THE INFLUENCE OF CLIMATE VARIABILITY ON JIGGER INFESTATION IN TESO NORTH SUB COUNTY, BUSIA COUNTY, KENYA

Mukhavali Celestine

A Thesis Submitted to the School of Disaster management and sustainable development in Partial Fulfillment of Master's degree in Climate Change adaptation and mitigation for sustainable development of Masinde Muliro University of Science and Technology

May, 2021

DECLARATION

This thesis is my original work and has not been presented for the award of a degree or any other award in any other university.

Signature……Date……

MUKHAVALI CELESTINE

CCA/G/302/15

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance of Masinde Muliro University of science and technology a thesis entitled "Influence of Climate Variability on Jigger Infestation in Teso North Sub-County, Busia County, Kenya"

1. PROF. S.B.B OTENG'I, PhD.

Department of Disaster Preparedness and Engineering Management

Masinde Muliro University of Science and Technology

Signature……Date……

2. DR. E. M. NEYOLE, PhD.

Department of Disaster Preparedness and Engineering Management

Masinde Muliro University of Science and Technology

Signature…….. Date……

COPYRIGHT

ACKNOWLEDGEMENT

I would like to acknowledge Masinde Muliro University for offering me the opportunity to pursue this post graduate degree, my supervisors' Professor Oteng'i and Dr E.M Neyole for their tireless sacrifice and efforts and to all lecturers in the Department of Disaster Preparedness and Engineering Management for equipping me with skills and knowledge. I also appreciate my fellow students Omolo David and David Akhonya for academic and moral support. My family members especially my husband Vincent Mackbay Omunyin for his moral and financial support. Above all I thank the almighty God for giving me strength to endure during the trying moments.

DEDICATION

I dedicate this thesis to my lovely husband Vincent Mackbay Omunyin, my children Taliayah Mackbay and Tophyl Mackbay, my parents Mr and Mrs Atenya, sisters and brothers.

ABSTRACT

For decades, climate variability has had great effect on human life; both positively and neg122`atively. These effects include rise in the global temperatures, changes in the precipitation patterns, increase in drought incidents and heat waves, stronger and more intense hurricanes, rise in sea level (1-4 feet by 2100), arctic regions likely to become ice free and negative impact on human health. Changes in climate have impacted negatively on human health where by it has led to increase in parasitic infestations like jiggers due to the general increase in global temperatures; which provide favourable environment for breeding. Such increase in parasites, in this case the jigger, has consequently affected the community at large; ranging from the full range of people. It has led to absenteeism from school among the school going children, repeat of classes as well as school dropouts, reduction in economic productivity, stigmatization, poverty, deformities, secondary diseases such as tetanus and death. This research aimed at establishing the influence of climate variability on jigger infestation, determining climate trend and variability of Teso North sub-county, assessing the relationship between jigger infestation and climate change, assessing the current impacts of jigger infestation and evaluating the measures of preventing and controlling jigger menace in Teso North sub-county. The study was carried out in Teso North sub-county because it has a humid tropical climate with warm temperatures and it is among the affected regions with jigger infestation in Kenya. The study focussed on climate parameters (independent variables- climate variability, temperature, rainfall and humidity) against jigger infestation (dependent variable) which was affected by some factors such as poverty, hygiene, level of education, public sanitation measures and gender (intervening variables). Methodologies adopted were descriptive, historical and correlation designs. Data was collected through questionnaires, interviews, observation, field check lists as well as photography. Data was presented in various ways such as photographs, frequencies, percentages, bars and maps. The study found out that climate variability has an influence on jigger infestation. The effect of climate on jigger infestation according to elders was seen to be more prevalent in dry seasons with 95.3% while some believed that jiggers are rampant and increases at wet seasons 3.1%. The change in climate over years was seen to affect the entire sub-county across all wards as informed by key respondents at Alupe Meteorological station indicating a complexity in weather prediction, they indicated that the weather patterns had become more varied with 88.8% (82 cases) of adults indicating a change in climate and community leaders indicating the same too. The change in the temperatures saw 88% of adults report that they had witnessed a change in temperature citing hot temperatures throughout the season while the meteorological department also agreed with the change in temperature. Recommendations such as provision of closed shoes by foundations, well-wishers and other concerned authorities and intensification of awareness programmes from the findings were made open and readily available for any concerned authority.

TABLE OF CONTENTS

DECLARATION ..... **II**

COPYRIGHT ..... **III**

ACKNOWLEDGEMENT ..... **IV**

DEDICATION ..... **V**

ABSTRACT ..... **VI**

LIST OF FIGURES ..... **XII**

LIST OF TABLES ..... **XIII**

LIST OF ACRONYMNS AND ABBREVIATIONS ..... **XIV**

OPERATIONAL DEFINITION OF TERMS ..... **XV**

LIST OF APPENDICES ..... **XVIII**

CHAPTER ONE: INTRODUCTION **1**

2.1 BACKGROUND OF THE STUDY 1

2.2 ANTHROPOGENIC CONCERNS AND JIGGER INFESTATION 3

2.2.1 Environmental characteristics *3*

2.2.2 Housing *3*

2.2.3 Hygiene *4*

2.2.4 Poverty *4*

2.2.5 Effects of Jigger Infestation *5*

2.3 STATEMENT OF THE PROBLEM 6

2.4 RESEARCH OBJECTIVES 9

2.4.1 General objective *9*

2.4.2 Specific objectives *10*

2.4.3 Research questions *10*

2.5 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY 10

2.6 SCOPE OF THE STUDY 11

CHAPTER TWO: LITERATURE REVIEW 13

2.7 CLIMATE VARIABILITY AND HUMAN HEALTH 13

2.8 *TUNGIASIS* DISEASE 14

2.8.1 Transmission of Tungiasis *14*

2.8.2 Life cycle of a jigger flea *15*

2.9 CLIMATE VARIABILITY AND INFECTIOUS DISEASES 16

2.10 CLIMATE VARIABILITY AND GENDER 17

2.5 FACTORS THAT PROMOTE JIGGER INFESTATION 19

2.6 JIGGER MENACE 20

2.6.1 Jigger menace in the world *20*

2.6.2 Jigger menace in Africa and Kenya *21*

2.7 JIGGER INFESTATION 23

2.7.1 Jigger infestation and seasonal weather variation *23*

2.7.2 Jigger infestation and age *24*

2.7.3 Jigger infestation and gender *25*

2.8 JIGGER CONTROL MEASURES BY SCHOOLS AND THE COMMUNITY 25

2.9 THEORETICAL FRAMEWORK AND CONCEPTUAL FRAMEWORK 26

2.9.1 Theoretical framework *26*

2.9.2 Conceptual framework *29*

CHAPTER THREE: RESEARCH METHODOLOGY 31

2.10 DESCRIPTION OF THE STUDY AREA 31

2.10.1 Study location 31

2.10.2 Physical characteristics 32

2.10.3 Socio-economic characteristics 32

2.11 RESEARCH DESIGN 33

2.12 STUDY POPULATION 33

2.13 SAMPLING STRATEGY 34

2.13.1 Sample size calculation 34

2.13.2 Sample selection 36

2.14 SURVEY DATA COLLECTION 37

2.14.1 Primary data 37

2.14.2 Secondary data 38

2.14.3 Tools for data collection 38

2.14.4 Questionnaires 39

2.14.5 Field Check lists 40

2.14.6 Key Informant Interview Schedule 41

2.15 CLIMATE VARIABILITY DATA COLLECTION AND MEASUREMENTS 41

2.16 VALIDITY OF RESEARCH INSTRUMENTS 41

2.16.1 Validity of data collection instruments 42

2.16.2 Reliability of data collection instruments 42

2.17 DATA ANALYSIS AND PRESENTATION 45

2.18 ETHICAL CONSIDERATION 46

2.19 LIMITATION OF STUDY 47

CHAPTER FOUR: RESULTS AND DISCUSSIONS 49

2.20 DEMOGRAPHIC INFORMATION 49

2.21 CLIMATE VARIABILITY AND JIGGER'S INFESTATION 53

2.21.1 Climate trends 54

2.21.2 Climate variability 57

2.21.3 Jiggers infestation and climate variability 59

2.21.4 Jigger infestation 59

2.21.1 Jigger prevalence 62

2.21.2 Perception on Jigger infestation and climate variability 64

2.22 EXTENT AND IMPACT OF JIGGER INFESTATION 67

2.22.1 Impacts of jiggers and their effects 67

2.22.2 Impact of Jiggers on children and adults 67

2.22.3 Impact on households 70

2.23 PREVENTIVE MEASURES 74

CHAPTER FIVE: CONCLUSION SUMMARY AND RECOMMENDATIONS 79

2.24 SUMMARY OF MAJOR FINDINGS 79

2.25 CONCLUSION 81

2.26 RECOMMENDATIONS 82

2.27 KNOWLEDGE GAP 83

REFERENCES 84

APPENDICES 90

APPENDIX I: QUESTIONNAIRE (A) 90

APPENDIX II QUESTIONNAIRE (B) 95

APPENDIX III: INTERVIEW QUESTIONS (A)..... 99

APPENDIX IV: INTERVIEW QUESTIONS (B) 100

APPENDIX V: OBSERVATION CHECKLIST..... 101

APPENDIX VI: BODY PARTS INFESTED WITH JIGGERS 102

APPENDIX VII: NACOSTI RESEARCH PERMIT..... 103

LIST OF FIGURES

Figure 2:1: The life cycle of jigger flea (complete metamorphosis). 16

Figure 2:2: A map of worldwide distribution of *Tungiasis* as of 2009 21

Figure 2:3: Jiggers distribution in Kenya 22

Figure 2:4: Conceptual framework..... 30

Figure 3:1: Map of the study area..... 31

Figure 3:2: Sampling procedure 35

Figure 3:3: Interview Process in the field at Aterait Village..... 39

Figure 4:1: Respondent's representation per village 50

Figure 4:2: Employment and gender 52

Figure 4:3: A mud hut and crack on the walls..... 53

Figure 4:4: Annual mean rainfall 54

Figure 4:5: Rainfall distribution in Teso North..... 55

Figure 4:6: Solar insolation (kwh/m^2) per day (A) and Temperature (B) 57

Figure 4:7: Children Jiggers infestation per ward..... 60

Figure 4:8: Influence of Age on jigger infestation 62

Figure 4:9: Prevalence jigger infestation by seasons 63

Figure 4:10: Climate of the area..... 64

Figure 4:11: Effects caused by jigger infestation on heels..... 68

LIST OF TABLES

Table 3:1: Selected study areas 34

Table 3:2: Respondents sampling calculation 36

Table 3:3: Questionnaire distribution Table 40

Table 3:4: Cronbach's alpha range and internal consistency 44

Table 3:5: Reliability Statistics 45

Table 4:1: Education level for adults 51

Table 4:2: Chi-Square on type of house and jigger prevalence 53

Table 4:3: Adults climate description 58

Table 4:4: Climatic conditions for jiggers prevalent. 59

Table 4:5: Chi-square on children infection and type of housing. 61

Table 4:6: Increase in jigger infestation 65

Table 4:7: Correlation between Climate variability and Increase in jigger infestation 66

Table 4:8: Absenteeism in school caused by jiggers' infestation 69

Table 4:9: Jiggers household infestation 71

Table 4:10: Chi-Square on bathing and jigger infestation 72

Table 4:11: Risk of jigger infestation in Adults 73

Table 4:12: Decreased economic activity due to jigger's infestation in Children .. 73

Table 4:13: Deformities caused by jiggers on adults 74

Table 4:14: Cause of jigger infestation children 76

Table 4:15: Community jigger control 77

Table 4:16: Source of information for children 78

LIST OF ACRONYMNS AND ABBREVIATIONS

AKT: Ahadi Kenya Trust

CDC: Centre for Disease Control and Prevention

CFCs: Chlorofluorocarbon

CFSR: Climate Forecast System Reanalysis

DPEM: Disaster Preparedness and Engineering Management

EPSD: Epidermal Parasitic Skin Diseases

FAO: Food and Agriculture Organization

GoK: Government of Kenya

HLGSA: Higher Local Government Statistical Abstract

IPCC: Intergovernmental Panel on Climate Change

KMD: Kenya Meteorological Department

MMUST: Masinde Muliro University of Science and Technology

MoALF: Ministry of Agriculture Livestock and Fisheries

NASA: National Aeronautics and Space Administration

USAID: United States Agency for International Development

UBS- Uganda Bureau of Statistics

WHO: World Health Organization

WMO: World Meteorological Organization

WPMR: Water Point Mapping Report

WWW: World Weather Watch

OPERATIONAL DEFINITION OF TERMS

Anthropogenic activities; includes environmental pollution or pollutants originating from human activities.

Anthropogenic heat; is the heat released into the atmosphere as a result of human activities, often involving combustion of fuels.

Climate; the composite or generally prevailing weather conditions of a region, as temperature, air, pressure, humidity, precipitation, cloudiness and wind averaged over a period:30yrs acceptable by WMO. Alternatively, it is the average weather conditions of a region over a long time.

Climate variability; refers to the way climate fluctuates yearly or seasonally either above or below a long-term average value.

Climate parameters; these are climatic elements. They include temperature, rainfall, humidity, solar radiation, wind.

Co-morbidity; is an indication of a medical condition existing simultaneously but independently with another condition in a patient.

Endemic; The constant occurrence of a disease or infectious agent in a given place or area.

Global warming; the average global surface temperature increases from human emissions of greenhouse gases and anthropogenic heat or activities.

Greenhouse gas effect; it is a natural process that warms the earth's surface; when the sun's energy reaches the earth's atmosphere some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse

gases. Greenhouse gases include water vapour, Carbon dioxide, Methane, CFCs, Nitrous Oxide and Ozone.

Jiggers; they are parasitic insects found in most tropical and sub- tropical climates.

Jigger infestation; refers to the presence of many jiggers/sand fleas in a particular area, on the surface of a host or anything that might contact a host or in the soil.

Microclimate; the climate of a small area as of confined spaces which may be different from that of the general region.

Milankovitch cycles; describes the collective effects of changes in earth's movements on its climate over thousands of years. These movements include eccentricity, axial tilt and precession.

Necrosis; Premature cell death due to external factors such as infection, injury, poisoning or inflammation which may hinder blood flow to the cell.

Stalk farms; remains from farm produce.

Suppuration - Formation of pus.

***Tungiasis*;** it is an inflammatory epidermal parasitic disease caused by infection with the female ectoparasitic jiggers.

Trend; is the general course or prevailing tendency; drift.

Prevalence - The proportion of individuals affected by a disease or condition within a particular time or period.

Preponderance; is the superiority in weight, power, numbers.

Variability; is how spread out or closely clustered set of data is.

Vector – An organism or vehicle that transmits the causative agent from the reservoir to a susceptible host.

LIST OF APPENDICES

Appendix I: Questionnaire (a) 90

Appendix II: Questionnaire (b) 95

Appendix III: Interview questions (a) 99

Appendix IV: Interview questions (b) 100

Appendix V: Observation checklist 101

Appendix VI: Body parts infested with jiggers 102

Appendix VII: Nacosti research permit 103

CHAPTER ONE: INTRODUCTION

2.1 Background of the study

Climate variability has become a global concern. Over the years, natural as well as human activities have had an impact on climate leading to tremendous changes in average climate parameters. Such natural activities include solar variation, Milankovitch cycles and volcanic eruptions (Desone, 2008). Human causes, also known as anthropogenic causes include emission of greenhouse gases through burning of fossil fuels, deforestation, burning of rain forests and land use changes (ibid). These effects have contributed to the general increase in global temperatures (global warming); for instance, the greenhouse gases like CO_2 and Nitrous Oxide trap some of the heat that radiates from the earth's surface, hence causing global warming.

Even though this phenomenon has its advantages, its demerits outweigh the merits. One of its adverse effects is the negative impact on human health. Climate variability has made it possible for parasites causing diseases to mutate and adapt in their environments making it difficult to fully eradicate the parasites with the available mechanisms. Some of the changes in climate have created breeding grounds for more parasites like jiggers and other disease vectors such as mosquitoes and snails (ibid). Jigger infestation poses a high risk of secondary infection like tetanus that can cause death (Kimani, 2012).

Jiggers infestation referred as *Tungiasis* is considered a nuisance with less attention given to it, and remains a public health problem for the poor. It is neglected by those affected by it, the medical and the scientific community at large (Heukelbach *et al*, 2001).

Jigger infestation is a menace associated with poor households and unhygienic conditions (Feldmeier and Heukelbach, 2009). A jigger (*Tunga penetrans*) is a parasitic insect that is found in most tropical (Mexico, Central America, Caribbean islands, Morocco, Tunisia, Lesotho and Swaziland) and sub- tropical climates (Mexican plateau, Vietnam, Taiwan, French Garden in Alexandaria in Egypt, Town Hall in Durban in South Africa, Mbeya in Tanzania, Kabale in Uganda). It thrives well when temperatures are high below the soil and its infestation may vary with seasons which bring us to the question of climate variability. The low latitudes near the equator take in much more solar radiation than the low latitudes near the poles. Busia county is closer to the equator hence its high temperatures which create a conducive environment for jiggers to breed (Feldmeier and Heukelbach, 2009).

For a long time, it has had an effect on occupants of many areas in the country. They include Busia, Murang'a, Kiambu, Kilifi, Nyeri, Kwale, Baringo, Kakamega, Siaya, Marsabit, Bomet, Bungoma, Elgeyo Marakwet, Homa Bay and Vihiga (Ahadi Kenya Trust, 2014). Teso-North sub-county is not an exception as jiggers in this area has had an effect on school age going children. For instance, it has been reported that 50 per cent of the children suffering from *Tungiasis* species may miss to attend classes (Ahadi Kenya

Trust, 2009). It may also result to school drop outs, repetition of classes and to some extent the death of the affected pupils.

The jiggers have also affected the community at large ranging from old age men and women as well as the middle aged. Its effects include inability to walk due to pain in the affected areas, disability as a result of amputation of the toes, fingers and even death in more severe cases (Ahadi Kenya Trust, 2009). Correlation between climate variations and jigger infestation will help come up with measures of preventing these effects.

2.2 Anthropogenic concerns and jigger infestation

2.2.1 Environmental characteristics

Environmental characteristics associated with jiggers include housing, hygiene as well as sanitation. Others include domestic animals in and around the house. Animals such as cows, pigs, dogs, sheep as well as rodents are known to be jigger hosts. Households with these animals are at a high risk of being infested. Some people in rural areas share their houses with these animals thus increasing the chances of spreading the jiggers to human beings (Nagy *et al.*, 2007).

2.2.2 Housing

The type of housing inhabited by individuals can be a major risk factor in transmission of *Tungiasis*. Mud houses and semi-permanent houses with earthen floors provide breeding

ground for jiggers. Cracks and crevices in these types of houses also provide hiding places for the jiggers (Olivier, 1974).

2.2.3 Hygiene

Poor hygiene is a major contributing factor to the spread of jiggers. Dirty and uncovered feet provide a ready host for the jiggers. Dusty earthen floors, cracked walls and sharing houses with domestic animals accelerate spread of jiggers. Households should be well cleaned and fumigated to prevent jiggers. Children and the elderly in the community mostly sit or play on the ground, if such grounds are dirty, this may be risky. Children are also not good at taking care of themselves hygienically thus high prevalence in them (Mwirigi, 2013), this could be attributed to poverty levels where children cannot afford basic cleaning utilities thus making them vulnerable.

2.2.4 Poverty

Tungiasis is a disease that is generally associated with economically disadvantaged communities. Poor families infested with jiggers have difficulties providing basic needs such as food, proper housing, clothing and foot ware. Earlier observations in Brazil established that *Tungiasis* is mainly a problem of populations living in poverty (Heukelbach *et al*., 2001). In resource poor communities in the endemic area, severe infestations occur, and high morbidity is common (Feldmeier *et al*., 2003).

An earlier study by Ahadi Kenya Trust (2008) further supports this observation that jigger infestation in Murang'a contributed to the appalling poverty levels in the area. The report revealed that jigger infestation had made the residents to languish in the quagmire of vicious cycle of poverty. People afflicted with jiggers are less economically active, which further raises poverty levels (Heukelbach *et al*., 2001).

2.2.5 Effects of Jigger Infestation

According to Ahadi Kenya Trust (2009), major causes include poor hygiene (low levels of hygiene and sanitation) and poverty. Effects of infestation are wide in range. First and foremost, it leads to high rates of school dropouts and poor performance of the infected pupils. The affected pupils may drop out of school due to inability to walk to school and even write as their nails and toes are infested. They may also perform poorly as they miss to attend classes.

It also creates more poverty as the affected persons are unable to work. Jiggers reduce the economic stability of a person because once infested one cannot be able to work. He/she has to rely on others for basic needs.

Moreover, it causes stigmatization. People infected with jiggers are stigmatized in society. This makes them to have low self-esteem. Stigmatization makes them to avoid seeking medication, hence worsening the situation.

When jiggers embed in places with friction such as the joints or in places where their growth is limited, for example, under the nails, they are likely to burst hence leaving gaping wounds, these makes the wound to be exposed to dirt hence they can easily contract tetanus. Also, when jiggers are extracted, they leave open wounds and the victims cannot afford to dress their wounds, hence exposure to tetanus. The HIV virus is passed from one person (if infected) to another due to sharing of pins and needles while removing jiggers.

Jigger infestation may also lead to deformities in the infected persons. People with heavy infestations are unable to walk or use their hands. With repeated removal of jiggers, loss of sensation can be experienced, and this can lead to necrosis or death of the tissue on the affected area. This may urgently require amputation as the surrounding areas are affected.

High infestation may result into death of the affected. This may happen in the case of multiple infestations or acquiring of secondary infections such as HIV/AIDS, anaemia, dehydration and tetanus. These may expose them to death.

2.3 Statement of the problem

Research has shown that jigger infestations occur because of poverty and unhygienic environments (Feldmeier and Heukelbach, 2009). It has also been documented that the infestation may be accelerated by changes in climatic parameters such as temperature,

rainfall, and humidity. Temperature-high temperatures that favour the development of larvae may enhance jigger proliferation under dry conditions. Such conditions may be evident in Teso North Sub County as it has a tropical humid climate with warm temperatures due to the influence of Lake Victoria (GoK, 2016).

Since the year 1981 there has been a noticeable increase in mean annual temperatures of 1^0C in the sub county. The temperatures in the sub county are also projected to increase by 0.2^0C between the years 2021 and 2065 (GoK, 2016). Jiggers also thrive best in humid and tropical climate which is evident in our study area.

Enscore *et al*. (2002) suggested that threshold temperatures might be important because excessively high temperatures adversely affect flea survival or the abilities of fleas to retain the foregut blockages thought by some to be required for efficient transmission and penetration of fleas. Numerous studies have noted that, at temperatures above approximately 27°–28°C (81°–82°F), these blockages begin to break down. (Hinnebusch, 1998) Recently, it was reported that these produced biofilm which is synthesized at temperatures below 27°C (81°F) but breaks down at higher temperatures, resulting in the loss or considerable reduction of any blockage in the flea's foregut (Jarret *et al*-, 2004).

Feldmeier and Heukelbach, (2009) noted that jiggers thrive best when there is low or no rainfall. Low rainfall enhances jigger proliferation as it provides the best conditions such as high temperatures, low humidity and dry seasons for jigger proliferation. Also, heavy

rains wash away the eggs, larvae, pupae, nymphs, and adult fleas hence hindering jigger proliferation so, control measures aimed at reducing the morbidity of jiggers should be put in place at this stage. Low humid conditions enhance jigger proliferation. High humidity in the atmosphere impairs the development of free-living stages of Tunga Penetrans.

According to Okong'o O (2016), Busia County is among the leading counties with jigger infestation with a prevalence of 50%. The County continues to register fresh infestations compared to other counties e.g Kakamega, Homabay and Vihiga (Ahadi Kenya Trust, 2016). Due to the high jigger prevalence in the County, there are chances of it being declared a health menace in the Country and the long-term effect of deformities with decreased mobility and productivity by the residents (Olita R, 2017). The increasing temperature in Western Kenya has seen a fast and a heavy infestation of jiggers among communities for the past 10 years. The communities attribute such changes in the environment to change in temperatures that caused a lot of dust and increased breeding of jiggers (Ifejike, *et al* 2008)

In the long run, the jigger menace has become a localized and region based health issue where it is commemorated every 3rd March annually and Busia County is among the affected Counties (Olita R, 2014). The reviewed literature has shown that there has been wide spread research on jigger infestation mainly on poverty and sanitation but a missing link on climate variability. The research therefore strives to bridge this gap by studying

and bringing to light the need to understand how climate variability influence jigger infestation in Teso North sub- County. Also, climate parameters that favour the nourishment of the jiggers were studied and the findings will help the relevant stakeholders to interrupt its cycle thereby curbing its spread in the long run.

The increase in jigger infestation has made the working population to lose the working hours seeking medication and has reduced the number of school going children as they have dropped out of school Ochieng, 2019. According to Ahadi Kenya Trust 2009 among the schools affected include Kamolo, Kiriko and Ikapolok primary school.

There is need to look beyond poverty and sanitation as this may take years to deal with hence if the study is not done the residents of Teso North will continue experiencing the looming crisis of jiggers in the area such as decreased economic productivity, disability, exposure to secondary diseases of jigger infestation (Ahadi Kenya Trust Trust, 2009). It is therefore from these research findings that the government and scientists may come up with a long-term solution beforehand.

2.4 Research objectives

2.4.1 General objective

The overall objective of the study was to determine the influence of climate variability on jigger infestation in Teso North sub-county.

2.4.2 Specific objectives

The specific objectives of the study were to:

i. Determine the relationship between jigger infestation and climate variability in Teso North.
ii. Determine the impacts of jigger infestation to Teso North residents.
iii. Evaluate measures of preventing and controlling jigger menace in Teso North sub-county.

2.4.3 Research questions

(i) What is the relationship and trend of jigger infestation and climate variability in Teso North?
(ii) What are the significant impacts of jigger infestation to Teso North residents?
(iii) What are the measures of preventing and controlling jigger infestation in Teso North?

2.5 Justification and significance of the study

Jigger infestation is a menace that directly affects economic and social wellbeing of communities. The menace has led to low self-esteem on residents causing stigmatization and social discomfort.

Teso North Sub-County is among the affected regions in the Busia County with high jigger infestation. The need to studying the influence of climate variability on jigger infestation in this region will help understand how to curb its effects on the community. This study is necessary as it will suggest mitigation measures to curb jigger infestation and evaluate jigger prevention measures in Teso North Sub- County in relation to climate variability patterns. The study will also recommend facility improvement measures for the community in Teso North sub-county. Eventually, the data collected will add to the existing body of knowledge on climate variability vis-a-vis jigger infestation.

Analysing the influence of climate variability on jigger infestation will help the residents of Teso North reduce the impacts of jiggers on human economic structures and wellbeing. Therefore, even though various studies have been done on the issue of jigger infestation in Teso North, no study known to the researcher has been done on the relationship and the link between jigger prevalence and climate variability in Teso North sub county of Busia County, hence a knowledge gap. It is this gap that the researcher sought to fill.

2.6 Scope of the study

The study covered parts of Teso North sub-county found in Busia Kenya. The research focused on climate variability and jigger infestation on the study community. The study covered 6 wards including Malaba Central, Malaba North, Malaba South, Angurai South, Angurai North and Angurai East. The study area covers a total surface area of 257.10km^2 and has a population of 117,947 (GoK, 2009). The study area borders Uganda to the West,

Mt Elgon to the North, Nambale and Teso South to the South. It is located on coordinates (0^0 45’06’’N, 34’25’’E), (0^0 35’’N, 34’15’’E) (WPMR, 2013).

The study will cover a duration of 30 years for climate variability trend, the period covers a vast time span owing to the fact that climate variability cannot be tracked in a period of less than 10 years and for proper variability analysis a 30 year period was suitable from the year 1987-2017.The jigger menace was studied based on their distribution in the locality and their impacts to children and older people, the control of jiggers at household and community level was sought for and reported accordingly.

CHAPTER TWO: LITERATURE REVIEW

2.7 Climate variability and human health

Greenhouse gas emissions primarily generated by human activities has changed earth's climate tremendously (Anthony *et al*, 2006). That, as of the year 2006, global warming of up to 0.5^0c was attributable to anthropogenic emissions. Scientific evidence on global warming has linked some health outcomes including thermal stress and rise in infectious diseases to general rise in global albedo.

The IPCC forecasts an increase in world average temperature by 2100 within the range of $1.4 – 5.8^0$c which will be greater over land. Scholars have pointed out that the rise in global temperatures will likely increase annual global rainfall, mid latitude and higher latitudes will become drier (Anthony *et al*, 2006). In addition, climate variations could tip the ecological balance and trigger epidemics. For instance, change in temperatures in particular affects vectors, pathogens and parasites (like sand flies) resulting in excessive breeding. Heavy rainfall on the other hand, flashes larvae (mosquitoes as well as the sand flies) from their habitat in pooled water. Evidence and anticipation of adverse health effects will strengthen the case of pre-emptive policies and will also guide priorities for planned adaptive strategies. The study also shapes input to both national and international policy debates. *Tungiasis* is a common, but neglected, public health problem in economically depressed communities (Heukelbach *et al.*, 2001).

2.8 *Tungiasis* disease

Tungiasis is a common, but neglected, public health problem in economically depressed Communities of South American, Caribbean and Sub-Saharan African countries (Heukelbach *et al.*, 2001). This ecto-parasite is caused by *Tunga Penetrans*, the sand flea, also called the jigger flea (Myers *et al*, 2014). The female jigger flea penetrates into the skin of its host, undergoes a peculiar hypertrophy and reaches the size of a pea. Embedded head first with its hindquarters at the surface of the skin, the flea is evident as a distinct, characteristic lesion on the skin; a globular white mass with a black dot at its Centre (Joseph *et al.*, 2006). The excretory pore which opens outwards through the skin allows the flea to respire, excrete and discharge newly produced eggs (Gordon, 1941, Eisele *et al.*, 2003). *Tungiasis* is a disease, that affects a broad range of domestic animals, such as dogs, cats, pigs, and other animals have been found infested include cattle, sheep, goats, horses, chicken rats, mice, elephants, monkeys and other wild mammalians (Nagy *et al.*, 2007). However, where humans live in close contact with these animals and where environmental factors and human behaviour favour exposure, the risk of infection is high although man is an accidental host (Heukelbach *et al.*, 2002).

2.8.1 Transmission of Tungiasis

Transmission of *Tungiasis* is strictly by infestation of *Tunga Penetrans* and humans become infested when walking in sandy soil in which female fleas are present. Infestation tends to involve the ankles and feet, particularly between the toes, it can also occur

anywhere in the body, including the head if the individual lies on the infested ground. In small children, lesions can occur at ectopic sites as far as the hands, elbows, neck, anus and the genitals Veraldi and Schianchi (2006). Patients with reduced sensation in their feet may have more severe infestations (Beverley, 2001).

2.8.2 Life cycle of a jigger flea

According to the Centre of Disease Control and Prevention, CDCP (2009), the life cycle of *Tunga Penetrans,* the jigger flea, begins when the eggs are shed by the gravid female into the environment, hatch into larvae in about 3-4 days and feed on organic debris in the environment. The larva malts twice and becomes a pupa with the adult hatching in 3-4 weeks. The pupae are in cocoons that are often covered with debris from the environment including sand, and pebbles. The larval and pupae stages take about 3-4 weeks to complete the life cycle. Adults seek out a warm-blooded host for blood meals. Both males and females feed intermittently on their host, but only mated females burrow into the skin of the host, where they cause a nodular swelling. Females do not have any specialized burrowing organs, and simply claw into the epidermis after attaching with their mouthparts. After penetrating and burrowing with only their posterior ends exposed to the environment. The female fleas continue to feed and their abdomens extend up to about 1 cm. Females shed about 100 eggs over a two-week period, after which they die and are sloughed by the host ‘s skin (CDC 2009).

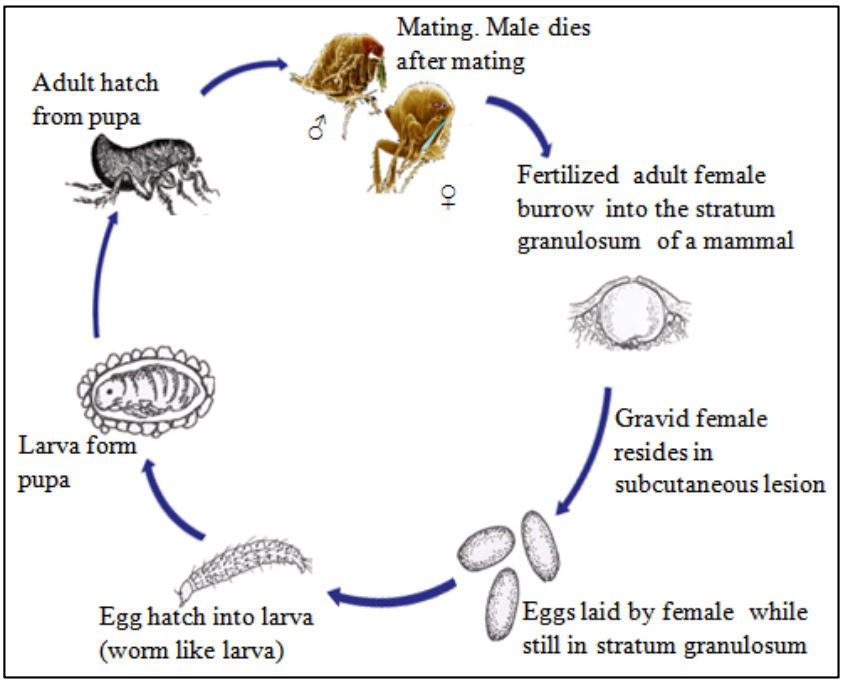

Figure 0:1: The life cycle of jigger flea (complete metamorphosis).

Source: CDC, 2009

Male flea which is distinguishable by its conspicuous copulatory organs dies after mating. The fertilized female fleas infest mammalian skin to develop and mature its eggs to perpetuate the cycle CDC, 2009.

2.9 Climate variability and infectious diseases

Studies suggest that infectious disease transmission should be viewed within an ecological frame work. Infectious agents obtain the necessary nutrients and energy by parasitalization of higher organisms. During the long process of human cultural evolution; population dispersal around the world and subsequent inter-population contact and

conflict, several distinct transitions in human ecology and inter-population ecology have greatly changed the patterns of infectious diseases in human population. It is their view that vector organisms like sand flies are very small and devoid of thermostatic mechanisms (Patz *et al*., 2006).

Their temperatures and fluid levels are therefore determined directly by local climate hence there is a limited range of climatic conditions; the climate envelope in which each infective or vector species can survive and reproduce. That, the incubation time for a jigger is typically very sensitive to changes in temperature, displaying an exponential relationship (Patz *et al*., 2006).

According to the World Health Organization report on epidermal parasitic skin diseases (EPSD); *Tungiasis* is geographically restricted to the Caribbean, sub-Saharan Africa and South American countries. The parasite is also climatically restricted compared to other epidermal parasitic skin diseases like; cabbies and head lice. Prevalence of *Tungiasis* in the tropics is highest in the dry season. (Feldmeier and Heukelbach, 2007).

2.10 Climate variability and gender

Climate impacts on men and women differently due to differences in their traditional roles, societal expectations, and livelihoods. Women, who make up the majority of the developing world's 1.4 billion poor, generally have lower incomes, less access to credit and decision-making authority, and limited control over resources, increasing their

vulnerability to many climate impacts. Moreover, different societal roles and responsibilities of men and women also present different opportunities for incorporating clean energy alternatives into their lives. (USAID, 2006)

Studies show that climate change projects can be markedly more effective when gender is considered. For instance, working on disaster risk reduction in South Africa, development (USAID, 2006) found that men had greater access to radios, whereas women were more likely to hear forecasts and early warnings if they were delivered through extension workers. Furthermore, those women also have important skills, influence, and knowledge in areas like natural resources management and farming. Climate change interventions can also provide opportunities to empower women; for example, in Honduras, women took charge of an abandoned community early warning system, facilitating rapid evacuations during Hurricane Mitch. (USAID, 2006)

According to USAID, 2006 the following approaches for integrating gender and climate were suggested: first, involvement of women in vulnerability assessments, to ensure that the evaluations do not focus solely on economic sectors dominated by men. Secondly, involvement of both men and women in the prioritization and design of climate adaptation projects and build on their indigenous knowledge. Thirdly, reach men and women through industrial as well as household clean energy interventions and lastly, make information, training, and technologies for climate change adaptation and mitigation accessible and relevant for all stakeholders.

2.5 Factors that promote jigger infestation

Jigger infestation is accelerated by changes in temperature, for instance high temperatures (30-34^{O}C) favors the development of larvae under very dry conditions. According to Heukelbach *et al*., 2005 prevalence of jiggers seemed to be high at the peak of dry season and low during wet season. Therefore, its prevalence increases with increase in temperature and its optimum when there is no humidity in the air.

Jiggers thrive best when there is low or no rainfall. Heavy rains wash away the eggs, larvae, pupae, nymphs, and adult fleas hence hindering jigger proliferation. In view of this, control measures aimed at reducing the morbidity of jiggers should be put in place at this stage. Low rainfall enhances jigger proliferation as it provides the best conditions such as high temperatures, low humidity and dry seasons for jigger proliferation (Feldmeier and Heukelbach, 2009).

Low humid conditions enhance jigger proliferation. On the other hand, high humidity in the atmosphere impairs the development of free-living stages of Tunga Penetrans. Jiggers also referred to as sand fleas generally thrive well in sandy and dry soils. Soil moisture, organic matter content, pH, texture and soil colour influences the prevalence of jiggers (Ndung'u, 2006). Similarly, sandy soils create suitable conditions for breeding of jigger (Wambani, 2017).

2.6 Jigger menace

Jiggers are global threat to human physiology; the jiggers' infestation causes major social and physical damages to families globally and regionally.

2.6.1 Jigger menace in the world

As of the year 2009, worldwide distribution of the jigger menace was present in 88 countries with varying degrees of incidence. This disease is of special public health concern in highly endemic areas like Nigeria, Trinidad, Tobago, and Brazil among others where its prevalence, especially in poor communities, has been known to approach 50% (Heukelbach *et al*., 2005). Kenya being one of these poor countries is also not left behind with counties like Busia, Murang'a, Vihiga, Kiambu, Nyeri among others recording high numbers of infestation (Ahadi Kenya Trust, 2009). Only sporadic occurrences have been reported in America, Oceania and Europe mainly in citizens returning from tropical areas after tourism and military missions. The map below shows the worldwide distribution of *Tungiasis* as of 2009 Figure 2.2

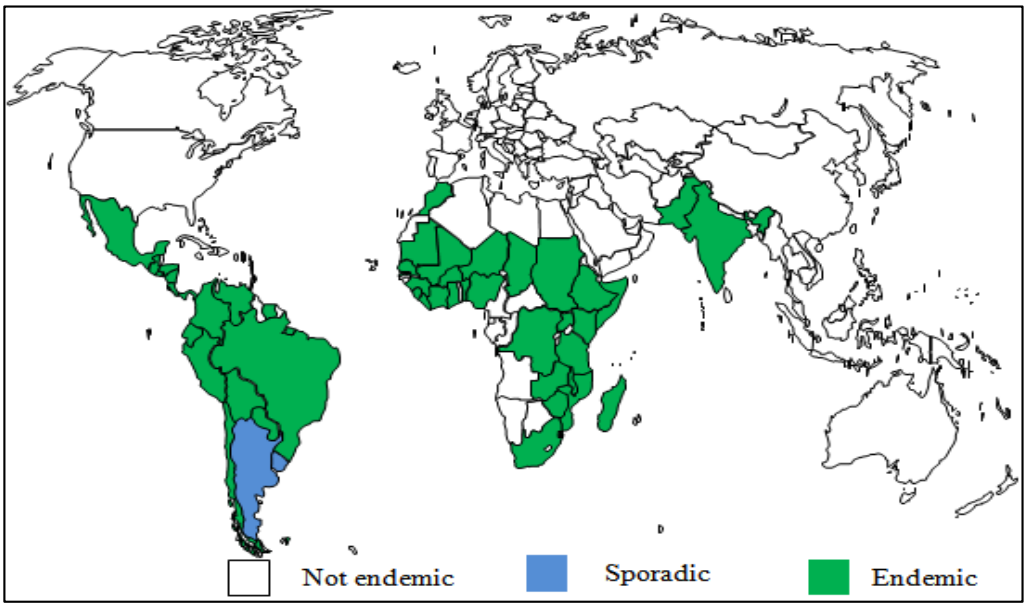

Figure 0:2: A map of worldwide distribution of *Tungiasis* as of 2009

Source: Feldmeier *et al*., 2004.

2.6.2 Jigger menace in Africa and Kenya

Kimani and Nyagero (2012), found out that jigger infestation is a menace that has affected populations mostly in sub-Saharan Africa (Kenya being one of them), the Caribbean and South America.

That 70.1% of their research population acknowledged poor hygiene and sanitation as the main cause of jigger infestation. 26.6% of the jigger infested persons reported that they were poor; others believed in myths and misconceptions on jiggers. About two thirds of the households were not aware of communal jigger prevention and control activities. Children were reported to be the most affected Ahadi Kenya Trust, 2009.

They concluded that, knowledge on jigger infestation is high but this has not been translated to jigger prevention and control. In all previous studies the contribution of climate variability was not considered by scholars.

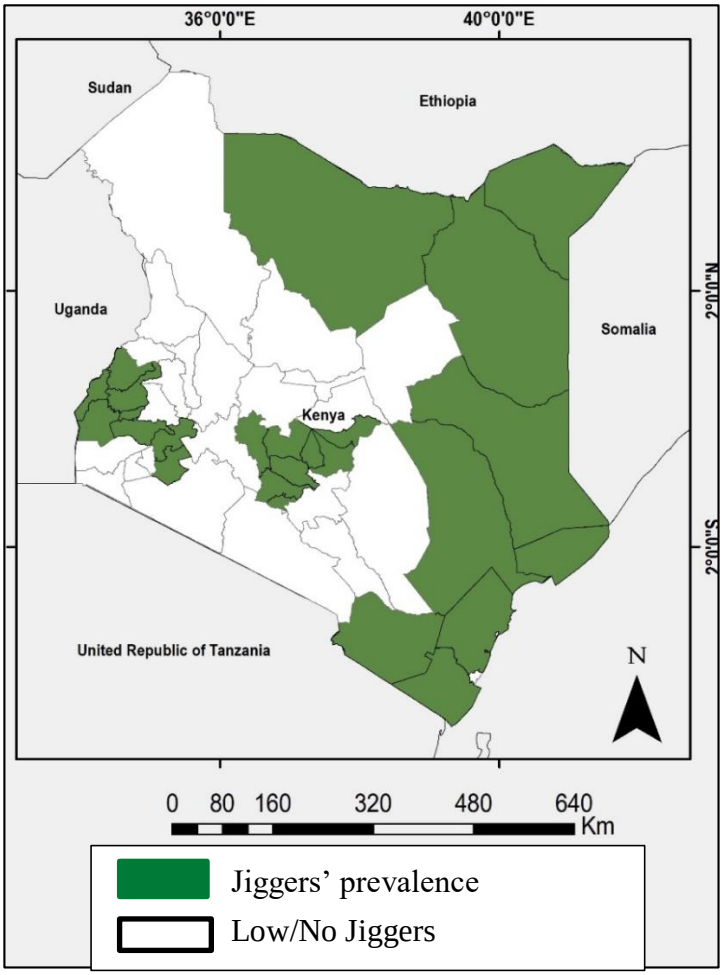

Figure 0:3: Jiggers distribution in Kenya

Source: Ahadi Kenya Trust, 2019

2.7 Jigger infestation

Jigger infestation is varied; jigger infestation can be altered by seasonal variations like temperatures and rainfall. The infestation can also be observed in variations by gender and age of the affected populations.

2.7.1 Jigger infestation and seasonal weather variation

Jiggers generally thrive best in humid and tropical climates. A study in Brazil revealed that the disease has a considerable weather seasonal variation. The prevalence of *Tungiasis* was observed to be highest at the peak of the dry season in the month of September, which was 54.4% while the lowest prevalence of 16.8% was observed after the first rain of the rainy season in the month of January (Heukelbach *et al*., 2005). A similar trend has been suggested in Kenya, as reported by several respondents during the Ahadi Kenya Trust team visit to Murang'a District (Ahadi Kenya Trust, 2019).

This means its prevalence increases with increase in temperatures and its optimum when there is low humidity in the air and decreases during the rainy season. Rainfall results in high humidity which impairs the development of free-living stages of *Tunga Penetrans*. Furthermore, heavy rains wash away the eggs, larvae, pupae, nymphs, and adult fleas. Therefore, control measures aimed at reducing morbidity should be scheduled to be in place before the attack rate increases, that is, at the beginning of the dry season (Heukelbach *et al*., 2005).

2.7.2 Jigger infestation and age

A relationship between jigger infestation and age bracket is known to exist. A study by Ndung'u (2015) shows that jigger prevalence is high between 5-14 years, decrease in adults and increases again in the elderly.

Another key thing to remember is that, *tungiasis* prevalence rate increases with increase in age bracket ranging from 4-6 years, 7-9 years, and then reaches peak at 10-12 years and starts decreasing such that children 16-18 years had the least prevalence. It was evident that the most prone age bracket in children is 10-12 years. He also showed that, although not statistically significant, the prevalence in adults increases toward the old age so that those with 55 years and above have a higher prevalence compared to adults of between 18- 55 years. The reason older people are more often infested by jiggers than younger adults may be attributed to co-morbidities that create situations that make it difficult for them to care for themselves. Similarly, children remain vulnerable because they may not have caregivers at home and are unable to take care of themselves due to lack of skills and resources to address the problem. Children are also known to be playful and they are not careful on where they sit. The elderly also spend most of their time seated close to the ground and in one place. This continued contact with the ground expose them to the jigger habitats hence the high risk of infestation (Ndung'u, 2015).

2.7.3 Jigger infestation and gender

The prevalence of *Tungiasis* among the male in the study locations (Murang'a County) was observed to be slightly higher compared to that of females, showing a clear preponderance of infestation in the male sex (Ndung'u, 2006). These results correspond to the findings of Community-based studies that have consistently shown *Tungiasis* prevalence of between 16% and 55% in typical endemic areas with a peak of age-specific disease occurrence in children of 5 to 14 years and the elderly, and a preponderance of infestation in the male sex. This may be linked to the factor of hygiene where the female gender is known to be well groomed most of the time compared to their male counterparts (Feldmeier *et al*., 2014)

2.8 Jigger control measures by schools and the community

Makena and Mwoma (2014) established that the jigger parasite is a threat to children's school attendance hence poor results because they will have covered very little by the end of the year. Their study recommended that school administrators should come up with strategies for curing those already infested and implement other programs aimed at eradicating the parasite among the school going children.

Three primary schools in Teso North sub-county were reported to be infested by jiggers thus threatening their closure (Olita, 2012). This justified our choice of location as the

study area. Poor hygiene was cited as the main cause of the menace; for instance, only two toilets in Akiriamasit Primary School for both teachers and more than 200 pupils.

2.9 Theoretical framework and conceptual framework

2.9.1 Theoretical framework

Tropical diseases are a burden to National and County health schemes plans and are becoming more expensive for families and the government. *Tungiasis* management depends on many factors which include beliefs, practices, and willingness of the persons involved, attitudes, skills and knowledge (Josephine, 2015).

The study by Josephine (2015) draws from a range of theories and the basics of jigger infestation and its control or management among communities was considered, the jigger relationship with climate is a theme that has many theories and the study adopts two theories: Constructivist Learning Theory and Maslow's theory, the theories are fundamental because they influence behavior for both the children respondents and adults respectively. Children are motivated and learn through experience, according to Brooks and Brooks (1993), the Constructivist Learning Theory states that people construct personal understanding and knowledge of the world through experiences and reflecting on the said experiences. The theory is based on the perception that learners too, learn from their experiences as they interact with the phenomenon (Brunner, 1961). Brunner (1961) emphasized that the learners should find out things for themselves in a school setting

facilitated by the teacher which should empower them to be thinking independently after formal schooling. These learning experiences may be limited among the children suffering from *Tungiasis* if they miss to enroll, attend or drop out of school and due to the resulting loss of health. The loss of health among children due to parasitic diseases includes reduced memory, intellectual and physical growth (Bleakley, 2003). This may also be the case for among the children suffering from *Tungiasis* which would further compromise their capacity to learn. Morkve (2013) noted that *Tungiasis* is a threat to learning process among the children in endemic areas.

In Maslow's theory of Human Motivation (Maslow, 1943) it is stated human beings are motivated to achieve certain needs. When one need is fulfilled a person seeks to fulfill the next one, and so on in hierarchical order. In this theory the fundamental principal is that before achieving cognitive (thinking) needs of a learner then the basic needs such a need for food and clothing must be fulfilled first. These basic needs include biological and Physiological needs such as air, food, drink, shelter, warmth, sex, sleep. Safety needs - protection from elements, security, order, law, stability, freedom from fear. Love and belongingness needs - friendship, intimacy, affection and love, from work group, family, friends, romantic relationships. Esteem needs - achievement, mastery, independence, status, dominance, prestige, self-respect, and respect from others. Finally, self-Actualization needs, realizing personal potential, self-fulfillment, seeking personal growth and peak experiences. Disabilities caused by *Tungiasis* among adults such as pain,

itching lack of sleep, difficulty in walking and grasping Morkve (2013) destabilizes the physiological state of the victims. Pain among children and adults has been described to give them a sense of despair and feeling anything can happen to them. It can therefore be said that the affected experiencing constant pain due to *Tungiasis* will be affected in the same way.

The need for love and sense of belonging may not be satisfied among the victims suffering from *Tungiasis*. This may be due to stigmatization and isolation in the schools and community (Feldmeir *et al.*, 2013; Morkve, 2013). This then would hinder the affected from unleashing their potential. Their self-esteem is also lowered due to ridicule in by their peers, isolation and inability to play when others are playing (Morkve, 2013). Thus, denying the children the sense of belonging and love among their peers.

Maslow theory also depicts that people perform best in an orderly, predictable environment and households. *Tungiasis* is likely to cause disorderliness due to lose of productivity among other members of the household and tension caused by stigma and isolation. This denies satisfaction of safety need. If a need is not satisfied for a long time the persons aspiration is lowered or undergo permanent phase out hence a person is satisfied by getting food only which is a basic need according to Maslow (1943). This is likely to discourage the victims in the process of acquiring basic education, improving their lives and subsequently becoming unproductive members of society. Therefore, the vicious cycle of poverty would be perpetuated in the future generations. *Tungiasis* may

therefore lead to loss of health, low sense of belonging and unfavorable environment important in production and nurturing children.

2.9.2 Conceptual framework

According to Moore and Sween, (2015) a conceptual framework is used to illustrate what you expect to find through your research, including how the variables you are considering might relate to each other. Figure 2.4 shows the main variables to be studied, the key factors, constructs or variables and the presumed relationships among them (Miles and Huberman, 1994).

The conceptual framework provides an illustration of how jigger infestation can be influenced by climate variability. The independent variable in the study is climate parameters (temperature and rainfall) which depend on intervening variables that cause change in jigger infestation which can either increase or decrease.

In Figure 2.4, jigger infestation which is the dependent variable can be achieved by studying the climate variability within the study area and the changes in climate trends of Teso North. This is also affected by some factors called the intervening factors which are the prime causes of jigger infestation to either decrease or increase. The research determined the influence of climate change and variability on jigger infestation and findings from the research helped in evaluating measures of preventing and controlling jigger menace in Teso North Sub-County.

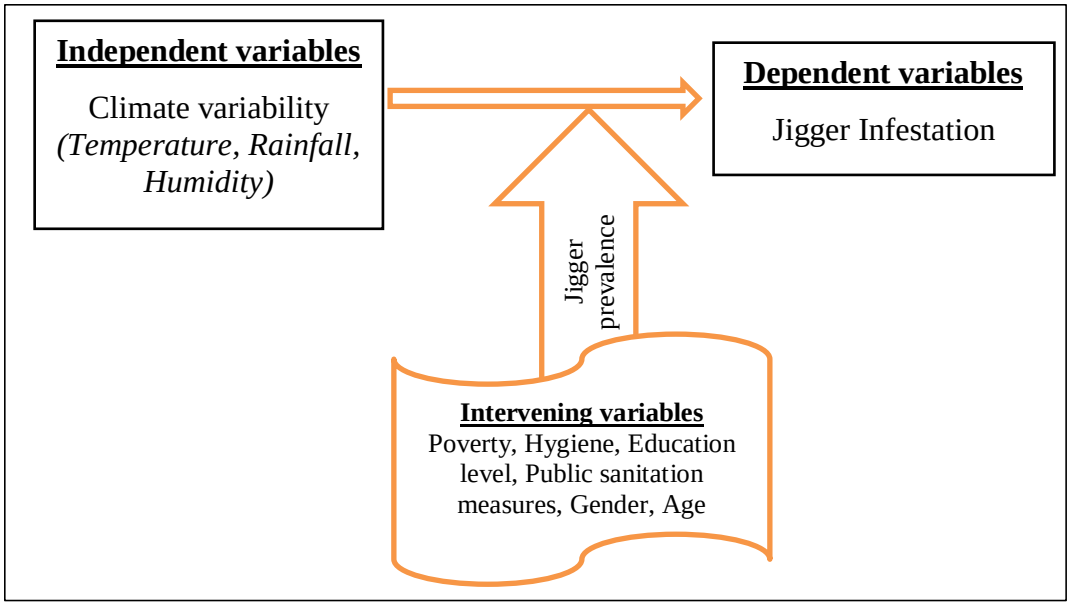

Figure 0:4: Conceptual framework
Source: Author 2020

CHAPTER THREE: RESEARCH METHODOLOGY

2.10 Description of the study area

2.10.1 Study location

Teso North sub-county is in Busia County within Western Region of Kenya. It covers a total surface area of 257.10km2 and has a population of 117,947 (GoK, 2009). It is located within latitude 3^0 860'N and longitude 39^0 9006'E (WPMR, 2013)

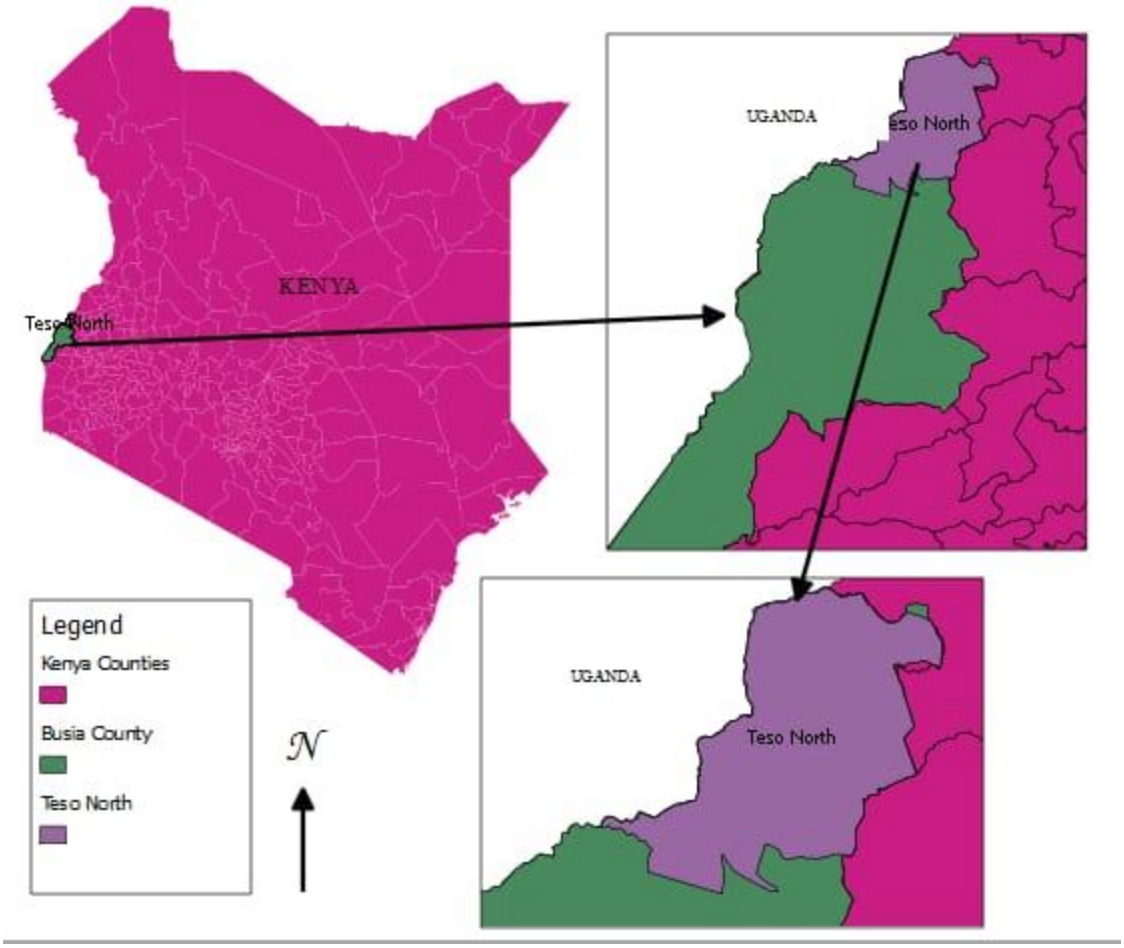

Figure 0:1: Map of the study area
Source: Author 2020.

2.10.2 Physical characteristics

Teso North is characterised by undulating landscape that lies at an altitude of between 1200m to 1350m above the sea level (GoK, 2016), the area has a bimodal rainfall pattern with the long rains falling between March, April and May (MAM) while the short rains fall between August, September and October. It receives rainfall that ranges between 1550mm to 1880mm and an The temperature of Teso North sub-county ranges from a minimum of 18^{o}C to a maximum of 30^{o}C (WPMR, 2013 (UBS, 2009).annual mean rainfall of 1500mm (GoK, 2016).

2.10.3 Socio-economic characteristics

According to FAO, 2011 the major crops grown in this area are Maize, beans and sorghum in order of preference, with the current areas planted including Maize 3200 Ha, Beans 2000 Ha and Millet 1500 Ha. The major livestock types are: indigenous chicken, zebu cattle, local goats, sheep in order of population.

The constituency has six wards namely; Angurai North, Angurai South, Angurai East, Malaba North, Malaba Central and Malaba south. The constituency covers an area of approximately 257.10 square kilometers with a population of 138,163 people, with 69,236 males and 68,927 females; it's largely inhabited by Iteso.

2.11 Research design

A descriptive survey design was adopted to determine the number of people affected by jiggers as well as the resultant effects of the infestation to different groups spread among the study population within Teso North sub-county. The correlation design was adopted in data analysis to show the relationship between climate variability, jigger infestation and control measures. Historical research design was used to collect and verify jigger events especially from community elders.

2.12 Study population

The target population was drawn from Teso North sub-county community at large; this included children, young adults, middle aged as well as community elders in the sub-County. It adopted a combination of sampling designs which include, Purposive sampling, convenience and random sampling (both simple and stratified).

Purposive sampling was used to select interviewees in the meteorological station because they are experts in the field of climate. Random (simple) sampling was used in the Locations to pick on community members to fill in questionnaires. Stratified sampling was based on the subdivision of wards (one location per ward) as illustrated in the (Table 3.1).

Table 0:1: Selected study areas

Ward	Area Selected	Method Used
Malaba Central	Akiriamasit	Census
Malaba North	Koruruma	Census
Malaba South	Kamolo	Census
Angurai South	Aedomoru	Census
Angurai North	Adanya	Census
Angurai East	Aterait	Census

2.13 Sampling strategy

The sampling strategy involved the sample calculation procedures and the sample selection process and locations.

2.13.1 Sample size calculation

The researcher employed purposive sampling in each stratum because climate variability influenced sample frames and reflected the subject matter the researcher intended to study

and establish their effects. The households were then selected randomly based on climatic regions (Hot and colder regions) Figure 3.2. The respondents were picked based on their age differences in each household and the Yamane's, 1967 formula was applied and it is calculated in (Table 3.2).

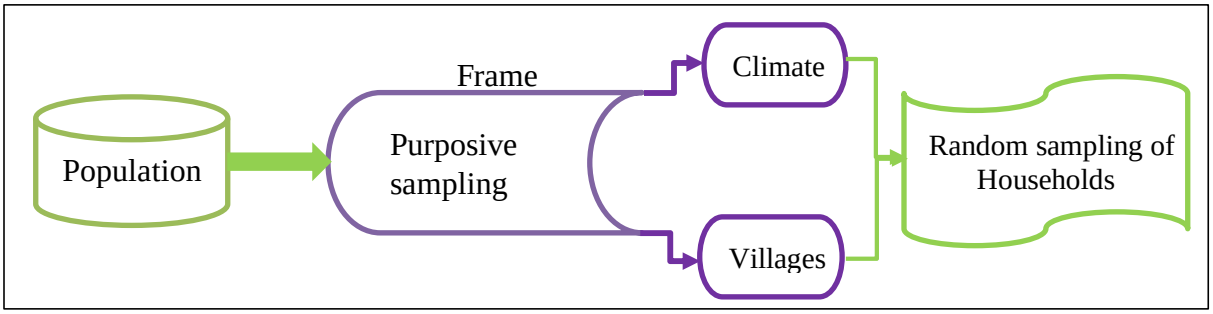

Figure 0:2: Sampling procedure

$$n = \frac{N}{[1 + Ne^2]}$$

$$n = [1 + Ne^2]$$

Source: Yamane (1967)

Where

n= Sample size

N=Population size

e=Sampling error (usually 0.10)

N- Total population

Table 0:2: Respondents sampling calculation

Ward	Selected study location	(Households)	Sample per ward	Sample size using Yamane's Formula
Malaba central	Akiriamasit	724	24	$n=N/(1+Ne^2)$
Malaba North	Koruruma	502	17	$n=(2924/1+2924\times0.1^2)$
Malaba South	Kamolo	412	14	$n=2924/30.24=96.69$
Angurai South	Aedomoru	284	9	
Angurai North	Adanya	429	14	
Angurai East	Aterait	573	19	
Total Population		2924		**97 households**

Source: KNBS, GoK 2009

2.13.2 Sample selection

The sample frame of the target population was selected based on the ward location. A total of 16.67% of the study area was sampled. According to Johanson, Brooks, (2010)

they suggest that in a discussion of exploratory studies a “samples with N’s between 10 and 30 percent can be considered to have many practical advantages. This translated to one village per ward of the six wards. Which include, Malaba Central ward, Malaba North, Malaba South, Angurai South, Angurai North and Angurai East.

2.14 Survey data collection

Data for the study were obtained from both primary and secondary sources. The primary sources were checklists, questionnaires and cameras. The Secondary data were obtained from Libraries, meteorological departments and online archives.

2.14.1 Primary data

The primary sources included first-hand information that was obtained from filling of checklists by target population through observation, photographing, filling questionnaires and conducting interviews. This study was informed by information gathered because of interviewing relevant stakeholders at Alupe sub-meteorological station and KMD with regard to data collected on climate parameters over the years. Questionnaires were also issued to various households within the Sub-County and key informants, chiefs, clergy heads and elders in the community. This facilitated acquisition of first -hand information regarding jigger infestation.

2.14.2 Secondary data

Secondary data were gathered from reviewing relevant text books, local newspapers, peer reviewed journals as well as internet sources. The secondary sources of data were also used to obtain climatic data which comprised of data from CFSR and covering Busia County and the target data were on solar insolation, temperatures and humidity. Rainfall data were obtained from Alupe meteorological station and for a period of 31 years.

These sources are readily available at the Masinde Muliro university library and on online archives therefore saved on time.

2.14.3 Tools for data collection

To achieve the research objectives and to ensure validity and reliability of the results, multiple data collection tools were applied, and comparisons made. These tools included questionnaires, interview schedules, field check lists, cameras, notebooks among others. The tools are described below:

Figure 0:3: Interview Process in the field at Aterait Village

2.14.4 Questionnaires

A total of 388 questionnaires were distributed in the study area. The questionnaires were used to collect data from six respondents sampled shown in Table 3.3. There were two sets of the questionnaires for Children (Appendix I) and Adults (Appendix II) showing a summary of information in the questionnaires.

Table 0:3: Questionnaire distribution Table

Ward	Selected study location	Number of households	Number of questionnaires
Malaba central	Akiriamasit	24	24x4=96
Malaba North	Koruruma	17	17x4=68
Malaba South	Kamolo	13	13x4=52
Angurai South	Aedomoru	10	10x4=40
Angurai North	Adanya	14	14x4=56
Angurai East	Aterait	19	19x4=76
Total		97	388

2.14.5 Field Check lists

Field checklists were used to collect data that were not captured in the questionnaire for instance emerging economic activities, sanitation levels, and body parts infested by jiggers.

2.14.6 Key Informant Interview Schedule

Interview schedule were used to collect data from the KMD personnel, Ministry of Health and community elders. One on one interview was conducted with KMD personnel at Alupe Meteorological station and the interview mainly focused on climate variability of Teso North Sub-County. The interviews for community elders focused on jigger events in the study area and those of Ministry of Health focussed on the history and prevalence of jiggers in the study area as illustrated in Appendix IV.

2.15 Climate variability data collection and measurements

Climate is a determinant of jigger infestation especially in the tropics. The study obtained climatic data from various secondary sources. The data from Alupe meteorological station which was majorly rainfall data and the other climatic data was obtained from Climate Forecast System Reanalysis (CFSR) and included humidity and temperature.

2.16 Validity of research instruments

The instruments for data collection were subdivided as per the variables and objectives to ascertain whether the content was comprehensive and representative of the behaviour domains that were measured. Content validity of the instrument used determined through expert judgement which involved discussing the items in the instruments with the supervisors, lecturers and colleagues.

2.16.1 Validity of data collection instruments

The validity of a test is a measure of how well a test measures what it is supposed to measure, (Kombo & Tromp, 2009). Content validity was used to validate research instruments. Content validity refers to the degree to which the content of the items reflects the content domain of interest. Is the content about what we say the test is about? (Miller, 2003). This ensured that the study objectives were captured to make the questionnaires adequate in form and content. The items constructed by the researcher were adopted and modified after discussion with research supervisors. To ensure content validity the questionnaires were assessed by supervisors who examined the items for suitability and consistency. This was done by piloting the questionnaires to 10 children and 10 adults in Mujuru village of the neighboring Matayos sub county. The 1selection of the sample was informed by the ages of the children and affected adults. Matayos was primarily chosen for the piloting because it has similar climatic and socio cultural characteristics as Teso North sub-county and is also jigger infested zone.

2.16.2 Reliability of data collection instruments

A pilot study was done in Mujuru village of Matayos Sub-county with samples being drawn from areas outside the study area-Teso North. This was meant to ascertain how reliable the instrument was. A pilot study helped to increase the clarity of the results. The

meteorologists, village heads and key informants interview schedule were un-structured, and responses were orally administered.

The degree to which an assessment tool produces stable and consistent result is defined as reliability. To test the reliability of the research instrument, the interview plan and questionnaire were piloted to 10 respondents' in Mujuru village. The responses were subjected to Cronbach's Alpha statistics that provides a measure of the internal consistency of a test or scale; which is expressed as a number between 0 and 1. Internal consistency describes the extent to which all the items in a test measure the same idea or construct and so it is associated with the inter-relatedness of the items within the test. It is a good practice to determine internal consistency before a test can be employed for research or examination purposes to ensure validity. Ideally, reliability estimates show the amount of measurement error in a test (Tavakol, 2011). The Cronbach's alpha range and its internal consistency are shown in Table 3.4.

Table 0:4: Cronbach's alpha range and internal consistency

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Source: Tavakol, 2011

The study reliability test was established with the help of Cronbach's α(alpha) which is used as a (lower bound) estimate of the reliability of a psychometric test. Cronbach's α (alpha) can be viewed as the expected correlation of two tests that measure the same construct. It assumes that the average correlation of a set of items is an accurate estimate of the average correlation of all items that pertain to a certain construct.

This study used 10 questionnaires to establish its reliability that was used for the study. The findings were as indicated in Table 3.5.

Table 0:5: Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.819	.798	10

From the findings, cronbach's Alpha value was 0.819. According to George and Mallery (2003) rule the instrument was reliable because the reliability test value was 0.819 which is greater than 0.8, from the alpha's internal consistency it indicates that the test was good. This verified the accuracy, consistency, dependability and predictability of the research instrument.

2.17 Data analysis and presentation

Data analysis was done using a combination of softwares including SPSS V 23 and Ms Excel 2016. The Questionnaires were checked for missing outliers before beginning the

analysis to confirm that all were filled, the correctly filled questionnaires were then coded in SPSS version 23 for analysis.

One-way analysis of variance was used to analyze data on the jigger's infestations and climate in Teso North through exploring of mean response scores of the above variables. Cross tabulations were used to determine jigger infestation per age, gender and household.

The climatic data obtained from Alupe meterological station specifically for rainfall was tabulated in excel for the 31 years' period. The Data obtained from CFSR and FAO on Climate were prepared using ArcGIS and the rainfall data uploaded to ArcGIS for seamless analysis. The presentation of data was done using bar charts, graphs, Tables, photographs and maps.

2.18 Ethical consideration

In Carrying out this research which involves people, it is bound to trigger suspicion and subsequent withdrawal of responses. Therefore, to prove authenticity, ethical considerations such as confidentiality and right to withdraw informed consent were considered. The researcher explained to the respondents the purpose of research and got their consent before data collection process begun. The confidentiality of the respondents was kept by pixelling/blurring their faces on photos that were to be published for purposes of the research; their personal information was not sought for but was awarded random

numbers for purposes of filling in the questionnaires. Appointments with respondents were arranged in advance and respondents were asked to omit their names and other personal information on the forms. Once the data was collected it was kept confidentially. In this regard a research permit were obtained from NACOSTI (Appendix V). The respondents were also assured of anonymity, confidentiality and protection of all their rights.

2.19 Limitation of study

The limitations were outlined in view of the fact that the approaches used were reliable and valid; but they also had their shortcomings which were beyond the researchers' control. Due to time and financial constraints it was not possible to cover each and every household and interview each and every child and elder.

The reliance on Community leaders as key respondents posed a limitation on basis that the informants were giving their opinions by filling a non-guided questionnaire on community jigger handling and jigger prevalence. This meant that respondents could have overrated themselves because, as Webster, Iannucci & Romney (2002) established, respondents tend to overrate themselves on positive traits. To overcome this, the researcher looked for any contradictory data among responses. Another limitation was that some children were not able to express themselves and needed a translator which could lead to biased translation or misinterpretation of the respondent's intended message. The information on jiggers within the community presents a mixed up and inconsistent

views from children to children and children to adults, these was experienced by children in same setting giving varied responses to same questions. The data on jiggers in Teso north was also limited and overall research on *tungiasis* and climate were scanty.

The study was confined to 3.3% (97) of the households in Teso North out of a household population of approximately 27924, the samples were drawn from children and elderly people with a population of 138,168 the 388 respondents represented a 0.28% of the population. Although the sample was relatively small, it was representative of the children and adults in Teso North sub-county, because the respondents were sampled from the six wards of Teso North Sub County which has different settings and environmental conditions, these limits the research to the issue of generalization of the findings.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter discusses the major findings and reports on the results of the research. The chapter presents data in tables, graphs and pictorials. It gives a general baseline survey.

2.20 Demographic information

There were a total of 381 filled and completed questionnaires with 189 and 192 for adults and children respectively.

The children had the highest returns at 192 with Akiriamasit recording 24% and the least record was from Kamolo at 13.5%. The mean age of adults was 44.2 years with more males reporting at 53.4% and females at 46.6% as shown on Figure 4.1.The number of boys and girl's respondents represented by boys were at 60.4% while girls were 39.6% indicating a dominance of males in the area a fact indicated by the 2009 Population and housing census indicating there were more male than females in the sub county. Children age dispersion had a mean of 5-9 years representing 35.9% while 0-4 years were 24%.

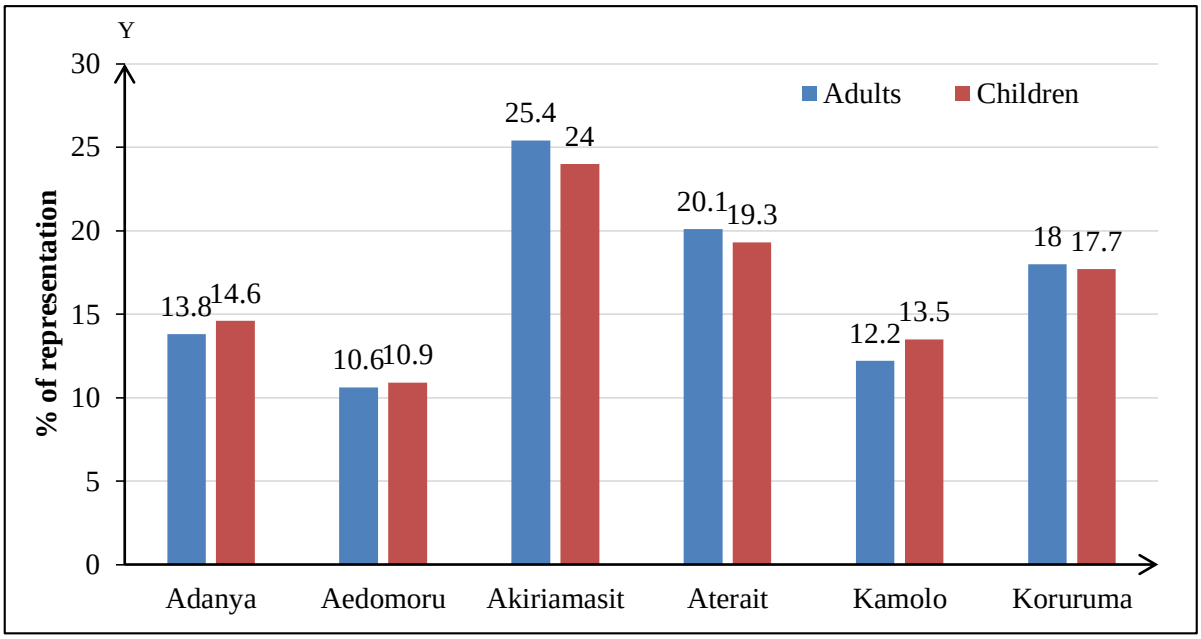

Figure 0:1: Respondent's representation per village

Source: Field data 2018

The education level was ascertaining if children were attending school was important in creating awareness channels and comparing the literate and illiterate infected by jiggers. The education level for adults indicated that most of the respondents had acquired at least secondary education, 33.3%, with 20.1% not having any form of education Table 4.1. There were more educated males than females with a mean =2.8 and 2.4 respectively (mean of 1-no education and mean of 5-University or higher). This saw more men attending Universities 11.9% and more females having no education at all 27.3% compared to 13.9% of males.

Table 0:1: Education level for adults

Level of Education	Frequency	Percent
None	38	20.1
Primary	50	26.5
Secondary	63	33.3
Post-secondary	20	10.6
University	18	9.5
Total	189	100.0

The employment rate was low in the area, the unemployed were 67% and employed were 33%. This saw more females get employed than males with 36.4% and 29.7%, respectively as shown in Figure 4.2. It was noted that employment and education levels were significant at $p<0.050$ which indicated that the more the education acquired the higher the possibility of employment at $r^2=0.596$.

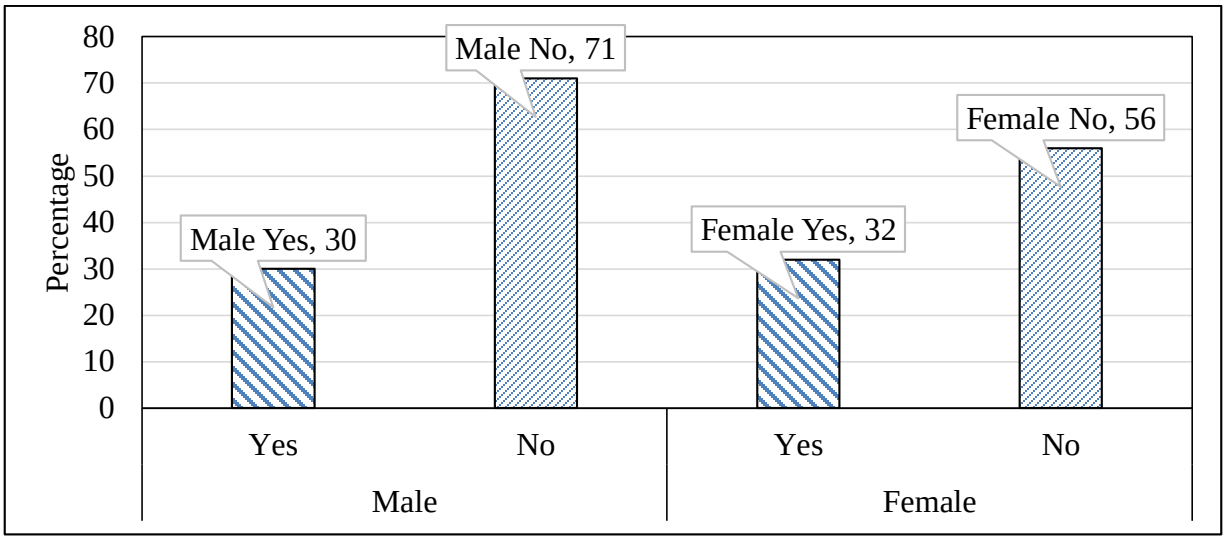

Figure 0:2: Employment and gender

Source: Field data 2018

The study established that jiggers infestation and housing are closely correlated, the type of materials used for construction were considered by this research to determine the type of housing and there was significant relationship between type of housing and jigger infestation in Teso North. The type of housing was found to be mud houses (66.7%), while brick houses accounted for 16.9% and blocks 13.2%, and stone houses 3.2% Figure 4.3. A chi-square test of independence was performed to examine the relation between housing type and jiggers prevalence in Teso North. The relation between these variables was significant, X^2 (9, N= 133.4), $p < .001$). Mud walled houses are more likely to be infested by jiggers than stones and block houses Table 4.2.

Table 0:2: Chi-Square on type of house and jigger prevalence

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	133.401[a]	9	.000
Likelihood Ratio	126.524	9	.000
Linear-by-Linear Association	8.365	1	.004
N of Valid Cases	189		
a. 7 cells (43.8%) have expected count less than 5. The minimum expected count is .22.			

Figure 0:3: A mud hut and crack on the walls

Source: Field data 2018

2.21 Climate variability and jigger's infestation

In the 1st objective of the study: to determine the relationship between jigger infestation and climate variability in Teso North. It was presented taking into consideration the

rainfall trend for 31 years, sunshine, temperatures and humidity. The section gives the findings based on secondary data acquired, their interpretation and discussion

2.21.1 Climate trends

The climatic variability's in the area took into account rainfall, sunshine, temperatures and humidity. The rainfall indicated a decreasing rainfall trend from 1987 with peak in 1989 and dropped in 2016 (102mm). The average rainfall in the 31 years indicated a hot and wet climate at 149.86 mm with a maximum precipitation at 196.20 mm which was experienced in the year 1989 (Figure 4.4).

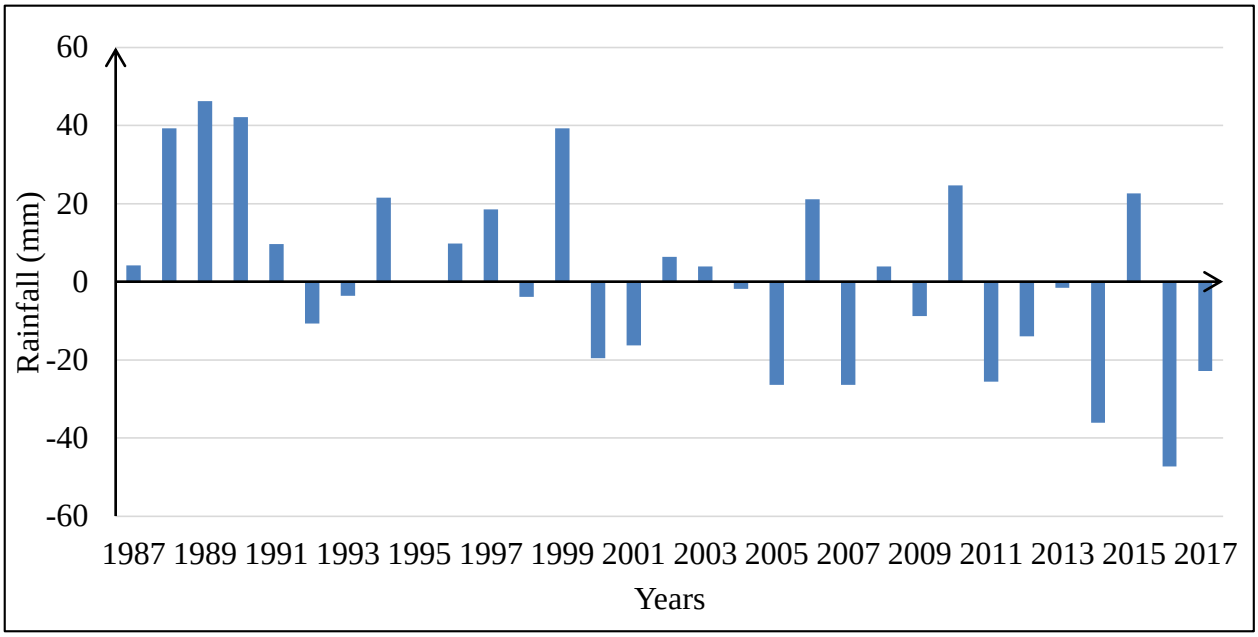

Figure 0:4: Annual mean rainfall

The created maps from CFSR data showed that rainfall in the sub county decrease with lower altitudes while there was much rainfall at the Northern part of the area. The rainfall in the Northern part of the study area is attributed to the relief rainfall as an effect of Mount Elgon while the further movement to the south the area creates a lee ward side of Mount Elgon Figure 4.5.

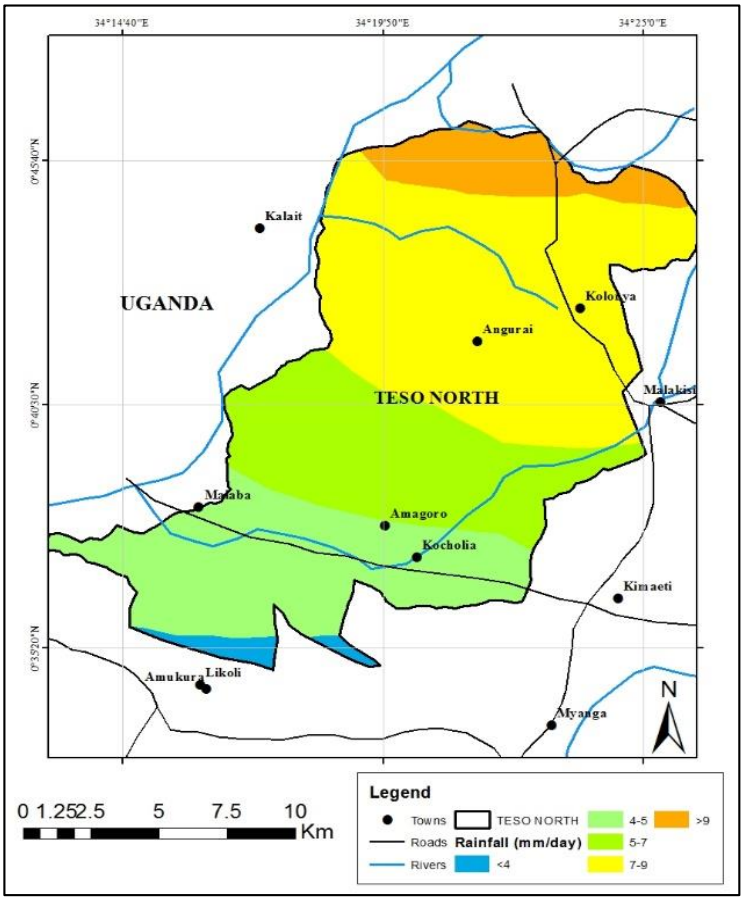

Figure 0:5: Rainfall distribution in Teso North

Source: KMD, 2018

Based on the CFSR data collected it was found out that the sunshine intensity in the area was reported by the respondents to be high which indicated higher temperatures greater than >23 kwh/m^2 Figure 4.6 (a), it was observed from a map of sunshine intensity in Teso North was more intense towards the south and less intense to the North, this was probably because of Mount Elgon effect causing high humidity in the area.

The sunshine intensity was directly proportional to temperatures in the study area. The temperatures measured in degrees centigrade indicated that the lower sides of the area were hotter at mean temperatures per day clocking 29^0 C while at the Northern parts the temperatures were cooler than lower zones. These were true as per the altitudes and the effect of Mount Elgon on the Northern zones. The humidity of Teso North was characterized by only two sets at 0.76 making up 99% of the area while some areas depicted a higher humidity in the south at Malaba North and Malaba Central. It was observed that the southern Part of Teso has a humidity and high solar intensity creating an ideal ground for jiggers to breed.

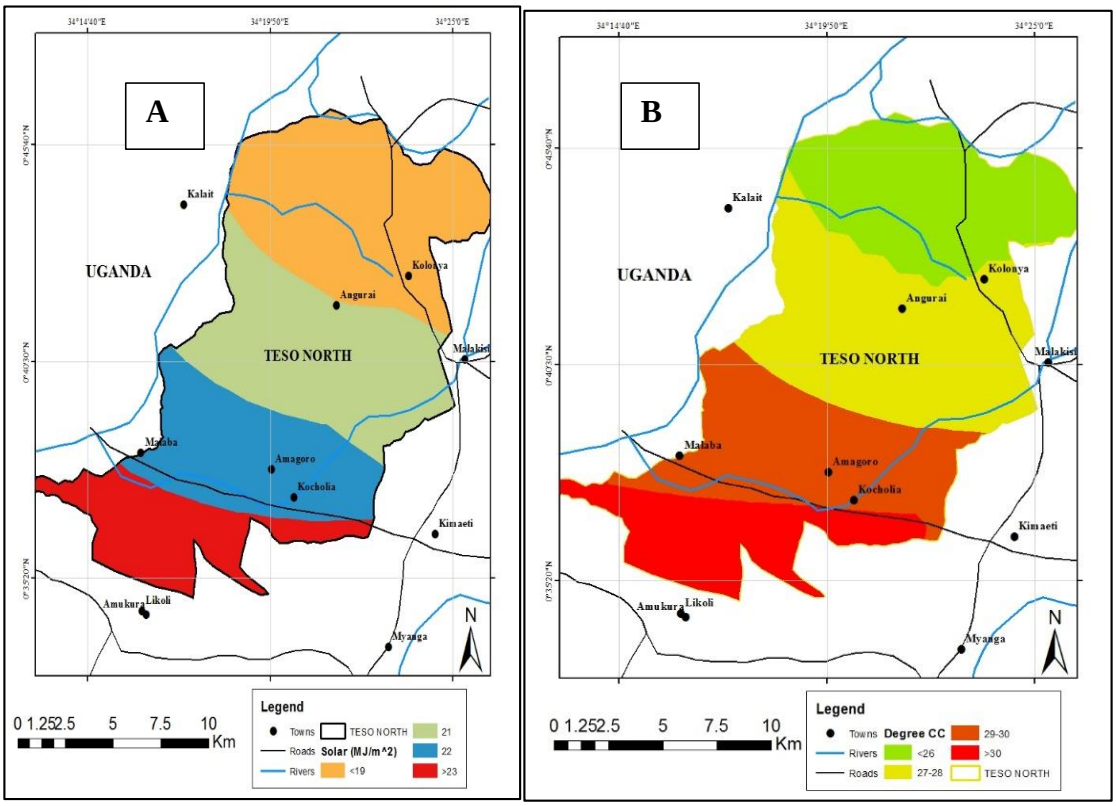

Figure 0:6: Solar insolation (kwh/m^2) per day (A) and Temperature (B)

Source: KMD, 2018

2.21.2 Climate variability

The change in climate over years as reported by key informants from KMD in Alupe indicated varied and erratic climatic changes in the past. The dynamic weather changes has made prediction by the locals with time .They indicated that the weather patterns have become more varied with 88.8% (82 cases) of adults indicating a change in climate and community leaders indicating the same too Table 4.3. The metrological departments

indicated a more reduced rainfall trends and an increased hot temperature across the years. The most variable change was indicated to be change to hot seasons.

Table 0:3: Adults climate description

		%	Dry seasons	Dusty seasons	Hot seasons	Short rains	Unpredictability	Total %
Change in climate	Yes	0.0	30.6	3.8	44.8	6.6	7.1	92.90
	No	7.1	0.0	0.0	0.0	0.0	0.0	7.10
Total		7.10	7.1	30.6	3.8	44.8	6.6	7.1

The change in the temperatures saw 88.8 % of adult's report that they had witnessed a change in temperature citing hot temperatures throughout the season while the metrological department also agrees with the temperature change. This indicated that there were more chances of increased attack of jiggers to the community.

The spread of jigger's under environmental conditions was indicated to spread under low humidity with 94.8% of adults and children indicated low humidity of 3.6% Table 4.4. The Ministry of Health key informant also indicated that the highest times when there are effects of jiggers are in hot conditions and low humidity. This was also reported by

community leaders and corroborates with what was recorded by children and adults in their questionnaire.

Table 0:4: Climatic conditions for jiggers prevalent.

		Frequency	Percent
Adults	High humidity	7	3.6
	Low Humidity	182	94.8
Children	Low Humidity	192	100

2.21.3 Jiggers infestation and climate variability

Jigger infestation and climate variability has been attached to increased fleas in tropical areas with decrease in some species of fleas (Heukelbach *et al*., 2005). The impact of climate on jiggers was sought for to answer one fundamental question if there is a relationship between jigger infestation and climate variability.

2.21.4 Jigger infestation

It was also observed that children were the most affected by jiggers with 73.4% getting infested by jiggers while there were 26.6% who had not had jigger's infestation. The

infestation of jiggers saw a high rate of jiggers in Adanya with 85.7% reporting infestation while Aterait recorded the least infestation at 64.9% Figure 4.7.

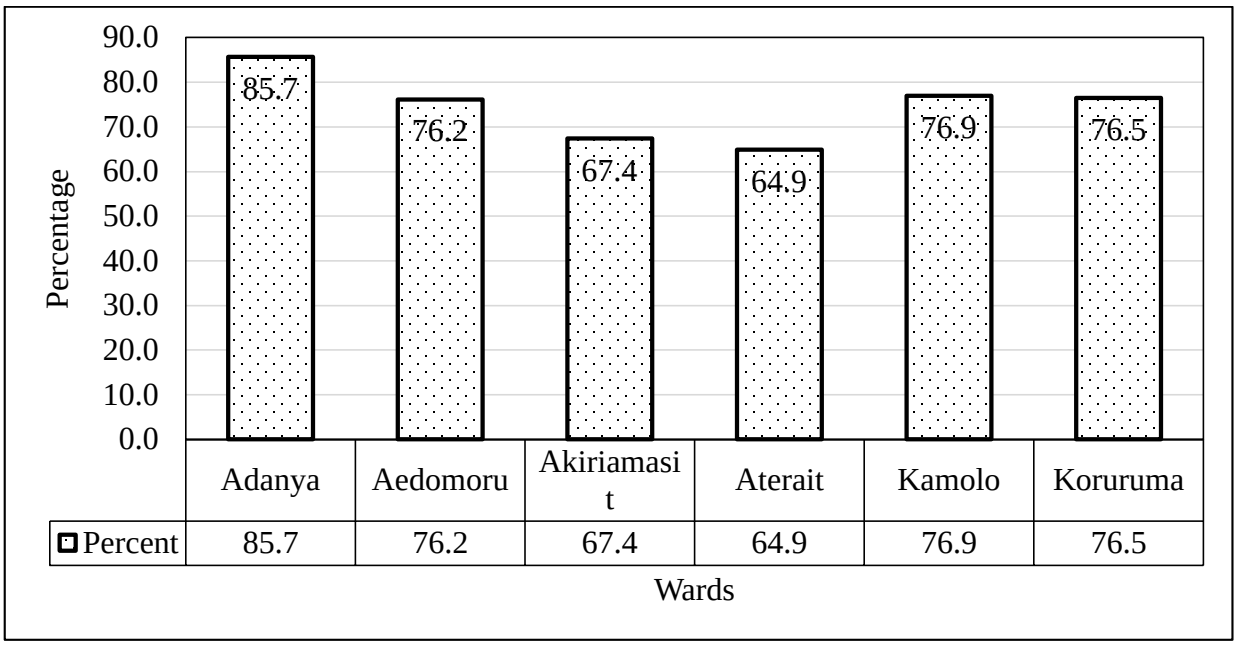

Figure 0:7: Children Jiggers infestation per ward
Source, Field data 2018

The significance level on children's infection and type of housing was conducted by Chi-square test and it was determined that there was no statistical significance between type of housing and infection (X=1, n=0.596) p=0.440 Table 4.5. This saw brick houses and blocks also get infected by jiggers, these showed that most of the children could be picking up jiggers at either school or in any other place rather than home.

Table 0:5: Chi-square on children infection and type of housing.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.596[a]	1	.440		
Continuity Correction[b]	.361	1	.548		
Likelihood Ratio	.604	1	.437		
Fisher's Exact Test				.496	.276
Linear-by-Linear Association	.593	1	.441		
N of Valid Cases	189				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.25.					
b. Computed only for a 2x2 table					

The children infested with jiggers were between ages 0-4 years, there were 87.0% of children infected and affected by jigger while the least group was between ages 15 to 18 as shown in Figure 4.6. This indicates inverse relations with age and jiggers' infestation.

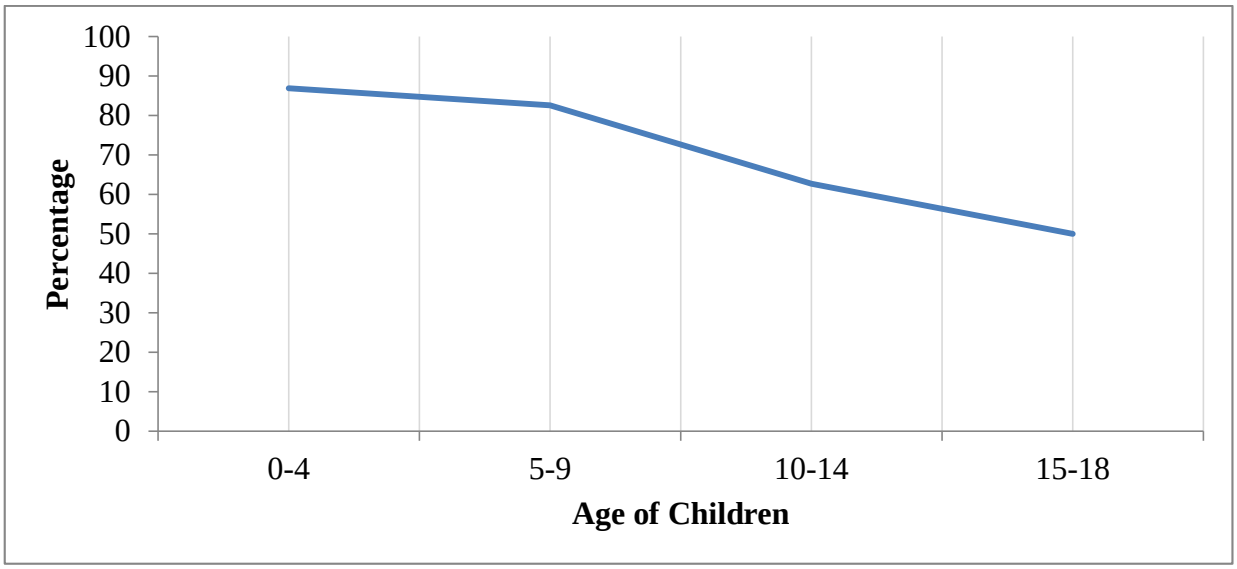

Figure 0:8: Influence of Age on jigger infestation

2.21.1 Jigger prevalence

The effect of climate as per elders was seen to be more prevalent in dry seasons with 95.3% Figure 4.9. Children indicated that there were more jigger's infestation during the dry season and there wasn't any jigger infestation at the wet seasons. This was established to be significantly true because most of them indicated that jiggers and dusty floors are a menace

"The jigger rate are usually high during dry seasons and we usually advice the children to water surfaces"-Parent

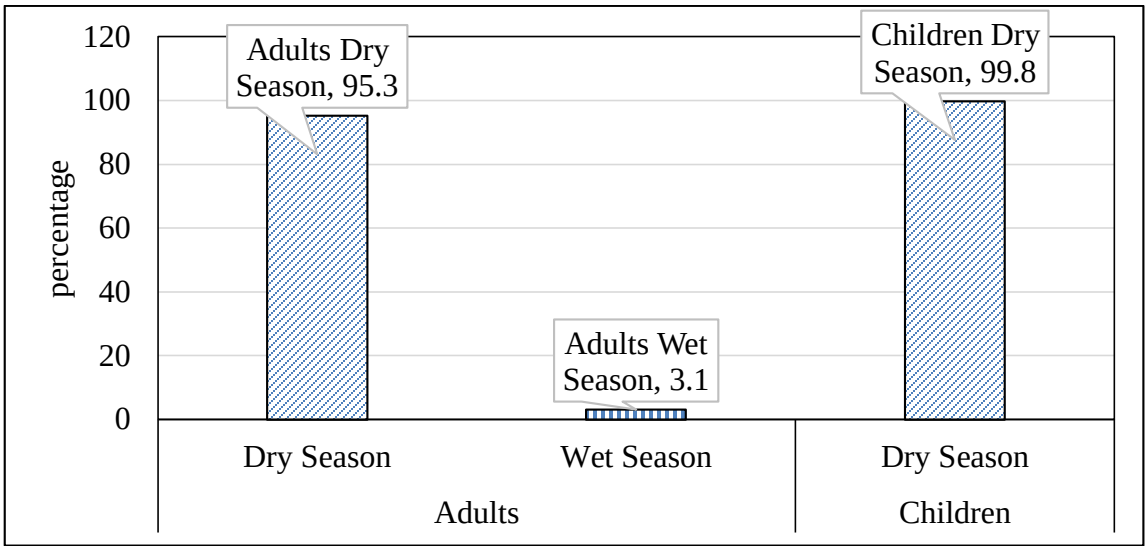

Figure 0:9: Prevalence jigger infestation by seasons

Source: Field data 2018

The climate of the study area according to children was reported to be hot and wet while adults indicated the same hot and wet climate Figure 4.10. The Alupe metrological station also indicated the climate to be classified as hot and wet which conforms to the public view and the findings in objective 1.

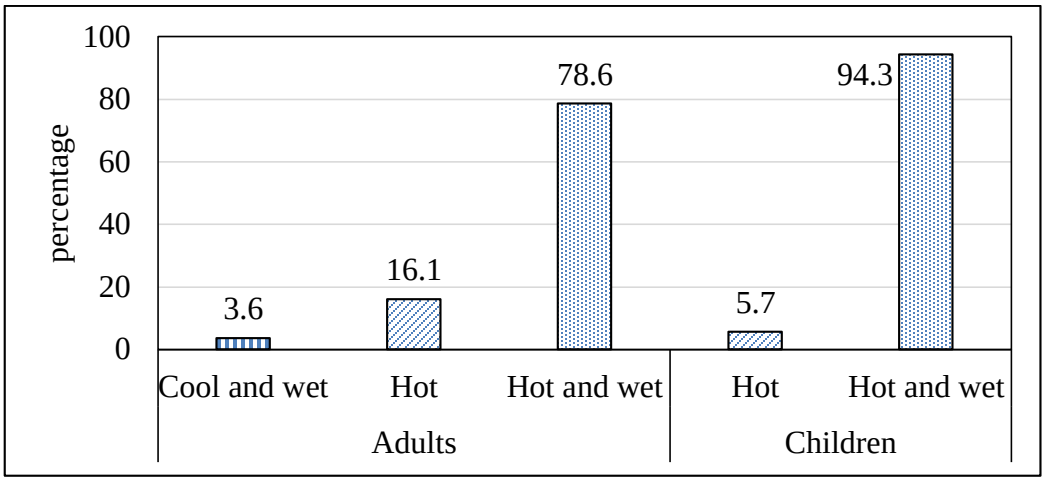

Figure 0:10: Climate of the area

Source, field data 2018

2.21.2 Perception on Jigger infestation and climate variability

There was reported increased jigger infestation over time by adults and the key stakeholders indicated a sharp increase of jiggers in the community. There were 95.3% of adults who indicated an increase in jigger infestation while 3.1% noted that there was no change in jigger infestation Table 4.6.

Table 0:6: Increase in jigger infestation

Increase infestation	Frequency	Percent
Yes	183	95.3
No	6	3.1
Total	189	98.4

The jigger infestation and climate variability were computed by a cross tabulation and it was observed that there was a general agreement that the variability in climate indicated by adults was because there was a relationship between climate and jigger infestation at 92.9% while 7.1% indicated no relationship between climate and increased jigger's infestation Table 4.7. This was supported by ministry of health official who indicated that climate variability was a key variable even if other measures were mitigated and climate remains a concern.

Table 0:7: Correlation between Climate variability and Increase in jigger infestation

			Increased infestation	**Total**
			Yes	
Change in climate	Yes	N	170	170
		% within Change in climate	100.0%	100.0%
		% within Increased infestation	92.9%	92.9%
		% of Total	92.9%	92.9%
	No	N	13	13
		% within Change in climate	100.0%	100.0%
		% within Increased infestation	7.1%	7.1%
		% of Total	7.1%	7.1%

The study therefore confirmed that that there is a significant relationship between climate variability and the jigger infestation in Teso North has indicated by Table 4.7 above where Change in climate corresponded with 170 respondents' which was an equivalent of 92.9% of the respondent's agreeing that increased infestation is a result of increased change in climate. Bitam *et.al* (2010), indicated that the increase in temperature and jigger

infestation shows that. The warmer temperatures predicted through most climate variability scenarios could lead to an increased expansion of flea vectors into the northern hemispheres which has seen areas of Busia increase in jigger infestation.

2.22 Extent and impact of jigger infestation

Jiggers have been reported to cause major damages both physically and socially to communities and individuals. The extent of jigger infestation in relation to community production levels, its contribution to the vicious cycle of poverty, children absenteeism in schools, deformities were addressed by the 2nd objective of the study. This section presents the impact of jiggers to individuals and households' livelihoods.

2.22.1 Impacts of jiggers and their effects

The most reported cases of jiggers impacted more on small children. The children indicated that jiggers infestation caused them lots of pain leading to deformities and other disabilities being reported by 95.3% of adults and reporting heavy infestation these conforms with Mazigo et.al (2012) research which found that the ≥45 year-olds showed highest prevalence of *tungiasis* (71.1%) and most severe parasite load Prevalence was slightly, but not significantly, higher in males than in females (45.3% versus 39.7%).

2.22.2 Impact of Jiggers on children and adults

The factors contributing to increased jigger infestation were increased poverty and increased temperature; these were seen to be the major issues raised by almost all the

respondent's including key informants. The children indicated proximity to animals and pets as key reason. According to the study conducted by Mazigo et.al; in Rural western Tanzania the impact of jiggers were Itching (68.3%), pain (38.6%) and ulcers (30.1%) were common. The22.1% of individuals found it difficult to walk due to *tungiasis*, and in 21.3% loss of toenails was observed, the findings corroborates with the effects reported by children and older people in study area that the reported deformities and effects included crippled legs, deformation and defaced feet/fingers and walking disabilities Figure 4.11.

Figure 0:11: Effects caused by jigger infestation on heels

Source: Field data 2018

The jigger infestation did not prevent children attending schools; there were 18.8% of children who said jigger's infestation had made them not to go to school. However, conducting a Pearson's Chi square test on children attendance to school it was found out

that (p=0.748, m=0.806) indicating that there was a positive skew towards 1 (0- likelihood of not attending school, 1- Likelihood of attending School) showing that the jiggers did not hinder children from attending school.

The children were drawn from different villages Akiriamasit was the most affected with 28.3% indicating that they had missed out in schools Table 4.8.

Table 0:8: Absenteeism in school caused by jiggers' infestation

Ward/Estate	Frequency	Percent
Adanya	5	17.9
Aedomoru	3	14.3
Akiriamasit	13	28.3
Aterait	7	18.9
Kamolo	5	19.2
Koruruma	3	8.8

The jiggers had no effect on students repeating classes which saw 12.5% and 87.5% saying that they had not repeated classes. Though jiggers affect children and production to a higher level there were few pupils who had dropped out of school due to jigger

infestations, there were 17.2% who had dropped and there other 82.8% indicated that they are not aware of any pupil who had dropped out of school due to jigger's infestation.

2.22.3 Impact on households

The jigger infestation per households indicated an often to rare attack by jiggers, with the more often 5.7%, often 52.6%, rarely 24% and not at all 17.7% Table 4.9. The households jigger infestation saw Adanya record the highest levels of often infestation by jiggers with Koruruma indicating the lowest infestation rates.

Table 0:9: Jiggers household infestation

Ward/Estate		Percent	Ward/Estate		Percent
Adanya	**More often**	7.7	Aterait	More often	7.9
	Often	61.5		Often	55.3
	Rarely	3.8		Rarely	15.8
	Not at all	26.9		Not at all	21.1
Aedomoru	**More often**	5.0	Kamolo	More often	4.3
	Often	45.0		Often	47.8
	Rarely	35.0		Rarely	39.1
	Not at all	15.0		Not at all	8.7
Akiriamasit	**More often**	4.2	Koruruma	More often	5.9
	Often	58.3		Often	41.2
	Rarely	16.7		Rarely	41.2
	Not at all	20.8		Not at all	11.8

The bathing frequencies by children indicated that bathing was done by more children with beddings being changed within a month for almost all of the respondent's, this indicated a medium level of hygiene and it could be a major factor of jigger prevalent infestation per households Table 4.10. The bathing frequency and the infestation by jiggers indicated that the more often the children bath the less the infestation by jiggers

while those who had not been infested by jiggers bathed more often. A chi square was conducted to test the significance of infection by jiggers and the bathing frequency in Teso North, it was established that there was a significant relationship between bathing and jigger infestation ($x=2$, $n=192$, $p<0.001$). It was also noted that children seldom took a bath at Aterait and Adanya villages while children at Kamolo villages frequently took bath.

Table 0:10: Chi-Square on bathing and jigger infestation

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	73.201[a]	2	.000
Likelihood Ratio	74.160	2	.000
Linear-by-Linear Association	37.895	1	.000
N of Valid Cases	192		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.95.			

However, there was an eminent danger not only to children but also to adults; it was observed that the risk of jiggers indicated there's a high risk to adults at 59.4% Table 4.11. The adults at risk can be attributed to old age care and the type of housing which had been found to majorly harbour jiggers.

Table 0:11: Risk of jigger infestation in Adults

Risk of infestation	Frequency	Percent
Very high	68	35.4
High	114	59.4
Moderate	7	3.6
Total	189	98.4

Table 4.12 indicates that adults reported that there is reduced economic activities caused by jigger infestation, there were 16.1% who said that jiggers and economic activity were not affecting productivity.

Table 0:12: Decreased economic activity due to jigger's infestation in Children

		Frequency	Percent
	Yes	158	82.3
	No	31	16.1
Total		189	98.4

The impact according to adults on how jiggers has affected their ways of life or any of their members in the family, they reported that reduced mobility was the most common effect of jiggers with 43.9% while least was pain at 3.2%, the further impact was investigated and it was found that feet deformity was the prevalent impact at 76.7% and fingers deformity was least experienced at 3.2% Table 4.13.

Table 0:13: Deformities caused by jiggers on adults

	Frequency	**Percent**
No impact	12	6.3
Crippled	26	13.8
Deformed feet	145	76.7
Deformed fingers	6	3.2
Total	189	100.0

2.23 Preventive measures

The study was to further evaluate measures of preventing and controlling jigger menace in Teso North and this was approached by understanding the causes of jigger infestation within the community.

Poverty and walking bare feet were categorized by children to be the most cause of jiggers while adults overlay saw poor hygiene to be the main cause of jigger infestation.

Measures of preventing and controlling jiggers.

The measures for controlling and preventing the jigger spread and control were sought from the public on their approach and local ways of handling jiggers, ministry and chief stakeholders in community. The perception of the community towards jigger infestation was of key importance in implementing and coming up with right strategies of jigger control.

The perception of the community towards jiggers were seen to be most of the residents agreed that jiggers are small organisms that are brought by cats, dogs and other domestic pets. There were 89% of adults and 65.1% of adults who believed that jiggers are caused by penetrating fleas Table 4.13.

Table 0:14: Cause of jigger infestation children

	Frequency	**Percent**
Penetrating flea	125	65.1
Insect	48	25.0
Don't know	19	9.9
Total	192	100.0

The community perspective indicated that there was awareness on jigger's infestation and they were being guided accordingly by ministry and church. There were also provision of closed shoes TOMs, Mobile clinics and Schools offered information on prevention and care to Jigger affected individuals Table 4.15. Adults indicated that the jiggers menace can be reduced by raising awareness further since some believed that jiggers are a curse or form of witchcraft by members of the community.

Table 0:15: Community jigger control

	Frequency	Percent
Regular use of closed footwear (TOMs)	139	72.4
Practicing proper personal hygiene	42	21.9
Practicing proper environmental hygiene	7	3.6
Avoid living close proximity with livestock	4	2.1
Total	192	100.0

The spread of information was seen to be crucial and adults got more awareness than children with 78.1% of the adults receiving information.

The source of information on jiggers was drawn majorly from relatives while learning through infestation was seen by 19.8% and health workers too contributed to knowledge base. Most of the children regular use of closed footwear, practicing proper personal hygiene and avoid living close proximity with livestock was the best way to prevent jigger infestation, while the ministry gives poor hygiene as a prevalent cause and the weather system. The adults indicated that awareness, cementing floors, closed shoes, exorcism, fumigation, hygiene, proper housing and watering dusty floors.

Table 0:16: Source of information for children

	Frequency	Percent
Relatives	114	59.4
Health worker	10	5.2
Radio/TV/Newspaper	10	5.2
Church	8	4.2
Neighbors	12	6.3
Have been infected	38	19.8
Total	192	100.0

The study noted that the major role on prevention should be from the government, carrying out public campaigns on measures of jigger control, distribution of medicine to the affected, empowering the community on importance of maintaining high hygiene and organizing mobile clinics to the affected communities. The residents also should seek for advice on ways to control jiggers and attend the public campaigns concerning jigger infestation.

CHAPTER FIVE: CONCLUSION SUMMARY AND RECOMMENDATIONS

2.24 Summary of major findings

The study covered 388 respondents from 189 for adults and 192 for children. There were 6 wards from Teso North. The children had the highest returns at 192 with Akiriamasit recording 24% and the least record was from Kamolo at 13.5%. The mean age of adults was 44.2 with more males reporting at 53.4% and females at 46.6%. The education level for adults indicated that most of the respondents had acquired at least secondary education 33.3%, with 20.1% not having any form of education. The employment rate was low in the area, the unemployed were 67% and employed were 62%. The type of housing was found to be mud houses 66.7% while cemented houses and bricks houses accounted for 16.9% and blocks 13.2%. It was found that 89% of adults believed that jiggers are caused by penetrating fleas compared to 50% of children who also believed in the same. Poverty and walking bare feet were categorized by children to be the highest cause of jiggers while adults overlay saw poor hygiene to be the main cause of jigger infestation.

The rainfall trend indicated a trend showing a decreasing rainfall trend from 1987 with peak in 1989 and going to lowest in 2016 (102mm). The effect of climate as per elders were seen to be more prevalent in dry seasons with 95.3% while some believed that jiggers are rampant and increases at wet seasons 3.1%. The climate of the area according to children was reported to be hot and wet while adults indicated the same hot and wet climate. The change in climate over years was seen to affect across all from the key

informants at Alupe metreological station indicating a complexity in weather prediction, they indicated that the weather patterns have become more varied with 88.8% (82 cases) of adults indicating a change in climate and community leaders indicating the same too. The change in the temperatures saw 88% of adults report that they've witnessed a change in temperature citing hot temperatures throughout the season while the metrological department also agreed with the temperatures change.

Children were the most affected by jiggers; with 73.4% getting infested by jiggers while there were 26.6% who had not had jigger's infestation. It was found out that jiggers and type of housing had no significance with the children being infested. The children infested with jiggers were between ages 0-4 years having seen 87% while the least group was between ages 15-18. However, the jigger's infestation did not hinder the children's attending schools; there were 18.8% of children who said jigger's infestation has made them not to go to school.

The most reported jigger infestation indicate more effect on small children and adults as posed by elders and the ministry officials, the jiggers infestation causes a lot of pain. The factors contributing to increased jigger infestation were increased poverty and increased temperature. The jigger infestation per households indicated an often to rare attack by jiggers, with the more often 5.7%, often 52.6%, rarely 24% and not at all 17.7%. The bathing frequencies by children indicated that bathing was done by more children with beddings being changed within a month for almost all of the respondents.

The most fundamental improvement measure on fighting jiggers was carrying out public campaigns on measures of jigger control, distribution of medicine to the affected, empowering the community in importance of maintaining high hygiene levels organizing mobile clinics to the affected communities; this was from the ministry's perspective. There were also provision of closed shoes TOMs, Mobile clinics and Schools offered information on prevention and care to jigger affected individuals. Adults indicated that the jigger menace can be reduced by raising awareness further since some believe that jiggers are a curse or form of witchcraft by members of the community. The adults indicated that awareness, cementing floors, closed shoes, exorcism, fumigation, hygiene, proper housing and watering dusty floors.

There was reported increased jigger infestation over time by adults and the key stakeholders indicating a sharp increase of jiggers in the community. The jigger infestation and climate variability were computed by a cross tabulation and it was observed that there was a general agreement that the change in weather indicated by adults was because of change in climate at 92.9% while 7.1% indicated no relationship between climate and increased jigger infestation.

2.25 Conclusion

The infestation of jiggers and climate variability in Teso North was found out to be very significant, the respondent's indicated that there has been a change in the local temperatures with increased dry periods and a sharp increase in jigger infestation. Despite

the introduction of closed shoes (TOMs) there is still a high level of infestation both to children and older people.

The menace of jigger infestation cuts across all the ages from young children to older people at 65 years and above being affected. The impact has seen deformities especially of the limbs and feet. This has caused reduced mobility and low self-esteem among the affected.

The communities voiced that the war against jiggers can only be eradicated by proper cleanliness and handling of *tungiasis* in proper ways. The cleaning of homesteads wasn't an enough measure if fumigation wasn't done and school going children be sensitized on hygiene and to wear closed shoes.

2.26 Recommendations

The study makes the following recommendations;

- The major issues were about going to school with no shoes to put on and this caused more issues and infections, I therefore recommend focusing on more provision of TOMs /Closed shoes

- There should be an increased awareness to children and community members on the link between jiggers and infection levels.

- The link between jiggers and environment should be further investigated since the link seems to be more complex.

- The community used less traditional jigger control methods and the study recommends that use of cow dung to suffocate and keep huts warm can be tried to reduce jigger spread.

2.27 Knowledge gap

The study focused on the impact of jiggers and its relations to climate variability and it was found that jiggers and climate variability were correlated and an increase in temperature increases jiggers spread, also the methods of jigger prevention and measures to curb its spread were found to be available but ineffective and swung into action only when there is an outbreak of jigger infestation.

Therefore, the spread of jiggers and its impact needs further studies on concrete and exclusive preventive measures since the occurrence and re-occurrence of jiggers is sporadic in Teso North. The preventive and control measures ought to be conclusive and traditional methods needs to be incorporated to prevent the spread of *tungiasis.*

REFERENCES

Ahadi Kenya Trust (2008). The Jigger Menace in Kenya. Anti-Jigger Magazine Final. Available at http://www.jiggerahadi.org/Anti%20. Jigger % 20 magazi% 20 Final. Pdf. Accessed 20th, November 2016.

Ahadi Kenya Trust (2009). About the Jigger. Retrieved on 31st October 2016 from www.ahadikenya.org .

Anthony, J., (2006). Climate Change and Human Health: Present and Future Risk. Volume 367.

Beverly, S., (2001). African Network for Health and Development Endemic. November 8th 2016 from www.environment.gov.au

Bitam, I., Dittmar, K., Parola, P., Whiting, M. F., & Raoult, D. (2010). Fleas and flea-borne diseases. International journal of infectious diseases, 14(8), e667-e676

Bleakley H (2003). Disease and development: Evidence from the American South. *J Eur Econ Assoc* 1: 376–386.

Brooks, J. G., & Brooks, M. G. (1993). In search of understanding: The case for constructivist classrooms. Alexandria, VA: Association of Supervision and Curriculum Development.

Brunner JS (1961). The Act of Discovery. Havard Educational Review, Vol. No. 31 1961.

CDC, (2009) Parasites and Health. Tungiasis Available at: https://www.mcdinternational.org/trainings/malaria/english/DPDx5/HTML/Frames/S-Z/Tungiasis/body_Tungiasis_page1 (Accessed on 26/01/2021 at 12:32pm)

Chelimo, J, J., (2014). Risk factors associated with Jiggers.

Climate Change and Human Health" Encyclopaedia of Public Health. Retrieved October 27th2016 from Encyclopaedia.com. www.encyclopaedia/education/almanacs/transcripts/and/maps.com

Collins Dictionary complete and Unabridged, 12th edn 2014. Harper Collins Publishers 1991-2014. Retrieved on 26th October 2016 from www.collinsdictionary.com

Conway, E., (2008). Global warming versus Climate Change. Retrieved November 8th 2016 from www.nasa.gov

Desone, D., (2008). Climate; Causes and Effects of Climate Change. Chelsea House Publisher Inprint of Infobase Publishing Company: New York.

Eisel, M., Heukelbach, J., Mark, E., Melhihorn, H, Meckes, O, Frank, S., Felmeir, H., (2003) Tunga Penetrans in Brazil: natural history of *Tungiasis* in man. Life cycle Parasitol. Res. 90: 87-99

Enscore, R.E., Biggerstaff, B.J., Brown, T.L., Fulgham, R.E., Reynolds, P.J., Engelthaler, D.M. *et al*. Modeling relationships between climate and the frequency of human plague cases in the southwestern United States, 1960–1997. *Am J Trop Med Hyg*. 2002; 66: 186–196

Feldmeier H Sentongo E and Krantz I (2014).*Tungiasis* (sand flea disease): A parasitic disease with particular challenges for public health. *European Journal of Clinical Microbiology & Infectious Diseases*, 32 (1): 19-26.

Feldmeier, H., (2003). Severe *Tungiasis* in Underprivileged Communities: case series from Brazil. Emerging Infectious Diseases 9: 949-955.

GoK, (2016). Climate Risk Profile for Busia. The Kenya MoALF. Nairobi, Kenya

Gordon, R, M., (1941). The Jigger Flea. Lancet. Volume 238, Issue 6150, 12 July 1941, Pages 47-49 https://doi.org/10.1016/S0140-6736(00)71405-X .

Heukelbach, J., De Oliveira F, A., Hesse, G (2001). *Tungiasis*: A neglected health Problem of Poor Communities. Tropical Medicine Internal Health Journal: 6: 267-272.

Heukelbach, J., Wilcke, T., Harms, G., Feldmeier, H., (2005). Seasonal Variation of *Tungiasis* in an Endemic Community. American Journal of Tropical Medicine & Hygiene 72(2):145-149.Available at Pdf. Accessed 24th March 2017 Kenya

Information Guide.com. (2015). Retrieved on 31st October, 2016 from www.kenyainformationguide.com.

Hinnebusch, B. J., Fischer, E. R., & Schwan, T. G. (1998). Evaluation of the role of the Yersinia pestis plasminogen activator and other plasmid-encoded factors in temperature-dependent blockage of the flea. *The Journal of infectious diseases, 178*(5), 1406-1415.

Ifejika Speranza, C., Kiteme, B., Ogalleh, S., & Gwamzhi, R. J. (2008). Assessment of indigenous knowledge to improve resilience to environmental and climate change: Case studies from Kenya and Nigeria.

Jarrett, C.O., Deak, E., Isherwood, K.E. et al. (2004); Transmission of Yersinia pestis from an infectious biofilm in the flea vector. J Infect Dis.; 190: 783–792

Johanson, G. A., & Brooks, G. P. (2010). Initial scale development: sample size for pilot studies. Educational and psychological measurement, 70(3), 394-400.

Joseph, J, K., Brazile, J., Mutter, J.,Shin, S., Ruddle, A., lvers, L., Lyon, E., Farmer, p., (2006). *Tungiasis* in Rural Haiti: A Community based Response.

Josephine J W (2015). Impact of *tungiasis* on school age children in Muranga county, Kenya.: Doctoral dissertation University of Nairobi

Kimani, B., Nyagero, J., & Ikamari, L. (2012). Knowledge, attitude and practices on jigger infestation among household members aged 18 to 60 years: case study of a rural location in Kenya. The Pan African medical journal, 13 Suppl 1(Suppl 1), 7.

Kombo K. D. & Tromp A. L. (2009) Proposal and Thesis Writing.An Introduction. Nairobi. Paulines Publication Africa.

Lake Victoria North Water Service Board., (2013). Water Point Mapping Report. Busia, Kenya

Makena, B., & Mwoma, T., (2014). Jigger Infestation a Menace to Children's School attendance. Journal of Education and Practice volume 5, Number 1

Martin, D., (2010). The Good Research Guide. 4th edn for Small Scale Social Research Projects. Open University Press Berkshire: England.

Maslow A (1943). A theory of human motivation. *Psychological Review, 50*, 370-396. Retrieved June 2015 ,from http://psychclassics.yorku.ca/Maslow/motivation.htm.

Mazigo, H. D., Bahemana, E., Konje, E. T., Dyegura, O., Mnyone, L. L., Kweka, E. J., & Heukelbach, J. (2012). Jigger flea infestation (*tungiasis*) in rural western Tanzania: high prevalence and severe morbidity. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *106*(4), 259-263.

Miles, M., & Huberman, A., (1994). Qualitative Data Analysis: An expanded approach Source book (2nd Ed.) Thousand Oaks: Sage.

Miller, George. (2003). The Cognitive Revolution: A historical perspective. Trends in cognitive sciences. 7. 141-144. 10.1016/S1364-6613(03)00029-9.

Moore, Matthew & Sween, Molly. (2015). Rural Youth Crime: A Reexamination of Social Disorganization Theory's Applicability to Rural Areas. Journal of Juvenile Justice.

Morkve A (2013). "Getting rid of plague": Jiggers removal program in Bungoma, Kenya, Community and health workers perspectives on *Tungiasis* in a high prevalence area, Masters *Dissertation* of University of Bergen

Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A. D., Bloom, A. J., ... & Usui, Y. (2014). Increasing CO 2 threatens human nutrition. Nature, 510(7503), 139-142.

Nagy, N., Abari, E., Haese, J., Calheiro, C., Heuilkabach, J., Meriche, N., Feldmeier,H., Mehihorn, H., (2007). Investigations of the Life Cycle and Morphology of Tunga Penetrans in Brazil. Parasitology Research 101: Supplement. 2: 233-242

Ndung'u, M., (2006). Epidemiology of Tunga Penetrans Infestation and Antigens characterisation.

Nyang'inja, R. A., Angwenyi, D. N., Musyoka, C. M., & Orwa, T. O. (2018). Mathematical modeling of the effects of public health education on *tungiasis*—a neglected disease with many challenges in endemic communities. Advances in Difference Equations, 2018(1), 426.

Ochieng, G. (2019). The Effects of Jigger Infestation on School Enrollment and Retention of Children in Rural Areas: A Case of South East Alego Ward, Siaya County Kenya (Doctoral dissertation, School of Human and Social Sciences, Daystar University).

Okong'o O., (2016). Busia County leads in jigger infestation. Retrieved on 31st October 2016 from www.talkafrica.co.ke

Olita, R., (2012). Jiggers Attack Teso Schools. Retrieved November 1st 2016 from www.thestar.co.ke/news

Oteng'i, B., (2014). Teach yourself Weather Instruments and Methods of Use, Vol. 1Land Surface Platform utafiti Foundation: Eldoret.

Patz, J.A., (2006). Climate Change and Infectious Diseases. Retrieved on 31st October, 2016 from www.encyclopaedia.com/education/almanacs

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International journal of medical education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

The American Heritage Student Science Dictionary, 2nd edn. (2014). Houghton Mifflin Harcourt Publishing Company America.

Uganda Bureau of Statistics. (2009.). Higher local government statistical abstract. Busia [Uganda: Uganda Bureau of Statistics.

Ugbomoiko, U., Ariza, L., Ofoezie I., Heukelbach, J., (2007). Risk factors for *Tungiasis* in Nigeria: Identification of targets for effective intervention. Journal for Tropical Medicine and Health. Page 111-113.Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2154384/Accessed 20th November 2016.

Veraldi, S., Schianchi, R., (2006). *Tungiasis*. Eur J Dermatol. 9:57-60

Wanga, J., (2014). Jiggers Index: New report names counties worst hit by the menace. Retrieved 31st October 2016 from www.dailynation.co.ke.

Webster, C. M., Iannucci, A. L., & Romney, A. K. (2002). Consensus Analysis for the Measurement and Validation of Personality Traits. *Field Methods*, *14*(1), 46-64. https://doi.org/10.1177/1525822X0201400104

APPENDICES

APPENDIX I: QUESTIONNAIRE (a)

QUESTIONNAIRE ISSUED TO COMMUNITY MEMBERS WITHIN TESO NORTH SUB-COUNTY (CHILDREN ONLY)

A: General Information

This questionnaire is meant to collect information on jigger infestation in the community, control measures adopted and its relation to climate variability. This information is being sought solely for academic purposes and will be treated with strict confidence. Kindly answer the questions by writing a brief statement or ticking the boxes provided as applicable.

Section A

Kindly answer the questions by writing a brief statement or ticking the brackets provided as applicable.

Name ……. (Optional)

School ……. Ward/Estate…….

1) Gender

Male [ ]

Female [ ]

2) Age .....

Section B: Jigger Infestation

1. According to your community, what are jiggers? .....

.....

.....

2. What causes the jiggers to spread?

.....

.....

3. Have you ever been attacked by jiggers?

Yes [ ]

No [ ]

4. Have you ever been absent because of jigger attacks?

Yes [ ]

No [ ]

5. Have you ever repeated classes because of the effect caused by jigger?

Yes [ ]

No [ ]

6. Are you aware of anyone who has dropped out of school due to jiggers?

Yes [ ]

No [ ]

7. What are the control measures adopted by your community towards control of jigger?

.....

.....

8a. Have you ever had about jigger?

Yes [ ] No [ ]

b) If yes, where did you hear about the jigger?

i. Relative

ii. Health worker

iii. Radio/TV/News paper

iv. Church

v. Neighbour

vi. Provincial administration

vii. Have been infected

viii. Other (specify)……

9. What do you think causes jigger infestation?

Penetrating flea [ ] Insect [ ] Don‘t know [ ]

Others (specify)……

10. How can one prevent jigger infestation?

i. Regular use of closed footwear [ ]

ii. Practicing proper personal hygiene [ ]

iii. Practicing proper environmental hygiene [ ]

iv. Avoid living in close proximity with the livestock [ ]

v. Others (specify……

11. How is *tungiasis* transmitted?

i. Walking bare feet in infested soil [ ]

ii. Presents of garbage litter [ ]

iii. Poor hygiene [ ]

iv. Living in close proximity to the livestock [ ]

v. Others (specify)…… …

SECTION C: Climate Variations and Jiggers

1. What is the general climatic condition of this place?

.....

.....

2. When are jiggers more prevalent?

During the dry season [ ]

During the wet season [ ]

3. Is rainfall in this region increasing overtime/

Yes [ ] No [ ]

APPENDIX II QUESTIONNAIRE (b)

QUESTIONNAIRE ISSUED TO COMMUNITY MEMBERS WITHIN TESO NORTH SUB-COUNTY -TO THE MIDDLE AGED

A: General Information

This questionnaire is meant to collect information on jigger infestation in the community, control measures adopted and its relation to climate variability. This information is being sought solely for academic purposes and will be treated with strict confidence. Kindly answer the questions by writing a brief statement or ticking the boxes provided as applicable.

Section A

Kindly answer the questions by writing a brief statement or ticking the brackets provided as applicable.

Name …….. (Optional)

Ward/Estate……..

1. Gender

Male [ ]

Female [ ]

2. Age .....

3. Education level

None [ ] Primary [ ] secondary [ ] Training post-secondary school [ ] University [ ]

4. Employment

Yes [ ] No [ ]

5. Household headship

Mother [ ] Father [ ] Grandparent(s) [ ] Child [ ] Caretaker [ ]

6. Type of house

Mud [ ] Bricks [ ] Stones [ ] Blocks [ ]

8. State of floor

Mud [ ] Wooden [ ] Cement [ ]

B. Jigger Infestation

1. According to your understanding, what are jiggers? .....

.....

.....

2. What causes the jiggers to spread?

.....

.....

3. Have you noticed decreased economic activities due to jigger attacks?

Yes [ ]

No [ ]

4. Have you observed any disabilities because of the effect caused by jiggers?

Yes [ ]

No [ ]

5. Are the jiggers increasing as years go by?

Yes [ ]

No [ ]

6. What do you think is jiggers' prevalence of late?

Heavy infestation [ ] Moderate infestation [ ] Mild infestation [ ]

7. What is the jiggers risk in this area?

Very high [ ] High [ ] Moderate [ ] Low [ ]

8. What are the control measures adopted by your community towards control of jiggers?

SECTION B: Climate Variations and Jiggers

1. What is the general climatic condition of this place?

.....

.....

2. When are jiggers more prevalent?

During the dry season [ ]

During the wet season [ ]

3. Have you observed any changes or variations in climate over the years?

Briefly explain your answer

.....

.....

4. Have you noticed any change in temperature over the years

Yes [ ] No [ ]

APPENDIX III: INTERVIEW QUESTIONS (a)

ALUPE METEREOLOGICAL STATION

INTERVIEWEE:

POSITION:

1. What is the general climatic condition of Busia County? (Teso North sub-County).
2. What is the
    i. Average annual temperature?
    ii. Average annual humidity?
    iii. Average annual rainfall?
    iv. Altitude?
3. What is the climate pattern in the region over a 30-year interval?
4. As a station, what are the adaptive measures you have taken towards curbing the effects of climate variability in the region?
5. What are the observable changes in climate in the region?
6. What are the observable effects of climate variability in the regions?
7. How to you control anthropogenic activities in the region?

APPENDIX IV: INTERVIEW QUESTIONS (b)

COMMUNITY ELDER

INTERVIEWEE:

OCCUPATION:

AGE:

1. What are jiggers?
2. What do you believe is the cause of their spread?
3. What measures has your community taken to eradicate jiggers?
4. What are the jigger patterns/events over the years?
5. When did you first observe the jiggers in this region?
6. Which population is more affected by jiggers; school going children, the youth or the elderly?
7. How have jiggers affected members of your community?
8. When are the jiggers more prevalent? Dry or wet season.
9. Have you observed any changes in climate over the years?

APPENDIX V: OBSERVATION CHECKLIST

The checklist below was used to record observations that were either not captured but deemed necessary for the research.

Item	**State**	**Place/Village**	**Remarks**
Sanitation (Home, environment e.t.c)			
Economic activities			
Jigger infested organs (e.g. arms, heels, toes etc.)			

APPENDIX VI: BODY PARTS INFESTED WITH JIGGERS

APPENDIX VII: NACOSTI RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MS. CELESTINE MUKHAVALI ATENYA
of MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY, 0-50400 BUSIA,has been permitted to conduct research in *Busia County*

on the topic: *THE INFLUENCE OF CLIMATE CHANGE AND CLIMATE VARIABILITY ON JIGGER INFESTATION IN TESO NORTH SUB COUNTY BUSIA COUNTY KENYA*

for the period ending:
20th June,2020

Permit No : NACOSTI/P/19/18753/30569
Date Of Issue : 20th June,2019
Fee Recieved :Ksh 1000

.....
Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

rant of Research Licenses is guided by the Science, ology and Innovation (Research Licensing) Regulations, 2014.

ONDITIONS

- License is valid for the proposed research, location and :ified period.
- License and any rights thereunder are non-transferable.
- Licensee shall inform the County Governor before nmencement of the research.
- :avation, filming and collection of specimens are subject to ther necessary clearance from relevant Government Agencies.
- License does not give authority to transfer research materials.
- COSTI may monitor and evaluate the licensed research project.
- Licensee shall submit one hard copy and upload a soft copy heir final report within one year of completion of the research.
- COSTI reserves the right to modify the conditions of the ense including cancellation without prior notice.

ional Commission for Science, Technology and Innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 25375

CONDITIONS: see back page