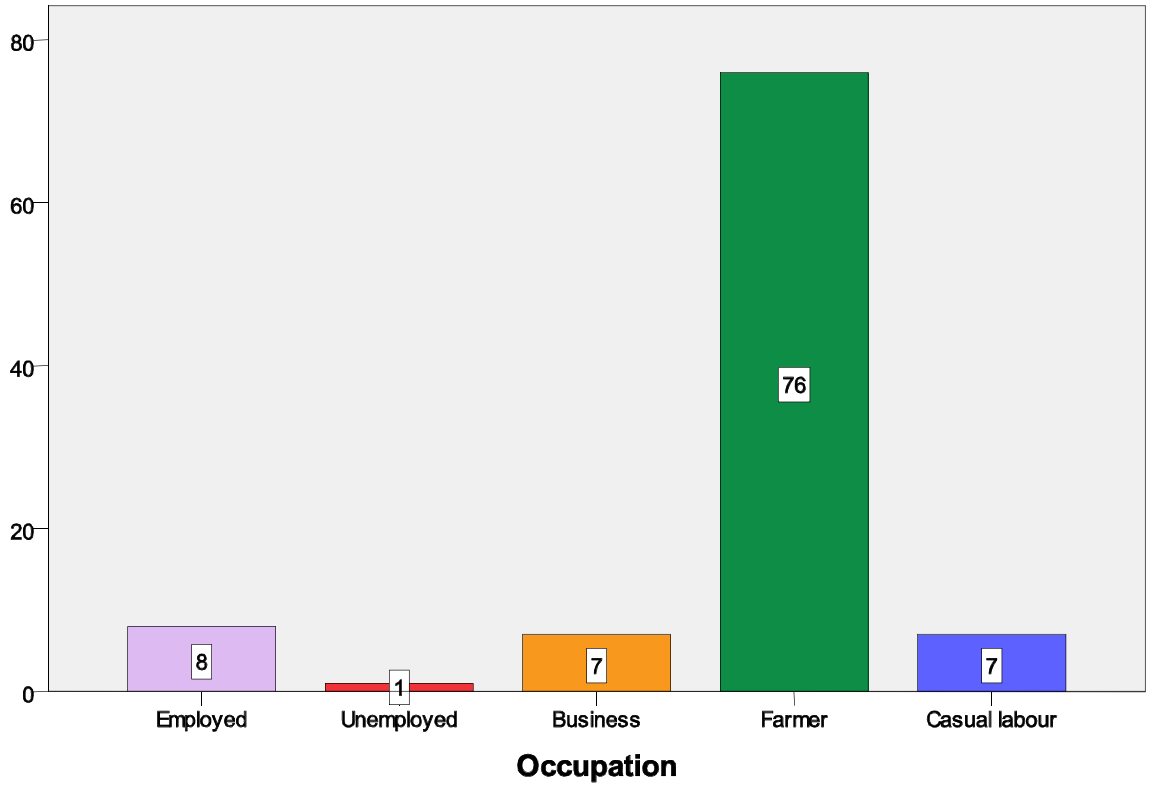


Figure 5.1: Respondents occupation in percentage

Source: Researcher, 2016

5.2.2 Respondents' Age

Four age groups of respondents were identified: Between 10 and 20, between 21 and 30, between 31 and 40 between 41 and 50, between 51 and 60 and the respondents above 60 years old.

The findings indicate that only 1.0% (n=1) are below or equal to 20 years old, 20.2% (n=20) are between 21-30 years old, 23.2 % (n=23) are between 31 – 40 years old 23.2% (n=23) are between 41 to 50, 16.2% (n=16) are between 51 to 60 and 16.2% (n=16) are over or equal to 61 years old as shown in Table 5.1.

Table 5.1: Age distribution of respondents in Kikuu River Sub-catchment

Age	Number of Respondents interviewed in the various age groups in Percentage
Between 10 and 20	1.0
Between 21 and 30	20.2
Between 31 and 40	23.2
Between 41 and 50	23.2
Between 51 and 60	16.2
above 60	16.2
Total	100.0

Source: Researcher, 2016

The results presented indicated that every community member despite their age takes part in conservation activities. The middle age (between 41 and 50) and 51 and 60 participate in conservation activities such as sand conservation, agro-forestry, planting Napier grass, terracing and tree planting. These conservation activities promote IWRM and help in reduction of poverty in drylands. The study indicates that 39.39% of the middle population is very active in conservation activities. This group is strong, wealthy with knowledge and very responsible in supporting the youth and elderly for a food secure community and reduction of poverty.

Therefore, the study indicates that the youth who formed 43.4% of the respondents are the largest group involved in conservation activities. In the study, the youth comprised of the respondents between 10 to 40 years of age. They provide labor for water resources management initiatives such

as sand conservation, planting Napier grass, construction of sand dams and construction of terraces and other rain-water harvesting structures.

This contributes to the well-being of the community in the study area as food is readily available for sale and household consumption. This compares to a study by Ramachadra, 2013 on the role of youth for green environment. The researcher noted that young people play an active duty in managing the environment. They can make their homes, schools and youth organizations environment friendly by adopting conservation best practices, recycling waste materials and preserving resources such as water and electricity. Engaging youth in environmental protection not only creates a direct impact on their behaviors and attitudes but also influence their parents, relatives, and families actions for improved natural resources management.

Youth are back bone of the nation. Through their involvement in the environment, conservation water is made available in water scarce areas, and the community can utilize the rain-water harvested for irrigated agriculture increasing food production. The youth also can get employment as water vendors and farmers when water is readily available improving livelihood and economic growth of the community. These results compare with a study by UNCAF in 2013. The research established that holistic approach and inclusion of women, youth, and men in the conservation of natural resources promote growth and improved livelihood in India.

5.2.3 Respondents' Gender

The distribution in percentages of the respondent showed that females were making 50.5 % (n=50) while male respondents made 49.5% (n=49). The study further found that a high number of females engaged in farming and conservation activities of the Sub-catchment. However, the gap was not wide among the respondents indicating that the conservation activities of the Sub-catchment are inclusive hence promoting the adoption of IWRM in the study area.

The research compares to the findings of a study on gender and environmental conservation for poverty alleviation by UN, 2011. The study established that women represent more than 70% of the world's poor due to unequal access to economic opportunities in both developed and developing countries. In developing countries, an increase of female participation in the environmental

conservation and workforce would reduce the number of people living in poverty. Therefore, the involvement of women in Kikuu River conservation activities is a vital technique for reducing poverty in the area. When they conserve water, they can do both small scales, and large scale farming for their household food produce as well as creating employment for and contributing to the economic development of the area.

5.2.4. Respondents' Level of Education

In Kenya, the education system is composed of three main levels of education referred to as the 8.4.4 system and includes primary, secondary, and higher education. Kenya has free compulsory Primary Education that takes eight years, and the official school age is from 7 years to 12 years. This stage focuses on literacy and numeracy skills, as well as preparation for secondary studies. Primary education ends with Kenya National Examinations (KCPE) which determines eligibility for proceeding to secondary education. Secondary education takes four years with the official age for this level being from 13 years to 18 years of age and culminates in national examinations which respectively determine eligibility for entry to higher education.

During the study, five education levels were identified: illiterate, primary, secondary level, middle college and university level. The results as shown in Table 5.2 indicates that 4.0% (n=4) are illiterate, 62.6% (n=62) had attained primary level education, while 9.3% (n=29) had achieved secondary education, 3.0% (n=3) attained middle college level and1.0% (n=1) had gone up to university level.

Table 5.2: Respondents' education level

Level of Education	Household's level of education in Percent
Primary	62.6
Secondary	29.3
Middle Level College	3.0
University	1.0
Illiterate	4.0
Total	100.0

Source: Researcher, 2016

Therefore, all households despite their level of education had adopted farming and conservation best practices because they reported having got training on IWRM from WRMA and water sector CSOs such as African Sand Dam and CESPAD. However the elderly faced some challenges in adoption of best practices since most of them lacked labor to practice some techniques such as terracing and construction of rain-water harvesting structures.

They also lacked or had limited finances to purchase organic manure for their farms and adopt irrigation methods. The results compare with a study by Caroline, (2009) on education and environmental conservation at London. This study established education, and public awareness as a practical indicator of conservation success, where the intervention concerned is focused on developing awareness and positive behavioral intentions towards the conservation target. It also compares to another research by Dobson, 2007 which noted that education, both formal and informal, is widely used as a conservation intervention to develop positive attitudes, and it is often assumed that effective education automatically leads to environmentally responsible behavior.

5.2.5. Marital Status of Respondents

Three levels of marital status were identified during the study; single, married and widowed. The marital status varies a lot by age, sex and to a lesser extent by area of residence along with living conditions. The study noted that 10.1% of the respondents were single and the number was equal to 10 male and female. The highest percentage of the respondents (86.9%) (n=86) were married, and the least category of the respondents was the windows that made 3% (n= 3) as shown in Table5.3.

Table *5*.3: Marital status of respondents

Categories of Marital Status	Marital status of respondents in Percentage
Single	10.1
Married	86.9
Widowed	3.0
Total	100.0

Source: Researcher, 2016

The high percentage of the married population representing 86% of the population also contributes

to the adoption of the best conservation and irrigation methodology at the study area. The married population had a family to support and needed water for domestic use. They married population are members of the WRUA at the River Sub-catchment and have attended capacity building vocational training hence understanding the importance of IWRM in environmental conservation and food produce. The population growth rate is high resulting to demand of food to feed the population and as a way of livelihood to meet the basic needs of the growing families.

The findings on family compare to the study by Rachel, (2015) on marriage and economic growth. The research found that states with the highest share of married people families are well compared to the states with the lowest share of such families.

They have $1,451 more in per capita GDP, 10.5 percent more upward mobility for low-income children, 13.2 % decrease in child poverty, and $3,654 more in median family income. The researcher concluded that the proportion of married parents in a state is a top indicator of economic outcomes. The share of married parents is a stronger predictor of economic mobility, child poverty, and median family income as it reduces crime level. In this regard, marriage leads to higher participation in the workforce and productivity for men. Rachel,(2015) also argued that the married men reported to work about 400 hours more and make about $16,000 more per year than their otherwise similar single peers, and they highly involved in conservation activities with the aim of increasing water to boost their farming occupation.

5.2.6 Family Size of the sampled Households

Family size in the study was considered as the number of individuals who reside and take meals in the respondent's household. Three categories of household size were identified: family with members from one to three persons, from three to six persons from six and above. The results show that households with members ranging from one to three persons were 11.1% (n=11), households with members ranging from three to six persons were 44.1% (n=44), family size ranging from six and above were 43.4% (n=43) as shown in Table 5.4.

Table 5.4: Household size

Categories of Household size	Family Size in Percent
below 3	11.1
Between 3 and 6	44.4
above 6	43.4
No response	1.0
Total	100.0

Source: Researcher, 2016

It was found that households with family size ranging from three and above representing 87.8% of the population tends to adopt conservation and irrigation best practices than other households as indicated in Table 5.4. The fact that the families with members between 3, 6 and above formed 87.8% of the respondents and all the respondents took part in conservation activities is a clear indication that big families contribute to effective water management for food produce and livelihood to the growing population. This high adoption of best practices and technologies by families with large household size can be explained by the high availability of labor in these families and more reliance on agricultural activities for livelihood. The findings compare with a study by Simon, *et al.,* (2012) and Alufah, *et al.,* (2012) which showed that household size had significant effects on the adoption of best conservation practices and water efficient irrigation methods.

5.2.7. Respondent's Farm size

The results showed that the majority of respondents own a large piece of land. As a result, five groups of farm size of respondents were identified as indicated in Table 5.5; 1 Acre, between 1 and 5 acres, between 5 and 10 acres, 10 and above acres of land. The study shows that 7.1% (n=7) owns a farm with size less than 1 acre, 78.8 % (n=78) have farms that vary between 1 – 5 acres, 7.1 % (n=7) have farms with size varying between 5 – 10 acres, 5.1 % (n=5) have farms with size above 10 acres, and only 2% (n=2) of the respondents did not respond. The average size of respondent's farms is 1.01 acres and the majority of household land size vary from 1 to 5 acres as shown in Table 5.5.

Table 5.5: Farm size

Categories of Farm Size	Households firm size in Percentages
Below 1 Acre	7.1

between 1 and 5	78.8
between 5 and 10	7.1
10 and above	5.1
No response	2.0
Total	100.0

Source: Researcher, 2016

Therefore all households despite the size of their farms and the location practice water efficient irrigation for their improved farm produce and livelihood. Those with a farm near the River have adopted irrigation methods while those far from the River have adopted one or two conservation techniques improving the productivity of their farms and livelihood of the residents. Irrigated agriculture avails fresh produce for business in the study area as well as food security for the households. Water efficient irrigation methods promote IWRM in the Sub-catchment. It helps reduce land degradation, retain land fertility and promote the availability of clean and safe water to the community. The households reported adopting best practices because they had received capacity building on IWRM and have knowledge that the best practices promote IWRM that help them become food secure.

These research results are comparable to other studies where most farmers with large farms adopt water-efficient measures. For example, the findings of a study by Tadesse & Belay, 2004 found out that farm size positively influences land conservation practices such as investment in anti-erosion ditches. This was similar to the findings of a study carried out in Nigeria and which proved that the output of the crop, the level of education, farm size and price of fertilizer were important factors influencing household food produce (Amanze, *et al.,* 2010). Another research by Yishak, (2005) pointed out a positive relationship between farm size and some of the plots owned on the adoption of SWC practices. Therefore, parameters such as farm size, location, and exposure to the knowledge on water efficient irrigation methods and conservation methods contribute to adoption and use of best practices in water management.

5.2.8. Types of Crops

Farm crops in the study area were characterized by intensive organic systems and involved the combination of food, fodder and tree crop. The crops grown in study area included maize, beans,

and sweet potatoes, vegetables and fruits that included banana, oranges, lemons and mangoes. The staple food of the study area is maize, peas, and beans. Fruits such as oranges and mangoes are the main cash crop in the study area targeting local and international markets.

The households are also doing Miraa as a cash crop through irrigation. In this regard, it is right arguing that irrigation is efficient for the production of various crops that support the community with household food and business for their livelihood. They can do irrigation for fruits, vegetables, and cereals. The households have currently introduced Miraa growing as a cash crop in the area. Miraa is done through both irrigated and rain-fed farming as elaborated in plate 5.4. The households practice intercropping as indicated in plate 5.1 as a means of improving productivity in their farms. They grow fruits such as oranges, peas, and maize.

Plate 5. 1: Orange and Peas farm at Kikuu River Sub-catchment
Source: Researcher, 2016

The vegetables and cereals in the study area are grown for sale and depend on local markets. The study indicated that fruits such as mangoes and oranges are sold both locally and exported to international markets. The households have formed marketing group that helps strengthen their bargaining power and sells their mangoes and oranges to international markets. It was established that the households through the leadership of the WRUA chairperson had been linked to potential

buyers helping them eliminate the challenge of poor prices from middlemen. The users come together and form a legal institution with the help of Water Resource Management Authority (WRMA). The purpose of forming a WRUA is to conserve the ecosystem, land, water and related natural assets in a Sub Sub-catchment (Water Act 2016).

Therefore, at Kikuu River Sub-catchment the households have formed WRUAs and use the entity to support the conservation and livelihood initiatives in the area. They all assemble their goods at a common place and sell to international buyers at a high price without exploitation by middle men. The marketing group receives post harvesting knowledge and modern farming capacity building from the WRUA chairperson who gets support from the buyers, the County government agricultural officers and extension persons. As shown in Table 5.6, 40.4% of the respondents combine both commercial and subsistence farming, 12.1 % are doing subsistence farming while 44.4% are involved in commercial farming. This is a clear indication of a food secure community with an improved livelihood.

Table 5. 6: Types of farming

Types of Farming	Households in Percentage
Subsistence	12.1
Commercial	44.4
Both	40.4
Not applicable	2.0
No response	1.0
Total	100.0

Source: Researcher, 2016

5.1.9. Types of livestock

95% of the households reported to keep livestock for food and provision of organic manure for their farms. Cattle is used by households to provide labor in the farms during land preparation for planting (ploughing) Donkey provide means of transport for household water, goods to the

area and business facility for the water vendors. The presence of Napier grass grown to conserve land and River banks promote livestock keeping since Napier grass is used as fodder for the animals.

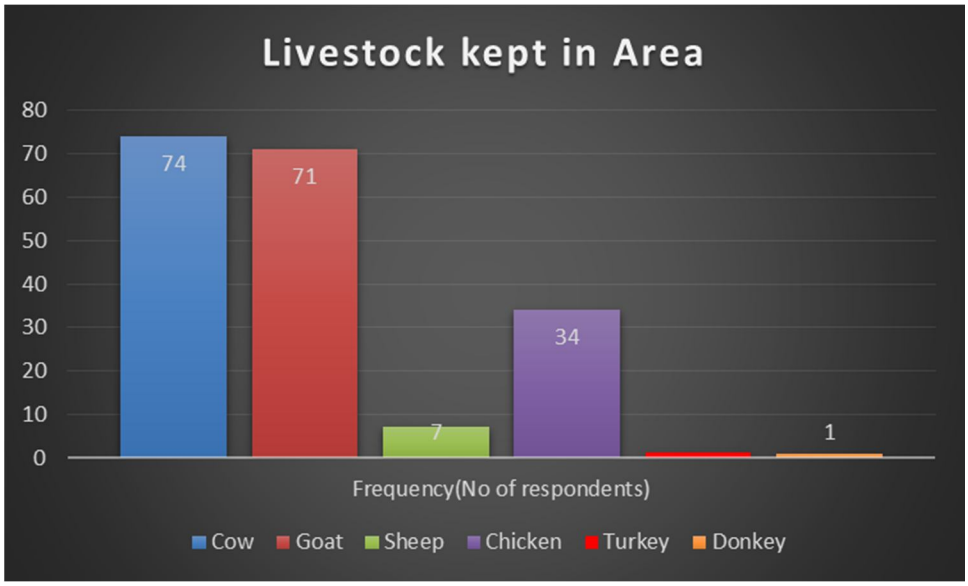


Figure 5.2: Types of livestock kept in Percentage

Source: Researcher, 2016

The largest percent of the livestock kept was the cow. The study results indicated that 74% of the households had one or more than two cows as illustrated in figure 5.2. The cows are used as means of transport, provide labor during farming, provide organic manure for the farms and also used as a source of food for the residents (milk and meat). The households reported that they were able to sustain the livestock due to high adoption of Napier grass that is used as a means of Riverbank and land conservation as well as fodder for the cattle. The results compare with Makueni County Long Rains Assessment (LRA) report in 2013 by NDMA.

The LRA assessment reported that, the feed available declined gradually through August and September in terms of both quality and quantity and lasted only two to three months. This affected Livestock productivity resulting to a fair body and livestock produce. This condition has taken a turn around in Kikuu which lies in the mixed agro-ecological zone. IWRM has increased water for livestock and fodder though planting Napier grass hence improved livestock body condition. The good body condition for livestock implies increased productivity in terms of milk, eggs, meat and

other livestock products and by-products. In addition it means improved fertility and reproduction hence increasing flock sizes.

5.3 Objective One: Level of Adoption of IWRM and its Contribution to Food Production.

5.3.1 Application of Kenya Water Sector Reforms in the Study Area

As reported by the key informant interviewees that included the Makueni County government director for water, Makueni WRUA council chair person, Kikuu River Sub-catchment has been a beneficiary of the water sector reforms in that, the management of the River is coordinated, inclusive and systematic. The community is reported to form a strong user association to coordinate the management of the Sub-catchment. It was noted that the WRUA was made of self-help groups, youth groups and women, learning institutions, famers and community members in the Sub-catchment. The WRUAs ensure water is available for both upstream and downstream users (Makueni WRUA Council, 2016). They create awareness to the users on the conservation of the River, equity in its abstraction and protection of the water from pollution. Therefore, the downstream users are assured of water for domestic, commercial and irrigated farming (WRMA, 2016).

5.3.2 Actors of Water Resources Management in Kikuu River Sub-catchment

The community in the study area reported that they have and apply knowledge of sustainable best practices. The conservation activities are inclusive and based on stakeholder engagement and every stakeholder play crucial role in the protection of Kikuu River Sub-catchment. The study indicates that the most preferred sustainable best practice is planting Napier grass by the community members. As shown in figure 5.5, 28.28% of the respondents grow Napier grass to protect degradation of Kikuu River and reduce water pollution. The community provide labor in the construction of sand dams for rain water harvesting as illustrated in plate 5.2. They keep livestock and also do crop farming. In this regard, the adoption of Napier grass helps increase water for irrigated farming and fodder for the livestock.

Plate 5. 2: Community members constructing a sand dam

Source: Researcher, 2016

Apart from community members, the administration is also involved in the conservation of the River Sub-catchment. It was noted that the area chief, village administrators, and the County government through Makueni County Sand Conservation and Utilization Authority take part in the conservation of the Sub-catchment. In this area, though sand is a mineral resource, the community and water management actors take sand as water storage facility. Every stakeholder takes action to promote sustainable sand harvesting.

The Sand Conservation and Utilization Authority in the county has recruited conservation officers on the ground who work with the WRUAs, administrative officers and the Nyumba-Kumi groups promoting the health of the River Sub-catchment. The sand in the River is only allowed for local construction and only harvested at distinct areas. They use mobile phones to mobilize themselves when the illegal sand harvester is seen in the River.

Women groups, self-help groups, and the youth have subscribed to the WRUA and are joining efforts with all other stakeholders to conserve the area. Civil society organizations are also providing both technical and financial support to the community groups and WRUAs in the restoration of Kikuu River Sub-catchment integrity. For example, African sand dam foundation was felt on the ground as community members reported to receive technical and material support

towards construction of sand dams along the River. Sand dams act as rain-water harvesting structures and avail water for domestic use and irrigation. Other water sectors civil society organizations such as Centre for Social Planning and Administrative Development were reported to provide capacity building knowledge and sensitize the community on IWRM. Therefore, all stakeholders are well engaged in the management of the Sub-catchment hence promoting the coordinated protection of water and land in the study area.

5.3.3. Level of adoption of IWRM by households in Kikuu Sub catchment

The field study noted that 17.2% of the households were practicing sand conservation for protection of the riparian land. 22.2% of the respondents are practicing agro forestry that includes farming of fruit trees used as food, cash crop and reduced degradation of the Sub-catchment. 28.35% have planted Napier grass at the land close to the River reducing water pollution and River bank degradation. The Napier grass is also used as fodder for cattle hence making the community food secure. Those with bigger plots of land with Napier grass earn extra income by selling excess fodder. 24.2 % of the respondents are doing terraces in their farms making the Sub-catchment fertile and productive as shown in figure 5.3.

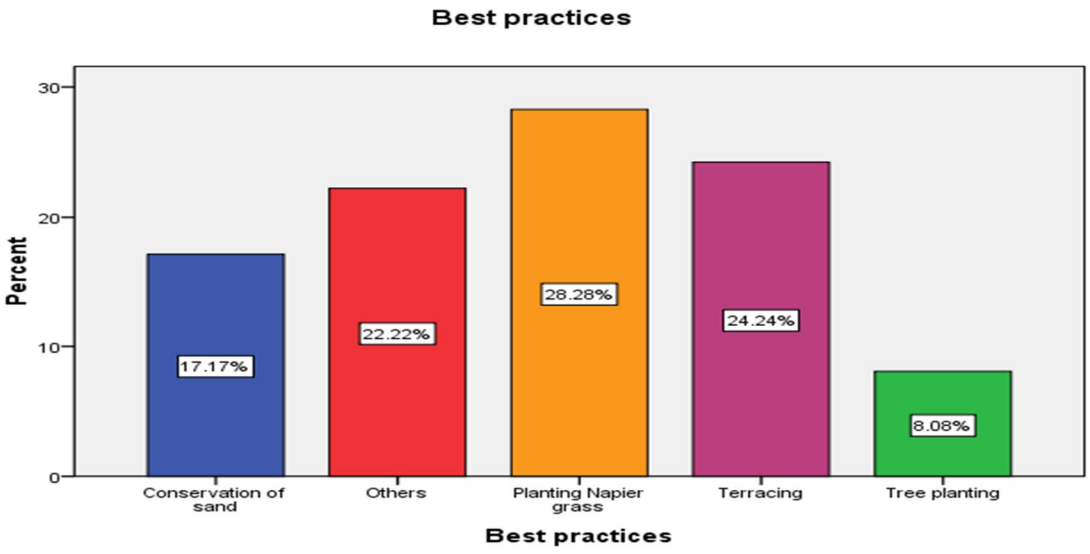


Figure 5.3: Best practices in Water Resource Management in the Study Area

Source: Researcher, 2016

Therefore, the research shows that 100% of the households sampled know and practice one or two best practices to the advantage of environmental conservation of the Sub-catchment and household food produce.

The respondents also said adoption of sustainable best practices in the conservation of water and land has helped them produce vegetables for both commercial and household consumption. This is because the Napier grass and sand conservation help raise water table as indicated in Plate 5.3.

Plate 5. 3: Raised water table at Kikuu River as a result of sand conservation and Napier grass

Source: Researcher, 2016

5.3.4 Testing of the Study Hypothesis

A chi test of the IWRM strategies adopted and farm produce was done. The main variables measured in the study area was the amount of food production per household and the number of best practices adopted in the conservation of water and other natural resources. The calculated value was compared with the critical value that informed the decision on whether to reject or fail to reject the null hypothesis as discussed in the following table:

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.99	20	.0309
Critical Value	31.41	20	.0270
N of Valid Cases	99		

a. 24 cells (80.0%) have expected count less than 0.05. The minimum expected count is .08.

The study null hypothesis adoption of Integrated Water Resource Management (IWRM) approach does not significantly affect the farm household productivity was rejected since the critical value was less than the calculated value at 0.05 significant levels and 20 DF. The Critical value was 31.41 while the calculated value was 45.99. Therefore, the alternative hypothesis adoption of Integrated Water Resource Management (IWRM) approach significantly influence the farm household productivity, or food security was adopted, and it was concluded that adoption of IWRM is important and promote household food production. The best practices of conservation through IWRM improve water for irrigated agriculture ensuring food supply during the dry and rainy season.

A continued supply of fresh vegetables and farm produce improve the nutrition of the society, and improved livelihood as the surplus can be sold in the local and international markets creating employment for the community in dry lands.

The research findings are comparable to the results of a study on drought and famine status of Makueni County by the National Drought Authority (NDMA) 2016. The NDMA assessment study noted that fresh commodities such as maize and vegetables were easily available in local markets. A kilogram of maize was retailing at Sh35 while the same quantity of rice and beans was going for Sh84 and Sh87 respectively. This was taken as the reasonable price that was manageable by the poor population in the county. The study by NDMA 2016 also reported that only 4% children in high potential areas faced malnutrition (NDMA, 2016).

The statistics presented a normal trend hence the adoption of IWRM approach has positively impacted household food production stabilizing drought and famine in the study area. This is good news to the residents of Makueni, a County that is characterized by perennial droughts and famines. It is a clear indication that water resource management intervention especially IWRM in the study area has promoted drought resilience improving livelihoods of the community.

5.3.5. IWRM and Food Production in Kikuu River Sub-Catchment

The crop production in Kikuu Sub-catchment that lies in the mixed agro-ecological zone has improved since 2012 due to IWRM adoption. The households reported having been taken through training on IWRM resulting to the establishment of a strong Water Resource Users Association that coordinates the water conservation activities in the Sub-catchment. Water volumes have increased, and the community no longer depends only on unreliable rain for their crop productivity. Although the survey was done during the dry season of August 2016, the household farms were seen wealth with various irrigated vegetables, Fruits and Maize crops. The community reported experiencing an increase in food produce and improved livelihood. They reported practicing irrigated agriculture for food produce and sold the extra produce at the local markets to earn their living as elaborated in figure 5.4 and figure 5.5.

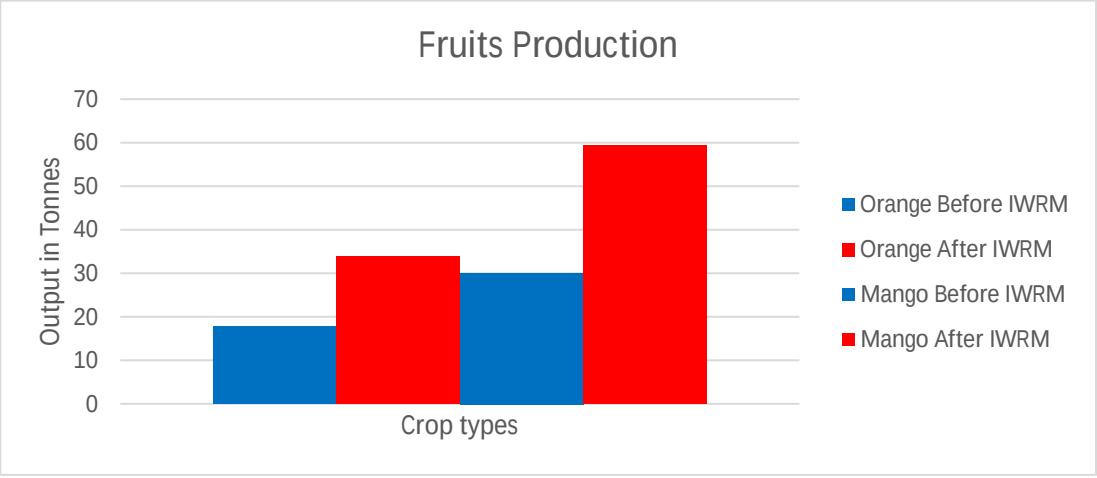


Figure 5.4 Oranges and Mangoes harvested in 2012 and 2016

Source: Researcher, 2016

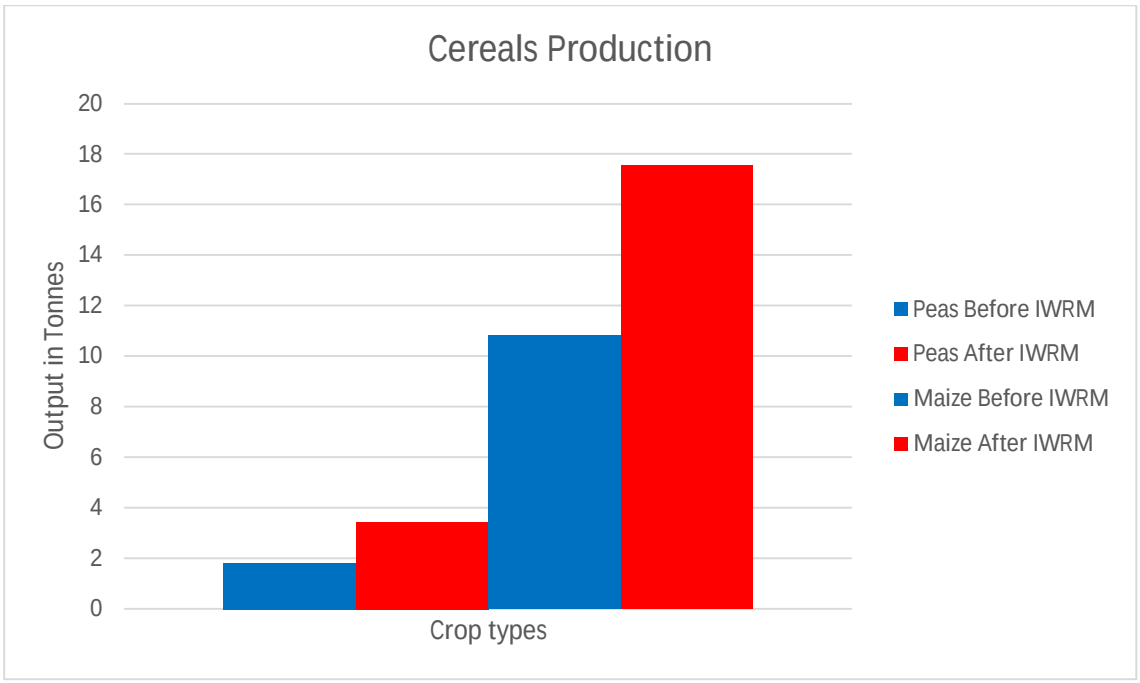


Figure 5.5 Maize and Pease harvested in 2012 and 2016

Source: Researcher, 2016

The main crops that were grown in the area before and after IWRM were mangoes, oranges, maize, and Pease. Figure 5.4 and 5.5 indicates that the production of both fruits and cereals increased with the adoption of IWRM. The researcher noted IWRM increased water for irrigated agriculture increasing the household farm production. The findings compare with a study by Bongani, 2009 on IWRM and livelihood in Limpopo basin where he noted that IWRM principles are potential to manage water resources and improve productivity within the dry Limpopo Basin. He also noted that conservation farming and crop water management in Limpopo improved crop yields by margins of more than 200 kg/ha. Therefore, IWRM is very critical in addressing food insecurity and community livelihood in dry or water scarce areas.

5.4 Objective Two: Local Conservation methods and their Contribution to Food Security.

This section discusses the local conservation techniques in the study area. It provides a cross tabulation of the local conservation methods and food production adopted in the Sub-catchment area. A correlation on conservation and study area livelihood is also provided. The benefits of adopting sustainable conservation best practices and challenges in adoption of the best practices

are clear in this section. There is also a clear illustration of the challenges of sand conservation process and a discussion on the most adopted local conservation technique.

5.4.1. Local Conservation Techniques Practiced

The study indicated that households apply local conservation techniques in the conservation of water and related natural assets. The most adopted local conservation technique was terracing. The study indicates that 30.3% of the households make terraces in their farms as shown in figure 5.6. The households have joined efforts and formed village groups that support themselves in the construction of terraces on the farms to retain water in the farm, the speed of surface water runoff and maintain the fertility of land hence promoting farm food production as shown in plate 5.4.

Plate 5. 4: Terraces for local land conservation at Kikuu River Sub-catchment

Source: Field data, 2016

The households have also constructed cut off drains to harvest road water runoff and reduce land degradation. 15.15% of the respondents were practicing contour farming while 8% of the households planted Napier grass on the farm to reduce soil erosion and retain farm fertility for increased household farm produce as indicated in figure 5.6. Other local techniques used for land and water management is the use of organic manure. Figure 5.6 indicates that 35.35% of the households in the study area use organic manure to reduce water pollution from the farms near the

River (In the event chemical fertilizers are used) and increase food production.

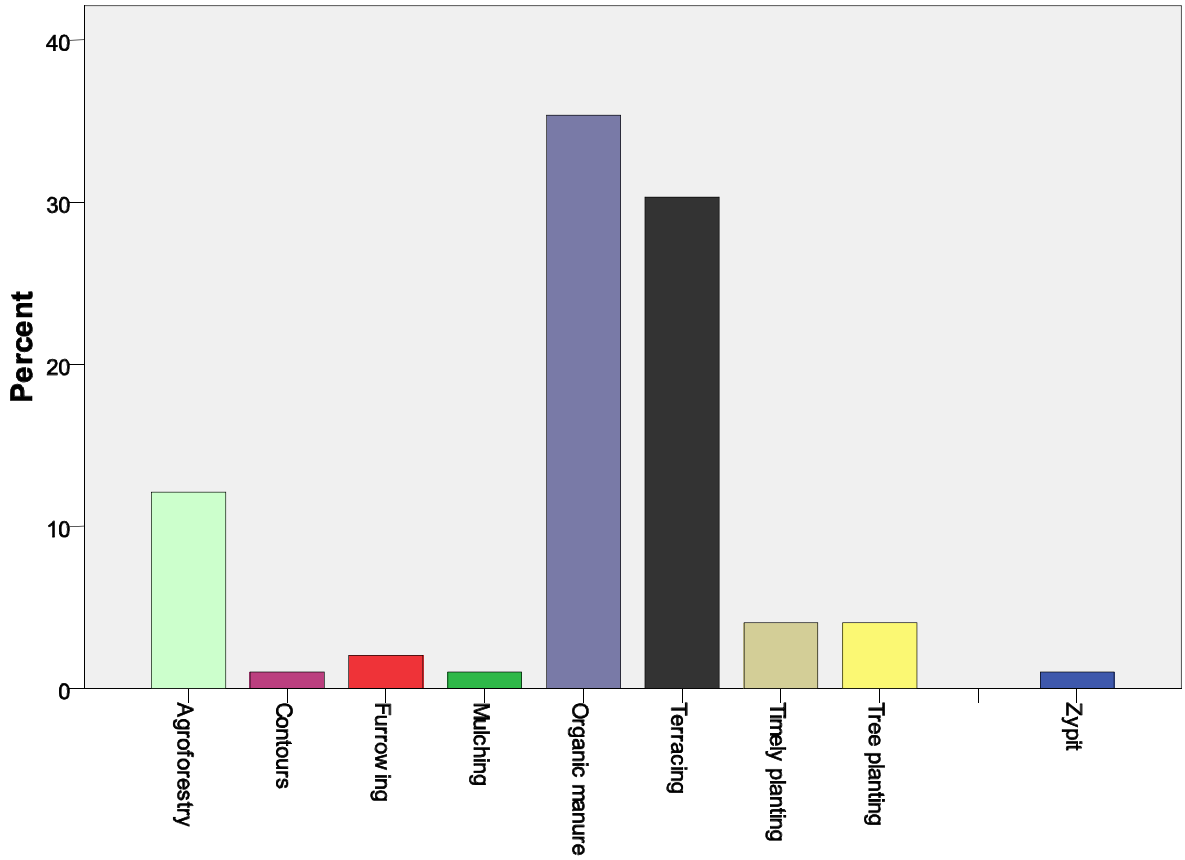


Figure 5.6: Local Conservation methods Adopted in Percentage

Source: Field data, 2016

They also use zypits and mulching method in the farms to promote effective crop growth and farm production. The households sampled at the study area had adopted drought resistant crops such as Peas, cassava and hybrid seeds that include maize and sweet potatoes as confirmed by the National Drought Management Authority Makueni County.

Table 5.7: Local conservation techniques and Quantity from farm

Conservation Method	Percentage of households that harvested above 5 tons of fruits	Percentage of households that harvested Above 5 sacks of cereals	Percentage of households that harvested Above 5 sacks of vegetable
Terracing	20%	10%	10%
Tree planting	10%	30%	10%
Planting Napier grass	40%	40%	30%

Source: Field data, 2016

The households who applied local conservation techniques such as terracing were able to harvest enough for their household consumption and commercial purposes hence improving their livelihood status. The study shows that 70% of the households were able to harvest over five tons of fruits. Furthermore, 80% of the respondents were able to harvest over five sacks of the cereals in a year as shown in Table 5.7. Therefore, local conservation is beneficial to the household food produce and well-being.

Unlike the joined efforts in IWRM approach, the local conservation methods are done by individual households in their farms. This help increase fertility of their farms hence increasing household food production. However, those who lack labor to practice the local conservation methods are likely to remain food insecure hence inequality in the sub-catchment. Therefore, it is important that the famers combine both the local conservation and IWRM that is holistic and inclusive for equitable and sustainable food production as well as community well-being.

5.5. Objective Three: Irrigation Methods at Kikuu Sub-catchment and Food Production

This section discusses the irrigation techniques that are used by the households in the study area for irrigation and the impact the techniques have on house hold food production. The analysis borrows widely on the study data and correlates various parameters. A critical analysis of the farm size and land use is also given in this section. The types of crops done by the households through both rain-fed agriculture and irrigation are discussed about the field data collected at Kikuu River Sub-catchment. The section also discusses the types of farming that include subsistence and

commercial based on the data collected from households who do irrigated farming for sale and food production in the household. Therefore, a cross tabulation of irrigation and farm produce is done to inform the impact of irrigation on household food produce and livelihood of the household at Kikuu River Sub-catchment.

5.5.1 Irrigation Methods adopted in Kikuu River Sub-catchment

Some of the irrigation methods adopted included; Zypits in which a farmer could make a rectangular surface pit, grow crops at the edges of the pit and put grass at the central part referred to as a mulching process. The use of Zypit is an advantage to the household as the crops can utilize the nutrients efficiently and retain water in the soil for a long period promoting farm production. The basin or zypit irrigation system was adopted by 16% of the households. They argued that Zypit or basin irrigation helps reduce the loss of nutrients and water. The households are required to make a rectangular shallow pit and put grass as a means of mulching and retaining water for the well-being of the crops as illustrated in plate 5.5.

Plate 5. 5: Basin/Zypit irrigation method for Miraa crop at Kikuu River Sub-catchment

Source: Researcher, 2016

Another irrigation method used was use of furrow in which water is directed in the farm by use of furrows and with the aid of water pump and pipes. This is the most applied irrigation technology in the study area. The research indicated that 28% of the household own a water pump machine to help get water to their farms which are located near the River and use horse pipe to direct the water

to the farm as elaborated in figure 5.7. 26% of the respondents had made furrows in the farm to facilitate irrigation and reduce soil erosion in the land.

Terraces were also used by 2% of the household to reduce soil erosion and retain water in the farm promoting farm productivity. The research indicated that 9% of the households used watering cane system for their crops. They would fetch water from the River by use of donkey and use containers to irrigate their fruits and vegetables. The method was tedious, and the respondents recommended that the government and other development partners come up with strategies for supporting household water supply. They felt the construction of water points, rain water harvesting structures, and sand dam would solve the challenge of water in the area.

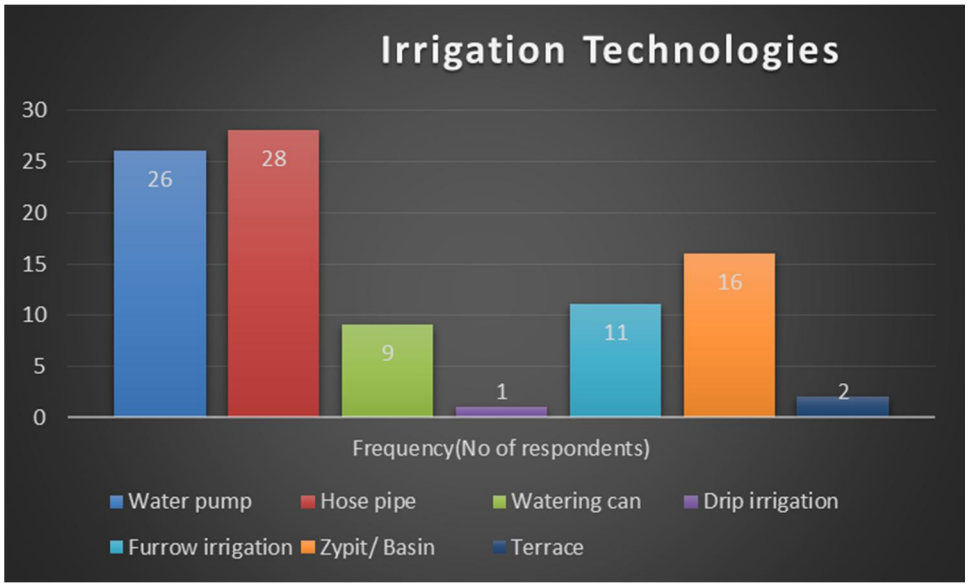


Figure5.7: Irrigation Methods

Source: Researcher, 2016

5.5.2. Irrigation and Food Production

The study shows that households who applied irrigation in their farms increased their produce. 70% of the respondents harvested above 5tons of fruits and 80 % reported harvesting over five sacks of cereals due to irrigation agriculture in the year 2015 and 2016 as indicated in Table 5.8. They would have more than two harvests because they depended on both rain-fed agriculture and irrigation.The application of IWRM and local conservation methods increased water that would meet the competing uses and promote irrigated farming. However other parameters such as farm size and the use of organic manure contributed to the farm output. Terraces would also improve the

fertility of the farm, retain water through rainwater infiltration and increase food production. Furthermore, timely planting also helps those who cannot do irrigation get significant yield as their crops get support from rain to maturity. Therefore, all best practices on the farm are important and local conservation as well as modern farming techniques should be adopted for efficient household food production and improved livelihood.

Table 5.8: Irrigation and farm production in 2015 and 2016

	Above 5tones of fruits (Mangoes and oranges)	Above 5 sacks of cereals	Above 5 sacks of vegetable
Households production in Percentage	70%	80%	50%

Source: Researcher, 2016

The findings compare with a study on innovative irrigation methods by Suresh, 2011 which observed that crop irrigation is the great user of water accounting about 70% of global freshwater uses. It also noted that increasing food and bio-fuel demand by continued population growth could be addressed through more irrigated areas, especially in developing countries. However, there has been mounting pressure to limit water supply to irrigated agriculture and to produce more food with less water. It also compares with a study by Ransford, 2015 which noted that water scarcity in agriculture is a challenge of increasing demand from nonagricultural uses to meet the needs of the people.

World food prices are determined by the overall performance of the irrigated farming, and low food prices are essential to the poor. The impact of irrigation and water management to increased food production can result from the control of existing water supplies. Therefore, water efficient irrigation methods would be efficient in promoting IWRM in the study area. Good irrigation methods would reduce water pollution and ensure access to safe and clean water for human consumption.

5.6. Benefits of Adopting IWRM and Local Conservation Techniques

The study sort to find out from the households selected the importance of Sustainable Water Resources Management that included application of local conservation and adoption of IWRM in their farms and general benefits. 73% of the households considered increased farm production to be a major benefit as indicated in Table 5.9. They argued that adoption of IWRM and local conservation practice increased the fertility of their land, reduced soil erosion and increased water volumes in the River.

The increased water volume helped them do irrigated farming resulting to multiple harvests throughout the year. The local techniques such as terracing retain water in the land and ensured perfect crop maturity even when the rains were limited. Moreover, 12% indicated that sustainable best practices reduced soil erosion. The households felt that practice of planting Napier grass reduced River bank degradation and rain water surface runoff that would reduce the production of their land. This results to relatively high food production making the community food secure and reduced rates of malnutrition. Less soil erosion also reduces water pollution hence limited water borne diseases in the study area as indicated in Table5.9. Additionally, 15% of the respondents said that conservation of sand and application of other conservation best practices have helped in availing water for both domestic and commercial use.

This finding compare with a review of IWRM in Israel (UNEP 2006) which noted that IWRM brings stakeholders into decision-making processes, which can create more equitable water management choices and prevent conflicts. It also compares to a study by GWP, 2007 that the integration stakeholders from different sectors and management institutions provides a platform for water users to adapt and respond collectively to the uncertainties over water management and conditions such as droughts. IWRM has led to an increased awareness of the sustainable development and the incorporation of social and environmental considerations into water management. The study also found that IWRM resulted to a move away from top-down, centralized approaches to water security towards more flexible, decentralized approaches which involve a variety of diversified governance structures at a local, basin, national, and transnational level. Therefore, sustainable water management is key in promoting water and land conservation for food production and improved livelihood.

Table5.9: Benefits of sustainable water management best practices

	Categories of Benefits Established	Number of households in Percentage
Effects of Sustainable Water management on Kikuu community	Availability of water for domestic use	15%
	Increased food production due to irrigated farming	73%
	Prevent soil erosion	12%

Source: Researcher, 2016

5.7 Challenges of Adopting Sustainable Water Management Best Practices

Makueni County is characterized by a rapidly growing population, water scarcity, and falling food production. Climate change and rapid population growth cause food insecurity and environmental degradation in the County (KNBS, 2009). The study results indicate that only 17.18% of the respondents take part in sand conservation. The high poverty rate forces the households over depending on natural resources hence participating in illegal sand harvesting rather than supporting the County government and the WRUAs in sand conservation. Due to the small number of people involved in sand protection and corruption, illegal sand harvesters from outside the County get into the River with Lorries and scoop sand for sale in urban areas. The households also lack finances to buy Napier grass that promotes Sub-catchment conservation practices and limited labor to make terraces, furrows and take part in tree planting practices as reported by the Sub-regional officer WRMA Kibwezi Sub-region.

The high poverty rate and food insecurity status contribute to a low percentage of the households in the communal groups for the construction of sand dams. Some members have been forced to drop out of the communal construction groups to look for food for their household and school fees for their children since they are not paid for their services in the construction, and they have limited livelihood strategies. It was noted that the sand dam foundation that is facilitating construction of sand dam use a cost-sharing methodology in which the community provide labor, some materials

such as sand and stones while the Foundation provide only technical support and cement for the sand dam construction as confirmed by WRUA chairperson. The process is wanting and force poor women and children to spend a whole day in the River helping in the construction.

The community recommended donors to come up with better strategy such as food for work would be better to support them get food on the table for their children as they work on River conservation activities. A business model would also be effective in which the development partners help construct the sand dam and charge the users a certain fee that would help them repay back the money used in the process. County government could also help with some materials and provide more technical support so as to aid the sand dam construction process.

6.0 CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATION

6.1. Introduction

This section presents a summary of the study findings, overall observation of the IWRM approach and its role in reducing food insecurity in dry lands. The conclusion on the IWRM approach importance is done in relation to the field information gathered. The researcher also gives recommendation to policy makers, development partners and academia in relation to research problem statement, objectives and field findings.

6.2. Summary of key Findings

This part discusses the key findings in brief in relation to the study objectives and field data. It briefly highlights the results and discussion on the adoption of IWRM and its impact to household food production at the study area, the local conservation techniques food security nexus and the water efficient irrigation methods used by the community at the study area as well as the contribution of the best practices to household food production and livelihood.

6.2.1 Adoption of IWRM and food production

The research established that there exist a coordinated and inclusive management of water, land and related assets at Kikuu Sub-catchment. The study found that WRUAs take lead in the conservation activities at the River. The youth, women groups and elderly have also key role to play in the management of the Sub-catchment. The learning institutions and water sector CSOs also participate in management of the Sub-catchment through providing technical and financial support to the WRUAs and the County government.

The county government has recently established Makueni County Sand Conservation and Utilization Authority which promote sand conservation and associated natural resource management in the Sub-catchment. The study also established that 100% of the community in the study area have knowledge of IWRM and apply one or two best practice for water and related natural resource management. The highest sustainable best practice adopted is planting Napier

grass that helps reduce degradation of the River banks and also acts as fodder for livestock in the study area.

The efficient management in the River has helped raise water table and ground water recharge for both domestic and irrigation purposes. Adoption of best practices has thus resulted to increased food production and improved livelihood.

6.2.2 Local Conservation Techniques and Food Production

Considering that IWRM entails application of indigenous knowledge and techniques, it was established that the community embraced local conservation techniques. The community is trying to address the IWRM principle that water is a finite resource; the community was found to practice conservation methods. They planted Napier grass, used timely planting, contour farming, tree planting, agro forestry and terracing. All the respondents interviewed used one or two local conservation strategies. The study shows that terracing was the highest local conservation technique used to reduce soil erosion and improve productivity of the farm in the area. 30.03 % of the respondents had constructed terraces in their farms and were able to retain water and fertility increasing both cereals and fruit production. This could promote long term benefit to environment and the community well-being.

Local conservation helped increase food production and livelihood of the community in the study area. The research shows that 73% of the community experienced an increase in food produce and 15% said sustainable best practices increased water for domestic use and commercial purposes by the Water vendors hence improving their livelihoods. The local conservation techniques adopted by the households are efficient for promotion of IWRM in the study area. If the techniques are well utilized then the area is assured of integrated water and land management for improved livelihood and food produce.

6.2.3 Water efficient Irrigation Methods and Food Production

It was established that the community in Kikuu River Sub-catchment are practicing irrigated farming as IWRM has increased water in the area. 50.3% of the respondents interviewed said they

practiced irrigation agriculture. The most used irrigation methods in the study area were identified and the major factors contributing to their adoption were seen as; farm size, location, crop yield, and support from the county government, knowledge from extension services, CSOs and local experience. The study noted that the beneficiaries were willing to adopt best practices and above 50% of the respondents had adopted IWRM and water efficient irrigation ways. They combined various local best practices such as furrows, terracing, zypits, mulching, use of organic manure and use of drought resistant food crops for food security in the household.

Those who dependent only on rain fed agriculture were the residents whose farms were far from the River. They lacked finances to buy water pump to get water in their farms for irrigation. They also said that they could not share the scarce water in the River with the households whose land is located near the River. Therefore, they recommended the county government and other development partners in collaboration with the local community to increase the conservation activities in the Sub-catchment such as construction of sand dams that would help supply the various households with water for irrigation and domestic use. Facilitation of the community to construct rain water harvesting structures would also help the households get water for irrigated farming and stop overdependence on unreliable rain-fed agriculture.

6.3. Conclusion

The main purpose of the study was to investigate the effect of Integrated Water Resource management on food security in Kikuu River Sub-catchment in Makueni County Kenya. It was noted that, Water Resources Users Associations (WRUAs) and development partners have successfully created awareness on water resources management and related natural assets management best practices. The community has adopted IWRM and water efficient irrigation means. The sustained practice of IWRM approach has potential to produce long lasting impacts and can go a long way in contributing to food security in the dry land communities. Therefore, the approach can be replicated in the county and other River Sub-catchments in Kenya.

6.4 Recommendations

Based on the findings of this study, the following specific recommendations apply:

6.4.1 National Government

Water Resource Authority (WRA) previously known as WRMA in Water act 2002 should engage with the relevant stakeholders towards Practice of Basin approach in water management through forming and strengthening WRUAs in various Sub-catchments of Kenya.

6.4.2 Water sector and Livelihood Civil Society Organizations (CSOs)

The water sector and livelihood CSOs e.g African Sand dam, Centre for Social Planning and Administrative Development and other development partners should;

Complete the unfinished projects in the study area and mobilize the community in the County and the country in general towards best practices in water resource management and promotion of a food secure community. This would help achieve the global transformation agenda (SDGs) of zero hunger, clean water and environment, reduced poverty, etc.

The development partners should also consider sustainability strategies while implementing water management and livelihood initiatives in the community. This could be done through mobilizing the community to own the initiatives and facilitate formation of community groups (WRUA) that can continue with topical issues in relation with water resources and livelihood.

Link the community groups and beneficiaries with other stakeholders. In linking communities to other organizations, it is important to develop partnerships with mutual benefits where all parties are equal. Memorandums of understandings can be developed to support such partnerships.

6.4.4 Recommendations for Further Research

The study recommends more studies to be conducted on:

Rain Water harvesting structures for irrigated farming and food security in ASAL Regions

Integrated Natural Resource Management and Climate change mitigation for poverty reduction

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APPENDIX II: HOUSEHOLD QUESTIONNAIRE

UNIVERSITY OF NAIROBI

AN ASSESSMENT OF INTEGRATED WATER RESOURCE MANAGEMENT/ IWRMAPPROACH FOR REDUCING FOOD INSECURITY AND POVERTY IN DRY LANDS- KIKUU RIVER SUB-CATCHMENT

I Ms. Eunice Kivuva a post-graduate student at University of Nairobi request for your support in gathering research data. I am conducting a research project to assess the impact of integrated water resource management/ IWRM approach for reducing food insecurity and poverty in dry lands. To meet the objectives of the study, several techniques are being used including conducting key informant interviews and household questionnaire. Kindly assist in providing the required information by answering this questionnaire. The information obtained will be used sorely for informing this study and will be confidential. Thank you very much.

NAME OF LOCATION: **DATE:**

NAME OF HOUSEHOLD HEAD/RESPODENT:

SECTION A: DEMOGRAPHICS

1. Gender of respondent

.☐ Male .☐ Female

2. Marital Status of respondent

☐ Single ☐ Married ☐ Widowed ☐ Divorced

3. Occupation of respondent

(i)……..

(ii)…….

(iii)……

(iv)……

(v)…….

(vi)……

4. Ages of respondent

☐ 10-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 60 and above

ii. Family size:----------

---

5. Level of Education

☐ Primary ☐ Secondary level ☐ Middle level college ☐ University

SECTION B: LAND USE AND IRRIGATION FOR FOOD PRODUCTION

6. What is the size of your farm?

☐ Below 1ha ☐ 1-5ha ☐ -5-10ha ☐ 10-15ha ☐ above 15 ha

7. Where is your farm located?

☐ Close to the River ☐ Far from the River

8. Do you practice Irrigated farming in your farm? Explain

……

……

9. Do you use any Irrigation technologies? If yes, which ones?

……

……

10. For how long have you been using these technologies?

……

……

11. Crop farming and food production

(i) What type of crops do you plant?

……

……

ii. How much agricultural produce do you get from your farm per year.

……

……

iii Do you do subsistence or commercial farming?

……

……

iv If you do commercial farming what is the target market for your farm produce

……

……

(v) Do you practice livestock keeping in your land?

……

……

SECTION C: Sustainable water management (IWRM and Local water management Approaches)

12. Do you know any best practice that can be used for sustainable water management?

☐ Yes ☐ No

13. If yes, list some of the best practices that you know and have adopted

……

……

14. What actions/activities have you taken as an individual or community to ensure that water is available today, tomorrow and for the future generation?

……

……

15. Why did you choose to take these actions?

……

……

16. List some of the stakeholders who take part in the water and related resources management activities

……

……

17. What technological devices and best practices do you use in your farms to retain its productivity and ensure efficient water use

……

……

18. Do you have any rain water harvesting structures in your farm? Explain

……

……

19. What benefits do you get by adopting the water management best practices?

……

……

20. What challenges do you face in implementing the best practices for sustainable water management?

……

……

21. What are the effects of sustainable water management best practices on your household food production and livelihood?

……

……

22. What are the effects of water management best practices on the natural environment?

……

……

23. Are there local water management techniques in this area?

☐ Yes ☐ No

Explain

……

……

24. How do the local water mangemnt techniques impact the community livelihood and food production.……
……

25. What support do you get from Government and NGOs in relation to water management and related resources conservation?

(i) Government (National and County Government)

……

……

(ii) NGOs (water sector and Livelihood CSOs)

……

……

26. What more support would you like to get on water management and natural assets conservation?

……

……

APPENDIX III: INTERVIEW GUIDE

UNIVERSITY OF NAIROBI

AN ASSESSMENT OF INTEGRATED WATER RESOURCE MANAGEMENT/ IWRMAPPROACH FOR REDUCING FOOD INSECURITY AND POVERTY IN DRY LANDS- KIKUU RIVER SUB-CATCHMENT

I Ms. Eunice Kivuva a post-graduate student at University of Nairobi request for your support in gathering research data. I am conducting a research project to assess the impact of integrated water resource management/ IWRM approach for reducing food insecurity and poverty in dry lands. To meet the objectives of the study, several techniques will be applied including conducting key informant interviews and household questionnaire. Kindly assist in providing the required information by answering this interview schedule. The information obtained will be applied solely for informing this study and will be confidential. Thank you very much.

KIKUU RIVER SUB-CATCHMENT

NAME OF INSTITUTION: **DATE:**

NAME OF RESPONDENT:

DEPARTMENT/SECTION:

1. Are there any sustainable environment and water management initiatives/techniques in this area?

   ____ Yes ____ No

If Yes, which ones?

2. What are the factors contributing to the adoption of IWRM?

   ……

   ……

3. To what extend is IWRM practiced in Kikuu River Sub-catchment

   ☐ Below 25% ☐ 25 – 50% ☐ 50 – 75% ☐ 75 – 100%

4. List the actors in environment and water resource management in the study area

   ……

   ……

5. How has IWRM impacted community household farm production and livelihood?

   ……

   ……

6. Does the management of water resources include youth, women and persons with disability?

   ☐ Yes ☐ No

   Explain

   ……

   ……

7. Are there local water management techniques in this area?

   _____ Yes _____ No

   Explain

   ……

   ……

8. Outline the most water efficient irrigation technologies adopted in Kikuu River Sub-catchment

   ……

   ……

9. What is the impact of irrigated farming on water resources- in the study area

……

……

10. How has the water efficient irrigation technology affected food production and community livelihood

……

……

11. Explain any support that your organization provides/has provided to the farmers in relation to water management and food production in the study area?

……

……

12. What are your future plans for the farmers who are yet to adopt water efficient irrigation technologies and are susceptible to land/ soil degradation as well as food insecurity?

……

……

13. Discuss the effects of IWRM on natural environment?

……

……

14. Explain your future plans for water and natural resource management as well as initiatives towards food secure community?

……

……

APPENDIX IV. OBSERVATION SCHEDULE

The observation study method will help the researcher to gather information on the characteristics of the study area along with the most water efficient technologies adopted in the study area. Additionally, types of crops and livestock kept will also be observed.

The following are the specific aspects that the researcher shall focus on:

1. Water efficient technologies used in the study area

……

……

2. Types of crops

……

……

3. Types of livestock

……

……

4. The size of farm

……

……

5. The location of farm

……

……