

**IMPACTS OF CLIMATE VARIABILITY ON THE OUTBREAK AND SPREAD  
OF NEWCASTLE DISEASE IN POULTRY FARMING IN KISII COUNTY,  
KENYA**

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## DECLARATION

I declare this is my original project work, and it has not been submitted to any institution for any degree award.

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This is to confirm that the candidate undertook the project report under my close supervision.

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## **DEDICATION**

I dedicate this work to my family, who endured the commitment during the study, and to my friends, whose prayers and encouragements were critical for the success of this work.

This work is designed to give the reader a comprehensive picture of the impacts of climate variability on the outbreak and spread of Newcastle Disease during the period and study area under consideration and at the same time provide the necessary details for examination work.

I received much help and encouragement in preparing this original work, and I must especially record my appreciation and constructive criticism by my research supervisor Dr. Cecilia Gichuki and my friends in my field of study.

I am also particularly indebted to my family; whose prayers and encouragement was vital for this work's success.

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## LIST OF ABBREVIATIONS AND ACRONYMS

<b>APMV-1</b>	Avian Paramyxovirus Type 1
<b>DJF</b>	December, January, and February
<b>FRIC</b>	Free Range Indigenous Chicken
<b>GDP</b>	Gross Domestic Product
<b>IC</b>	Indigenous Chicken
<b>JJA</b>	June, July, and August
<b>KMS</b>	Kisii Meteorological Station
<b>MAM</b>	March, April, and May
<b>MDGs</b>	Millennium Development Goals
<b>ND</b>	Newcastle Disease
<b>NDV</b>	Newcastle Disease Virus
<b>NDVIt</b>	Time of Newcastle Disease Virus Infection
<b>SDGs</b>	Sustainable Development Goals
<b>SON</b>	September, October, and November
<b>SSA</b>	Sub-Saharan Africa
<b>T<sub>max</sub></b>	Maximum Temperature
<b>T<sub>min</sub></b>	Minimum Temperature
<b>WAHID</b>	World Animal Health Information Database

## ABSTRACT

Newcastle disease is an infection of domestic poultry and other bird species caused by Avian Paramyxovirus Type 1 virus. A highly contagious and often-severe disease that occurs globally and causes devastating losses in both commercial and village chickens. The study sought to examine the impact of climate variability on the outbreak and spread of the Newcastle disease in Kisii County, Kenya. The objectives of the study were: to examine how climate has varied between 1990 and 2019 in Kitutu Chache South Constituency; establish farmers' perception of the effects of climate variability on Free Range Indigenous Chicken in Kitutu Chache South; examine the relationship between climate variability and the occurrence of Newcastle disease as well as to assess the socio-economic costs of Newcastle disease on poultry farmers. Descriptive survey study design was selected and it included both qualitative and quantitative approaches. The research study targeted poultry farmers; thus, sampling size was determined to be 500 farmers and 10 Key informants from the County Departments. The research used simple random and purposive sampling methods. Primary data was collected from poultry farmers using questionnaires, and secondary data was collected from Kisii Meteorological Services from 1990-2019. The primary data was analyzed in STATA-14 and SPSS-20 using descriptive statistics, Spearman's Correlation, and Linear regression models. Cronbach's Alpha formula, weighted mean, and chi-square were used to identify farmers' perceptions within six items. Secondary data was analyzed in R-Studio using the Mann-Kendall trend test with Sense slope estimators to determine trends in climatic variability. The results showed a significant increase in minimum and maximum temperatures at ( $p < 0.05$ ); and a decreasing trend in the mean amount of rainfall. This study confirmed that poultry farmers from Kitutu Chache South were significantly aware of climate variability and its effects on chicken production ( $\chi^2 = 68.17$ ;  $df = 5$ ;  $p = 0.000$ ) with Cronbach's Alpha ( $\alpha$ ) of 0.712, which showed reliable consistency within the items. There was a significant and robust relationship between climatic variables and chicken death due to the Newcastle Disease virus ( $p < 0.001$ ). It was determined that climate factors influence chicken productivity, and a slight change of climate variables could lead to an average loss of about KES.236.78 per chicken. The results further showed that poultry farmers are adapting strategic measures to mitigate the effects of climate change, such as vaccination, using the herbal medication, and consuming and selling chicken before infection. These adaptation strategies were found to be statistically increasing chicken productivity ( $p < 0.05$ ) with a marginal probability range of 1.4% to 27.3%. However, farmers are constrained by challenges such as inadequate funds, inadequate extension services, and erratic prediction of the seasonality of the Newcastle Disease outbreak. Therefore, from the study findings, the study recommends that the County and the National governments harmonize climate issues when drafting policies on Newcastle Disease.

## CHAPTER ONE: INTRODUCTION

### 1.1 Background to the Study

Climate Change researchers have shown that the temperature of the earth's surface has been increasing over time, triggering fluctuations in daily weather patterns. The World Meteorological Organization and the United Nations Environment Program started the Inter-Governmental Panel on Climate Change (IPCC) to research this matter. The IPCC got scientists from diverse institutions and scientific professions to generate and create proof of future temperature and rainfall differences. The socio-economic and ecological impacts created by climate change are projected (IPCC, 2014 & 2018).

Climate changes also generate life-threatening scenarios, for instance, heat waves, cold waves, droughts, frosts, floods, and cyclones (Trimmel *et al.*, 2018). The IPCC (2014) reported that extreme circumstances showed certainty, unlimited susceptibility, and tough experience of various biomes. The IPCC (2014) also indicates that self-assurance of periods and frequency of heat waves have been universally amplified since the 1950s, and the intensity records continue to rise.

In Africa, climate variation is a critical issue affecting livestock production (Shewmake *et al.*, 2008). Poultry farming of diverse types and different ages, sex, phase of production, and reproduction have been greatly affected by climatic variations (Alade & Ademola, 2013). According to the study by Miller *et al.*, (2007), Chickens cannot endure high temperatures, erratic rainfall, and high humidity irrespective of their different stages of life. When there is no moisture absorption in the breathing system of chicken, birds tend to breathe quickly. Likewise, when there is high ambient temperature, birds use moisture from their respiratory tract causing them to pant. The panting makes it possible for birds

to increase airflow over the mucous membrane and hence eradicate heat from the body. Normally, sweating is not the process of heat elimination in birds as perceived in humans (Dortmans, 2011).

Chende (2012) researched on indigenous chicken in some parts of Ethiopia. The research study established that rainy days were upsetting to the breeder hens. Enhanced rainfall and moisture escalated the disease occurrences in poultry and livestock, leading to minimal production. Poultry plays a key role in the lives of the poor rural communities in developing countries. In Kenya, both hybrid and indigenous poultry are reared, where indigenous poultry accounts for a significant portion of the economy and is a source of income to small-scale farmers (Kingori et al., 2010). Most farmers in rural areas rear chicken because the capital required is low and affordable due to cheap household labor.

Free Range Indigenous Chicken (FRIC) plays an important role in improving the nutritional status and boosts the income for most rural households (Henning et al., 2013). The chicken provides proteins in meat and eggs to the world's population as they are majorly reared as food supplements (Enahoro et al., 2019 & Kingori et al., 2010). Many farmers keep poultry as the simplest investment since its primary importance is to support households whenever they are in financial crises, such as getting medicine, clothing, and school fees when needed. More benefits related to chicken rearing are controlling pests, providing farm manure, traditional ceremony contributions, cleanliness, and hygiene as FRIC feeds on leftover foods (Chende, 2012).

Despite their importance, Free Range Indigenous Chicken face many challenges. These include predation by snakes and birds of prey, poor housing, poor nutrition, climate variability, attacks by pests and diseases (Alade & Ademola, 2013). The climate strongly determines the distribution of disease vectors, their transmission, and evolution and can

influence factors related to the emergence of poultry diseases and birds response to the conditions.

The Newcastle disease (ND), which is caused by Avian Paramyxovirus Type 1 (APMV-1), is a significant challenge for poultry farmers and producers worldwide (Sultan *et al.*, 2020). The disease can either generally be directly or indirectly influenced by weather patterns and climate change. For example, the distribution and change in climatic patterns proportionately affects the Newcastle diseases. The outbreaks are generally associated with alternating heavy rains, persistent drought, and continuous rising temperatures (Brown & Bevins, 2017). High temperatures are associated with the development of some serious pathogens or parasites that have a life cycle outside the animal host. This has impacts of shortening the generation times and increasing the numbers of the generations per year, leading to an increased number of pathogens and parasites.

In Kitutu Chache South Constituency, Kisii County, poultry industry ranks second in priority after livestock husbandry, where local birds are dominant. This enterprise is constantly affected by seasonal outbreaks of Newcastle disease, locally known as “Omosando,” It leads to a high chicken mortality rate hence causing significant financial losses to farmers.

Even though people are aware that the disease is related to ecological changes, research on the other side has found that some environmental drivers facilitate the dynamics of the emergence of the disease (Odey *et al.*, 2018). Therefore, more research was needed on the causes and methods of controlling the disease, which could reduce its incidence.

## **1.2 Statement of the Problem**

Indigenous breeds of chicken in Kenya form about 76% of the total poultry population and produce about 55% and 47% of the total meat and eggs, respectively. Despite this contribution, poultry production is constrained, especially among small-scale farmers, due to Newcastle disease. Different communities and households rear Free Range Indigenous Chicken for commercial or subsistence purposes. However, numerous challenges affect the rearing of Free Range Chicken in most parts of the world, including the high cost of farming inputs and climate variability, which is an excellent determinant of poultry production and health status.

To improve the productivity of Free-Range Chicken amid climate variability, farmers need to be guided by scientific information and effective interventions to reduce the spread of the virus causing Newcastle Disease. Even though there are many mechanisms of adapting to these phenomena, such as developing new vaccines against the virus, quarantine of the chicken to limit the spread of the virus, and using of traditional herbs, the attempt to adapt is still at early stages in most parts of the developing nations.

There have been many research studies about the cause of Newcastle Disease and its effects on Free Range Chicken around the world by various scientists. However, there is still the existence of scanty information about the relationship of climate variability and Newcastle Disease. Therefore, this research needed to broaden the relationship between climate variability and the spread of Newcastle Disease among Free Range Chicken. This research study also modeled a framework that would allow exploration of the specific effects and control of Newcastle Disease in Kisii County, Kenya. Massive losses of FRIC due to Newcastle disease are significant. However, efforts made to address this problem worldwide are not adequate.

### **1.3 Research Questions**

The following research questions guided the research:

- i. How has climate varied between 1990- 2019 in Kitutu Chache South Constituency?
- ii. How do farmers perceive the effects of climate variability on Free Range Indigenous Chicken varieties in Kitutu Chache South Constituency?
- iii. What is the relationship between climate variability and the occurrence of Newcastle Disease in free-range indigenous chicken?
- iv. What are the socio-economic costs of Newcastle Disease to poultry farmers in Kitutu Chache South Constituency?
- v. What measures have the affected farmers taken to control and manage Newcastle Disease in Kitutu Chache Constituency?

### **1.4 Research Objectives**

#### **1.4.1 Main Objective**

The study aimed to determine the impact of climate variability on the outbreak and spread of Newcastle Disease in poultry farming in Kisii County, Kenya.

#### **1.4.2 Specific Objectives**

The specific objectives of the study were:

- i. To examine the variability of climate change since 1990 - 2019 in Kitutu Chache South Constituency
- ii. To establish farmers' perception of the effects of climate variability on Free Range Indigenous Chicken varieties in the Kitutu Chache South Constituency.

- iii. To examine the relationship between climate variability and the occurrence of Newcastle disease in Kitutu Chache South Constituency.
- iv. To assess the socio-economic costs of Newcastle Disease to the poultry farmers in the area of Kitutu Chache South Constituency.
- v. To identify measures taken by farmers to control and manage the Newcastle disease Kitutu Chache South Constituency.

### **1.5 Research Hypotheses**

The research study tested the following three hypotheses;

- i. There is no significant relationship between the climatic variability and the outbreak and spread of Newcastle Disease in Kitutu Chache
- ii. There is no significant relationship between farmers' perception of the effects of climate variability and the adaptations methods of keeping Free Range Indigenous Chicken in Kitutu Chache.
- iii. The socio-economic costs of Newcastle Disease to the poultry farmers are low and insignificant.

### **1.6 Justification and Significance of the Study**

#### **1.6.1 Justification of the Study**

The most vital impacts of climate variability experienced in the agriculture sector, are in poultry farming, crop farming, and livestock rearing. Therefore, these changes in climate patterns are linked to human livelihoods and economic growth of well-being (IPCC, 2012). This phenomenon of climate and economic dynamics poses human uncertainty for present and future generations. Thus, there is a desire to research and study the connection between climate and livelihoods on local, regional, and international scales to grasp and solve

complex socio-economic problems within our societies. However, the transfer of these traditional interventions within our community to the current and future generations using the trendy science of trans-disciplinary approach and intergenerational equity is necessary. In conclusion, it is better to integrate community-based methods to understand these concepts of climate variability and poultry farming, which will finally advance our development agendas (Qian-qian et al., 2015).

The research study gives a fundamental outlook on the comprehensive and valuable guide into the relevant agencies that can be involved in the research and policy practice, especially the government embarking on projects that would exploit the benefits of poultry farming in Kenya to improve livelihoods (Odey et al., 2018). Updating farmers on positive precautions taken concerning the outbreak of the diseases is necessary. The scientific information from this study would be important to livestock health workers and poultry farmers on both local and international scales. Lastly, the findings of this study would inform the decision-making of poultry vendors, traders, and consumers and provide policy makers with vital information to process better management policies of poultry farming.

## **1.7 Scope and Limitations of the Study**

### **1.7.1 Scope of the study**

This study sought to determine diverse climate trends from 1990 to 2019; establish the relationship between climate variability and the outbreak of Newcastle Disease, sought farmers' perception about climate variability and Newcastle diseases to poultry farming. The study also assessed the socio-economic costs of the Newcastle Disease to poultry farmers and the strategies employed by farmers to cope with Newcastle Diseases at Kitutu Chache area in Kisii County, Kenya. The study covered only Free-Range Indigenous

Chicken (FRIC) within the South of Kitutu Chache in Kisii. However, the study was limited to these objectives and only within the Kitutu Chache area. Qualitative and quantitative data sampled and collected within 520 respondents, included poultry farmers and key Informants, the analysis of this data done and results used to present a strategic model framework to Newcastle Disease among farmers in Kitutu Chache South and Kisii County at large.

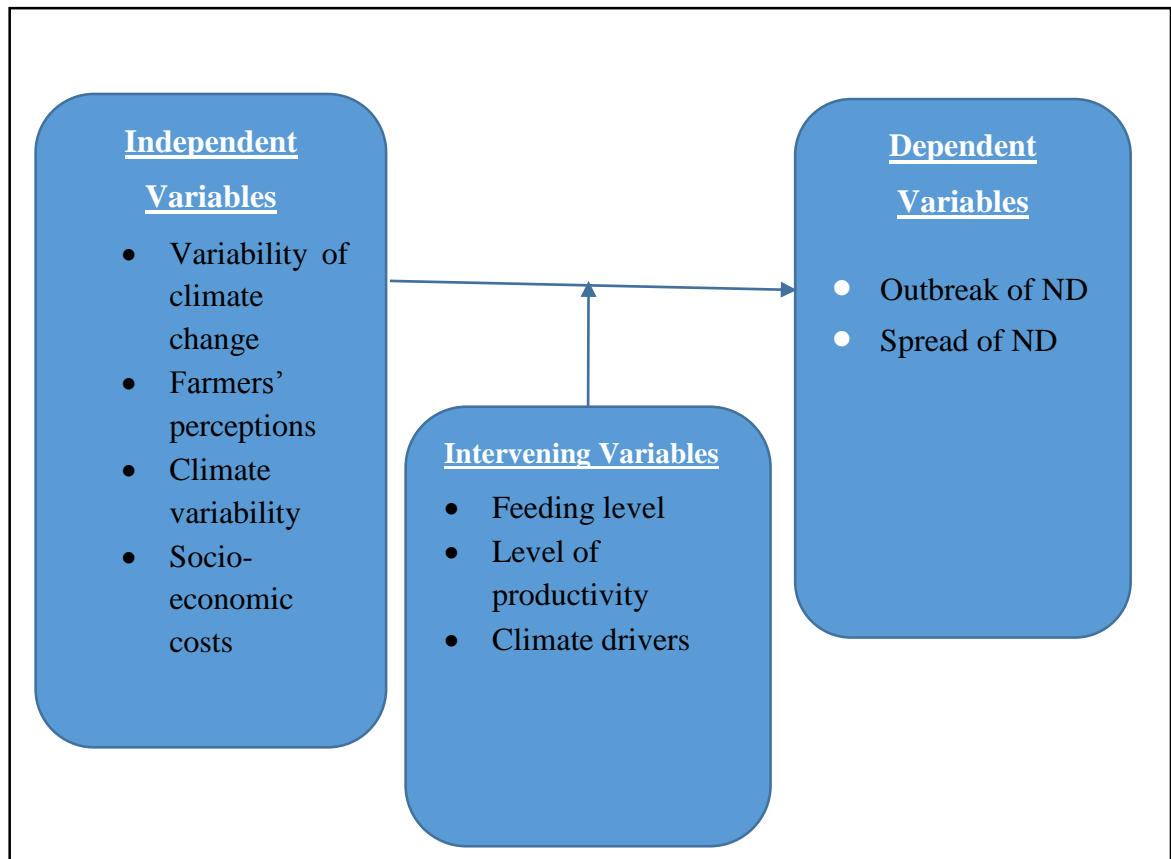
### **1.7.2 Limitations of the study**

The research encountered the following limitations; time, financial constraints, and challenges of seasonal roads, which lessened the effectiveness of collecting data and reduced the study period. The researcher made an effort to overcome these challenges through the following ways: On-time constraints, the researcher limited the study to cover two months. This was achieved using time schedules, which guided the researcher. Concerning financial constraints, the researcher created a budget for the study. In this case, the source of funds was from personal savings, friends, and family. The researcher also opted to conduct the study by reaching all the study areas putting on gumboots, jackets, and carrying umbrellas to protect the researcher from wet rainy, and cold season.

### **1.8 Conceptual Framework**

Climate change results in changes in weather patterns, which affects poultry farming. The independent variables are; Climate variability (Rainfall, Temperature), the Virus of the Newcastle Disease, and farmers' Free-Range Chicken. Intervening variables include feeding level, productivity level, socio-economic factors, and climate drivers such as poverty. The dependent variables were farmers' perception, adaptation measures, the

spread of Newcastle Diseases, effects and costs of Newcastle Disease to farmers of Free-Range Indigenous Chicken.



**Figure 1.1: Conceptual framework**

The climate change variables such as temperature and rainfall patterns create a conducive environment for Newcastle Disease virus vectors, thereby leading to the spread of Newcastle Disease and outbreaks among Free Range Indigenous Chicken. Socio-economic factors, chicken feeding levels, types of chicken reared, level of chicken productivity, and climate drivers such as poverty were intervened to balance the independent variables against the dependent variables. For example, feeding levels and the type of chicken reared determines the level of the immune system in Free Range

Indigenous Chicken (FRIC) fight against diseases (Wakamatsu *et al.*, 2006). Unvaccinated young FRIC are hypersensitive to weather patterns compared to older ones. The type of rearing house and mode affects the FRIC productivity and maturity level; for instance, when mixed (young and old), the young ones die for being stepped on and competition for food (Wondmeneh *et al.*, 2016).

## 1.9 Definition of Terms

**Newcastle Disease:** It is a disease that is virulently caused by a form of avian Paramyxovirus type-1 virus that affects the respiratory systems of wild birds and poultry (Brown & Bevins, 2017)

**Disease spread:** This is a way of movement and transmission of Newcastle Disease by causative agents.

**Climate variability:** Is a statistical change in the weather pattern over some time (IPCC, 2014)

**Climate perception:** This is the knowledge or belief accompanying climate change phenomena (Ansari *et al.*, 2018).

**Poultry farming:** This is the practice of keeping wild birds and chicken domestically (Wondmeneh *et al.*, 2016)

**Linear regression model:** This is a mathematical model used to predict the influence of independent variables over dependent variables

**Mann-Kendall Correlation (Tau):** The Mann-Kendall trend test is a non-parametric mathematical model used to identify trends in data collected over time series or a period (Bhuyan *et al.*, 2018)

**Free Range Indigenous Chicken:** A type of chicken that is freely moving within arrange of places such as homesteads.

**Climate adaptation:** Is a way of coping or reversing the effects of climate change (IPCC, 2013).

**Adaptation challenges:** Challenges and constraints experienced when using adaptation methods to climate change.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter presents the empirical literature according to the study objectives, highlighting gaps not assessed by previous studies. The arrangement of chapters follows this order, climate variability, poultry farmers' perception, and the relationship between Newcastle Disease and climate variability on the existing studied literature.

### **2.2 Climate variability**

#### **2.2.1 Rainfall**

Rains during the wet seasons have become unreliable and significantly reduced over time (Bhuyan *et al.*, 2018). The number of days rains are falling have declined from 60 to 30 days during short and wet rainy seasons in some parts of the world where January and February have indicated a prolonged reduction (Bhuyan *et al.*, 2018), leading to lower amount of rainfall during these seasons.

A study in Libya by Ageena *et al.*, (2014) showed that rainfall has intensified within the country especially coastal regions, and the rainfall is expected to increase erratically, causing disastrous floods. On the other hand, Kenya has recorded a 50mm annual reduction of rainfall and an increase of 1°C in temperature in some parts of the country such as the Thika River Basin since 1960 (Maina & Messo, 2017), and the study further suggested that rainfall would keep fluctuating in the next 30 years. There has been an annual mean increase of temperature at the rate of 0.33°C per decade in Western and Central Ethiopia (Yang *et al.*, 2020), and it is expected to rise in the coming decades. Unpredictable and fluctuating rainfall trends have frequently resulted in floods and

droughts accompanied by disastrous landslides and prolonged dry spells that lead to famine and hunger (Gebrechorkos *et al.*, 2020).

### **2.2.2 Temperature**

Scientific projections about the consistency of climate change are always the same across different models, though there have been some fluctuation trends (Bari *et al.*, 2016). A study in East Africa by Gebrechorkos *et al.*, (2020) shows that temperatures of the regions simultaneously increased with an average of 1.2°C and were expected to rise between 0.05 - 2.5°C from 2000 to 2050. Most likely, Kenya's temperature is expected to grow by a range of 1.3°C to 3.9°C as at 2016 to 2100, with a higher increase expected in the Northeastern part of Kenya. However, the month of March, April, and May (MAM) is expected to increase by small margins in temperature as compared to June, July, and August (JJA). Global air temperature has risen by 0.85°C from 1880 to 2012 (Zhang *et al.*, 2020), and global surface temperature is expected to rise by 0.47°C from 2016 to 2035 (Asfaw *et al.*, 2018).

## **2.3 Farmers' perception**

### **2.3.1 Poultry farmers' perception of climate variability**

Perception is a key factor that determines farmers' choices to improve their livelihood outputs. Ochieng & Koske, (2013) found that teachers from Kisumu Municipality, Kenya perceived that climate variability poses a threat to communities' livelihoods' ( $p < 0.0001$ ). A study in Ethiopia by Cochrane *et al.*, (2020) reported that farmers' perceptions about climate variability were different from that of Meteorological stations information. This difference implied that farmers' response to climate variability depends on the effects of climate variability on their livelihoods. However, farmers in KwaZulu-Natal, South

Africa, perceived the effects of climate variability based on their impression, direct personal experience, and knowledge (Hitayezu *et al.*, 2017). There are many studies including Alemayehu & Bewket, (2017) in Central highlands of Ethiopia, in the Dabus watershed, North-West Ethiopia and the study by Ndunda & Mungatana, (2013) along the River Nairobi watershed in Kenya showed that socio-economic factors such as level of education, age, and gender were significantly influencing farmers ( $p < 0.05$ ) related perception about climate change and its effects.

### **2.3.2 Poultry farmers' perception of Newcastle Disease**

Newcastle disease (NCD) is a vital concern to most poultry farmers in many parts of the world especially rural areas of developing nations (Wong *et al.*, 2017). Richard *et al.*, (2017) reported that sensitization of farmers about vaccines would increase the number of flocks reared and therefore determine market prices. Poultry farmers perceive climate change as the most threat to their chicken production (Alade & Ademola, 2013). However, there are different types of Newcastle Diseases around the globe and hence Newcastle Disease virus is the most constraint that affects chicken production rather than other diseases in the world like Gumboro (Sultan *et al.*, 2020). It is better to put precautions against this virus to help minimize its spread and the resultant threat to farmers in most African households to increase poultry and wild birds production (Rauw *et al.*, 2010).

### **2.4 Newcastle Disease vector (APMV-1)**

The known Newcastle Disease is a virulent form of avian Paramyxovirus serotype-1 (Brown & Bevins, 2017 & Ferreira *et al.*, 2019) which affects the respiratory system of poultry and wild birds. The diseases spread so fast in the first two decades of its emergence in 1926, and still, it remains an endemic disease of chicken in many parts of the world

depending on geographical and temporal types (Dimitrov *et al.*, 2016). Despite vaccines employed since the 1950s, Newcastle Disease remains a strain of all its types (Terfa *et al.*, 2018). However, many experiments have been done and reported that host novel genes of APMV-1 in poultry are modulated after a short time of infection and therefore causing failure of vaccines in chicken (Kapczynski *et al.*, 2013).

## **2.5 Influence of climate variability on the spread Newcastle Disease**

Changes in weather patterns such as humidity, rainfall, sunshine, and temperature influence the spread of Newcastle Disease (Richard *et al.*, 2017). However, the linkage of the spatial and temporal distribution of climate variability is significantly correlated to the outbreak of Newcastle Disease (Dimitrov *et al.*, 2016). Studies by Nyaiyo, (2014) at Suneka in Kenya statistically found that the death of chicken due to Newcastle Disease was correlated to weather patterns during August, December, July and January at a significance level of  $p < 0.05$ . Climatic conditions affect poultry and wild birds' behaviors, physical mobility and physiological modification hence are vulnerable to transmission of the Newcastle Disease virus (Alade & Ademola, 2013). The same results were empirically noted by Tilakasiri, (2015) which showed that high relative humidity, high temperatures, and heavy rains were related to the mortality rate of chicken and the spread of Newcastle Disease in the Ilorin area of Nigeria.

## **2.6 Social-economic effects of Newcastle Disease**

Newcastle Disease has effects on households' income during the outbreak periods (Di-Falco *et al.*, 2012). Studies by Henning *et al.*, (2013) in Myanmar showed that rural farmers of chicken and wild birds would lose US\$30.7 to US\$167.8 without using vaccines against the effects of Newcastle Disease. However, the use of vaccines to withstand

Newcastle Disease also cost farmers but not as much as deaths of chicken could have cost. Mu *et al.*, (2011) evaluated the economic loss of Newcastle Disease due to climate change, the study found that an increased probability of outbreak would result in loss of US\$106 million in China and US\$28 million in the United States in the year 2011-2030. Newcastle Disease is related to social factors such as age, level of education, and experience, these factors have the probability to reduce or increase the effects of climate variability depending on the farmers' capacity (Wolfert *et al.*, 2017).

## **2.7 Existing adaptation strategies to control Newcastle Disease**

Poultry scientists have come with different vaccines to curb the effects of Newcastle Disease amidst climate variability (Rauw *et al.*, 2010). However, there are many other measures of adaptation used by farmers against Newcastle Disease instead of vaccination. This included using traditional herbs, poultry quarantine, improved chicken feeds, and rearing of improved chicken breeds that are immune to Newcastle Disease (Dortmans, 2011). Rural farmers are encouraged to control Newcastle Disease by use of husbandry practices to limit the spread, this method of adaptation is not costly as other methods, therefore, reduces economic losses. Lv *et al.*, (2019) in the South of China explored the impact of herbal medicine *vis a vis* vaccine medicine on Newcastle Disease, the results showed that chemical vaccines were more effective than herbal medicine and therefore encouraged farmers to use vaccines as a way to control Newcastle Disease. A study in Northeastern Madagascar suggested that vaccination of chicken would cover at least 40% in less than 5 years, double the chicken population in the area.

## **2.8 Benefits and Challenges facing Poultry farming in Kenya**

Free-Range Chicken is the most critical domesticated species for purposes of proprietorship, access to animal protein, and the potential for gaining income. In Sub-Saharan Africa (SSA), 85% of all families keep FRIC, with women owning 70 percent of them. Poultry gives around 20% of protein eaten in developing nations (Phinzi *et al.*, 2019).

Free-Range Chicken assumes fundamental importance as far as change of diet is concerned and wages the income of numerous poor country family units which constitute a worldwide resource for a huge number of people who live beneath the poverty line (Kingori *et al.*, 2010). It gives rare animal protein in a type of meat, eggs, and gives the proprietors income which helps to meet basic family costs, for example, drugs, clothing, and school fees.

Families can likewise build their wages by exploiting occasional high demand poultry markets or festive occasions for example, at religious celebrations or festivities. Different advantages incorporate nuisance control, arrangement of excrement, commitment to customary functions, celebrations, neatness and cleanliness (Richard *et al.*, 2017), FRIC feed on stays of nourishments, which could have generally spoiled and dirtied the earth in residences.

In Kenya, keeping poultry stands out as the most prevalent domesticated project because of its low capital and space necessities. Poultry contributes around 55% to domesticated products and 30% of agrarian total Gross Domestic Product (GDP) and 7.8% of the aggregate GDP (Lwapa *et al.*, 2019).

Despite their importance, Free Range Indigenous Chicken projects are faced with many constraints and challenges. The diseases affecting indigenous chicken include Newcastle disease, Fowl typhoid, and Gumboro, Coccidiosis, and eye infection. Kingori *et al.*, (2010) singled out Newcastle disease to be the most significant source of economic losses in indigenous chicken. It was also established that the estimation of economic losses from Newcastle disease per household rounded up to a mean of 40 birds per year in the coastal lowlands of Kenya.

## CHAPTER THREE: RESEARCH METHODOLOGY

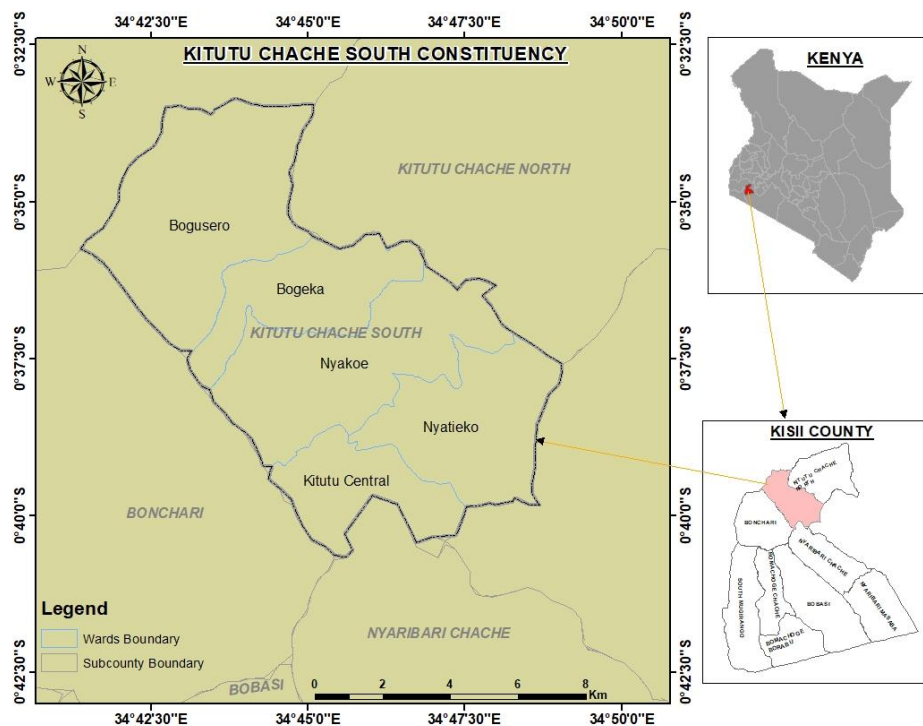
### 3.1 Introduction

This chapter presents the study area, research study design, and target population, sample size, sampling procedure, data collection techniques and methods of data analysis.

### 3.2 Study Area

#### 3.2.1 Location

The study area (Kisii County) is one of the 47 counties in Kenya, the county borders Nyamira County to the North East, Narok County to the South, and Homa-Bay and Migori Counties to the West. The Kisii County lies between latitude  $0^{\circ} 40' 38.4''$  South, and longitude of  $34^{\circ} 34' 46^{\circ} 61''$  East and covers an area of 1,317.5 km<sup>2</sup>. The map (Figure 3.1) below illustrates the location of Kitutu Chache Constituency within Kisii County.



**Figure 3.1: Maps of Kitutu Chache South Constituency (Source: Generated from ArcGIS)**

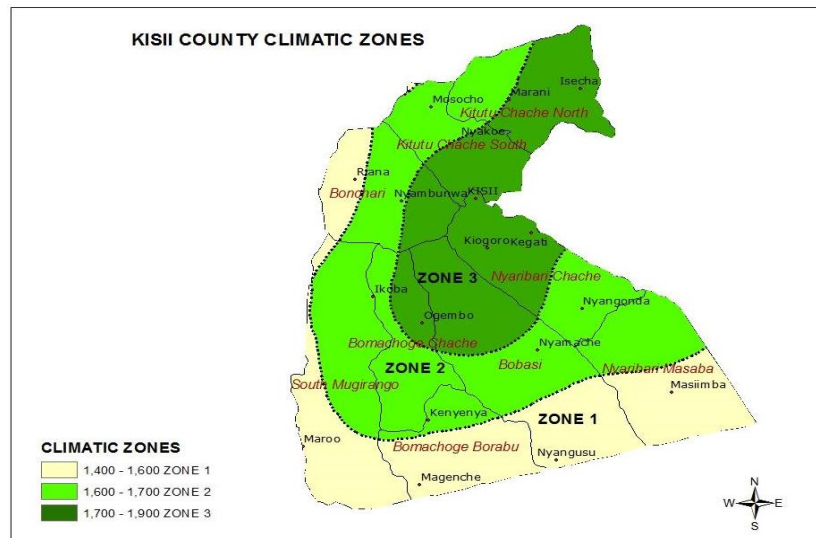
Hilly, ridges, and valleys characterize the topography of Kisii County. The first zone covers areas lying below 1,500m above sea level. It is located on the western boundary and includes parts of the Suneka, Marani, and Nyamarambe Divisions. The second zone covers areas lying between 1,500 -1,800m above sea level located within the Western parts of Keumbu and Sameta Divisions, the Eastern Marani, and Gucha River basin. The third zone covers areas lying above 1,800m above sea level in parts of Eastern and Southern Keumbu, Masaba, and Mosochi Divisions. The most notable features of these topographical zones are hills of Nyamasibi (2,170m), Sameta (1,970m), Kiamwasi (1,785m), Kiong'anyo (1,710m), Kiongongi, Kiombeta, Sombogo, Nyanchwa, Taracha, and Kegochi among others. The general slope of the land is from east to west with depressions and valleys.

Permanent rivers that flow westwards into Lake Victoria traverse the County. Among the notable rivers are Gucha, Mogusii, Riana, Mogonga, Chirichiro, and Iyabe. Seventy-five percent of the County has red volcanic soils (nitosols) which are deep in organic matter. The rest of the County has clay soils that have poor drainage (phaezems); red loams; and, sandy soils. In the valley bottoms, there exist black cotton soils (verisols) and organic peat soils (phanosols). The red volcanic soils support the growth of cash crops such as tea, coffee, pyrethrum, and subsistence crops such as maize, beans, and potatoes.

### **3.2.3 Climate patterns**

The area of study is Kitutu Chache South Constituency, Kisii County. This area exhibits a highland equatorial climate that results in long and short rainfall patterns with an average annual rainfall of 1600mm. The long rains take place between the months of March to May, while the short rains between the months of October to December every year. The months of January and February are relatively dry, while the coldest months are June, July,

and August. The maximum temperatures range between 21°C to 31°C, while the minimum temperatures range between 11°C to 20°C. The outlined conditions suit the growing of crops like bananas, Beans, coffee, maize, pyrethrum, and tea, as well as dairy farming.



**Figure 3.2: Climate zones of Kisii County**

### 3.2.4 Socio-Economic activities

The economic activities characterizing the area include crop farming, livestock farming and fishing. The people produce food crops and cash crops. This includes; food crops such as maize, beans, finger millet, bananas, sweet potatoes, cassava, arrow roots, sorghum, tomatoes, carrots, avocados, and vegetables while the cash crops include coffee, tea, pyrethrum, bananas, avocados and sugarcane.

Kisii County has two main minerals namely, soapstone and granite. Soapstone mining at Tabaka has employed over 10,000 people. However, the mineral is underutilized as, besides curving, other products like chalk, talc powder, ceramic tiles, and paints can be produced. Granite is mainly found in Bonchari and is unexplored. Granite can be used to

manufacture tiles for tabletops, countertops, tile floors, stair treads, and carving of monuments.

Quarrying activities are mainly for the extraction of sand, clay, ballast, and soapstone in the County. There is wildlife in this area, wild animals found in these forests include: porcupines, monkeys, snakes, and various species of birds. Other unique attraction sites include Ngoro ya Mwaga in Manga Hole (a hole believed to be a habitation of natural spirits). Tourists visiting the site are encouraged to carry some firewood which they throw into the hole; if smoke blows from the hole, then it is a sign of acceptance. Permanent rivers like Gucha can be used for fishing activities while waterfalls at Keera in Chitago Borabu can be used for sporting activities if well exploited.

### **3.3 Research study design**

The study adopted an exploratory survey research design that determined the seasonal occurrence of Newcastle Disease in relation to the elements of weather. It incorporated both primary and secondary methods of gathering information on the effects of climate variability on the disease in free-range chicken in the Constituency.

#### **3.3.1 Target population**

The target population consisted of small-scale poultry farmers in Kitutu Chache South constituency. The area had an estimated population of about 142,132 people (KBS, 2019). The Constituency consists of the following wards; Bogisero, Bogeka, Nyakoe, Kitutu Central, and Nyatieko. The area had a size of 104.40km<sup>2</sup>. The respondents would be poultry farmers who had been rearing indigenous chicken for at least five years.

### 3.3.2 Sample size

The sample size of the study area was estimated by the formula (eq.1) indicated by Cossia, (2011) to calculate the sampling size of the respondents within Kitutu Chache South Constituency. The formula was employed since it was easier to use and estimate the number of respondents for the survey. However, this formula distributed the respondents (100people) equally among the 5 wards of Kitutu Chache as shown in Table 3.1.

$$n = \frac{NCV^2}{CV + (N - 1)e^2} \dots \dots \dots \text{eq. 1}$$

Where;

n = Sample size

N= Population of the sampling area

CV = Coefficient of variation (0.5)

e = the precision value (0.05)

**Table 3.1: Sample size frame**

Kitutu Chache South Constituency Wards & their populations						Total Population
Ward	Bogisero	Bogeka	Nyakoe	Kitutu Central	Nyatieko	Constituency
Target Population	24,872	13,254	23,096	50,363	20,546	142, 132
Sampled Population	20	11	17	36	16	100

### **3.3.3 Sampling procedure**

The study contained two different sampling procedures.

a) Purposive sampling: – this approach was applied to major informants for the study.

The use of purposive sampling was ideal for the study as respondents were more knowledgeable of the topic of the study and more experienced to provide adequate information on the happenings with a study area. Purposive sampling aimed to retrieve the most accurate information and thus, sampling would be biased when it excludes effective informants in a study area (Cossia, 2011). Respondents from the Meteorological and Agricultural Departments were interviewed for the study.

The study also adopted systematic and random sampling to collect data from poultry farming households within the wards (Table 3.1); Bogisero, Bogeka, Nyakoe, Kitutu Central, and Nyatieko. Systematic random sampling, unlike purposive sampling, involves the researcher picking the top and most experienced or qualified subject from a population, and then selecting a number of subjects from a list. The sampling process was simple, less costly, and respondents had more chances of being selected to take part in the study as shown in Table 3.1 . Furthermore, the study divided the locations into sub-locations where farmers were chosen using snowballing sample technique.

### **3.3.4 Data collection and tools**

Primary data was collected from poultry farmers using questionnaires, the study used both open-ended and closed questions. The questionnaires were distributed among 500 household farmers for collection of information such as the season of the year deaths of FRIC occurred due to Newcastle Disease, perception of farmers about climate change,

socio-economic factors of Newcastle Disease to poultry farmers, and mitigation and adaptive measures put in place to manage Newcastle Disease.

Key Informant Interviews (10 individuals) were scheduled for one veterinary officer, three livestock officers, one business officer, four business vendors, and one agriculture director at Kisii County. The informants provided supplementary data to the information collected from farmers to enhance the accuracy of the information. Secondary data was obtained regarding climatic variables (temperature and rainfall) on monthly basis from Kisii Meteorological Department (KMD) from 1990 to 2019.

### **3.4 Methods of data analysis**

Climatic variables (Minimum temperature, Maximum temperature and rainfall) were securitized for missing values and computed in the form 1990-2019 which was selected for the study period. The data was analyzed by Non- Parametric test in modified Mann-Kendall test with Sen's slope estimator (Mann, 1945) in R-Programing Studio to determine the trends of annual, monthly, and seasonal climatic variables, then presented in a graphic design drafted in Excel 2016.

Farmers' levels of awareness about climate and Newcastle Disease were assessed on a Likert scale of 5 and analyzed using the Cronbach's Alpha formula to test for internal consistency of the items (Cronbach, 2004). However, George & Mallery, (2003) suggests that the value of Cronbach's Alpha ( $\alpha \geq 0.7$ ) according to the rule of thumb is considered good. The study adopted mean weight approach for each item as 1 = Strongly Unaware, 2 = Unaware, 3 = Neutral, 4 = Aware and 5 = Strongly Aware for all the 6 statements. The level of awareness was considered as the only variable, and the chi-square test was used

to test the hypothesis. The analysis was performed in SPSS 20.0, the results were presented in tables and graphics.

The data from the questionnaire survey were entered, cleaned, coded, and analyzed in Statistical Package Social Sciences (SPSS). The data were transformed in STATA-14 and MS. Excel-2016 formats to permit various analyses. The study employed descriptive analyses such as frequencies, arithmetic mean, and standard errors to compute and describe the distribution of the field data.

Hypotheses were tested using Pearson Correlation Coefficient to test the significant relationship between the climatic variables and Newcastle Disease outbreak. The significance level for each hypothesis was decided at 5% and 1% levels of significance.

The linear regression model was used to test and show the effects of climate variables (temperature and rainfall) on Free Range Indigenous Chicken (FRIC) and the spread of Newcastle disease. The study also determined the effects of the climatic variables on socio-economic losses through climate and Newcastle Disease-related mortality. Lastly, post-estimation analysis (marginal effects) was used to quantify the effects of climate variability on chicken by mortality rate. The analysis was computed in STATA-14, thereby presented in tables and graphic format.

**Table 3.1: Summary of Research Methodology**

No	Objectives	Sources of data	Parameters	Methods of analysis
1	Examine the variability of climate change since 1990 – 2019	Secondary data: Climate data collected from KMS from 1990-2019	Climate parameters such as Rainfall, Max and Min temperatures	Non-Parametric analysis: Modified Mann-Kendell (M-K) in R Graphical presentations in Excel
2	Farmers' perception of climate variability and FRIC varieties	Primary data: Data collected from farmers' survey by use of Likert scale questionnaires	6 items about perceptions on climate variability and NCD, measured in a 5-Likert scale	Descriptive statistics: Weighted mean, Cronbach Alpha for internal consistencies in Chi-square used for inference in SPSS
3	Relationship between climate variability and occurrence of NCD	Primary data: The data were collected from farmers' survey by using short structured questions	Climate variables: Max and Min temperatures Seasons of NCD occurrence	Parametric analysis: Correlation matrix and linear regression analysis in SPSS
4	Socio-economic costs of Newcastle Disease to the poultry farmers	Primary data: The data were collected from farmers' survey by using short structured questions The observation was also used	Independent variables: Socio-economic factors e.g. sex, age, occupation e.tc The dependent variable was the number of death incidences	Descriptive statistics such as percentage, frequencies, mean, and standard deviation Parametric analysis: Multiple linear regression in STATA
5	Measures were taken by farmers to control and manage Newcastle Disease	Primary data: The data were collected from farmers' survey by using short structured question In-depth Interviews was also used	Independent variables included adaptations measures such as chicken vaccination etc. The dependent variable used or not used	Descriptive statistics such as percentages, frequencies, mean, and standards deviation Parametric analysis: Multiple linear regression to show the effects of STATA

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

#### **4.1 Introduction**

This chapter provides sequential results obtained from the field and gives a detailed discussion of the study in dependence with the objectives, thereby presenting findings in tables and graphical format, interpreting and synthesizing the findings for better decision-making and policy implications. The arrangement of the chapter takes the order; socio-economic characteristics of respondents, climate variability, farmers' perceptions, climate variability and occurrence of Newcastle Disease, socio-economic costs of Newcastle Disease, and finally presented strategies of adaptation and challenges faced by poultry farmers.

#### **4.2 Characteristics of the respondents**

##### **4.2.1 Respondent gender and education level**

Most people sampled were high school leavers (34.6%) of which 35 were male and 65 were female as shown in Table 4.1 below. The gender and educational levels were normally distributed and this led to the quality of data.

Women sampled were (46.4%) lower than that of men (53.6%), though women are the most reported keepers of chicken than men (Mulisa *et al.*, 2014) in the rural areas, however this study considered men as the household heads. The study also sampled learned people at the University level (28%), primary level people (29.6%), and people who had no education were also sampled (7.8%) as shown in Table 4.1.

**Table 4.1: Sex and level of education of the sampled respondent**

Variable	Sex of the respondent			
	Male	Female	%	
Level of Education	Tertiary/University	71	69	28.0
	High School	101	72	34.6
	Primary	73	75	29.6
	No formal education	21	18	7.8

**4.2.2 Respondents' age and their experience**

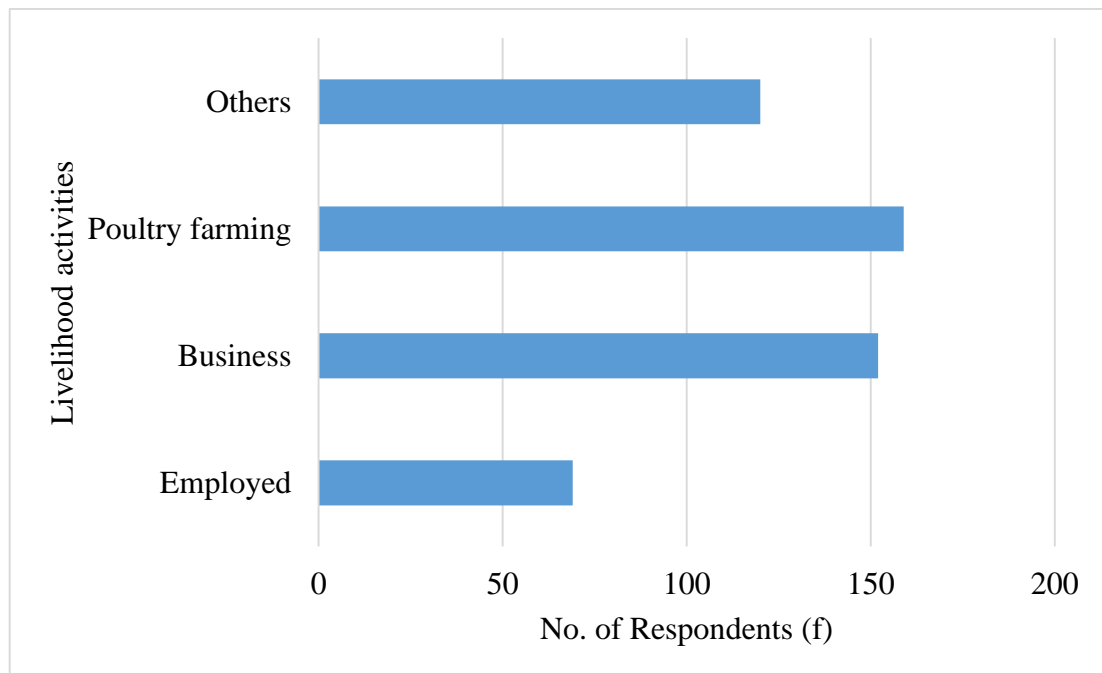
The distribution of respondents considered different ages of 35-45 (28.8%) who were knowledgeable and had an experience of more than 10years in rural poultry farming, therefore the data obtained were not bias. 26.6% of the respondents were aged between 25-35 years who had 5 years and above experience. Those respondents who were aged below 25 and above 55 years were 16% and 6.8% respectively. However, those who had more than 55 years had more than 19 years of experience.

**Table 4.2: Age and experience of the respondent**

Age	Frequency	Percent (%)	Experience (Yrs.)
Below 25	80	16.0	2.7
25 – 35	133	26.6	4.9
35 – 45	144	28.8	7.0
45 – 55	109	21.8	13.5
Above 55	34	6.8	19.2

### 4.2.3 Respondents' livelihood activities

The main livelihood activities in Kitutu Chache South Constituency were mixed farming that included poultry farming (31.8%); small-scale business (30.4%) and the employed group were (13.8%). The other activities such as artisan, carpentry, and those who were schooling stood at (24.0%), however, all the respondents practiced poultry keeping as the main source of livelihood or integrated it as part of the farming activities in their households (Figure 4.1). A review by Janetschek & Iacobuta, (2019) researchers from Stockholm Environment Institute suggested that smart farming activities against climate change are the way to end poverty and hunger in most parts of the world.

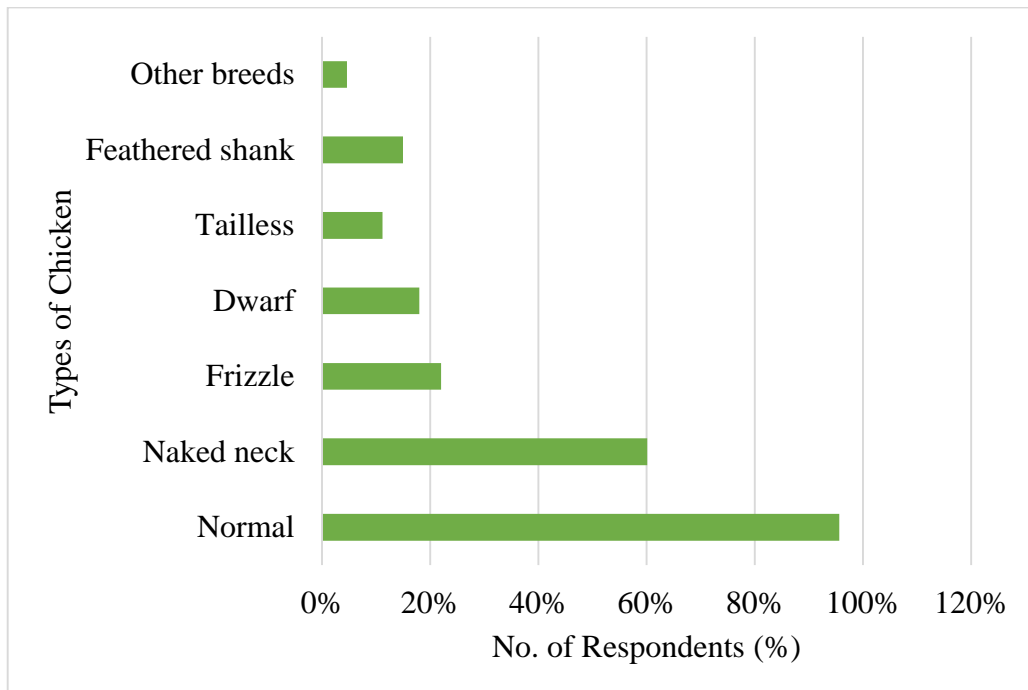


**Figure 4.1: Main Livelihood activities in Kitutu Chache South**

### 4.2.4 Types of Chicken reared

The sampled chicken were phenotypically identified by this study where normal chicken (42.2%) was the most kept type of chicken within 95.6% of the Kitutu Chache households. The naked neck (Nyaigoti Chenge-26.5%), Frizzle (Oyuyu-9.7%), Dwarf (Okuto-8.0%),

feathered shank (Nyamatisi-6.6%), Tailless (5.6%), and other forms of breed (2.0%) which included improved indigenous breeds such as Chituoni, as shown in figure 4.2 below. Phenotypic identification has been used to distinguish chicken rather than genetic variability in many parts of the world (Laenoi *et al.*, 2015).



**Figure 4.2: Reared chicken type**

### **4.3 Kitutu Chache South Climate Variability (1990-2019)**

This study analyzed climate variables of Maximum temperatures, Minimum temperatures, and rainfall patterns as the main climate variables.

#### **4.3.1 Rainfall Variability**

##### **4.3.1.1 Annual and monthly rainfall Trends**

From the analysis (Table 4.3), there were no mean annual rainfall trends for the period 1990-2019 ( $\tau = -0.067$ ;  $p = 0.617$ ; though the results showed a decrease in the annual

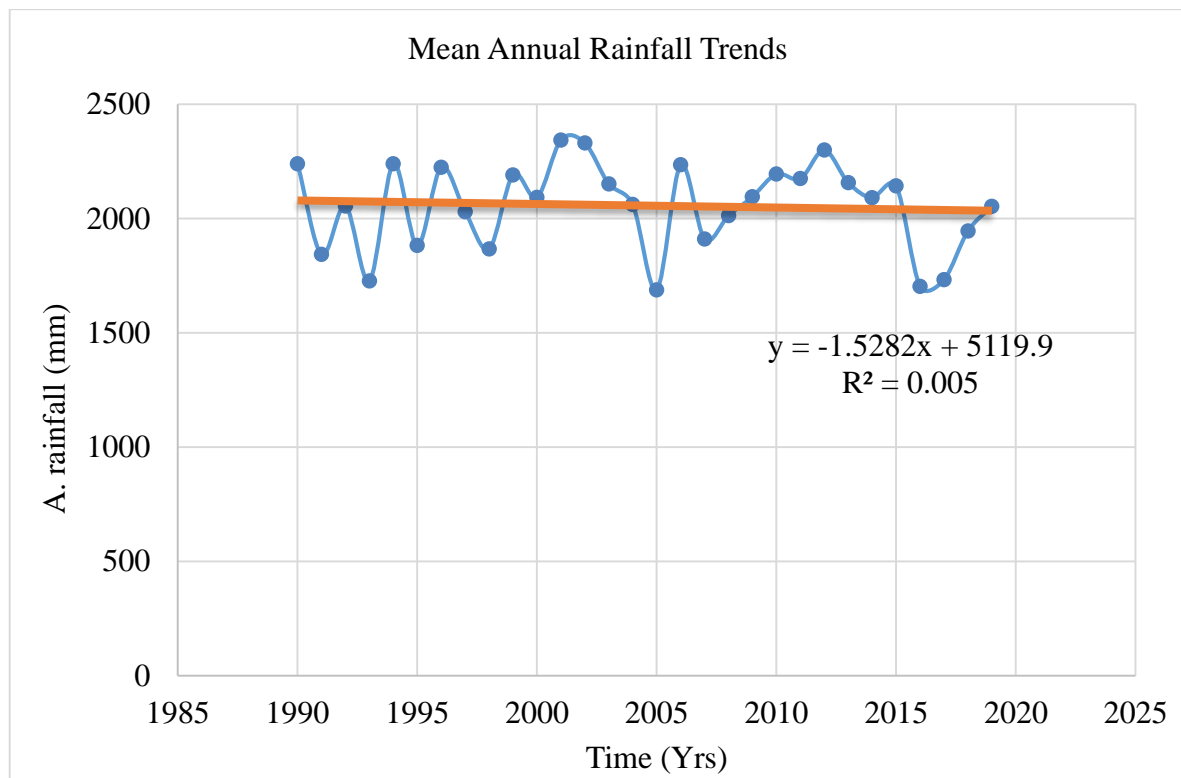
rainfall. These findings from Kitutu Chache South Constituency were in agreement with some studies such as the study in Baringo county Kenya, which found that annual rainfall in Baringo was not trending but fluctuated between 2003 and 2016. However, this study noticed that there was high variability for rainfall mean from year to year, with 2005 experiencing the lowest amount of rains in the series while 2001 recording the highest amount of rains annually.

**Table 4.3: Kitutu Chache Monthly and Annual Rainfall variability**

Months	tau	z-value	p-value
January	<b>-0.306*</b>	-2.355	0.019
February	<b>-0.391*</b>	-3.016	0.003
March	-0.062	-0.464	0.642
April	0.057	0.428	0.669
May	0.012	0.071	0.943
June	<b>-0.168</b>	-1.285	0.199
July	<b>-0.216</b>	-1.659	0.097
August	<b>0.191</b>	1.462	0.144
September	<b>0.228</b>	1.748	0.080
October	0.044	0.321	0.748
November	0.076	0.571	0.568
December	<b>0.090</b>	0.678	0.498
Annual	-0.067	-0.500	0.617

Note: \* means  $p < 0.05$

There was a significant decrease in rainfall amount received during January and February (Table 4.3). The amount of rainfall in January towards February had been decreasing in some parts of Kitutu Chache. This study found that June and July showed a declining trend in the number of rains experienced, though was not significant while September and December portrayed a positive and increasing amount of rainfall though was not significant. To conclude, there was a depressing rainfall pattern throughout the years. However, similar results were reported by a study by Bari *et al.*, (2016) in the Northern region of Bangladesh which found that pre-monsoon and post-monsoon rainfall were increasing, though there were decreases in some areas by 1.28 mm/year. Generally, the annual rainfall was fluctuating in trends as in this study all over the years as illustrated in Figure 4.3.



**Figure 4.3: Kitutu Chache mean annual rainfall trend (1990-2019)**

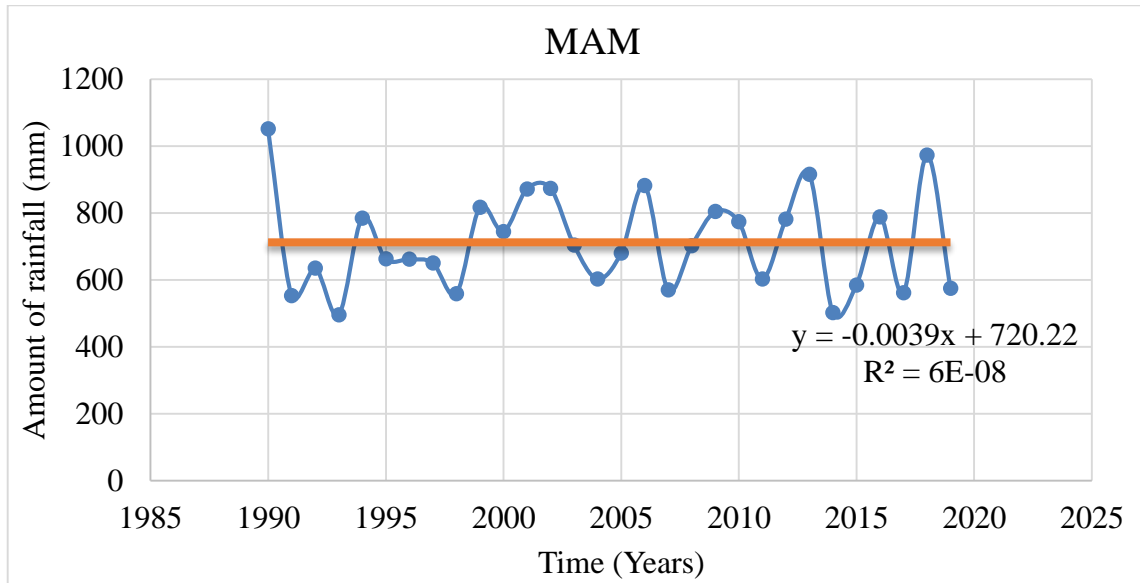
#### 4.3.1.2 Seasonal rainfall Trend

There was no significant trend in all the seasons of the year ( $p > 0.05$ ), except SON showed an increase and DJF showed a reducing trend that was not significant. The season of JJA showed a general decrease of amount rainfall with ( $p > 0.05$ ). Therefore, it implies that dry seasons of the year are becoming drier and drier (Table 4.4).

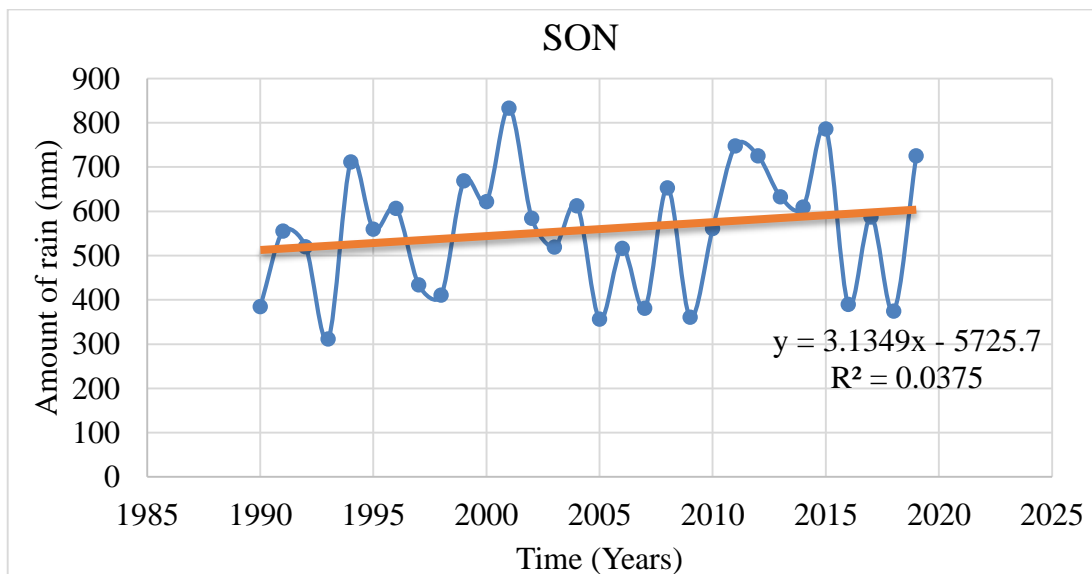
**Table 4.4: Kitutu Chache Seasonal Rainfall variability**

Seasons	tau	z-value	p-value
MAM	0.044	0.321	0.748
JJA	-0.062	-0.464	0.643
SON	<b>0.140</b>	1.070	0.284
DJF	<b>-0.229</b>	-1.726	0.084

The months of March, April and May (MAM, long rains season) were not significantly trending, though there was a positive correlation ( $\tau = 0.044$ ;  $p > 0.05$ ) and (SON, short rains) were also positively correlated ( $\tau = 0.140$ ;  $p > 0.05$ ). This implied that the MAM and SON were increasingly receiving rains though was not significant as illustrated in (Figure 4.4 & 4.5). However, Gebrechorkos *et al.*, (2020) conversely supported this study, where it was reported that the seasons of MAM and OND showed a maximum and significant variability.



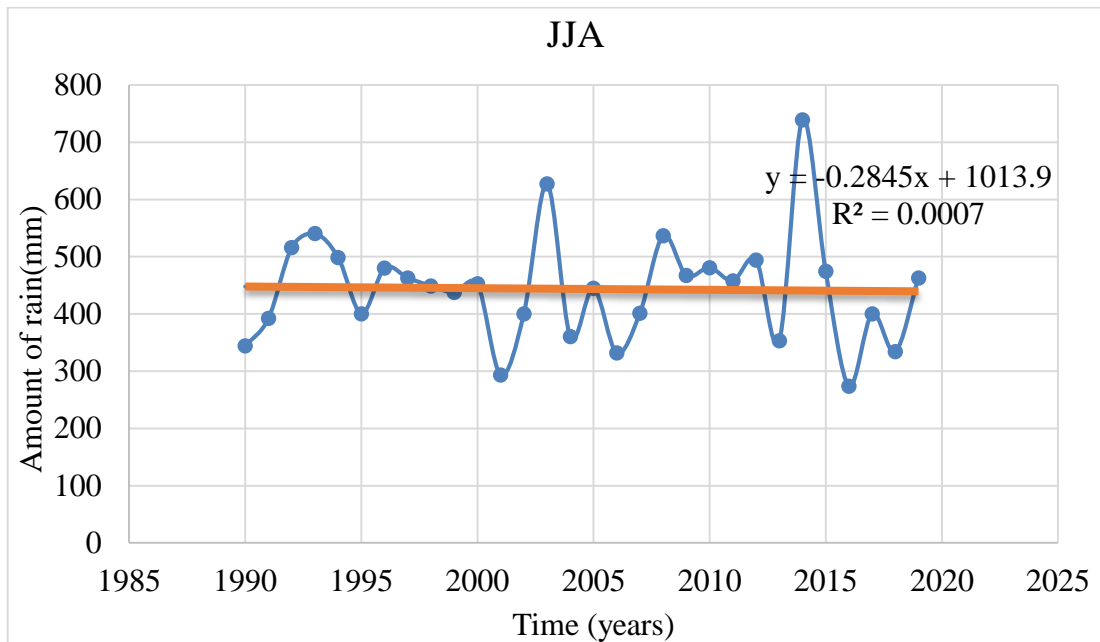
**Figure 4.4: Kitutu Chache long rain (MAM) seasonal trend (1990-2019)**



**Figure 4.5: Kitutu Chache short rain (SON) seasonal trend (1990-2019)**

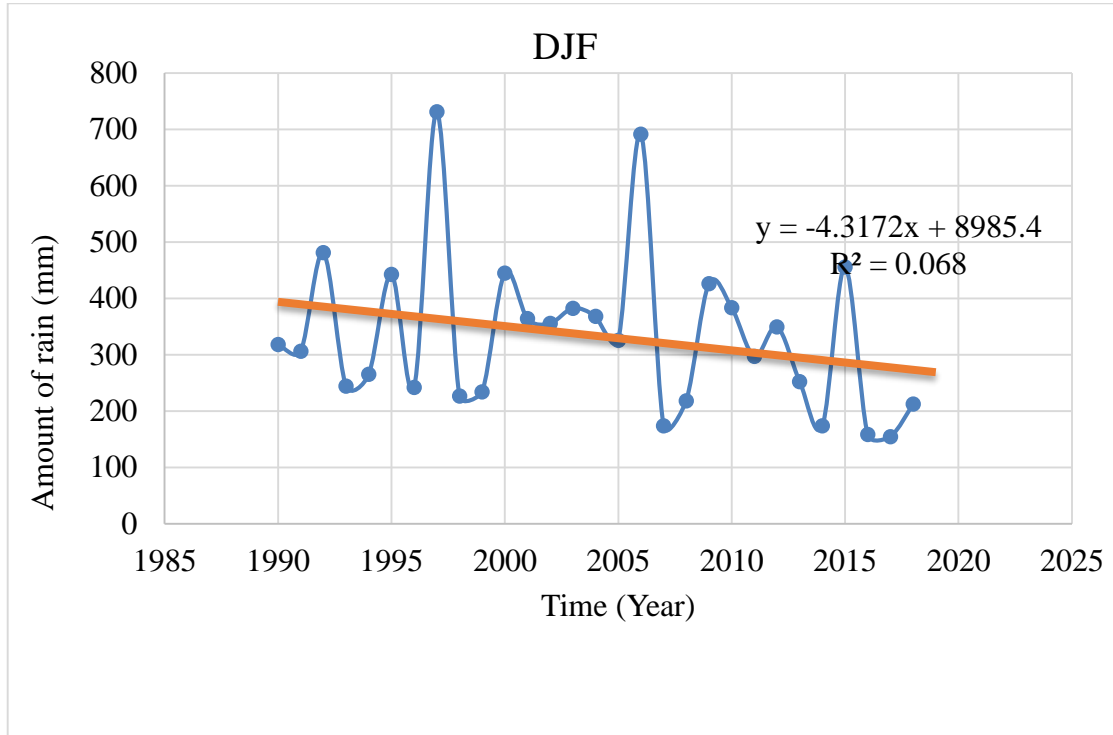
This study found that there was a negative correlation for dry periods in both short and long dry seasons (JJA and DJF) ( $\tau = -0.062$  and  $\tau = -0.229$ ;  $p > 0.05$ ) respectively. This implied that dry seasons were reducing though were not significant. The year 2014 and

2003 showed high rainfall while 2001 and 2016 were the driest years during the seasons of June, July, and August as shown (Figure 4.6).



**Figure 4.6: Kitutu Chache dry season of (JJA) trends (1990-2019)**

There was high rainfall during the years 1997 and 2006 during the dry month of December to January (Figure 4.7), however in 1997 rains were associated with El-Nino as is indicated in other studies (Sunday *et al.*, 2014).



**Figure 4.7: Kitutu Chache dry seasons of (DJF) trend (1990-2019)**

#### **4. 5: Kitutu Chache Seasonal Rainfall variability**

##### **4.4.1 Temperature variability**

##### **4.4.1.1 Monthly and Annual trends**

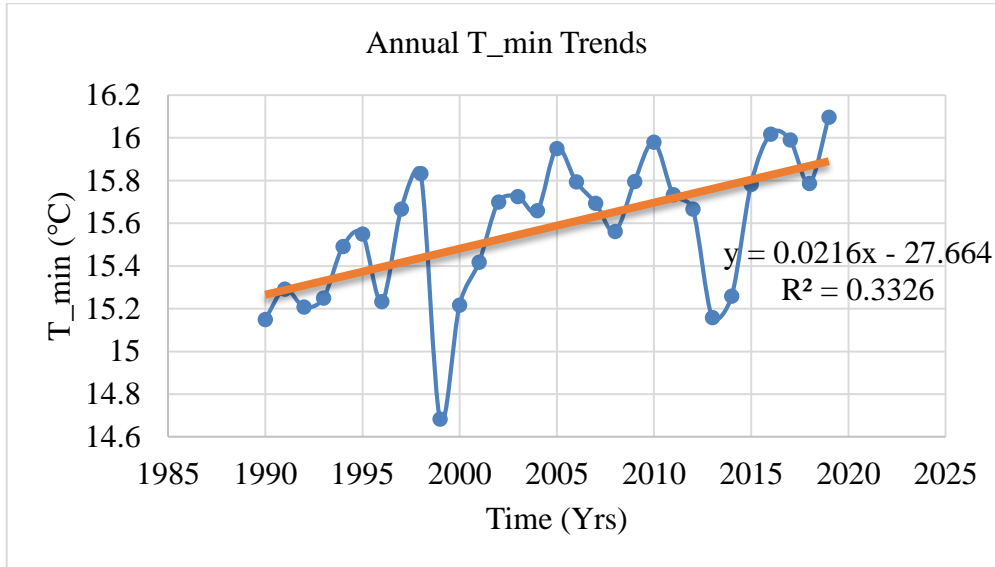
The variation of mean  $T_{min}$  and  $T_{max}$  as shown in Table 4.5 below, there were significant and positive annual correlation temperature trends from 1990-2019 ( $\tau = 0.342$ ;  $p = 0.008$ ,  $\tau = 0.476$ ;  $p = 0.0002$ ) of maximum and minimum temperatures respectively. From the results, the study deduced that there were significant increasing trends of temperatures within Kitutu Chache for a period between 1990 -2019. These results were not unique to this study, similar results had been found in other areas such as (Tabari *et al.*, 2011). Gavrilov *et al.*, (2016) in Vojvodina, Serbia found that there was a positive and significant trend in rainfall between the years 1949–2013 and 1979–2013 in the different models used.

**Table 4.6: Kitutu Chache Monthly and Annual Temperature variability**

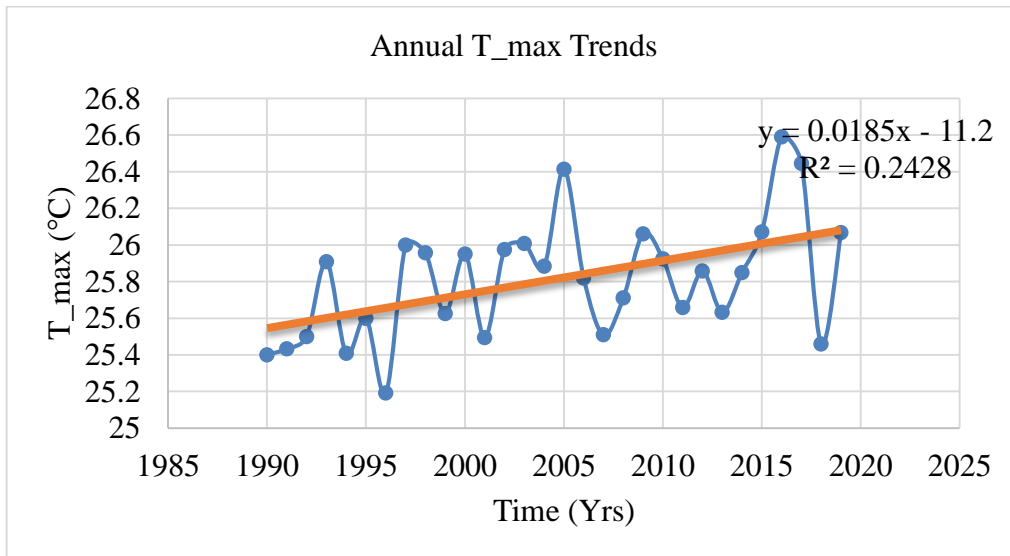
Maximum Temperatures				Minimum Temperatures		
Months	tau	z-value	p-value	tau	z-value	p-value
January	0.184	1.411	0.158	0.356*	2.751	0.006
February	0.278*	2.142	0.032	0.292*	2.251	0.025
March	0.200	1.535	0.125	0.310*	0.239	0.017
April	0.113	0.857	0.391	0.218	1.679	0.093
May	0.186	1.431	0.152	0.280*	2.161	0.031
June	0.1678	1.285	0.199	0.329*	2.542	0.011
July	0.308*	2.375	0.018	0.474*	3.665	0.0002
August	0.131	1.001	0.317	4.529*	3.505	0.0005
September	-0.122	-0.929	0.353	0.416*	3.229	0.001
October	0.032	0.233	0.816	0.368*	2.842	0.004
November	0.076	0.573	0.567	0.269*	2.086	0.037
December	-0.055	-0.413	0.680	0.280*	2.143	0.030
Annual	0.342*	2.641	0.008	0.476*	3.675	0.0002

Note: \* means  $p < 0.05$

There was a significant increase in T<sub>min</sub> for all the months from 1990-2019 in Kitutu Chache South Constituency from January to December (Table 4.5). On the other hand, observations made showed that only February and July had a significant increase in T<sub>max</sub> however, in other months of the year there was an increase in temperature but was not significant (Table 4.5). October November, and December showed no trend for T<sub>max</sub> but had a significant increase in T<sub>min</sub>. Therefore, this study concluded that temperatures were increasing at an alarming rate in Kitutu Chache South Constituency. Similar to the studies such as (Bari *et al.*, 2016 & Ferrati *et al.*, 2009) showed an increasing trend in temperature but were not significant as in this study.



**Figure 4.8: Annual Minimum temperature trends in Kitutu Chache South (1990-2019)**



**Figure 4.9: Annual Maximum temperature trends in Kitutu Chache South (1990-2019)**

#### 4.4.1.2 Temperature seasonal trends

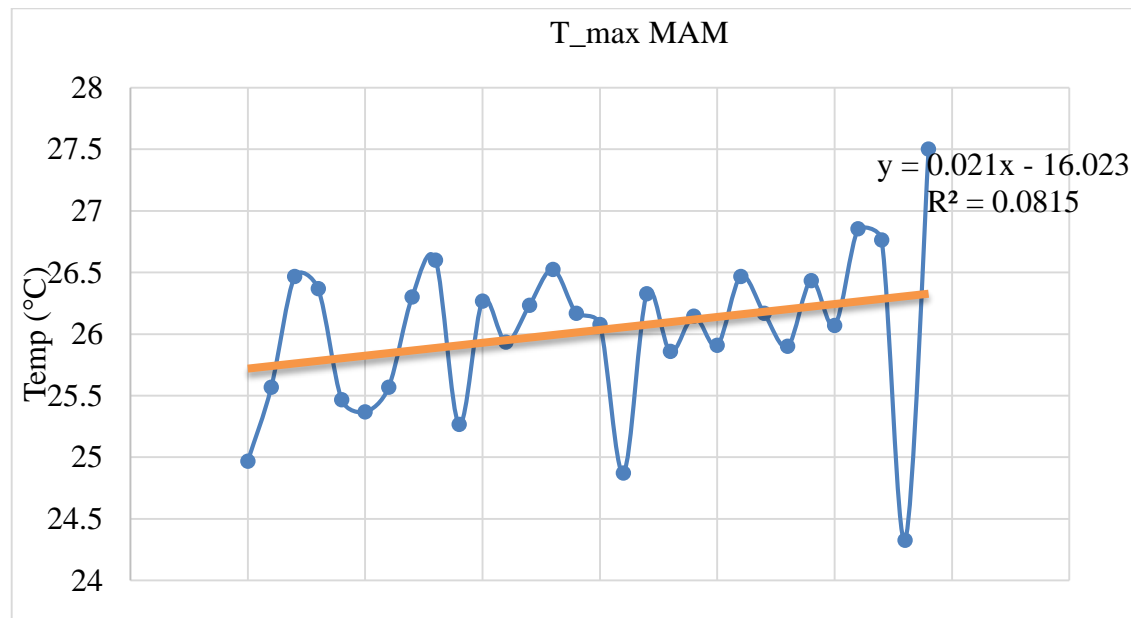
There were significant changes in T<sub>min</sub> seasonal trends during the 1990-2019 period (Table 4.6). There were no significant trends in T<sub>max</sub> temperature except JJA, which was

a warming increase due to maximum temperature increase. The seasons of SON and DJF showed a decrease in warming temperatures even though were not significant. These results were in contrast to the study, which showed high seasonal temperatures trends of DJF being warmest while JJA being the coolest.

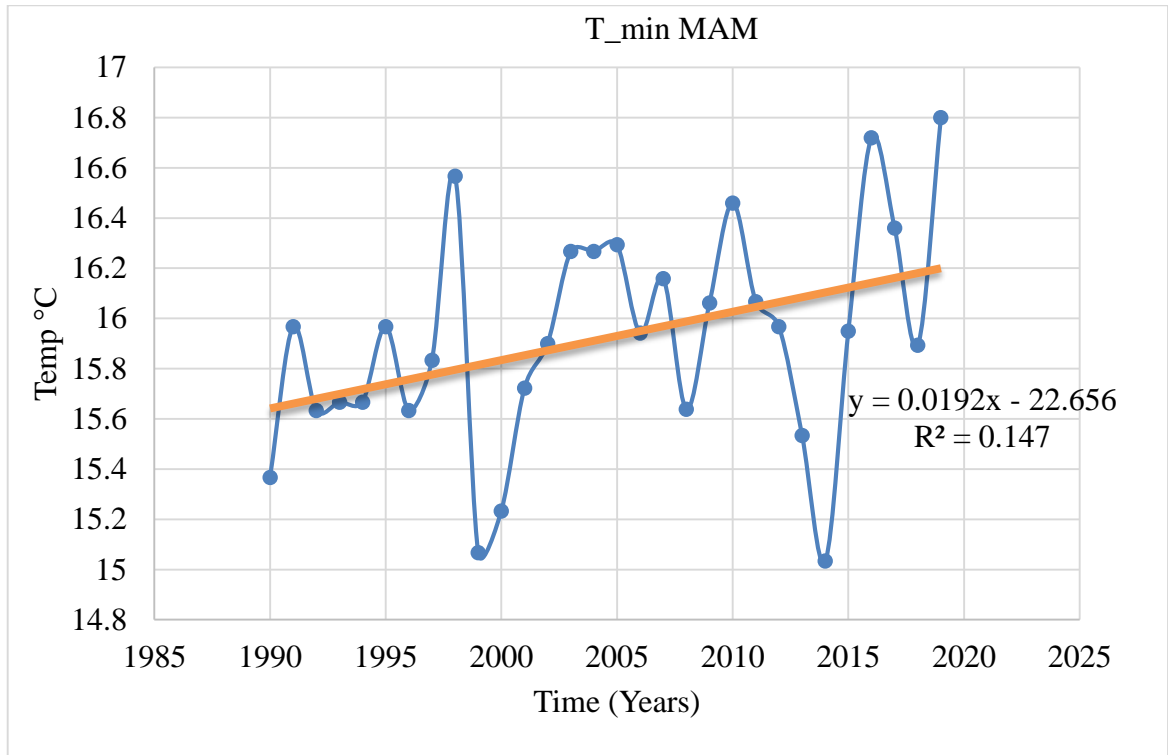
**Table 4.7: Kitutu Chache Seasonal Temperature variability**

Seasons	Maximum Temperatures			Minimum Temperatures		
	tau	z-value	p-value	tau	z-value	p-value
MAM	0.189	1.448	0.148	0.278*	2.143	0.032
JJA	0.239	1.838	0.066	0.494*	3.819	0.0001
SON	-0.053	-0.393	0.695	0.455*	3.519	0.0004
DJF	-0.053	-0.053	0.115	0.303*	2.288	0.0002

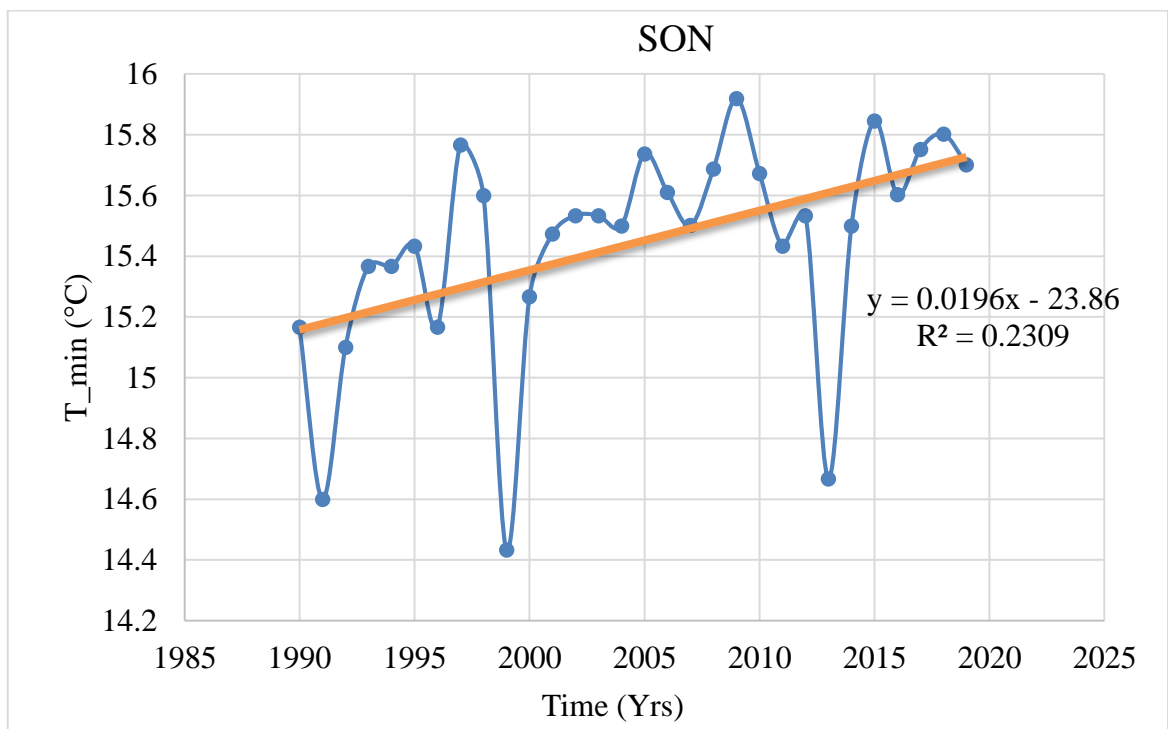
Note: \* means  $p < 0.05$  showing a change in trends



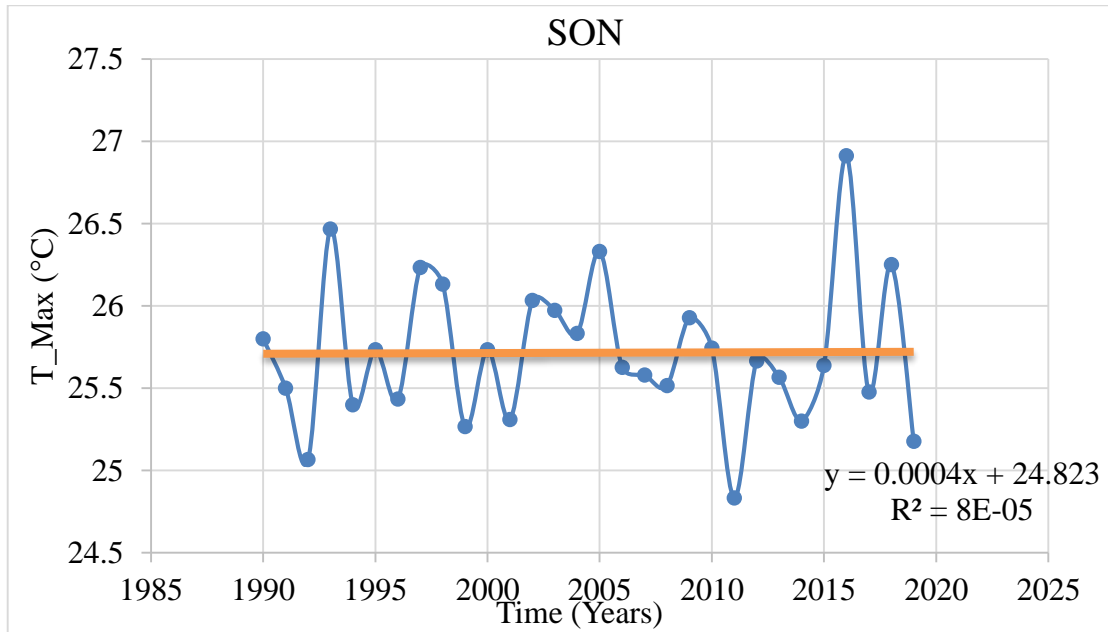
**Figure 4.10: MAM maximum temperature trends in Kitutu Chache South (1990-2019)**



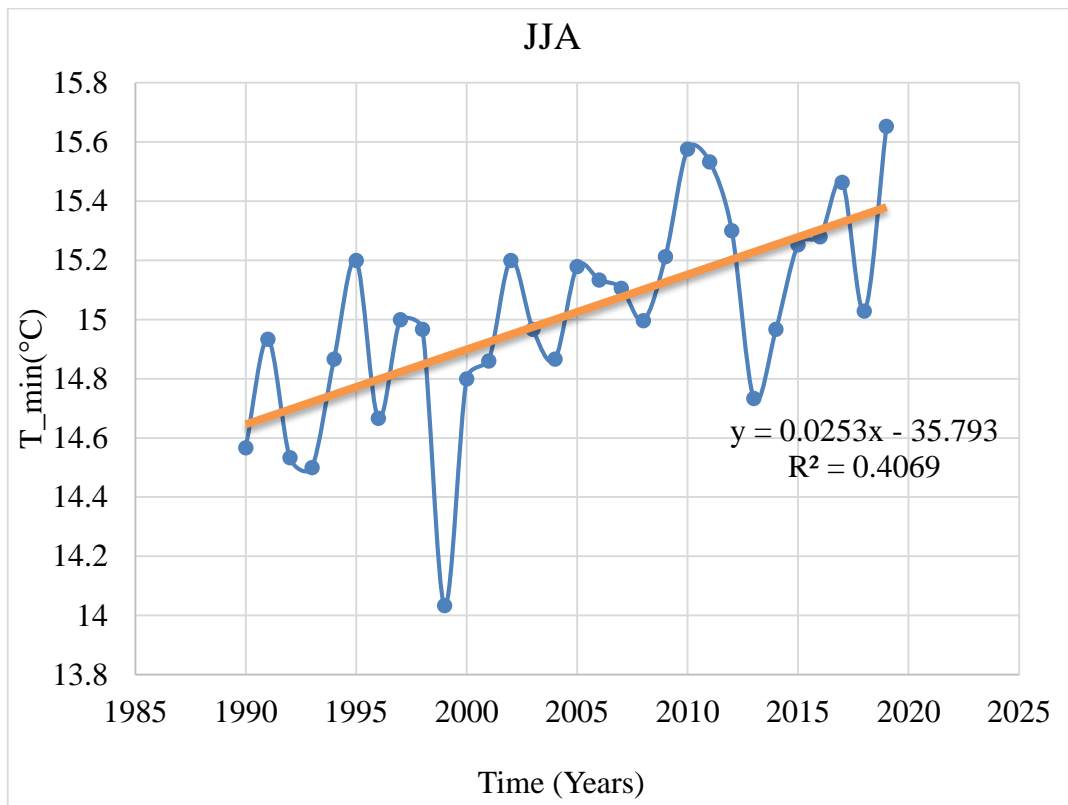
**Figure 4.11: MAM minimum temperature trends in Kitutu Chache South (1990-2019)**



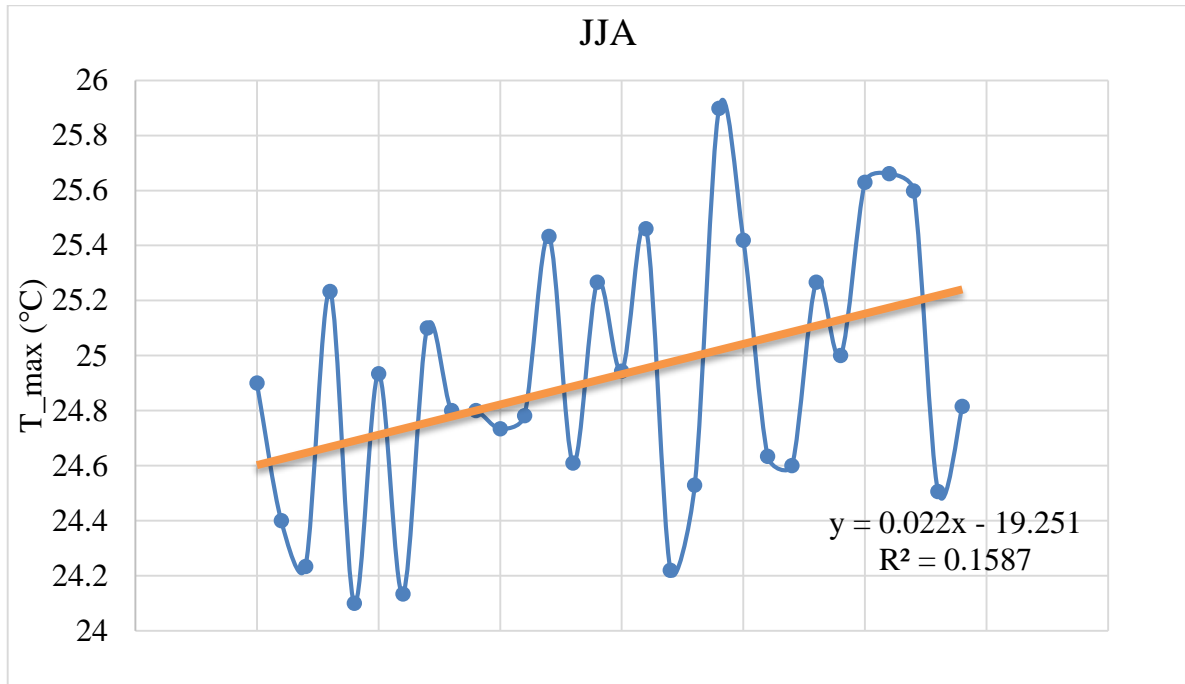
**Figure 4.12: SON minimum temperature trends in Kitutu Chache South (1990-2019)**



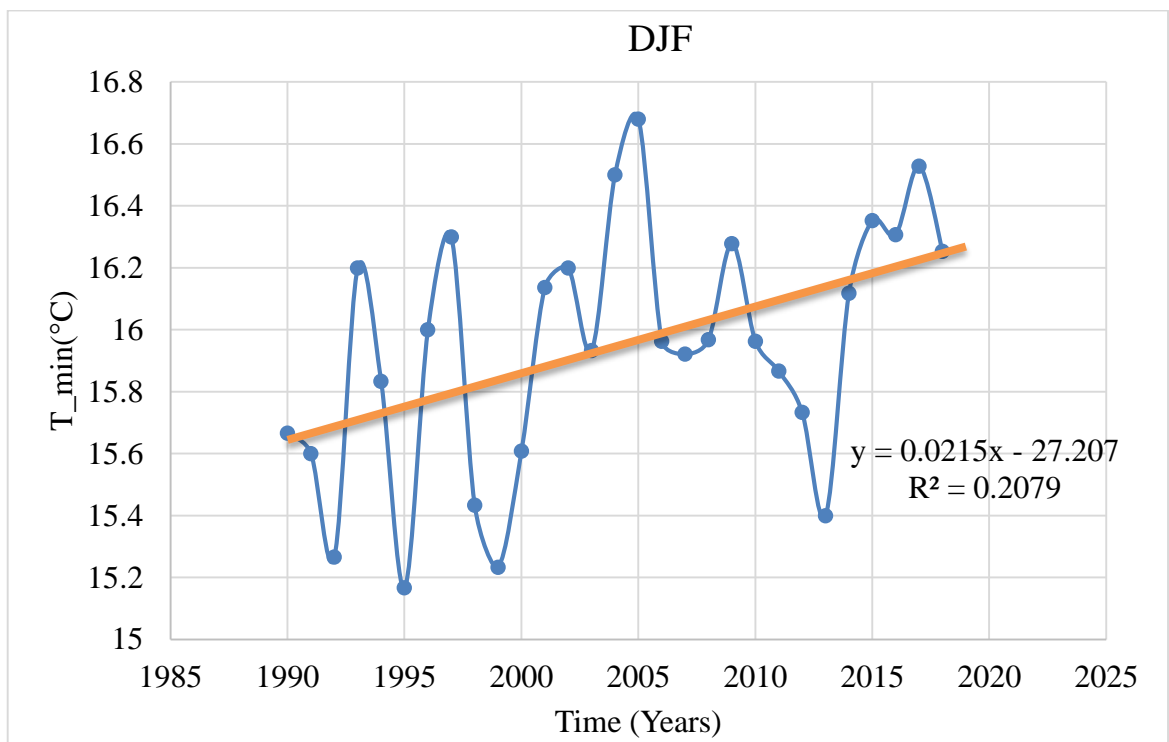
**Figure 4.13: SON maximum temperature trends in Kitutu Chache South (1990-2019)**



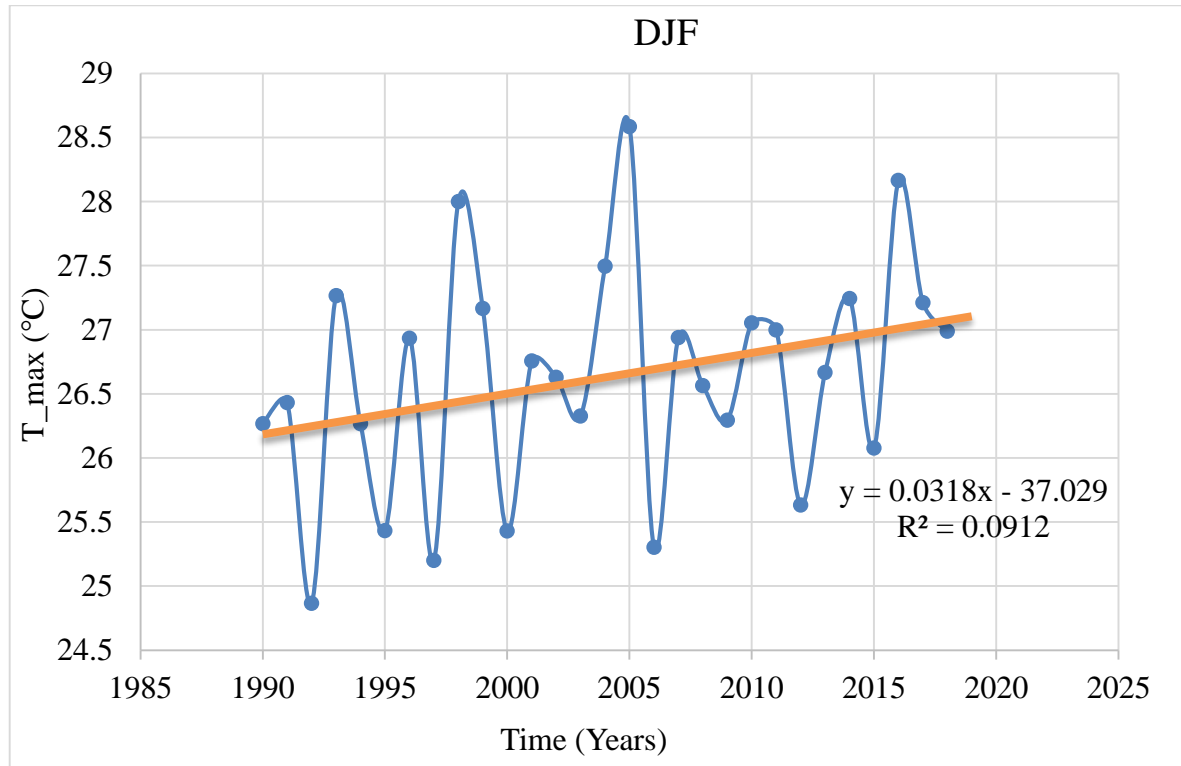
**Figure 4.14: JJA minimum temperature trends in Kitutu Chache South (1990-2019)**



**Figure 4.15: JJA Maximum temperature trends in Kitutu Chache South (1990-2019)**



**Figure 4.16: Maximum DJF temperature trends in Kitutu Chache South (1990-2019)**

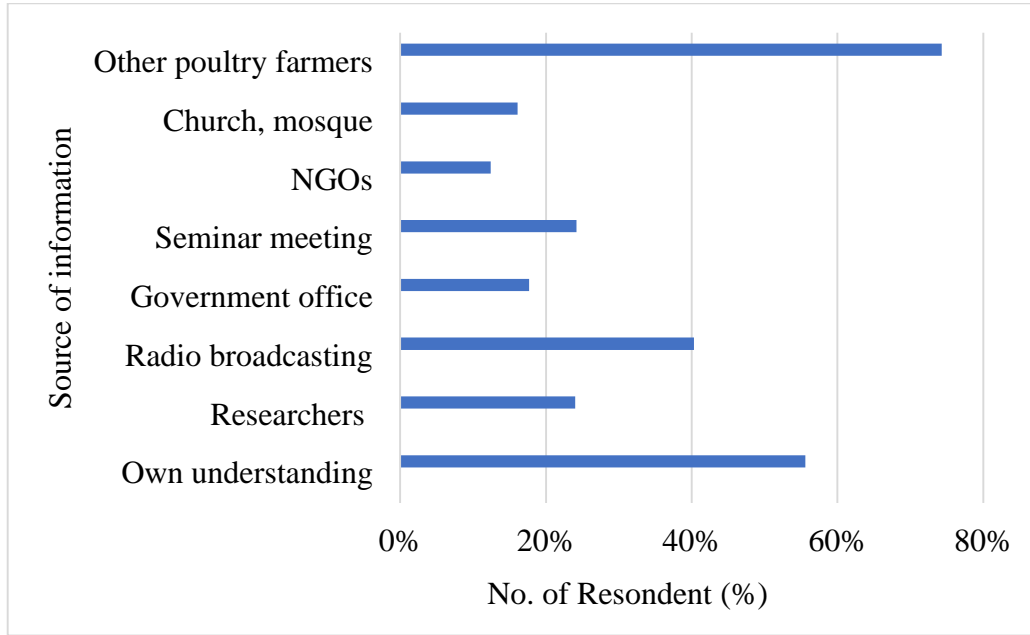


**Figure 4.17: DJF maximum temperature trends in Kitutu Chache South (1990-2019)**

#### **4.5 Kitutu Chache Poultry farmers' perceptions and information**

##### **4.5.1 Farmers' sources of information**

The study determined that the understanding of climatic conditions and their impacts on poultry production by farmers is vital to improving adaptability. Kitutu Chache farmers perceived climate change as constraining the productivity of poultry farming. However, the information to perceive climate change effects come from different sources as shown in (Figure 4.18) below. Most of the farmers received information about climate change from other farmers in the neighborhood (28.1%); those who had their own understanding (21.0%); from radios (15.2%); from Government offices (6.7%); from Non-Governmental organizations (4.7%); from church and other religious practices were (6.1%); and finally, from researchers and seminar training stood at 9.1% and 9.2% respectively.



**Figure 4.18: Farmer’s source of information**

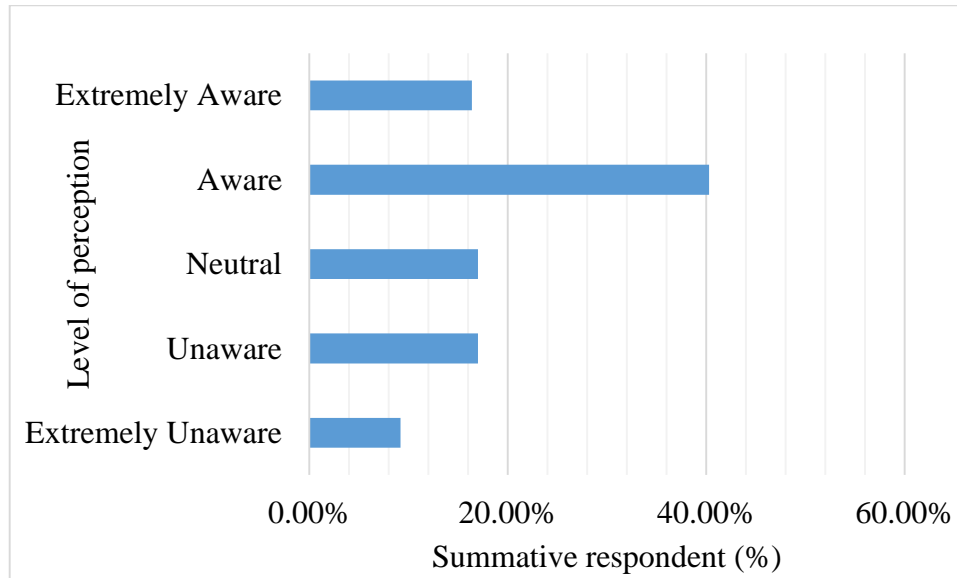
#### **4.5.2 Farmers perception about climate variability and Newcastle Disease**

The results in this study showed reliable consistency of Cronbach’s Alpha ( $\alpha$ ) = 0.712. The study found that farmers in Kitutu Chache were significantly aware of climate variability and its effects on Newcastle Disease ( $\bar{X}^2 = 68.17$ ;  $df = 5$ ;  $p = 0.000$ ). However, all the items had a weighted mean ranging from 3.01 to 4.00, which showed that farmers were aware of all the items, which were in question (Table 4.7). Studies of Namdeo & Rout, (2016) and Ochieng & Koske, (2013) in different parts of Kenya used the same procedure of analysis and found that their respondents were significantly aware of climate change and its effects.

**Table 4.8: Weighted mean of farmers' perceived items**

<b>Statements</b>	<b>Mean</b>	<b>Rank</b>	<b>Std. Dev</b>	<b>X<sup>2</sup></b>	<b>df</b>	<b>P</b>
Chicken fertility is reduced	3.25	IV	1.33	68.17	5	0.000
Climate variability adds heat stress to the chicken	3.61	I	1.13			
Anomalies in climate increase the spread of ND	3.46	III	1.13			
High temperatures led to the spread of Newcastle disease	3.14	V	1.16			
Climate has led to the spread of the disease	3.33	IV	1.17			
The weight of the chicken is reduced	3.47	II	1.24			

Most of the poultry farmers were aware (40.3%) of the effects of climate change on Newcastle disease by spreading the virus during extreme climatic events. 16.4% were extremely aware, 9.2% were extremely unaware, 17.0% of the respondent were neutral or unaware of the effects of climate change on poultry production in Kitutu Chache South Constituency as shown (Figure 4.19).

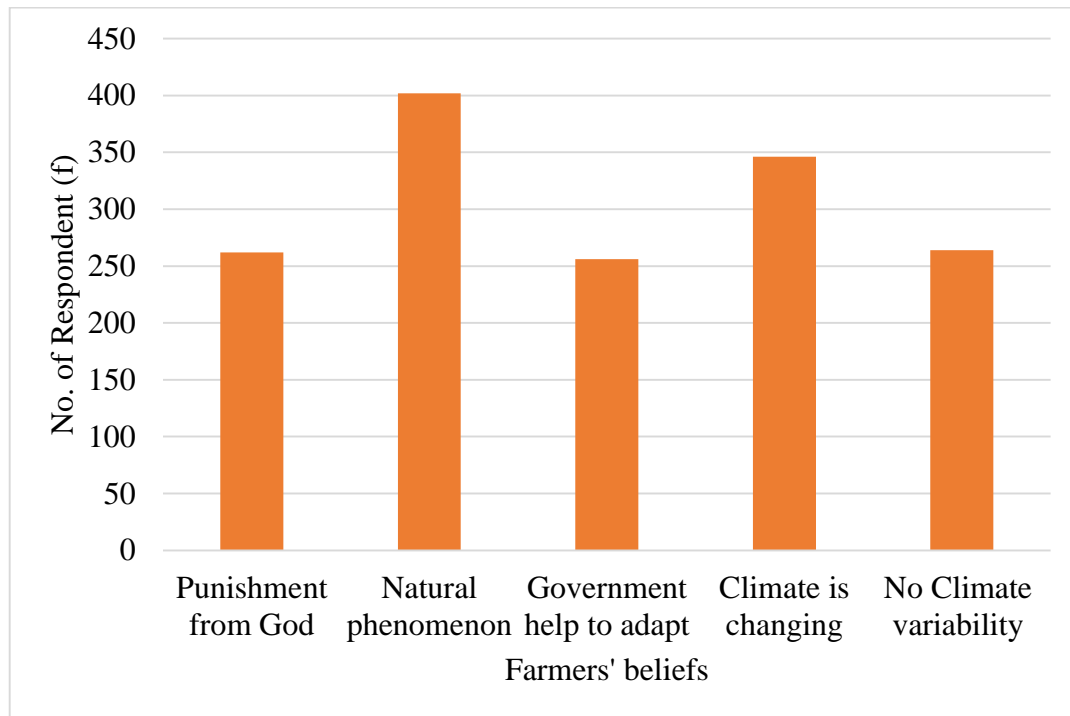


**Figure 4.19: Summative level of awareness about Climate variability and Newcastle Disease**

The same results were also found in other studies, that farmers are significantly aware that climate change and its impacts affect FRIC in both the developed and developing nations (Zamasiya *et al.*, 2017). In conclusion, 33.6% of the farmers were not sure of the future of poultry farming, 33.0% had been optimistic that the future would be good, 19% worse, and only 8.0% agreed that future poultry farming in Kitutu Chache would be very good when adaptation measures were put in place.

However, farmers' beliefs determined the measures taken against climate variability in Kitutu Chache South Constituency. 61.2% of the population believed in climate change and its effects while 38.8% did not believe in climate change. 26.3% of the farmers believed that climate change is a natural phenomenon, 17.1% believe that climate change is a punishment from God, 16.7% of the population believed that only Government can help to adapt against climate change as shown in figure 4.20. These results agreed with many studies on farmers' beliefs about climate change worldwide, that most of the farmers

believe about climate variability and its effects on the agricultural outputs (Luu *et al.*, 2019).

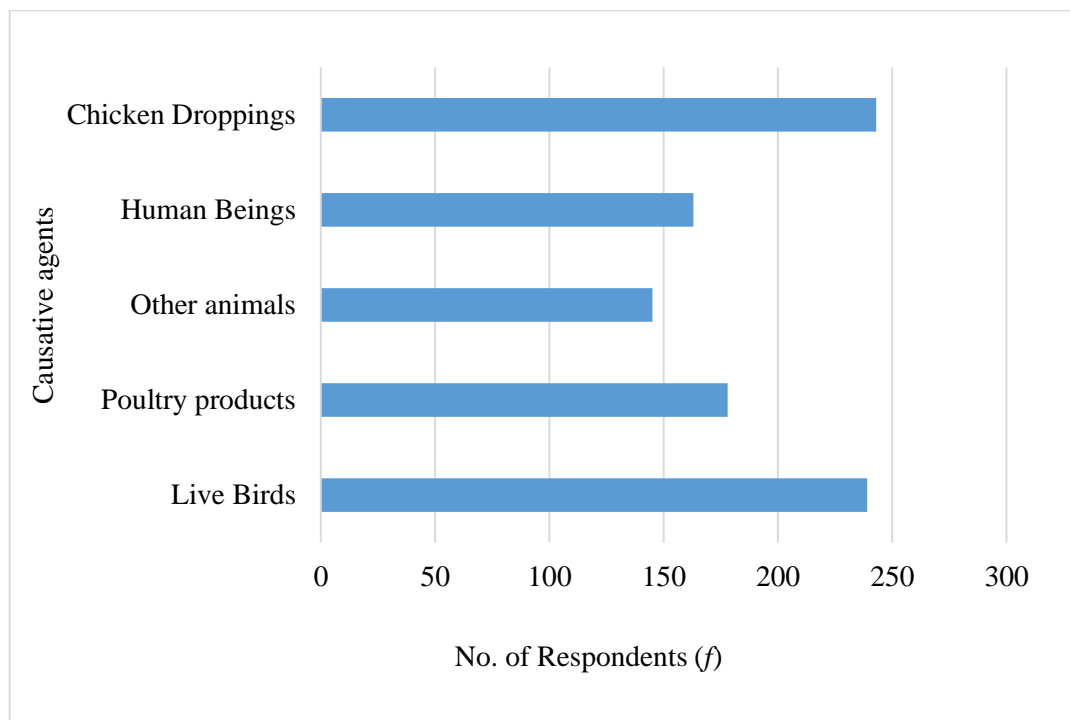


**Figure 4. 20: Respondents belief about climate variability**

#### **4.6 Climate variability and Newcastle Disease**

##### **4.6.1 Causative agents of the spread of Newcastle Disease**

Some causative agents drive the spread of Newcastle Disease virus such as chicken droppings (25.1%) compared to other factors that cause the spread of Newcastle Disease. Live birds (24.7%), infected poultry products (18.4%), human factors (16.8%), and other animals like cats and dogs that consume infected birds also contribute to the spread of Newcastle disease by (15.0%). These results were supported by the study of Brown & Bevins, (2017) and Nyaiyo, (2014). The causative agents of this study are further illustrated in the graph (Figure 4.21) as shown below

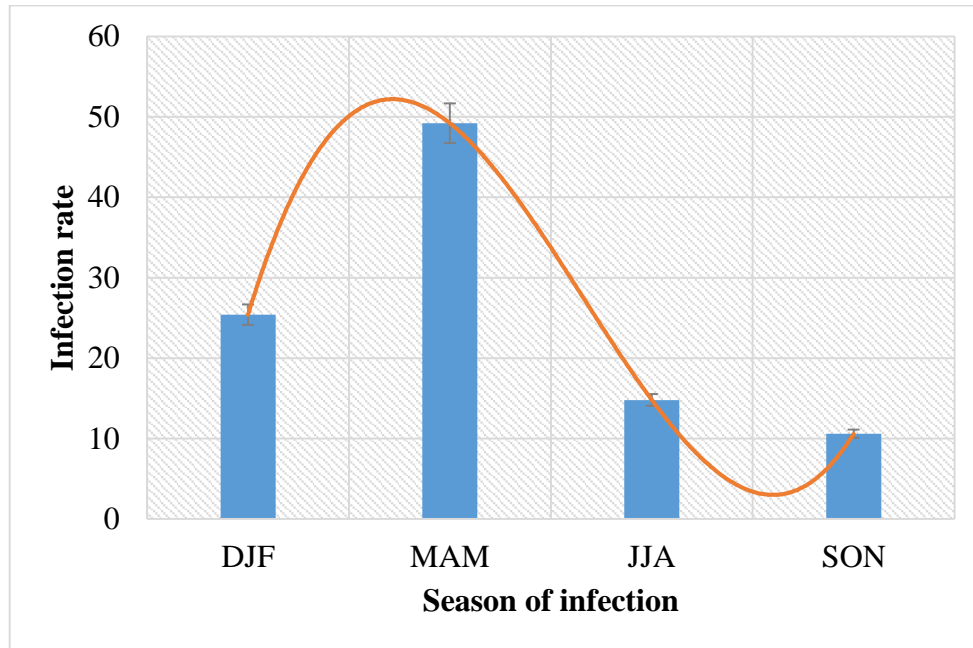


**Figure 4.21: Causative agents of Newcastle Disease Spread and number of respondents**

#### **4.6.2 Seasonal Trends of the Newcastle Disease Virus (NDV) and Poultry mortality**

The months of March, April, and May (MAM) marked the highest (49.5%) emergence of Newcastle Disease Virus Figure 4.22. The disease spreads so quickly causing high mortality of Free Range Indigenous chicken (FRIC) during MAM season due to high rainfall which is conducive for virus survival (Ferreira *et al.*, 2019). The months of December, January, and February (DJF) marked (25.4%) of chicken deaths, and the month of June, July, August (JJA) marked (14.8%) of chicken deaths and finally, the month of September, October, and November (SON) marked the lowest (10.3%) of death cases due to spread of Newcastle Disease (Figure 4.22). The results implied that dry seasons would reduce the number of death cases, however post-dry season periods would report more deaths (Wondmeneh *et al.*, 2016). The results from this study were in agreement with

studies done by Nyaiyo, (2014) from Kenya and Tilakasiri, (2015) from Nigeria, whose findings reported that in March and April there were more deaths of chicken due to adverse weather conditions such as high rainfall than other seasons of the year. It is therefore, deduced that seasonal climate variations (temperature and rainfall) affect the spread of the Newcastle Disease virus to FRIC in most of the rural households (Henning *et al.*, 2013).



**Figure 4.22: Seasonal spread of Newcastle Disease and Death of FRIC.**

#### 4.6.3 Correlation matrix of climate variability to spread of NDV (APMV-1)

There was a significant correlation of ( $p < 0.01$ ) among all the predictor variables (NDVt, T<sub>min</sub> T<sub>max</sub> and rainfall). NDVt were positively correlated with rainfall ( $r = 0.352$ ;  $p < 0.01$ ); and negatively correlated with maximum and minimum temperature (T<sub>max</sub> = -0.966 and T<sub>min</sub> = -0.778;  $p < 0.01$ ). The positive correlation between T<sub>max</sub> and T<sub>min</sub> ( $r = 0.808$ ;  $p < 0.01$ ; (Table 4.8) showed similar association between temperature variables. A weak relationship was realized between temperature and rainfall with T<sub>Max</sub> ( $r = -0.33$ ;  $p < 0.01$ ) and T<sub>min</sub> ( $r = 0.266$ ;  $p < 0.01$ ; (Table 4.8).

**Table 4.9: Correlation matrix of Predictor variable to spread of NDV**

Variables	NDVIt	Rainfall	T_max	T_min
NDVIt	1.0000			
Rainfall	0.3520**	1.0000		
T_max	-0.9664**	-0.3304**	1.0000	
T_min	-0.7777**	0.2658**	0.8075**	1.0000

Note: \*\* means  $p < 0.01$  at significance level

The above (Table 4.8) indicated that climate factors are associated with Newcastle Disease outbreaks due to fluctuations in environmental conditions, which favors the spread of the APMV-1 virus. Studies such as Dimitrov *et al.*, (2016) and Ferreira *et al.*, (2019) consistently argued that pathogen and virus-causing organisms were favored by environmental conditions. However, Key Informant respondents from the study area also supported these arguments; “Pathogen survive and multiply depending on climate/ weather variability. Likewise, when the temperature is either too high or low, egg production and live weight are affected...” Kisii County Business Development officer.

#### **4.6.4 Effects of Climate variability on the spread of Newcastle Disease virus**

The study used regression analysis to measure the effects of climate variables on seasonal deaths of chicken due to the spread of Newcastle Disease in Kitutu Chache South Constituency (Table 4.9) below. During the analysis maximum temperature was omitted in the regression model because of the high correlation with minimum temperature ( $r^2 = 0.808$ ;  $p < 0.01$ ) that would cause collinearity in the results. There was a positive and significant increase in chicken deaths due to rainfall variability ( $p < 0.001$ ) which favored the spread of Newcastle Diseases among chickens. While there was a negative and

significant decrease of chicken deaths with increased minimum temperature ( $p < 0.001$ ) which reduces the spread of Newcastle Disease. Generally, the study deduced that climatic factors have potential effects on the Newcastle disease spread among Free Range Chicken.

**Table 4.10: Regression coefficient showing the effects of climate factors on seasonal deaths of chicken due to outbreak of NDV (APMV-1)**

<b>Variables</b>	<b>Coefficient</b>	<b>Std. Err</b>	<b>T</b>
Rainfall	0.003***	(0.0001)	22.62
Minimum temp.	-2.357***	(0.0620)	-38.00
Constant	37.56***	(0.958)	39.21

\*\*\*means  $p < 0.001$  at significance level

It is reported from other studies that adverse climate conditions increase the emergence of Newcastle disease (Nyaiyo, 2014 & Tilakasiri, 2015) these results were in agreement with this study's results. Increasing temperatures increases the spread of Newcastle disease among chickens, as temperature reduces the frequency of chicken's death occurrence. It is reported that high rainfall limits Free-range indigenous chicken behaviors within their environment; the cold environment affects the breathing systems of chicken.

#### **4.7 Socio-Economic Cost of Newcastle Disease**

##### **4.7.1 Economic costs of climate variability on chicken production**

There was a positive and significant relationship between prices of infected chicken and rainfall variability ( $r = 0.083$ ;  $p < 0.05$ ) while there was also a positive and insignificant relationship between prices of infected chicken and minimum temperature ( $r = 5.318$ ;  $p > 0.05$ ) as shown in Table 4.10. These results implied that as climate variables change, there is a change in the prices of chicken due to the outbreak of Newcastle disease.

**Table 4.11: Analysis showing the effects of climate variability on prices of infected chicken due Newcastle Disease spread**

	<b>Coefficient</b>	<b>p-value</b>	<b>t</b>	<b>Std. Error</b>
Rainfall	0.083*	0.030	2.18	0.038
Min. temperature	5.318	0.778	0.28	18.84
Intercept	106.4	0.715	0.37	291.0

Note: \* means  $p < 0.05$  at significance level

**Table 4.12: Predictive price marginsa**

<b>margins</b>	<b>T</b>	<b>P</b>	<b>St. Err</b>
236.77	39.67	0.000	5.96

Economically, the marginal effect results showed that farmers had the probability of losing an average of KES. 236.78 Per small change of climate conditions (Table 4.11). Moreover, these results were in agreement with respondents' opinion that they would lose an average of KES.350.84 per chicken during the outbreak of Newcastle Disease. Similarly, studies by Henning *et al.*, (2013) from Myanmar also reported that prices of chicken would reduce by 28.8% due to Newcastle Disease in poultry and also additional cost on vaccines.

In addition, poultry farmers reported that extreme alternating wet and dry seasons would affect eggs and meat production amongst the chicken breeds. In that instance, 60.6% of the farmers reported that extreme fluctuations of wet and dry weather conditions would increase eggs and meat production while 39.4% reported that alternating wet and dry conditions would decrease eggs and meat production in chicken (see Table 4.12).

**Table 4.13: Alternating dry and wet seasons**

<b>Response</b>	<b>Frequency</b>	<b>Percent (%)</b>
Increase	303	60.6
Decrease	197	39.4
Total	500	100.0

In the analysis of Severe and prolonged dry spell, it was observed that 22% of the respondents of the farmers agreed that severe and pronged dry spells increased the spread of Newcastle Disease and therefore caused reduction of chicken productivity while 78% of the farmers agreed that prolonged dry spells would reduce chicken productivity (Table 4.13).

**Table 4.14: Severe and prolonged dry spell**

<b>Responses</b>	<b>Frequency</b>	<b>Percent (%)</b>
Increase	110	22.0
Decrease	390	78.0
Total	500	100.0

Most of the studies reported that the spread of Newcastle Disease during the dry season was not as much as in wet seasons therefore most of the effects of Newcastle Disease are felt during wet seasons (Salinas-Ramos *et al.*, 2019). In addition, 82.8% of the respondents reported that high temperatures and high amounts of rainfall could reduce the production of chicken among farmers' households of Kitutu Chache South Constituency, of which 17.2% of the respondents (Table 4.14) suggested that high temperatures and rainfall could increase the production of the eggs and meat in chickens.

**Table 4.15: High temperatures and rainfall**

<b>Response</b>	<b>Frequency</b>	<b>Percent (%)</b>
Increase	86	17.2
Decrease	414	82.8
Total	500	100.0

The above results were in agreement with many studies around the world, that suggest that an increase in temperature reduces the quality and number of eggs hatched by chicken (Kingori *et al.*, 2010). The survey from Kitutu Chache South farmers deduced that weather conditions were a great factor in the contribution of chicken levels of production. Conclusively, the occurrence of Newcastle Disease happened every year and its effects have huge losses resulting from deaths, reduction in egg production, fluctuation of prices of chicken in the market, and increase in production costs through the purchase of drugs and vaccination.

#### **4.7.2 Relationship effects of socio-economic factors on death occurrence of chicken**

This research study tested how socio-economic factors could affect the death occurrence of Chicken due to the spread of the Newcastle Disease virus. The socio-economic factors included, age of the respondent, level of experience of the farmer, and level of education.

The study found out that the experience of the farmer was significantly associated with the death occurrence of chicken ( $p < 0.05$ ). On the other hand, there was no significant correlation between the age of the farmer, farmers' level of education, number of chickens reared, and the main occupation of the farmer and size of the family with the occurrence of chicken's death during the outbreak of Newcastle Disease ( $p > 0.05$ ; Table 4.15) in Kitutu Chache South.

**Table 4.16: Linear regression between socio-economic factors and number of deaths occurrence for chicken reared**

<b>Variables</b>	<b>Coefficients</b>	<b>Std. Error</b>	<b>t-value</b>	<b>p-value</b>
Age of the farmer	0.428	1.205	0.36	0.722
Experience of the farmer	7.018	2.145	2.722	0.156
Level of education	-4.691	1.267	-3.71	<b>0.000</b>
Household size	0.021	0.423	0.05	0.816
Marital status	-2.205	2.626	-0.84	0.403
Main occupation	0.36	1.069	0.34	0.736
<b>Intercept</b>	<b>38.999</b>	<b>6.755</b>	<b>5.77</b>	<b>0.000</b>
	R-squared =	0.0557		
	Prob > F =	0.0002		
	F (7, 492) =	4.14		

**\* Means  $p < 0.05$**

There were positive and significant correlations between farmers' levels of experience and death occurrence among chicken due to the spread of Newcastle Disease. This implied that as the level of experience increases the handling and caring of chicken against Newcastle Disease also improves. Therefore, improving adaptation methods would depend on the years of experience of the farmer (Ansari *et al.*, 2018).

There was a negative and insignificant correlation between marital status and occurrence of chickens' death due to Newcastle Disease with Kitutu Chache Constituency in Kenya. However, single households and married people would have different perceptions and handling care of chicken against the effects of Newcastle Disease (Mabuku *et al.*, 2019).

The number of chickens was positively and insignificantly correlated with the occurrence of chicken death, this implied that death occurrence of chicken would increase in number though were not significant ( $p > 0.05$ ). During the outbreak of Newcastle Disease among FRIC, a large and crowded number of flock would speedily spread the Newcastle Disease virus to other chicken (Laenoi *et al.*, 2015).

The age of the farmer was positive and insignificantly correlated with the occurrence of chicken's death among the household of Kitutu Chache South, which implied that a decrease in ages would increase the deaths of Chicken though was not significant. Mabuku *et al.*, (2019) noticed that older household heads were keen on the adaptation methods than young people, and therefore would take care and handle poultry chicken effectively to improve productivity.

The level of education was negative and significantly correlated with the death occurrence of chicken; these results meant that as the level of education reduced, there were increased chickens' death. Highly educated people would have the knowledge to handle and care for chickens during the outbreak of Newcastle Diseases as compared to illiterate people. Ali & Erenstein, (2017) noted the same results as in this study, where they found that highly educated people would adapt better against the spreading diseases of livestock due to climate variability as compared to people with little knowledge.

There was positive and insignificant correlation between household sizes to the death occurrence of chicken in Kitutu Chache South, which implied that as the number of people in the household increased, the chickens' death due to Newcastle Disease also increased. Human beings are regarded as causative agents of Newcastle Disease spread among chickens (Sultan *et al.*, 2020). Thus, a human being needs to take precautions when

handling chicken during the outbreak of Newcastle Disease. The results showed that there was a negative and insignificant correlation between farmers' main occupation and the death occurrence of chickens during the outbreak of Newcastle Disease. The occurrence of chickens' death reduced with increased farmers' concentration of poultry farming as the main occupation (Wong *et al.*, 2017) hence farmers would handle and care for the chicken as the main sources of livelihoods in the households. Generally, the socio-economic factors had an influence on chicken death occurrences and control of Newcastle disease among chickens in Kitutu Chache South.

#### **4.8 Farmers' adaptation methods against the spread of Newcastle Disease**

Adaptation measures can reduce the negative impacts of climate change and the spread of poultry diseases. The study found out that farmers use different methods to control the disease. There was significant use of movement restriction, vaccination of chicken, and use of traditional herbs, receiving support from authorities, prior selling of infected chicken and prior consuming the infected chicken, (See Table 4.17). The poultry farmers in Kitutu Chache South Constituency did not significantly use improved Kienyeji breeding, improved feedings and burying of the infected chicken (see Table 4.17).

**Table 4.17: Descriptive analysis of adaptation methods**

<b>Variable (dummy)</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
Adapted to Newcastle Disease	1.252	0.435	1	2
Improved FRIC breeding (Kienyeji)	1.548	0.498	1	2
Restrict movement of the Chicken	1.458	0.499	1	2
Vaccination of chicken	1.320	0.467	1	2
Use of traditional herbs	1.676	0.469	1	2
Use of Improved chicken feedings	1.602	0.490	1	2
Receive supports relevant authorities	1.814	0.389	1	2
Prior selling of infected chicken	1.636	0.482	1	2
Prior consuming infected chicken	1.798	0.402	1	2
Burly died and infected chicken	1.488	0.500	1	2

**Table 4.18: Linear regression results of adaptation measures that are used to increase chicken production due Newcastle Disease by Kitutu Chache poultry farmers**

<b>Adaptation Methods</b>	<b>Coefficients</b>	<b>p-value</b>	<b>t</b>	<b>Std. Error</b>
Improved FRIC breeding (Kienyeji)	0.042	0.299	1.04	(0.040)
Restrict movement of the Chicken	0.179***	0.000	4.69	(0.038)
Vaccination of chicken	0.273***	0.000	7.18	(0.038)
Use of traditional herbs	0.111***	0.002	3.05	(0.036)
Use of Improved chicken feedings	0.014	0.729	0.35	(0.039)
Seeking veterinary services	-0.097**	0.043	-2.03	(0.047)
Prior selling before infection	0.188***	0.000	5.40	(0.034)
Prior consuming before infection	0.104**	0.021	2.32	(0.044)
Burly died and infected chicken	0.033	0.379	0.88	(0.037)

\*\*\* P < 0.001 and \*\* p < 0.05 at the level of significance

#### 4.8.1 Improved FRIC breeding (Kienyeji) and feedings

The study found that rearing of improved FRIC among Kitutu Chache South households was a positive but insignificant adaptation method ( $p > 0.05$ ) against the spread of Newcastle Disease. 45.2% of the respondents (See Table 4.18) reported that they were rearing improved Indigenous chicken; however, rearing of improved indigenous would not curb the spread and outbreak of Newcastle Disease among chickens. Though, this study found that rearing of indigenous chicken would improve chicken productivity by 4.2% (Table 4.16) amid Newcastle Disease spread owing that improved chickens are quite immune to contagious diseases (Wondmeneh *et al.*, 2016). The use of improved feeds for chicken also could not significantly control the spread of the Newcastle Disease among chicken though 39.8% of the farmers reported that they were using improved feeds to improve chicken production in Kitutu Chache South.

**Table 4.19: Number of households rearing improved chicken**

Response	Frequency	Percent	Cumulative %
Yes	226	45.2	45.2
No	274	54.8	100.0
Total	500	100.0	

#### 4.8.2 Restriction of movement

Restricting chicken movement during the outbreak of Newcastle Disease was a positive and significant adaptation method to control the spread of Newcastle Disease among chickens ( $p < 0.001$ ) (Table 4.17). The study also found that 54.2% of poultry farmers (Table 4.18) in Kitutu Chache South responded to the house and restricted FRIC

movement during the emergence of Newcastle disease in their neighborhoods. The study deduced that restricting chicken movement had a probability of 17.9% to reduce the spread of Newcastle Disease among Chicken. Therefore, Kisii County Livestock Officer reported that, the advice given to farmers was to clean their poultry houses frequently, disinfect and observe hygiene when handling chickens. Studies done by Hellin *et al.*, (2013) confirmed that contagious diseases among chickens would be reduced by restricting wild birds and chicken movement.

**Table 4.20: Frequencies of households restricting chicken’s movement**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	271	54.2	54.2
No	229	45.8	100.0
Total	500	100.0	

#### **4.8.3 Vaccination of chicken**

This study found that the vaccination of chicken was a positive and significant adaptation method to curb the rate of Newcastle Diseases spread during its outbreak ( $p < 0.001$ ). These results implied that as the level of vaccination increased, the spread of Newcastle Disease reduced. The study found that 68.0% of poultry farmers (Table 4.20) used vaccines such as ND-vaccine and infectious bronchitis (IB) vaccine to control the effects of Newcastle Disease among chickens. Additionally, the study found that the use of vaccines against the Newcastle Disease had a probability to reduce the effects of Newcastle Disease by 27.3% among chicken (Table 4.17). Veterinary officers mainly did vaccination from the Kisii county Livestock Department who formed an integral part of disease control. However, as reported, most farmers frequently sought for veterinary services to

protect their chicken against Newcastle Disease. The same results were found in studies such as Kapczynski *et al.*, (2013) and Zmrhal & Slama, (2020) which reported that vaccines were the best method that would improve the productivity of chicken amid the Newcastle Disease outbreak.

**Table 4.21: Farmers respondent to vaccination against Newcastle Disease**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	340	68.0	68.0
No	160	32.0	100.0
Total	500	100.0	

#### **4.8.4 Use of traditional herbs**

The study found that farmers used traditional herbs positively and significantly against the outbreak of Newcastle Disease in Kitutu Chache South ( $p < 0.001$ ). However, 32.4% (Table 4.21) of the farmers agreed to be using traditional herbs to fight Newcastle Disease amongst their chicken and the study noticed that using traditional herbs would reduce the effects of Newcastle Disease spread by 11.1% (Table 4.17). Lv *et al.*, (2019) also found that the use of traditional herbs had the potential to reduce the risk of Newcastle Disease among poultry farmers in China. The study showed that farmers used traditional herbs especially aloe because it is locally available and was believed to be effective against a wide range of diseases and ailments. The farmers harvested aloe leaves, cleaned them with water, and crushed them before mixing with drinking water for chickens. The “medicated” water was offered to all birds until they showed signs of good health.

**Table 4.22: Frequencies of households using traditional herbs**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	162	32.4	32.4
No	338	67.6	100.0
Total	500	100.0	

#### **4.8.5 Seeking veterinary services**

Seeking veterinary services had a negative and significant influence on adaptation methods used by the poultry farmers ( $p < 0.05$ ), this implied that seeking advice from veterinary services as an adaptation method would reduce the effects of Newcastle Disease such as purchasing medicine. However, only 18.6% of the farmers (See Table 4.22) had received support from the local veterinary services. Further, this study estimated that seeking consultative services from the veterinary officers had a probability of 9.7% to improve chicken production amid the Newcastle Disease outbreak and spread (Table 4.17). This was through the department of Livestock and Poultry within Kisii County, which had employed extension and veterinary officers. The extension officers were responsible for educating poultry farmers on methods of improving productivity and giving general advice as far as poultry is concerned. On the other hand, veterinary officers vaccinated poultry and taught farmers different poultry diseases, signs and symptoms, and their methods of disease control. The veterinary officers also procured drugs on behalf of the government to vaccinate the chickens. The government had started a project of small-scale indigenous poultry improvement project through the Ministry of Agriculture, Livestock, and Fisheries in the county as reported by the Key Informant (County Livestock officers). Lastly, studies by Bartolini & Vergamini, (2019) also confirmed that extension services from experts

always improved and determined farmers' perception to adopt appropriate adaptation mechanisms that would increase farming yields.

**Table 4.23: Number of people seeking veterinary services**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	93	18.6	18.6
No	407	81.4	100.0
Total	500	100.0	

#### **4.8.6: Prior to selling the chicken before the infection**

Selling the chicken before infection was a positive and significant method of adaptation among Kitutu Chache South of Kenya ( $p < 0.05$ ) (Table 4.17), selling chicken before the infection would reduce losses by the farmers due to the outbreak of Newcastle Disease. However, 36.4% of the farmers (Table 4.23) reported that they were selling chicken before infection to reduce their losses during the ND outbreak. Moreover, the study found that selling chicken had a probability to reduce losses by 18.8% during the time of the ND outbreak. Most of the farmers sold their chicken after realizing there was an outbreak of Newcastle Disease to avoid the cost of losses. Chung & Promburom, (2015) also reported in their study that most of the farmers take precautionary actions against disease and pests that could invade their farm and livestock to reduce the risks of losses.

**Table 4.24: Respondents selling their chicken prior to infection during ND outbreak**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	182	36.4	36.4
No	318	63.6	100.0
Total	500	100.0	

#### 4.8.7: Prior consumption of chicken before the infection

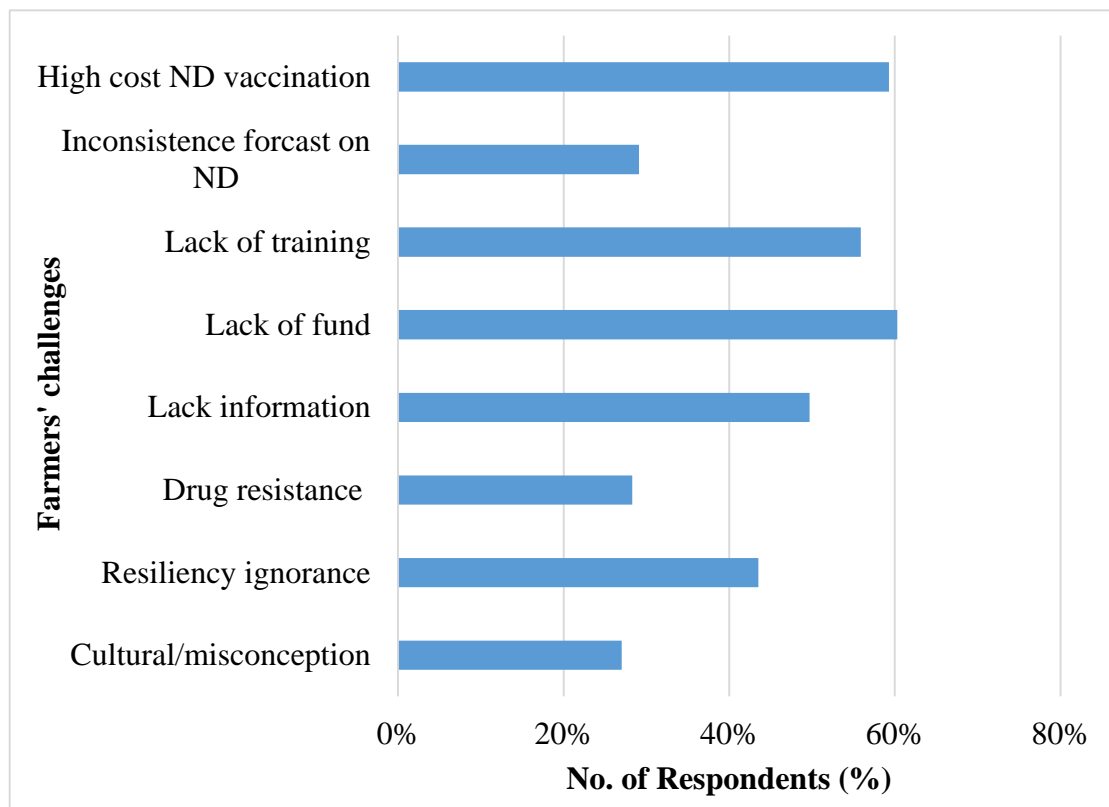
Consuming chicken before it got infection was found to be positively and significantly correlated to reduction of Newcastle Disease effects ( $p < 0.05$ ) Table 4.17. They found that consumption of chicken had a probability of 10.4% (Table 4.17) to reduce the effects of Newcastle Disease and its spread among chicken. However, only 20.2% of the respondent (Table 4.24) were consuming chicken before infection. More so, burying of infected chicken was also used to minimize the spread of Newcastle Disease though it was not significant and it could only prevent the spread of Newcastle Disease by 3.3% (Table 4.17) but the majority of the households (51.2%) adopted this method of burying the infected chickens to avoid the spread of Newcastle Disease. Henning *et al.*, (2013) also reported that such as consuming, burying, and selling used in rural areas by small-scale farmers in Myanmar to reduce the spread of Newcastle Disease. Finally, the study discussed the significant methods of adaptation by farmers; this would help the relevant authorities to formulate better policies for Kitutu Chache South to improve their poultry livelihood during climate change effects.

**Table 4.25: Those who prior consumed the chicken before the infection**

<b>Response</b>	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative %</b>
Yes	101	20.2	20.2
No	399	79.8	100.0
Total	500	100.0	

#### 4.9 Poultry farmers constrained to adaptation strategies

Kitutu Chache poultry farmers from Kisii County are constrained by various challenges even though they were significantly adapting to mitigate the effects of climate change on the spread of Newcastle Disease among chicken. Therefore, this study identified some of the constraints faced by farmers in Kisii County such as high cost of vaccinations; inconsistent forecast of Newcastle Disease spread; lack of training; lack of enough funds; lack of information facilities; drug resistance; resilient ignorance of farmers; culture and misconceptions.



**Figure 4.23: Constraints faced by Kitutu Chache South Poultry farmers**

Farmers from Kitutu Chache South Constituency use vaccination to cure their poultry chicken. 59.3% of the farmers reported that drugs for vaccines are costing more funds that

some of them could not raise. Therefore, some of them divert to traditional herbs of chicken treatment, which are not effective as compared to drugs or vaccines.

Farmers are not able to determine which season, the outbreak would occur. 29.1% of the farmers agreed that there was inconsistent predictability of Newcastle virus spread. 55.9% of the farmers responded that they lack training from extension officers on what to do when there is Newcastle Disease spread. The Kisii County Livestock department reported the same results; “There is inadequate funds to hire extensional officers” Livestock officer.

However, most of the farmers reported that lack of funds was the main constrain that hinders the adaptation strategies against Newcastle Disease. Farmers are not able to access drugs for vaccinations and improved breeding. On the other hand, 49.7% of the farmers agreed that they lack proper information on the outbreak of Newcastle Disease.

The results showed that 28.3% of the farmers reported that drugs are becoming resistant, 43.5% of the farmers reported that most of the farmers are ignorant about the Newcastle Disease and its cause, and finally the study deduced that 27.0% of the farmers are not considering adaptation methods due to misconceptions and culture perceived by farmers. These results were in agreement with those done by (Henning *et al.*, 2013; Kapczynski *et al.*, 2013; Miller *et al.*, 2007 & Richard *et al.*, 2017) who identified similar constraints in their study.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1 Summary of the findings**

The study investigated the impact of climate variability on the outbreak and spread of Newcastle disease in poultry farming in Kisii County, Kenya. The study was guided by five objectives, namely; to examine the variability of climate change since 1990 - 2019 in Kitutu Chache South Constituency, to establish farmers' perception of the effects of climate variability on Free Range Indigenous Chicken varieties in the Kitutu Chache South Constituency, to examine the relationship between climate variability and the occurrence of Newcastle disease in Kitutu Chache South Constituency, to assess the socio-economic costs of Newcastle Disease to the poultry farmers in the area of Kitutu Chache South Constituency, to identify measures taken by farmers to control and manage the Newcastle disease Kitutu Chache South Constituency.

As regards objective one, the study found that there were no mean annual rainfall trends for the period 1990-2019 though the rainfall has been decreasing annually in Kitutu Chache South. Further, the study established that there was a significant decrease in rainfall amount received during January and February in Kitutu Chache as is the case in other areas of the world. Likewise, in June and July, rainfall was declining in trend while in September and December rainfall was increasing in amount.

As regards the second objective, the study found that farmers in Kitutu Chache were receiving information about climate change from different sources such as farmers-farmers relations, own understandings, from radios, from Governmental offices, from Non-Governmental organizations, from church and other religious practices. Similarly, the

study revealed that farmers in Kitutu Chache South were significantly aware of climate variability and its effects on Newcastle Disease.

Further, the study revealed that some causative agents drive the spread of Newcastle Disease viruses such as chicken droppings, live birds, infected poultry products, human factors and other animals like cats and dogs that consume infected birds contribute to the spread of Newcastle disease. The months of March, April, and May marked the highest emergence of Newcastle Disease Virus due to high rainfall, which is conducive for virus survival. However, other seasons also registered death cases though not much as in MAM. There was a correlation between climate factors (minimum temperature, maximum temperatures, and rainfall) and Newcastle Disease outbreaks.

Generally, the study deduced that climatic factors have potential effects on the Newcastle disease spread among Free Range Chicken, which significantly influenced chicken prices. Economically, the marginal effect results showed that farmers had the probability of losing an average of KES.236.78 per unit change of climate condition.

The study also found that the experience of the farmer, and marital status of the farmer were insignificantly associated with the death occurrence of chicken. On the other hand, there was no significant correlation between ages of the farmers, farmers' level of education, number of chickens reared, the main occupation of the farmer, and size of the family with the occurrence of chicken's death during the outbreak of Newcastle Disease in Kitutu Chache South.

Finally, the study indicated that adaptation measures could reduce the negative impacts of climate change and the spread of poultry diseases. From the study, it was determined that farmers use different methods to control the disease. There was significant use of

movement restriction of chicken, vaccination of chicken, use of traditional herbs, and support from authorities, prior selling of infected chicken and prior consumption of the infected chicken.

## **5.2 Conclusions**

The study concluded that both seasonal and annual mean rainfall were trending and fluctuating in Kitutu Chache from 1990 to 2019. On the other hand, the variation of the average temperatures showed that there was a significant seasonal and annual increase in temperature during 1990-2019 and Kitutu Chache is becoming warmer and warmer. Therefore, most of the households were experiencing effects of climate variability that need climate forecasting and better adaptation measures that would help households to improve their livelihoods as climate parameters fluctuate.

The study found out that most of the farmers were significantly aware of climate change and its effects on their livelihoods such as poultry keeping. Thus, this study concluded that the community of Kitutu Chache required more education about climate awareness to help the households determine measures taken against climate variability and Newcastle Disease to help them cope with the situation.

The correlation between the spread of Newcastle disease, the season of the year, temperatures and rainfall was significant. It showed that climatic factors are associated with new cases of Newcastle disease prevalence due to fluctuations of environmental conditions, which favor the spread of the APMV-1 virus. Thus, there is need for scientists to carry out more research to identify the extent of climate vulnerability to the Newcastle Disease to help the poultry farmers take precautionary measures to counter the outbreak of Newcastle Disease.

The study deduced that climatic factors were proportionately influencing the potential of Newcastle disease spread. The Newcastle Disease increased with seasonal weather changes, which affect chicken productivity. However, the results confirmed that poultry farmers would lose an average of KES.236.78 per unit change in climate factors and economically an average of losing KES.350.75 per chicken during the outbreak of Newcastle Disease. Therefore, poultry farmers need to adopt forms of livelihoods or sell their chicken before infection to minimize losses during the Newcastle Disease outbreak.

The study concluded that farmers should be encouraged to keep poultry chicken depending on their capacity. Thus, there is a need to capacitate farmers' knowledge and participate in decision-making. Most of the adaptation measures can reduce negative impacts of climate change such as improved breeding, use of improved feedings, and burying the infected chicken. However, adaptation was taken into account but there were some challenges faced by farmers such as high cost of vaccinations; inconsistent forecasts of Newcastle Disease spread; lack of training; lack of enough funds; lack of information facilities; drug resistance; ignorance of farmers; culture and misconceptions. Finally, farmers should take more precautions of using vaccines against Newcastle Disease

### **5.3 Recommendations of the study**

Based on the result findings, the study recommends for actions and policies to mitigate the effects of Newcastle disease spread to enhance the productivity of poultry in Kitutu Chache South Constituency.

First, the study recommends that the national government should devolve and set up weather stations at local levels to help the community monitor and forecast changes in temperatures and rainfall to help them take precautions against adverse climatic events, known as a precautionary principle for community preparation. The devolved and national

governments are urged to strategize and provide extension services to farmers periodically to create awareness and technical guidance on dealing with Newcastle disease such as handling and taking hygiene precautions.

Second, there is need to establish quarantine programs through proper housing to minimize the spread and outbreak of Newcastle disease during adverse weather seasons. This will reduce the risk of the APMV-1 virus spreading among chickens. The County and National administrators are required to subsidize drugs for farmers to vaccinate their chicken against Newcastle disease. In addition, administrators should reduce the tax paid on chicken feeds thus reducing the cost of buying poultry inputs.

Third, farmers should keep chicken mortality records and disease occurrence periods. This helps relevant authorities to monitor the epidemiology and measure the effects of climate variability on chicken production due to Newcastle Disease spread. Farmers should adopt better adaptation methods such as vaccination, quarantine, and use of traditional herbs to improve their chicken productivity such as keeping the improved chicken breeds, using herbal medication to reduce the cost of drugs. This facilitates the commercialization of chicken to enhance income earning to improve food security in the local area.

#### **5.4 Areas for further study in future**

Following the objectives and the scope of this study, suggestions for future research in order to complete the research include;

##### **5.4.1 Suggested research area one**

Investigation of the influence of climate variability on other poultry diseases such as fowl pox and Gumboro.

#### **5.4.2 Suggested research area two**

Study to determine the effectiveness of using traditional herbs to control and manage the Newcastle Disease virus.

#### **5.4.3 Suggested research area three**

Development of a model for predicting and forecasting Newcastle Disease outbreaks from weather-related variables such as rainfall and temperatures.

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## **APPENDICES**

### **Appendix I: Consent Form**

Hello, my name is Henry Sese, a master's student at Kenyatta University in the department of Environmental Education. I am carrying out a study on Climate change and variability in Kisii County, Kenya a case study on Newcastle disease.

#### **Why is the study being carried out?"**

The study is being carried out in a bid to investigate the effects of variations in climatic factors on the outbreak and spread of ND in Kitutu Chache South Constituency.

#### **How many people are taking part in the study?**

A total of about 500 respondents in Kitutu Chache South Constituency will be sampled.

#### **What is involved in the study?**

The study will involve the interviewer asking questions from the questionnaire and the interviewer filling in the answers. The answers will later be analyzed to provide information that can be used in informing the different stakeholders on the study findings.

#### **How long will this study take?**

The interview will take about an hour to fill.

#### **What are the risks of the study?**

It is unlikely that there are any risks in taking part in the study. However, if you get tired of answering the questions you can take a break at any given time.

**What are the benefits of taking part in the study?**

There might not be any direct benefit to you from the study but the findings may be used in decision making aimed at investigating the effects of variations in climatic factors on the outbreak and spread of ND in Kitutu Chache South Constituency.

**What are other available options?**

You do not have to participate in the study. The study is voluntary and once you enroll you can choose to stop participating in the study at any given time.

**What are the costs?**

There is no cost to you for taking part in the study. You will also not receive any payment for taking part in the study.

**Contact information**

Henry Sese has explained to you the risks and benefits of participating in the study and can be contacted on the cell phone number 0723842121. Further information can be gotten from Kenyatta university department of Environmental Education, P. O. Box 43844 Nairobi.

**Confidentiality of the study.**

Any information given will be treated with utmost privacy and confidentiality. The information will be useful in finding the solutions to the effects of variations in climatic factors on the outbreak and spread of ND in Kitutu Chache South Constituency and will be important for policymakers in the County and beyond. The information given will be used for general reports and will not include any name of the information source.

**Signature**

Signing below indicates that you have been informed about the research in which you voluntarily agree to participate and that you have asked any questions that you may have and that the information given to you has permitted you to make a fully informed and free decision about your participation in the study. A copy of this consent will be provided to you.

Signature .....Date.....

**Instructions**

- 1. One questionnaire per person.
- 2. Do not include the name of the respondent anywhere.
- 3. Tick as appropriate and respond where applicable.
- 4. All questions to be answered.

Date of interview

Time interview started .....

Time interview ended .....

**Appendix III: Questionnaire for Poultry Farmers**

My name is Henry M. Sese. I am a postgraduate student at Kenyatta University pursuing a Master’s Program in Environmental Studies on Climate Change and Sustainability. I am currently researching the impacts of climate variability on poultry farming for my project. I, therefore, humbly request your assistance by responding to my questions so that I conclude this study successfully. Please tick as appropriate.

**Personal Data & Socio-Economic Status**

- 1) Name..... Village.....
- 2) Sex of the respondent; Male [ ] Female [ ]
- 3) What is your age brackets  
Below 25 [ ] 25-35 [ ] 35- 45 [ ] 45 – 55 [ ] Above 55
- 4) How long have you been keeping livestock poultry?  
.....
- 5) Level of Education; Tertiary/University [ ] High School [ ]  
Primary [ ] No. Formal education [ ]
- 6) Marital status; Single [ ] Married [ ]
- 7) What is the number of people in the house (Household size)  
.....
- 8) What is your occupation? Employed [ ] Business [ ] Poultry farming [ ] others [ ]  
Specify.....  
.....

8). which type (phenotype) of free-range indigenous chicken do you keep?

<b>Chicken Common Name</b>	<b>Response</b>	<b>Numbers</b>
Normal	[ ]	
Naked neck (Nyaigoti chenge)	[ ]	
Frizzle (Oyuyu)	[ ]	
Dwarf (Okuto/onkuru)	[ ]	
Tailless	[ ]	
Feathered shank (Nyamatisi)	[ ]	
Others	[ ]	
	Total Pop.	

9) Among all the chicken you keep, please rank them in numbers (1 to 6) according to their contribution in production with regard to the effects of climate change and viability.

Normal [ ]

Naked neck (Nyaigoti chenge [ ]

Frizzle (Oyuyu) [ ]

Dwarf (Okuto/onkuru) [ ]

Tailless [ ]

Feathered shank (Nyamatisi) [ ]

10) In case one could sell infected chicken, how much could it cost.....?

12). what is the average cost of chicken .....

13). which season or months of the year do most chicken die .....

14). to your assessment, what could have caused the spread of the disease?

(Please circle that apply)

- a) Infected live birds
- b) Infected poultry products
- c) Other animals like dogs and cats
- d) Human beings
- e) Dropping from the infected chicken

15). When the chicken is infected with ND, what happens to the following?

- a) How does it affect the prices?
- b) How does it affect production?
- c) How does it affect the farmers' income?

## **Part 2: Disease and Climate Variability**

1. What are the sources of the information about Newcastle Disease and climate change?

(Tick all that apply)

- 1) Own understanding
- 2) From researchers and elites
- 3) From radio broadcasting
- 4) Government office
- 5) Seminar meeting
- 6) Non-governmental organizations (NGOs)
- 7) Church, mosque
- 8) From other poultry farmers

2. Are you aware of climatic changes e.g. wind, humidity, and temperature, and rainfall rates in recent years?

Yes [ ] No [ ]

3. In the previous years, have you ever observed changes in the production of eggs because of climate change?

Yes [ ] No [ ]

4. Please, tell us what happens to the production of eggs due to climate changes in the following patterns. (Please tick appropriately).

Statement	Increase	Decrease
Alternating dry and wet seasons	[ ]	[ ]
Severe prolonged dry spells	[ ]	[ ]
High temperatures and abundant rainfall	[ ]	[ ]
Severe rainfall and heavy humidity	[ ]	[ ]
After a long period of drought	[ ]	[ ]

5. To what extent do you agree with the effects of climatic variability on chicken production?

(1 = Extremely Disagree 2= Disagree 3 = Neutral 4= Agree 5 = Extremely Agree)

Statements	1	2	3	4	5
Chicken fertility is reduced	[ ]	[ ]	[ ]	[ ]	[ ]
Climate variability adds heat stress to the chicken	[ ]	[ ]	[ ]	[ ]	[ ]
Anomalies in rainfall and temperature increase the spread of Newcastle disease	[ ]	[ ]	[ ]	[ ]	[ ]
High temperatures enhance the spread of Newcastle disease	[ ]	[ ]	[ ]	[ ]	[ ]

Climate has led to the spread of the disease					
The weight of the chicken is reduced	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Do you have any strategies you use to reduce the impacts of climate variability on your poultry farming?

Yes  No

If yes, which one? (Tick all the appropriate ones)

<b>Adaptation Strategies</b>	
Improved indigenous /kienyeji chicken	<input type="checkbox"/>
Restricting the movement of chickens to the neighborhood	<input type="checkbox"/>
Vaccination of the chicken at an earlier stage	<input type="checkbox"/>
Use of traditional herbs	<input type="checkbox"/>
Use of improved feedings to boost immunity against ND	<input type="checkbox"/>
Receive supports from the Government and NGOs	<input type="checkbox"/>
Selling the infected chickens to reduce the cost of loss	<input type="checkbox"/>
Consuming the infected chicken	<input type="checkbox"/>
Burying the infected chickens to control the spread of the ND	<input type="checkbox"/>

11) Which institutions have given you support against Newcastle Disease?

Government

Department.....

Type of support.....

Name of NGO

.....  
.....

Type of support

.....

12) What are the problems hindering adaptation and mitigation strategies to climate variability impacts to poultry?

<b>Constrains</b>	
Cultural and misconception resistance	[ ]
Ignorance by some farmers to adopt resilient mechanisms	[ ]
Resistance of bacteria to drugs due to climate anomalies	[ ]
Lack of media information about the ND spread	[ ]
Lack of funds to facilitate the keeping of poultry farming	[ ]
Lack of training from veterinary and extension officers	[ ]
Resistance of bacteria to drugs due to climate anomalies in temperature and rainfall	[ ]
Inconsistence climate variability to forecast the outbreak of Newcastle Disease	[ ]
High cost of Newcastle Disease vaccination drugs	[ ]

10). what do you think the future of poultry farming will be in relation to climate variability?

Very Good [ ]

Good [ ]

Not sure [ ]

Worse [ ]

Worst [ ]

What is your perception of the impacts of climate variability on poultry farming?

Reply with (1. Highly perceive, 2. Perceive 3. Not perceive 4. Highly not perceive)

<b>Perceptions</b>				
Punishment from God	[ ]	[ ]	[ ]	[ ]
Climate change is just a natural phenomenon	[ ]	[ ]	[ ]	[ ]
We can't do anything the only government can help to adapt to climate change	[ ]	[ ]	[ ]	[ ]
Yes the climate is changing	[ ]	[ ]	[ ]	[ ]
Climate variability and change are not there.	[ ]	[ ]	[ ]	[ ]

11). what do you think can be done to help you mitigate or adapt to climate variability impacts?

(Please tick the most applicable)

- a) Creation of climate variability awareness to poultry farmers [ ]
- b) Crossbreeding of poultry to make them resistant to alternating seasons [ ]
- c) Providing the chicken with necessary vaccines to enable them to adapt to any climatic changes [ ]
- d) More research to be done by scholars on diseases affecting poultry [ ]

\*\*\*\*Thank you for your participation\*\*\*\*

**Appendix IV: Interview Schedule for Livestock and Poultry Department**

1. Name (optional) the position of the County

.....

2. Do you think there is a relationship between climate variability impacts and poultry keeping?

- i. Yes [ ]
- ii. No [ ]

Why?.....

.....

.....

.....

.....

3. What mechanisms is your ministry putting in place to reduce the impacts of climate variability on poultry farming?

- i. Something [ ]
- ii. Nothing [ ]

Please explain how

.....

.....

.....

.....

.....

.....

.....

4. Do you think the poultry farmers have a coping mechanism for these impacts?

i. Yes [ ]      ii. No [ ]

ii. If yes, which are these mechanisms/strategies?

5. Are these mechanisms sustainable?

i. Yes [ ]      ii. No [ ]

Kindly explain

.....

.....

.....

.....

.....

6. Do you think some factors decrease the coping mechanism of poultry farming?

i. Yes [ ]      ii. No [ ]

Which?.....

.....

.....

.....

7. Where do you see poultry farming within Kitutu Chache South Constituency in the near future?

.....

.....

.....

.....

8. What do you think is to be done to the poultry farmers to address this emerging issue of climate variability to poultry production for sustainable development?

.....

.....

.....

.....