DETERMINANTS AND EFFECTIVENESS OF ADOPTED DROUGHT MITIGATION STRATEGIES AMONG HOUSEHOLDS IN THARAKA SOUTH SUB-COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Arts in Geography of Chuka University

CHUKA UNIVERSITY

OCTOBER 2024

DECLARATION AND RECOMMENDATIONS

Declaration

This thesis is my original work and has not been presented for an award of a degree in any institution.

Signature.. Date ..14|10|2024..........

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Recommendations

This thesis has been examined, passed and submitted with our approval as the University supervisors.

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DEDICATION

I dedicate this work to my dear daughters; Claire Patience and Clara Precious for being part of my life; my husband Martin Kariuki and to my dear parents; Nyaga Gacaga and Jane Muthoni for their encouragements and unwavering support.

ACKNOWLEDGEMENTS

I am deeply grateful to the Almighty God for keeping me inspired and courageous throughout this research. My sincere appreciation goes to, Dr. Moses Kathuri Njeru, Dr. Paul Njue Nyaga and Mr. Hannington Sitati, my research advisors, who provided genuine encouragement and support to help me complete this study. They dedicated a significant amount of time to thoroughly review my work and making significant corrections as needed. May God bless them abundantly for their remarkable support.

I would like to express my sincere gratitude to the Department of Social Sciences, under the chairmanship of Dr. Oudo of Chuka University, for the support they have provided in shaping my research work. Moreso, I appreciate the insight of the entire faculty of humanities and social sciences under the leadership of Dr. Christopher Kiboro for guiding me appropriately in my research work. Their guidance and assistance have been invaluable. I would also like to extend a special appreciation to James Muthomi my course mate at Chuka University for his encouragement and immense contribution towards this research work. Your support has been instrumental in the successful completion of this project.

My acknowledgment would not be complete without appreciating all the households in Tharaka South Sub-County. Without your selfless participation and generous contributions, this study would not have been a success. Your involvement and support have been crucial in making this research project a reality. Most importantly, I would like to appreciate the Director of Department of Agriculture, Livestock and Fisheries, Director, County Drought Management Authority and Director, Grassroot Development Initiatives Foundation- Kenya (GRADIF) for providing valuable information that made this research a success. Lastly, I do appreciate my spiritual parents; Rev. Fred Njau and Pastor Grace Njau of World Harvest Christian Church-Chuka, thank you for being there when I needed encouragement. You were a source of encouragement and a strong pillar of hope during this journey of research work.

ABSTRACT

Drought has always disrupted most of agricultural activities over the globe. Rainfall amounts and intensities are becoming very unpredictable, and so increasing the levels of drought occurrence and persistence. More than four fifths of Kenya’s land is ASAL including the greater part of Tharaka Nithi County. Therefore, the study examined the mitigation measures that are being applied by households in Tharaka South Sub-County to counter drought predicament. To achieve this purpose, the study examined the intensity of adoption of Drought Mitigation Strategies (DMS) the determinants of adoption of DMS and the perceived effectiveness of DMS among farming households in Tharaka South Sub-County. Tharaka South is located between latitude 00^{o} 02’S and 00^{o} 17’S and between longitude 37^{o} 29’E and 38^{o} 00’E. The study used descriptive research design. A sample of 397 respondents was chosen from a target population of 18623 households and three key informants making a total of 400.Cluster random sampling was used to select households while purposeful sampling was used to select key informants. The study used questionnaires, interviews and direct observation to collect data. The descriptive statistics, frequencies, percentages and Pearson’s correlation coefficient were used to analyse data. The quantitative data were analysed using Statistical Package for Social Sciences (SPSS) version 2020. The data was presented using graphs and tables. The study found out that planting drought tolerant crops, crop diversification and rain water harvesting had high adoption intensity with an average of (89.7%), (84.2%) and (78.1%) respectively. Soil water conservation had the lowest adoption intensity being adopted by only 6.1% of the sampled households. From the Pearson correlation test, there was significant positive correlation between DMS adoption and income (0.988, $p<0.001$), level of education (0.986, $p<0.003$), land area (0.983, $p<0.006$) and a negative correlation between DMS adoption and age (-0.593, $p>0.003$). A statistically significant positive correlation (0.106) existed between the perceived effectiveness and the overall adoption of DMS. This study recommends aligning drought mitigation efforts with people's own perspectives and carrying out assessments upfront to provide the necessary baseline information to support appropriate and strategies that are more likely to be effective and widely adopted.

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ABBREVIATIONS AND ACRONYMS

ASALs	- Arid and Semi-Arid Lands
CBOs	- Community Based Organizations
DMS	- Drought Mitigation Strategies
ENSO	- El Niño-Southern Oscillation
FAO	- Food and Agriculture Organization
IPCC	- Intergovernmental Panel on Climate Change
ISAPSIFSL	- Integrated and Sustainable Agricultural Productions Systems for Improved Food Security and Livelihood
KALRO	- Kenya Agricultural and Livestock Research Organization
KCSAP	- Kenya Climate Smart Agriculture Project
KDHS	- Kenya Demographic and Health Survey
KMD	- Kenya Meteorological Department
NACOSTI	- National Commission of Science and Technology and Innovation
NDMA	- National Drought Management Authority
NGOs	- Non-Governmental Organization
OCHA	- Office for the Coordination of Humanitarian Affairs
SDGs	- Sustainable Development Goals
UN	- United Nations
UNDP	- United Nations Development Programme
UNDRR	- United Nations Office for Disaster Risk Reduction
WMO	- World Meteorological Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Drought is a significant natural hazard that has extensive economic, social, and environmental impacts (Tadesse, 2016a). According to Tadesse (2016b), droughts are significant natural disasters that have far-reaching effects on the economy, society and ecosystems.

Droughts have substantial effects on ecosystems and agricultural output, which can have a considerable influence on food prices, trade, and the welfare of impacted communities. Water shortages, for plant growth and development, can result from drought. Crop yields and agricultural output decline as a result of decreasing water availability. As a result, there is less food produced, which might result in food shortages and higher food costs in the impacted areas. The local and worldwide food commerce are affected by decreased agricultural output brought about by drought. When drought-affected regions cannot produce enough food to fulfil their needs, they are forced to import food which might increase global demand and raise food prices. People who depend on certain locations for their food supply in other parts of the world are also impacted in addition to the affected population (UNDRR, 2021)

Ecosystems suffer significant effects of drought by reducing vegetation growth and forests cover which have negative impact on animals and biodiversity. Dehydration stress causes illnesses and even death in a variety of animal and plant species, which further compromises the resilience and health of ecosystems. Reduced biodiversity and altered species distribution are two effects of drought. While certain species, particularly those that are already endangered or have unique habitat requirements, are more adaptable to dry conditions, others experience higher stress and even risk extinction. Long-term droughts can modify the kinds of vegetation, with more drought-tolerant plant species displacing less tolerant (Wilhite, 2014).

The dynamics of ecosystems and the habitats of species are impacted negatively by reduction in vegetation cover. Drought can result in a shortage of water for industrial and non-agricultural uses. Communities and businesses that depend on a reliable water supply are put under pressure as a result, creating economic and social problems. Addressing these effects and increasing drought resilience through a variety of actions such as enhanced water management, climate adaptation plans and sustainable farming practices is significant (UNDRR, 2021).

More effective, productive, inclusive, transparent, and adaptable food systems are necessary to achieve the UN Sustainable Development Goal 2 of a "world with zero hunger" by 2030 (FAO, 2017). The existing agricultural system will need to be urgently changed or modified in order to address this. According to the FAO (2017), the agricultural sector is still vital for economic growth and means of subsistence. Worldwide, there are over 570 million small-scale farmers, and 28% of all workers are employed in food production and farming (FAO, 2017).

One of the primary causes of drought throughout the world is the El Nino Southern Oscillation, which is a cyclic shift in breezes and sea surface temperatures along the tropical eastern Pacific Ocean. According to UNDRR,' (2021) during an El Niño Southern Oscillation (ENSO), droughts are likely to occur almost everywhere in the world. The western Pacific basin islands, including the Hawaiian Islands, Australia, India, Argentina, Brazil, the Republic of Indonesia, the Philippines, different areas of the United State of America, portions of eastern and southern Africa, and central America appear to be the regions where ENSO and extreme droughts interact most strongly. Widespread droughts are expected to become more frequent and severe, with special forecasts for Mexico, the United States, southern Australia, the majority of Africa, Southeast Asia, Eastern Europe, and the majority of central and southern America.

According to Dai (2017), mega droughts are defined as multi-decadal events which are associated with long periods of abnormally dry periods. An example of mega drought is the 2010s drought in south-western United State of America, which was said to resemble the terrible massive drought that occurred in the same region in the 16th century.

Asia as a continent is significantly affected by dry spells. Some countries in South East Asia were devastated by droughts between 2015 and 2017 (FAO, 2019). Vietnam and Indonesia experienced their droughts; with life-threatening drought being connected to severe respiratory infection in Indonesia which affected more than 270,000 people. Central Asia, Afghanistan experienced three successive years of dry spell, resulting in food shortage for 5 million people in 2001, due to nearly total failure in rain fed agriculture, reduced irrigated farm productivity and death of livestock (Agrawala & Barlow, 2001). South Asia was not left out where multiple years of droughts were reported, leading to increased water crisis and food insecurity among millions. India had droughts in 2015-2016 which affected 330 million people; women and children being major casualties with increased wasting among mothers and increased child labour.

According to FAO (2019), the years 2012 and 2013 drought in northern Brazil virtually destroyed all rain-fed agricultural vegetation, causing massive cattle death which resulted to transfer and sales of beef at lower prices. Fishing and water supplies in the lower basin sections were impacted by salty water intrusion as Rio Sao Francisco river's flow rate decreased to its lowest levels. The 2009-2010 Caribbean drought led to severe water deficits, large loss of agricultural and livestock products which led to inflated food prices and bush fires. Dry corridor of Central America suffered the 2014-2017 droughts, being the worst in decades, which left 3.5 million people asking for humanitarian assistance. According to Zandalinas (2018), the effects of previous weather-related extremities like droughts show that some ecosystems and numerous human systems are significantly vulnerable to present climatic variability. Drought magnitude cannot be measured on a scale interval but through the intensity of effects resulting from its effect on vegetation, humans and animals. Among the factors that affect drought are rainfall variability, which has a large number of impacts on livelihoods of people as well as economies of most African countries (Gautam, 2021).

Drought-related climate change is unpredictable and variable, which creates hazards that limit the opportunities and development of multitudes of residents in Sub-Saharan Africa. According to Shiferaw and Tesfaye (2014), dry spell and flooding cause 80% of fatalities and 70% of revenue loss in Sub-Saharan Africa. Regular droughts have been shown to slow gross domestic product growth in many African nations (Syroka & Nucifora, 2010) and jeopardize development progress (Hellmuth *et al*., 2009). According to the Inter-Governmental Panel on Climate Change, drought is one of the main obstacles to agricultural output and practices in Sub-Saharan Africa (Sharma & Ravindranath, 2019).

Majority of droughts in Africa were experienced in the periods of between 1960s and 1980s in the Sehal region of Sub-Saharan Africa, and in 1980s to 2000s in East African region, the most recent being in 2017 to 2022 (Aucla *et al*., 2019). African countries have experienced rather prolonged droughts which severely affected the economic development and caused cases of malnutrition, famine, loss of life, migration and social conflicts. In the 2006 drought incidence, which was experienced in the Horn of Africa, approximately 18.0 million people suffered food shortages in Ethiopia, Eritrea, Somalia, Northern Kenya and Djibouti (Mwaluma & Mwangi, 2008).

Extended periods of drought lead to drying up of water sources, consequently, reduced amounts of rainfall for rain-fed agriculture. These effects later lead to reduced crop production; hence, famine and death of human and livestock as a result of lack of water and vegetation for livestock. Shortage of water and livestock feeds have in the past led to tension among communities, resulting in increased inter-communal conflict. The Kenyan, Somalia and Ethiopian drought of the year 2009 severely affected many lives, putting them at a risk of hunger causing deaths to livestock (Goston, 2021).

Kenya has approximately 10 million people living in the ASAL areas which are threatened by drought and famine. Either, sixty percent of households live in these ASAL zones thus explaining the high poverty incidences due to climatic shocks, environmental degradation, insecurity and diseases of human caused or in somewhat way caused by drought conditions (Mwaluma & Mwangi, 2008). The ASAL regions most likely to be affected by drought lie along the Kenyan borders with Somalia, Uganda and Ethiopia; and the socio-economic problems caused by drought have cross-cutting issues within the countries involved. This owes to the fact that most of the inhabitants of these ASALs are pastoral communities with traditional practices such as livestock keeping, thus movements of people and animals in pursuit of water and pasture is unavoidable across the borders (Odhiambo, 2013).

According to Office for the Coordination of Human Affairs (OCHA, 2022), the ASAL regions of Kenya have been affected by more than three consecutive poor rainy seasons (2010-2011, 2016-2017 and 2020-2022), with the 2020-2022 being the more severe and prolonged, resulting in extensive livelihood losses and significant population relocation, leaving more than 2.9 million people in urgent need of humanitarian support. Worst drought cases in Kenya have greatly reduced crop production and damaged livestock, which left nearly 2.4 million people in the ASAL region with food problems, about 368,000 people in emergency levels of hunger, and over 785,000 children with malnutrition cases. Families in some counties were forced to start adoption of extreme coping strategies; cases of children marriages reported in some areas and school dropouts, in Kilifi, Kwale and Tana River; laborious activities in order to support families, such as charcoal production to generate income and walking for long distance s in search of water.

NDMA (2022), through its National Drought Early Warning Bulletin reported twelve counties, Marsabit, Mandera, Garissa, Wajir, Kilifi, Tana River, Makueni, Lamu, Samburu, Kitui, Isiolo and Laikipia in the drought phase. This owes to the fact that there has been poor performance of October to December short rains, and March to May long rains. This shortage in rainfall leads to a drought pattern that affects crop production and livestock. To solve the problem of agricultural production and produce wastage, farmers, particularly those who rely on rain-fed agriculture, needs to be adequately prepared in case of drought during the growth of their crops. In consecutive years, farmers from Tharaka South have incurred losses due to climate change that causes drought (Recha *et al*.,2017).

Ngigi (2003) in his study on rainwater harvesting for improved food security, found that the adoption of water pans, earth dams, and underground tanks for water storage was prevalent, with around 40% of households using these technologies. However, he noted that maintenance and management of these water harvesting structures was a challenge.
The introduction of drought-tolerant crop varieties, particularly sorghum and millet, has been an important drought mitigation intervention. Ifejika (2010) reported that over 60% of farmers in Makueni had adopted drought-tolerant sorghum and millet varieties, which were seen as more resilient to the region's erratic rainfall patterns. Mungai et al., (2019) described the importance of establishment of community drought management committees that coordinate early warning, emergency response, and long-term adaptation strategies. He also noted that the level of community participation and ownership of these initiatives was a key factor in their effectiveness.

1.2 Statement of the Problem

Tharaka South Sub-County, located in Kenya's ASALs, has heavily been impacted by the persistent challenge of drought, which has significantly affected the livelihoods and food security of the local households. In response to this pressing issue, various DMS have been adopted and implemented by the households. However, the intensity of adoption and effectiveness of these strategies in addressing the specific needs and challenges faced by the households in the region remains unclear.

The existing literature on DMS in Tharaka South Sub-County is limited, and there is a lack of empirical evidence on the extent to which the adopted strategies have been successful in enhancing the resilience of local households. Understanding the effectiveness of the DMS is crucial for ensuring that the strategies are tailored to the specific needs of the households and contribute to their long-term resilience against the impacts of drought.

Despite the government and the NGOs effort in introducing the DMS, the extent to which these strategies have been effective in addressing the needs and challenges of households in Tharaka South Sub-County is not well documented. This lack of empirical evidence on the intensity of adoption, determinants of adoption and effectiveness of adopted DMS hinders the ability of policymakers and development practitioners to make informed decisions and implement more effective DMS in the region. This study will contribute to filling this knowledge gap and provide a better understanding of the factors that influence the adoption and effectiveness of these strategies. Addressing this knowledge gap is essential for enhancing the resilience of households in Tharaka South Sub-County and ensuring the sustainability of drought mitigation efforts in the long term.

1.3 Purpose of the Study

The study's goal was to analyse the intensity of adoption, analyse the determinants of adoption and asses the perceived effectiveness of households adopted DMS in Tharaka-South, Tharaka Nithi County by assessing the strategies put across and how effective are they.

1.4 Research Objectives

The study sought to achieve the following objectives:

i. To establish the intensity of adoption of DMS among households in Tharaka South Sub-County, Kenya.
ii. To establish the determinants of adoption of DMS among households in Tharaka South Sub-County, Kenya.
iii. To assess the perceived effectiveness of DMS among households in Tharaka South Sub- County, Kenya.

1.5 Research Questions

Based on the research objectives, the study sought to answer the following research questions:

i. What is the intensity of adoption of DMS among households in Tharaka South Sub-County?
ii. What are the determinants of adoption of DMS among households in Tharaka South Sub-County?

iii. What is the perceived effectiveness of DMS among households in Tharaka South Sub-County?

1.6 Significance of the Study

The findings will inform farmers, local and national leadership on what has been done at different times and what has been achieved by households in mitigating drought. This vital information will guide future planning on DMS to enhance agricultural productivity. The findings can serve as a baseline for future studies, enabling comparisons over time to assess the effectiveness of implemented strategies and the evolution of community responses to drought. Understanding which strategies are most effective can help households better withstand future droughts and reduce their vulnerability.

1.7 Scope of the Study

This study was conducted among households in Tharaka South Sub-County in Tharaka Nithi County, Kenya. The respondents were purely drawn from Tharaka South sub-county. Household was the study unit while household's head were the respondent.

Thematically the study looked at the agricultural innovations developed by households to mitigate drought. Therefore, the study investigated the determinants and effectiveness of adopted DMS among households in Tharaka south Sub-County. The study involved households, department of agriculture and fisheries and NGOs who are the main stakeholders in the agriculture development in Tharaka Nithi County.

Methodologically, this research used the descriptive research method to evaluate the determinants and perceived effectiveness of household's DMS in Tharaka South, Tharaka Nithi County, Kenya. To take part in the study, participants were chosen at random from the defined population clusters.

1.8 Study Limitations

Some respondents did not have adequate information on the changes in production after adoption of different DMS. The limitation was addressed by ensuring that survey questions were clear and specific, guiding respondents to provide more accurate information about the changes in production.

1.9 Study Assumptions

The study was anchored on the following assumptions:

i. Most households had adopted different DMS
ii. Most respondents would be cooperative to provide genuine, reliable and accurate responses

1.10 Operational Definition of Terms

The study operationalised key terms as follows:

Adoption: The acceptance, uptake and subsequent practice of a strategy or technology for mitigating drought.

Agricultural Operations: Growing and harvesting of crops or rearing of animals for the purpose of making profit or providing a livelihood.

Determinant: Refers to a composite of attributes whose presence or absence may influence a farmer's decision on whether to adopt or not adopt DMS.

Drought Mitigation: To lessen the severity or the impacts of drought

Drought: A calamity that develops slowly and is characterized by absence of rainfall and has a negative influence on the environment, farm economics, human health, and energy supplies.

Effectiveness: Capability of agricultural stake holders' DMS in producing desired results in agriculture.

Household Head: Refers to a person (male or female) who makes or influences major decisions regarding the household and farm resources including decisions on agricultural practices.

Household: A collection of individuals residing together and sharing common living spaces, resources and responsibilities.

Intensity: Refers to the number of DMS adopted and recorded per household and the rate of adoption of different DMS.

Stakeholders: people or organisations with a vested interest or stake in the mitigation of drought.

Strategies: Deliberate measures undertaken by the stakeholders to reduce the adverse effects of drought.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of Drought

Drought is one of the most complex and less understood disasters. There is much confusion within the policy and scientific communities, on the exact characteristics of drought, which triggers attempts to explain to somewhat extent, the lack of improvement on preparedness to counter this natural disaster in most parts of the world. The phenomenon is a slow-onset, creeping natural hazard which is a normal aspect of almost all climates of the world, with serious environmental, social and economic impacts on life. Impacts of drought are largely unstructured, spreading over a larger geographical area, in comparison to other damages caused by other natural disasters (Wilhite, 2014).

Drought is a natural disaster that affects many aspects of life and livelihoods, including agriculture, energy, food security, health and water resources. It represents one of nature's greatest obstinate and destructive catastrophes (Svoboda, 2000). Around the world, there are droughts, which might have disastrous repercussions on the environment, economy, people, and way of life.

2.2 Drought Mitigation Strategies

Accessibility to current and precise data on which to make choices, institutional and policy frameworks that support a nation's readiness, communication of warnings and necessary actions, and application of the communicated information: which contain a variety of risk management strategies for decision makers as well as efficient and reliable decision makers' activities are essential elements of an efficient drought risk mitigation strategy (White & O' Meagher, 1995).

Monitoring and giving early warnings on the trends of droughts in all parts of the vulnerable regions is a responsibility mandated to bodies such as; World Meteorological Organization (WMO), which promotes the global networks for the monitoring of weather, climate, water levels, and various other physical variables on earth, Food and

Agriculture Organization (FAO), which deals with global food supply and agricultural prosperity in emerging economies, the Kenya Meteorological Department (KMD) which plays important role in providing early warnings concerning droughts and floods. The National Drought Management Authority (NDMA) leads on drought preparedness and responses in ASALs.

The most immediate interventions to climate problems, according to Solh & Van Ginkel, (2014) are biophysical technologies. However, these technologies can only solve these problems if they are supported by institutional reform and policy. The Integrated and Sustainable Agricultural Productions Systems for Improved Food Security and Livelihoods (ISAPSIFSL, 2012) was developed in response to the drought, among the innovative strategies that are adopted to boost and stabilize production of food known as Dryland systems to help in mitigating the effects of droughts in developing and developed countries. The system suggests switching from the conventional emphasis on a few key research aspects to an integrative method of agro-ecological system research. The strategy includes cattle, crops, ranches, trees, water, soils, and policies, all of which are thought to raise the overall influence of outputs and enhance livelihoods in an environmentally friendly manner while also assisting people in realizing their full potential.

There is a need in understanding the links between climate and land surface feedbacks of water budgets influencing soil moisture estimates and precipitation anomalies (Pulwarty & Sivakumar, 2014). Monitoring of drought requires a comprehensive and integrated approach to determine the extent and impacts of drought. Characterizing, observing, and comprehending shifts in vegetation and usage are crucial because they have a significant impact on both ecologically sound land use and the interactions between the atmosphere and the land that influence climate change (Townshend & Latham, 2008).

Drought is perceived as a persistent developmental issue which requires intervention of multiple sectors and multiple dimensional response, especially in Africa (Gautam, 2021). These comprehensive technological, institutional, and policy measures offer optimal solutions for enhancing livelihoods through enhanced agricultural output and household capacity building for income diversification, thereby mitigating the adverse impacts of drought on consumption (Shiferaw & Tesfaye, 2014).

Throughout the twentieth century, governments have typically responded to drought by providing emergency, temporary, and long-term assistance to impacted areas. The Livestock and Grain Producers Association of New South Wales commended both the Australian state and federal governments for their efforts in drought relief. This acknowledgment led to the formation of the National Drought Consultative Committee by the Minister for Primary Industry in 1984 to evaluate Australia's drought policy. In contrast, drought relief efforts in South Africa have mainly concentrated on supporting the livestock sector, with little attention given to crop farming (Wilhite, 2019).

The Chinese government's policies to combat drought, including measures like early warning dissemination, post-disaster aid, technical guidance, and financial and logistical assistance, have notably enhanced farmers' resilience to drought. However, given that only a small fraction, approximately 5% of villages, have benefited from these initiatives, there remains considerable scope for the government to expand and strengthen its support mechanisms (Huang *et al*., 2014)

The measures outlined in Makova's (2019) research on drought mitigation effectiveness in Chegutu district, Zimbabwe, encompass vital approaches crucial for communities to manage and adjust to drought effects. These strategies include food assistance, labour-for-food programs, drought-resistant crops, livestock sales, conservation agriculture, financial remittances and irrigation initiatives. Providing food aid is a common immediate response to alleviate hunger and food shortages during droughts. Food aid entails providing food supplies to impacted communities to ensure their essential nutritional needs are fulfilled during crises. Food for work involves providing food assistance to individuals or communities in return for their involvement in public works projects or community-based initiatives. It not only addresses immediate food needs but also helps in community development and infrastructure improvement. This current study shall build on the existing knowledge by establishing the various DMS.

Planting and promoting drought-resistant or drought-tolerant crop varieties are crucial in regions prone to water scarcity. These crops can withstand dry conditions better than traditional varieties, helping maintain agricultural productivity during periods of drought. During severe droughts, farmers sell or reduce their livestock herds to cope with feed and water shortages. While this strategy provides immediate income to address immediate needs, it also poses risks to the community's long-term livelihood and resilience. Conservation farming practices emphasize sustainable land management techniques to improve soil health and water retention. Implementing these practices can help mitigate the impacts of drought by enhancing the land's ability to cope with water scarcity (Shiferaw & Tesfaye, 2014).

Financial assistance and remittances from family members or friends living in other regions or countries can provide much-needed support to communities facing drought-related challenges. These cash transfers can be used to purchase essential items, including food and water. Investing in irrigation infrastructure and systems enables farmers to access and utilize water even during periods of drought. Irrigation can significantly increase agricultural productivity and reduce the dependency on rainfall (Tesfaye 2015). It’s important to note that the effectiveness of these DMS may vary depending on the specific context, severity of the drought, and the level of implementation and support as noted by Opiyo et al., (2015). A comprehensive approach that combines multiple strategies and incorporates long-term sustainability measures is often the most effective way to address the impacts of drought and build resilience in vulnerable communities. Additionally, promoting climate-smart agricultural practices and community-based disaster risk reduction initiatives can further enhance the ability of communities to withstand drought events.

According to Hellmuth (2007), effectively managing climate variability and extremes involves employing strategies to minimize risk, boost productivity, diversify livelihoods, improve market access and information, and enhance infrastructure. Access to climate and credit information aids farmers in making informed decisions and facilitates index insurance adoption. Early warning systems and information monitoring enable proactive measures and community resilience-building through safety nets and social protection programs during droughts (Shiferaw & Tesfaye, 2014).

According to Fosu-Mensah et al., (2012), increasing temperature has a negative impact on net farm revenue, while increasing precipitation has a positive impact. The impact varies across different regions and farm types in Africa. Adaptation measures can assist in alleviating the adverse impacts of climate change on agriculture. He also pointed out that climate change represents a serious threat to African agriculture, but implementing adaptation strategies can strengthen the resilience of the agricultural sector.

The strategies aim to avert agricultural production shortages caused by climatic disruptions when production falls below the necessary level. Farm households employ various pre- and post-drought coping measures tailored to the severity of the shock. These measures encompass reduced food sales, consumption cutbacks, heightened borrowing at higher rates, increased seasonal out-migration, loan defaults, school withdrawals by children, distress sales, and liquidation of productive assets such as livestock, trees, and land (Shiferaw & Tesfaye, 2014).

Mushore and Muzenda (2013) study, identified that in Bikita District, Zimbabwe, the community is utilizing various disaster management strategies (DMS), including food aid, food-for-work programs, livestock sales, remittances, and irrigation schemes. The findings indicated that the most effective DMS were food aid and food-for-work initiatives, while remittances and irrigation were deemed the least effective. Furthermore, the study revealed that 72% of the community expressed dissatisfaction with the overall effectiveness of the DMS in place. These strategies faced several challenges, including inadequate service delivery from NGOs and government agencies in addressing droughts, poverty, corruption, resource scarcity, unclear beneficiary selection criteria, and a lack of market access, all of which contributed to the inefficiency of the DMS.

Different coping strategies have been employed in Kenya, for example, by the Northern Kenya pastoralists. These include; old and feeble cattle are slaughtered, households are divided into smaller groups and sent to new locations, and bush resources like aloe vera, charcoal, and firewood are sold, seeking labour wages in towns, and reducing food consumption among household members (Opiyo *et al.*, 2015). Even though these adjustments are being made, maintaining normal yearly level of consumption is still a problem, for example in the long droughts, such as the Sahelian drought of 1980s in Africa. Households are therefore forced to reduce their meal ratio in a day with children and women forced to bear the burden of drought (Tesfaye & Assefa, 2010). Frequent exposures to climatic shocks leads to depletion of assets, weakening the pre and post drought adoptions, making adaptability and manageability of these strategies difficult (Shiferaw & Tesfaye, 2014).

Water shortage in agriculture due to droughts has been managed, to some extent through use of resilient crop varieties and many years of research through genetic engineering and plant breeding have led to production of drought tolerant crops which increase yields in the environments prone to droughts (Cattivelli *et al.* , 2008). Some drought adaptation strategies include, adjusting land use, adopting new technologies, diversifying farming practices, and implementing risk management measures.

According to Hall (2017), drought tolerance in maize, pearl millet, groundnut, sorghum and cowpea played an important role in fighting serious droughts in the 19th century. National and international research institutes have gained a firm ground on fighting droughts through identifying drought tolerance genes, and modifying these crops so as to help improve their productivity in drought vulnerable areas of Africa, and even Kenya

International Crops Research Institute for Semi-Arid Tropics, together with national partner organizations have emphasized on improving the tolerance of millet and sorghum. This owes to the fact that these two crops play important roles in the food cycles of most dryland areas, as well as being used as feeds, fuel sources, brewing industries as well as construction materials (Shiferaw & Tesfaye, 2014).

Udmale et al., (2014) highlights the pivotal role of administrative strategies alongside household-level adaptation measures in drought resilience. In response to severe drought events in Maharashtra State, the government implemented various relief measures, including employment provision, drinking water supply, and fodder distribution in cattle camps. Additionally, the government offered low-interest agricultural loans, crop insurance schemes, and waived electricity bills based on the severity of drought conditions.

Introduction of multipurpose grain legumes has been one of the efforts directed at improving the productivity of the dryland areas. Legumes are cheap protein sources for smallholder farms which generate farm income, serve as livestock feds and in a larger benefit help restore soil fertility in these areas. In Africa, most cultivated legume is cowpea followed by groundnuts. With the assistance of the International Institute of Tropical Agriculture, several nations have introduced better cowpea cultivars (Shiferaw & Tesfaye, 2014). Common bean and chickpea types that can withstand drought are being grown in parts of Africa with extremely fluctuating rainfall (Tesfaye & Walker, 2015).

Maize growing in Kenya is mostly rainfall reliant and therefore dry conditions have detrimental effects on the production of the crop. Development of several drought resistant varieties, some under field trials, and some undergoing genetic modification in different laboratories in Africa and other parts of the world offers promising solutions to drought effects on the crop productivity (Shiferaw, 2014).

Generally, the impact of drought resistant crop varieties grown between 2006-2016 was that drought resistant maize could generate 0.88 billion US$ as a result of increased maize grain harvests, thus reducing risk of shortage over 10 years when conservative and optimistic yield improvements remain the same. Released varieties have traits including shorter anthers-silking intervals, reduced barrenness, reduced evapotranspiration, staying functionally green during grain filling that allow them to survive under these conditions of drought (Bruce & Barker, 2002).

The key to DMS lies in effective weather forecasting and early warning systems. These inform household's decision making as to what strategies to employ. It also helps plan their agricultural production like making decisions on what crop types and varieties to grow in the coming season. It also enables them predict on if there will be adequate pastures and water availability in the coming periods. This information is vital in planning and decision making about the number of stocks to retain and making preparations on how they will manage pasture resources in case of drought predicaments (Kaua, 2019).

Solh (2014), noted that drought mitigation interventions can be carried out through system where low but sufficient amounts of moisture is available approach.in dry areas that have little water availability approach, the system focus on particular outcomes which start with the needs and constraints in agricultural communities, being the starting point in modelling the research agenda. In areas that receive rainfall but in low amounts that cannot sustain a whole season of crop production and animal keeping. In such areas, strategies are put forward to improve the efficiency of crop performance by augmentation of the water available using irrigation. Besides irrigation, these areas can support crops, only that rainfall is inadequate to sustain full performance. Thus, drought tolerant crops are introduced into such areas with early maturity and high performance under drought conditions.

Expected increase in aridity in certain zones of the world lead to decisions in which parts of a country shift in terms of the types of cultivated crops and geographical location. These shifts are likely to occur in the geographical location of the systems of agriculture. Regions that currently continue to develop certain classifications of aridity will likely fill the agro-ecological niches of ecosystems that currently exist in a somewhat moister zone, ultimately being displaced by systems in a more arid environment. Rain-fed irrigation is a type of irrigation where the crops and soil depend on atmospheric precipitation. These systems provide readily available moisture from rainfall and support much of agricultural activities during the rainy seasons. Extending these systems, used in conjunction with or alternately with irrigation water and rainfall in many regions and have demonstrated substantial effectiveness. As a result, the augmentation of these two systems would help in improving production. The water macro and micro catchment harvesting of water would lead to supplementary irrigation (Solh & Van Ginkel, 2014).

Capacity building and knowledge-sharing are essential components of DMS. Investments in the training and capacity development of local communities, extension services, and government agencies are crucial in enhancing their ability to effectively implement DMS (Erbaugh *et al.*, 2021). Promotion of knowledge exchange and the sharing of best practices fostered collaborative learning and adaptation (IDMP, 2022).

Diversification and adaptation of livelihoods strategies are important to reduce the dependency on rain-fed agriculture and enhance household resilience (Speranza, 2010). Improving access to markets and financial services, including drought insurance and microcredit, is a crucial strategy to enable farmers and pastoralists to cope with the economic impacts of drought (Hellmuth *et al*., 2009; Makaudze, 2018).

Effective water management and conservation strategies have been a key focus of drought mitigation efforts. Water harvesting and storage techniques, such as the construction of dams, reservoirs, and rainwater harvesting systems, improves water availability during drought periods (Oweis & Hachum, 2006). The adoption of water-efficient agricultural practices, including the use of drought-resistant crops, drip irrigation, and conservation agriculture, has been promoted to optimize water use and minimize the impacts of drought on food production (Rockström *et al*., 2010).

The Famine Early Warning Systems Network (FEWS NET), a leading provider of early warning and analysis on food insecurity, has been instrumental in providing timely information on drought conditions and potential impacts across the continent (Verdin *et al.*, 2005). Additionally, the African Drought Monitor, developed by the University of California, Santa Barbara, utilizes satellite data and climate modeling to enhance the accuracy and timeliness of drought predictions (Bayissa *et al.*, 2017).

Mushore and Muzenda (2013) noted that food aid, food for work, and sale of livestock, remittances and irrigation scheme are DMS people are using in Bikita District in Zimbabwe. Kaua (2020) identified the adaptation strategies to climate change that included engagement in diverse economic activities by pursuing alternatives to farming such as employment and bee keeping. He also noted that people carry out small scale irrigation along river banks, early planting, use of cover crops, diversification of cropping, cultivation of drought tolerant crops, planting fast maturing crops, furrowing, crop rotation, use of *zai* pits, mulching, planting grass along rivers, migration and reduced meal count.

In an article on weather prediction, Kenya Meteorological Department (KMD) (2021) urged farmers in Tharaka-Nithi to embrace climate-smart concepts, technologies, and managerial practices, such as drought-tolerant and quickly maturing varieties, preservation, minimal or no tillage, applying mulch, growing cover crops on farms, and collecting rain water, among others. Extension agents for agriculture and livestock were requested to advise farmers on the best types and varieties of crops to grow. Residents were exhorted to increase rainwater collection from surface runoff and roof catchment, while those who lived upstream of rivers and lakes were counseled to increase soil conservation to lessen the silting up of reservoirs and water pans.

In the agricultural and rearing of animals' setups, several of the present crop-related methods for adapting to climate-related risks comprise small-scale collection of rainwater, the use of good agricultural practices, sustainable farming, growing drought-resistant and varieties that mature quickly, handling after harvesting and incorporating trees into farming practices. Crops can adapt to climate change over a longer period of time by improving water gathering, developing irrigation systems, expanding conservation agriculture and improving irrigation (UNDP, 2013).

In order to sustain animal health, current livestock coping mechanisms include regular vaccination, deworming, and vector management; conserving and preserving pastures and feed; limiting animal movement; improving animal housing; and enhancing milking cleanliness. Establishing veterinary services, continuously monitoring diseases, providing training on livestock management and market assessment, improving water conservation methods, investing in cold storage facilities, offering training on livestock heat control, upgrading slaughterhouses, and conducting educational workshops on preservation and value-added techniques. These actions aim to enhance long-term resilience. Services like systems for pre-emptive alerts, the growth and capacity enhancement of agricultural outreach and the upgrading agricultural marketing technology and infrastructures are just a few examples of off-farm activities to promote adaptation to climate change (Gioto *et al*., 2016).

In his 2014 study examining the socio-economic factors influencing the adoption of rainwater harvesting and conservation techniques in the semi-arid Tharaka sub-County, Recha observed that the majority of farmers employed between one to six rainwater harvesting and conservation methods, indicating a recognition of their advantages. The use of in-situ technologies was more prevalent than that of micro-catchment and macro-catchment systems. The variety of techniques adopted was found to be affected by factors such as years of education, size of arable land, availability of labor, and the number of livelihood options. Furthermore, the selection of rainwater harvesting techniques was primarily driven by the intent to capture and conserve soil moisture rather than to enhance soil quality.

The findings from Nabwire's (2020) study on the adoption of rainwater harvesting technologies within the Kilifi County community indicated that 92.6% of households employed rooftop water harvesting methods, whereas only 3.5% utilized water pans or ponds. Additionally, a significant majority (93.5%) of residents in Kilifi County expressed a strong interest in better organizing and capturing more surface water runoff. The study revealed that while most households are aware of rainwater harvesting technologies, they encounter obstacles to adoption due to issues such as gaps in training and socio-economic factors.

DeGroote et al. (2013) noted that the level of adoption of drought-tolerant crop varieties has been mixed. He found that adoption rates for drought-tolerant maize were relatively high, reaching up to 60% in certain areas. However, the adoption of drought-tolerant varieties for other crops like sorghum and millet were lower. Factors influencing the level of adoption included availability of seeds, access to extension services, and perceived benefits by farmers.

Adoption of DMS tends to be higher among wealthier households as they have greater capacity to invest in these practices. Poorer households often lack the resources to effectively implement these strategies, leading to lower levels of adoption (Nyariki *et al*., 2009)

2.3 Determinants of Adoption of DMS

Bihon (2015), in his examination of factors impacting agricultural production in the Tigray region of northern Ethiopia, found that Factors influencing production included land size, ownership of oxen, fertilizer usage, availability of improved seeds, age, access to electricity, irrigation capacity, soil quality, distance to district markets, average plot distance from homesteads, and crop rotation practices. Additionally, farmers engaged in off-farm activities to meet cash needs, particularly in situations with limited access to credit. According to a report by the Esikuri (2005), farmers encounter obstacles in adopting these strategies, stemming from environmental, economic, and institutional factors.

According to Njeru et al., (2020) in his study on the socioeconomic factors that influence the adoption of eco-friendly farming practices in the agroecosystems of Embu County, Kenya, noted that factors such as farmer characteristics (for instance age, education, farm size), access to extension services, and technology-specific factors (such as profitability, complexity) influence the adoption of technologies. Also, conflicting attitudes towards conservation and environmental protection programs can hinder the adoption of sustainable practices by communities. Project approaches and the involvement of farmers in the development and implementation of technologies can affect the rate of adoption.

Policies and regulations, as well as access to markets and credit, also play a role in shaping farmers' decisions to adopt a technology.

2.3.1 Socioeconomic Determinants of Adoption of DMS

The capacity of farmers to adjust to drought conditions is influenced by the attributes of their households and surrounding communities (Huang *et al*., 2014). Adoption of DMS is influenced by behavior and characteristic of households including, gender of the household head, age of the household head, the attitude and perception of the households' DMS, levels of income for household head, level of education for the household head and their farming experience.

Female headed households are more likely to adapt to climate variability since they are responsible for much of the agricultural work hence have greater experience than men. Women possess a strong body of knowledge and expertise that can be used in drought adaptation (United Nations Women Watch, n.d). Male headed households are more likely to access information on the availability of technologies and to adapt DMS because men are more labor efficient than female headed households (Esiobu & Onubougu, 2014). Control to land resources like ownership, agricultural practices and access and control of both social and economic resources is bestowed on men. This makes women's possibility to put values into drought mitigation difficult.

FAO (n.d) notes that the age increases experience and perception of drought effects hence likelihood to adapt. According to Shiferaw and Holden (1998), adoption of DMS, is likely to be higher on young farmers because they can withstand the strain involved in agricultural production as compared to older farmers who are less willing to take risks accompanied by new agricultural innovations. Also, more exposure and access to education of younger farmers, makes them more receptive to change. Higher levels of education are associated with higher adoption rates of new technologies since education enables understanding and interpretation of agricultural information. Education increases awareness of available DMS. Ability to undertake and evaluate new agricultural techniques is enhanced by farmer's education. Also, more educated farmers are better able to forecast future trends (Uddin *et al*., 2014).

Experience determines the practicability of the DMS (Agrawal, 2002). The likelihood to adapt to drought is higher on more experienced farmers because of their better knowledge and information on drought in relation to agricultural practices and accumulation of farming knowledge and skill as a result of long farming experience. This contributes to faster adoption of DMS (Hassan & Nhamachena, 2008).

Poverty decreases people's capacity to make choices increasing their vulnerability to drought impacts (GoK, 2013). Nhamachena and Hassan (2008) noted that higher income farmers are likely to take risk and have more access to information hence more willing to adopt DMS. Terms of property ownership determines the farmers' willingness to invest in DMS. Esiobu and Onobougu (2014) note that vulnerability to drought effects can be reduced through diversification of income sources by increasing off farm income opportunities. Economic diversity especially for natural dependent communities provides them with choices increases their ability to cope with drought stresses.

According to Esiobu and Onobougu (2014) large scale farmers invest more capital and resources hence easy adaptation to drought increasing thereby agricultural production. Households with large farms easily adopt DMS because they are assured of investment returns (Carlisle, 2016). Deressa (2009) notes that adoption of DMS is inversely related to farm size since the larger the land size the higher the cost implications. Land size and land characteristics dictate the drought mitigation strategy to be adopted.

Large households increase labour availability reducing its cost hence encouraging adoption of DMS which are labour intensive (Esiobu, 2014). Conversely, Owino et al., (2014) noted that family size is negatively related to adoption of DMS because of its consumption pressure. This forces them to divert part of their labour to off farm activities in order to earn income to ease consumption pressure. Household dependency increases venerability to drought effects since adaptive capacity is characterised by sustainable households.

Mwaluma and Mwangi (2008) noted that Kenyan farmers' perception and reaction to climate change unveiled a widespread sense of vulnerability among farmers, particularly concerning the persistent threat of drought. Many reported tangible setbacks such as diminished crop yields and water scarcities, exacerbating feelings of despair and frustration. The primary hurdles to implementing effective drought-resilient measures were identified as inadequate water access and limited financial resources.

2.3.2 Institutional Determinants of Drought Mitigation Adoption

Li (2018) research on farmers' responses and governmental aid in China, observed that farmers' involvement in community organizations, financial aid from the government, and institutional support from local authorities and access to disaster alerts via media channels all contribute positively to farmers' efforts to mitigate drought impacts.

Farmers who have access to extension services are more likely to be aware of changing climatic conditions Extension services ensures passage of information to farmers hence increasing the probability of adoption of drought mitigation measures (Nhemachena & Hassan, 2008). According to Rogers' diffusion of innovation model, dissemination of information is a key factor in influencing adoption decisions (Rogers, 2003). Vulnerability to drought impacts can be reduced through access to information as knowledge and awareness of drought impacts makes households to adapt more to drought. This is because farmers are able to choose the measures that enable them to cope better with drought. Access to affordable credit increases the financial resources of farmers and their ability to meet transaction costs of adopting drought mitigation measures they take (Nhemachena & Hassan, 2008).

Research indicates that higher levels of social capital within farm households significantly boost their capacity to adapt to drought. Therefore, it is imperative for the government to prioritize support for farming communities and individual farmers with lower levels of social capital (Huang *et al*., 2014). Membership to social networks provides farmers with a forum to discuss their experiences with different DMS. This determines the strategies that they will adopt depending on the experience of different farmers (Deressa, 2011).

Market centres serve as avenues for exchanging information on technologies; enables farmers to access market for their products and enables access to inputs thus increasing the adoption of drought mitigation measures. On the other hand, livestock and crop diversification is favored by remoteness from markets (Nhamachena & Hassan, 2008).

2.3.3 Households' Perception of Drought and Adoption of DMS

Kangai et al., (2021) in their study on determinants of climate change adaptation and perceptions among small-scale farmers of Embu County, noted that farmers' perception on drought and its impacts has a strong bearing on how they adapt. Social networks and extension services are very important as they help in passing information on mitigation strategies improving farmers' perception. The strategies adopted by households in drought mitigation, are determined by their perceptions.

The choice of drought mitigation strategy is determined by the household's perception towards drought effects. Although drought is a global phenomenon various regions and people are affected and react differently (Shongwe, 2014). Deressa (2011) noted that higher numbers of drought mitigation measures adopted were recorded in households with higher perception of drought.

2.4 Effectiveness of DMS on Agricultural Production

Women and young people are among the most susceptible categories and have the least adoption rates of drought adaptation techniques (Recha, 2014). More measures are needed, especially for young people and women, to provide jobs and aadditional revenue streams. Additionally, there is a need for better food processing and preservation methods, as well as the introduction of livestock types that are better suited to the environment. Farmers need trustworthy information to comprehend the necessity of climate change adaptation and to be able to quickly access the right extension services. However, due to a lack of resources, both financial and human, these organizations are unable to provide the services in an efficient manner. Strengthening organizational and monetary capabilities of the relevant stakeholders is necessary for the effective implementation of climate adaption measures.

There's a growing global concern regarding the inefficiency of current drought management practices, which predominantly focus on crisis intervention rather than addressing root causes. By adopting national drought policies centred on risk reduction and supplementing them with drought mitigation or preparedness plans at different governmental levels, nations can enhance their capacity to cope with droughts (Pulwarty & Sivakumar, 2014).

Makova (2019) suggests that as the capacity to adapt to climate change diminishes, the impacts of droughts are likely to worsen. Despite being a challenge, communities have developed various coping mechanisms based on local resources, but their effectiveness remains uncertain. He discovered that a staggering 72% of Chegutu district's population in Zimbabwe was oblivious to the efficacy of all employed DMS. These strategies face formidable hurdles within the community, including subpar service delivery by NGOs and government bodies engaged in drought alleviation, as well as challenges stemming from poverty, corruption, resource constraints, ambiguous beneficiary selection criteria, and insufficient market access. These factors collectively undermine the effectiveness of drought mitigation measures.

Bihon (2015), in his examination of factors impacting agricultural production in the Tigray region of northern Ethiopia, found that the average annual crop yield among respondents fell below the recommended annual food requirement set by international organizations. Only 11% of cultivated land was irrigated, and the use of chemical fertilizers by most respondents fell short of regional standards. Although farmers expressed interest in adopting improved seeds, the varieties provided did not align with their preferences. Extension agents primarily focused on activities unrelated to their profession.

Mushore and Muzenda (2013) noted that in Bikita District, Zimbabwe, the community employs various disaster management strategies (DMS), including food aid, food-for-work programs, livestock sales, remittances, and irrigation schemes. Their study revealed that the most effective DMS were food aid and food-for-work initiatives, while remittances and irrigation were found to be the least effective. Additionally, 72% of the community expressed dissatisfaction with the overall effectiveness of the DMS in place. These strategies were hindered by several challenges within the Ward, such as inadequate service delivery from NGOs and government agencies in addressing droughts, as well as issues related to poverty, corruption, resource scarcity, unclear beneficiary selection criteria, and a lack of market access, all contributing to the inefficiency of the DMS.

Despite being a persistent challenge in communities, farmers have developed various coping mechanisms utilizing locally available resources. However, the effectiveness of these strategies remains dubious. The majority of farmers lack awareness regarding the efficacy of all strategies to mitigate drought employed. These strategies face hindrances such as inadequate service delivery by non-governmental organizations (NGOs) and government departments in addressing droughts, as well as issues like poverty, corruption, resource scarcity, ambiguous beneficiary selection criteria, and market deficiencies, consequently rendering the drought mitigation efforts inefficient (Makova, 2019).

The rural areas of Tharaka Nithi County have a poverty rate of 40%, which is considered to be high. Rainfall unreliability, cropping and animal husbandry techniques, poor infrastructure, lack of accessibility to credit services, inadequate marketing structures, prevalent droughts, floods, livestock and crop diseases, wildlife threats, and environmental deterioration are all factors that contribute to the high rate of poverty (GoK, 2014). More than 89 percent of families utilize firewood as their primary source of energy, while 8 percent use charcoal. The most used cooking fuel is firewood. Only 8%

of households primarily utilize electricity for illumination. In order to prevent severe damage and the destruction of large numbers of trees, clean alternative energy sources must be made available (KNBS, 2013).

The county has a malnutrition incidence of 30%, which is significantly greater than the national mean of 20.9% and considerably behind the target level of 16.2 % (Kenya Demographic and Health Survey (KDHS), 2014). Poor rain dispersion, high food costs, inadequate infrastructure, the community land ownership system, and low acceptance rates are some of the causes contributing to food insecurity. Controversy over rights to land as a result of the lengthy property adjudication process, boundary issues, and disagreements over grazing land (GoK, 2013), notably in the Meru sub-county. Due to this, farmers are less able to invest in programs that promote resilience.

UNDP (2013) identifies significant challenges to agricultural production in Tharaka Nithi County, including weather variability and climate change impacting planting schedules, heightened water stress during crop establishment, and excessive rainfall during harvest periods. Other obstacles include post-harvest losses, limited market access due to inadequate road infrastructure, low levels of literacy among agricultural workers, insufficient storage and value-added facilities, and exploitation of producers by intermediaries. The ability of individuals to invest in behaviors that boost productivity and resilience is influenced by their level of poverty. Farmers' access to knowledge and technology on land usage is limited by illiteracy. Agriculture production has also been impacted by prolonged joblessness and a lack of young participation in the industry. It is anticipated that the effect will have a detrimental influence on the county's economy, resulting in decreased agricultural and animal output, hunger, starvation, excessive livestock mortality, and a decline in revenue for local residents.

Due to high pricing, low income, distance from input markets, and a lack of timely supply of inputs, there is limited usage of inputs. In general, farmers cannot afford the ideal levels of inputs, technological advances, agricultural knowledge, and financial assistance. Poor roads and market facilities in the county causes high transport expenses, which in turn hinders an efficient distribution system for highly perishable animal products like milk and meat. This leads to inflated pricing for food and other essential commodities (Recha *et al*., 2017).

Chogoria, Marimanti and Chuka are the primary market hubs for the whole county because the majority of the trading centers that served as farmers' sales outlets have collapsed. The county is devoid of agro-based businesses that would give value to agricultural and livestock goods and help farmers sell their produce for high prices. Farmers are being forced to sell their raw goods to intermediaries at extremely cheap rates due to a shortage of storage infrastructure and the ability to add value to their commodities. Due to unpredictable and inconsistent rainfall, agricultural productivity has changed throughout time. The production of the different crops is significantly impacted by rising temperatures, little rainfall, and deficient soil fertility. Pest and disease assaults on crops and animals have increased, which has resulted in lower crop yields, worse quality food, and even complete crop failure. Marketing is further hampered by varied output (Gioto *et al*, 2016).

Due to payment delays to farmers, the tea and coffee industries have been severely impacted; as a result, the majority of farmers have shifted to cultivating bananas, sorghum, green gram, and dairy. The county contains several particularly arid places. A system of irrigation is consequently required so that farmers may increase food output. Additionally, a number of initiatives to increase agricultural output, like the building of irrigation facilities and efficient utilization of land, have been hampered by a lack of finance (Gioto, 2017).

2.4 Theoretical Framework

The study was anchored on two complementing theories: The diffusion of innovation theory and the theory of change.

2.5.1 The Diffusion of Innovation Theory

This study is informed by the Roger's model theory and Weiss model theory. The theory of diffusion of innovation was propagated by Everett Rogers in the year 1962. The theory provides a framework for understanding how new ideas, products, or practices spread and are adopted within a population over time. The diffusion of innovation theory outlines a process through which individuals and communities adopt new ideas or practices. This process typically involves stages such as knowledge, persuasion, decision, Implementation and confirmation.

At the knowledge stage, households become aware of the existence of the DMS and gain an understanding of how they function. The level of knowledge and awareness about the mitigation strategies can influence the subsequent stages of the decision-making process (Pannell *et al*., 2006). Persuasion stage: households form a favorable or unfavorable attitude towards the DMS. This may be influenced by factors such as the perceived characteristics of the strategy for example relative advantage, compatibility, complexity (Peres *et al.*, 2010).

Decision stage is where households engage in activities that lead to a decision to adopt or reject the DMS. The decision to adopt or reject the strategy can be influenced by various factors, including the household's socioeconomic characteristics, access to resources, and perceptions of the mitigation strategies (Pannell *et al.*, 2006). Implementation stage: At this stage, households put the adopted DMS into practice. The level of implementation can be influenced by factors such as the complexity of the strategies, the availability of support and resources, and the households' ability to integrate the strategies into their existing practices (Pannell *et al*., 2006).

Confirmation stage is the final stage, households seek reinforcement for the decision they have made to adopt or reject the DMS. The level of adoption may be influenced by the perceived effectiveness of the mitigation strategies, the social influences within the community, and the availability of continuous support and information (Pannell *et al*., 2006).

According to Rodgers, the degree to which people differ from one another in particular aspects affects the uptake and spread of innovation. He emphasizes that while information on new concepts or technologies may need more work, it flows more easily among a more homogeneous group. This explains the deviations in adoption of the DMS by the households.

Rogers acknowledged that the theory places considerable emphasis on the attributes of innovations themselves, such as relative advantage, compatibility, complexity, trialability, and observability. Critics argue that this may oversimplify the complex process of diffusion, overlooking other influential factors. The theory presents diffusion as a linear process, moving from innovation introduction to widespread adoption. However, diffusion processes are often more complex and nonlinear, influenced by feedback loops, communication dynamics, and external shocks. The theory may not adequately address the influence of cultural and contextual factors on the diffusion process. Adoption patterns can vary significantly across different cultural settings, socioeconomic contexts, and geographic regions, which may not be fully captured by the theory.

Njeru et al., (2020) applied the theory of diffusion of innovation in his research on Eco-Friendly Farming Practices and the extent of their adoption in the agroecosystems of Embu County, Kenya. The study aimed to identify the socioeconomic factors affecting the adoption of Eco-Friendly Farming Practices (EFFPs) and found that 71.1% of households were classified as high adopters, whereas 2% had not adopted any practices.

Erik Baekkeskov applied the diffusion of innovation theory in his research on development communication and the diffusion of innovations in agricultural and rural contexts, particularly in developing countries. This has shed light on the role of communication channels, social networks, and cultural factors in promoting agricultural innovations and rural development. Lubell (2008) applied diffusion of innovation theory in his research on the diffusion of conservation practices and innovations in agricultural and environmental management. His work explores the social dynamics and factors influencing the adoption and spread of sustainable practices among farmers and resource managers. Lubell employs social network analysis to understand how information, knowledge, and practices related to conservation and environmental management spread within social networks of farmers, landowners, and stakeholders. He examines the role of social connections, communication channels, and interpersonal relationships in facilitating or hindering the diffusion process. Since the theory has been used in the previously mentioned situations, it can also be applied to research on the adoption of DMS.

Enhancing the diffusion of DMS and related technologies in Tharaka South requires examining the factors that separate different groups of households that accept and those that reject mitigation strategies, as well as assessing their farming practices and characteristics. Thus, the diffusion of innovation theory contributed satisfactorily to our understanding of the variations in the ways that households in the Tharaka South Sub County adopted different methods.

2.5.2 Theory of Change

The theory of change was developed by Weiss in the year 1995. The theory seeks to answer the questions; How, Why and Who In this research the theory will guide in answering the following questions; how the change shall be brought, why the change is necessary and who shall benefit from the change. The theory of change in this study will fit well in addressing the drought mitigation measures that are adopted in Tharaka South and how they will cause change in mitigating drought. This study reviews the effects of drought and the significance of mitigating them. This research shall benefit the households and the agricultural policy makers on the effective strategies of mitigating drought. The households shall benefit by increasing their farm yields while the policy makers shall come up with appropriate new techniques of combating drought.

Nevertheless, this theory of change was found to have some limitations that include the following: Weiss suggested in 1995 that the weakly expressed underlying assumptions of complicated programs are a major factor in their difficulty to analyze. The early and midterm modifications that are necessary for achieving a longer-term objective are often given little attention since stakeholders are often unsure of how the intended change process will play out. Lack of understanding of the steps required to achieve a long-term goal will lessen the possibility that all crucial issues connected to the long-term objective will be resolved. Recognizing the presumptions made is essential to this procedure. The Theory of Change's primary idea is to comprehend and explicitly state the presumptions that will result in the desired change.

The theory of change was applied by Thornton in the year 2017 in agricultural research for development program. Therefore, it will also be appropriate in this current study in assessing the farmers' drought mitigating strategies so as to come up with policies and recommendations for future planning.

2.6 Conceptual Framework

The study shall be guided by the conceptual framework on Figure 1 that is based on study objectives and literature review.

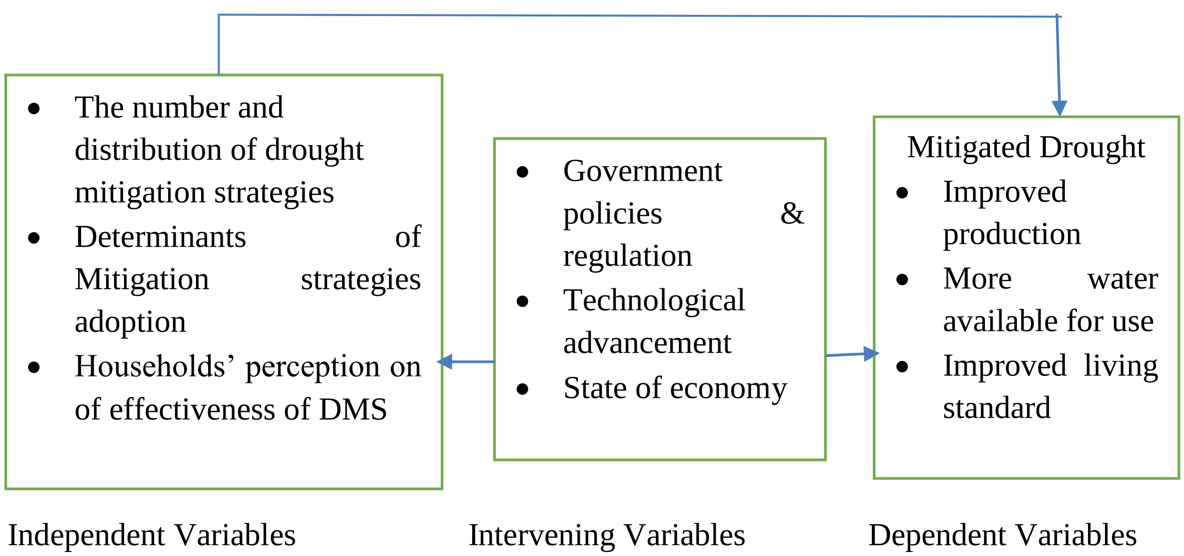

Figure1. Intensity and Effectiveness of Adopted DMS and Determinants of their Adoption

The arrows on the conceptual framework on Figure 1 show the relationship among the independent, intervening and dependent variables. The independent variables include: drought mitigating strategies, factors influencing adoption of mitigation strategies and. households' perception on level of effectiveness of DMS.

The socio-economic characteristics of household heads such as age, level of income, gender, level of education, farming experience, perception and attitude are some of the independent variables identified in the study. In addition, institutional factors such as the accessibility to information on DMS through extension services, membership to Community Based Organizations dealing with drought mitigation, access to loaning facilities and land tenure, were other independent variables examined in the study. Access to information and the type of information received would greatly influence attitude formation and this makes it crucial in the framework. When households are informed and knowledgeable about an issue, they tend to be more confident and build up on their ability, skills and experience. If households are convinced that the DMS are applicable, then they would engage in such.

Influence of climatic perception on adoption of the strategies was also examined as independent variable in the study. Climatic conditions may influence households to adopt or fail to adopt certain mitigation strategies. It is expected that households who enjoy a better quality of life are expected to possess positive attitudes towards adoption of the DMS.

The framework considers government policy, technological advancement and state of the economy as intervening variables. The government may develop policies touching on agricultural and environmental management, which may influence and change households practice on drought mitigation. Technological advancement may negatively or positively influence adoption of certain strategies. For instance, technology may favor modern strategies at the expense of traditional strategies. When the economy favors the agricultural sector, there is likelihood of more households adopting DMS. However, if the agricultural sector suffers greatly from a poor state of the economy, there is likelihood that households may develop a negative attitude towards agricultural systems. The intervening factors comprise Government policies, technological advancement and state of economy. The dependent variable is the mitigated drought, indicated by improved living standards, more water available for use and improved production. The effectiveness of strategies is based on their impact on the drought mitigation. Intervening variables affects the relationship between the independent variables and the dependent variables. They affect the implementation and outcomes of mitigation strategies.

CHAPTER THREE
METHODOLOGY

3.1 Study Location

Tharaka Nithi County is among the 47 counties in Kenya. It is located between latitude 00^{o} 02'S and 00^{o} 17'S and between longitudes 37^{o} 29' and 38^{o} 00' East. The county is situated in the eastern part of Kenya, bordered by Meru County to the north and east, Kitui County to the south, and Embu County to the west. Tharaka's administrative subdivisions are sub-counties, constituencies, and wards to facilitate governance and service delivery. Some of the sub-counties include Tharaka North, Tharaka South, Chuka, and Maara (GoK, 2012b).

As of the 2019 census, the County had a population of approximately 393,177 people. The population primarily engages in agropastoral activities and is categorized into three distinct livelihood zones: the mixed farming zone, the marginal mixed farming zone, and the rainfed/irrigation farming zone (Government of Kenya, 2013). Tharaka-South subcounty is situated within Kenya's Arid and Semi-Arid Lands (ASALs) (Kirraine *et al.*, n.d.). The region experiences a bimodal rainfall pattern, with annual precipitation ranging from 500 to 800 mm, while temperatures fluctuate between 24 and 37 degrees Celsius, occasionally reaching up to 40 degrees Celsius (NDMA, 2014). Tharaka subcounty encompasses four agroecological zones: lower midland 4, lower midland 5, intermediate lowland 5, and intermediate lowland 6 (Owino *et al.*, 2014).

The river Tana main tributaries traverse the region. These tributaries are Mutonga, Kathita, Kithino and Thingithu. The majority of the soils are humic Nitisols, which are deep, well-weathered, and naturally fertile to high productivity. However, owing to extensive agriculture without proper nutrient replenishment, the soil's fertility has decreased. Cassava, millet, green grams, pigeon peas, cowpeas and maize are the principal crops farmed in Tharaka South. There is also livestock rearing like, cattle, goats, sheep and poultry (Kaua, 2019).

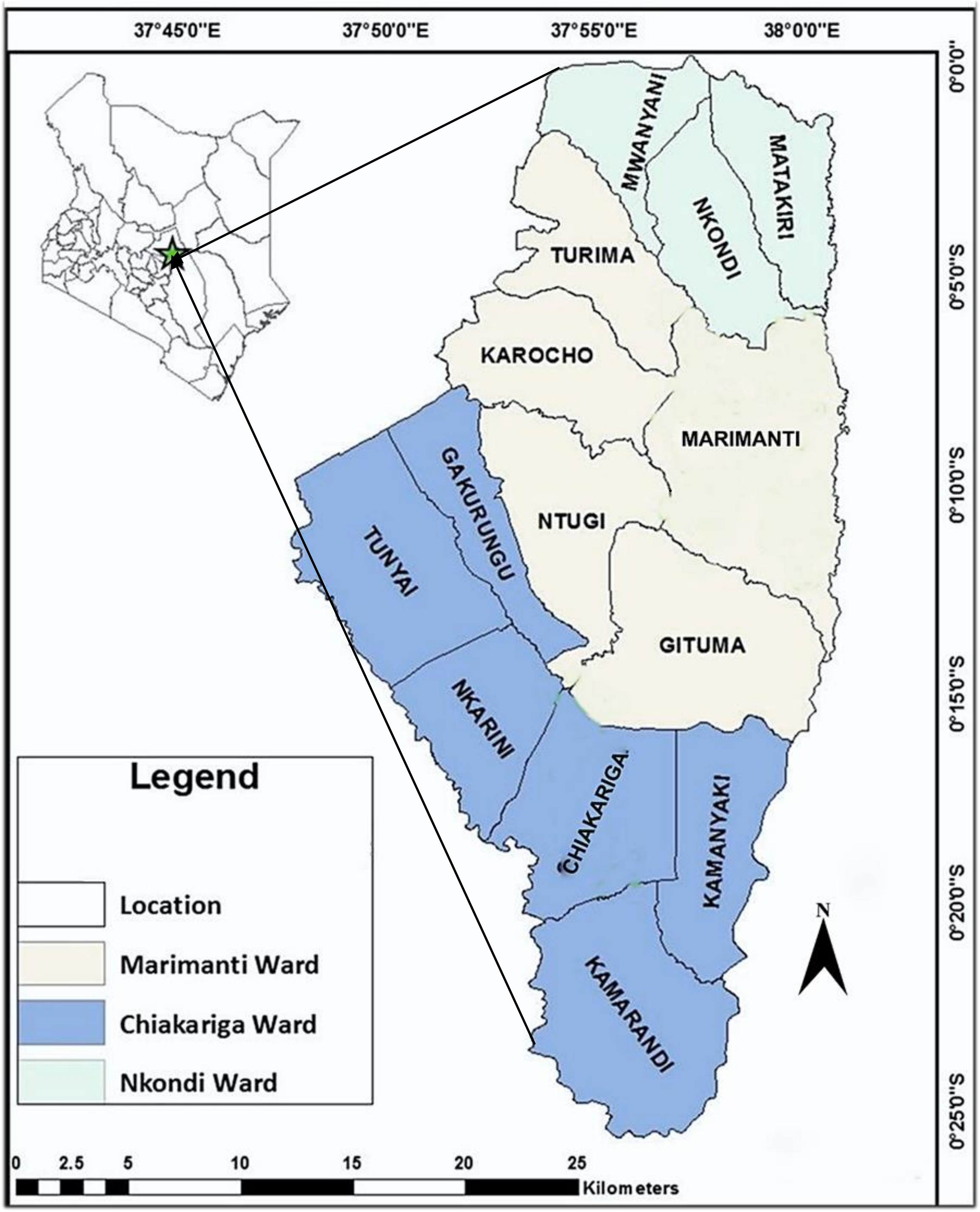

Figure 2. Map of Tharaka South Sub-County

Source: Physical and Urban Planning Office, Tharaka Nithi County

3.2 Research Design

The descriptive research design was employed in the researcher. The respondents were chosen randomly from the target demographic of households and purposefully for key informants. Descriptive research design allows analysis of facts and helps in developing an in-depth understanding of the research problem, and can utilize both qualitative and quantitative research methods (McComber, 2022).

3.3 Target Population

The study's target population was formed by 18,623 households as provided by the census (2019) and the key informants from Director of Department of Agriculture, Livestock and Fisheries, Director, County Drought Management Authority and Director, Grassroot Development Initiatives Foundation- Kenya (GRADIF).

3.4 Sampling Procedures

This research used cluster sampling to choose the respondents. A total of 397 respondents were selected from a population of 18,623 households using Krejcie and Morgan formulae,

$$S = \frac{(X^2NP(1-P)}{d^2(N-1) +(X^2P(1-P)}$$

Three key informants were chosen using purposive sampling. These informants included: director of department of agriculture, livestock and fisheries, director county drought management authority and non- Governmental organisations, (Grassroots Development Initiatives Foundation- Kenya (GRADIF). The sample population was selected from three wards which formed the 3 clusters. These clusters included Chiakariga, Marimanti and Nkondi. Proportionate sampling was carried out to arrive at the sample size from the three clusters.

3.4.1 Sample Size

A sample size was selected from the population of 18623 using the Krejcie and Morgan formulae:

$$S = \frac{(X^2NP(1-P)}{d^2(N-1) + (X^2P(1-P)}$$

Where: S= required sample size

X2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N = the population size

P = the population proportion (assumed to be o.50 to provide the maximum sample size)

d = the degree of accuracy expressed as a proportion (0.05 which is the acceptable error)

$$\frac{(3.481\times18623\times0.5(1-0.5)}{(0.05^2(18623-1) + (3.841\times0.5(1-0.5)} = 397$$

By applying the Krejcie and Morgan formula with the given population size of 18,623, the calculated sample size is obtained. To obtain the sample size for each cluster, a proportionate sampling was done using the formulae below:

$$\frac{\text{Ward population}}{\text{Total population}} \times 397$$

Table 1

Proportionate Sample Size by Wards

Ward	Ward households	Sample Size
Chiakariga	9713	207
Marimanti	5187	111
Nkondi	3723	79
Total	18623	397

Source: Kenya National Bureau of Statistics Report, 2022

The study therefore used a sample size of 397 households and 3 key informants, thus a total of 400 respondents.

3.5 Research Instruments

Instruments used in this study were household head questionnaires, interview schedules and observation schedules.

3.5.1 Questionnaires

The study used questionnaires to collect data from households. The semi-structured questionnaires with both open-ended and closed questions were used to obtain data on the intensity of adoption of DMS, determinants of adoption of DMS and perceived effectiveness of DMS.

3.5.2 Interviews

The study used interview schedules to obtain data from the key-informants on the DMS adopted, factors influencing adoption and perceived effectiveness of different DMS. Interviews were appropriate as the researcher engaged the respondent one on one, hence getting first-hand information which was more reliable. Interviews also provided an in-depth data since the unclear questions were clarified. The information obtained from key informants was used to clarify data from the household heads.

3.5.3 Observation Schedule

In the study, direct field observations, following a structured observation schedule, were utilized to enhance the information gathered from the questionnaires. This schedule was specifically created to aid in the collection of data regarding the adoption of DMS, including: rain water harvesting, planting drought tolerant crops, crop diversification, agroforestry, water saving irrigation and soil water conservation

3.6 Validity

To ensure the research instruments are valid, the questionnaires were tested using face to face content validity to ensure their suitability for use in data collection. Pre-testing was done before administering the questionnaires to the target population, in order to adjust any questions where necessary to avoid confusion and enhance feedback. Pre-test interviews were used in studying participants who were not part of main study sample, but with similar qualifications, to validate reliability of data that will be collected together with consistency in response. The data collection instruments were also subjected to pilot study in Tharaka North Sub-County Key informants also provided necessary information to ensure accuracy of the inferences given by the study.

3.7 Reliability

Rigorous data collection methods, including household questionnaires, key informants' interviews, and field observations, were used. To ensure reliability of this questionnaire, test-retest method was used and correlation coefficient calculated. A correlation coefficient of 0.8 was obtained; therefore, the questionnaire was considered reliable for the purposes of this study as noted by Mugenda and Mugenda (2003) and Wallen (2002) that a correlation above 0.7 is reliable for study.

3.8 Piloting

Pilot study was conducted in Tharaka North to enhance the reliability of the research. In conforming with the advice of Mugenda and Mugenda (2003), questionnaires were administered to 40 households (10% of the sample size) in Tharaka North since Tharaka South which is the study area and Tharaka North have similar climatic conditions and share similar economic activities. Pilot study was important since it showed the likely responses from the respondents and necessary adjustments were done before the actual research was conducted.

3.9 Data Collection Procedures

An introductory letter was obtained from Chuka University, and then research permit was obtained from the National Commission of Science and Technology and Innovation (NACOSTI). Primary data was collected using a combination of open-ended questionnaires, close-ended questionnaires, key informant interviews, and an observation schedule. The questionnaires were administered in person to the officers and household heads by the researcher. If the household head was present, they were interviewed. In cases where the husband was not present, the wife was interviewed instead. If neither the husband nor the wife was available, the oldest member of the household over the age of eighteen was interviewed, as they are considered an adult at that age. If none of the aforementioned categories of respondents were present, the interview was postponed.

3.10 Intensity of Adoption of DMS by Households

The intensity of adoption of DMS was analysed by use of percentages, mean and mode. To compute the percentage, the number of respondents who had employed a given drought mitigation strategy was divided by the sample size of 400 and then multiplied by 100%. The intensity of adoption was based on the percentage of adoption. The data was then presented by the use of tables showing the various drought mitigations and the percentage of adoption. Also, the number of DMS adopted per household was computed and presented using bar graph.

3.11 Determinants of Adoption of DMS

The parameters considered include; socioeconomic determinants, institutional determinants and climate and weather patterns perception. Pearson's correlation coefficient was used to analyse data and determine the strength and direction of the relationship between the determinants of adoption of DMS and their adoption. The data was analysed by the use of SPSS version (2020) statistical software.

3.12 Perception on the Effectiveness of DMS

The perceived contribution of a certain strategy towards reduction in drought impacts was considered. The perceived effectiveness of the DMS were analysed by the use of SPSS version 2020 to show the relationship between the adoption of DMS and their perceived effectiveness. The data was presented using table.

3.13 Ethical Considerations

The study considered all the relevant ethics in its development and execution. Data Collection was approved by Chuka University Research Ethics Committee. The research permit was sought from the National Commission for Science, Technology and Innovation (NACOSTI). After obtaining all the documents, data was collected from the Households and key informants with informed consent. The respondents were assured of confidentiality of the information provided. A good rapport was also established with respondents to win their trust.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Intensity of Adoption of DMS among Households

To achieve this objective, we sought information on the adopting households, number and types of DMS adopted by households in Tharaka South Sub County. The results obtained are presented hereunder:

4.1.1 Status of Adoption of DMS among Households

The study sought information on the status of adoption of DMS among farming households and the results are presented on Figure 3.

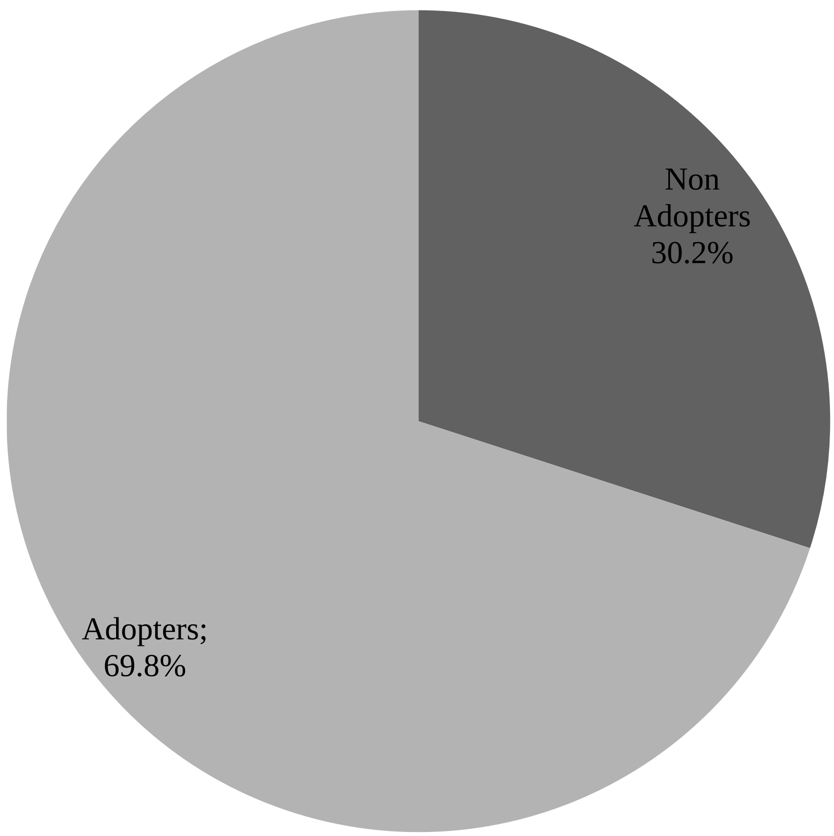

Figure 3: Status of Adoption of DMS by Households

Information on Figure 3 shows that more than two thirds (69.8%) of the farming households in Tharaka South Sub County had adopted one or more DMS, whereas about a third (30.2%) of the households had not adopted. The proportion of the non-adopters included those who had either used a strategy once and abandoned it or had never adopted any strategy at all. With a great majority adopting the DMS, indicates that most households are taking steps to prepare for or reduce the impacts of droughts. This high adoption of DMS could be motivated by the households' need to protect their source of livelihoods. Some of the sources of livelihoods in Tharaka South are Agri-based and others are off farm businesses. In addition to water being a basic human need, these Agri-based ventures largely depend on constant water supply.

Additionally, people who had experienced droughts in the past may be more likely to adopt mitigation strategies in order to avoid the negative consequences of future droughts. There are a variety of DMS that can be adopted, depending on the specific circumstances. Some common strategies used included, changes in land use practices, such as planting drought-tolerant crops, crop diversification, agroforestry, rearing indigenous animals and rainwater harvesting. The adoption of DMS is an important step in preparing for and reducing the impacts of droughts such as low crop and animal yields. By taking steps to conserve water and develop new water sources, communities become more resilient to drought conditions.

4.1.2 Intensity of Adoption of DMS

The study sought information on the intensity of various DMS adopted in Tharaka South. The degree of intensity of adoption of different DMS per household was recorded based on the percentages of adoption. Three categories were created based on the intensity of adoption: low intensity adoption (50% and below), medium intensity adoption (between 51 and 75%) and high intensity adoption (between 76 and 100%).

The study sought the information on the intensity of adoption of DMS in Tharaka South per ward (Chiakariga, Marimanti and Nkondi) and the results are presented in Table 2, Table 3 and Table 4 respectively.

Table 2

Intensity of Adoption of DMS in Chiakariga Ward

Drought Mitigation Strategy	% Adoption	Degree of Intensity
Rainwater Harvesting	97.1	High
Crop Diversification	91.2	High
Cultivating Drought Tolerant Crops	85.1	High
Rearing of indigenous animals	74.1	Medium
Agroforestry	68.4	Medium
Membership to a CBO	27.6	Low
Irrigation	20.7	Low
Livelihood Diversification	14.3	Low
Early warning Systems on Weather Conditions	10.1	Low
Soil Water Conservation Measures	6.4	Low

According to the information presented on Table 2, out of ten evaluated DMS in Chiakariga ward, three of the strategies had high intensity of adoption. Rainwater harvesting had the highest intensity of 97.1% followed by crop diversification 91.2% and planting drought tolerant crops 85.1%. Two strategies had medium intensity of adoption, including rearing of indigenous animals 74.1% and agroforestry 68.4%.

A half of the strategies had low intensity of adoption in Chiakariga ward. Joining community-based organization on drought mitigation was adopted by 27.6% of households, irrigation was found in 20.7% of the households, livelihood diversification was adopted by 14.3% of the households, early warning systems on weather conditions found in 10.1% of the households while soil water conservation measures were least adopted having being practiced by 6.4%of households.

The results of adoption of DMS among households in Marimanti ward are presented in Table 3.

Table 3

Intensity of Adoption of DMS in Marimanti Ward

Drought Mitigation Strategy	% Adoption	Degree of Intensity
Drought Tolerant Crops	93	High
Crop Diversification	82	High
Rearing of indigenous animals	78.2	High
Rainwater Harvesting	64.8	Medium
Agroforestry	61.7	Medium
Livelihood Diversification	33.1	Low
CBO Membership	19	Low
Irrigation	11.4	Low
Early warning Systems on Weather Conditions	12.6	Low
Soil Water Conservation	6.3	Low

According to the information presented on Table 3, ten DMS were evaluated in Marimanti Ward. Out of these, three of the strategies had high intensity of adoption. Planting drought tolerant crop had the highest intensity of 93% followed by crop diversification 82% and rearing of indigenous animals 78.2%. Two strategies had medium intensity of adoption, including rainwater harvesting with 64.8% and agroforestry 61.7%.

A half of the strategies had low intensity of adoption in Marimanti ward. Livelihood Diversification was adopted by 33.1% of the households, joining CBO on drought mitigation was adopted by 19% of households, Irrigation was found in 11.4% of the households, early warning Systems on weather conditions found in 12.1% of the households while Soil Water Conservation was least adopted being adopted by 6.3% of households.

The results of adoption of DMS among households in Nkondi ward are presented in Table 4.

Table 4

Intensity of Adoption of DMS in Nkondi Ward

Drought Mitigation Strategy	% Adoption	Degree of Intensity
Drought Tolerant Crops	91.1	High
Crop Diversification	79.5	High
Rearing of indigenous animals	76	High
Rainwater Harvesting	72.3	Medium
Agroforestry	57.2	Medium
Livelihood Diversification	30.7	Low
CBO Membership	23	Low
Irrigation	13.2	Low
Early warning Systems on Weather Conditions	9.7	Low
Soil Water Conservation	5.7	Low

According to the information presented in Table 4, out of the ten DMS evaluated in Nkondi Ward, three strategies had a high intensity of adoption. Planting Drought Tolerant crops had the highest intensity at 91.1%, followed by crop diversification at 79.5% and rearing of indigenous animals at 75%. Two strategies had a medium intensity of adoption, including rain water harvesting at 72.3% and agroforestry at 57.2%.

Half of the strategies had a low intensity of adoption in Nkondi Ward. Livelihood Diversification was adopted by 30.7% of households, Community Based Organization on Drought Mitigation was adopted by 23% of households, Irrigation was found in 13.2% of households, Early Warning Systems on Weather Conditions were found in 9.7% of households, and Soil Water Conservation was the least adopted, being implemented by only 5.7% of households.

The study further compared the intensity of adoption of different DMS in the three wards (Chiakariga, Marimanti and Nkondi) in Tharaka South Sub-County and the results are presented on Table 5.

Table 5

Intensity of Adoption of DMS by Wards

DMS	Chiakariga	Marimanti	Nkondi	Average rate	Intensity
Drought Tolerant Crops	85.1	93	91.1	89.7	High
Crop Diversification	91.2	82	79.5	84.2	High
Rainwater Harvesting	97.1	64.8	72.3	78.1	High
Rearing of indigenous animals	74.1	78.2	76	76.1	High
Agroforestry	68.4	61.7	57.2	62.4	Medium
Livelihood Diversification	14.3	33.1	30.7	26	Low
CBO Membership	27.6	19	23	23.2	Low
Irrigation	20.7	11.4	13.2	15.1	Low
Early warning Systems on Weather Conditions	10.1	12.6	9.7	10.8	Low
Soil Water Conservation	6.4	6.3	5.7	6.1	Low

The information on Table 5 shows that four DMS were common across the three wards in the sub-county. The adoption of these strategies that had high intensity of adoption varied across the wards, with different strategies topping the list in different wards being adopted by more than three quarters of the households. In Chiakariga ward, rainwater harvesting tops the list with 97.1% rate of adoption among the households while in Marimanti and Nkondi wards, adoption of drought tolerant crops topped their list with adoption rate of 93% and 91.1% respectively among households. These findings are in the line with the findings of Nabwire (2020) who reported high adoption rate of rain water harvesting in Kilifi County. The findings on adoption of drought tolerant crops agree with the findings of Kaua (2020) who reported high adoption of drought tolerant crops in Tharaka south as an adaptive strategy to climate change.

Planting drought tolerant crops had high intensity across the three wards being adopted by more than three quarters of the households with adoption rate of 85.1% in Chiakariga ward, 93% in Marimanti ward and 91.1% in Nkondi ward. This high intensity adoption of drought tolerant crops across the wards indicates the important role of the strategy in mitigating drought. These crops have low water requirements and therefore could grow well in Tharaka South with low rainfall amounts.

Crop diversification was also highly adopted among the three wards, with Chiakariga topping the list with households' adoption rate of 91.2% followed by Marimanti with 82% household adoption rate and Nkondi ward with an adoption rate of 79.5% among households. According to the study Chiakariga recorded high intensity of rainwater harvesting being adopted by more than three quarters of the households with adoption rate of 97.1%. This high adoption of rainwater harvesting in Chiakariga ward is an indicator of its important role in drought mitigation in the ward. In Marimanti, rainwater harvesting adopted by slightly below three-quarters (64.8%) of the households and Nkondi recorded slightly below three-quarters (72.3%) adoption rate of rainwater harvesting among households.

Agroforestry as drought mitigation strategy was highly reported in Chiakariga with slightly below three-quarters (68.4%) adoption rate followed by Marimanti ward which reported 61.7% adoption rate of agroforestry and the least was Nkondi which reported 57.2% adoption by households. According to the study rearing of indigenous animals, was most popular in Marimanti ward with 78.2% followed by Nkondi ward with 76% adoption rate and Chiakariga with 74.1% rate of adoption by households. The study recorded low levels of adoption intensity of five DMS that is, livelihood diversification, membership to a CBO, irrigation, early warning systems and soil water conservation, across the three wards.

The findings of this study noted that, in all the three wards, half of the evaluated DMS were widely accepted and adopted by more than half of the households. These strategies were planting drought tolerant crops, crop diversification, rain water harvesting, rearing of indigenous animals and agroforestry. These findings agree to observations by Kaua (2020) which reported the popularity of the strategies. This implies that these approaches are widely adopted by households and may be instrumental in mitigating the effects of drought in the county as noted by Esikuri (2005).

On average in the three wards, four mitigation strategies had high intensity of adoption in Tharaka South, being adopted by about three-quarters of the households. Planting drought tolerant crops was the most widely adopted with 89.7% of the households, followed by crop diversification with an average of 84.2%, rain water harvesting with 78.1% and rearing of indigenous animals with an average of 76.1%. Drought tolerant crops are able to survive with minimal precipitation and the high adoption rate of drought-resistant crops indicates a proactive approach towards adapting to water scarcity. These crops require less water to thrive, minimizing losses during dry periods. Crop diversification with water-efficient varieties on the other hand, reduces dependence on any single crop that might be highly susceptible to water stress. This practice helps maintain food security and income even during droughts.

The high intensity of adoption of rainwater harvesting strategy indicates a strong community focus on capturing and storing rainwater for later use. This can be vital during droughts when natural water sources become unreliable. Rearing of indigenous animals' strategy likely involves adopting animals with less feeds requirements such as goats and raising breeds of livestock well-suited to local climate conditions, including drought. These animals often require less water and can survive on sparse vegetation. Agroforestry had medium intensity of adoption being adopted by 62.4% of the households on average. Across the wards, planting trees, especially drought-tolerant varieties, can improve soil moisture retention and create microclimates that benefit surrounding vegetation. It also combats desertification in the long run

The study found out that on average, five DMS had low adoption intensity. Diversifying income (livelihood diversification) of 26% beyond agriculture can provide a safety net during droughts when agricultural productivity suffers. This could include encouraging skills development and fostering non-farm businesses. Community based organization on drought mitigation shows an adoption rate of approximately 23.2%. This low adoption rate suggests a potential gap in community-wide collaboration and planning for drought preparedness. Strong community organizations could play a vital role in resource sharing, knowledge dissemination, and coordinated action during droughts.

The relatively low adoption rate (15.1%) of irrigation might be due to factors like limited access to water sources, high infrastructure costs, or energy constraints. It's crucial to explore sustainable irrigation techniques that minimize water usage. A low adoption rate for early warning systems (10.8%) is a major concern. These systems can provide crucial lead time to prepare for a drought and implement water-saving measures. Soil water conservation strategy was the least adopted on average (6.1%) across the wards.

Practices that improve soil health and water retention capacity are essential for drought preparedness. This could involve techniques like mulching and cover cropping as noted by Njeru *et al* (2020).The results reveal a positive trend in DMS with high adoption rates for rainwater harvesting, crop diversification, and drought-resistant crops. However, the low adoption of crucial approaches like early warning systems and soil water conservation requires immediate attention. By promoting community collaboration, raising awareness, and exploring sustainable solutions, the community can improve its preparedness for future droughts and become more resilient to water scarcity. The data provided sheds light on the adoption rates of various DMS within Tharaka South Sub-County. This information is crucial for understanding how prepared the population is to face water scarcity and its associated challenges

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The study revealed that on average, slightly above three-quarters (78.1%) of the respondents had adopted rainwater harvesting as a drought mitigation strategy (Table 5). This percentage shows that greater than three quarter of the sample population had adopted the strategy in the area. Rain water harvesting was mainly done from the rooftops which involved collecting rainwater from rooftops using gutters and pipes which directed water into storage tanks. Majority of the households were only able to collect in small scale and used it for domestic purposes other methods of collecting rainwater that were observed included farm ponds and subsurface dams across rivers.

This study revealed that Tharaka South is characterized by an arid and semi-arid climate. This region experiences erratic and unpredictable rainfall patterns, with long dry spells and frequent droughts. Rainwater harvesting helps communities in this region to store and utilize the limited rainfall effectively during the dry periods. The study findings mirror with Gitonga *et al*. (2020) in his study in Tharaka South who found what that the Tharaka South residents had immensely adopted rainwater harvesting as a drought mitigation strategy. Although due to limited storage, majority of the households tap rain water in small scale for the domestic purposes as compared to agricultural practices. The main challenges to harvesting rain water were cited as, in availability of capital to finance the projects like buying huge tank, digging dams and even acquiring the tools necessary for rain water harvesting. This is in accordance with Nabwire (2020) findings.

The study further sought information on crop diversification as a strategy of drought mitigation adopted by households. Figure 4 shows various crops planted on a piece of land.

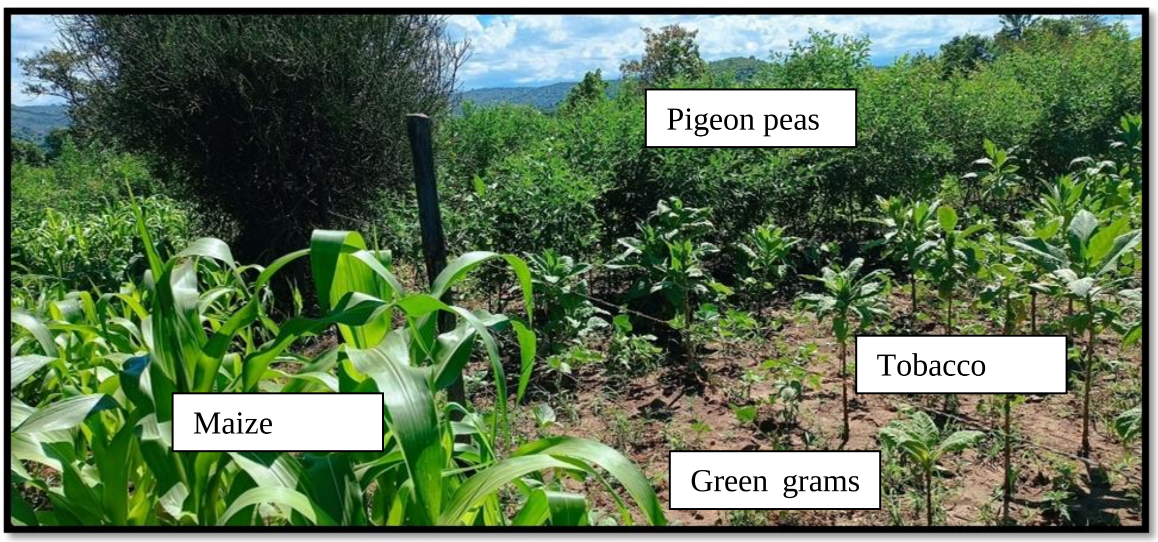

Figure 4: Crop Diversification on a Farm *(Cajanus cajan, Nicotiana tabacum, Viagna radiata & Zea mays)* in Nkarini Village

According to the study, above three-quarters (84.2%) of the households had adopted crop diversification as a drought mitigation strategy. This means that slightly above three quarters of the households had adopted diversification as drought mitigation strategy. This can be attributed to the risk reduction in cases of some crop failure during drought periods. Different crop species require different growth conditions. This gives the probability of some crops doing well in different weather and climatic conditions. By growing a variety of crops with different water requirements and maturity periods, farmers can ensure that at least some of their crops will survive and provide yields, even when others fail (Nhamachena & Hassan, 2008). The households also noted that crop diversification enables them to grow a variety of crops for different purposes like, protein provision, vitamins both cash crops and food crops. Some of the crop species grown as indicated by the study were, green grams, cowpeas, pigeon peas, millet, sorghum beans, maize and tobacco. The study revealed that crop diversification has also its limitations since it is difficult to commercialize the produce profitably.

The study sought information on the adoption of drought tolerant crops as a mitigation strategy. Use of drought tolerant crops had a high intensity of adoption as revealed by the study. Above three quarters (89.7%) in average of the households in Tharaka South Sub-County were in favor of planting drought tolerant crops as drought mitigation strategy. Figure 5 shows mixed cropping of Pigeon peas (*Cajanus cajan*) and sorghum (*sorghum bicolor*), drought tolerant crops in the same piece of land.

Figure 5: Mixed Cropping of Pigeon Peas (*Cajanus cajan*) and Sorghum (*sorghum bicolor*) Drought Tolerant Varieties in Matakiri village

According to the study, planting of drought tolerant crops had the highest intensity of adoption across the three wards in Tharaka South sub-county. These crops included cowpeas *(Vigna unguiculata),* sorghum (*sorghum bicolor*) millet *(Pennisetum glaucum)* and cassava *(Manihot esculenta.)* Pigeon Peas (*Cajanus cajan*) green grams *(Vigna radiata),* tobacco *(nicotiana tabacum).* Planting drought tolerant crops was more common in Marimanti and Nkondi than Chiakariga. Some households in Marimanti had adopted planting peanuts *(Arachis hypogaea*) which despite being drought tolerant crop, it also had high prices in the market. Additionally, crops that take long to mature are being abandoned in favor of fast-growing ones like green grams. To preserve these native crop kinds, the locals also keep seeds in unique storage spaces like big pots and granaries that are constructed specifically for that purpose. This is in agreement with the report by Kenya Agricultural and Livestock Research Organization (KALRO) that sorghum cultivation has increased in Tharaka South.

The findings on high intensity of adoption of drought tolerant crops agree with the observation by Cattivelli et al., (2008) that many years of research through genetic engineering and plant breeding have led to production of drought tolerant crops which increase yields in the environments prone to droughts. However, these results disagree with the findings of Mokakha et al., (2013) and Odhiambo (2013) which reported average adoption of drought tolerant crops. This adoption can be attributed to the realization of the frequency and impacts of drought hence willingness to mitigate it.

Further the information on rearing of indigenous animals as drought mitigation strategy was sought. According to the study, 76.1% of the households had adopted indigenous animals as drought mitigation strategy.

Figure 6: Zebu (*Bos tauras indicus)* Grazing in an Open Field in Igumo Village

Indigenous animals are more resilient to droughts and other environmental stresses compared to non-native species. Indigenous animals are better able to survive and maintain productivity during periods of feed and water scarcity due to their genetic adaptations and grazing behaviors. The findings in this study mirrors with Kaua (2019) who found out that indigenous animals were used as a mitigating strategy to drought conditions. Other livestock management strategies adopted include: reducing the herd size to manageable numbers, adopting animals with less food requirement such as goats instead of cattle, keeping birds and even bee keeping. Interbreeding the indigenous animals with hybrid breeds was also a practice that was gaining popularity in Tharaka South. These improved breeds had higher yielding potential as compared to the pure indigenous animals and also could survive the climatic conditions in the region. The animals were left to graze freely in the fields during of season periods.

The study noted that, slightly below three-quarter (62.4 %) adopted agroforestry as drought mitigation strategy. Trees were found to provide essential ecosystem services, such as improving soil fertility, regulating microclimate, and enhancing water infiltration, which ultimately improved the productivity and resilience of agricultural systems during prolonged dry periods. Tree canopy provided much-needed shade, thereby reducing evapotranspiration and conserving water resources. The study further noted that trees provided economic benefits through sale of tree products, such as firewood, charcoal, and timber, particularly during drought seasons when other agricultural activities are disrupted. It was also noted that some trees were a source of food for instance tamarind (Tamarindus indica) pawpaw *(Carica papaya)*, oranges *(Citrus sinensis)* and mango *(Mangifera indica)* trees making the residents to get alternative sources of food during drought. Other traditional trees were left out during clearing the farms in order to help in conserving soil. These trees were incorporated in the same farm with the grown crops. This study findings mirrors with UNDP (2013) which found out that agroforestry was an appropriate strategy of drought mitigation.

According to the study, livelihood diversification was adopted by 26% on average of the sampled households in the study area which was a low level of adoption. Livelihood diversification activities noted by the study included; seeking for employments, charcoal burning, sand harvesting in the rivers and quarrying. Most of these activities have a negative impact in the environment and leads to global warming. This therefore necessitates the policy makers to discourage the activities that degrade the environment and support activities that promote environmental conservation. The study found that the decline in livelihood options was causing a rise in incidences of crime, especially among the youth who drop out of school due to a lack of school fees and other hardships. There was also an erosion of the community's moral values as immorality rises and competition on limited resources like water ravaged by climate change-induced hardships. Increased desperation due to rising hardships was also leading to an increase in family breakups and domestic violence. These findings agree with the report by Gioto et al., (2017) that drought can exacerbate conditions that lead to immorality, such as increased competition for scarce resources like water and food, which may intensify conflicts and ethical compromises in affected communities.

The study noted that slightly below a quarter of the sampled households (23.2%) belonged to a community-based organization that dealt with drought mitigation. The low adoption of some of this drought mitigation strategy could be attributed to households' lack of knowledge on the importance of CBOs. Examples of these CBOs include *Bunge la Wananchi* which focused on planting tree nurseries, protecting trees and natural resources like rivers from exploitation. Other organizations were NGOs like, GRADIF and KCSAP which was implemented through the docket of Agriculture, Livestock and Fisheries. Farmers network educated farmers on drought mitigation and also provided the resources required in mitigating drought. These resources included: extension services, water tanks, seeds, farm tools and even farm inputs. Despite the benefits associated with community-based organization, some residents viewed them as time wastage and felt that spending time in their farms rather than attending NGOs meeting was more beneficial. They also noted that the organizations do not cater for their needs like land preparation, provision of enough seeds, farm in puts and farm tools. These findings mirror with DeGroote et al., (2013) and KMD (2021).

Irrigation was adopted by 15.1%on average of the sampled households in Tharaka South. The households engage in small-scale irrigation practices along the banks of permanent rivers, including the River Tana, River Thingithu, and River Mutonga. This represents a low adoption intensity of the DMS in the study area. The low adoption of irrigation was attributed to its high cost of installation and inadequate water especially during drought. Irrigation was mainly done on maize to supplement the low unreliable rainfall in the area. The study noted that, irrigation enabled farmers to increase their agricultural productivity and reduced the dependency on rainfall. These findings mirror Tesfaye’s (2015) who noted that; investing in irrigation infrastructure and systems enables farmers to access and utilize water even during periods of drought. Irrigation can significantly increase agricultural productivity and reduce the dependency on rainfall.

Weather forecasting information was used by 10.8% to plan their farming calendar. This low adoption of the strategy was attributed to the lack of area-based channels that give information on weather patterns. Majority of the respondents reported that there were no government programs that gave them early warning bulleting on weather. Those who got the information about weather forecasting were getting them from the radios and a few from the internet. Many farmers were cited to be using the indigenous weather forecasting techniques to predict weather. These findings are consistent with the research findings of Kaua (2019) and Njeru et al., (2020).

Some farmers were using unreliable rainfall patterns where they planted crops based on seasons like long rains season and short rains seasons without necessarily putting into considerations, the fact of climate change. The key to developing effective drought mitigation techniques is early warning systems and weather predictions. These assist households in making decisions on the strategies to apply in the upcoming season. It also aids in the planning of their agricultural output, such as choosing which crop sorts and types to plant for the upcoming growing season. It also helps them forecast whether there will be enough pastures and water available in the next season. The findings agree with Cane and Arkin (2000).

Planning and decision-making regarding the quantity of stocks to keep, as well as making arrangements for the management of pasture resources in the event that circumstances indicate that lean periods may come, depend heavily on this information. This is similar to what Cane and Arkin (2000) had earlier observed. The respondents cited that the bulleting was significant since it helped them to plan on what to plant. This means that the government ought to develop more accessible weather forecasting channels to ensure that more households access the information and use it effectively.

Soil water conservation was the least adopted among the DMS with an average of 6.4% adoption rate. The main conservation strategy adopted was minimum tillage. Others were planting under tree shade and along the river banks. The community engages in early planting to ensure they can fully utilize the available rainfall. They also plant crops under the shade of trees to increase the chances of the crops surviving through drought conditions aand also planting of crops in Zai pits to aid in water retention. Additionally, the people use cover crops as a strategy.

The study further sought information on the number of DMS adopted per households and the result are presented on Figure 7.

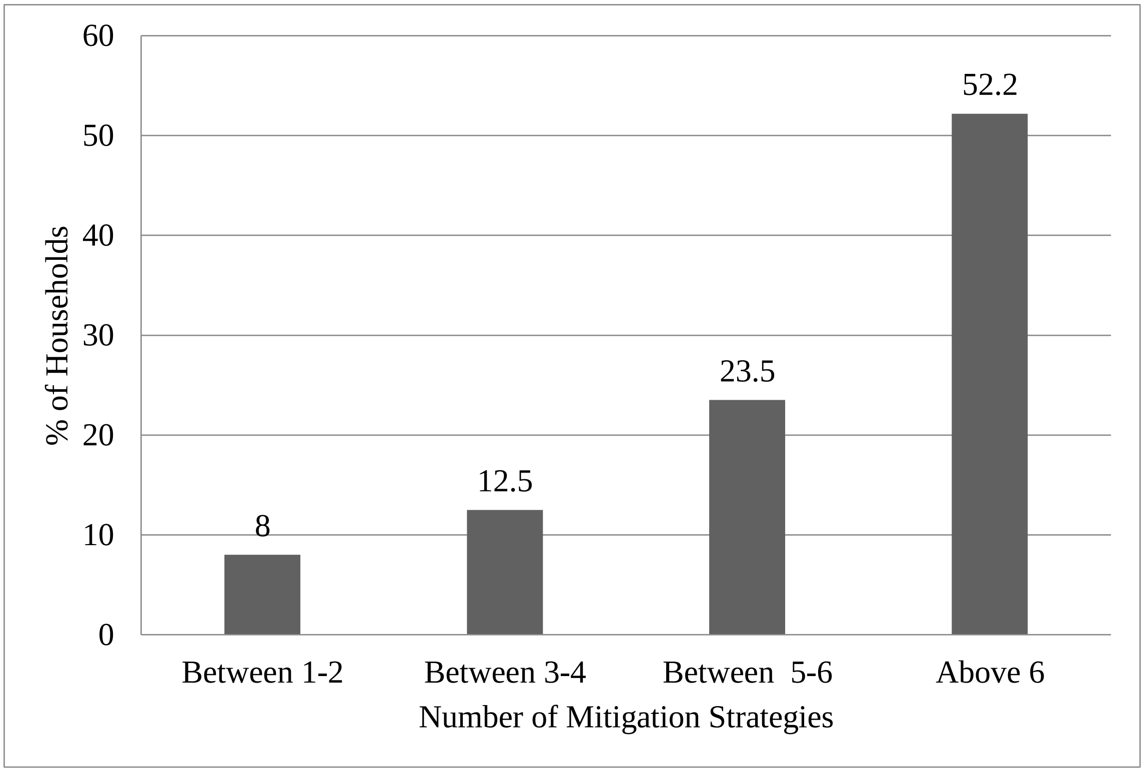

Figure 7: Number of DMS Adopted by Households

According to information on Figure 7, slightly more than half (52.2%) of the households had adopted more than six DMS. This means that the community is aware of the impacts of drought and it's willing to counter it. The study noted that majority of households used more than one strategy concurrently either to supplement each other or as precaution measure in case some fails. Some other households used the strategies and if they fail to give the desired results, they abandon them temporarily and rekindle them after some seasons. If household heads anticipate greater benefits from adopting the strategy rather than not adopting it, they are more likely to implement the strategy compared to situations where they expect lower benefits from the innovation (Huckett, 2010). Slightly more than a quarter (27%) of the households had adopted five to six mitigation strategies. Either used them together at a point or one at a time depending on the expected results from the strategy.

The findings on the high number of household's adoption of DMS was collaborated by the reports from key informants who ascertained the adoption of DMS mentioned. Key-informants also reported that some of the lowly adopted DMS are highly rated to be effective in mitigation drought. The ministry of agriculture, livestock and fisheries reported that the government was offering subsidies and agricultural education to the farmers through extension officers directly and through NGOs like, National Agricultural Value Development Chain Development Project (NAVCDP).

4.1.3 Challenges Faced in Adopting DMS

The study highlighted the challenges faced by households in Tharaka South in adopting DMS as follows; households had limited access to agricultural extension services and technical support to adopt and effectively implement drought mitigation technologies and practices. The region faced chronic water scarcity, with limited access to reliable and sufficient water sources for agricultural and domestic use, hindering the adoption of water-intensive DMS. Tharaka South is a predominantly rural and low-income region, where many households lack the financial means to invest in DMS. The inherent uncertainty associated with climate change and drought patterns can made households to be hesitant to adopt new, untested mitigation strategies.

4.2 Determinants of Adoption of DMS

The study sought information on the determinants of adoption of DMS. The determinants were classified into socio-economic, institutional and drought perception factors. The socio-economic factors included: gender, age, education level, gross income per year, household size and number of dependents. The institutional factors include: extensional officers, government support, market access, land area and land tenure.

4.2.1 The Relationship between the Perception of Drought and the Adoption of DMS

A strong link exists between how people perceive climate change and their adoption of DMS. When households recognize changes in rainfall patterns and increasing drought frequency, they are more likely to embrace DMS. To determine whether the adoption of DMS is correlated with drought perception, a calculation of the Pearsons correlation was made. Highly significant correlation of 0.751 was found, as shown on the Table 6.

Table 6

Pearson's Correlation between the Perception of Drought and the Adoption of DMS

		Adoption of DMS	Perception of climate change
Adoption of DMS	Correlation Coefficient	1.000	0.751
	Sig. (2-tailed)		0.001
	N	400	400
Perception of climate change	Correlation Coefficient	0.751	1.000
	Sig. (2-tailed)	.000	
	N	400	400

Adoption of drought mitigation methods is positively impacted by perceptions of drought. This is due to the fact that the adoption process starts with the perception of the issue, which prompts an action. Therefore, a household's attitude toward climate change will influence the mitigation techniques they choose to deal with the problem. This is in agreement with the findings of Shongwe (2014).

Therefore, if a household perceives drought as a pressing concern, they are more likely to take action and adopt DMS to address the problem. The recognition of the climate change challenge is a crucial first step that then drives the selection and implementation of appropriate response measures. The adopted measures are geared towards reducing the impacts of drought as perceived by the households. The results above confirm what Mwaluma & Mwangi (2008) found out perception of climate change patters and drought mitigations strategies citing household with knowledge about climate change patterns have a higher likelihood of embracing indigenous drought mitigations strategies.

4.2.2 Socio-economic Determinants of Adoption of DMS in Tharaka South

The goal of the study was to determine the impact that different socioeconomic factors had on Tharaka South households' adoption of DMS. The socioeconomic characteristics, such as the income level and gender of the head of the household, household's head level of education, the household's dependency, households' size and the head's age were all investigated.

Table 7

Correlation between Socioeconomic Factors and Adoption of DMS

		DMS	Gender	Age bracket	Education level	Gross income per year	Household size	Dependents
Adoption of DMS	Pearson Correlation	1	0.889	-0.593	0.986	0.988	0.360	0.603
	Sig. (2-tailed)		0.007	0.003	0.003	0.001	0.001	0.001
	N	400	400	400	400	400	400	400
Gender	Pearson Correlation	0.889	1	-0.072	-0.029	.108*	0.029	-0.061
	Sig. (2-tailed)	0.007		0.151	0.569	0.031	0.567	0.226
	N	400	400	400	400	400	400	400
Age bracket	Pearson Correlation	-0.593	-0.072	1	0.047	.101*	0.010	0.095
	Sig. (2-tailed)	0.003	0.151		0.349	0.042	0.836	0.058
	N	400	400	400	400	400	400	400
Educ Level	Pearson Correlation	0.986	-0.029	0.047	1	-0.077	-0.094	.104*
	Sig. (2-tailed)	0.003	0.569	0.349		0.124	0.061	0.038
	N	400	400	400	400	400	400	400
Gross income per year	Pearson Correlation	0.988	.108*	.101*	-0.077	1	-0.012	0.064
	Sig. (2-tailed)	0.001	0.031	0.042	0.124		0.809	0.202
	N	400	400	400	400	400	400	400
House hold size	Pearson Correlation	0.360	0.029	0.010	-0.094	-0.012	1	-0.047
	Sig. (2-tailed)	0.001	0.567	0.836	0.061	0.809		0.347
	N	400	400	400	400	400	400	400
Depe-dent	Pearson Correlation	0.603	-0.061	0.095	.104*	0.064	-0.047	1
	Sig. (2-tailed)	0.001	0.226	0.058	0.038	0.202	0.347	
	N	400	400	400	400	400	400	400

The results of the study reveal several significant socioeconomic factors affecting the adoption of DMS. The Pearson correlation analysis indicates a very strong positive correlation between the adoption of DMS and gross income per year (0.988, $p < 0.001$), suggesting that higher income levels enable households to invest more in such mitigation strategies. These findings agree with the findings of Njeru *et al*., (2020) who reported statistically significant positive relationship between income from agriculture and level of adoption of EFFPs. This suggests that higher income positively influences the adoption of DMS. Increased income enhances access to information and decision-making capabilities. Furthermore, it reduces risk aversion, thereby increasing the willingness to adopt these techniques. This finding is consistent with studies by Deressa (2009) and Nhemachena and Hassan (2008), which also reported that wealthier households adopted more of climate adaptation measures.

Education level also shows a strong positive correlation with adoption of DMS (0.986, $p < 0.003$). This implies that higher educational attainment equips individuals with better knowledge and skills to adopt and manage mitigation measures. The positive effects of education demonstrate that high literacy rates are essential for adoption since they improve a farmer's capacity to get and comprehend information about new technology. As noted by Njeru et al. (2020), higher educated households would benefit more from environmental education and increased conservation activities. Araro et al., (2020) in his study on Climate change and variability perception, impacts and adaptation strategies among smallholder farmers in the Amhara Region, Ethiopia, noted that Educated farmers were more likely to participate in agricultural extension services and training programs, where they learnt about DMS and how to implement them effectively. Also, higher education enables farmers to better understand and utilize agricultural research on drought-resistant crops, soil conservation, and water management. This aligns with findings by Uddin et al., (2014) who noted that education increases awareness and understanding of climate change, thereby fostering the adoption of adaptive practices.

Gender of the household head show a strong positive correlation with the adoption of DMS (0.889, $p<0.007$).This indicates that female headed households are focused on more agricultural responsibilities than men. Female-headed households were more likely to agricultural technologies compared to male-headed households, as women are more attuned to their roles in land cultivation, crop harvesting, and other related agricultural tasks, as noted by Njeru et al. (2020). This may because of their role in ensuring food availability to the family which makes them engage more on drought mitigation. This suggests that extension programs should be developed and executed to harness women's potential in promoting the spread of DMS among rural households. In her research on sustainable farming methods in South Africa, Cele (2016) found out that women dominated food production on farms since they were primarily in charge of deciding what meals to prepare for their families. As a result, they were involved in many important farming decisions, such as which technologies to use.

Household size and the number of dependents also exhibit positive correlations (0.360, $p<0.001$, and 0.603, $p<0.001$, respectively) with the adoption of DMS. Larger households and those with more dependents may have greater labor availability and a stronger motivation to adopt strategies that ensure water availability and food security. Also, larger households face greater risks in terms of food security and livelihood stability during drought periods. The need to ensure the well-being of all members makes them more proactive in adopting strategies that mitigate these risks. This is agreement with findings of Deressa (2009) who found that, larger Ethiopian households were more likely to adopt multiple DMS due to their higher vulnerability to food insecurity and income loss during droughts. This finding resonates with the work of Fosu-Mensah et al., (2012), who found that larger households are more likely to engage in various drought mitigation practices.

Conversely, the age bracket shows a negative correlation (-0.593, $p>0.003$), suggesting that younger farmers are more inclined to adopt Drought Mitigation techniques compared to older farmers. Younger farmers are generally more adept at using modern technology and accessing information, enabling them to stay informed about the latest DMS and techniques. Araya et al., (2019) found that younger Ethiopian farmers were more likely to adopt modern irrigation techniques due to their higher familiarity with information and communication technologies compared to older farmers. Also, younger farmers have higher education levels and are more likely to attend agricultural training programs, equipping them with knowledge and skills to implement advanced DMS. A study by Nkonya et al., (2011) in Uganda found that younger farmers were more likely to participate in training programs, leading to higher adoption rates of soil and water conservation practices. Younger farmers tend to be more open to taking risks and trying new methods compared to their older counterparts, who may prefer traditional farming practices.

Willingness to innovate makes younger farmers more likely to adopt new DMS. Rogers (2003) discusses how younger individuals are typically early adopters of new technologies and innovations due to their higher risk tolerance and openness to change. Younger Kenyan farmers were more likely to adopt labor-intensive soil conservation practices due to their physical capability and adaptive mindset. This trend is consistent with findings by Deressa (2011), which indicated that younger farmers tend to be more open to adopting new technologies and practices. However, these findings, contradicts with those of Kaua (2020) who noted a positive significance correlation between age and adoption of indigenous climate change adaptive strategies.

Overall, these results highlight the critical role of socioeconomic factors such as income, education, gender, age of the household head and household dynamics in influencing the adoption of DMS, reinforcing the findings of previous studies and underscoring the need for targeted strategies that consider these variables.

Table 8

Correlation between Socio-economic Factors and the Adoption of Crop Diversification

		n of crop diversifi cation	gender	Age bracket	Educatio n level	income per year	Househo ld size	Depende nt
Adoption of crop diversi fication	Pearson Correlation	1	0.649	0.742	.890	0.792	0.543	0.492
	Sig. (2-tailed)		0.004	0.003	0.001	0.001	0.023	0.032
	N	400	400	400	400	400	400	400
Gender	Pearson Correlation	0.649	1	-0.072	-0.029	.108*	0.029	-0.061
	Sig. (2-tailed)	0.004		0.151	0.569	0.031	0.567	0.226
	N	400	400	400	400	400	400	400
Age bracket	Pearson Correlation	0.742	-0.072	1	0.047	.101*	0.010	0.095
	Sig. (2-tailed)	0.003	0.151		0.349	0.042	0.836	0.058
	N	400	400	400	400	400	400	400
Educ level	Pearson Correlation	.890	-0.029	0.047	1	-0.077	-0.094	.104
	Sig. (2-tailed)	0.001	0.569	0.349		0.124	0.061	0.038
	N	400	400	400	400	400	400	400
Gross income per year	Pearson Correlation	0.792	.108*	.101*	-0.077	1	-0.012	0.064
	Sig. (2-tailed)	0.001	0.031	0.042	0.124		0.809	0.202
	N	400	400	400	400	400	400	400
Household size	Pearson Correlation	0.543	0.029	0.010	-0.094	-0.012	1	-0.047
	Sig. (2-tailed)	0.023	0.567	0.836	0.061	0.809		0.347
	N	400	400	400	400	400	400	400
Depen dents	Pearson Correlation	0.492	-0.061	0.095	.104*	0.064	-0.047	1
	Sig. (2-tailed)	0.032	0.226	0.058	0.038	0.202	0.347	
	N	400	400	400	400	400	400	400

The correlation analysis between socioeconomic factors and the adoption of crop diversification reveals several significant relationships. The study found a very strong positive correlation between education level and the adoption of crop diversification (0.890, $p < 0.001$). This suggests that higher educational attainment enhances the ability to implement and manage diverse cropping systems effectively, which aligns with findings from studies by Deressa (2009), who also observed that education significantly influences the adoption of various agricultural practices.

Gross income per year also shows a strong positive correlation (0.792, $p < 0.001$) with the adoption of crop diversification. This indicates that households with higher incomes have more resources to invest in different crops, enabling better risk management and productivity. This observation is consistent with the findings of Nhemachena and Hassan (2008), who reported that wealthier farmers are more capable of diversifying their crops due to better financial capacity.

Age bracket exhibits a significant positive correlation (0.742, $p<0.003$) with adoption of crop diversification. This suggests that older farmers are more likely to adopt and benefit from crop diversification strategies. This finding is supported by the work of Deressa (2011), who found that older farmers often have more experience and knowledge, which can contribute to the successful implementation of diverse cropping systems. Household size and number of dependents also show positive correlations (0.543, $p< 0.023$ and 0.492, p-value 0.032, respectively) with adoption of crop diversification. Larger households and those with more dependents may have more labor available to manage diverse crops and a stronger motivation to ensure food security through diversification. This finding is consistent with Fosu-Mensah et al., (2012), who noted that larger households are more likely to adopt multiple agricultural practices.

Gender has a significant positive correlation with adoption of crop diversification (0.649, $p<0.004$), indicating that female-headed households may be more effective in implementing crop diversification strategies. This could be due to the active role women play in managing diverse agricultural tasks, as highlighted by studies such as those by (United Nations Women Watch, n.d). Overall, the study underscores the importance of socioeconomic factors such as education, income, age, land size, and household dynamics in influencing the adoption of crop diversification strategies. These findings reinforce the results of previous studies and highlight the need for policies that consider these variables to promote sustainable agricultural practices

Table 9

Correlation between Socioeconomic Factors and the Adoption of Drought Tolerant Crops

		drought tolerant crops	Gender	Age bracket	Education level	Gross income per year	Household size	Dependents
Adoption of drought tolerant crops	Pearson Correlation	1	0.629	0.897	0.812	0.749	0.765	0.581
	Sig. (2-tailed)		0.001	0.003	0.001	0.004	0.002	0.042
	N	400	400	400	400	400	400	400
Gender	Pearson Correlation	0.629	1	-0.072	-0.029	.108*	0.029	-0.061
	Sig. (2-tailed)	0.001		0.151	0.569	0.031	0.567	0.226
	N	400	400	400	400	400	400	400
Age bracket	Pearson Correlation	0.897	-0.072	1	0.047	.101*	0.010	0.095
	Sig. (2-tailed)	0.003	0.151		0.349	0.042	0.836	0.058
	N	400	400	400	400	400	400	400
Education level	Pearson Correlation	0.812	-0.029	0.047	1	-0.077	-0.094	.104*
	Sig. (2-tailed)	0.001	0.569	0.349		0.124	0.061	0.038
	N	400	400	400	400	400	400	400
Gross income per year	Pearson Correlation	0.749	.108*	.101*	-0.077	1	-0.012	0.064
	Sig. (2-tailed)	0.004	0.031	0.042	0.124		0.809	0.202
	N	400	400	400	400	400	400	400
Household size	Pearson Correlation	0.765	0.029	0.010	-0.094	-0.012	1	-0.047
	Sig. (2-tailed)	0.002	0.567	0.836	0.061	0.809		0.347
	N	400	400	400	400	400	400	400
dependents	Pearson Correlation	0.581	-0.061	0.095	.104*	0.064	-0.047	1
	Sig. (2-tailed)	0.042	0.226	0.058	0.038	0.202	0.347	
	N	400	400	400	400	400	400	400

The correlation analysis between socioeconomic factors and the adoption of drought-resistant crops reveals several significant relationships. The study found a very strong positive correlation between age bracket and the adoption of drought-resistant crops (0.897, $p < 0.003$). This suggests that older farmers are more likely to effectively adopt drought-resistant crops, possibly due to their accumulated experience and knowledge. Similar findings have been reported by Deressa (2009), indicating that age significantly influences the adoption of climate adaptation strategies.

Education level also shows a strong positive correlation (0.812, $p<0.001$) with the adoption of drought-resistant crops. This suggests that higher educational attainment enhances the ability to implement and manage drought-resistant crops effectively. This finding aligns with studies by Nhemachena and Hassan (2008), who observed that education plays a critical role in the adoption of various drought mitigation practices.
Gross income per year demonstrates a significant positive correlation (0.749, $p<0.004$) with the adoption of drought-resistant crops. This indicates that households with higher incomes have more resources to invest in drought-resistant crops, enabling better adaptation to drought. This observation is consistent with the findings of Maddison (2006) and Deressa (2011), who reported that wealthier farmers are more capable of adopting advanced agricultural technologies due to better financial capacity.

Household size and the number of dependents also show positive correlations (0.765, $p< 0.002$ and 0.581, $p<0.042$, respectively) with the adoption of drought-resistant crops. Larger households and those with more dependents may have more labor available to manage drought-resistant crops and a stronger motivation to ensure food security through resilient agricultural practices. This finding is consistent with Fosu-Mensah et al., (2012), who noted that larger households are more likely to adopt multiple agricultural practices.

Gender has a significant positive correlation with the adoption of drought-resistant crops (0.629, $p< 0.001$), indicating that female-headed households may be more effective in implementing drought-resistant crop strategies. This could be due to the active role women play in managing diverse agricultural tasks, as highlighted by reports such as those by (United Nations Women Watch, n.d).

Overall, the study underscores the importance of socioeconomic factors such as age, education, income, household size, and dependents in influencing the adoption of drought-resistant crops. These findings reinforce the results of previous studies and highlight the need for policies that consider these variables to promote sustainable agricultural practices.

4.2.3 Institutional Factors Affecting the Adoption of DMS in Tharaka South

The results on table 10 show a correlational analysis between institutional factors and the adoption of DMS. Understanding these relationships is crucial for designing policies and strategies that promote the adoption and sustainability of the strategies.

Table 10

Correlation between Institutional Determinants and the Adoption of DMS

		Adoption of DMS	Land area	Land tenure	Market access per month	Gov't support	Extension officer contact
Adoption of DMS	Pearson Correlation	1	0.983	-0.013	0.792	0.853	0.958
	Sig. (2-tailed)		0.006	0.005	0.006	0.003	0.004
	N	400	400	400	400	400	400
Land area	Pearson Correlation	0.983	1	-.108*	-0.043	0.009	0.055
	Sig. (2-tailed)	0.006		0.031	0.396	0.853	0.274
	N	400	400	400	400	400	400
Land tenure	Pearson Correlation	-0.013	-.108*	1	-0.041	-0.044	0.004
	Sig. (2-tailed)	0.005	0.031		0.413	0.382	0.941
	N	400	400	400	400	400	400
Market access per month	Pearson Correlation	0.792	-0.043	-0.041	1	-0.029	-0.016
	Sig. (2-tailed)	0.006	0.396	0.413		0.559	0.746
	N	400	400	400	400	400	400
Gov't support	Pearson Correlation	0.853	0.009	-0.044	-0.029	1	0.048
	Sig. (2-tailed)	0.003	0.853	0.382	0.559		0.337
	N	400	400	400	400	400	400
Extension officer contact	Pearson Correlation	0.958	0.055	0.004	-0.016	0.048	1
	Sig. (2-tailed)	0.004	0.274	0.941	0.746	0.337	
	N	400	400	400	400	400	400

The analysis reveals an exceptionally strong positive correlation (0.983, $p < 0.05$) between land area and the adoption of DMS. This suggests that households with larger land areas are more likely to implement and benefit from these strategies. This finding agrees with the findings of Njeru et al., (2020) who noted a positive relationship between land size and adoption of EFFPs in Embu County ecosystems. Larger farms have a faster and more persistent positive association between adoption and farm size, which may be because of return on investment and also there is availability of greater land for more trials. Also, land size has a positive effect on adoption of DMS because those who have larger land have more capital and resources to invest in mitigation strategies.

Larger land sizes often facilitate the adoption of drought mitigation and sustainable land management strategies, primarily due to better resource availability, economies of scale, and greater capacity to invest in such measures. Large land size provides economies of scale and more opportunities for diversification and investment in soil and water conservation measures as noted by Shiferaw et al., (2014). Larger land sizes are associated with higher adoption rates because they allow for more extensive implementation of these technologies, which can be capital intensive. The study noted that households with larger land sizes were more likely to adopt a combination of mitigation strategies since they benefited from greater resource availability and reduced risk. These findings agree with the findings of Kaua (2020) and Shiferaw et al., (2013) in their studies on factors influencing adoption of rainwater harvesting in western Kenya.

The results show a weak negative correlation (-0.013, $p>0.05$) between land tenure and adoption of DMS. This correlation is statistically insignificant, implying that land tenure securities have no major influence on the adoption of DMS. This study found the relationship between land tenure and DMS to be complex and context-dependent. Land tenure security was not always the most decisive factor, as other socio-economic, institutional, and contextual factors significantly influenced the adoption of DMS.

These findings compare favourably with earlier findings by Asrat et al., (2004) in Ethiopia who found that formal land ownership was not a significant factor in farmers' willingness to adopt conservation strategies. Asrat et al., (2004) opined that farmers might embrace technologies even in unstable land tenure conditions, provided that the short-term costs are minimal and the benefits are realized swiftly. This means that secure land tenure alone is not sufficient to ensure the adoption of sustainable practices as other factors such as household income, access to extension services, market access, infrastructure, and education and perception of climate risk can be more decisive in influencing adoption rates and have a more significant impact on the adoption of DMS. However, the findings on insignificant influence of land tenure on adoption of DMS, contradicts other studies that revealed that land tenure is a strong indicator of adoption behaviour.

A moderately strong positive correlation (0.792, $p < 0.05$) exists between market access per month and adoption of DMS. This suggests that households with more frequent access to markets are more likely to implement the strategies. There are a few possible explanations for this relationship. Households' heads with better market access typically have higher incomes due to easier and more frequent opportunities to sell their produce. This financial stability enables them to invest in drought mitigation measures. Furthermore, the demand for agricultural products can drive innovation and adoption of practices that ensure consistent production, such as DMS.

Market access means increased access to inputs and produce markets hence greater capacity to adopt. Proximity to markets provides farmers with better access to agricultural inputs such as seeds, fertilizers, and equipment necessary for implementing DMS (drought-tolerant crops, irrigation systems). The findings agree with the findings of Kamara (2004) who in his study on how market access affects input use and agricultural productivity in Machakos, found that improved market access was associated with higher input use and better adoption of irrigation and other drought mitigation measures. Ojo et al (2021) on his study on impacts of market access on input use and agricultural productivity in Niger noted that the productivity of cereal crop farmers improved with better access to inputs, regardless of farm size in the study area. Additionally, the research showed that market access had a positive and significant impact on the use of fertilizers, agrochemicals, and high-yielding seeds. Also, Market access facilitates social interactions and collective action among farmers, leading to shared learning and implementation of DMS.

Proximity to markets often leads to the formation of cooperatives and farmer associations, which can play a critical role in promoting and facilitating the adoption of drought mitigation practices. This is in agreement with Maddison (2006). Markets often serve as hubs for information exchange. Farmers with better market access are more likely to be exposed to new technologies, practices, and innovations in drought mitigation through interactions with other farmers, traders, and extension services. Markets attract government and non-governmental organizations (NGOs) that provide support services, including training, subsidies, and infrastructure development for drought mitigation. Improved market access is often accompanied by better infrastructure (roads, storage facilities), which can reduce post-harvest losses and support the adoption of DMS as opined by Maddison (2006) and Ojo et al., (2021).

Further, a strong positive correlation (0.853, $p<0.003$) is observed between government support and the adoption of DMS. This means that government support, through various forms of assistance, plays a crucial role in encouraging the adoption of DMS. This support can come in different forms, such as financial subsidies, training, provision of resources, and technical assistance as noted by Li (2018). The study, found out that, the government provided the households with seeds, subsidized fertilizer, extension services at a low cost, training and relief food. These services were found to be provided by the government through partnership with NGOs such as KCSAP. However, the households highlighted that the services reached only a small proportion of farmers since they were offered at a distant location and only at a few designated sites. The households that received government support noted that it went way further in helping them mitigate drought.

The study's' findings corroborate what Li (2018) found out that, government initiatives, such as subsidies or technical assistance programs, can play a significant role in promoting the adoption of mitigation strategies. Financial incentives can help reduce the initial investment costs associated with mitigation strategies, making them more accessible to communities. Technical assistance programs can provide valuable knowledge and skills on how to design, install, and maintain mitigation strategies effectively. This agrees with the report by Li (2018), that infrastructure development and drought Mitigation is the role of Government funded research.

The main sources of extension services included the ministry of agriculture and Non-Governmental Organizations. Exceptionally, the results show a strong positive correlation (0.958, $p <0.05$) between contact with extension officers and the adoption of DMS. These findings mirror Njeru et al., (2020). This suggests that access to extension officers who can provide technical guidance, drought information and support is a crucial factor for the success of drought mitigation. Extension officers can play a vital role in educating communities about the benefits of drought mitigation, advising on the most appropriate mitigation strategies for specific local conditions, and troubleshooting any challenges that arise during implementation or maintenance. According to Rogers (2003), access to information through access to extension services significantly helps in embracing mitigation strategies.

The findings presented here highlight the importance of considering institutional factors when designing and implementing rainwater harvesting programs. Land area, market access, government support, and access to extension services all play a role in the adoption of these initiatives. By addressing these institutional factors, policymakers and development agencies can create an enabling environment that promotes the widespread adoption of rainwater harvesting practices, contributing to water security and sustainable agricultural development, particularly in drought-prone regions.

Livelihood diversification is a crucial process that enables individuals to supplement their farm income, achieve financial goals, and prepare for the future. Understanding how institutional factors influence livelihood diversification is essential for creating an environment that supports informed financial decision-making and drought mitigations strategies. Information on Table 11 shows correlation matrix on the relationship between institutional factors and livelihood diversification.

Table 11

Correlation between Institutional Factors and Livelihood Diversification

		Adoption of Livelihood Diversification	Land area	Land tenure	Market access per month	Gov't support	Extension officer contact
Adoption of Livelihood Diversification	Pearson Correlation	1	0.665	-0.026	0.778	0.088	0.824
	Sig. (2-tailed)		0.007	0.565	0.023	0.002	0.004
	N	400	400	400	400	400	400
Land area	Pearson Correlation	0.665	1	-.108*	-0.043	0.009	0.055
	Sig. (2-tailed)	0.007		0.031	0.396	0.853	0.274
	N	400	400	400	400	400	400
Land tenure	Pearson Correlation	-0.026	-.108*	1	-0.041	-0.044	0.004
	Sig. (2-tailed)	0.005	0.031		0.413	0.382	0.941
	N	400	400	400	400	400	400
Market access per month	Pearson Correlation	0.779	-0.043	-0.041	1	-0.029	-0.016
	Sig. (2-tailed)	0.023	0.396	0.413		0.559	0.746
	N	400	400	400	400	400	400
Governmental support	Pearson Correlation	0.088	0.009	-0.044	-0.029	1	0.048
	Sig. (2-tailed)	0.002	0.853	0.382	0.559		0.337
	N	400	400	400	400	400	400
Extension officer contact	Pearson Correlation	0.824	0.055	0.004	-0.016	0.048	1
	Sig. (2-tailed)	0.004	0.274	0.941	0.746	0.337	
	N	400	400	400	400	400	400

A moderately strong positive correlation (0.665, $p < 0.05$) exists between land area and the adoption of livelihood diversification. This may be because, larger land ownership might be associated with greater wealth or income, allowing individuals to have more disposable income to save and invest, facilitating more robust financial planning strategies. Furthermore, land ownership can serve as collateral to secure loans, which can be used for investments or to finance future goals, potentially influencing financial planning practices. It's important to note that the correlation coefficient is not very strong; suggesting that land area is just one factor among many that influence livelihood diversification. Further, the study observed a weak and statistically insignificant negative correlation (-0.026, $p > 0.05$) between land tenure and livelihood diversification.

The study also observed a strong positive correlation (0.778, $p < 0.05$) between market access per month and the adoption of livelihood diversification, suggesting that households with more frequent access to markets are more likely to engage in other off-farm activities. Communities with better market access have greater income-generating opportunities, leading to higher disposable income that can be used for saving and investing, which are central aspects of income diversification. Additionally, frequent market interactions may expose individuals to a wider range of financial products and services, potentially increasing their awareness of the importance of diversifying their income sources.

The data reveals a weak positive correlation (0.088, $p<0.05$) between government support and the adoption of livelihood diversification. This correlation is not statistically significant, suggesting that government initiatives may not have a substantial direct impact on financial planning practices. However, it's important to consider the types of government support provided. While direct financial aid might not necessarily translate into effective income diversification, government programs that promote financial literacy or provide access to affordable financial planning services could have a more significant influence.

The number of contacts officers and income diversification showed a strong positive correlation (0.824, $p < 0.05$) suggesting that access to professional guidance and support plays a crucial role in successful financial planning. Extension officers can equip individuals with the knowledge and skills necessary to set realistic financial goals, create budgets, evaluate financial products, and make informed investment decisions. By providing personalized guidance and addressing specific financial concerns, extension officers can empower individuals to take charge of their financial futures and translate financial planning principles into actionable steps.

Table 12

Correlation between Institutional Factors and the Adoption of Crop Diversification

		Adoption of crop diversification	Land area	Land tenure	Market access per month	Gov't support	Extension officer contact
Adoption of Crop diversification	Pearson Correlation	1	.892	.012	.674	.818	.715
	Sig. (2-tailed)		.006	.002	.002	.000	.001
	N	400	400	400	400	400	400
Land area	Pearson Correlation	.892	1	-.108*	-.043	.009	.055
	Sig. (2-tailed)	.006		.031	.396	.853	.274
	N	400	400	400	400	400	400
Land tenure	Pearson Correlation	-0.012	-.108*	1	-.041	-.044	.004
	Sig. (2-tailed)	.002	.031		.413	.382	.941
	N	400	400	400	400	400	400
Market access per month	Pearson Correlation	.674	-.043	-.041	1	-.029	-.016
	Sig. (2-tailed)	.002	.396	.413		.559	.746
	N	400	400	400	400	400	400
Government support	Pearson Correlation	.818	.009	-.044	-.029	1	.048
	Sig. (2-tailed)	.000	.853	.382	.559		.337
	N	400	400	400	400	400	400
Extension officer contact	Pearson Correlation	.715	.055	.004	-.016	.048	1
	Sig. (2-tailed)	.000	.274	.941	.746	.337	
	N	400	400	400	400	400	400

The study established a strong positive correlation between most institutional factors and the adoption of crop diversification. Land area has the strongest correlation (0.892, $p < 0.05$), followed by government support (0.818, $p < 0.05$) and extension officer contact

(0.715, p <0.05). Interestingly, land tenure shows a weak negative correlation (-0.012, p < 0.05) with crop diversification, suggesting that land ownership status may not be a major influence. Market access on the other hand, was found to have a moderate positive correlation (0.674, p <0.05). According to Nhamachena and Hassan (2008) more frequent market interactions encourage diversification. Overall, these findings highlight the importance of land availability, government initiatives, access to professional guidance, and market connections in promoting the adoption of crop diversification practices.

Table 13

Correlation between Institutional Factors and the Adoption of Drought Tolerant Crops

		Adoption of drought tolerant crops	Land area	Land tenure	Market access per month	Government support	Extension officer contact
Adoption of drought tolerant crops	Pearson Correlation	1	.776	.023	.239	.596	.871
	Sig. (2-tailed)		.014	.000	.021	.028	.008
	N	400	400	400	400	400	400
Land area	Pearson Correlation	.776	1	-.108*	-.043	.009	.055
	Sig. (2-tailed)	.014		.031	.396	.853	.274
	N	400	400	400	400	400	400
Land tenure	Pearson Correlation	.023	-.108*	1	-.041	-.044	.004
	Sig. (2-tailed)	.000	.031		.413	.382	.941
	N	400	400	400	400	400	400
Market access per month	Pearson Correlation	.239	-.043	-.041	1	-.029	-.016
	Sig. (2-tailed)	.021	.396	.413		.559	.746
	N	400	400	400	400	400	400
Government support	Pearson Correlation	.596	.009	-.044	-.029	1	.048
	Sig. (2-tailed)	.028	.853	.382	.559		.337
	N	400	400	400	400	400	400

Extension officer contact	Pearson Correlation	.871	.055	.004	-.016	.048	1
	Sig. (2-tailed)	.008	.274	.941	.746	.337	
	N	400	400	400	400	400	400

Table 13 indicates that, this study found a strong positive correlation (0.776, $p < 0.05$) between land area and the successful implementation of drought tolerant crops, suggesting that larger landholdings facilitate the adoption of drought-resistant varieties. Interestingly, land tenure shows a weak positive correlation (0.023, $p<0.05$), implying that land ownership has a slightly positive but negligible influence. Market access on the other hand, has a relatively low but positive correlation (0.239, $p<0.05$), suggesting that more frequent market interactions play a role in encouraging the use of drought-resistant crops. Government support shows a moderate positive correlation (0.596, $p < 0.05$). In addition, extension officer contact showed a strong positive correlation (0.871, $p < 0.05$). These results indicate the critical role of government initiatives and access to professional guidance in promoting the adoption of drought-resistant crops. The results are similar to what Deressa (2011) found emphasizing on the importance of land availability, government interventions, and extension services in fostering climate-resilient agricultural practices.

4.3 Perception of Effectiveness of DMS and the Adoption of DMS

Perceived effectiveness of DMS may be influential in the adoption of DMS. The study sought to find out the relationship between the perceived effectiveness and the adoption of DMS. The results obtained are represented in Table 14.

Table 14

Correlation between the Perception of Effectiveness of DMS and the Adoption of DMS

	Statistics and the P-value		Rain water harvesting	Crop diversification	Drought tolerant crops	Water saving irrigation	Soil water conservation	Rearing indigenous animals	Agroforestry	Livelihood diversification	Community support network	Climate information
effectiveness perception	Pearson correlation	1	-0.010	-0.004	-0.023	-0.005	-0.017	-0.066	-0.036	-0.041	-0.040	-0.017
	P-value	0.106*	0.008	0.003	0.04	0.07	0.01	0.187	0.470	0.410	0.423	0.034
	N	400	400	400	400	400	400	400	400	400	400	400
Rainwater harvesting	Pearson correlation	-0.010	1	-0.005	0.038	-0.046	0.011	0.003	0.053	-0.058	0.053	0.052
	P-value	0.838		0.926	0.453	0.360	0.828	0.948	0.290	0.246	0.291	0.296
	N	400	400	400	400	400	400	400	400	400	400	400
Crop diversification	Pearson correlation	-0.004	-0.005	1	-0.040	-0.039	0.068	-0.001	0.056	0.016	0.007	-0.002
	P-value	0.943	0.926		0.428	0.431	0.172	0.989	0.265	0.747	0.895	0.963
	N	400	400	400	400	400	400	400	400	400	400	400
Drought tolerant crops	Pearson correlation	-0.023	0.038	-0.040	1	-0.027	0.017	0.065	0.014	-0.008	-0.001	-0.037
	P-value	0.644	0.453	0.428		0.587	0.731	0.198	0.778	0.875	0.979	0.459
	N	400	400	400	400	400	400	400	400	400	400	400
Water saving irrigation	Pearson correlation	-0.005	-0.046	-0.039	-0.027	1	0.012	0.002	-0.001	0.071	-0.004	-.129*
	P-value	0.917	0.360	0.431	0.587		0.814	0.966	0.979	0.158	0.932	0.010
	N	400	400	400	400	400	400	400	400	400	400	400
Soil water conservation	Pearson correlation	-0.017	0.011	0.068	0.017	0.012	1	0.007	0.003	0.010	0.048	0.007
	P-value	0.741	0.828	0.172	0.731	0.814		0.890	0.955	0.840	0.337	0.889
	N	400	400	400	400	400	400	400	400	400	400	400
Indigenous	Pearson	-0.066	0.003	-0.001	0.065	0.002	0.007	1	-0.019	0.035	0.056	0.018

animals	correlation											
	P-value	0.187	0.948	0.989	0.198	0.966	0.890		0.700	0.490	0.263	0.726
	N	400	400	400	400	400	400	400	400	400	400	400
Agroforestry	Pearson correlation	-0.036	0.053	0.056	0.014	-0.001	0.003	-0.019	1	-.114*	-0.050	0.011
	P-value	0.470	0.290	0.265	0.778	0.979	0.955	0.700		0.023	0.315	0.833
	N	400	400	400	400	400	400	400	400	400	400	400
Livelihood diversification	Pearson correlation	-0.041	-0.058	0.016	-0.008	0.071	0.010	0.035	-.114*	1	-0.080	0.035
	P-value	0.410	0.246	0.747	0.875	0.158	0.840	0.490	0.023		0.110	0.483
	N	400	400	400	400	400	400	400	400	400	400	400
Community support networks	Pearson correlation	-0.040	0.053	0.007	-0.001	-0.004	0.048	0.056	-0.050	-0.080	1	-0.074
	P-value	0.423	0.291	0.895	0.979	0.932	0.337	0.263	0.315	0.110		0.142
	N	400	400	400	400	400	400	400	400	400	400	400
Climate information	Pearson correlation	.106	0.052	-0.002	-0.037	-.129*	0.007	0.018	0.011	0.035	-0.074	1
	P-value	0.034	0.296	0.963	0.459	0.010	0.889	0.726	0.833	0.483	0.142	
	N	400	400	400	400	400	400	400	400	400	400	400

The correlation results in the Table 14 offers valuable insights into the relationship between perceived effectiveness of DMS and the adoption of various DMS within Tharaka South. A statistically significant positive correlation (0.106) exists between the perceived effectiveness and the overall adoption of DMS. This suggests that households perceiving a certain strategy effective are more likely to embrace the practice that can help them cope with drought impacts. Crop diversification emerges as the most widely positively perceived strategy (0.943), indicating its importance in drought mitigation. According to the study, crop diversification provided security of yield such that in case of crop failure due to insufficient rains, the farmer was secure with the other types of crops.

Rainwater harvesting (0.838), water-saving irrigation (0.917), planting drought tolerant crops (0.644) and Soil water conservation (0.741) were highly perceived to be effective in drought mitigation. Rainwater harvesting, crop diversification, and water saving irrigation all have high effectiveness ratings, indicating their value in mitigating drought impacts. Soil water conservation practices and planting drought tolerant crops also show positive effectiveness highlighting the importance of maintaining healthy soil for water retention and crop productivity during dry periods. This indicates a strong focus on water conservation and adapting agricultural practices to a drier climate.

However, the effectiveness of these drought mitigation measures face formidable hurdles within the community from a collection of factors, including subpar service delivery by NGOs and government bodies engaged in drought alleviation, as well as challenges stemming from poverty, corruption, resource constraints, ambiguous beneficiary selection criteria and insufficient market access as opined by Makova (2019).This highlights potential areas where further education, resource allocation, or infrastructure development might be needed. These findings agree with the report by UNDP (2013).

Agroforestry (0.470) livelihood diversification (0.410) and community support networks (0.423) show a moderate positive correlation, suggesting that communities recognize the importance of social collaboration in dealing with drought. This could be due to various factors, such as limited access to financial resources or a lack of awareness about income-generating activities that are resilient to drought as opined by Recha *et al*. (2017). Indigenous animals (0.187) and climate information (0.106) have low positive correlations with perceived effectiveness. This indicates that climate information alone is not reliable without the ability to apply the necessary measures to combat drought.

Water-saving irrigation techniques, while lowly adopted, have a high effectiveness rating (0.917), suggesting that promoting their use could significantly improve water management, consequently helping in drought mitigation. The data indicates a weaker link between perceived effectiveness of agroforestry (0.470) and livelihood diversification (0.410) strategies. This may be due to factors beyond just drought, needing further investigation.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The study was designed to achieve three objectives: to establish the intensity of adoption of DMS among households, to establish the determinants of adoption of DMS among households and to assess the perceived effectiveness of DMS among households in Tharaka South Sub- County. The study was guided by diffusion of innovation theory and theory of change. Descriptive survey research design was used to determine the intensity of adoption and evaluate the determinants of adoption and perceived effectiveness of DMS among households in Tharaka South Sub- County

The study found high adoption rates of DMS, including planting drought tolerant crops (89.7%), crop diversification (84.2%), and rainwater harvesting (78.1%). Irrigation, early warning and soil water conservation had low levels of adoption with 15.1%, 10.8% and 6.1% respectively. The study revealed that slightly above half, of the sampled households had adopted five to ten DMS. For the people of Tharaka Nithi, these strategies are crucial in managing water scarcity and improving agricultural resilience. Policymakers should continue to promote and support these practices to enhance local adaptation to climate variability. This supports Sustainable Development Goals (SDG) 13 (Climate Action) by fostering climate resilience and SDGs 1 and 2 (No Poverty and Zero Hunger) by improving agricultural productivity and food security.

The research indicated a strong correlation between the perception of climate change and the adoption of DMS. Farmers in Tharaka South who perceive drought as a significant threat were more likely to implement adaptive measures. This underscores the need for awareness campaigns to educate farmers about climate change. Aligning with SDG 13, these initiatives can enhance community resilience. Additionally, informed farmers can contribute to achieving SDGs 1 and 2 by adopting practices that ensure sustainable livelihoods and food security.

The study revealed that income levels, education levels and household size significantly influence the adoption of adaptation strategies. For Tharaka South households, high income, higher education levels, larger household and better market access facilitate more effective drought mitigation practices. Policymakers should focus on improving market infrastructure and providing financial support to small-scale farmers. This aligns with SDG 1 by reducing poverty through economic opportunities and SDG 2 by enhancing food security through improved agricultural practices.

The findings highlighted the critical role of government support, extension services, and land size in the adoption of mitigation strategies. The correlation coefficients between the adoption of DMS and, land area, market access per month, gross income per month government support and extension officer contact were found to be significant. Effective government policies and active extension officer engagement significantly boost the implementation of these strategies in Tharaka South. Policymakers should enhance support programs to encourage widespread adoption. This supports SDG 13 by promoting adaptive capacities, SDG 1 by securing livelihoods, and SDG 2 by ensuring sustainable food production systems.

The study found that strategies such as rainwater harvesting, irrigation, crop diversification and the use of drought-tolerant crops are perceived as highly effective by households. For the people of Tharaka Nithi, these strategies have proven beneficial in mitigating drought impacts. Though irrigation and soil water conservation had low adoption intensity they were highly perceived as being effective in drought mitigation. Policymakers should focus on scaling up these strategies and providing continuous support. This directly contributes to achieving SDG 13 by enhancing climate resilience, SDG 1 by improving economic stability, and SDG 2 by promoting sustainable agriculture and food security.

In general, the findings emphasize the importance of supporting the adopted DMS that align with global sustainable development goals, ensuring that communities in Tharaka Nithi can thrive amidst changing climatic conditions.

5.2 Conclusions

Based on the study objectives, the study concluded that, planting drought tolerant crops, crop diversification and rain water harvesting, were the most applied strategies to mitigate the impacts of drought. Membership to community-based programmes, irrigation and soil water conservation were the least adopted strategies, yet highly perceived as effective in drought mitigation among households in Tharaka south sub county. Among the determinants of adoption of DMS, gender of the household head, education level, gross income, household size, number of dependants, land area, market access, government support and extension officers' access had statistically significant relationship with adoption of the DMS. Drought perception possesses a noteworthy impact on the adoption of DMS. The association between land tenure and age of the household head with adoption was not statistically significant.

5.3 Recommendations

In order to enhance the adoption of DMS, several targeted interventions are recommended:

i. Providing financial assistance and incentives to poorer households is essential to enable them to adopt effective drought mitigation measures. This could include subsidies for purchasing drought-resistant seeds, irrigation equipment, and other necessary technologies.

ii. Enhancing educational opportunities for farmers can significantly improve their ability to understand and implement advanced agricultural practices. Extension services should focus on providing training and workshops that increase farmers' knowledge and skills in drought mitigation.

iii. Implementing gender-sensitive strategies that leverage the strengths of both male and female-headed households can enhance the overall effectiveness of drought mitigation efforts. This includes ensuring equal access to resources, information, and training for both genders.

iv. Intensifying extension services is crucial for increasing awareness and adoption of DMS. Governments should invest in strengthening these services to ensure timely and effective dissemination of information and support to farmers.

v. Encouraging farmers to participate in community organizations and social networks can foster a supportive environment for sharing knowledge and experiences. These platforms can serve as valuable forums for discussing and promoting effective drought mitigation practices.
vi. Developing better market infrastructure and access can help farmers sell their produce at fair prices, thus increasing their financial capacity to invest in drought mitigation measures. Ensuring timely access to markets for inputs and outputs is critical.
vii. Efforts should be made to enhance farmers' perceptions of drought and its impacts through awareness campaigns and education. Positive perceptions can motivate farmers to adopt multiple and effective drought mitigation measures.
viii. Developing and implementing comprehensive national and local policies focused on drought risk reduction and preparedness can significantly improve resilience. These policies should integrate financial, educational, institutional, and perceptual factors to address the diverse needs of farmers.

5.4 Suggestions for Further Research

The study makes the following suggestions for further study:

i. Effectiveness of community participation in drought mitigation programs in Tharaka South Sub- County, Kenya
ii. Effectiveness of government policies and programs in addressing drought in Tharaka South Sub County Kenya
iii. The influence of drought mitigation measures on food security among farming households in ASALs.
iv. Challenges facing farming households in the implementation of DMS in ASALs.

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APPENDIX I

LETTER TO THE RESPONDENTS

Dear respondent,

I am a student at Chuka University doing a Master's degree in Geography. I am carrying out research in Tharaka South sub-county, targeting agricultural stakeholder's drought mitigation interventions. The research will involve agricultural stakeholder's answering questions based on their opinions regarding the drought mitigation interventions in Tharaka South. Their opinions will be of importance in this research endeavour. I wish to assure you that you will not be subjected to any strenuous exercise and a provision will be given to those who may not wish to be involved. The findings will be confidential and will be used only for the purpose of this research. I wish to get responses through a questionnaire and your opinions, will be highly appreciated.
I kindly request you to take part in the research.

Thankyou.
Yours sincerely

Mary Mukami

APPENDIX II
HOUSEHOLD HEADS' QUESTIONNAIRE

Serial No……….

The goal of this survey is to get feedback from household heads. Your name doesn't need to be written anywhere. Your information will only be used for this study's purposes and will be kept **private**. Answering **honestly** and **completely** is requested.

SECTION A: ADOPTION OF DMS

1.Have you adopted any strategy to mitigate drought impacts?

adopted [ ]   Not adopted [ ]

2 If you have adopted any strategy information on the table below shows the various DMS. Please tick appropriately the strategies that you have employed in your household.

DMS	**Adoption status**	
	Yes	No.
Rainwater harvesting:		
Crop diversification:		
Use of drought-resistant crop varieties:		
Water-saving irrigation techniques:		
Soil conservation practices:		
Rearing of indigenous animals:		
Agroforestry		
Livelihood diversification:		
Community support networks:		
Climate information and early warning systems:		
Others (specify)		

3. Which NGOs support household's drought mitigation efforts in this Sub- County?

……………………………………………………………………………………………

4. State how the above-named NGOs have supported households’ efforts to mitigate drought

5. Which crop types do you grow? (specify)..

6. Where do you get seeds from?..

7.How do you obtain information on Drought Mitigation Intervention Strategies?.

- Extension agents
- Print media
- Internet
- Television
- Radio
- From fellow farmer

8.Which challenges do you face when adopting DMS?

....

SECTION C: DETERMINANTS OF ADOPTION OF DMS

Socioeconomic Determinants

Please tick where applicable

1. What is your age bracket

A. Below 20 years [ ]

B. 21 to 40 years [ ]

C. 41 to 60 years [ ]

D. Above 60 years [ ]

2. Please tick your gender

Male [ ]

Female [ ]

3. What is your highest Level of education

A. No formal education [ ]

B. Primary education [ ]

C. Secondary education [ ]

D. Tertiary education [ ]

How many members are dwell in this household ?..........................

4. How many members are dependent on the household income?.........................

5. What is the main Source(s) of Income for the Household…………………………

6. On average, how much income do you get per year (in KShs.) from agriculture?

- 1-25,000
- 26,000-50,000
- 51,000-75,000
- 75,000-100,000
- Over 100,000

7. Do you have access to credit facilities? Yes…… No…….

8. If yes, through what channels do you access credit facilities?

………………………………………………………………………………………………

9. How many times have you accessed credit facilities in the last one year?

………………………………………………………………………………………………

10. How much credit were you able to access?...

11. For what reasons did you access the credit facility(s)?

………………………………………………………………………………………………

Institutional Determinants

1. What is the total area of your land ………………..acres.

2. what is the type of your land tenure:

   A. Own purchased [ ]
   B. Inherited [ ]
   C. Hired [ ]
   D. Communal [ ]
   E. Government [ ]

3. For how long have you practised agriculture on this farm?........................

4. Which is your nearest produce and inputs market?

………………………………………………………………………………………………

5. How many times do you access the market(s) per month?

……………………………………………………………………………………………..

6. How many times have you contacted with extension officers in the last one year?

Mode of contact	Number of contacts
Was visited by an extension officer	
Successfully visited extension office	
Attended an extension training meeting	

7.Were the extension services offered by the;

Government ministry [ ]

NGOs [ ]

8. In which ways does the government support households' drought mitigation efforts?

…………………………………………………………………………………………

9. Which other means do you access agricultural information?

…………………………………………………………………………………………

10. Are you a member of any (CBO) that deals with drought mitigation?

Yes [ ] No [ ] If yes, how many CBOs do you belong to?....................................

11. what issues does the CBO deal with?

…………………………………………………………………………………………

Climate change perception

1.Have you perceived any changes in local climate patterns in the recent past?

changed [ ] Not changed [ ] If yes, in what way has the climate changed?

………………………………………………………………………………………..

2. How would you gauge the change in climate?

Greatly changed [ ] Changed [ ] Not changed [ ]

3. What have been the impacts of this climate change on your livelihoods?

…………………………………………………………………………………………

SECTION D: PERCEPTION ON THE EFFECTIVENESS OF DMS

1. The following statement relate to Drought Mitigation Intervention Strategies. Indicate the extent to which the statements apply to you. Strongly agree (SA), agree (A), Neutral (N), disagree (DA) and strongly disagree (SDA).

DMS	SA	A	N	DA	SDA
1) Water harvesting has availed water to cope with drought effects.					
2) Crop diversification has reduced the risks of losing the total yields due to drought.					
3) Drought tolerant crops have made farmers to maintain production despite the impacts of drought.					
4) Indigenous animals are adapted to extreme weather conditions that makes them cope with effects of drought.					
5) Agroforestry has helped to conserve soil water hence reducing the effects of drought.					
6) CBOs help to share resources and knowledge on drought mitigation.					
7) Irrigation allows farmers to supplement natural rainfall and ensure that crops receive necessary water for growth.					
8) Diversifying livelihood reduces reliance on a single income source which can be vulnerable to the effects of drought.					
9) Farmers rely on weather focusing information to make decision on DMS.					
10) Soil water conservation such as mulching help to reduce the rate of evaporation.					

2. In your opinion what can be done to promote and boost the effectiveness of these DMS?

APPENDIX III

QUESTIONNAIRES FOR KEY INFORMANTS

1. Name……………………………………………………………………..

2. Please tick your age bracket

   A. Below 20 years [ ]

   B. 21 to 40 years [ ]

   C. 41 to 60 years [ ]

   D. Above 60 years [ ]

3.Pease tick your gender

   Male [ ]

   Female [ ]

4. What are the strategies implemented to mitigate drought in Tharaka South Sub County?

…………………………………………………………………………………………………

5. Which stakeholders, organizations, or institutions are involved in implementing drought mitigation interventions in Tharaka South Sub County?..

6.How do farmers obtain information on Drought Mitigation Intervention Strategies?

7. How are local communities involved in the planning and implementation of these strategies?

…………………………………………………………………………………

8. How would you assess the resilience of communities in Tharaka South Sub County to drought?

…………………………………………………………………………………………………

9. Are there any specific community-based initiatives or practices that contribute to enhancing resilience to drought? Yes ( ) No.( ) Which ones?

10. In your opinion, what additional measures or support could further strengthen community resilience to drought?

…………………………………………………………………………………………………

11. Based on your experience and observations, what recommendations would you make to improve the effectiveness of drought mitigation interventions in Tharaka South Sub County?

……………………………………………………………………………………………

12. Have there been any challenges or limitations encountered in implementing these intervention strategies? If yes, what are they?

…………………………………………………………………………………………

13.The following statement relate to DMS Indicate the extent to which the statements apply to you. Strongly agree (SA), agree (A), Neutral (N), disagree (DA) and strongly disagree (SDA).

DMS	**SA**	**A**	**N**	**DA**	**SDA**
1) Water harvesting has availed water to cope with drought effects.					
2) Crop diversification has reduced the risks of losing the total yields due to drought.					
3) Drought tolerating crops has made farmers to maintain production despite the impacts of drought.					
4) Indigenous animals are adopted to extreme weather conditions that makes them cope with effects of drought.					
5) Agroforestry has helped to conserve soil water hence reducing the effects of drought.					
6) CBOs help to share resources and knowledge on drought mitigation.					
7) Irrigation allows farmers to supplement natural rainfall and ensure that crops receive necessary water for growth.					
8) Diversifying livelihood reduces reliance on a single income source which can be vulnerable to the effects of drought.					
9) Farmers rely on weather focusing information to make decision on DMS.					
10) Soil water conservation such as mulching help to reduce the rate of evaporation.					

14. Is there any additional information or insights you would like to share regarding the effectiveness of intervention strategies for mitigating drought in Tharaka South Sub County?..........

APPENDIX IV

OBSERVATION CHECKLIST

Drought intervention strategies observation checklist (a tick shall indicate a strategy in use while a cross will indicate strategy not in use)

DMS	Used	Not Used
Rainwater harvesting: Collecting and storing rainwater in tanks, ponds, or cisterns during periods of rainfall for later use in irrigation or livestock watering		
Crop diversification: Planting a variety of crops with different water requirements and maturity periods to spread the risk of crop failure during droughts		
Use of drought-tolerant crop varieties: Selecting and planting crop varieties that are more tolerant to drought conditions and require less water for growth		
Water-saving irrigation techniques: Adopting irrigation methods such as drip irrigation or sprinkler irrigation that deliver water directly to the roots of plants, minimizing evaporation and water waste		
Soil conservation practices: Implementing measures such as mulching, contour ploughing, and terracing to reduce soil erosion, improve water retention, and preserve soil moisture		
Rearing of indigenous animals: Adjusting livestock management practices, such as reducing herd size, rotating grazing areas, and providing supplemental feed, to cope with limited forage and water resources		
Livelihood diversification: Engaging in non-agricultural income-generating activities, such as off-farm employment, small-scale businesses, or artisanal work, to supplement household income and reduce reliance on rainfed agriculture		
Community support networks: Participating in community-based organizations, cooperatives, or informal networks for mutual assistance, sharing resources, and accessing information and support during droughts		
Climate information and early warning systems: Utilizing climate information services, weather forecasts, and early warning systems to anticipate drought conditions and take timely adaptive measures to mitigate impacts on crops, livestock, and livelihoods		

APPENDIX V

RESEARCH LICENSE

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