THE EFFECTS OF AGRICULTURAL DROUGHT ON LIVELIHOODS VULNERABILITY IN YATTA SUB- COUNTY OF MACHAKOS COUNTY, KENYA

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DECLARATION

I hereby declare that this research project is my own original work and that it has never been presesented for the award of degree in this or any other institution.

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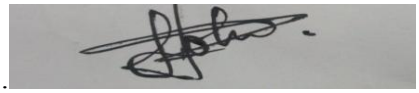
Signature…  Date……13/11/2020….

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DEDICATION

I dedicate this work to my beloved parents Elijah Okindo and Catherine Okindo, to my daughter Natalie , my brothers Nixon, Haron and Calestus, to my siter inlaws Claire and Inviolata for their support & encouragement throughout my study.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ASALs	Arid and Semi-Arid lands
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KNBS	Kenya National Bureau of Statistics
MAM	March, April and May
NACOSTI	National Commission for Science, Technology and Innovation
NDMA	National Drought Management Authority
OND	October, November and December
RAI	Rainfall Anomaly Index
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

ABSTRACT

Agriculture offers livelihoods to about (60%) 3/5 of Africa ‘s active work force, and still contributes 17% to the continent’s (Africa) total gross domestic product that accounts for its 2/5 of the total foreign currency earnings. In that, any long term changes in rainfall patterns and temperature zones shifts will lead to huge negative effects on agriculture, food provision and water availability in Africa. This study looked at the effects of changes in rainfall patterns and temperature variations on vulnerable livelihoods in Yatta. The research objectives of the study were; to determine the temporal and spatial characteristics of agricultural drought, analyze the impacts of agricultural drought on small scale farming and determine coping mechanisms to the effects of recurrent agricultural drought in the study area. The specific area of study was Ikombe ward in Yatta of Machakos County. The research used both secondary (obtained through e- journals and researches, relevant books and existing metrological reports) and primary data (obtained from the field) sources. Methods of data collection involved; Photography, interviews, field observation and questionnaires. A sample size of 100 respondents was selected using Nasurma’s formula from a study population of 34,684 using simple random sampling technique. The collected information was analyzed through descriptive statistics and then summarized using the Statistical Package for Social Science computer software version, rainfall anomaly index (RAI), correlation and regression analysis. The outcome of the analyzed data was presented using tables and graphs. Through the results it was clear that Yatta area’s temperature and rainfall had a negative correlation(r=-0.6) in that a decrease in rain was accessioned by an increase in temperature leading to agricultural drought. The study also established that in a period of five years, Yatta frequently encountered agricultural drought that lasted for 1-2 years thus leading o shuttered and high livelihood vulnerability. Lastly it was established that most farmers in Yatta, had low levels of education that made it difficult for them to be involved in formulation of policies and new coping mechanisms thus increasing vulnerabilities of their livelihoods. The study concluded that agricultural drought occurred in the study area, when the weather conditions were hot and dry thus leading to high temperatures. Subsequently the study recommends that agricultural officers in Yatta should involve the farmers in the area in formulation of easily applicable mechanisms that will help them practice proper dry land farming that will be resistant to agricultural drought thus reduced livelihood vulnerability.

CHAPTER ONE: INTRODUCTION

1.0 Background of the study

Globally, economic damages associated to natural disasters are estimated to be worth USD 80 billion annually, (Carolwicz, 1996; Wilhite, 2000) of which one – fifth of it is caused by droughts. The US Federal Emergency Management Agency (FEMA, 1995) states that; economic, social, and environmental losses associated to drought are on the rise compared to those from others hazards like floods, earthquakes and frosts. Drought is a transient lack of water, which is partly, caused by abnormal climatic conditions that damages an activity, or the environment (Wilhite et al,1985& Goodrich et al 2006).

Droughts has several economic and environmental impacts whose onsets and endings are hard to be determined, thus making this hazard to be the most complex of all other hazards (Below et al 2007). As earlier mentioned, the number of drought victims, is steadily rising worldwide and nationwide, in that over the last decade, these victims on average rose from a total of 1.5 million to 4.5 million people per year (ISDR, 2010). According to National Drought Management Authority (NDMA, 2011) drought leads to shattered livelihoods, hunger, deaths, nutrition-related diseases and migration of communities in search of greener pastures and water, sometimes leads to disagreements between communities.

Arid and semi lands (ASALS) usually experience bad weather conditions such as erratic rainfall that varies from 200mm to 500mm, meaning that periodical droughts are part of their climatic systems (Kandji,2006). This means therefore that, dryness is one of the characteristics of the ASALs, but droughts are sudden reduction in rain water for a certain time, affecting a given area (Warren, A &Khogali, M 1991). According to (Moradi, et al,2011; Joshi, K. 2019 &Khatibi et al 2019) drought becomes a challenge in rural areas when rainfall volumes extremely changes. The horn of Africa has high drought frequencies that sometimes cause conflicts among the arid and semi-arid communities (Balint et al., 2013) who mostly practice small scale farming and livestock keeping as their sources of livelihoods. This makes it hard for the continent to eradicate extreme poverty and food

insecurity thus making it hard to achieve the Millennium Development Goals (MDGs) (Enfors & Gordon 2008; Nyakudya & Stroosnijder 2011).

In the past years, Kenya has experienced a number of droughts episodes, for instance there was the 2008/2009 and 2010/2011 drought that was the most recent and it hit hard the arid and semi-arid regions of the country (Zwaagstra et al., 2010). In the years 1999-2001, drought victims were above 4.4 million in Kenya, while in the Horn of Africa more than 12 million people were affected (OCHA, 2001). Even though Kenya is cut up into half by the equator, it has only a few sections that experience high and regular rainfall (>2000mm), hence making it a drought-prone country. Arid pastoral zones and semi-arid agricultural areas have most of its people engaging in dry land farming and livestock keeping thus this made them to be the most affected by the drought occurrences in the country. In 2006, drought was declared a national tragedy by the Kenyan government since the number of people affected grew from 2.5 million in 22 districts in mid-December 2005, to 3.5 million in 37 districts by mid-January 2006 (IFRC, 2006). It can then be concluded that drought is a major barrier to the social and economic growth worldwide most especially the 3rd worlds like Kenya.

A study by Alam et al, (2011); on geographical investigation of precipitation distribution and its impact on agricultural drought in Barind, Bangladesh, found out that although the region was prone to disasters attack, drought left the area with devastating effects as compared to other disasters. Furthermore, this study was prompted by the fact that there were very few rainfall studies that contribute to the agricultural drought situation in Barind region. When undertaking the study, it utilized spatial analysis of rainfall data for 38 years thus concluding that the western part of the study region was more prone to agricultural drought that other parts of the region.

According to Hillier, (2012), the 2011 famine in the Horn of Africa was the most severe of them all that affected more than 13 million people. Another study by, S.Shukia et al (2000); recurrent agricultural drought forecast system for food –insecure regions of East Africa, using soil moisture posteriori estimates came up with an agricultural drought forecast

system that can be used to provide early warning mechanisms that can enable informed decision making, thus mitigating the severe effects of agricultural drought in an area.

According to Wilhite et al (2000), when drought is considered as a hazard, it is wide and can be classified into different types; agricultural, hydrological, meteorological and socio-economic droughts. Agricultural drought which is the drought of interest for this study is defined as any agricultural impacts resulting from inadequate water supply for agricultural use. It also occurs when the soil moisture of a given area is stressed, leading to great decrease in crop and forage yields thus making it (soil moisture data) an important aspect to monitor agricultural drought than rainfall data though not readily available like the rainfall data that this study utilized to understand agricultural drought. High demand for water, weather condition and soil changes are linked to agricultural drought as this leads to a decrease in levels of ground water reservoirs (Narasimhan, B.& Srinivasan, R. 2005; Vergni & Todisco 2011; Potopova, et al 2015).

In the wake of climate change, seasonal rainfall has become erratic while droughts have become more frequent and severe impacting negatively on rain-fed agriculture thus increasing vulnerability of these livelihoods. It is therefore important to improve the ability of these livelihoods and enable them make accurate drought forecasts within sufficient lead-time (Mwangi et al, 2014). This informed the study gap for this current study, whereby it intended to fill by exploring effects of agricultural drought on small scale farmers (livestock keeping &crop farming) in Yatta, Machakos county.

1.1 Statement of the Problem

According to United Nations Framework Convention on climate change (UNFCCC, 2007) land being a natural resource base where agriculture thrives, so if climate change related effects are not mitigated, they might cause a permanent negative effects on it and yet at this time there is an increasing demand for fundamental human requirements such as food, fiber and energy. This is because, human dependence on agriculturally related livelihoods especially the poor, is high (Slater et al., 2007) and agriculture's gross world output is 24%,

while its land use area is at 40%. When it comes to Africa's work force, it is still agriculture that provides 60% of the livelihoods and contributes 17% to the continent's (Africa) total gross domestic product and accounts for 40% of its foreign currency earnings (Harsch, 2004).

Arid and semi- arid lands ecosystems are fragile due to frequent drought and climate change variability. There is a high dependency on agriculture in ASALs, which is highly vulnerable to all types of droughts thus making this livelihood unsustainable to small scale farmers. This means that any land use activity that is to be undertaken requires careful planning and implementation to avoid exacerbation of this fragility. Long term changes in rainfall designs and temperature zones shifts increases negative effects on agriculture, food provision and water availability (DFID 2004; Kinuthia, 1997). A decline in adequate water supply for agricultural use is one among the many effects brought about by agricultural drought when it hits a given locality. Agricultural sector is highly vulnerable to weather variability meaning that lack of rainfall, high temperatures, little or no soil moisture and inadequate water supply leads to crop and forage failures leading huge agricultural losses (Wheaton et al, 2005).

Also in monitoring and assessing Agricultural drought, one has several indices to choose from such as; normalized difference vegetation index (NDVI), a soil moisture index, heat stress and water balance (Wilhemi et al, 2002). Although there has been tremendous progress aimed at assessing and monitoring droughts through developments of various indices such as; standard contribution of rainfall to runoff (SCRI), standardized precipitation index (SPI) among others, there is still need to help in early forecasting and understanding of agricultural type of drought as this will not only reduce its negative effects on livelihoods but will ensure sustainable agriculture in arid and semi-arid lands. Therefore, understanding the characteristics of agricultural drought, will lead to engaging in suitable mitigation measures to its effects thus reducing or eliminating livelihood vulnerability. This study's aim was to address the effects of agricultural drought on livelihoods vulnerability.

According to Zwaagstra et al., (2010) drought is a primarily recurrent natural disaster in the arid and semi- arid lands in Kenya thus threatening lives of 25% of its population and 50% of the national livestock base. Most residents in Yatta reported to have suffered crop failures, water shortages, frequent droughts that has led to most households relying on relief foods (LTI, 2007). Charcoal burning, sand harvesting, poultry farming, rabbit keeping and boda boda transport are some of the off- agricultural livelihoods that Yatta residents engage in. Regardless of these other sources of livelihoods not directly dependent on rainfall to thrive, the frequent droughts in the area haven't spared them. Residents report that due to crop failure that is as a result of drought makes it hard for them to purchase chicken feeds due to lack of funds that they get from sell of farm produce thus making hard for them to practice poultry farming as alternative source of livelihood. On the other hand, rabbit keepers suffer too in that, persistent drought makes it hard for weeds that rabbits eat to grow, thus leading to death due to starvation or even very little returns when sold. This has left Yatta residents with food shortages, unsustainable and vulnerable livelihoods to recurrent droughts

1.2 Research Questions

To achieve the laid out objectives the following questions guided the study:

1. What are the temporal and spatial characteristics of drought that is experienced in Yatta, sub- county of Machakos County?
2. To what extent are livelihoods vulnerable to drought in Yatta?
3. What coping mechanisms are there to mitigate effects of agricultural drought in Yatta?

1.3 Research objective

General objective

The general objective of this study was to examine the effects of agricultural drought on rain-dependent livelihoods in Yatta, Machakos County.

Specific objectives

The specific objectives of the study are:

- To determine the temporal and spatial characteristics of agricultural drought in Yatta,Ss Sub -county of Machakos
- To analyze the impacts of agricultural drought on small scale farming in Yatta
- To determine coping mechanisms to the effects of recurrent agricultural drought in Yatta

1.4 Justification of the study

This study aimed at exploring the nature of agricultural drought by looking at its spatial and temporal characteristics and how this affects small scale agriculture in Yatta leading to food insecurity and livelihood vulnerability. Furthermore, the various coping mechanisms that are employed by the farmers to try and mitigate the negative impacts of Agricultural drought in the study area. Finally, the study analyzed the various effects that agricultural drought brought to small scale farmers in Yatta.

The information from this study will provide information on the various impacts and negative effects associated to agricultural drought in arid and semi-arid lands that will later assist in early drought forecasting leading to implementation of beforehand mitigation measures that are geared towards reducing or elimination of agricultural losses, food insecurity and increased livelihood vulnerability, because if it is not addressed will lead to abject poverty.

1.5 Scope and Limitations of the study

This study limited itself to determine the effects of agricultural drought on livelihood vulnerability and was restricted to a randomly selected farming population in Yatta, Ikombe ward. The study focused on the effects that the farmers experienced in their farms not forgetting their livestock that were associated with hydrological drought that affects water availability and forage, the analysis of the coping mechanisms employed to mitigate

the effects and the various ways to reduce agricultural drought livelihoods vulnerabilities. The study's scope was guided by its questions and objectives.

1.6 Operational definitions

Vulnerability-Is the degree to which rain- fed agriculture is damaged due to exposure to drought and its inability to bounce back due to poor economic status of a given household

Livelihood-is any rainfall- dependent activity or activities carried out by a specific household on its farm in order to meet the household's food and economic needs.

Agricultural Drought-Is a prolonged period (more than a month) of dryness i.e high temperatures and low or no rain that can support any rain- fed agriculture in a given locality during planting season.

Small scale farmers- a person or people engaging in any rain-fed activity and livestock keeping in a small scale.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter explores both empirical and theoretical studies which formed the core of identifying, describing and explaining, the effects of agricultural drought on livelihood vulnerabilities in arid and semi-arid ecosystems. Empirical studies include review of various research in agricultural drought while the theoretical part of this chapter includes; global concept of drought, the arid and semi –arid ecosystem, monitoring, analyzing of agricultural drought and its role in livelihood vulnerability.

2.1 Drought Hazard

Drought is a complex phenomenon that has devastating effects when it affects a region, moreover it lasts longer compared to other natural hazards such as floods, frosts, landslides, hurricanes and earthquakes (Nafarzadegan et al, 2012). Drought are a regular occurrence in many parts of the world impacts negatively and gravely on water – dependent sectors such as rain fed agriculture thus making it difficult to meet their water and food demands (Karami, S.A & Keshavarz, M. 2010; FAO, 2011). Despite drought 's having a confusing definition, Onyango, Ngania et al, (2014), classifies it into four types depending on the sector involved – hydrological, agricultural, socio-economic and meteorological droughts. Whereby, **meteorological drought** entails a decrease in rain for a specified session, below an accepted statistical quantity of the long-term average for a certain time period. Its definition involves only precipitation statistics (Wambua et al., 2014).

Agricultural drought; it is drought that is experienced when moisture level in soil is inadequate to support average crop yields (Huang, .et al 2015).

Hydrological drought; occurs where the water in natural and artificial reservoirs drop below a specific threshold in a certain period of time, thus resulting to decrease in the normal river flows, ground water levels (streams, rivers, lakes, aquifers) and stored water reservoirs. The impact of this type of drought is on water reservoirs which tends to manifest at a slow pace since it involves stored water which is used with minimal recharge (Sheffield et al., 2012).

Socio-economic drought; this is a type of the drought that affects human activities indirectly or directly, thus relating to meteorological anomaly that is outside the normal range of issues considered by private and public administrative bodies in money making resolutions, whereby manufacturing and larger economy is affected.

2.1.1 Associated Impacts of drought

Among the natural disasters affecting the South African economy, drought is among the leading disastrous. This is due to the fact that, its effects target the social, and environmental sections of the economy (Buckland, Eele and Mugwara, 2000). A report by the United Nations Development Programme (UNDP) shows that regardless of drought affecting a large number of individuals, most them find it hard to understand it due to its high level of complexity as compared to other natural hazards (UNSO, 1999). Drought has overspreading impacts on a household economy and that of a nation. Decreased agricultural production, processing of water intensive nonagricultural products, hydroelectric energy production and household water availability thus leading to serious health repercussions, are among the first hand impacts of drought. On the other hand, the low industrial output, high inflation rates, mass layoffs of workers leading to high rates of unemployment are secondary effects of droughts thus in the end low demand on products, expenditure, savings and gross domestic product (Vogel, Laing and Monnik 1999). Many sectors of most economies are affected by drought because in most them water is used as a key raw material in the production of goods and service provision

2.1.2 Drought in Kenya

The topography of Kenya, is in a way that a combination of the location of its Rift Valley and its climatic conditions has forced a large section of the population to live in disaster prone areas. Dryland ecosystems is home to 11 million citizens because they constitute to 80% of the total land mass and 70 % of the country's national livestock herd. Arid and semi-arid lands despite covering a higher percentage of the landmass are highly prone to recurrent droughts thus leading to an increased vulnerability of these populations living there. High population growth and reduced land carrying capacity in arid and semi-arid lands has resulted to high pastoralist vulnerability which is closely related to livestock-based livelihoods. (UN, 2004).

According to Ellis (1992&1995) arid and semi- arid lands of Turkana and Maasai (200-700mm of rain per year), experience frequently one –year droughts than multiyear droughts forcing 20% of population to migrate temporarily in search of water and pasture for livestock. Apparently, the single–year droughts do not cause livestock mortality. Agriculture is the main sector of the Kenyan economy and its performance strongly influences overall economic performance. Livestock production entails is a manufacturing strategy whereby individuals put up and herd animals as a source livelihood, especially in ASALs. 26% of the national agricultural production comes from arid and semi-arid livestock production while on the other hand it contributes 70% and 75% of Kenya's livestock and wildlife output respectively (GoK, 2005).

2.2 Arid and Semi-Arid Ecosystems

Arid and Semi-arid lands are fragile areas that are known for hunger; due to low food production and famine frequencies despite the fact that a large portion of its population undertakes agriculture. Rising temperatures and periodic droughts have worsened the already fragile situation of the small-scale farmers who depend on rain-fed agriculture for survival. Agriculture's high and direct reliance on climate and in turn high human dependence on agricultural livelihoods especially the poor allows for increased vulnerability in these places (Slater et al., 2007).

Arid and semi- arid ecological zones that have an annual rainfall of between 300mm-600mm (FAO, 1987). These areas have short growing periods of between 1-74 days and 75- 119 days thus makes them unsuitable for farming because of unpredictable rainfall patterns that have huge fluctuations. Recurrent droughts in dryland ecosystems have resulted to high vulnerability levels of most livelihood practiced in the arid and semi-arid lands. Furthermore, this situation has been made worse by climate change and its effects such as livestock diseases, animal and crop pest, limited access to relevant technologies, credit & financial services and lack of connections to agro processing.

However, more focus is put towards livelihood preservation and different sources of income by most families, such that there is limited effort that is being put in place to enable investments in primary social services that are key for human survival. Human activities

such as overgrazing, cultivation of marginal lands, charcoal burning have led to loss of vegetation cover that has in the end caused high soil erosion and desertification in arid and semi – arid lands. (KFSSG,2006).

2.3 Agricultural drought

The immediate and noticeable effect of this type of drought is in the reduction seasonal output of crops and other related production. Its extreme effect is famine, that brings with it associated effects such as long-term food shortage in a restricted region in the long run causing a widespread animal diseases and death due to starvation. Agricultural drought comes about as a result of interactions between of meteorological and hydrological droughts on crop yields. Different plants have specific warmth, moisture and nutritional provisions during their growth periods for them to optimize their growth in that if there is inadequate moisture during the growing period of a crop then it will be affected leading to a decline in its output (Vergni & Todisco 2011). Furthermore, according to Enfors & Gordon, (2008) is more common than meteorological droughts due to factors such as; dry spells, water losses through surface run-offs, drainage of soils and evaporation rates. Whereby, dry spells will occur when there is short period of time i.e few weeks (5- 15 days) which are viewed to be harmful in semi-arid agricultural systems as it is frequent. These insufficient water supply constraints make it hard for small scale agriculture to meet the food and economic demands.

Agricultural drought may also occur due to low or prolonged lack of precipitation (Wilhite and Blintz 1985). The parameters that determine the agricultural drought are: precipitation, evapotranspiration, available soil moisture, moisture requirements of the plants. Consequently, agricultural droughts connect different features of meteorological drought to agricultural production. While it is generally associated with arid and semi-arid climates, this drought can occur in areas that normally enjoy adequate rainfall and moisture levels. This may be the case if the supplied water is inadequate for both plant use and storage. Usually, agricultural drought is characterized by hot and dry, winds which can be followed by damaging floods (Wambua et al., 2014).

2.4 Methods of Determining Agricultural Drought

According to Mutai et al., (2014) agricultural drought is stated as an extended period of low rainfall leading to extensive damage on plants, specifically loss of yields. Therefore, long term rainfall mean of a given region can be used to determine drought characteristics of a given region, especially if its rainfall falls below 75% of the long term rainfall mean then the conditions are termed as drought period. Agricultural drought is the most important drought in arid and semi-arid regions, because it leads to food insecurity as crop yields are directly affected by insufficient soil moisture, Boken (2005). This according to Wilhite, (2005) needs to be addressed through assessing, monitoring and ensure early planning thus help reduce community vulnerability to drought. In order to try and alleviate the expected effects of agricultural drought, decision makers have come up with various indices to monitor this drought on temporal and spatial scales. White and Walcott, (2009) compiled a list of potential agricultural indices such as: Palmer drought severity index index(PDSI), Prescott (ratio) index, Enhanced vegetation index(EVI), Normalized Difference Vegetation Index (NDVI), Standardized Precipitation Index (SPI), Rainfall Anomaly Index (RAI), Standardized Anomaly Index (SAI), Rainfall Decile Index(RDI) among others.

The above mentioned indices have been used in different studies globally and regionally to monitor and determine agricultural drought. Standardized Precipitation Index (SPI) for any location is based on a calculation of the long-term precipitation record for an objective period (3 months, 6 months, going forward). The SPI can produce not only monitoring information index values but also the information of probability, percent of average, and precipitation deficit during drought. (Hayes et al., 2000). The SPI can be calculated for a variety of time scales and for different water variables such as soil moisture, ground water, snow-pack, reservoir, and stream-flow. This feature allows the SPI to monitor both short-term and longer-term water resources. Guttman (1999) pointed out that at least 50 years of data are needed for drought periods of 1 year or less and that SPIs with time scales longer than 24 months may be unreliable. The SPI is used by the Colorado Climate Center, the

Western Regional Climate Center, and the National Drought Mitigation Center of the United States to monitor drought conditions.

A study by Onyango, (2014); analysis of meteorological drought in north eastern province, Kenya used the SPI index in calculating and quantifying precipitation deficit thus coming up with various drought frequencies in the area. Tourian et al, (2020) conducted a research on unsustainability syndrome-from Meteorological to Agricultural drought in arid and semi-arid regions. In this study they used standardized precipitation index to show the distribution of dry years in the southern and eastern regions of Fars province in Iran. Among the many indices used in a research by Bahareh et al, (2017) on Multilevel Drought Hazard Assessment under climate change scenarios in semi-arid regions used SPI to as one of the methods to analyze drought i.e meteorological drought.

In addition to White and Walcott, (2009) works, a Rainfall Anomaly Index (RAI) was developed by van Rooy (1965) and it entails ranking and assigning magnitudes to both the positive and negative precipitation anomalies. This index is expressed as below;

$$\mathrm{RAI} = \pm 3 \frac{\mathrm{P} - \overline{\mathrm{P}}}{\overline{\overline{\mathrm{E}}} - \overline{\mathrm{P}}}$$

Where P; is the measured precipitation, $\overline{\mathrm{P}}$ is the average precipitation, and ,$\overline{\mathrm{E}}$ is the average of 10^{th} extreme

Whereby for positive anomalies, the prefix is positive and $\overline{\mathrm{E}}$ is the average of the 10 highest precipitation values on record; while on the negative anomalies, the prefix is negative and the 10 lowest measurements are used. Then later this index values are judged against a 9-member classification scheme, ranging from extremely wet to extremely dry (Van Rooy, 1965). This has also been applied in studies on drought analysis and monitoring, they include Kenyatash, & Dracup 2002;(Shiau and Modarres ,1980) used monthly rainfall data to calculate drought index which was to analysis regional drought in Ceara and classified

drought in three cluster Moderate and severe drought (Freitas and Max,2005). The long term mean can be used to determine drought characteristics he showed that if rainfall falls below 75% of the long term then the conditions are termed as drought period. Study done Farmwest used effective precipitation to determine drought since drought start when effective precipitation becomes depressed (Onyango ,2014), 2013) where he this equation to calculate effective precipitation (EP in (mm) = (RAIN - 5) x 0.75.

Rainfall Decile Index (RDI) is achieved by dividing occurrences over a long-term rainfall data. The outcome is grouped into different subsets that are referred to as deciles. The leading subset has of rainfall data of the least being 10%, the second 's subset has 20% being the least and lastly it is in the last group where we find the median whose rainfall data does not exceed 50% of the total record of occurrence over the period of record (Hayes, 2000).

Standardized Anomaly Index(SAI) another tool used measure drought characteristics of a place. According to (Katz and Glantz ,1986) when using it, one needs to change recorded precipitation data of a station into units, obtain deviation numbers from the long term station mean and finally compare the outcome in order to obtain a constant variance value.

2.5 Vulnerability concept

Vulnerability is the degree to which a unit is susceptible to harm due to exposure, stress and its lack of ability to cope, recover from the negative effects, (Kasperson et al. 2000). Cannon, T. 2001, & Cannon et al, (2004), states that vulnerability is about the future not the present i.e. information about it gives a picture of the future condition since it is about linking the present to the future. It can give an indication of what may happen to a given population in situations of particular hazards.

World Food Program, (1996) states that, there is vagueness surrounding the utilization of vulnerable and vulnerability as they are usually associated with the poor and poverty. The term vulnerability, depends extremely on given circumstances, i.e. according to Brooks et al (2005), the very elements that make a structure vulnerable to a hazard and this will depend on the nature of the system and the nature of hazard in place. Vulnerability

reserves, economic strength, and access to resources are key elements of drought-coping ability (Fratkin and Roth 1990, Downing and Bakker 2000). Traditional drought-coping mechanisms of pastoral communities in Africa, that entailed splitting livestock in different categories distributed all over the country under the watch of relatives seem to have become less effective because of changes in socioeconomic and political aspects. Vulnerability contexts are different for different regions, sources, need specific adaptation measures, and support policies.

2.6 Research gaps

Karuri et al, (2019) did a study on the drought coping mechanisms of farmers in Machakos county. Its focus was to evaluate drought coping mechanisms used by farmers in Machakos county leaving out the aspect of the type of drought being experienced and its associated effects. This is due to the fact that small scale farmers need to understand the problem (type of drought) before coming with effective coping mechanisms and as mentioned earlier, agricultural drought is more frequent in arid and semi-arid areas than other types of droughts. Furthermore, agricultural drought leads to insufficient supply of water required by dry –land farming thus there is need to understand it wholly by small scale farmers in order to formulate suitable coping mechanisms and identify its effects in their farms before it attacks their livelihoods. David undertook a study in (2018) on factors affecting Maize yield in Machakos and found out that its production was largely (99%) affected by weather variation especially rainfall among other factors. Weather variations, does not affect only rainfall element alone but also the temperatures and soil moistures of a given locality leading to dryness thus less water for agriculture.

In (2013), Mburu carried out a research on the consequences of climatic changeability on arid and semi-arid agriculture and the coping plans among the small scale farmers in Yatta district, Kenya. The study found out most farmers undertaking dryland farming in Yatta had low knowledge on climate change and variability yet it had huge effects on agriculture. This is due to the fact that climate change and variability is that it is a global phenomenon whose effects are felt locally. A comparison between climate change and variability and

agricultural drought characteristics, finds that agricultural drought is easily understood as farmers relate well with what the experience in their day to day life. Agricultural drought effects are not farfetched from those that are caused by drought and since Yatta experiences drought frequently it will be easier for them to understand and help mitigate its effects and reduce agricultural loss. It was easier to start with known to unknown i.e. from agricultural drought to climate change.

The current study on the effects of agricultural drought on livelihood vulnerability in Ikombe, Yatta sub-county was meant to fill these gaps that emanated to the reviewed literature. Such as the need to understand the nature of agricultural drought and its effects on Dry land farming which is the main source of livelihood in arid and semi-arid lands.

2.7 Theoretical framework

This study was informed by the capability theory (Sen., 1999). This theory focuses on conditions necessary for people to lead functional lives. According to Sen, starvation is faced by a person if they are unable to access food despite it being available to all those who can afford it because drought and famine affect people and places differently depending on the ability of a given household's ability to acquire food in time of crisis so does vulnerability (Sen 1989, 1999). Sens theory on entitlement insists on the need to finalize arrangements in spatial terms, and how the said arrangements impacts the overall occurrence of a human being. Nussbaum, (2011), questions whether the ability to lead fully functional life is with people, in the capability approach. The components of such lifestyle includes among others; natural systems that depend on a firm climatic system. The baseline is there is need to secure the basic critical elements that allow full functioning of human life such as adaptation strategies and a deep understanding of the environment.

Drought cripples a human's ability to use a given resource such as land, water that they have. A case where drought affects livelihood practices, and destroys an area's infrastructure, then a person's functioning will be limited. In that case, climate change related effects such as drought will interfere completely with the proper functioning of people's lives (Schlosberg, 2009).

The most important aspect of the capability approach is that it calls for involvement of communities themselves in defining and designing various adaptation policies that are meant to protect them and their vulnerable livelihoods against hazards that jeopardize their functioning ability (Schloberg, 2009; Ribot, 2000). In conclusion, this theory emphasizes the need to analyze specific community needs that hinder them from being able to adapt to the effects of drought and come out empowered and strong to drought and measuring the success of implemented adaptation policies.

2.8 Conceptual Framework

The study focus was on the effects of agricultural drought on livelihood vulnerability in Yatta especially on small scale farmers. Informed by capability approach, agricultural drought leads to reduced soil moisture that affects crop and animal forage which leads to low production yields and huge loses to the farmers thus highly vulnerable. On the other hand, depending on the farmer's ability to engage in irrigation, access to drought resistant crops and animals he /she will be able to reduce the impacts of agricultural drought thus high production yields and reduced loses thus less vulnerable.

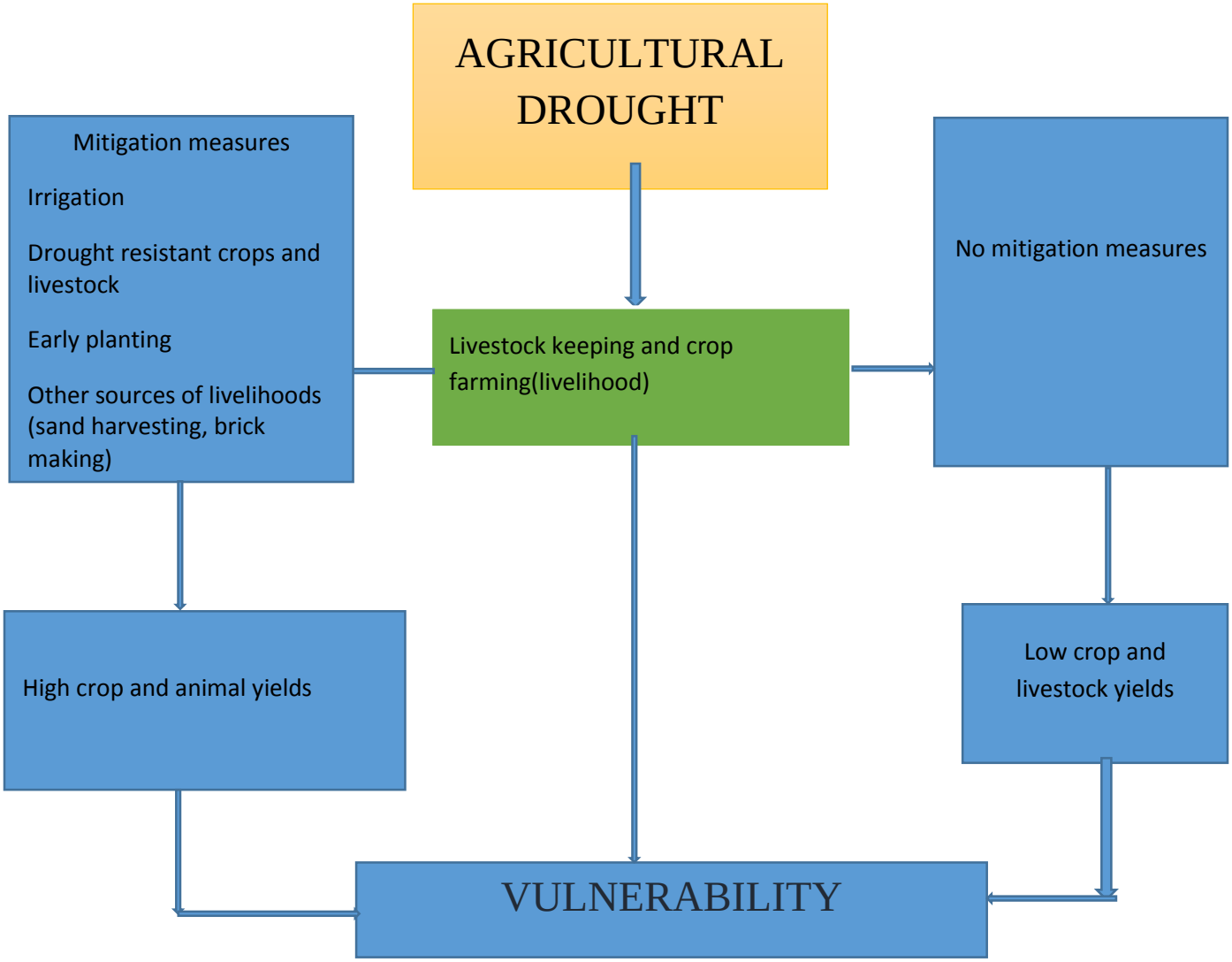

Figure 1: Conceptual Framework

Source; Researcher Design, 2019

CHAPTER THREE: STUDY AREA AND METHODOLOGY

3.1 Study area

3.1.1 Location and size

This study was conducted in Yatta sub-county of Machakos county which is located between latitudes $1°37'$ & $1°45'$ S and longitudes $37°15'$ & $37°23'$ E. This sub county has further been sub- divided into five wards; Katangi, Ikombe, Ndalani, Kithimani and Matuu. Yatta sits on total area of 2469.1 square Kilometers (Republic of Kenya, 2009).

3.1.2 Climatic Conditions, Topography and Livelihoods

Yatta sub-county has an average annual rainfall of 450-800mm which is a bimodal rainfall pattern thus making the area a semi-arid region. The bimodal rainfall pattern starts in March to May(MAM) while the second season starts in October to December(OND).The average annual temperatures ranges between 25-29 ℃ (Republic of Kenya , 2009). This makes the area prone to agricultural droughts thus making rain fed agriculture to be highly unreliable and of low crop and animal yields due to high evaporation rates leaving the soils dry. According to (GOK 2012), Yatta has ecological zones which have short to medium cropping seasons thus forcing farmers to rely on few drought resistant crops such as; cowpeas, green grams, maize, millet, sorghum, pigeon peas, onions, tomatoes and mangoes.

Barber et al., (1981; USDA, 1978;) states that, Yatta area has Lithisols, Rhodic Ferralsols, Ferric Luvisols and Acrisols as its main soil types that are highly erodible and of low

fertility thus making dry bush at its main natural vegetation type and highly prone to frequent droughts.

Small scale mixed farming (crops, livestock and poultry) is the main source of livelihoods in Yatta by most farmers among other livelihoods such as sand harvesting, basket weaving, brick making, water purification just to mention a few Macharia, (2010).

Yatta sub -county was chosen because the area is one of the arid and semi-arid areas of Kenya that experiences frequent droughts due to erratic rainfall thus leading to low crop and livestock yields. This makes it hard for the area to be food secure and its livelihoods especially small scale farming (Yatta Development Plan 2008-2012). Furthermore, the study area was easily accessible to the researcher and since it has frequent droughts it was

suitable for undertaking a study on the effects of agricultural drought on livelihoods vulnerability.

IKOMBE WARD WITHIN YATTA SUB-COUNTY MAP

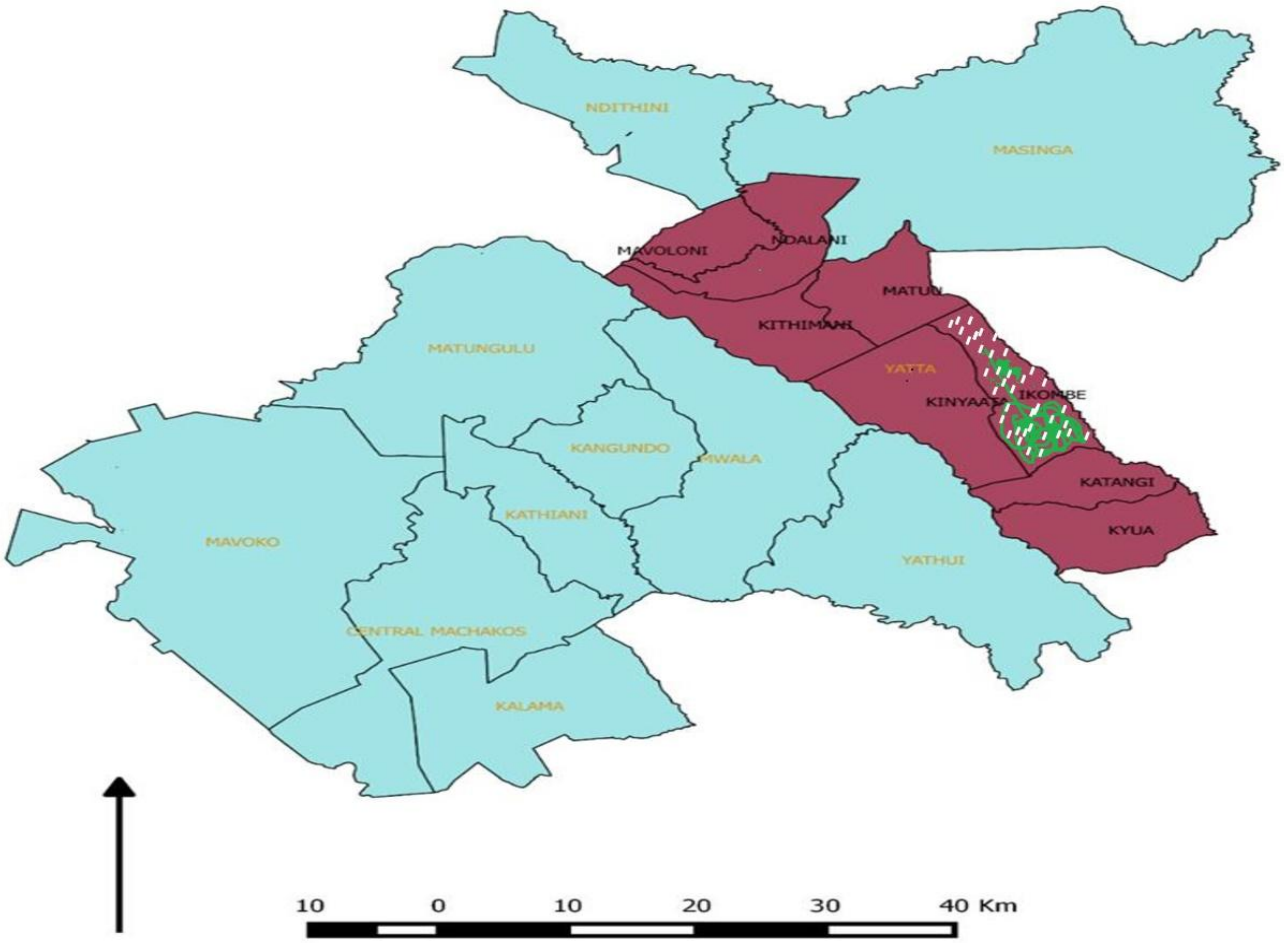

Figure 1: Machakos county map

Source: Machakos County Government (2017)

3.2 Methodology

This section entails descriptions on how the researcher carried out the study through highlighting the research design, targeted population; sampling techniques and sample size; data collection methods and methods of data analysis.

3.3 Research Design

This study used a mixed method research, an approach used in collection and analysis of "mixed' quantitative and qualitative data in a single study (Crewell and Clark 2011). The approach involved collection, merging, integration or linking of two types of data (qualitative and quantitative) obtained from respondents. Quantitative and qualitative data was collected from the field using questionnaires, photography and interview schedules. Integration of both quantitative and qualitative data helped the researcher to get the breadth and in- depth of the study and eliminated the weaknesses that were inherent in one method. The design involved the collection and analysis of quantitative data on effects of agricultural drought on livelihoods vulnerability in Yatta, Machakos County after which qualitative data was used to explain results in depth (Houtz, 1995). This approach was appropriate as it enabled quantitative data to provide a general picture of the reality while qualitative data helped to refine or explain the study. The design attempted to establish nature and extent of cause-and-effect relationship between independent (agricultural drought) and dependent variables (small scale farming).

The researcher conducted prior visit to the ward before the actual data collection exercise in order to familiarize herself with the study area and make prior appointments with local authority, county agricultural officials and the farmers. This was in important as allowed the researcher to create a rapport with the locals, enabled the research assistants to go through the questionnaires and how to undertake the actual data collection exercise beforehand. Both qualitative and quantitative data were collected using various data collection methods such as; photography, filling in of questionnaires, interviews and direct observations. These data were later analyzed in line with the study objectives.

3.3 Study's Population

All farmers in Ikombe ward, Yatta Sub County, Machakos County were part of this study's sampling frame. Ikombe ward has an area of 33140km^2 and an estimated total population of 34, 684 people (KNBS 2009). The ward's total population was targeted by this study including the county's agricultural and environmental officers who were key informants.

3.4 Sampling strategy

The study used stratified sampling in that the study population was divided into two groups i.e. males and females' farmers who were interrogated on their personal encounter with agricultural droughts in their farms.

Random sampling was used per group, where a unit of the sample was selected at random while the rest of the sample units were chosen at even intervals until the desired number of units was obtained. This technique was preferred to ensure that each member of the target population had equal and independent chance of being included to produce unbiased sample of study. Moreover, the population under study, was homogeneous so a sample of 100 respondents was still a representation as increasing the sample size did not imply different results.

· The 100 respondents were obtained from a total population of 34684 using the Nasuirma model explained below.

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

C_v = Coefficient of variable (0.5)

N = Population target, in this case 34684 (KNBS 2009)

e = Tolerance at desired level of confidence (0.05)

n = sample size

$$n = \frac{34684 \times (0.5)^2}{(0.5)^2 + (34684 - 1)0.05^2}$$

$$n = 99.71 \approx 100$$

3.5 Nature and sources of data

This study relied on both secondary and primary data, whereby primary data was obtained from the study area through the questionnaires, photography and observation. Secondary data was from published materials on the topic. Quantitative data such as the number of

livestock in a household farm, coping mechanism to agricultural drought was collected through observation and interviews methods.

The rainfall and temperature data of Machakos metrological station was fed in excel where through different parameters were calculated. These parameters included; monthly and annual mean, range, the years with highest and lowest rainfall amounts and temperatures. These results were presented in tables and graphs. These parameters were calculated as below:

- ✓ **Mean** was calculated using the equation below

$$\bar{x} = \sum_{n}^{i} x/N \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where $\bar{x}$ is mean rainfall

X is the monthly rainfall

N is the months

i is the starting month

n is the last month

The calculated mean was plotted together with the long term monthly mean of the study area in order to compare the two curves with an aim of getting the departure from each other. This was used to determine the start of agricultural drought during rainy season (fig 5). Since according to (IPCC, 2014) agricultural drought start when rainfall falling below the long term mean mark.

On the other hand, monthly rainfall for Ikombe was clustered into two seasons namely; March, April, May (MAM) and October November, December (OND). The two graphs were drawn for each season and in order to visualize the rainfall behavior of the three months in the area. This gave specific characteristics of both seasons in terms of onset and cessation of rainfall in the study area (fig 6).

- ✓ **Rainfall anomaly Index** (RAI) was calculated using Van Rooy equation (1965) below;

$$RAI = 3\ \frac{P-\bar{P}}{\bar{M}-\bar{p}}$$ for the positive……..**2**

Where: $\bar{M}$ is the mean of ten highest precipitations.

P is specific precipitation

$\bar{p}$ is mean annual precipitation

$$RAI = -3\ \frac{P-\bar{P}}{\bar{X}-\bar{p}}$$ for the Negative……**3**

Where; $\bar{X}$ is the mean of ten lowest precipitation values.

- ✓ **The correlation analysis** was done using the Pearson coefficient of correlation (r) to find out whether there was any functional relationship between rainfall and maximum temperature such that what happens to rainfall when temperature was low or high since agricultural drought is understood to be water stress phenomena which could be accessioned by either lack water due to lack of rain or excess temperature (Shiau, 2009).

$$\mathbf{r_{xy}} = \frac{\sum_{i=1}^{n} x_1 y_1 - \frac{(\sum_{i=1}^{n} x_1)(\sum_{i=1}^{n} y_1)}{n}}{\sqrt{\left[\sum_{i=1}^{n} x_1^2 - \frac{(\sum_{i=1}^{n} x_1)^2}{n}\right] \times \left[\sum_{i=1}^{n} y_1^2 - \frac{(\sum_{i=1}^{n} x_1)^2}{n}\right]}} \ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where:

r = Pearson coefficient of correlation

x = independent variable (rainfall)

y = dependent variable (temperature)

n = number of years under study

Also the study sought to test P-value in the study area as this was to help determine whether the correlation between rainfall and maximum temperature was significant. This gave rise to regression analysis with the confidence level being at 95% therefore α =0.05.

Y = ax+b…….5

Using Van Rooy's classification it was possible to categorize the study area's agricultural drought extent for the 38 years. The analysis was able to state how wet or dry each year under study was thus and how it affected agriculture in the study area.

Table 3.1: Classification RAI by Van Rooy (1965)

RAI Classification	Description
≥ 3.00	Extremely wet
2.00 to 2.99	Very wet
1.00 to 1.99	Moderately wet
0.50 to 0.99	Slightly wet
0.49 to –0.49	Near normal
-0.50 to –0.99	Slightly dry
-1.00 to –1.99	Moderately dry
-2.00 to –2.99	Very dry

Secondary data was sourced from desk research on the subject matter, interviews were conducted with agricultural officers on the various coping mechanisms carried out by farmers together with the advices that they give them.

3.5.1 Photography

This method was used to capture the different sources of livelihoods that the farmers in Yatta engaged in such as brick making, basket weaving, poultry farming. Also through this method the study was able to capture some of the coping mechanisms that farmers in Ikombe employed on their farms to counteract the effects of agricultural drought. They included irrigation of crops especially for the farmers along the banks of river Mwitasiano.

3.5.2 Direct observation

The study employed this particular technique in observing some of the effects that were associated with drought on the environment in Yatta and also the various effects of irrigation of crops by use of salty water. Also through direct observation the researcher was able observe the bare farms and canals that farmers dig around their farms to contain and retain water during the rainy seasons.

3.5.3 Questionnaires

This study's questionnaire had varied types of questions i.e (closed and open ended). This method of data collection, was preferred because of its reliability and variability in terms of how the respondents would frame their responses thus reducing biasness and similarity in the answers. But on the other hand capitalizing on anonymous thus leading to collection of reliable and firsthand information and maximizing on large numbers of respondents. The questionnaires were administered to farmers since it is appropriate for them to answer the questionnaires.

3.5.4 Interview schedule

Interview schedules were used to get responses from agricultural officers in the area of study. This method was preferred since it enabled the researcher to obtain detailed information about the feelings, perceptions and opinions of the officers. The interview guide seeked information on effects of drought on the crop and livestock rearing; coping mechanisms that Yatta farmers employ to counteract the effects of drought; environmental impacts of the coping mechanisms to the environment and policies and strategies that should be put in place to mitigate the negative effects of drought to ensure security of farmers' livelihoods.

3.6 Data Analysis

Collected data was analyzed both quantitatively and qualitatively according to the research questions. Quantitative analysis was applied for close ended questions for instance the

effects of agricultural drought observed by farmers on their farms that provided participants with alternative responses from which to choose. Descriptive statistics was used to summarize quantitative data collected from the questionnaires. All the quantitative data was analyzed using the Statistical Package for Social Science (SPSS) computer software version 20, thereafter frequency distributions and percentages were computed and presented in tables and graphs.

The qualitative data obtained, underwent thematic analysis, discussions then later editing and coding, narration of the respondent's views, suggestions and encounter with drought e.g. policies on reduction of agricultural vulnerability in arid and semi-arid areas. The study obtained rainfall and temperature data for Machakos metrological station from the Kenya Metrological department headquarters. This data was in monthly form where rainfall 38 years (1980-2018) and maximum temperatures 34 years (1980 - 2014).

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings from the analysis of the data collection. The chapter also presents the interpretation of the results of analysis in relation to the effect of drought on livelihood vulnerability in Yatta, Machakos County, Kenya.

4.1.1 Response rate

The target population of this study comprised of 100 farmers from Yatta Sub- County, Machakos County. Out of the sampled population there were 93 completed questionnaires from the respondents while 7 of them were returned unfilled. The response rate is presented as in table 4.1.

Table 4.1: Response Rate

Response	Frequency	Percentage
Response	93	93
Non response	7	7
Total	100	100

From the values in Table 4.1, it can be observed that the response rate was 93% and according to Mugenda and Mugenda (2003) a response rate above 50.0% can adequately be used in establishing the research objectives and answering research questions.

4.1.2 Demographic characteristics

Demographic information was sought from the respondents in order to understand their characteristics. The responses from respondents are presented below.

4.1.2.1 Gender of participants.

The study sought to determine the gender of respondents who participated in the study. The results are presented in Table 4.2 below.

Table 4.2: Gender of the Respondents

Gender	Frequency	Percentage
Males	37	40
Females	56	60
Total	93	100

Source; field data 2019

The findings in the Table 4.2 show that majority of respondents were female (60%). This can be attributed to the fact that men migrate to take up paid work in urban areas.

4.1.2.2 Age of participants

The study sought to find out the age of participants. The response data is recorded in the table 4.3 below

Table 4.3: Age of Participants

Age bracket	Frequency	Percentage
15-24 years	12	13
25-35 years	25	27
36-45 years	37	40
46-55 years	14	15
55 and above	5	5

Source; field data 2019

The findings in the table 4.3 shows that a total of 81 (80%) of participants are aged 25years and above which is a likely indication that they are experienced enough with their environmental conditions in Yatta Sub County. There is also a large population of household below 50 years and such a population is likely to be more willing to access information on effects of drought on livelihoods.

4.1.3 Education level

The study also sought to find out the education level of respondents. The findings were indicated as follows.

Table 4.4: Education level of the respondents

Level	Frequency	Percentage
Primary	24	26
Secondary	34	37
College	19	20
University	16	17
Total	93	100

Source; field data 2019

The results show that most of the respondents 37% (34) had secondary education, 26% (24) had primary education; 20% (19) had college education while 17% (16) had completed university level. The findings above clearly indicate that a big percentage of the population (74%) has attained at least secondary level of education which means they are well suited enough to acquire information on effects of drought on livelihoods as well as applying suitable coping mechanisms.

4.1.4 Farm characteristics

4.1.4.1 Farm sizes

The study sought to find out the farm sizes that each household own. The results are presented in table 4.5 below. From the findings, majority (68%) of households had between

1-3 acres of land; 22% had between 4-6 acres while only 10% had farm sizes of 6 acres and above. The findings indicate that majority of farmers had smaller acreage of farms.

Table 4.5: Household farm sizes

Farm size	Frequency	Percentage
1-3	63	68
4-6	20	22
6 and above	6	6
Over 10 acres	4	4
Total	93	100

Source; field data 2019

4.1.4.2 Farm size under crop cultivation and livestock keeping

Table 4.6 below indicates respondents' farm sizes under crop cultivation and livestock keeping. From the findings, it is clear that most of the respondents as shown by 65.6% had farm sizes between 1-3 acres under crop cultivation and livestock keeping; 22.6% had less than 1 acre; 7.5 % had between 5-6 acres while only 1.1% had acreage of 10 acres and above. These findings indicate that majority of farmers had relatively small sizes of farms to practice both crop cultivation and livestock keeping on large scale to act as a cushion against effects of drought.

Table 4.6: Farm sizes under crop cultivation and livestock keeping

Farm size	Frequency	Percentage
Less than 1acre	21	22.6
1-3	61	65.6
4-6	7	7.5
7-9	3	3.2
10 and above	1	1.1

Source; field data 2019

4.2 The temporal and spatial characteristics of agricultural drought in Yatta, Machakos County

In addressing objective **one** of the study, the following results are discussed;

4.2.1 Rainfall analysis (1980-2018)

This monthly rainfall data for 38 years was obtained from Machakos weather station, from it this study found out that, the study area had a mean annual rainfall of 666.3 mm indicating that Yatta is a semi-arid region with an annual rainfall of below 700mm, (GOK, 2000). In the year 1998 the region recorded the highest amount of rainfall of about 1110.2 mm which was associated with the EL Nino rains that the country experienced at that time (GOK, 2002). On the other hand, year 1987 recorded the lowest amount of rainfall of 334mm thus these fluctuations in rainfall led to the area experiencing the worst agricultural drought, (GOK, 2017) as illustrated in figure 2 below

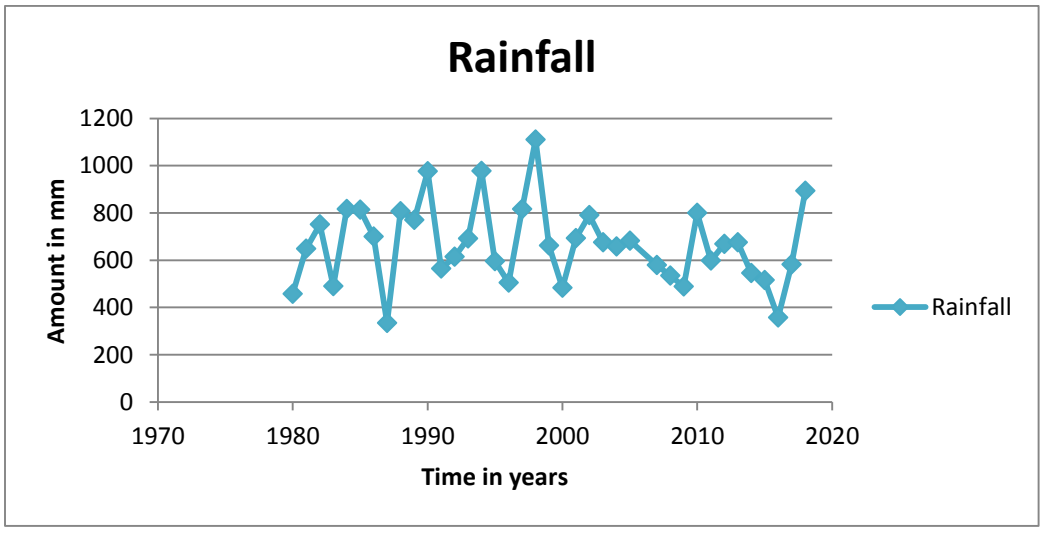

Figure 3: Machakos annual rainfall from 1980 to 2018

4.2.2 Mean Maximum Temperature analysis (1980- 2014)

When analyzing maximum temperature of the area for 34 years, the study found out that the area had a mean temperature of 25.2 ^{0}c, whereby 24.1 ^{0}c was the study areas' lowest maximum temperature recorded in the year 1989 and in 2011 it recorded its highest temperature of 26.1^{0}c. See figure 2 below

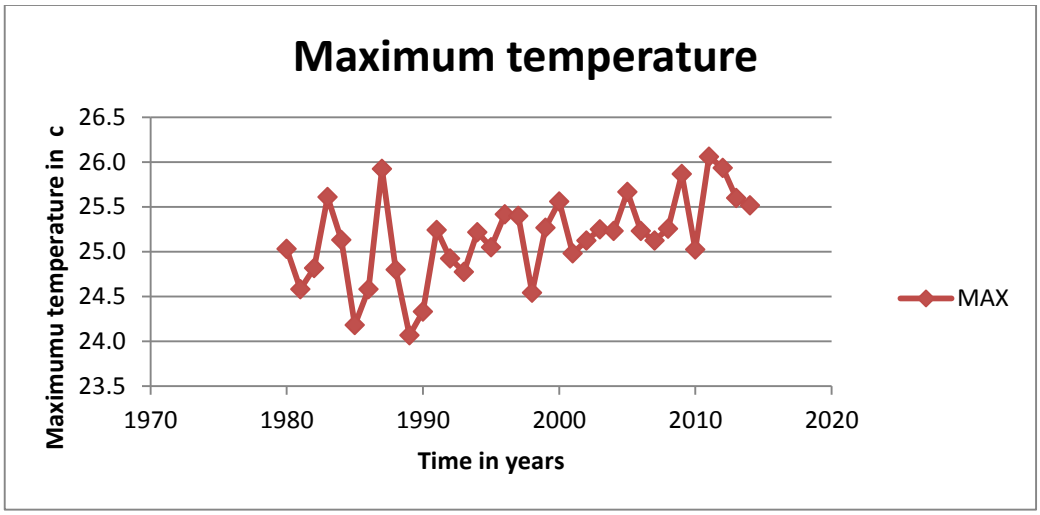

Figure 4: Maximum temperature from Machakos station 1980 to 2014

4.2.3 Long term monthly mean rainfall and monthly mean rainfall analysis

The study found out that there existed a significant difference between the long term monthly mean and the month mean rainfall in that, the monthly mean was depressed than the long term monthly mean in both the MAM and OND seasons. In addition to that, the results further showed that; the study area experienced bimodal type of rainfall with MAM season being depressed than OND as shown in figure 3 below.

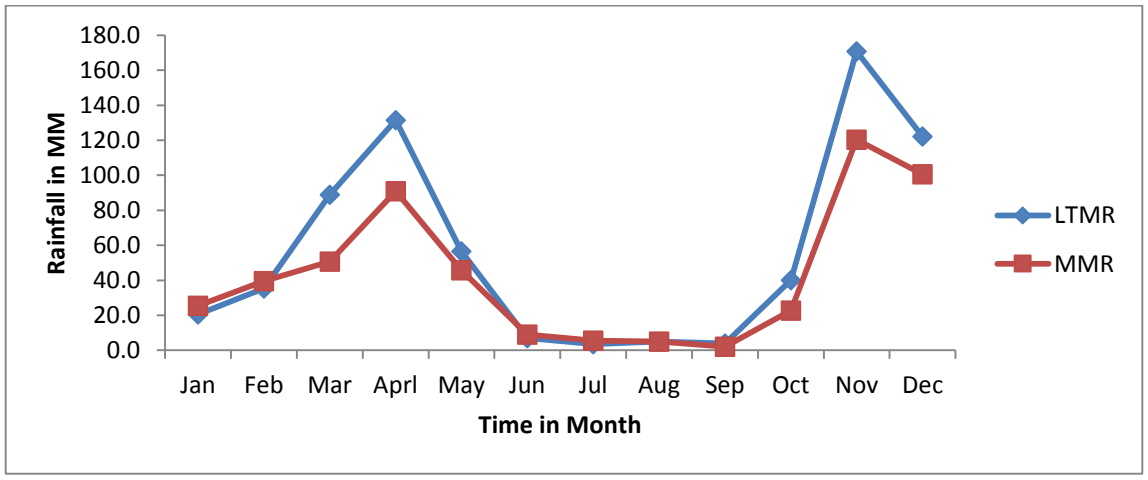

Figure 5: Long term monthly mean and monthly mean rainfall 1980 to 2018 from Machakos station

4.2.4 Analysis on the MAM season characteristics

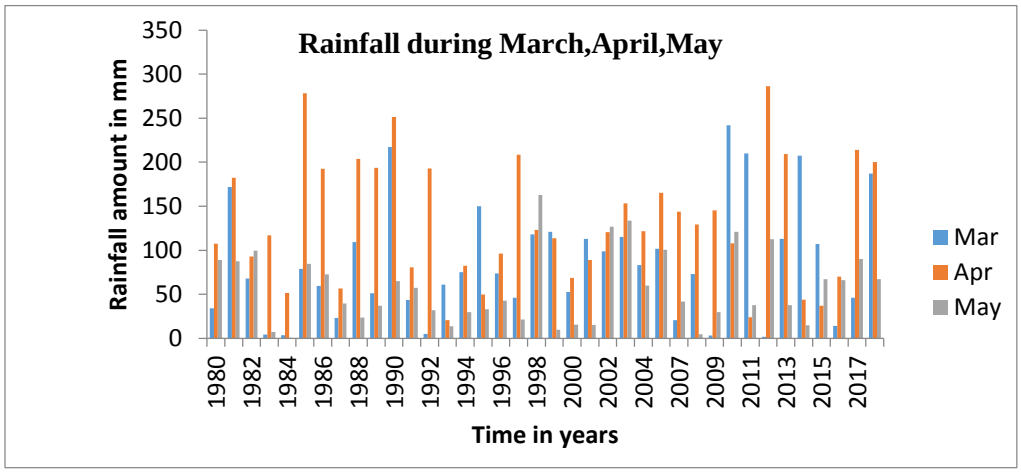

Figure 6: MAM seasonal rainfall 1980 to 2018

As shown from fig 6 above, the MAM season of the study area was characterized by low rainfall amounts in march which is rainfall onset month and the month of May which is the cessation rainfall month these low values during onset and cessation lead to reduction of seasonal rainfall resulting to increase in agricultural drought frequency and duration in the study area. For instance, in the year 1983 the rain onset shifted to almost the end of March and cessation came very early May thus making that year to have prolonged and severe drought during MAM season.

4.2.5 Analysis on the OND season characteristic

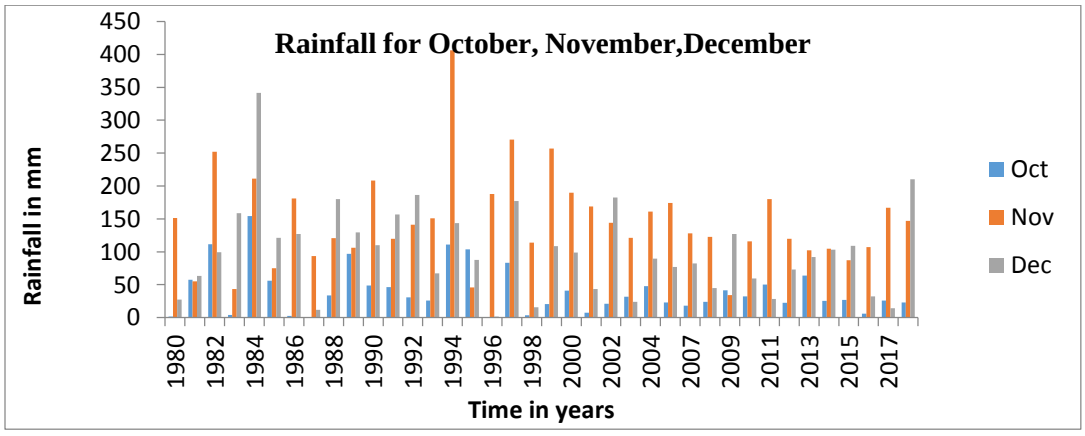

Figure 7: OND rainfall 1980 to 2018 from Machakos station

Source: Machakos station

From fig 7 above on the OND season it was noted that, October received the lowest amount of rainfall followed by December in the study area. These are onset and cessation months respectively, whereby any delay in onset shortens the rainy season in most years while early cessation had the same impacts on the rainy season thus leading to agricultural drought and vulnerable livelihoods dependent on rainfall such as agriculture and livestock keeping in year 1981 and 1987. However, OND season showed to be more reliable in the study area than MAM since we have more months reaching the Long term monthly mean of 100mm than during MAM season.

4.2.6 Drought frequency analysis using Rainfall Anomaly Index (RAI)

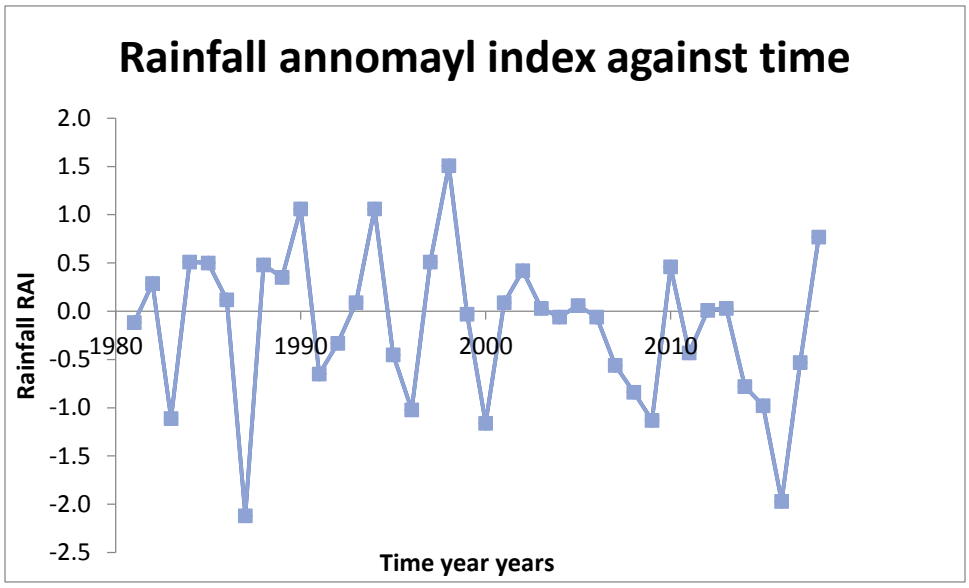

Figure 8: RAI against time

In every 10 years the study area experienced more than three agricultural droughts. As from 1980 to 1990 the drought was reported in 1980, 83, 87. Between 1990-2000 drought years were 1991, 95, 96 and 2000.From 2000-2010 drought years were 2007, 08, and 09. Lastly between year 2010 and year 2018 drought years were 2014, 15 and 2016. This showed that drought in the study area was very common as shown in the fig 8 above.

4.2.7 Analysis of the strength of drought using RAI

Rainfall anomaly index from the study area showed that the study area experiences drought of various magnitude, such that there were (1987 and 2016) years of extreme drought. More than half of years in the period under the study experienced below normal rainfall that resulted to increased drought intensity in the study area. See table 3 below:

Table 7: **Weather conditions classification RAI adapted classification used by van Rooy (1965)**

RAI Classification	**Description**	**Years**
≥ 3.00	Extremely wet	Nil
2.00 to 2.99	Very wet	Nil
1.00 to 1.99	Moderately wet	1990,1994.1998
0.50 to 0.99	Slightly wet	1984,1985,1988,1997,2010,2018
0.49 to –0.49	Near normal	1981,1982,1986,1989,1992,1993,1999.2001. 2002,2003, 2004,2005,2006,2011,2012,2013
-0.50 to –0.99	Slightly dry	1991,1995,2007,2008,2014,2017
-1.00 to –1.99	Moderately dry	1980,1983,1996,2000,2009,2015
-2.00 to –2.99	Very dry	1987,2016

4.2.8 Comparison between Maximum temperature and Rainfall using Pearson correlation coefficient.

The study found out that rainfall was negatively correlated with temperature meaning that a decrease in rainfall was accessioned by an increase in temperature and this resulted to drought in the study area. The correlation of r= -0.6 implied moderate negative correlation relationship existed between rainfall and temperature in the study area. Therefore, agricultural drought in the study area occurred when the weather conditions were hot and dry leading to high temperature. See figure 9 below

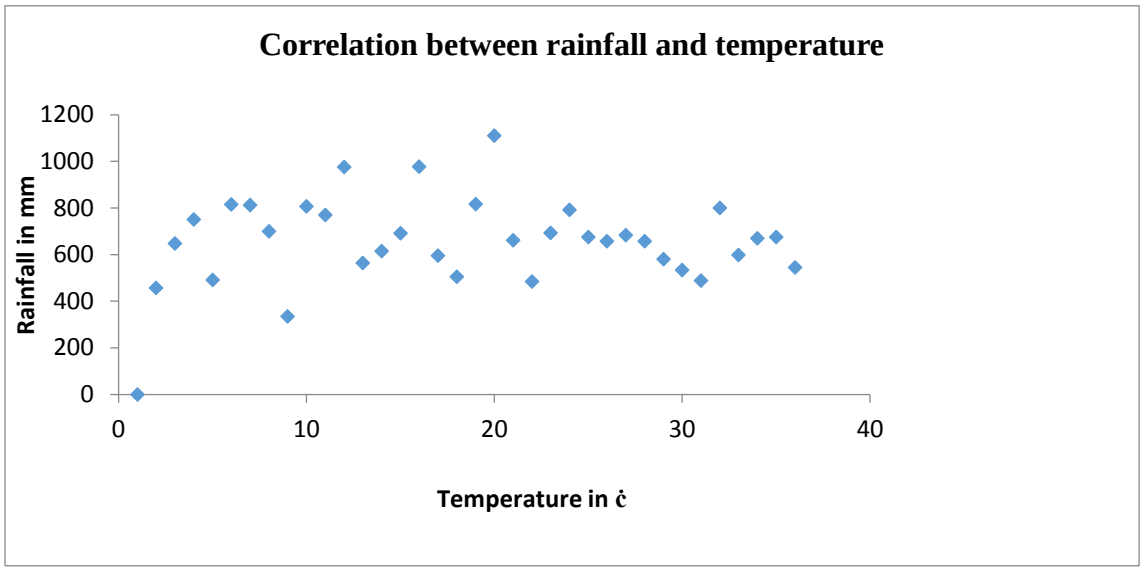

Figure 9: Correlation between rainfall and temperature

4.2.9 Regression analysis between maximum temperature and rainfall

The relationship between rainfall and temperature was significant at $\alpha = 0.05$ where $p < \alpha$, p= where was 0.0003. See figure 8

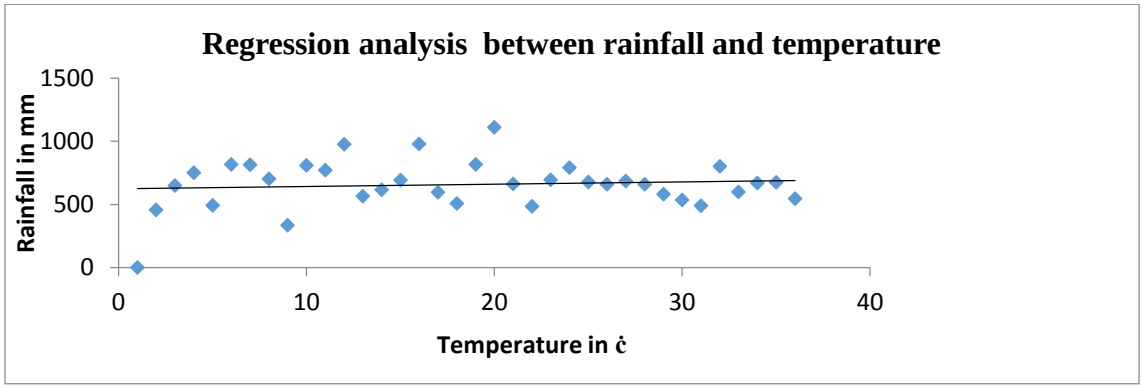

Figure 10: Regression analysis for temperature and rainfall

4.3 The linkage between agricultural drought and livelihoods vulnerability in Yatta, Machakos County

In addressing objective two of the study, the following results are discussed;

4.3.1 Frequency of encounter with drought

The study also asked respondents to indicate how frequent they have encountered drought when undertaking livestock rearing and crop growing in a period of 5 years. The results are presented in table 4.8 below.

Table 4.8: Frequency of encounter with drought

Observation	Frequency	Percentage
None	4	4
Once or twice	19	20
Frequently	63	68
Most frequently	7	8
Total	93	100

Source; field data 2019

From the table above, majority of respondents (68%) indicated that they have frequently encountered drought when undertaking livestock rearing and crop growing in a period of 5 years.

4.3.2 Duration of Drought

On how long has drought lasted, responses are presented in the table 4.9 below.

Table 4.9: Duration of drought

Period	Frequency	Percentage
Less than 1 year	2	2.2
1-2 years	87	93.5
2-3 years	4	4.3
3-4 years	0	0
More than 4 years	0	0
Total	93	100

Source; field data 2019

Table 4.11 shows the duration of drought in Yatta. Majority (93.5%) of farmers indicated that drought has lasted for a period of between 1-2 years; 4.3 % indicated that it lasted for between 2-3 years and only 2.2% of respondents indicated that it has lasted for less than a year. These findings clearly show that drought is a menace in the area and this must be linked to agricultural drought and livelihoods vulnerability in Yatta, Machakos County.

4.3.3 Effects of Drought

The respondents were also asked to indicate from the list below how frequent or most frequently, the listed effects of drought were experienced in their farms. Below is a list of effects of drought on agriculture.

Table 4.10: Effects of Drought

Effects of drought	Frequency	Percentage
Livestock mortality	74	80
Stunted growth of crops	92	99
Emaciated livestock	87	94
Low crop yield and animal production	77	83
Crop pest and animal diseases	79	85
Drying and yellowing of crops before maturity	90	97
Dry cracking soils	78	84
Wind erosion	71	76

Source; field data2019

From table 4.10 above, the findings reveal that 99% of farmers have experienced stunted growth of crops in their farms; 97% have seen their crops drying and yellowing before maturity; 94% have had emaciated livestock; 85% have suffered crop pest and animal diseases; 84% have experienced dry cracking soils; 83% have experienced low crop yield and animal production; 80% have incurred livestock mortality and a further 76% have been exposed to wind erosion**.** Since the answers were given in multiples, they cannot tally to

100%. Nevertheless, these findings clearly indicate that there is a strong linkage between agricultural drought and livelihoods vulnerability in Yatta, Machakos County.

Other effects of drought mentioned by respondents include:

- ✓ High cost of fodder
- ✓ Death of poultry
- ✓ High salinity in soil
- ✓ Sale of livestock to avoid their loss and
- ✓ Failed crops given to livestock as fodder.

4.5.4. Crop production and livestock rearing in the last 2 years

The study sought to find out the current performance of crop production and livestock rearing in your household farm in the last 2 years. The findings are presented in table 4.11 below. From the findings, majority (85%) indicated that the performance has been poor in the last 2 years.

Table 4.11: Crop production and livestock rearing in the last 2 years

Produce in the last 12 months	Frequency	Percentage
Excellent	2	22
Very good	12	13
Good	33	35
Fair	47	51
Poor	79	85
Very poor	37	40

Source; field data

4.5.5 Reasons for poor performance

The study asked respondents to give some of the reasons related to drought that lead to poor performance of livelihoods especially livestock keeping and crop production. The findings are presented in table 4.12 below.

Table 4.12: Reasons for poor performance

Reasons for poor performance	Frequency	Percentage
Rainfall pattern	93	100
Limited access to drought resistant varieties of seeds	81	87
Unreliable water for irrigation	93	100
Health related problems	14	14
Poor road Network	24	26

Source; field data 2019

From the table above, rainfall pattern and unreliable water are the main causes for poor performance in agriculture with each getting a 100% response. Another widespread cause is limited access to drought resistant varieties of seeds.

Other reasons suggested by respondents include;

1. Lack of information on good dry land farming practices and climate variability
2. Lack of skills in improvement of livestock farming
3. Poor methods of farming

4.4 Livelihoods coping mechanisms to recurrent agricultural drought in Yatta, Machakos County

In addressing objective **three** of the study, the following results are discussed;

4.4.1. Involvement in formulation of coping mechanisms

The study also sought to find out whether the respondents have ever been involved in formulation of coping mechanism; from the findings, majority (76%) indicated that they have never been involved in formulation of coping mechanism while only 24% of respondents indicated that they have been involved. The findings are presented in fig. 4.6 below. These findings call for agricultural officers to involve Yatta residents in formulation of coping mechanism for them to be fully involved.

4.4.2: Kinds of coping Mechanisms to the effects of drought

Respondents who indicated that they have ever been involved in formulation of livelihood coping mechanisms to drought in their area were further asked to indicate the coping mechanisms to the effects of drought that they have applied to help mitigate the effects of drought. The findings are presented in the table 4.13 below.

Table 4.13: Coping mechanisms

Coping mechanism	Frequency	Percentage
Planting varieties of drought tolerant crops	84	90
Irrigation of crops	3	3
Migration of livestock to other areas during drought	12	13
Keeping large herds of livestock	14	15
Engaging in a variety of farming activities	29	31
Greenhouse farming	7	8

Source; field data 2019

From table 4.16, majority of farmers (90%) plant varieties of drought tolerant crops as their coping mechanisms to the effects of drought such as green grams, pigeon peas, pawpaw as these crops are able to utilize the short growing season in the area. This is followed by engaging in a variety of farming activities (31%) such as poultry farming; keeping large herds of livestock (15%) ensures that in case of extreme drought, a farmers may not lose all of his livestock; migration of livestock to other areas during drought (13%) this helps in escaping the wrath of the drought in an area and still allows in the utilization of pasture in other areas; greenhouse farming (8%) this allows farmers to not to rely upon rain fed agriculture that is not reliable in arid areas and irrigation of crops (3%) allows a farmer to engage in horticulture that enable him to have food supply during dry periods thus no

starving. From the interviews with agricultural officers and some of the farmers in the area, the following were some of their suggested coping mechanisms;

1. Early planting of maize and green grams
2. Harvesting rain water
3. Digging wells along river banks to tap water for domestic use and for their animals.
4. Keeping goats over cattle since they withstand effects of drought more than cattle. They also breed faster.

4.4.3 Factors hindering formulation and coping mechanism to effects of drought

The study sought to find out the factors hindering formulation and application of coping mechanisms to curb the effects of drought. The results are presented in table 4.14 below.

Table 4.14: **Factors hindering formulation and coping mechanism**

Factors hindering formulation and coping mechanism	Frequency	Percentages
Lack of exposure to seminars	64	69
Lack of information about drought	57	61
Low levels of education	49	53
Reliance on relief food	36	39
Lack of scientific and technical skills	89	96

Source; field data 2019

From table 4.14, majority indicated lack of scientific and technical skills (96%) as the leading hindrance to formulation and coping mechanism to effects of drought. This is brought about by lack of exposure to new agricultural technologies such as soil acidity testing and how to record keeping; lack of exposure to seminars (69%) that are meant to discuss and address drought related issues has made it hard to formulate the mechanism. Lack of information about drought (61%) such as its characteristics, the onset and cession months of it in a given area helps one to plan before hand on how to salvage his or her livelihoods.

Low levels of education (53%) and reliance on relief food (39%) are also hindrances to formulation and coping mechanism to effects of drought in Yatta. Most of the farmers that were interviewed had low levels of education meaning that interpretation of metrological information on weather was not up to date and also researching on various available literatures on drought was not possible. On the hand, reliance on relief makes it difficult for most farmers to step up and try other livelihood alternatives to help them survive during the dry periods.

The other factor that was mentioned as a hindrance to formulation and coping mechanism was lack of interest on seminars. This is brought about by the high expenses that are involved in attending the seminars and the seminars targeting only the educated ones makes them not to be interested in them.

4.4.4: Environmental effects of coping mechanisms

Respondents were asked to indicate environmental effects that the following coping mechanisms cause in Yatta area. The responses are presented as follows:

4.4.4.1 Planting trees

i) Will lead to high charcoal burning practices in the area thus leading to low food production
ii) Reduced crop yields as most land will be put under tree planting leading to low crop farming
iii) Increases plant cover thus reducing drought effects such as wind erosion.

4.4.4.2 Greenhouse farming

i. Water shortage
ii. Lack of water supply
iii. Infestation by pest and diseases.
iv. Food security
v. Prevention of excessive sunlight

4.4.4.3 Dry land irrigation of crops

- ✓ Increased salinity of soil
- ✓ Water shortage
- ✓ Irregular rainfall pattern
- ✓ Growth of crops
- ✓ Exploitation of available water sources
- ✓ Reduces famine
- ✓ Inadequate space
- ✓ Better harvest

4.4.4.4 Migration of livestock to other areas;

- ✓ Poor health
- ✓ Overcrowding
- ✓ High death rate
- ✓ Death of livestock on the way
- ✓ Better livestock quality
- ✓ Growth of vegetation on places of emigration
- ✓ Increase in soil erosion

4.4.4.5: Engaging in other livelihoods

- ✓ Reduced ground cover leading to soil erosion
- ✓ Lack of rainfall due to deforestation
- ✓ Low rainfall due to deforestation
- ✓ Environmental degradation
- ✓ Improved lifestyle
- ✓ Air pollution
- ✓ Further drought
- ✓ Drying of rivers

4.5 Summary of the results and findings

This chapter discussed in detail the results and the findings of the study in relation to its set objectives. The study topic of the study was; the effects of agricultural drought on livelihoods vulnerability in Yatta. The study had targeted 100 respondents in the study area and was able to get feedback from 93 of them which was a good number that represented the area. The study was addressed to greater percentage by the findings since all the three set objectives that guided the study were discussed in depth. In that objective **one**, of study sought to identify the temporal and spatial characteristics of agricultural drought in yatta. This was addressed by the results and findings showing the study area's temperature and rainfall analysis for 38 years. Also the area's temperature and rainfall anomalies were calculated in order to understand the agricultural drought in Yatta. From this information the specific years (1987, 2016) had extreme drought. Finally, objective one was concluded by showing that there was a negative correlation between temperature and rainfall in the area meaning that any decrease in rain in Yatta was accessioned by an increase in temperature leading to drought.

In addressing objective **two,** that sought to find the linkage between agricultural drought and livelihoods vulnerability. The results and findings showed that, in a period of five years' farmers in Yatta frequently encountered agricultural drought that lasted for period of 1-2 years that led to mortality of their livestock, stunted growth of crops, occurrence of pests and diseases that led to poor crop and animal yields in the area, thus shuttered livelihoods leading to high vulnerability levels due to drought. Also from the results discussion on this objective it was concluded that; poor rainfall patterns that were associated with drought were the main factor contributing factor to poor performance of rain fed dependent livelihoods in Yatta.

Finally, in addressing objective **three** of the study, that sought to find out some of the coping mechanisms that farmers in Yatta the results and findings of the study showed that a greater percentage of the farmers in Yatta have not been involved in any formulation of coping mechanisms. This implies that most of the farmers have no knowledge on how to

cope with the effects of agricultural drought to their livelihoods thus increasing livelihoods vulnerability in Yatta. From the results it was clear that most farmers' educational levels made it difficult for them to be involved in practicing some of the coping mechanisms that were suggested by the agricultural officers in the area. Finally, the study was able to find out some of the coping mechanisms that were suggested by agricultural officers and some of the farmers in Yatta such as early planting of drought resistant crops (green grams, pigeon peas), harvesting of rain water, digging of wells along river banks to tap water for domestic use and watering their animals and keeping and rearing of drought.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study established that the study area experienced three agricultural droughts in every 10 years with various magnitude whereby there was extreme agricultural drought was in the years 1987 and 2016. This occurred when there was a decrease in rainfall that was accessioned by an increase in temperature. This affected crop farming and livestock keeping in Ikombe as most farmers (80%) faced huge loses such as low harvest and loss of their livestock due to reduced fodder.

Crop and livestock farmers in Ikombe engaged in various mitigation measures in order to save their livelihoods and reduce their vulnerability to agricultural drought. Most farmers (90%) in the study area planted drought tolerant crops as a coping mechanism to the effects of agricultural drought such pigeon peas, pawpaw, green grams while on only 31% of them engaged in varied farming activities such poultry farming, early planting in order to secure their livelihoods during and after agricultural drought. It was clear that those that engaged in a variety of coping mechanisms were able to salvage their livelihoods and hence reduced livelihood vulnerability to the effects of drought.

In order to survive through especially after adversely being affected by agricultural drought, some of the farmers shifted to new livelihoods such as charcoal burning, basket making as alternatives to crop farming and livestock keeping. This alternative sources of livelihoods have negative effects on the environment such as air pollution leading to increased greenhouse gases in air which accelerates climate change. Also reduced vegetation cover leads low evaporation rates which reduces amounts of water vapor in the atmosphere thus low rainfall leading to agricultural drought. Alternative livelihoods also pose a risk to sustainable dryland farming which contributes a greater percentage to the GDP, i.e. large acres of land lie bare and farmers don't utilize and embrace new techniques meant to reduce agricultural vulnerability and are that are meant to empower farmers economically through sustainable dryland farming.

5.2 Conclusions

Based on this study's findings, the following conclusions can be drawn:

a) There was a significant relationship between rain fall and temperature, in that agricultural drought occurred when the weather conditions of the area were dry and hot due to the fact that a decrease in rainfall was caused by an increase in temperature.

b) Most household heads in Yatta depend on livestock keeping and crop farming as the main source of livelihood but do not practice appropriate coping mechanisms that are key such as rain fall harvesting, greenhouse farming due to low levels of education, technological knowhow and high poverty levels amongst them. Furthermore, this has made it difficult for most farmers to seek expertise advice or engage in agricultural seminars that are geared towards educating the farmers on proper farming methods, appropriate livestock species for drylands thus reduce or eliminate the effects of agricultural drought on their livelihoods.

c) Farmers need to be aware on some of the negative impacts associated with some alternative sources of livelihoods such as irrigation of crops along the banks of river mwitasyiano leads to increased soil salinity as the water is salty. This has future negative impacts on agriculture in Yatta as it will affect its ph. thus making hard for cops to grow thus leading to low food production in the area and high livelihood vulnerability.

d) Farmers' accessibility to drought resistant crop seeds was limited accompanied by little or no interactions with agricultural professionals in the area on how to improve their agricultural skills leading to livelihood vulnerability.

5.3 Recommendations

a) Agricultural officers should involve ikombe farmers in formulation of coping mechanisms that are easily applicable to them; such as harvesting rain water, early planting and rearing of drought resistant crops and livestock

b) County should avail and engage farmers in planting a variety of drought resistant crops to improve the livelihood of communal farmers since they can still harvest surplus for sale even if the rainfall is below normal.

c) Agricultural officers should help in educating farmers on fertilizers, seed varieties, crop diversification, sustainable livelihood diversification and interpretation of drought early warning systems. This should be availed to farmers at a subsidized cost, through loans that's are flexible to farmers.

d) Farmers to be educated on the importance of early vaccination for their livestock against foot and mouth disease, spider bite among other diseases that affect livestock during dry season. It is also important to for them to keep records of their farms as this will assist in tracking the performance of everything that goes on in their farms thus know areas of improvements and maintenance.

e) Residents should be encouraged to practice afforestation activities that will increase plant cover thus reducing wind and soil erosion.

5.4 Suggestions for further study

1. The effects of agricultural drought on animal and plant species in arid lands.
2. The role of indigenous knowledge in reduced effects of agricultural drought in arid and semi-arid lands.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR FARMERS

My name is **Nyambane Sheilah** from the **University of Nairobi**. I am undertaking a research on the **EFFECT OF DROUGHT ON LIVELIHOOD VULNERABILITY IN YATTA, MACHAKOS COUNTY, KENYA.** With me is a document with a set of questions on my topic of research mentioned above. It is my humble request that you may answer the questions sincerely. Please note that the information you give in this document will be used purely for academic purposes.

1. Demographic Information

Gender: [ ] Male [ ] Female

Age {years}: [ ] 15 – 24 [ ] 25 – 35 [ ] 36 – 45 [ ] 46-55 [ ] over 55

Level of education: [ ] Primary [ ] Secondary

[ ] College [ ] University

Farm Size(acres) ……

Size of farm under crop cultivation and livestock keeping……

Which of the following sections best describes the period that you have been practicing have been agriculture in your farm?

[ ] less than 10years [ ] 10-20 years [ ] 20-30 years

[ ] 30-40 years [ ] 0ver 40 years

2. Knowledge on drought

Circle the statements below from 1 to 5 that you feel best represents your knowledge on drought

i) No [ ]

ii) Minimal [ ]

iii) Extensive [ ]

iv)DK or R [ ]

Have you ever been interviewed on the effects of drought before in your farm?

[ ] Yes [ ] No

Indicate how frequent, you have encountered drought when undertaking livestock rearing and crop growing in a period of 12 months

i) None [ ]

ii) Once or twice [ ]

iii) Frequently [ ]

iv) Most frequently [ ]

If frequently or most frequently, what effects of drought did your farm experience. Below is a list of effects of drought on agriculture. [TICK ALL THAT APPLY TO YOUR FARM]

i) Livestock mortality [ ]

ii) Stunted growth of crops [ ]

iii) Emaciated livestock [ ]

iv) Low crop and animal yields [ ]

v) Crop pest and animal diseases [ ]

vi) Drying and yellowing of crops before maturity [ ]

vii) Dry cracking soils [ ]

Viii)Wind erosion [ ]

Others

In the past 12 months has your farm experienced any kind of drought?
Yes [ ] No [ ]

If yes, how long did the drought(s) that you experienced in the past 12 months in your farm last?

i) Less than a month [ ]

ii) 1 -6 months [ ]

iii) 1 -2 years [ ]

iv) 2-5 years [ ]

v) More than 5 years [ ]

Were you the only one who experienced the drought in this area?
Yes [ ] No [ ]

If No, which other places in the area, were affected by the drought. Give names
…….

3. State of livelihoods

Which of the below livelihoods does your household farm practice:

i. Crop farming [ ]
ii. Livestock rearing [ ]
iii. Livestock rearing and crop production [ ]
iv. Others ……..

Name the types of crops and livestock that you keep and grow in farm

Livestock (all) Crops

For crop production, how many times in a year do you plant [SPECIFY WHICH CROPS?]

Crop ……

Which of these statements best describes the current performance of crop production and livestock rearing in your household farm in the last 12 months?

1. Excellent [ ]
2. Very good [ ]
3. Good [ ]
4. Fair [ ]
5. Poor [ ]

6. Very poor [ ]

[IF OPTION 5 OR 6 IS SELECTED ABOVE] below are some of the reasons related to drought that lead to poor performance of livelihoods especially livestock keeping and crop production [READ THE LIST AND MARK ALL THAT APPLY TO YOUR HOUSEHOLD FARM]

1. Size of land [ ]
2. Rainfall pattern [ ]
3. Limited access to drought resistant varieties of planting seeds [ ]
4. Pest and diseases attacking crops [ ]
5. Unreliable water for irrigation [ ]
6. Health related problems [ ]
7. Poor road network [ ]
8. Others

……
……

Have ever received professional advice from any agricultural officers in your area regarding the effects of drought to livelihoods especially livestock keeping and crop farming?

[ ] Yes [ ] No Dk or R [ ]

If yes, what was that advice?.....

How did the advice improve the state of your livelihood (livestock and crop farming) currently regarding the effects of drought……?

4. Coping Mechanisms to the effects of drought

Have you ever been involved in formulation of livelihood coping mechanisms to drought in your area before?

YES [ ] NO [ ]

IF YES, which of the following coping mechanisms to the effects of drought has your farm applied to help mitigate the effects. [TICK THAT APPLIES IN YOUR HOUSEHOLD]

i) Planting varieties of drought tolerant crops [ ]

ii) Irrigation of crops [ ]

iii) Migration of livestock to other areas during drought [ ]

iv) Keeping large herds of livestock [ ]

v) Engaging in a variety of farming activities e.g aviary, hunting,

vi) Greenhouse farming [ ]

others…….

In your own opinion, which of the factors below would you consider to be hindering the formulation and application of coping mechanisms to curb the effects of drought? [TICK ALL THAT APPLY IN YOUR CASE]

[ ] lack of exposure to the seminars due to financial constraints

[ ] lack of information about drought

[ ] low levels of education

[ ] reliance on relief food

[ ] lack of scientific and technical knowledge to undertake the laid out coping mechanisms

Others ……

In your opinion, what are the environmental effects do the following coping mechanisms cause in yatta area

1. Planting a varieties of drought resistant crops……

2. Green house farming……

3.dry land Irrigation of crops ……

4. Migration of livestock to other areas……

5. Engaging in other livelihoods, e.g Charcoal burning……

Others……
…….

THANK YOU FOR PARTICIPATING

APPENDIX 2: INTERVIEW GUIDE

1. What are effects of drought have you observed in yatta, on the crop and livestock rearing?
2. Has there been any significant changes in rainfall and temperature patterns in yatta changed over time
3. In what ways has drought affected the plant and animal species in Yatta?
4. Which coping mechanisms does the Yatta farmers employ to counteract the effects of drought?
5. What environmental impacts has the employed coping mechanisms brought to the environment?
6. In your opinion which policies and strategies that should be put in place to mitigate the negative effects of drought and help yatta farmers to ensure their livelihoods are secure?
7. Does your department offer any assistance to the Yatta farmers? Kindly explain your response

APPENDIX 3: FIELD PHOTOGRAPHY ON VARIOUS ACTIVITIES AND NATURE OF LAND IN IKOMBE

APPENDIX 4:

Mchakos RAI 1980-2018
Temperature1980-2014

Year	RAI
1980	-1.3
1981	-0.1
1982	0.3
1983	-1.1
1984	0.5
1985	0.5
1986	0.1
1987	-2.1
1988	0.5
1989	0.4
1990	1.1
1991	-0.7
1992	-0.3
1993	0.1
1994	1.1
1995	-0.5
1996	-1.0
1997	0.5
1998	1.5
1999	0.0
2000	-1.2
2001	0.1
2002	0.4
2003	0.0
2004	-0.1
2005	0.1
2006	-0.1
2007	-0.6
2008	-0.8
2009	-1.1
2010	0.5
2011	-0.4
2012	0.0
2013	0.0

Machakos annual rainfall 1980-2018

Years	Rainfall
1980	457.1
1981	648.3
1982	750.9
1983	490.5
1984	815.7
1985	813
1986	700.5
1987	334
1988	807.1
1989	770.1
1990	975.7
1991	564
1992	615
1993	691.4
1994	977.6
1995	595.2
1996	505.4
1997	816.3
1998	1110.2
1999	661.4
2000	483.8
2001	693
2002	791.2
2003	675.8
2004	657.5
2005	682.7
2007	579.9
2008	534
2009	488
2010	799.8
2011	598.1
2012	669
2013	674.9
2014	545.1
2015	516

Max

Year	MAX
1980	25.0
1981	24.6
1982	24.8
1983	25.6
1984	25.1
1985	24.2
1986	24.6
1987	25.9
1988	24.8
1989	24.1
1990	24.3
1991	25.2
1992	24.9
1993	24.8
1994	25.2
1995	25.1
1996	25.4
1997	25.4
1998	24.5
1999	25.3
2000	25.6
2001	25.0
2002	25.1
2003	25.3
2004	25.2
2005	25.7
2006	25.2
2007	25.1
2008	25.3
2009	25.9
2010	25.0
2011	26.1
2012	25.9
2013	25.6
2014	25.5

2014	-0.8
2015	-1.0
2016	-2.0
2017	-0.5
2018	0.77

2016	357
2017	582
2018	893