IMPACT OF CLIMATE VARIABILITY ON THE OCCURRENCE OF SELECTED CATTLE DISEASES IN UPPER RIVER REGION, THE GAMBIA

BY

CHAM, Fafa Oggo

MTech/SPS/2015/6073

WEST AFRICAN SCIENCE SERVICE CENTER ON CLIMATE CHANGE AND ADAPTED LAND USE

FEDERAL UNIVERSITY OF TECHNOLOGY

MINNA

MARCH, 2018

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THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTERS OF TECHNOLOGY (MTech) IN CLIMATE CHANGE AND ADAPTED LAND USE

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DECLARATION

I hereby declare that this thesis titled: “**Impact of Climate Variability on the Occurrence of selected cattle diseases in Upper River Region, The Gambia**” is a collection of my original work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) have been duly acknowledged.

CHAM Fafa Oggo

………………………………

(MTech/SPS/2015/6072)
SIGNATURE/DATE

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGERIA

CERTIFICATION

This thesis titled: "**Impact of Climate Variability on the Occurrence of Selected cattle diseases in Upper River Region, The Gambia**" by Cham, Fafa Oggo (MTech/SPS/2015/6073) meets the regulations governing the award of degree of Masters of Technology in Climate Change and Adapted Land Use of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

Professor (Mrs). I. C. Alemede ……………………….
Major Supervisor Signature & Date

Professor A.A. Okhimamhe ……………………...
Director, WASCAL Signature & Date

Professor M.G.M. Kolo ……………………..
Dean, Post Graduate School Signature & Date

DEDICATION

This work is dedicated to my entire family who were very patient and supportive during the entire programme.

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Praise be to the Almighty who gave me the strength and all that is required to complete this programme. Please *Ya Allah, Ya Rabi* increase me in blissful knowledge with *barka* that I will use to benefit Mankind.

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ABSTRACT

The study was conducted in Upper River Region, The Gambia with the aim of determining the relationship between variabilities in climate parameters and the occurrences of common cattle diseases. The study was to establish the relationship between climate variability and the occurrence of common cattle diseases, to compare by gender cattle farmers' perception and understanding of climate variability, its impact and their coping strategies and also to determine the degree of climate variability in the study area. One hundred and eighty-seven (187) structured questionnaire adopting face-to-face individual respondents interviewed and six focused group discussions (3 for men and 3 for women) were separately held in three of the seven districts of the Region. In the focused group discussions, participatory rural appraisal tools including pairwise ranking and matrix scoring were employed. Spearman correlation and regression analysis was conducted to assess the relationship between climate variables and the selected diseases. To find out the difference between female and male cattle owners, frequency analysis and Pearson chi-square tests were done. Mann-Kendall and standardized anomaly tests were also conducted to assess the nature of climate variability. Findings showed that the occurrence of each of the common cattle diseases is correlated to at least one of the climate variables, temperature being the most influential. For instance, monthly occurrence of reproductive and urinary tract infections was positively associated with minimum temperature ($r = 0.177$, $p = 0.027$), humidity ($r = 0.174$, $p = 0.038$), rainfall ($r = 0.265$, $p < 0.001$) and wind speed ($r = 0.166$, $p = 0.038$) in the Basse area at 0.05 alpha value. The study further revealed that there was no significant difference between gender and perceptions on questions relating to temperature, wind speed and rainfall trends. However, there were significant gender effects on most of the questions relating to impact and adaptation to climate variability. Only rainfall was found to be following a monotonic trend, however, the standardized anomaly demonstrated both monthly and yearly variations in all climate variables. Based on these observations, the following conclusions were made; a) the occurrence of common cattle diseases was influenced by climate variability, b) there were lots of gender differences in perception, impact and adaptation to climate variability and c) Climate variability does exist and its extent was great for many to detect, though the causes were not well understood by most cattle owners, particularly women cattle owners. In view of these, it was recommended that cattle management practices be improved to minimise the impact of climate variability on cattle health. Moreover, interventions to assist cattle owners cope with climate variability should be gender sensitive.

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LIST OF ACRONYMS AND ABBREVATONS

AEZ	Agricultural Ecological Zones
ANOVA	Analysis of Variance
BQ	Black Quarter
BVD	Bovine Viral Diarrhoea
BVDV	Bovine Virus Diarrhoea Virus
CBPP	Contagious Bovine Pleuropneumonia
CV	Climate Variability
DLS	Department of Livestock Services
DWR	Department of Water Resources
FAO	Food and Agricultural Organisation
FGD	Focused Group Discussion
FMD	Foot and Mouth Disease
FMDV	Foot and Mouth Disease Virus
GBoS	Gambia Bureau of Statistics
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIT	Gastro- Intestinal Tract
GMD	Gambian Dalasi
GoTG	Government of The Gambia
HS	Haemorrhagic Septicaemia
IBR	Infectious Bovine Rhinotracheitis
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LIPS	Low Input Production System
LSD	Lumpy Skin Disease
NGO	Non-Governmental Organization
PPR	Pest de Petite Ruminant
PRA	Participatory Rural Appraisal
RES	Respiratory Tract Infections

RUT	Reproductive and Urinary Tract
SAT	South African Territories
Spp.	Species
T. *brucei*	*Trypanosoma brucei*
T. *congolense*	*Trypanosoma congolense*
T. *vivax*	*Trypanosoma vivax*
TADs	Transboundary Animal Diseases
Tryps.	Trypanosomiasis
UNFCCC	United Nations Framework Convention on Climate Change
URR	Upper River Region
WASCAL	West African Science Service Center on Climate Change and Adapted Land Use

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Africa's contribution to global greenhouse gases (GHGs) emission is relatively small yet it is likely to be severely affected by climate change because of adverse direct effects, high agricultural dependence, and limited capacity to adapt (Das *et al*., 2016). Already floods, increased health problems in both human and animal, and reduced crop yields are recorded in many African countries. These are not likely to fade away anytime soon. In fact, the Intergovernmental Panel on Climate Change (IPCC) in 2007 predicted that in Africa, from 75 million to 250 million people are likely to be exposed to increased water crisis and food accessibility as yields from rain fed agriculture is expected to reduce by 50 % and sea level rise threatening large populations at low-lying coastal areas.

The Sahel is often referred to as the hot-spot for global climate change owing to its high temperatures, increasing variable rainfall, and frequent droughts and storms (Jaiteh and Sarr, 2011). The Intergovernmental Panel on Climate Change (IPCC) in 2007 predicted that temperatures are likely to increase by 2.10 ^{0}C by 2065 and 4.00 ^{0}C by the end of the century and that rainfall will continue to vary regarding onset, cessation, duration and amount. The variable rainfall nature coupled with high temperatures is negatively affecting and are expected to continue to negatively impact both crop production and livestock rearing. Nardone *et al*. (2010) and Cox *et al*. (2015) stated that escalating global temperatures are projected to create an increase in drought, which will affect feed and crop productions, intensifying the process of desertification in these systems and reducing the carrying capacity of rangelands and other livestock systems. This could also increase the prevalence of other risk factors due to the availability and cost of grain making agricultural systems more vulnerable and impairing their relative ability to adapt to changing conditions.

Agricultural production in most part of Africa in general and in The Gambia in particular is subsistent in nature and characterized by low investment and largely rain fed dependent. This has tremendously reduced crop yields and led to high livestock mortality. For instance, in The Gambia, the 27 % drop in normal rainfall created a decline in both cash and food crop yields, (Jallow *et al.*, 1999 and Yaffa, 2013).

Livestock is very pivotal in the livelihoods of the ever growing world population, particularly those in Africa where poverty is the order of the day. Besides providing the much needed protein from meat and milk products, it is also enhancing crop production by providing labour and improving the soil fertility. Livestock also serves as bank for majority of the rural poor as well as a form of prestige. These benefits are anticipated to increase as worldwide demand for livestock products is likely to increase as a result of the rising human population, urbanization and their growing affluence. Despite being very crucial to the livelihoods of the population, livestock production system is still traditional, characterized by low investment and highly dependent on natural vegetation, which makes it vulnerable to climate variability (Daffeh 2010). Climate variabilities are already impinging on agriculture in general and livestock production in particular. It is already clear that poor livestock keepers are among those whose livelihoods are most vulnerable to climate change (Kimaro and Chibinga, 2014). Citing Thornton *et al*. (2009), Megersa *et al*. (2014a) reported that climate change and variability impacted livestock production in the arid and semi-arid environments by affecting pasture production, water availability, increase disease risks and heat stresses. The emergence of pests and diseases into new areas is likely to increase morbidity and mortality of livestock (Rowlinson, 2008).

1.2 Statement of Research Problem

Climate variability effects such as flood, droughts, high temperatures, late onset and shortened rainfalls are already catalogued in The Gambia (Jaiteh and Sarr, 2011; Yaffa, 2013). Owing to the traditional management system, characterised by high dependence on natural vegetation and low investment, cattle production in The Gambia looks susceptible to climate variabilities. Disease outbreaks are already a problem for cattle owners as cattle mortality and cost of disease control are increasing due to emerging and re-emerging of diseases. The re-emergence of contagious bovine pleuropneumonia (CBPP) 2012 after 40 years of absence (Secka et al., 2015) is a typical case to cite.

Furthermore, when governments and non-governmental organisations intervene to curb the impacts of climate variability, it is often not gender sensitive. Usually, a single approach in reducing climate variability effects on both men and women is employed. This may largely be due to the assumption that women and men are not only affected by climate variability in the same way but also have the same perception and adaptation measures to climate variability.

1.3 Aim and Objectives

The study aims to examine the degree to which climate variability impacted on selected cattle diseases in Upper River Region, The Gambia. Its specific objectives include to;

i. Assess the nature and degree of climate variability in the study area

ii. Examine the relationship between climate variability and the occurrence of common cattle diseases

iii. Compare by gender cattle farmers' perception and understanding of climate variability, its impact and their copping strategies and

1.4 Research Questions

In pursuant of the stated objectives, the following research questions were used to guide the research work.

i. What is the pattern (spatial and temporal) of the climate parameters (rainfall, temperature, humidity and wind) in the study area?

ii. Are variabilities in climate parameters correlated to common cattle diseases?

iii. Is there any difference in perception, impact and coping strategies of climate variability between men and women?

1.5 Justification for Study

Livestock plays key roles in the socio economic wellbeing of Gambians, contributing 29.60 % to Agricultural Gross Domestic Product (GDP) and 8.60 % to National GDP. According to FAO (2012), these figures could have been greater if the livestock enhancement of crop production were accounted. That is, if the provision of much needed labour in pulling the shine hoe and seeder and fertilizing of agricultural lands were accounted for.

The Gambia, like any other country is certainly not immune to climate variability and change impacts. Its agriculture, that is, livestock and crop production is particularly vulnerable to climate variability. There is evidence that severe floods, droughts and increased temperatures have occurred in the past and are likely to occur in the future

(Jaiteh and Sarr, 2011 and Yaffa, 2013). It is also unequivocal that these effects negatively impacted both livestock and crop production. These concern issues are a source of motivation to find out the impacts of climate variability on agriculture, that is both crop and livestock production. Unfortunately, when these effects are being assessed, the focus is often on crop and not livestock. There is very little or no research work done in this area, thus prompting the current study. The results of this research will be helpful to policy makers particularly in predicting occurrence of diseases, thus enabling timely controlling of outbreaks.

1.6 Scope and Limitation

The study was limited to the Upper River Region, The Gambia, however, the results obtained can be used to represent the country. The disease outbreak and treatment records were only available from 1995, thus the research depended on this. Additionally, the problem of under reporting in the disease surveillance system was another limitation of this study. Besides, the absence of the estimated annual cattle population of the study area served as another limitation of the study.

1.7 Description of Study Area

The Gambia has a tropical climate characterized by a seven-month long dry season (November – May) and a five-month rainy season stretching between June and October. In the dry season, temperatures range between 18^0 and 30 ^{0}C while it ranges from 23^0 to 33 ^{0}C in the wet season. According to The GCCPD (2016), temperature has been rising in the order of 0.5 ^{0}C per decade, recording the lowest mean temperature of 25.8 ^{0}C in 1947 and the highest mean temperature of 28.2 ^{0}C in the year 2000. While average temperature is increasing, annual rainfall amounts have decreased by 30 % from 1950 to 2000 (Jaiteh, 2010). The reduction is both in the length of rainy season and quantity of rainfalls recorded in the month of August, which used to be the wettest month (GoTG, 2007). The Upper River Region is the focus of the study, the second largest region in the country occupying about 2000 Square Km (Figure 1.1). It is located in the eastern part of the country with latitude and longitude of 13.42570 N and 14.00720 W, respectively (GBOS, 2013). According to the Food and Agricultural Organisation (FAO) Land Use Planning Project (TCP/Gam/6715), there are six Agricultural Ecological Zones (AEZ), named as AEZ 1, AEZ 2, AEZ 3, AEZ 4, AEZ 5 and AEZ 6 established in The Gambia. The Upper River Region is categorized in AEZ 6. This Agro ecological zone corresponds entirely to the Upper River Region. This zone has characteristics of a growing period of over 135 days and the start of the growing season falls around the first half of June. The cumulative rainfall is between 700 to 800 mm per annum. The natural vegetation in this zone consists of grasslands with scattered trees. The vegetation in this zone has been heavily modified through human interference in the form of cultivation and bush fire.

The population (Table 1.1) of Upper River Region in 2003 was 182,586 persons with an 18 % increment over the 1993 figure and further increased to 239,916 in 2013 representing an increase of about 23 % (GboS, 2013). Crop and livestock production are the main sources of livelihood and as presented in Table 1.2, the Upper River Region is the Agricultural region with the largest cattle population, about seventy-nine thousand, four hundred and twelve cattle (DLS, 2016). The Upper River Region has one of the lowest proportion of the economically active working people (21.70 %) and its percentage of the working male population are higher than that of the females (GboS 2013).

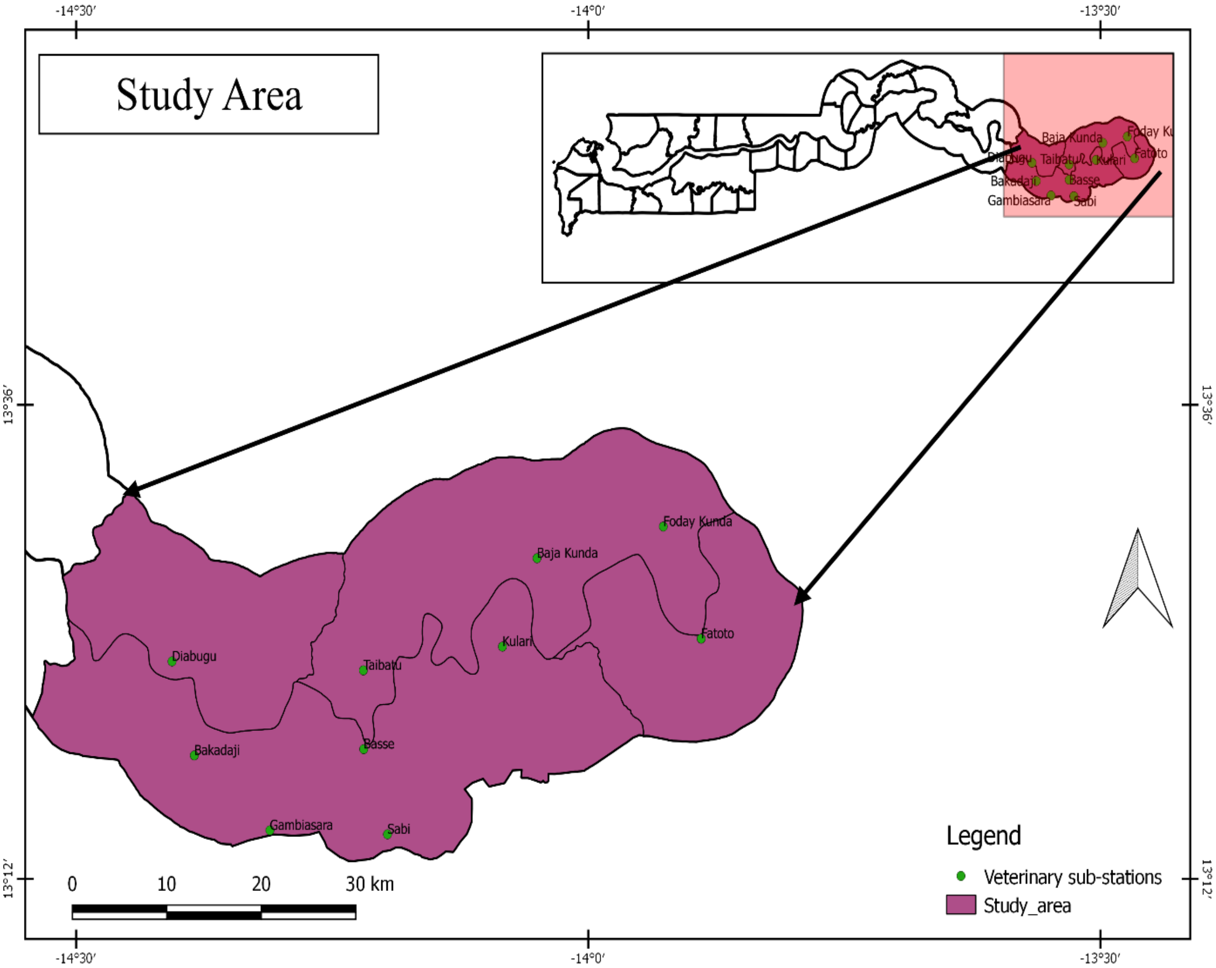


Figure 1.1 Study Area Map

Table 1.1 Population distribution of Upper River Region by district and sex

DISTRICT	MALE	FEMALE	TOTAL
Kantora	18,154	20,630	38,784
Tumana	17,998	19,563	37,561
Basse Fulladou East	24,695	25,295	49,990
Jimara	20,948	22,512	43,460
Wuli West	11,663	10,883	22,546
Wuli East	11,130	12,561	23,691
Sandu	11,372	12,512	23,884
Total	**115,960**	**123,956**	**239,916**

Source: GBoS 2013

Cattle production is a major activity practiced in Upper River Region where 500 households are reported to own over 70,000 cattle. However, cattle production is still traditional, depending mainly on the natural vegetation as source of feed. This natural vegetation is communally owned and the rules guiding its usage and management are not enforced (Table 1.2).

Table 1.2 Upper River Region Cattle Population Distribution by District

DISTRICT	CATTLE POPULATION
Kantora	13,543
Tumana	13,740
Basse Fulladou East	18.027
Jimara	14,969
Wuli East	13,018
Wuli West	6,977
Sandu	9,138
Total	79,412

Source: DLS CBPP Vaccination Report, 2015

CHAPTER TWO

2.0 LITERATURE REVIEW

This literature review looked at climate change globally, in West Africa and in The Gambia and the common cattle diseases in Upper River Region of The Gambia. It also observed the livestock production systems in The Gambian, livestock farmers' perception of climate change, impacts of climate change on livestock and adaptation to climate change.

2.1. Conceptual Framework

2.1.1. Climate change

The definition and concept of climate change is probably as varied as its geographical effects. For instance, the Intergovernmental Panel on Climate Change (IPCC) 2007 referred to climate change as "Change in the state of the climate that can be identified (using statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period, typically decades or longer". These variabilities according to the 2007 IPCC report are either natural or as a result of human activities. This definition, however, contravenes that of the United Nations Framework Convention on Climate Change (UNFCCC), which attributes the changes to anthropogenic activities that are either direct or indirect (IPCC, 2007). However, both definitions hold the view that the change must be persistent and of reasonable period, that is, at least 30 years.

The effects of climate change are unequivocally varied; some regions of the world are more severely affected than others. Developing countries that are recognised to be the poorest of the world, are most affected by climate change because they have least capabilities to respond to climate change (Olmos, 2001). Hence, the ability to adapt to climate change or the vulnerability to climate change is largely poverty related.

2.1.2. Climate variability

Climate Variability on the other hand, is the variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes) of the climate on all temporal and spatial scales. It may be due to internal processes within the climate system or as a result of natural or anthropogenic external forcing (IPCC, 2007). This research work is interested in climate variability, irrespective of what may be the cause.

2.1.3. Adaptation

Adaptation is a key word used in climate change study and there are several definitions of adaptation found in climate change literature. However, for the purpose of this study, only few definitions will be given. “Adaptation to climate is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides” (Smit *et al*., 2000).

“Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer-term climate change” (Smit *et al.* 2000). According to Smit *et al*. (2000) adaptation can be unplanned or planned, and can be carried out in reply to or in expectation of change in conditions. “Adaptation is also referred to as modifications in natural or human systems in response to actual or expected climatic impetuses or their effects, which reduce harm or exploits beneficial. It is also described as strategies for reducing and managing the risk of climate change" (IPCC 2007, IPCC 2014). Adaptation could be planned usually undertaken by governments or Non- Governmental Organisations (NGOs) as a policy initiative or autonomous that are mainly reactive. For adaptation to be effective, it must be appropriate for the particular area, that is, it must not only be robust but be appropriate. Olmos (2001) postulated that adaptation to climate change would be a big challenge to poorer nations although there are many countries that can withstand climate change impacts.

2.1.4. Gender

The terms gender and sex are often use interchangeable, however, they are different in meaning. In an attempt to distinguished between sex and gender, Unger and Crawford (1993) described gender as social organization of the relationship between the sexes. While sex refers to biological difference between man and woman, gender is the socially construed behaviour or activities assigned to men and women by the society they find themselves.

There are research works on gender and climate, however, it is still not controversial to state that there is not much research on gender and climate change (MacGregor, 2010). Climate change impact affects all countries, although its distribution amongst regions, generations, age classes, income groups and gender is different (IPCC, 2001). Climate change causes and effects are gender non- neutral not only because of the difference in experience by men and women but also that women are more severely affected than men (Aguilar, 2006; Demetriades and Esplen, 2008). Kimaro and Chibinga (2013) also recognised that the vulnerability of women to climate change is largely associated to their high exposure to natural hazards, their direct dependence on climate sensitive resources and their inadequate ability to adapt to and manage with climate change. Where women and girls have fewer capabilities and resources than men, this undermines their capacity to adapt to existing and predicted impacts of climate change, or to contribute important knowledge and insights to adaptation and mitigation decision-making processes (Demetriades and Esplen, 2008).

2.2. Review of Related Literature

2.2.1 Livestock production in The Gambia

Livestock plays key roles in the socio economic wellbeing of Gambians as it contributes at least 29.60 % to the Agricultural Gross Domestic Product (AGDP) and about 8.60 % to the Gross Domestic Product (GDP). According to FAO (2012), these percentages could have been greater if its contribution in enhancing crop production were accounted for. Livestock, particularly cattle provide much of the needed fertilizer and labour in the farm. Besides, livestock rearing provides meaningful livelihood for those in the production, processing and marketing value chain in the rural, peri-urban and urban settlements. Cattle also provide a safe investment that can be stored and provides increase returns through reproduction and body weight gain. For these reasons, almost every rural household (98 %) in rural Gambia rear at least cattle, sheep, goats, or chicken (Daffeh, 2010).

According to Robinson et al. (2011), FAO's classifications of world's livestock system includes pastoralist, agropastoralists and mixed crop-livestock production systems. In the Gambia, mixed crop-livestock production system is the main production system racticed. However, there are two distinct livestock production methods in The

Gambia; the traditional and improved or modern systems. Albeit its importance, the Low-Input Production System (LIPS) or traditional production system is still the dominant cattle production system. This is characterized by low investment, subsistence in nature, and free range practiced widely in the rural areas. In this system of production, cattle are rarely housed, instead they are kept in kraals all nights near villages during the dry seasons and in uncultivated lands away from the settlements during the rainy seasons (FAO, 2012). Thus rendering cattle very vulnerable to climate variability threats. High disease risk due to ecto- and endo-parasites, vector and vector-borne diseases and other infectious diseases are major causes of livestock productivity losses (GoTG, 2016**).** The other form of cattle rearing, the modern or improved production system is an attempt to consolidate and improve on the weakness of the LIPS. It is mainly practiced by small scale dairy farmers who are mainly concentrated in the Greater Banjul Area. In this form of production, exotic breeds (Friesian) are used and are promoted through the private sector (FAO, 2012).

The Gambia has a very high livestock density but are threatened by a number of factors that include the destruction and degradation of their natural habitats, which led to shortages of feed and water. As a mean of minimising the shortages of feed and water, cattle owners resorted to unregulated transhumance. Thus leading to the introduction and re-emergence of Transboundary Animal Diseases (TADs). The re-emergence of Contagious Bovine Pleuropneumonia (CBPP) after forty-one years of absence (Secka *et al*., 2015) is a clear manifestation. In spite of all the benefits and the degree of the changes that are expected to occur to livestock systems, the claim made by Thornton *et al*. (2009) that intersection of climate change and livestock in developing countries is a relatively neglected research area is particularly true for The Gambia. There is very little research done on climate change and livestock in The Gambia.

2.2.2. Climate change and variability

2.2.2.1 Global climate change and variability

According to the IPCC (2014), each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere (IPCC, 2014). In Nepal, Sujakhu *et al.*, 2016, reported that over a 30-year period, temperatures rose by 1.02 ^{0}C with variations up to 10.40 % from the mean of the entire period. Separating this period into 3 time spans, it was found that mean annual temperature rose by 0.18 and 0.90 ^{0}C during 1978–1987 and 1988–1998, respectively, and by 1.56 ^{0}C in the period after 1999. They further asserted that average temperatures during winter have risen significantly (1.98 0C) over the last 30 years.

The changes in climate parameters such as increases in global average air and oceans temperatures together with widespread melting of snow and ice and the rising global average sea level are all evident of warming of the climate system. This is justified by the report of IPCC, (2007), which revealed that the rise in temperatures is consistent with sea level rise and decrease in snow and ice. While temperatures are increasing globally, precipitation is increasing in certain regions and decreasing in other areas. This is confirmed by Mugalavai *et al*. (2008), who reported that while some regions of America, Europe and Asia experienced an increase in rainfall, the Sahel, Mediterranean, southern Africa and parts of southern Asia were exposed to a decline in rainfall between 1900 and 2005. Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen (IPCC, 2014).

2.2.2.2 Climate change and variability in West Africa

In West Africa, Gouro *et al*. (2008) reported significant drop in rainfall through the 70's and 80's and significant variation of rain fall in the last 40 years in Niger, Burkina Faso and Ghana. Similarly, Kima (2014) reported that there was a serious decline in rainfall in the Boulgou Province of Burkina Fasso from 1998 to 2004. From 1960 to 2010 temperature records showed a warming trend and decreasing total annual rainfall throughout West Africa Sahel though rainfall was not uniform as temperature (Ly *et al*., 2013).

2.2.2.3. Climate change and variability in The Gambia

Jaiteh and Sarr (2011) reported that The Gambia lies within the tropical sub-humid eco-climatic zone. There are two distinct seasons in The Gambia; a long dry season occurring from November to May and a shorter wet season happening between June and October. Average rainfall ranges from 800 to 1200 mm annually and found to be decreasing from south to north. (Jaiteh and Sarr 2011). Average temperatures in The Gambia range from 18 to 28^0 C in January to 23 to 36^0 C in June. While rainfall decreases from south to north, temperature increases from west to east. The highest ever temperature recorded is 45^0 C and the lowest is 9^0 C. The effects of the Atlantic Ocean moderate temperatures in the western part of the country (Jaiteh and Sarr, 2011), thus lowering temperatures in this part of the country.

The Gambia's greenhouse gases (GHGs) emission may be relatively low, (below 0.01 % of the global emission) however, there are evidence of climate variability and its impact (INDC, 2017). Jaiteh and Sarr (2011) observed that there was reduction in both the amount and length of precipitation and increased frequency and length of dry spells. Similarly, Yaffa (2013) highlighted drop in the rainfall below average for at least 29 years out of 40 years in the North Bank Region of the Gambia. It has been reported by both McGranahan *et al*., 2007 and Jaiteh and Sarr (2011) that The Gambia is one of the most vulnerable countries to sea level rise. Mean temperatures are expected to increase between 3.00 ^{0}C and 4.50 ^{0}C by the year 2075 (Jaiteh and Sarr 2011).

2.3. Perception on Climate Change and Variability

Even though unusual events with respect to climate parameters are happening quite often, there are varying perception on climate change in not only between countries but also within countries. For instance, Chen and Kates (1994) cited in Smithers and Smith (1997) acknowledged that despite a strong lobby on the limitation of greenhouse gases (GHGs), it is still argued that the problem is not sufficiently serious.

Although Kima (2014) detected that the perception of the climate being hotter was consistent with observed meteorological data, Sujakhu, *et al.* (2016) highlighted that there was less consensus among respondents regarding seasonal changes than annual changes. Megersa *et al*. (2014a) reported that less than 45 % have received information about climate change even though they associated changes in climate parameters like rainfall to deforestation and desertification. Conversely, Mandleni (2011) stated that 60 % of the respondents receive some climate change information through radio and extension workers. A study in British Columbia, Canada lamented that like others in other parts of Canada and the neighbouring country (USA), majority of respondents believe global climate change is occurring and is affecting their livelihoods (Cox *et al*., 2015).

Although, several research geared toward measuring perception are done in the past, very few try to compare between women and men. Furthermore, a mere face-to-face interview or sometime by mail might not generate adequate reliable information. Thus, this research will measure and compare perception of women and men cattle farmers using focused group discussions with specific emphasis on certain participatory rural appraisal (PRA) tools in addition to the personal face-to-face interviews.

2.4. Impacts of Climate Change and Variability on Livestock

Chatikobo *et al*. (2013) highlighted that the most frequently reported constraints to livestock production include shortage of feed and water, high incidence of diseases and mortality rates, and weak veterinary extension. Owing to the production system (Low Input Production System) practice in most parts of Africa, **l**ivestock particularly cattle are expected to be hard hit by climate variability especially with reduction in precipitation and continuous increase in temperature. This is due to the high dependent on rain fed agriculture especially for growth and development of pasture and for the watering of livestock.

Climate change directly and indirectly affects livestock, the direct effects according to Mandleni (2011) include reduced animal growth, poor value animal products, and animal production in general. Mandleni (2011), perceived the indirect effects to be declined in quantity and quality of feedstuffs for example, pasture, forage, grain severity and distribution of different species of livestock, and other effects such as increase in livestock diseases and pests. Kimaro and Chibinga (2013) opined that climate change directly impacts on livestock by influencing its health, growth, reproduction and productivity performance, as a result of increased ambient temperature and concurrent changes in heat exchanges that causes heat stress, Similarly, Abdela and Jilo (2016) lamented that climate change affects livestock health through several paths; the level of growth of pathogens or parasites and the distribution and the abundance of disease vectors being influenced by temperature and rainfall.

There are however conflicting reports on the effect of climate variability on livestock. For instance, while IPCC (2007) associated the high mortalities of livestock to increased droughts, Mertz *et al.* (2009) reported that farmers in the Eastern Saloum of Senegal identified wind as the major climate parameter causing poor livestock health. Nyariki *et al.* (2009) branded long distance movement in search of water and pasture as a key factor affecting animal health in the Massai traditional livestock production. Megersa *et al*. (2014b) highlighted that inter-annual variations in seasonal rainfall was a better predicator of trends in cattle number than total annual rainfall.

Although there are many other research works on the impact of climate change on livestock production (Megersa *et al*., 2014a and IPCC, 2007) which highlighted that high livestock mortalities and poor animal health are expected to increase due mainly to climate change and variability, there are few research works that try to find the relationship between the occurrence of common cattle diseases and climate variability. Hence, a motivating factor for this research work.

2.4.1. Climate variability and animal diseases

Kimaro and Chibinga (2013) described livestock production as among the most climate sensitive economic sectors in developing countries and the rural communities as more vulnerable to the adverse effects of climate change. Although it is acknowledged that there is little knowledge on the relationship between climate change effects and animal health, the impact of climate variability on the occurrence of animal diseases can be related to its effects on the hosts, vectors and pathogens (Kimaro and Chibinga, 2013). Moenga *et al*. (2013) revealed that there were marked association between disease occurrence and climate variability pertaining to humidity, wind direction and speed and temperature.

2.4.2. Effect of climate variability on hosts

Abdela and Jilo (2016) highlighted that mammalian cell immunity level may be supressed when severely exposed to ultraviolet B (UV-B) as a result of ozone layer depletion. While prolong exposure to ultraviolet radiation might weaken reaction to immunization, climate stress such as heat, inadequate feed and water can also lower hosts' immunity (Abdela and Jilo 2016; de Gruijl *et al*., 2012). Temperatures above the range of 10 to 30 ^{0}C affect most domesticated animals by supressing their feed intake and immunity (Bett et al., 2016; Das et al., 2016).

2.4.3 Impact of climate variability on pathogens

Climate variability can interfere with the distribution and occurrence of non-vector borne diseases as it can increase or decrease the survival of the pathogens in the environment or predisposes the susceptible animal to infections (Kimaro and Chibinga, 2013). Quoting Van den Bossche and Coetzer (2008), Kimaro and Chibinga (2013) stated that pathogens like the infective spores of Anthrax and Blackleg, viruses that cause Pest de Petite Ruminant (PPR) and Foot and Mouth Disease (FMD) are sensitive to changes in temperature and humidity. Abdela and Jilo (2016) stated that the rate of development and spread of pathogens and parasites can be influenced by higher temperatures, greater humidity and wind speed. Van den Bossche and Coetzer, (2008) also revealed that El Niño may result in disease outbreaks related to flooding.

2.4.4 Impact of climate variability on vectors

On vector-borne diseases, Kimaro and Chibinga (2013) opined that temperatures and moisture not only frequently impose on vector distribution but also interfere with the feeding frequency of the arthropod vectors, which has an influence on their ability to transmit diseases. Precipitation, humidity and temperature to a great extent dictate the survival, production, development and behaviour and population dynamics of arthropods vectors (Abdela and Jilo 2016). Similarly, Chatikobo *et al*. (2013) demonstrated that rain promotes ecto-parasite activity, and subsequently, high prevalence of vector borne diseases.

2.4.5 Effect of climate variability on epidemiology

Kimaro and Chibinga (2013) revealed that there are other ways climate change can alter transmission rate, though difficult to accurately predict. Abdela and Jilo (2016) cited the movement of pastoral communities in East Africa to grazing lands meant for wildlife during the drought from 1993 to 1997 as an example. This movement resulted in cattle been infected with a mild lineage of rinderpest transmitting the disease both to other cattle and to susceptible wildlife.

2.5. Common Cattle Diseases

According to the veterinary clinic records of all the sub-stations in Upper River Region, diseases with most outbreak and treatment records are foot and mouth disease (FMD), Blackleg (BQ), contagious bovine pleuropneumonia (CBPP), haemorrhagic septicaemia (HS), trypanosomiasis, reproductive and urinary tract (RUT), gastro intestinal tract (GIT) and respiratory tract (RES) infections. These diseases were considered as the common cattle diseases.

2.5.1. Foot and mouth disease

Foot and Mouth Disease (FMD) is a viral disease principally of cloven-footed animal but also occur naturally in other animals (Davies, 2002). FMD is a highly contagious disease and the main domesticated species affected are cattle, sheep, goats and pigs (Sobrino et al., 2001).

Aetiology

The FMD Virus has seven types; A, O, C, South African Territories (SAT) 1, SAT 2, SAT 3 and Asia 1. Although it's distribution is worldwide, it is endemic in Africa and Asia. FMD virus can survive for long periods at neutral Ph, particularly at low temperatures (Alexandersen *et al*., 2003). The virus types A, O, and C are the strains that have been identified in Europe, whilst in the Asia, the common types are O, A and Asia 1. SAT 3 is confined in Southern Africa but strains 1 and 2 are seen all over Africa. In the Middle East, the strains found are A, O, Asia 1 and SAT 1 (Davies, 2002).

Epidemiology

According to Davies (2002), there are several factors that influence the epidemiology of FMD; the incubation period, the infectious period and the quantity of virus particles expelled, the spread of virus by aerosol, the survival of virus in fomites, the persistence of the virus in carcases, the existence of carriers, and the density of the host populations.

2.5.2. Black quarter (BQ)

Black quarter (BQ) also called blackleg is a disease affecting cattle, sheep and other ruminants and was first reported in 1870 (Useh *et al*., 2006 a). It is characterized by inflammation of the skeletal and cardiac muscles, gangrenous myositis, severe toxaemia and high mortality rate (Daffeh, (2001). Symptoms of BQ in cattle include high fever, depression, anorexia, and often a marked lameness with swelling of the heavy muscles, which become hot and painful when palpated. The skin over the affected areas becomes dry, hard and dark in colour and progress of the disease is rapid and death occurs from toxaemia within 24-36hrs after the first appearance of the fever.

Aetiology

Black quarter is caused by *Clostridium chauvoei*, which derived its name from Professor J. A. B. Chauveau, a French bacteriologist (Useh *et al*., 2006 b). Daffeh, (2001) described the bacterium as a gram-positive rod shaped spore forming anaerobic bacterium, which is highly resistant to environmental influence and disinfectants. Thus enabling it to persist in the soil for many years.

Epidemiology

There are several conflicting reports on the seasonal occurrence of BQ, while some reported high occurrence in the summer, others stated that there is minimal occurrence during the summer (Sivakumar *et al*., 2012). Blackleg is an endemic disease in both developed and developing countries of the world and is a well-known cause of financial loss to cattle raisers in many parts of the world (Useh *et al.*, 2006b). According to Useh *et al.* (2006 b) BQ is enzootic in areas associated with flooding and has high mortality rate. Daffeh (2001) reported that most BQ outbreaks in Nigeria occur during the rainy season, from April to September. On the contrary, Zavoloka (1988) cited in Daffeh (2001), highlighted that Black Quarter disease is more often in the dry season when pastures are low and near ground level thus giving the animals the possibility to ingest the soil containing spores. Beside rainfall and temperature, soil composition is also believed to have influence over the survival of *Clostridium chauvoei* as incidence of *clostridia* diseases has been associated with areas of soils with high humus content (Daffeh, 2001).

2.5.3. Contagious bovine pleuropneumonia (CBPP)

Also called lung sickness, contagious bovine pleuropneumonia (CBPP) is an insidious pneumonic disease of cattle that has not only impede food security but also affects peoples' livelihoods in affected countries and characterized by severe coughing, weakness, emaciation and sometimes by elevated temperature (Adamu and Aliyu, 2007). Amanfu, 2009 described CBPP as the most serious infectious cattle disease following the eradication of rinderpest and regarded as major constraint to cattle production in Africa. Secka *et al*. (2015) revealed that CBPP impacts animal health and poverty of livestock-dependent people through decreased animal productivity, reduced food supply, and the cost of control measures.

Aetiology

Contagious bovine pleuropneumonia (CBPP) is caused by *Mycoplasma mycoides* subspecies mycoides small colony variant (MmmSC) (Amanfu, 2009).

Epidemiology

Contagious bovine pleuropneumonia was first described in Europe in 1564 and has, with the exception of South America and Madagascar, occurred throughout the world and transmission depends upon direct contact between infected and susceptible animals, with fomites apparently playing no role in the spread of the disease (OIE 2008; Amanfu 2009). Thiaucout *et al*. (2004) and Secka *et al*. (2015) argued that the epidemiology of CBPP in Africa is dominated by four factors, which are; cattle are the only species affected, there is no reservoir in wild animals, clinical cases or chronic carriers are the usual sources of infection, direct contact and cattle movements play a very important role in the maintenance and extension of the disease. The three most important factors responsible for spreading CBPP are; closeness of contact, intensity of infection and the number of susceptible animals (OIE, 2008). After a long absence of between 40 and 50 years, CBPP has re-emerged in some countries notably in The Gambia and Botswana (Amanfu et al., 1998; Secka et al., 2015).

2.5.4. Haemorrhagic septicaemia (HS)

After the eradication or control of rinderpest and decline in mortality of livestock due to foot and mouth disease, Haemorrhagic septicaemia (HS) became one of the most economically important disease that affect mainly cattle and buffalo, Benkirane and De Alwis (2002) cited in Shivachandra *et al*. (2011). Shivachandra *et al*. (2011) described HS as a highly fatal and septicaemia disease characterized by initial high temperature and occurs in acute, sub-acute and chronic forms. It is a per acute to acute, often fatal infectious disease and characterised by pneumonia and haemorrhagic septicaemia.

Aetiology

Haemorrhagic septicaemia is caused by two specific serotypes of *Pasteurella multocida* called B:2 (Asian serotype) and E:2 (African serotype) (Shivachandra *et al*., 2011; Magyar *et al*., 2017). The Asian form is caused by serotype B whilst the African form is primarily by serotype E. *Pasteurella multocida* is short non-motile, rod shaped gram-negative microbes capable of capsule formation.

Epidemiology

Although the developed countries are less affected with HS, Benkirane and De Alwis, (2002) highlighted that the disease has occurred in many countries, particularly in Africa and Asia. The disease occurs commonly in several countries in Africa including Senegal, Mali, Ivory Coast, Nigeria, Egypt, Sudan, Congo, Congo Democratic Republic, Zambia and Gambia. The disease occurs in Asia particularly in Southern and South – East Asia. It has also been recorded in North and South America and also in Europe (Coetzer *et al* 1994 in Daffeh, 2001). In the Gambia, it is presently one of the major infectious diseases of cattle (Daffeh, 2001). Okoh, 1980 reported that haemorrhagic septicaemia is prevalent in domestic cattle in Nigeria during the rainy season, especially in marsh-land and swampy places. Similarly, Alwis (1992) lamented that HS is usually associated with wet, humid weather and an increased incidence is recorded during wet seasons. However, it is also revealed that outbreaks of HS do occur at all times of the year but those occurring during wet seasons tend to spread, presumably due to the longer survival of the organism under moist conditions (Alwis (1992); Shivachandra et al., 2011).

2.5.5. Trypanosomiasis

Trypanosomiasis is a vector-borne infectious disease of both humans and animals that is expected to respond to climate change (Steverding 2008; Moore *et al*., 2012). Steverding (2008) reported that in animals the disease is manifested by fever, listlessness, emaciation, discharge from the eyes, oedema, anaemia, and paralysis.

Aetiology

In animals, trypanosomiasis is caused by protozoan parasites of the genus Trypanosoma (*T. congolense, T. vivax and T. brucei spp*), which live and multiply extracellularly in blood and tissue fluids of their mammalian hosts and are transmitted by the bite of infected tsetse fly of the Glossina spp. In human trypanosomiasis the causative agents are two subspecies of *T. brucei* called *T. brucei gambiense* and *T. brucei rhodesiense* (Moore et al., 2012).

Epidemiology

Authié (1994) has highlighted that tsetse fly of the Glossino spp, which can transmit the trypanosomes that are infective for cattle can be found in one-third of the African continent. There are breed of cattle that are tolerant to trypanosomiasis, however, according to Authié (1994), the degree of resistant is largely influence by physiology and nutritional conditions and by the severity of the tsetse challenge. According to

Claxton *et al*.(1992), there is a strong correlation between prevalence of tsetse fly and incidence of infection in the N'dama Cattle.

2.5.6. Reproductive and urinary tract (RUT) infections

Reproductive and urinary tract (RUT) infection are infections that affect organs of the reproductive and urinary systems. Reproductive diseases are a big concern to cattle owners as the reproductive tract pathogens cause lot of damages including embryonic deaths, stillbirths and weak calves (Wikse, 2005). According to Wikse (2005), the seven pathogens; *Brucella abortus, Leptospira hardjo-bovis, Campylobacter fetus*, infectious *bovine rhinotracheitis* (IBR) virus, bovine viral diarrhoea (BVD), *Tritrichomonas foetus* and *Neospora caninum* are of most worry to beef cattle herd. As a result of the common management system, many urinary tract diseases are hardly noticed or not until the later stage (Mueller, 2007). According to Mueller (2007), diseases like Post-parturient haemoglobinuria are triggered by cold weather. Enzootic haematuria, which is a non-infectious disease is associated with feed intake, that is, long term consumption of bracken fern and 'teart' pastures that contain high molybdenum level (Mueller, 2007). Mueller (2007) also highlighted that bacillary haemoglobinuria also called 'Red Water Disease' caused by *Clostridium haemolyticum* occurs especially on wet alkaline pastures and aggravated by stress.

2.5.7 Respiratory tract (RES) infections

Ailments affecting the respiratory tract are of concern to cattle owners since they cause huge economic losses through death and increased costs on medication. Respiratory diseases are influenced by the infectious agents, environment and immunity of the host animal (Accurate, 1997). Although their causes are many and complex, stress factors, viral and bacterial infections are nearly involved in all severe cases (Bagley 1997). Bagley (1997) highlighted that viral respiratory infection such as Infectious Bovine Rhinotracheitis may be existing in nearly all herds, however, they cause illness to those cattle with lowered levels of immunity. Bagley (1997) further stated that, bacterial infection like *pasteurella*, which causes respiratory diseases takes opportunity of stressful conditions to cause diseases.

2.5.8 Gastrointestinal tract (GIT) infections

Many pathogens cause GIT infections leading to severe financial losses to cattle owners. These infections are transmitted by direct contact or through the faecal-oral route. One of the most important viruses associated with GIT infections is bovine virus diarrhoea virus (BVDV). Development of disease linked to BVDV depends on both the virulence of the virus and the susceptibility of the host (Brownlie, 1987). *Salmonella* spp. Infections can also cause gastrointestinal problems to cattle of all ages particularly cattle that are exposed to very stressful conditions (Gruenberg, 2016.).

2.6. Adaptation to climate variability and change

Adaptation defers from region to region, from one situation to another and it is limited by poverty and awareness levels. Measuring climate variability and change is a challenging and complex task as different sectors are most impacted in different settings, hence influencing factors may be many. For instance, water for irrigation may be an issue in a locality whereas pasture could be in another.

There is no single adaptation strategy that is applicable to all systems, all situations or for both short and long term impacts. While Ifejika (2010) enumerated the adaptation strategies of livestock farmers in Makueni District of Kenya, as walking long distance with herd to access water, dig shallow wells in river beds, purchase water and increase supplementary feed, Taruving *et al*. (2013) highlighted diversification of livestock species as the practice in the Eastern Cape Province of South Africa. Kima (2014) stated the use of crop residue, vaccination of livestock and the supplementation of concentrates. Unlike all the afore mentioned authors, Mertz *et al*. (2009) disclosed that youth migration is a key adaptation measure to climate change impacts in the Eastern Saloum of Senegal.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Data Collection

3.1.1 Climate data

Meteorological data from two meteorological stations (Basse and Fatoto) including monthly minimum and maximum temperatures, rainfall, humidity, and wind speed were collected from the Department of Water Resources (DWR). The minimum and maximum temperature, rainfall, wind speed and humidity data for Basse was from January 1981 to December 2016. For the Fatoto meteorological station, minimum and maximum data dated from January 1981, while that of rainfall, humidity and wind speed are from January 1988 to December 2016.

3.1.2 Veterinary clinic records

Veterinary Clinic Records from 1995 to 2016 were collected from the Regional Veterinary office in Basse. The data consist of compiled monthly reports of trained staff of the Department of Livestock Services (DLS) called Livestock Assistants who are posted across the length and breadth of the region. They are supervised by the head of the regional office who is most of the time a veterinary doctor. Most of these livestock assistants have more than a decade of fieldwork experience. The dataset contain only the number of cases reported to the livestock assistants by the farmers, which the livestock assistants compiled as their monthly reports. The regional officer in turn compiles the reports from the various sub-stations at district level as the regional monthly report. The dataset contains several years but is not detailed enough to show date of outbreaks, age and sex of cattle and specific villages where the outbreaks occurred.

3.2 Sampling

The Upper River Region (Figure 1.1) was subjectively chosen for this research due to its high livestock population. A multiple tier stratified random selection technique was employed to select a random sample of individual cattle owners for questionnaire administering. First, of the seven districts, Sandu and wuli East (in the north) and Kantora (in the south) were randomly selected by means of lottery. The names of all the districts were separately written on a small piece of paper and wrapped. Those in the south bank were put in a pot and those in the north bank in another pot. A six-year-old boy was called to select two papers from the pot that contained the districts in the north and one from the pot that contained the districts in the southern part. Meteorological report showed that the north eastern part of the country receives the least amount of rainfall, thus the reason for choosing two districts in the northern part of the Region.

In the second stage, nineteen villages (5, 6 and 8 villages in Wuli East, Sandu and Kantora districts, respectively) were selected. A stratified random selection was carried out to select the villages. These villages represent about 45 % of the number of villages with cattle population of at least 200 and were obtained from the 2015 contagious bovine pleuropneumonia (CBPP) vaccination campaign records of the Department of Livestock Services. Names of all the villages with the right criteria were listed on a piece of paper separating them by district. The first village on each list was selected and then every other second village counted. At the village level, randomized selection of the herds was done. The selection of the herds followed the same procedures as that of the district selection except that the drawing of the herds was done by another person. The cattle ownership of each selected herd was established by sex. The manager of each selected herd provided the names and sexes of all the cattle owners in his herd. Fifty percent of male and female owners for each herd were selected and was based on who is available or most accessible. In some herds, the fifty percent target was not met because the supposed respondents were not available. Finally, 187 respondents were available for the survey.

3.2.1 Research questionnaires

The questionnaire administration was conducted to compare between male and female cattle owners, their perception on climate variability (CV) as well as climate variability impacts and adaptation measures employed. Cognizant of the high illiteracy level of cattle owners, face-to-face interview was deemed the most effective form of administering the developed questionnaire. Besides, face-to-face interview allows for more in-depth discussion of the interview questions, however, it limits the sample size and breath (Cox *et al.*, 2015). The time taken for in-depth discussions and to meet local protocols consume a lot of time, thus limiting the number of respondents that could be reached within a specified period. Both qualitative and quantitative questionnaires were designed, developed and administered to 187 respondents from 19 villages in 3 districts.

The questionnaires were first drafted, edited by both the main and co-supervisors, pretested and necessary adjustments made before finally adopted. Although the questions were written in English, the interviews were done in either *Mandinka* or *Pulaar* depending on what the respondent understood and all respondents were met at their respective homes. M*andinka* and *Pulaar* are local languages spoken in The

Gambia. To avoid misinterpretation of the questions, an orientation programme was organised for the field workers that participated in the survey before the exercise. The questionnaire was divided into four section: sociodemographic, perception, impact and adaptation. Section one, which dealt with the sociodemographic issues looked at name, age, sex, village, district, experience and number of cattle own by the respondent. The second section asked questions about the perceptions of cattle owners on climate variables like temperature, rainfall and wind speed, stating if these climate variables are increasing, decreasing or not changing.

In the third section, cattle owners' views on the impact of climate variability on cattle health were examined. In this section, the researchers also wanted to know if respondents have done something to deal with variabilities in temperature, wind and rainy season. If respondents answered in the affirmative, a follow-up question of "how do you deal with it" was asked. On the contrary, if the response was no the question "why have you not done anything" was asked. The fourth and final section explored how cattle owners adapt to the impacts of climate variability. The purpose of the survey, which was written on the questionnaire was clearly explained to all respondents and was also emphasized that participation was completely voluntary.

3.2.2 Focused group discussion (FGD)

Adapted from Mertz *et al.* (2008) with some modification, focused group discussions (FGD) were held to triangulate the information obtained from individual respondents. In each of the 3 selected districts, two FGDs (one for males and one for females) were carried out. The discussions with the males and females were separately held to avoid influence of responses by either side thus enabling comparison between gender.

Participatory Rural Appraisal (PRA) tools including proportional pilling and pairwise ranking were employed. The livestock assistants in each of the selected districts conducted the preparatory work, arranged for the date and venue of the meeting. The village heads and president of women groups were contacted for the selection of participants and agreeing on the venue and time of the meeting. The participants' selection criteria were mainly cattle ownership and willingness to share knowledge with the research team.

Ranking of adaptation strategies according to the mostly practiced strategy by means of pairwise ranking was carried out during the focused group discussion. Pairwise ranking is a participatory rural appraisal tool used to systematically compare various options by comparing the options in pairs (Gay *et al.*, 2016). A list of possible options is constructed and placed in a matrix table comparing each item to the other items individually and then the number of times it was chosen is summed. The item with the largest sum is deemed to be the most important item. As the participants try to compare a pair of options, they gave reasons for choosing one option at the expense of others. Where reasons were not given, the moderator of the session asked participants to explain their reasons for the choice they made. At times there are difference in opinion amongst participants but consensus was always reached. The adaptation strategies were driven from the answers given by individual respondents when answering the question on adaptation measures.

Proportional pilling is a simple and visual method that is convenient for illustrating relative values and proportions from the perspective of the respondents (Watson, 1994). It also provides a basis for further discussion and useful for comparing the present and past events and practices. For these reasons, proportional pilling was adapted from Watson (1994) to determine changes in certain parameters, which include;

- Temperature
- Wind
- Rainfall
- Wind speed
- Disease outbreaks
- Cattle mortality

The group discussions were moderated by staff of the Department of Livestock Services in the selected districts while the lead researcher was the scriber. However, the lead researcher sometimes interjects to pose questions specially to clarify certain issues.

3.3. Data Analysis

Different approaches were taken to answer each research question; thus data analysis was approached on the basis of answering the research question.

3.3.1 Research question 1

What is the pattern (temporal) of the climate parameters (rainfall, temperature, humidity and wind) in the study area?

3.3.1.1 Standardized Anomaly Index

The climatic index anomaly was constructed to determine the variations of climate parameters (rainfall, temperature, humidity and wind speed), thus enabling the determination of the degree of climate variability in the Upper River Region. In the anomaly construction, the data was divided into two; data with expected behaviour and anomaly that shows the variability from the expected, which is used to determine climate variability phenomenon (Kawale and Chatterje, 2011).

The anomaly time series of a location is constructed from the raw time series by removing a base value (usually referred to as the mean of the data) from it. Although there is no absolute truth in choosing the reference interval, the 30-year period normally chosen by climate scientist was adapted for this study. The mean and standard deviation of the entire observation that is the climatology (1981 -2010), year 2014, 2015 and year 2016 were computed. The formula for the climate index anomaly is applied.

Thus the formula;

$$Yyi = (Q_I - Q) / \sigma X \text{ where} \qquad (3.1)$$

Yyi is climate index anomaly

Q_I is the value of each month

Q is the calculated mean

σX is the standard deviation

3.3.1.2 Mann kendall test

Mann Kendall test was also use to statistically detect the trend in temperature, rainfall, humidity and wind speed for both Basse and Fatoto. The average of the two stations for each variable were computed as the regional data and then Mann Kendall test also conducted. Mann Kendall test was used because it does not require the data to be normally distributed and moreover have low sensitivity to abrupt breaks due to non-homogenous time series (Karmeshu, 2012). The null hypothesis (H_0) of this test assumed that there is no trend, that is, the data is independent and randomly ordered. The H_0 is tested against the alternative hypothesis (Ha) that assumed that there is a trend

(Karmeshu, 2012). Adapted from Karmeshu (2012), the Mann-Kendall formula used is as follows;

$$\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign\ (Gj - Gi) \qquad (3.2)$$

$$\text{Sign}\ (Tj - Ti) \begin{cases} 1\ if\ Gj - Gi > 0 \\ 0\ if\ Gj - Gi = 0 \\ -1\ if\ Gj - Gi < 0 \end{cases} \qquad (3.3)$$

Where G_j and G_i are the annual values in year j and I respectively.

According to Karmeshu (2012), variance for the S-statistics is computed as defined by the equation below.

$$A^2 = (n(n-1)\ (2n+5) - \Sigma t_i(i)(i-1)\ (2i+5))/18 \qquad (3.4)$$

t_i representing the numbers of ties to extent i

Autocorrelation test was done for all the variables to determine whether to use the modified Mann Kendall test or the simple Mann Kendall test. The auto correlation test was conducted using the R Software. The XLSTAT added plugin in EXCEL was used to perform the Mann Kendall test.

3.3.2 Research question 2

Are variabilities in climate parameters correlated to common cattle diseases?

Adapted from Zhang *et al.* (2010) Spearman's correlation tests were performed between all the common diseases and each of the climate variables for each of the two meteorological stations. The minimum and maximum temperatures were summed up and divided by two to represent the average temperature. Since there are two meteorological stations within the region, for each variable, the average of the records from the two stations were taken as the regional climate data. Spearman's correlation test was also conducted for each disease with climate variables (temperature, rainfall, humidity and wind speed) data of the region.

The data were initially tested for normality and stationarity and transformed where it was non-stationary. Although there are many methods to test normality of a data, the Shapiro-Wilk test was used because it is best suited to samples of less than 5000 observations (XLSTAT Guide, 2015). In the stationarity test, Dickey-Fuller Method was used. The Dickey-Fuller Method, uses the null hypothesis (H_0) p = 1 and the alternate hypothesis (Ha) as |<1. The data contained different variables, thus the H_0 set for the analysis was, "All the data variables have a unit root for their series", which is the data variables were not stationary and the alpha value was set at 0.05 but alpha value of 0.1 was also considered. This was deemed necessary cognizant of the under reporting problem confronting the disease surveillance system. In transforming the non-stationary variables, the Box-Cox transformation approach was employed. The transformation was done to ensure that the data meets assumptions of the analyses to be done.

Following the correlation test, multiple linear regression was calculated to determine the degree to which GIT and RUT infections can be predicted by the climate variables they were correlated to. To ensure the assumptions for multiple linear regression were not violated, diagnostic tests for multicolinearity, homoscedasticity and the normal distribution of residuals were performed. The data were also tested for the presence of outlier. The statistical software JASP was used for the correlation test and EXCEL plugin XLSTAT 2014 was used to conduct all the other mentioned analyses.

3.3.3 Research question 3

Is there any difference in perception, impact and coping strategies of climate variability between men and women?

Frequency analyses and Pearson's chi-squared test were generated for all question statements and significance was set at the standard P value < 0.05. The category sex was used as dependent variable on questions relating to a) perception on climate variability b) effects of climate variability and c) management or adaptation to the effects of climate variability. Where there were association, a one-way ANOVA Test was also conducted and Turkey HSD Post Hoc analysis carried out to separate treatment means. However, Post hoc test could not be performed for some variables because they were either less than three groups or were fewer than two cases.

The responses to questions on years of experienced in cattle management, number of cattle owned, age of respondents and the estimated annual cost on treatment were transformed during the analysis. The mathematical formula to determine the width of the category was employed, which was thus;

$$\frac{Maximim - Minimum}{Number\ of\ category} = \frac{Range}{Number\ of\ category} \qquad (3.5)$$

However, in the response relating to the estimated cost on treatment, there was an outlier that was disregarded when determining the width.

The software SPSS Version 23 (2015) was used to conduct these analyses.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Pattern of the climate parameters (rainfall, temperature, humidity and wind) in the study area

4.1.1 Mann kendall test

The autocorrelation test conducted in the R Software as showed in the Appendix A revealed that all the climate variable; rainfall, temperature, humidity and wind speed for each of the two stations were not auto-correlated. This necessitated the use of simple Mann-Kendall test instead of the modified Mann-Kendall test to determine the trend of climate variables.

The Mann-Kendall test as displayed in Table 4.1 presented the trend of climate variables for both meteorological stations in the Region. The average of the two stations was regarded as the regional climate data. For the climate parameters (temperature, wind speed and humidity) calculated p-values were greater than the assigned p-value (0.05), thus their null hypothesis accepted. However, the precipitation for Fatoto and the region was different. The Mann-Kendall test showed exciting perception about the annual rainfall data. There were significant p-values for Fatoto (0.010) and the regional average (0.034), as a result, their null hypotheses were rejected. This implies the rainfall variability in Fatoto and the region was monotonic. A fitted linear line for both Fatoto and the region (Figure 4.1) showed increasing trend. The S statistics for the region was however stronger than that of Fatoto, meaning the trend is more significant in the region than in Fatoto. The null hypothesis for the rainfall data of Basse, that is, there is no trend, cannot be rejected because the calculated p- value (0.088) was greater than the assigned p-value (alpha = 0.05).

Table 4.1 Results of the Mann-Kendall test for climate variable for Upper River Region

Station	Variable	Kendall's tau	S	Var(S)	p-value (Two-tailed)	alpha	Result Interpretation
Fatoto		-0.147	-59.000	2829.667	0.276	0.05	Accept H0
Basse	Temperature	-0.016	-6.000	2773.333	0.924	0.05	Accept H0
Region		-0.075	-30.000	2823.333	0.585	0.05	Accept H0
Basse		0.203	128.000	0.000	0.084	0.05	Accept H0
Fatoto	Rainfall	0.248	156.000	0.000	0.034	0.05	Reject H0
Region		0.298	188.000	0.000	0.010	0.05	Reject H0
Basse		0.075	42.000	4820.667	0.555	0.05	Accept H0
Fatoto	Humidity	0.190	50.000	1592.667	0.220	0.05	Accept H0
Region		-0.030	-18.000	5300.000	0.815	0.05	Accept H0
Basse		0.227	107.000	3849.000	0.088	0.05	Accept H0
Fatoto	Wind speed	0.181	67.000	2685.000	0.203	0.05	Accept H0
Region		0.078	39.000	4078.333	0.552	0.05	Accept H0

Source: Author's field work (2017)

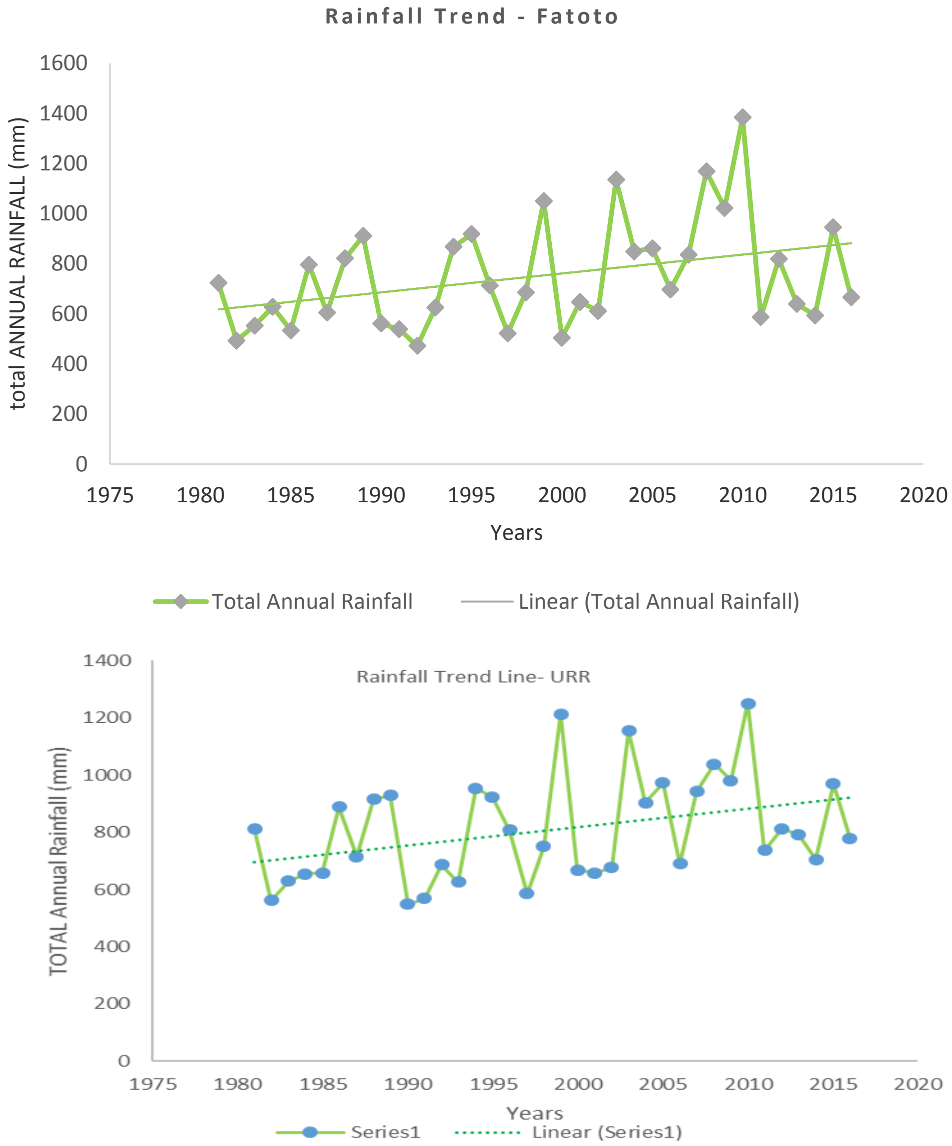


Figure 4.1 Linear trend line for rainfall data of Fatoto and Upper River Region (URR)

4.1.2 Standardized anomaly

Although there was no monotonic increase or decrease in most of the climate variables, the monthly standardized anomaly indexes revealed significant variations between months in both Basse and Fatoto (Figure 4.2). In Fatoto, the monthly rainfall standardized index revealed that there is a forward shift of rainfall onset from May in the climatology and 2014 to June in 2015 and 2016. Although in 2015 and 2016 there was rainfall in the month of June in both Basse and Fatoto, it looked insignificant compared to the climatology and 2014. Regarding cessation of rain, the anomaly index revealed that there was rainfall in October during the climatology, in 2014 and in 2016, the 2016 October rainfall was insignificant in Basse.

In Fatoto, the rainfall in October for 2015 was significant but there was less rainfall for 2014 and 2016 of the same period. In general, it looked as if the rainy season has shortened from October to September. There is also a shift in the peak of the rainy season. While the peak of the rainy season for the climatology was in August, 2015 has two peaks, in July and September and the rainfall peak for 2014 was in July in the Basse area. In the Fatoto area, the peak of the rainy season moved from July in 2014, August in the climatology and 2015 to September in 2016.

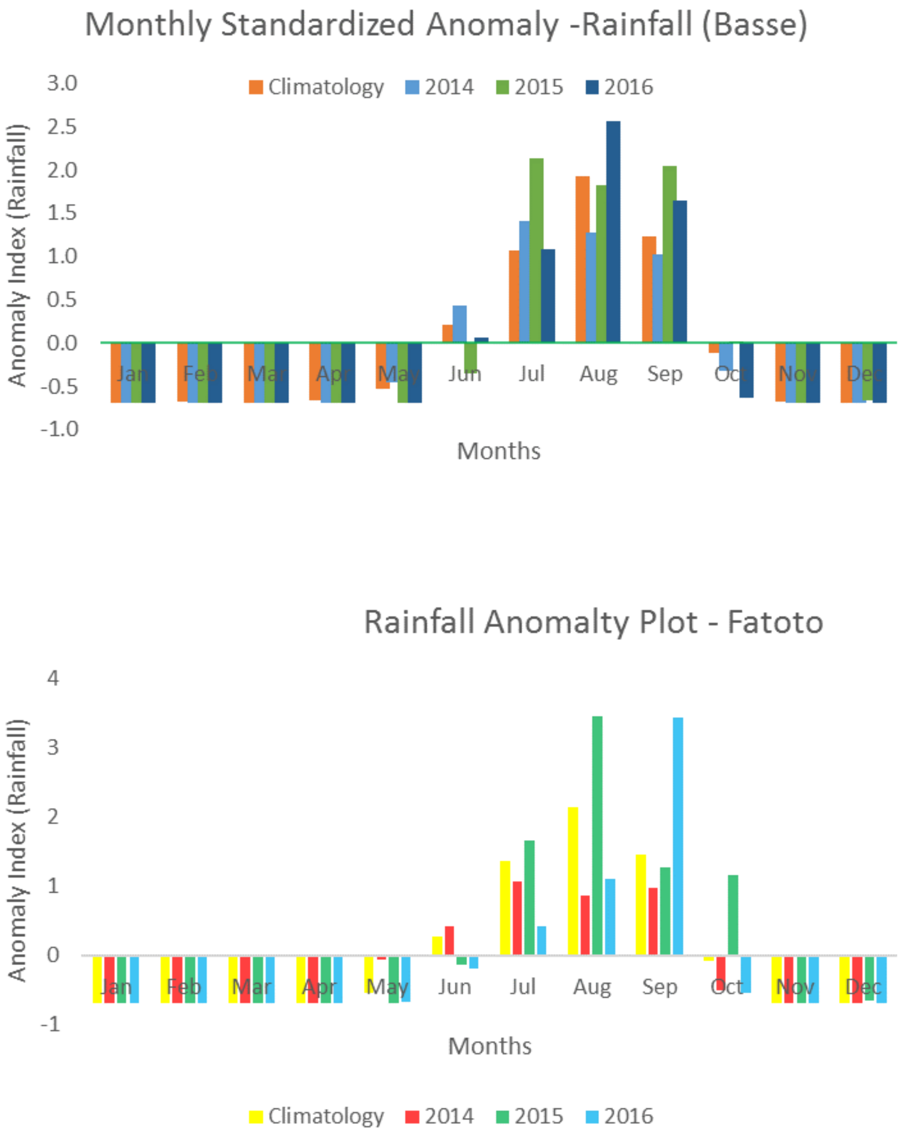


Figure 4.2 Monthly standardized anomaly rainfall for Basse and Fatoto

Similarly, the annual rainfall standardized anomaly (Figure 4.3) revealed a lot of inter annual variations in both areas. In Basse, the rainfall of 16 of the 36 years is below average while in Fatoto, of the 36 years, 21 were less than the average. While 1999 was the wettest year in Basse, in Fatoto, it was 2010. The lowest amount of rainfall in Basse was in 1990, whereas in Fatoto, it was in 1992.

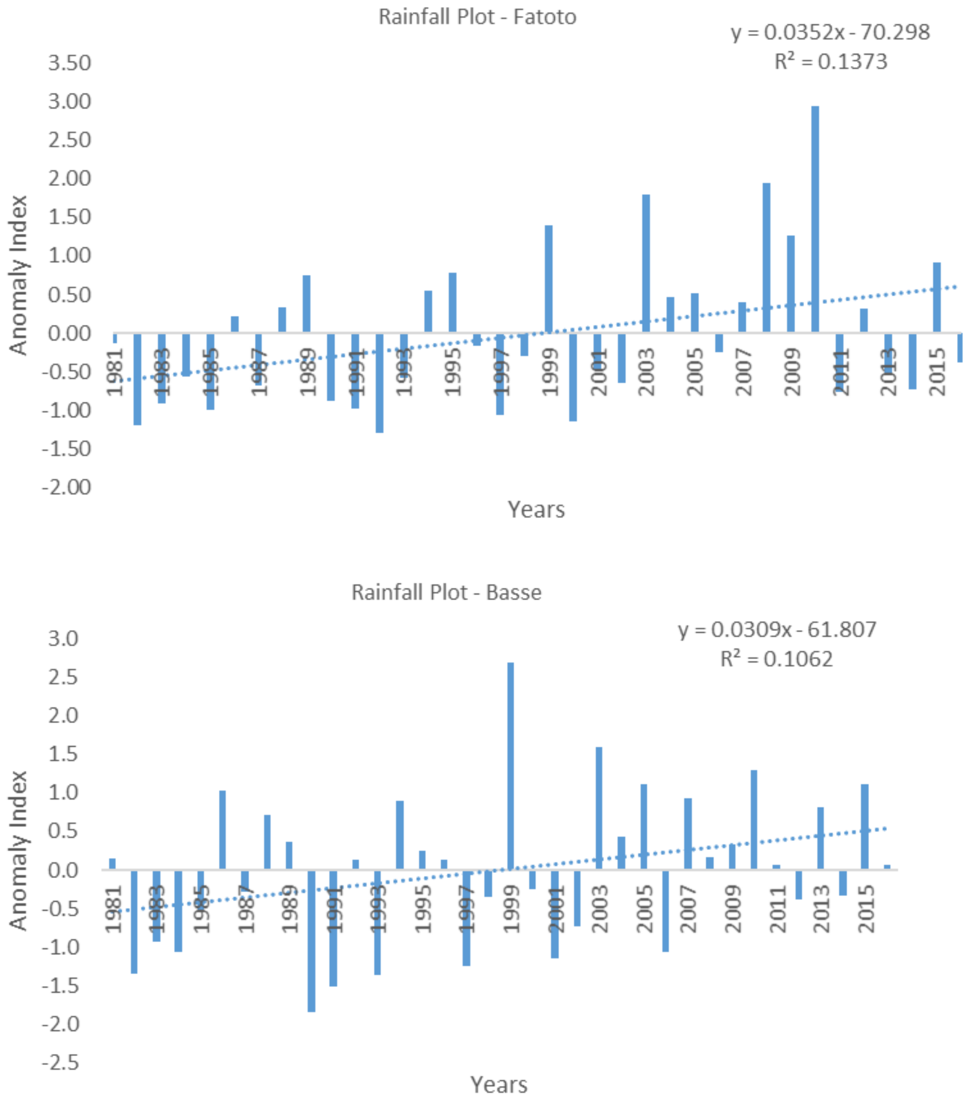


Figure 4.3 Annual rainfall standardized anomaly for Basse and Fatoto

As presented in Figure 4.4, the anomaly index for the average temperature of the region exhibited dissimilarities in monthly average temperature. From June to October, the temperature in 2014 and 2015 was higher than that of the climatology (1981-2010). While in October, temperature was somewhat moderate in the climatology, it was high in 2014, 2015 and 2016. Comparison of the two areas was not done because the temperature data for Fatoto was less than the 30 – year selected period. In the annual standardized anomaly for the region as represented in Appendix B, 1985 was the year with the lowest temperature, while 1997 has the highest temperature.

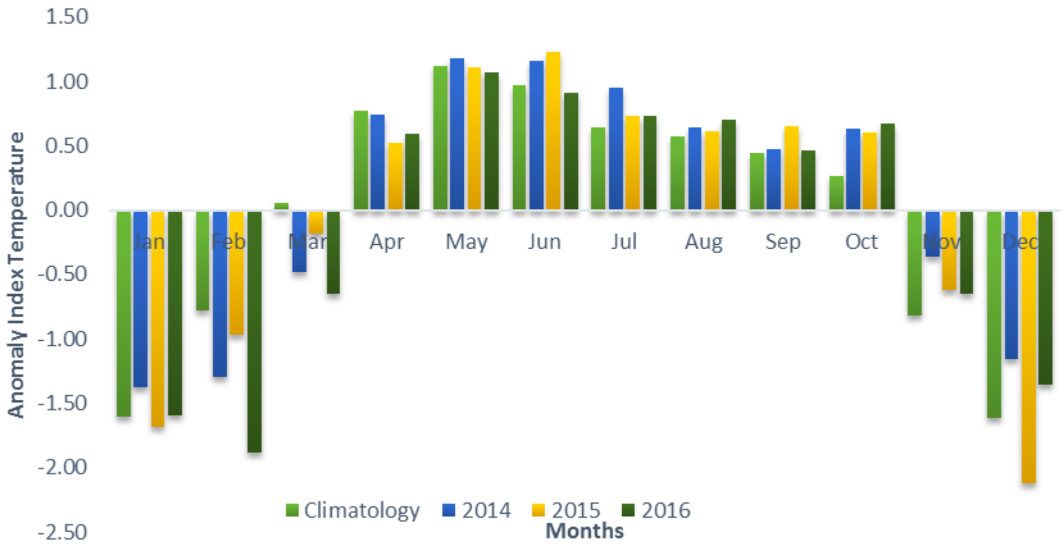


Figure 4.4 Monthly temperature standardized anomaly for Region

Although there was no monotonic increase or decrease in humidity and wind speed for both areas, the standardized anomaly index as in Figures 4.5 and 4.6 disclosed deviations in the monthly humidity and wind speed data for Basse. The climatology was more humid in July, and November, and in August and October the relative humidity of the climatology was equal to that of 2015. The climatology has equal relative humidity with 2014, 2015 and 2016 in September. In comparing variations of the annual standardized anomaly for the relative humidity of Basse and Fatoto, the trend line for Basse showed a downward trend while that of Fatoto revealed an upward trend (Appendix C). In Basse, the relative humidity was extremely low in 2005 and in Fatoto, 1992 has the lowest relative humidity.

The difference in the trends could be associated with size of settlement and human activities. Basse being a much larger settlement, has a downward trend, which may be due to the presence of less vegetation from which evapotranspiration could happened. There are much more buildings in Basse than in Fatoto, which implies less vegetation in Basse than Fatoto thus lesser evapotranspiration in Basse than Fatoto. Consequently, the likely downward trend in Basse.

About the wind speed, the monthly standardized anomaly index divulged that wind speeds in 2014, 2015 and 2016 were stronger than the wind speed of the climatology. In the climatology, the wind speed is below average in all the months. The annual standardized anomaly for the wind speed of both Basse and Fatoto showed much above the average in 2014, 2015 and 2016 (Appendix D). The difference in the wind speed of the climatology and the wind speed of the other years could be attributed to change in the environment. Human activities, that is, logging and farming led to serious deforestation in the area thus paving the way for winds to move without any obstruction. The humidity and wind speed standardized anomaly indexes for Fatoto, were not computed because the data was not up to a 30-year period.

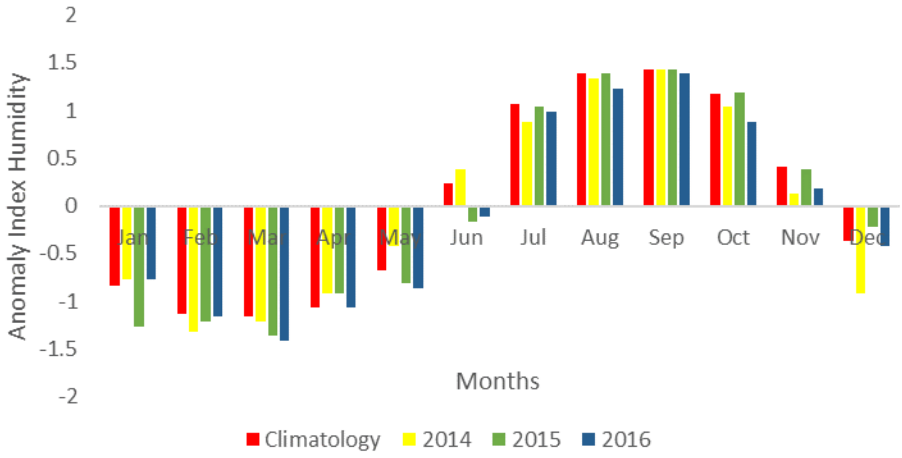


Figure 4.5 Relative humidity anomaly index (1981-2010 compared to 2014, 2015 and 2016)

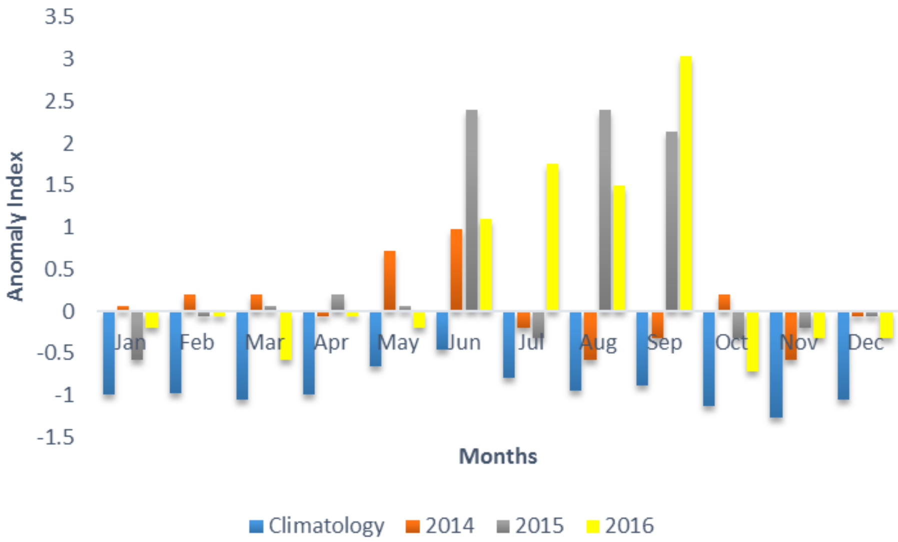


Figure 4.6 Wind speed anomaly index (1981-2010 compared to 2014, 2015 and 2016)

The observations made by IPCC (2007), Jaiteh and Sarr (2011), IPCC (2014) and Sujakhu *et al.* (2016) that temperatures have increased or are likely to increase is in line with the results of this study. The study results also corroborated the views of cattle owners that temperature is increasing. The increasing temperature is a possible signal of the evidence of warming being noticed due to variability in climate.

For the rainfall, although Gouro et al. (2008), Jaiteh and Sarr (2011) and Yaffa (2013) all reported a decline in the amount of rainfall, this study revealed an increasing trend. This difference in study results with Yaffa (2013) and Jaiteh and Sarr (2011) is associated with the difference in the reference dates of the three different studies. While Yaffa (2013) and Jaiteh and Sarr (2011) looked as far back as the 60$_{S}$, the reference date of this study is from 1981 to 2016. However, the statement by Jaiteh and Sarr (2011) that the length of the rainy season is reducing is upheld by this study. The increasing wind speed is associated with the increasing deforestation. As wind blows, there are little or no barrier that could reduce its speed.

The increasing temperature and wind speed and the decreasing length of the rainy season could negatively affect cattle health in the Upper River Region. The reduction in the length of the rainy season is likely to lead to feed and water shortage for cattle. This may prompt temporal nomadism thus risking the spread of disease especially with increasing wind speeds. Furthermore, the exposing of cattle to high temperature may not only reduce their response to vaccinations but may also supress cattle immunity level (Abdela and Jilo, 2016) and decrease their grazing periods. Moreover, the stress that could be inflicted on cattle due to feed and water shortage as well as heat from high temperature could provide a favourable condition to opportunistic bacterium like

Pasteurella molticida to cause disease. Equally important, the increased wind speed and humidity indirectly negatively affect cattle health by enhancing the pathway for the proliferation and distribution of disease causing organisms.

4.2 Correlation between Common Cattle Diseases and Climate Parameters

In the stationarity test, the computed p-values of all the common cattle diseases and climate variables including rainfall, minimum and maximum temperatures and humidity were lower than the significance level alpha = 0.05. The computed p-value 1 of wind speed (0.080) and average temperature (0.219) were greater than the significance level alpha = 0.05 (Table 4.2).

The null hypothesis, which stated that there is a unit root for the series is rejected in the case of the common diseases and all climate variables except average temperature and wind speed. The null hypothesis for the wind speed (p = 0.080) and average temperature (p = 0.219) cannot be rejected because their computed p-value were greater than the assigned p-value 0.05. As a result, transformation of the values of the wind speed and average temperature was done.

Table 4.2 Stationarity test and transformation results of clinic and climate variables

Variable	p-value 1	p-value 2
Black quarter(BQ)	0.002	
Haemorrhagic septicaemia (HS)	<0.0001	
Foot and mouth disease (FMD)	<0.0001	
Contagious bovine pleuropneumonia (CBPP)	<0.0001	
Trypanosomiasis (Tryps)	0.004	
Gastro-intestinal tract (GIT) infections	0.001	
Respiratory tract (RES) infections	0.037	
Reproductive and urinary tract (RUT) Infections	0.030	
No. of cases	0.009	
Maximum temp.	<0.0001	
Minimum temp.	<0.0001	
Average temp.	0.219	0.257
Rainfall	<0.0001	
Humidity	<0.0001	
Wind speed	0.080	0.040

Source: Author's field work (2017)

p-value 1 is p –value before Box-Cox Transformation, p-value 2 is p –value after Box-Cox Transformation

4.2.1 Common cattle diseases

The results in Table 4.3 showed that trypanosomiais (tryps) is the most reported disease (9,798) with a mean of 62.41 and standard deviation of 51.536. Gastro-intestinal tract (GIT) infections, which has a mean of 16.24 and standard deviation of 17.168 has total reported cases of 2,550. The number of reported cases, mean and standard deviation values for contagious bovine pleuropneumonia (CBPP) were 1045, 6.70 and 34.068 respectively. There were 974 reported cases of Respiratory tract (RES) infections and 551 cases of Reproductive and urinary tract (RUT) infections while Haemorrhagic septicaemia (HS) and Black quarter (BQ) each has 108 reported cases.

Table 4.3 Descriptive statistics of reported diseases in the Upper River Region of The Gambia

Diseases	Maximum	Total	Mean	Std. Deviation
BQ	21	108	.70	2.364
HS	26	108	.68	2.669
FMD	250	755	4.84	30.810
CBPP	302	1045	6.70	34.068
Tryps	232	9798	62.41	51.536
GIT Infections	97	2550	16.24	17.168
RES Infections	31	974	6.20	6.764
RUT Infections	19	551	3.55	3.950
All Cases	454	15164	74.70	77.385

Source: Department of Livestock Services’ Monthly Reports

BQ – Black Quarter, HS – Haemorrhagic Septicaemia,
FMD – Foot and Mouth Disease,
CBPP – Contagious Bovine Pleuropneumonia, Tryps – Trypanosomiasis,
GIT – Gastro Intestinal Tract, RES – Respiratory Tract Infection,
RUT – Reproductive and Urinary Tract Infections

4.2.1.1 Black quarter (BQ)

Black Quarter as showed in Figure 4.7, occurred in all the months except July, the highest occurrences were in February (20.8 %) and January (16.7 %) and then between August (12.5 %) and September (12.5 %). The suggestion of this report that BQ occurs year round added to the conflicting statements as echoed by Sivakumar *et al.*, (2012). While this study suggested that BQ occurs in both dry and wet seasons, Daffeh (2001) also stated that BQ occurs in both the wet and dry seasons but more in the wet seasons.

The occurrence of BQ year round may not be easily explained, however, the existence of certain conditions in the study area could provide a possible explanation. The occurrence of BQ in almost all the months could be associated with the extensive traditional management system practiced in The Gambia coupled with improper disposal of carcass of cattle that died of BQ. Normally, all carcasses including those cattle that died of BQ are left to rot and decay on grazing lands, cattle tract and watering points. These areas serve as reservoirs for infection as the *Clostirdium chauvoei*, which can resist harsh environmental conditions can remain viable in the soil for many years creating opportunity and favourable condition for the proliferation of the bacteria (Daffeh, 2010).

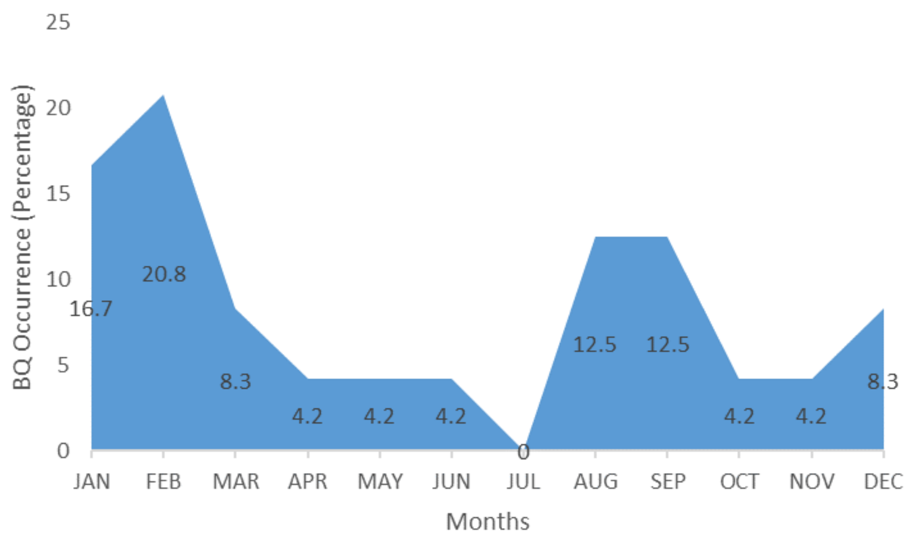


Figure 4.7 Monthly occurrence of black quarter in Upper River Region (1995 - 2016)

The Spearman's correlation analysis (Figure 4.8) showed negative significant correlation between average temperature of the region and monthly occurrence of BQ (r = -0.176*, p < 0.028). There was no other climate variable that BQ was statistically significantly correlated. The Spearman's correlation analysis showed no statistically significant correlation between rainfall and monthly occurrence of BQ in Upper River Region. This is contrary to the findings of Daffeh (2001) and Useh *et.al* (2006) who revealed that there was a strong correlation between rainfall and BQ occurrence. However, Daffeh (2010) has not perform statistical test instead based the suggestion on the observation of a superimposed graph, which may be responsible for the difference in suggestions. For Useh *et al.*, (2006) the difference in results may be due to difference in geographical location and climatic condition. The study result is however, in line with the suggestion made by Moenga *et al.*, (2013), that there exist noticeable association between disease occurrence and climate variability pertaining to temperature.

The correlation between BQ and average temperature does not mean a cause effect relationship but could be related to the influence temperature has on the spread and rate of growth of pathogens. As Abdela and Jilo (2016) stated, higher temperatures can influence the rate of development and spread of pathogens.

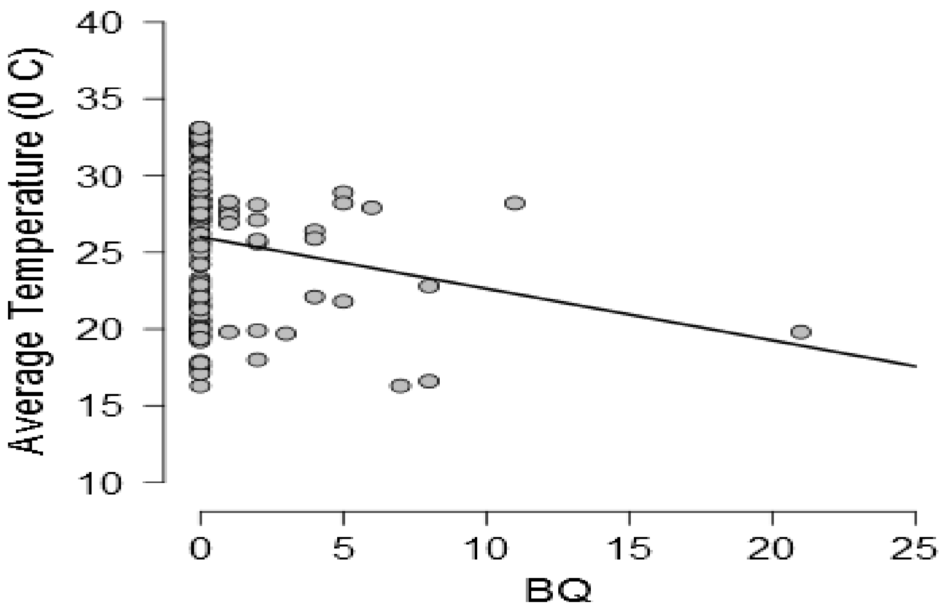


Figure 4.8 Correlation between black quarter (BQ) and average temperature.

4.2.1.2 Haemorrhagic Septicaemia (HS)

There were also 108 reported cases of HS and on a monthly basis, HS occurrence was most frequent in September (20 %) followed by August (15 %) and July (10 %), as in Figure 4.9. Seasonally (Figure 4.10) there is more HS occurrence in the rainy season than in the dry season.

The finding that HS occurred more (55 %) in the wet season than dry season (45 %) is substantiated by Okoh (1980) who observed that haemorrhagic septicaemia is prevalent in domestic cattle in Nigeria during the rainy season. The findings of the study also echoed the claim made by Daffeh (2010) that HS occurs throughout the year.

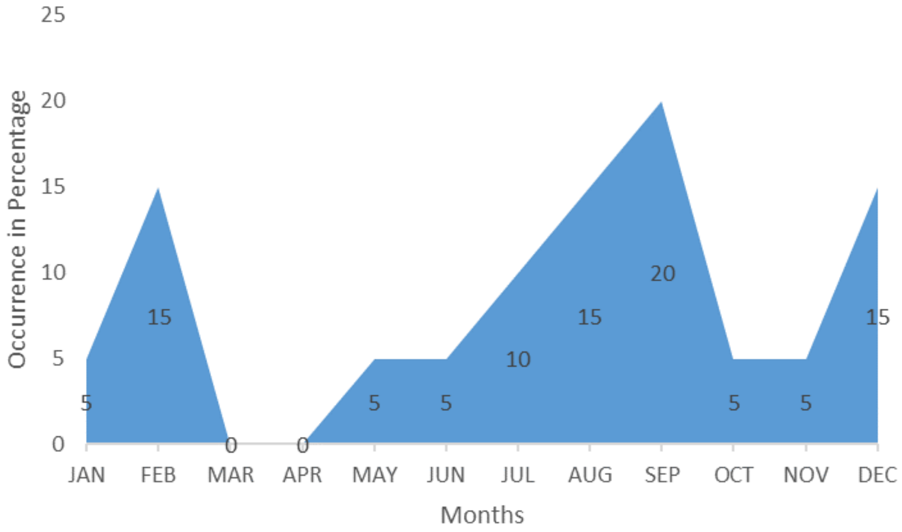


Figure 4.9 Monthly Occurrence of Haemorrhagic Septicaemia Outbreaks in (1995-2016)

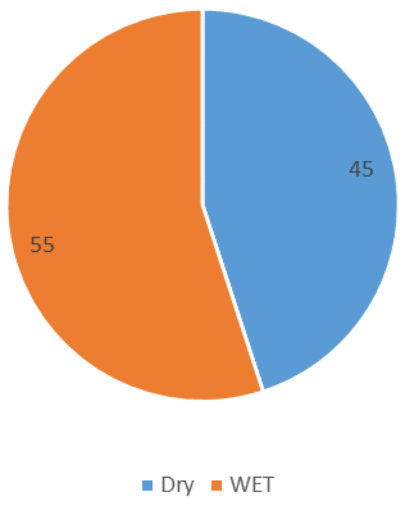


Figure 4.10 Seasonal occurrence of Haemorrhagic Septicaemia Outbreaks (1995 – 2016)

In Basse, HS was statistically significantly correlated with maximum temperature (r = -0.165, p = 0.038) and rainfall (r = 0.171, p = 0.033). Considering alpha value of 0.1, HS was also correlated with humidity (r = 0.160, p = 0.054). The correlation between maximum temperature and HS was negative. In Fatoto, the Spearman correlation analysis revealed that HS was associated with wind speed (r = 0.168, p = 0.036) and with rainfall (r =0.149, p = 0.062) at alpha value of 0.1. For the region as a whole, there was a negative correlation between HS and minimum temperature (r = -0.166, p = 0.037), average temperature (r = -0.148, p = 0.064) and was positively correlated with rainfall (r = 0.148, p = 0.064) and humidity (r = 0.141, p= 0.077) though at alpha value of 0.1 (Table 4.4).

The result depicting significant correlation between HS and humidity authenticated the study reports of Alwis (1992) and Daffeh (2001) who both declared that high rainfall and high humidity correspond to high HS incidence. It is also in line with the statement which suggested that high wind squall could have been one of the factors responsible for the re-emergence of HS in Hungary" (Magyar *et al*., 2017). These significant correlations could be attributed to some factors. It has been noted that some pathogens are sensitive to changes in humidity (Kimaro and Chibinga, 2013). Abdela and Jilo (2016) also recognized that the rate of development and spread of pathogens are influence by greater humidity. Furthermore, transmission of HS infection could be via aerosol, thus strong wind has potential to move the *Pasteurella multicida* bacteria from affected areas to non-affected areas, hence spreading the disease. Moreover, the cattle management system characterized by free extensive system, high dependence on natural vegetation and un-house condition all expose cattle to the hazards of strong winds, high humidity and low rainfall, thus subjecting them to stress. The low rainfall could result in low pasture and water availability, which could lead to transhumance thus possible means of spreading the disease. All these effects culminated can add mammoth stress to cattle, which is a gateway for HS occurrence. Daffeh (2001) reported that stress factors could trigger carrier animals to shed virulent organism. Furthermore, the correlation between HS and rainfall could be linked to the fact that moist conditions prolongs survival of the *Pasteurella multicida* (Benkirane, 2002). Similarly, the strong association of HS and wind speed could understandable be due to infection mechanism (through inhalation of the *Pasteurella multocida* bacteria) coupled with free range management system, where large herds graze freely in communal grazing lands particularly during periods of high winds and in humid environment (Benkirane and De Alwis, 2002).

With temperature, the association could be linked to the effects temperature has on the host. Ultraviolet B (UV-B) supresses mammalian cell immunity (Abdela and Jilo, 2016) and in fact it is found that temperature above the range of 10 to 30 ^{0}C affects most domestic animal by supressing their feed intake and immunity (Bett *et al.*, 2016, Das *et al.*, 2016). The supressing of feed intake and immunity enhance the opportunistic *Pasteurella Mutocida* bacterium to take advantage of and cause disease.

Table 4. 4 Correlation matrix of haemorrhagic septicaemia (HS) and climate variables for Fatoto, Basse and the Region

Station	Climate Variable	Spearman's rho	p-value
	Humidity	0.087	0.33
	Maximum temp.	-0.07	0.487
	Minimum temp.	0.021	0.796
Fatoto	Ave Temp	-0.11	0.168
	Rainfall	0.149	0.062
	Wind Speed	0.168*	0.036
	Humidity	0.16	0.054
	Maximum temp.	-0.165	0.038
Basse	Minimum temp.	-0.032	0.691
	Ave Temp	-0.116	0.147
	Rainfall	0.171*	0.033
	Wind Speed	0.111	0.165
	Humidity	0.141	0.077
	Maximum temp.	-0.166*	0.037
Region	Minimum temp.	-0.015	0.85
	Ave Temp	-0.148	0.064
	Rainfall	0.148	0.064
	Wind Speed	0.155	0.052

Source: Author’s field work (2017)

*****Correlation is significant at the 0.05 level (2-tailed) ******Correlation is significant at the 0.01 level (2-tailed) *******Correlation is significant at the 0.001 level (2-tailed)

4.2.1.3 Foot and mouth disease (FMD)

From January 1995 to December 2016, 250 cases of FMD were reported (Figure 4.11), all of which occurred between January and March. This suggested that FMD occurs only in the dry season. Disease occurrence, transmission and distribution is very complex, making it difficult to explain the exact reason for the occurrence of FMD in the dry season only. This can however, be related to some happenings within the study area. Foot and Mouth Disease is highly contagious (Sobrino *et al*., 2001) and according to Davies (2002) some of the factors that influence the epidemiology of the disease are large cattle movement and density of the host population. Cattle movement in the study area is highest because of not only transhumance but also the search for feed during this period. Incidentally, highest wide speeds are also experience during this period.

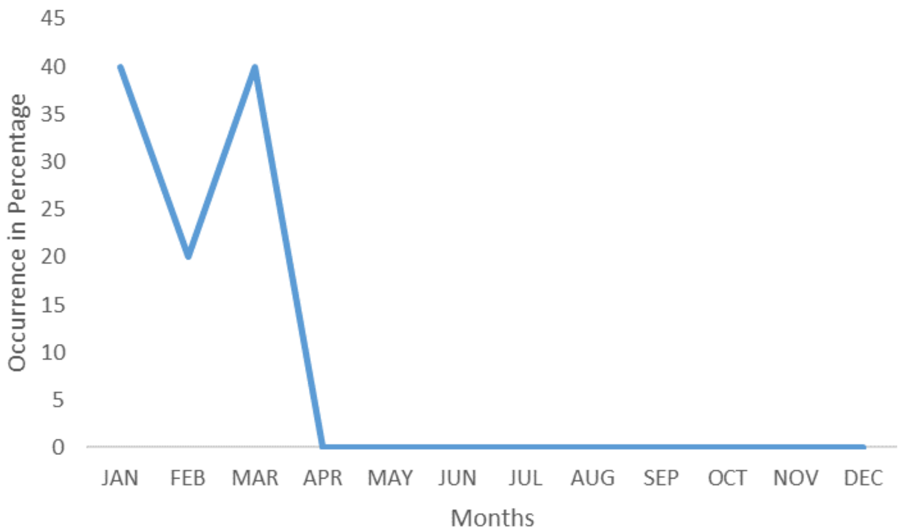


Figure 4.11 Monthly occurrence of foot and mouth disease in Upper River Region

The Spearman's correlation test for Fatoto suggested that humidity (r = -0.253, p = 0.005), minimum temperature (r = -0.261, p = 0.001) and rainfall (r = -0.195, p = 0.015) were all negatively correlated to FMD. There was however a statistically significant positive correlation between HS and wind speed (r = 0.165, p = 0.041). Similarly, there was negative correlations between FMD and minimum temperature (r = -0.255, p = 0.001) and rainfall (-0.208, p = 0.01) in Basse. Besides, the average temperature (r = -0.182, p = 0.023) was also associated negatively to FMD. For the region, minimum temperature, average temperature, rainfall and humidity were all negatively correlated with FMD (Table 4.5).

With low rainfalls, large transhumance in search of pasture and water becomes rampant. This brings cattle from different areas together in one grazing area, increasing the possibility of spreading FMD, a possible reason for the negative association between FMD and rainfall. The negative relationship between FMD and temperature and humidity could be linked to the conducive condition that these variables provided for the survival and proliferation of the virus. According to Alexandersen *et al*. (2003), FMD virus can survive for long periods at neutral pH, particularly at low temperatures.

Table 4. 5 Correlation matrix of foot and mouth disease and climate variables

Station	Climate Variable	Spearman's rho	p-value
Fatoto	Humidity	-0.253**	0.005
	Maximum temp.	0.104	0.299
	Minimum temp.	-0.261**	0.001
	Ave Temp	-0.014	0.861
	Rainfall	-0.195*	0.015
	Wind Speed	0.165*	0.041
Basse	Humidity	-0.162	0.053
	Maximum temp.	0.029	0.715
	Minimum temp.	-0.255**	0.001
	Ave Temp	-0.182*	0.023
	Rainfall	-0.208**	0.01
	Wind Speed	0.144	0.074
Region	Humidity	0.156	0.052
	Maximum temp.	0.035	0.663
	Minimum temp.	-0.259**	0.001
	Ave Temp	-0.049	0.546
	Rainfall	-0.209**	0.009
	Wind Speed	-0.209	0.009

Source: Author's field work (2017)

*****Correlation is significant at the 0.05 level (2-tailed) ******Correlation is significant at the 0.01 level (2-tailed) *******Correlation is significant at the 0.001 level (2-tailed)

4.2.1.4 Trypanosomiasis (Tryps)

The Spearman's correlation test confirmed that monthly occurrence of tryposomiasis was only statistically significantly correlated to average temperature ($r = 0.404$, $p < 0.001$) and rainfall ($r = 0.157$, $p = 0.05$) amongst all the climatic variables in Fatoto (Table 4.6). In Basse, it was also only correlated to rainfall ($r = 0.175$, $p = 0.03$) but for the regional data, trypanosomiasis was correlated to both rainfall ($r = 0.179$, $p = 0.025$) and average temperature ($r = 0.413$, $p < 0.001$).

This result can be related to the avowal made by Patz et al.(2000), which acknowledged that additional warming is likely to affect the epidemiology of vector-borne disease. The statistically significant, positive correlation between average temperature and trypanosomiasis can be explained in two ways. Firstly, temperature has effect on the vector that transmit trypanosomiasis. According to Kimaro and Chibinga, (2013) temperature is known to not only impose on vector distribution but also interferes with the feeding frequency of the arthropod vectors, which influences their ability to transmit disease. Secondly, research has revealed that high temperature potentially affects immune system of animals. This is verified by Abdela and Jilo (2016) who quoted Aucmp (2003), that mammalian cell immunity could be compromised when exposed to long and shrill ultraviolet radiation.

Similarly, rainfall according to Chatikobo et al. (2013) promotes high prevalence of vector borne diseases as rainfall to an extent dictates survival, production and development and population dynamics of vectors (Abdela and Jilo, 2016).

Table 4.6 Correlation matrix of trypanosomiasis and climate variables

Station	Climate Variable	Spearman's rho	p-value
	Rainfall	0.157*	0.05
	Maximum temp.	-0.055	0.587
Fatoto	Minimum temp.	-0.053	0.511
	Average temp.	0.408***	< 0.001
	Humidity	0.15	0.094
	Wind speed	0.036	0.685
	Humidity	0.1	0.23
	Maximum temp.	-0.082	0.308
	Minimum temp.	0.01	0.898
Basse	Average temp.	-0.033	0.685
	Rainfall	0.175*	0.03
	Wind Speed	0.034	0.669
	Rainfall	0.114	0.156
	Maximum temp.	-0.085	0.288
Region	Minimum temp.	-0.03	0.705
	Average temp.	0.413***	< 0.001
	Rainfall	0.179*	0.025
	Humidity	0.156	0.068
	Wind speed	0.055	0.491

Source: Author's field work (2017)

*****Correlation is significant at the 0.05 level (2-tailed) ******Correlation is significant at the 0.01 level (2-tailed) *******Correlation is significant at the 0.001 level (2-tailed)

4.2.1.5 Gastro intestinal tract infections

Of the 2,550 Gastro Intestinal Tract infections reported (Table 4.2), 46. 2 % were in the summer (June, July, August, September, and October) and 53.8 % occurred during the dry season, that is, from November to May. Table 4.7 presented that average temperature ($r = 0.279$, $p < 0.001$), humidity ($r = 0.176$, $p = 0.027$), wind speed ($r = 0.159$, $p = 0.047$) and rainfall ($r = 0.165$, $p = 0.039$) of the region were all positively correlated to monthly Gastro Intestinal Tract Infection occurrence. For Basse, GIT was associated to humidity and rainfall but at alpha value of 0.1 (Table 4.6). In Fatoto, humidity ($r = 0.213$, $p = 0.017$) and average temperature ($r = 0.302$, $p < 0.001$) were both significantly, positively correlated to the monthly occurrence of GIT infections. In summary, the Spearman's correlation test illustrated that monthly GIT infection occurrence is strongly associated to temperature, rainfall, humidity and wind speed.

Rainfall and moisture play extremely vital roles in the distribution of internal parasites as they provide ideal environment for their survival and multiplication. Sejian *et al*. (2015) suggested that increased atmospheric humidity provides a suitable situation for the multiplying of pathogens and other disease vectors. Similarly, temperature controls the rate at which eggs and larvae develop. Climate warming has the potential to increase pathogen development and survival rates, disease transmission and host susceptibility (Harvell *et al.*, 2014 and Sejian *et al*., 2015). For instance, the development of eggs is dependent upon temperature; the lower the temperature, the smaller the percentage of eggs that develop embroys. Furthermore, research has revealed that temperatures above the range of 10 to 30 ^{0}C affect most domestic animals by supressing their immunity (Bett *et al*., 2016 and Das *et al*., 2016). These statements are conceivable reason for the significant correlation between GIT infections and these climate variables (rainfall, huidity temperature). Aditionally, wind does not only carry pathogens, but also enhances adverse condition, adding stress to cattle consequently compromising immunity level of cattle, thus paving ways for infections.

Table 4.7 Correlation matrix of gastro intestinal tract infections and climate variables

Station	Climate Variable	Spearman's rho	p-value
Fatoto	Average temperature	0.302***	< 0.001
	Minimum temp.	0.036	0.659
	Maximum temp.	-0.091	0.363
	Humidity	0.213*	0.017
	Rainfall	0.153	0.056
	Wind Speed	0.086	0.288
Basse	Maximum Temperature	-0.094	0.239
	Rainfall	0.152	0.06
	Humidity	0.161	0.053
	Minimum temp.	0.079	0.326
	Average temp.	0.038	0.639
	Wind Speed	0.148	0.065
Region	Ave. Temperature	0.279***	< 0.001
	Maximum temp.	-0.086	0.285
	Minimum temp.	0.049	0.543
	Humidity	0.176*	0.027
	Rainfall	0.165*	0.039
	Wind speed	0.159*	0.047

Source: Author’s field work (2017)

*****Correlation is significant at the 0.05 level (2-tailed) ******Correlation is significant at the 0.01 level (2-tailed) *******Correlation is significant at the 0.001 level (2-tailed)

4.2.1.6. Respiratory tract (RES) infections

There were 974 cases of RES infections reported from January 1995 to December 2016. The largest number of cases were received in the months of August and February and the lowest number of cases were seen in April (Figure 4.12).

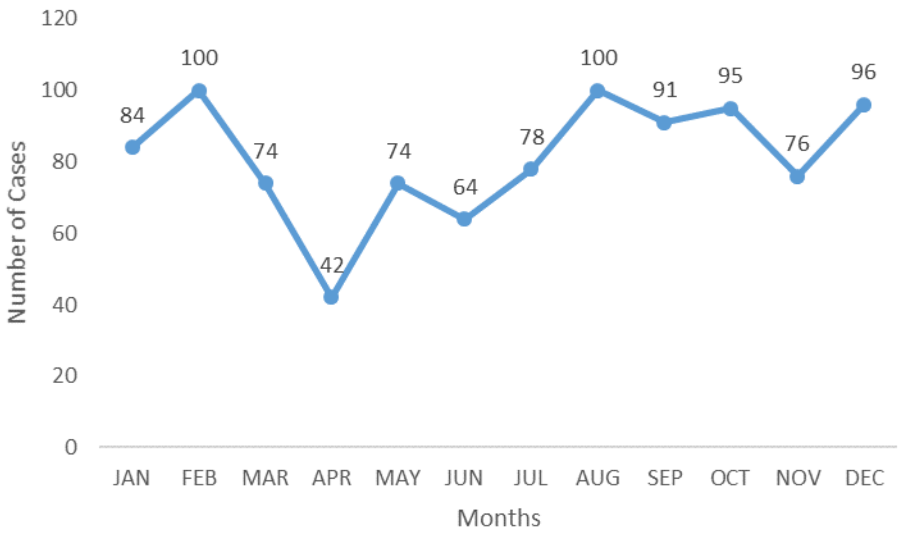
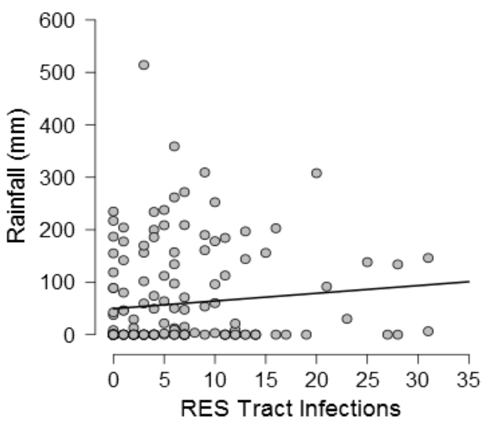


Figure 4.12 Monthly occurrence of respiratory tract infections

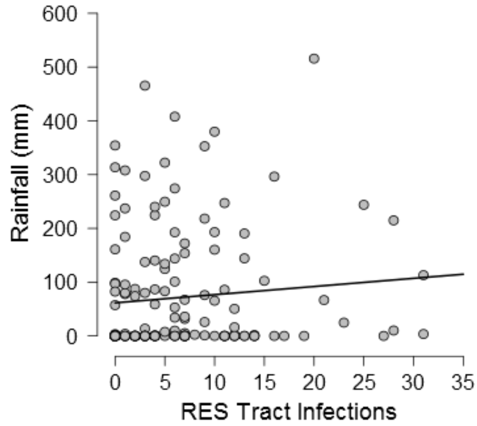
The Spearman's correlation test established that the occurrence of monthly RES infections was only correlated to total monthly rainfall, this occurred in all the three stations; Basse, Fatoto and the region (Figure 4.13).

Respiratory infections in cattle are many and can be complex, however, factors of stress, viral infections and bacterial infections are almost involved in cases of severe disease (Bagley, 1997). Accurate (1997) stated that stress could be a factor for RES infections. These statements are possible influences ascribed to the statistically, positively significant correlation between RES and rainfall. Housing of cattle is uncommon, thus cattle are exposed to heavy rains and muddy ground throughout the rainy season. This consequently exposes the cattle to stress, providing opportunity for infections.

RES – Rainfall Correlation Plot – Fatoto



RES – Rainfall Correlation Plot - Basse



RES – Rainfall Correlation Plot - Region

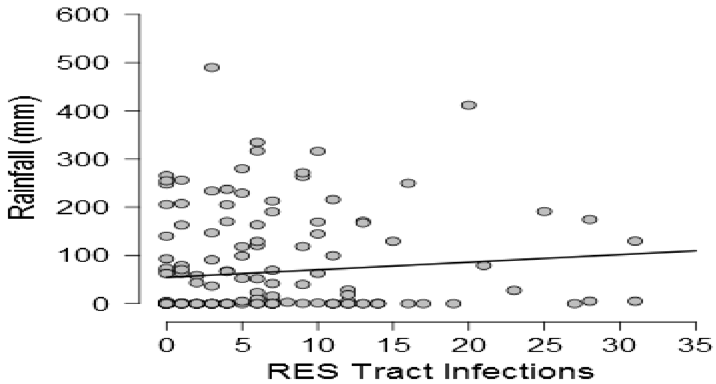


Figure 4.13 Correlation plots between respiratory tract infections and monthly total rainfall

4.2.1.7 Reproductive and Urinary Tract (RUT) Infections

Five hundred and fifty-one cases of RUT infections were reported from January 1995 to December 2016. Although RUT infections occurred in all months, the peaks of occurrence were in August, June and July and the lowest number of cases were recorded in November and April (Figure 4.14). It was also evident that there were more cases in the summer than in the dry season.

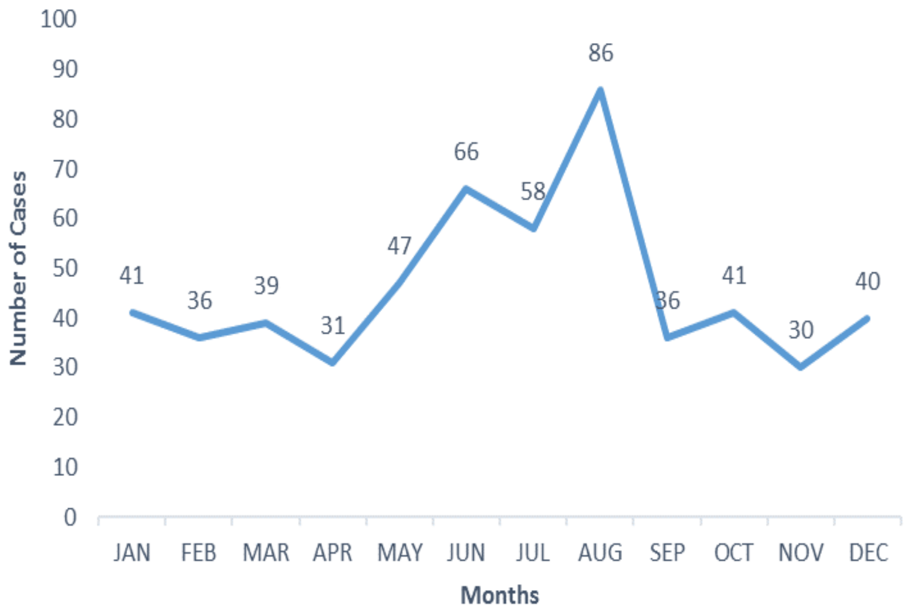


Figure 4.14 Monthly occurrence of reproductive and urinary tract infections

In Fatoto, the Spearman's correlation test demonstrated that monthly occurrence of RUT infections was significantly positively correlated to humidity (r = 0.185, p = 0.041), minimum temperature (r 0.218, p = 0.007), rainfall (r = 0. 265, p < 0.001) and wind speed (r = 0.158, p = 0.05). Similarly, the Spearman's correlation test established that RUT infections was statistically, significantly associated with the same variables in Basse (Table 4.8). From the regional perspective, wind speed (r = 0.186, p = 0.021), minimum temperature (r = 0.198, p = 0.013), rainfall (r = 0.289, p < 0.001) and humidity (r = 0.168, p = 0.037 were all statistically, significantly associated with monthly RUT infections.

Table 4.8 Correlation matrix of reproductive and urinary tract infections and Climate Variables

Station	Climate Variable	Spearman's rho	p-value
	Average temp.	0.025	0.757
	Minimum temp.	0.218**	0.007
	Maximum temp.	-0.088	0.382
Fatoto	Humidity	0.185*	0.041
	Rainfall	0.263***	<0.001
	Wind Speed	0.158*	0.05
	Average temp.	0.062	0.442
	Minimum temp.	0.177*	0.027
Basse	Maximum temp.	-0.145	0.071
	Humidity	0.174*	0.038
	Rainfall	0.265***	< 0.001
	Wind Speed	0.166*	0.038
	Average temp.	0..032	0.696
	Minimum temp.	0.198*	0.013
Region	Maximum temp.	-0.138	0.087
	Humidity	0.168*	0.037
	Rainfall	0.289***	< 0.001
	Wind Speed	0.186*	0.021

Source: Author’s field work (2017)

*****Correlation is significant at the 0.05 level (2-tailed**), ****Correlation is significant at the 0.01 level (2-tailed), *** Correlation is significant at 0.001 level (2-tailed)

The strong association between the monthly occurrence of RUT infections and climate variables (minimum temperature, rainfall, humidity and wind speed) is linked to the direct and indirect effects the variables have on the survival and distribution of pathogens. Although Gupta *et al*. (2016) suggested a negative correaltion between rainfall and human Brucellosis (a disease affecting the reproductive organs) this study recognized a statistically, positively significant relationship between rainfall and monthly occurrence of RUT infections. Their result which established that Brucellosis in human is positively associated to wind speed and humidity is similar to the result of this study, which indicated that wind speed and humidity are positively in association with monthly occurrence of RUT infections.

Disease transmission and distribution is very complex as there are several factors that are responsible. However, the positive correlation between RUT infections and these climate variables could be linked to the following. One possible factor to explain the positive relationship between rainfall and RUT infections could be high worm infestation during period of the rainy season. It is not characteristics of cattle owners to carry out routine deworming of their cattle, thus exposing cattle to the effects of high worm infections. For the rainfall, the suggestion for the strong relationship is linked to the heavy down pours that lead to floods, which provide favourable conditions for the proliferation of many pathogens (Sejian *et al*., 2015). Furthermore, with heavy rainfalls, some grazing areas are flooded rendering it inaccessible to cattle. As herders practice temporal nomadism specially to reduce this impact, cattle from different areas are gathered in a grazing area, enhancing the transmission of RUT infections. This may be further aggravated by the poor disposal methods of aborted foetuses and afterbirths. The consumption of 'tart' pasture during the rainy season could be another reason for the strong association between rainfall and RUT infections. Moreover, the heavy worm infestation load that occurs during the wet season could also be another factor that explains the strong association between RUT infections and rainfall. Farmers hardly practice routine deworming programmes.

The sensitivity of a number of pathogens to humidity and temperature changes (Kimaro and Chibinga, 2013) coupled with ability of greater humidity and wind speed to influence the development and spread of pathogens are conceivable reasons for the strong association between RUT infections and climate variability. Minimum temperature and high humidity provide conducive environment for the proliferation of pathogens. The strong association between RUT infections and minimum temperature can be linked to the fact that cold weather triggers the occurrence of certain RUT infections (Mueller, 2007).

4.3. Regression analyses

For each area (Fatoto and Basse) and the region as a whole, GIT and RUT infections were regressed with the climate variables they were correlated.

4.3.1 Fatoto regression analysis

The Backward method of the regression analysis (Table 4.8) confirmed that minimum temperature, rainfall and wind speed statistically, significantly predicted monthly RUT infections occurrence ($F_{3, 149} = 6.763$, $p < 0.001$, $R^2 = .120$, R^2 adjusted = .102) in Fatoto.

The analysis revealed that if the other variables (rainfall and wind speed) are constant, minimum temperature (Beta = 0.091, t = 1.095, Sig = 0.275) do not statistically significantly predict RUT infections occurrence. However, rainfall (Beta = 0.254, t = 3.063, Sig. = 0.003) and wind speed (Beta = 0.214, t = 2.764, p = 0.006) both significantly contributed to the prediction of monthly RUT infections occurrence when other variables are constant.

An increase of 1.10 % in the monthly occurrence of RUT infections in the Fatoto would occur with a millimetre (mm) increase in the monthly total rainfall. On a bigger scale, one knot increase in the average monthly highest wind speed, will increase the monthly occurrence of RUT infections in Fatoto by 25.30 %. With the highest possible R square value of .120 and the lowest variance inflation factor (VIF) value of 1.018 (Appendix E), the equation RUT infection can thus be written as;

RUT = -1.565 + 0.011 x RF + 0.253 x WS + 0.100 x T Min, where RF is referred to as rainfall, WS means wind speed and T Min stands for minimum temperature.

For Gastrointestinal (GIT) infections, the regression analysis (Table 4.9) confirmed that average temperature and humidity significantly predicted its occurrence in Fatoto ($F_{2, 122} = 8.050$, $p < 0.001$, $R^2 = .117$, Adjusted $R^2 = .102$). Both average temperature (Beta = 0.247, t = 2.838, sig = 0.005 and humidity (Beta = 0.189, t = 2.172, sig. = 0.032) significantly contributed to the prediction of GIT infections (Appendix E). The monthly occurrence of GIT infections is expected to rise by 51.50 % and 17.60 % if there is a degree Celsius increase in average temperature and a percent increase in humidity respectively. With the highest possible R^2 value as .117 and the collinearity statistics at tolerance of .955, the equation for GIT infection can be formulated as;

GIT = -2.877 + 0.515 x average temperature + 0.176 x humidity.

Table 4.9 Reproductive and urinary tract and gastro intestinal tract infections regression matrix – Fatoto

Dependent Variable	Model		df	F	p-value	R^2	Adjusted R^2
	Humidity	Regression	3				
RUT	Wind Speed	Residual	149	6.763	< 0.001	.120	.102
	T Min	Total	152				
	Ave temperature	Regression	2				
GIT	Humidity	Residual	122	8.050	< 0.001	.117	.102
		Total	124				

Source: Author's field work (2017)

4.3.2 Basse regression analysis

In Basse, the regression analysis (Table 4.10) indicated that monthly occurrence of RUT infections was significantly predicted by wind speed and rainfall ($F_{2,149}$ = 5.297, sig = 0.006, R^2 = .066, Adjusted R^2 = .054). GIT was not regress with any of the climate variables of Basse, because there was no statistically significant correlation.

Both rainfall (Beta = 0.164, t = 2.020, sig = 0.045) and wind speed (Beta = 0.165, t = 2.025, sig = 0.045) significantly contributed to the prediction of monthly GIT infections when other variables were constant. An increase of 0.6 % and 12.2 % in the occurrence of monthly GIT infections could be realized with a millimetre (mm) increase in total monthly rainfall and one knot increase in wind speed respectively. The equation of monthly GIT infections occurrence at the highest possible R Square value of .066 and the lowest Variance Inflation Factor (VIF) of 1.055 was expressed as; Z = 1.848 + .006 x rainfall + .122 x wind speed (Appendix F). The association of GIT and other climate variables in Basse was not very significant (only at alpha value of 0.1), thus no regression analysis was done.

Table 4.10 Reproductive and urinary tract infections regression matrix – Basse

Dependent Variable	**Model**		**df**	**F**	**p**	**R^2**	**Adjusted R^2**
RUT	Rainfall	Regression	2				
	Wind speed	Residual	149	5.297	0.006	0.066	0.054
		Total	151				

Source: Author’s field work (2017)

4.3.3 Region regression analysis

In the region, (Table 4.11) as a whole, monthly RUT infections was significantly predicted by minimum temperature, rainfall and wind speed ($F_{3,151}$ = 5.464, sig = 0.001, R Square = 0.098, Adjusted R Square = 0.080). Although, individually the contribution of minimum temperature (Beta = 0.088, t = 1.041, sig = 0.299) in the prediction of RUT infections was insignificant, rainfall (Beta = 0.190, t = 2.238, sig = 0.027) and wind speed (Bata = 0.182, t = 2.347, sig = 0.020) significantly contributed in the prediction of monthly RUT infections in the region. Considering the highest possible R Square value of .098 and the lowest VIF value of 1.008, the equation for the monthly occurrence of RUT infections in the region is formulated as; RUT = -908 + .097 x T Min + 0.008 x RF + 0.185 x WS, where T Min stands for minimum temperature, RF means rainfall and WS is wind speed.

Regressing monthly GIT infections with climate variables of the Region (Table 4.10), average temperature, humidity and wind speed were found to statistically, significantly explain monthly occurrence of GIT infections in the region ($F_{3, 153}$ = 4.469, sig = 0.005, R Square = 0.081, Adjusted R Square = 0.063). At constant variables, humidity (Beta = 0.240, t = 2.776, sig = 0.006) and wind speed (Beta = 0.201, t = 2.585, sig = 0.11) significantly contributed to the prediction but the contribution of minimum temperature (Beta = -0.072, t = -0.836, sig = 0.405) was insignificant.

It is likely that 89.3 % increase in the monthly occurrence of GIT infections will occur when monthly wind speed increases by a knot. A percent increase in humidity could also result to an increase of monthly GIT infections by 20.70 %. With VIF value between 1.010 and 1.240 and with highest adjusted R Square value of 0.063, the equation for the monthly occurrence of GIT infection in the region was articulated as;

Y = 3.019 + 0.207 x humidity + 0.893 x wind speed – 0.347 x minimum temperature.

Table 4.11 Reproductive and urinary tract and gastro intestinal tract infections regression matrix – Region

Dependent Variable	Model		df	F	p	R^2	Adjusted R^2
	T Min	Regression	2	5.464	<0.001	0.098	0.080
RUT	Rainfall	Residual	149				
	Wind speed	Total	151				
	Ave. temp	Regression	3	4.469	0.005	0.081	0.063
GIT	Humidity	Residual	153				
	Wind speed	Total	156				

Source: Author’s field work (2017)

4.4 Difference in Perception, Impact and Adaptation Measures to Climate Change between Men and Women

4.4.1 Socio-demographic characteristics of respondents

The socio-demographic characteristics of respondents, as presented in Table 4.12 revealed that 44 % of the 184 respondents were females and the others males (56 %). The result showed 6 % of the respondents were less than 21 years, 37.50 % from 21 to 35 years and 28.80 % between the ages of 36 and 50 years. Those between 51 and 65 years were 17.90 % of the respondents and 9.80 % were over 65 years. There was no female respondent above 65 years and majority of the female respondents (50.60 %) were between 21 and 35 years. There were 4.9 % of the female respondents below 21 years, 28.40 % between 36 and 50 years and 12.30 % from 51 to 65 years. A chi-square test conducted on the age of female and male respondents that owned cattle, showed significant statistical difference X^2 (4, n = 181) = 25.04, $p < 0.001$. The significant difference is such respondents with 65 years or more are likely to be males ($F_{4,179}$ = 7.049, $p < 0.001$).

On the number of cattle own by respondents, the research result indicated that majority of the women (47) have no more than 21 cattle. Only 10 women own between 61 and 100 cattle. On the other hand, 57 male respondents own no fewer than 40 cattle. About 43 male respondents owned between 1 and 20 cattle. Chi- square test also suggested a statistically significant difference X^2 (4, n = 181) = 13.25, p = 0.010. between male and female regarding the number of cattle own. The Post hoc test ($F_{4,176}$ = 3.476, p-value = 0.009) indicated that the respondents who owned between 61 and 100 cattle were significantly different from those who owned between 1 and twenty and from 21 to 40 cattle. This significant difference is such that males are having greater number of cattle than females. The results of the study on educational level showed that 54 males received non-formal education, 2 primary level, 5 secondary level, 1 tertiary level and 41 none. The educational level for the female respondents were 48, 4, 0, 0, and 29 for non-formal, primary, secondary, tertiary and none, respectively. There was no statistically significant different (X^2 (4, N = 184) = 6.50, p = 0.162) between male and female with respect to educational levels (Table 4.10).

Of the 66 respondents that have more than 20 years' experience of cattle production, 71.2 % were males and 28.8 % were females. There were 20 males and 15 females with cattle production experience of between 16 and 20 years. Twelve of the respondents (7 males and 5 females) had 11 – 13 years of experience in cattle production. Those with 10 years of experience or less were 71 (29 males and 42 females). The chi-square test revealed a statistically significant difference (X^2 (4, N = 184) = 13.14, p = 0.011) between level of experience of male and female cattle producers. The post hoc test results showed significant ($F_{4,179}$ = 3.443, p = 0.010) difference between respondents with less than six years and those with more than 20 years of experience such that males are likely to have more experience (more than 20 years) than females.

The socio-demographic characteristics (Table 4.12) result recognized that males are richer than women both in numbers of cattle owned and experience in cattle management. This confirms the statement that women are poorer and more disadvantage than men. The implication is that climate variability impacts are likely to be harder on women than men. This is justified by the statement made by Demetriades and Esplen (2008) that fewer resources could undermine the capacity to adapt to existing and predicted impacts of climate variability.

Table 4.12 Respondents' socio-demographic characteristics

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P - value
Age category of respondents (n = 184)						
< 21 years	4	7	11			
21-35	28	41	69			
36-50	30	23	53	25.04	4	0.000
51-65	23	10	33			
>65	18	0	18			
Number of cattle own by respondents (n = 181)						
1-20	43	47	90			
21-40	18	22	40			
41-60	8	2	10	13.25	4	0.010
61-80	7	3	10			
81-100	24	7	31			
Educational level of respondents (n =184)						
Non Formal	55	47	102			
Primary	2	4	6	6.50	4	0.162
Secondary	6	0	6			
Tertiary	2	0	2			
None	38	30	68			
Years of experience in cattle management						
<6 years	14	23	37			
6-10 years	15	19	34			
11-15 years	7	5	12	13.14	4	0.011
16-20 years	20	15	35			
<20 years	47	19	66			

Source: Author's field work (2017)

4.4.2 Perception on climate variable trends

Table 4.13 presented the results on respondents' perception on trends of climate variables and some climate variable effects. On the length of the rainy season, 94 % of the 184 respondents mentioned decreasing, 5.40 % said increasing while only one person (0.50 %) claimed to have no idea. Most of the respondents (94.60 %) held the view that rainy seasons starts late and only 5.40 % said the contrary. Regarding temperature trend, 162 said temperature is increasing, 19 mentioned decreasing, two stated no change and one said no idea (n =184). According to the majority of the respondents (90.8 %), wind speed is increasing, 6.50 % decreasing, 1.10 % no change and 1.60 % have no idea. Statistically, there was no significant effect of sex with response to the trends of rainy season, temperature and wind speed and the on-set of the rainy season.

Table 4.13 Respondents' perception on trend of climate variability

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P - value
What is the rainy season trend? (n =184)						
Increasing	6	4	10	1.34		
Decreasing	97	76	173		2	0.542
No Idea	0	1	1			
What is the trend of rainy season on set? (n =184)						
Early	8	2	10	2.48	1	0.487
Lately	95	79	174			
What is the temperature trend? (n = 184)						
Increasing	92	70	162	3.46		
Decreasing	9	10	19		3	0.433
No change	2	0	2			
No Idea	0	1	1			
What is the Wind speed trend? (n = 184)						
Increasing	91	76	167	6.48		
Decreasing	10	2	12		3	0.662
No change	0	2	2			
No Idea	2	1	3			

Source: Author's field work (2017)

The results of the focused group discussions for both men and women corroborated the views of individual respondents on climate variables trend. The average results of Kantora, Sandu and Wuli obtained from the proportional pilling exercise, showed that rainfall is decreasing while temperature, wind and drought frequencies are increasing (Tables 4.14 and 4.15). The result also showed that on-set of rainfall is starting late.

The views of the respondents that temperature and wind are increasing are in line with the findings of Mertz *et al*., (2009) and IPCC (2007). Although Mertz *et al.*, (2009), reported that rains varied too much and thus difficult to determine the trend, the result of this study showed an overwhelming majority describing the rainy season as decreasing and starting late. This study revealed that there was no statistically significant difference between sex with respect to response on climate variable trends. This is possible due to the fact that variability in the trends of climate variables are evident for most to detect. This is in line with Mertz *et al*., (2009), who noted that the views of men and women regarding variability in climate parameters were similar.

Table 4.14 Proportional pilling of trends of events from 2008 to 2016 in Upper River Region (men)

Variables	2008-2010	2011-2013	2014-2016
Rainfall	R R R R R	R R R	R R
temperature	T T	T T T	T T T T T
Wind Speed	S	S S S S	S S S S S
Feed availability	F F F F F F	F F F	F
Water availability	W W W W W W	W W W	W
rainfall onset	R R R R R	R R R R	R
Drought frequency	P P	P P P	P P P P P
Disease occurrence	D	D D D	D D D D D D
Cattle mortality rate	M M	M M M	M M M M M

Source: Author’s field work (2017)

Table 4.15 Proportional pilling of trends of events from 2008 to 2016 in Upper River Region (women)

Variables	2008-2010	2011-2013	2014-2016
Rainfall	R R R R R R	R R R	R
temperature	T T	T T	T T T T T T
Wind Speed	S S	S S S	S S S S S
Feed availability	F F F F F	F F F	F F
Water availability	W W W W W	W W W	W W
rainfall onset	R R R R R	R R R R	R
Drought frequency	P	P P P	P P P P P P
Disease occurrence	D D	D D D	D D D D D
Cattle mortality rate	M M	M M M	M M M M M

Source: Author’s field work (2017)

On the frequency of drought (Table 4.16), most of the 184 respondents (90.80 %) mentioned an increasing trend but there are few (8.70 %) who are of the view that drought frequency is decreasing. Only one respondent has no idea about the drought frequency situation. On flood frequency, 47.80 % of the respondents characterised it as increasing, 41.3 % thought it is decreasing, 3.80 % believed there is no change and 7.80 % have no idea.

Answering the question "do you notice climate variability", over half of the respondents (101), responded in the affirmative and the others either said no (24) or have no idea (59). Of the respondents who said yes, they believe climate change is caused by the following; Allah (15), tree felling (40), smoke (3), and burning (3). Beside the 39 respondents who claimed to have no idea, one respondent believed that nothing remains the same forever and climate is no exception. Whether they received climate variability information or not, 50.50 % of the respondents said yes while 49.50 % said no. Of those who responded yes, 73.10 % received the information through radio, 14.00 % by attending training, 7.50 % heard it from colleagues, 3.20 % from elders, and from school children and TV each 1.10 %.

There was no gender effect on the statement "trend of drought frequency" but effect of gender on the statement "trend of flood frequency" was significant with chi-square value of X^2 (3, N = 184) = 27.04, $p < 0.0001$. There was significant difference between groups of gender perception on flood frequency ($F_{3, 180} = 10.337$, $p < 0.001$) such that women are likely to either say no change or have no idea compared to men who most probably to say decreasing or increasing. Although gender has no effect on responses to the causes of climate variability, gender significantly affected the response to the question “Have you notice climate variability” (X^2 (2, n = 184) = 12.54, p = 0.002). The ANOVA test revealed statistically significant difference between respondent who said yes and those who have no idea ($F_{2,181}$ = 6.620, p = 0.002). The statistically significant difference is such that males are likely to notice climate variability compared to females. Similarly, the response to the source of information was not affected by gender, but the responses to receiving climate variability information was significantly associated with gender (X^2 (1, n = 184) = 5.56, p = 0.013). However, the Post hoc tests could not be performed because there were fewer than three groups.

According to the study results, climate change/variability information dissemination does not look impressive, however, other study reported similar trend. While a little over 50 % received climate variability information in this study, Megersa *et al*., (2014a) reported that only 45 % received information. Mandleni (2011) stated a more impressive percentage (60 %) of the respondents that received climate change information. Women’s low access to climate variability information may be linked to the triple role (Reproductive, productive and community management) they performed. As women try to accomplish these roles, listening to radio or attending to training programmes which are the main source of climate variability information would be limited.

There were many sources of climate variability information mentioned by the respondents, however, extension workers as source of information that is mentioned by Mandleni (2011) was completely absent in this list. Again the impression of the result is that women are disadvantage in accessing information. Possible explanation to this is either they cannot afford the means to access information (radio or TV set and attend training programmes) or are busy and have little time for the media.

Climate variability looked very well noticed by the respondents, however, the causes of the variability was not well understood by the respondents. This is manifested by the respondents' association of climate variability with natural phenomena caused by Allah (God). The low understanding of climate variability is associated with the low access to climate variability information.

Table 4.16 Respondents' perception on frequency and awareness of climate variability effects

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P - value
What is the trend of drought frequency? (n =184)						
Increasing	90	77	167			
Decreasing	13	3	16	5.71	2	0.401
No change	0	1	1			
What is the flood frequency trend? (n = 184)						
Increasing	49	39	88			
Decreasing	53	23	76			
No change	0	7	7	27.04	3	0.000
No Idea	1	12	13			
Do you notice climate variability? (n = 184)						
Yes	68	33	101			
No	12	12	24	12.54	2	0.002
No Idea	23	36	59			
If yes, what causes climate variability? (n =101)						
Allah	8	7	15			
Tree	32	8	40			
Felling				6.91	5	0.865
No Idea	24	15	39			
Smoke	2	1	3			
Burning	1	2	3			
Eminent	1	0	1			
Do you receive information about climate variability? (n = 184)						
Yes	60	33	93	5.56	1	0.013
No	43	48	91			
If yes, from where? (n =101)						
Radio	43	25	68			
TV	1	0	1			
Colleagues	2	5	7			
Elders	2	1	3	10.76	5	0.154
School children	0	1	1			
Training	12	1	13			

Source: Author's field work (2017)

4.4.3. Climate variability effects/impacts

4.4.3.1 Temperature variability effects on cattle health

Table 4.17 showed the views of the respondents on temperature variability effect on cattle health and how they have dealt with temperature variability. Majority (60.10 %) of the 183 respondents held the view that temperature variability has negative effects on the health of their cattle, 8.70 % believed it has no effect and 31.10 % have no idea about the effect of climate variability on cattle health.

Follow-up questions were asked to determine how temperature variability affect cattle and degree to which temperature variability affect cattle health. Over eighty-six percent of the 110 respondents regarded temperature effect on cattle health as severe, about eleven percent viewed the effect as moderate and 1.80 % took it to be low. On how temperature variability affects cattle, thirty percent of the 110 respondents believed that temperature variability adds stress to cattle and 24.50 % of the respondents are of the opinion that temperature variability affects cattle by reducing their grazing period. While 16.40 % have no idea of how temperature affects cattle health, 10.00 % and 13. 60 % of the respondents claimed that it burns cattle skin and increase the demand for water respectively. Few (5.50 %) said temperature variability causes natural water bodies, which are cattle drinking points to dry quickly.

There was a very strong gender response X2 (2, n = 183) = 23.49, $p < 0.001$ to the question whether temperature variability affects cattle health. There was also statistically significance difference between groups ($F_{2,180} =$ 13.251, $p < 0.001$) such that more males said yes compared to females who are have no idea. Although there was no gender effect on the statement “extent to which temperature variability affects cattle health", the gender response to how temperature variability affect cattle health was statistically significant X^2 (5, n = 184) = 12.70, p- value = 0.026. The Post hoc test of the ANOVA ($F_{5,104}$ =2.714, p = 0.024) disclosed a statistically significant difference between respondents who said "burn skin" and those who mentioned "add stress". It is such that more male respondents mentioned burn skin compared to the female respondents.

Table 4.17 Respondents' perception on temperature variability effects on cattle health

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P - value
Does temperature variability affects cattle health? (n = 183)						
Yes	77	33	110			
No	7	9	16	23.49	2	0.000
No Idea	18	39	57			
If yes, how does temperature variability affects cattle health? (n = 110)						
Reduced Grazing period	22	5	27			
Increasing water demand	12	3	15			
Burn skin	11	0	11	12.70	5	0.026
Add stress	18	15	33			
Dry water bodies	4	2	6			
No idea	10	8	18			
What is the extent of temperature variability effects on cattle health? (n =110)						
Severe	68	27	95			
Moderate	8	5	13	0.937	2	0.626
Low	1	1	2			

Source: Author's field work (2017)

4.4.3.2 Rainfall variability impact on cattle

A little over 84 % (51.90 % males and 32. 20 % females) of the 184 respondents acknowledged that variability in rainy season affects their cattle health (Table 4.18). The number of respondents that said no were almost equal for both males (6) and females (5), however, there was huge difference between males (1) and females (17) who said have no idea. On how rainfall variability affects cattle health, the respondents mentioned reduced feed availability (83), reduced water availability (12), reduced feed and water availability (45), reduced productivity (4) and 10 respondents claimed to have no idea. Over 78 % of the 154 respondents described the effect of rainfall variability as severe, 16.90 % regarded it as moderate, 2.60 % took it to be low and a mere 1.90 % deemed to have no idea.

Gender effect was not visible in how rainy season variability affects cattle and the degree to which it affects cattle. However, there was gender effect (X^2 (2, n = 183) = 20.59, $p < 0.001$) on the statement "rainy season variability affects cattle health". The difference between group was significant ($F_{2,180} = 11.410$, $P < 0.001$) such that females are less likely to have an idea on whether rainy season variability affects cattle health or not when compared to males.

Table 4.18 Respondents' perception on rainfall variability effects on cattle health

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	p-value
Does rainfall variability affect cattle health? (n =183)						
Yes	95	59	154			
No	6	5	11	20.59	2	0.000
No Idea	1	17	18			
If yes, how does rainfall variability affect cattle health? (n= 154)						
Reduced feed availability	46	37	83			
Reduced water availability	11	1	12			
Reduced feed and water availability	28	17	45	8.444	4	0.077
Reduced productivity	4	0	4			
No Idea	6	4	10			
What is the extent of the effects of rainfall variability on cattle health? (n = 154)						
Severe	78	43	121			
Moderate	14	12	26			
Low	3	1	4	6.201	3	0.102
No Idea	0	3	3			

Source: Author's field work (2017)

4.4.3.3 Wind speed variability effects on cattle health

In Table 4.19, on wind speed variability, respondents were asked whether wind affects cattle health and if yes how and to what extent. About 64 % of the 184 respondents said wind speed variability affects cattle health, 12.60 % ricocheted that it does not affect cattle health and 23.50 % have no idea. Pointing out how wind speed variability affects cattle, 69.20 % of the 117 respondents echoed that heavy winds carry disease pathogens, 18.80 % held the view that heavy wind carries dust which gets in cattle nostrils, 6.80 % said wind makes cattle lost, 3.40 % held the view that it causes cattle to stop grazing and 1.70 % have no idea about how wind variability affects cattle.

On the severity of wind speed variability effects on cattle, eighty-four out of 154 respondents regarded the effects of wind speed variability on cattle health as severe, 27 described it as moderate, four said the effect of wind variability on cattle health is low and two respondents claimed to have no idea. There was no significant sex effect on any of the three questions pertaining to wind.

Table 4.19 Respondents' perception on wind speed variability effects on cattle health

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	p-value
Does wind speed variability affects cattle health? (n = 183)						
Yes	65	52	117			
No	16	7	23	2.614	2	0.271
No idea	21	22	43			
If yes, how does wind speed variability affects cattle health (n = 117)						
Carries disease organism	45	36	81			
Carries dust	14	8	22	9.307	4	0.054
Stops cattle from grazing	4	0	4			
Makes cattle missing	2	6	8			
No Idea	0	2	2			
What is the extent of wind speed variability effects on cattle health? (n = 117)						
Severe	47	37	84			
Moderate	16	11	27			
Low	2	2	4	2.705	3	0.439
No idea	0	2	2			

Source: Author's field work (2017)

Thornton *et al*. (2009) organized the impact of climate change on livestock under seven headings; feed (quality and quantity), heat stress, livestock diseases and disease vectors, biodiversity, systems and livelihoods and indirect impacts.

The research findings on the perception of the respondents on effect of variability in climate parameters to cattle health can also be categorized under the following headings; feed, diseases and heat stress. *"The biggest threat to our cattle health is hunger, they are always sick because there is no adequate grass to feed on".* These were the words of respondents during the survey. This statement is in line with the scientific knowledge that insufficient feed could lead to weak immunity. The respondents pointed out that the increasing temperatures is not only adding stress to cattle but also reducing their grazing period. The cattle run away from the hot sun to find shade under trees thus reducing the number of hours they could have grazed.

The respondents also associated the early drying of natural cattle watering points to less rains and high temperature that enhances evaporation rate. The association of the increase demand for water to increasing temperature could also be linked to the fact that dehydration is enhanced when the body is exposed to lot of heat and consequently the need to replace the lost water. The reduction of feed and water availability associated with variability of rainy season is well understood considering the cattle management system practiced. Cattle are mainly dependent on natural vegetation and water bodies for feed and water respectively. Any negative change in the trend and on-set of the rainy season could lead to corresponding shortage of feed and water. Similar statement was echoed by Nyariki, *et al.* (2009) who mentioned that the long trek of cattle in search of feed and water affects cattle health

The respondents' assertion that wind carries pathogen and dust indicated that wind is implicated in cattle health. This is corroborated by Mertz *et al.*, (2009) who reported that wind is incriminated in cattle's poor health in the Saloum Region of Senegal.

4.4.4. Management and adaptation to climate variability

4.4.4.1 Climate variability management

As showed in Table 4.20, less than seven percent of the respondents said they have done something to deal with temperature variability and a bit more than 93.00 % have not done anything to deal with temperature variability. Asked what have they done, they responded "tree planting (71.40 %) and "prayers 28.60 %). One hundred percent of those who did nothing with temperature said they have no idea of what to do, since it is a natural phenomenon. Gender was not associated with either respondent having to deal with or why not dealing with temperature variability. There was no measure of association computed for the cross tabulation of gender with how respondents dealt with temperature variability because at least one variable in each 2-way table upon which measures of association were computed was a constant. The responses were only from the male respondents.

Over 86.00 % of the 183 respondents have not done anything with variability in rainy season trend and 13.70 % believed they have done something. Fourteen (14) out of 25 respondents have been planting trees while the others (11) depended on fasting and praying for situation to change in the positive. For those who did nothing, 38.00 % of the 158 respondents believed that they cannot do anything because it is a natural phenomenon and the majority (62.00 %) have no idea of what to do. There was gender effect on how rainfall variability was dealt with (X^2 (1, N = 25) = 7.64, p = 0.006), although ANOVA test disclosed statistical significant difference between groups ($F_{1,23}$

= 10.120, p-value = 0.004) no Post hoc test could be performed. This is because there were fewer than three groups. On the question why nothing was done, there was strong gender association with it, (X^2 (1, N = 158) = 46.42, $p < 0.001$). Albeit the significant difference between and within groups ($F_{1,156} = 64.90$, $p < 0.001$), Post hoc test could not be performed because there were fewer than three groups.

On wind variability, only about 9.00 % said they have done something while a little over 91.00 % have not done anything. Tree planting was the activity carried out by all those who said they have done something with wind variability. No idea was the only reason forwarded for not doing anything against wind variability. There was gender effect (X^2 (1, N = 101) = 4. 80, p = 0.029) on the question “Have you deal with wind speed variability” with statistically significant difference between groups ($F_{1,99} = 4.934$, p = 0.029) but Post hoc test could not be performed because there were fewer than three groups.

Clearly, variability in climate parameters has been noticed. However, what causes these variabilities is still not known or clear to most of the respondents. As a result, ideas of how to manage the variability became a stumbling block. Even most of those who tried to manage the variability in climate variables felt that it is a natural phenomenon and thus only Allah has solution to it. Consequently, leading them to fasting and praying for a positive change. A possible explanation of the low understanding of the causes of climate variability could be link to the little access to climate variability information.

Table 4.20 Respondents' management of climate parameter variability

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	p-value
Have you done anything to deal with rainy season variability? (n= 183)						
Yes	18	7	25	2.907	1	0.088
No	85	80	158			
If yes, what have you done? (n = 25)						
Tree planting	7	7	14	7.64	1	0.006
Fast and pray	11	0	11			
If no, why not? (n = 158)						
Natural	53	7	60	46.42	1	0.000
No Idea	32	66	98			
Have you done anything to deal with temperature variability (n = 101)						
Yes	7	0	7			
No	61	33	94	3.650	1	0.056
If yes, what have you done? (7)						
Trees planting	5	0	5			
Prayers	2	0	2			
If no, why not? (n = 94)						
No Idea	61	33	94			
Have you done anything to deal with wind variability? (n =101)						
Yes	9	0	9			
No	59	33	92	4.795	1	0.029
If yes, what have you done? (n = 9)						
Tree planting	9	0	9			
If no, why not? (N = 92)						
No idea	59	33	92			

Source: Author's field work (2017)

4.4.4.2 Climate variability adaptation strategies

The results of the survey (Table 4.21) indicated that nearly 55 % of the 184 respondents have change their production method and close to 45 % did not change. In describing the present practices that were not initially practiced, of the 78 respondents, 21.80 % mentioned feed conservation, 27.70 % buy feed supplements like cotton seeds, groundnut cake, and rice straw, 6.90 % follow cattle both dry and wet season, 18.80 % carry-out regular treatment, 17.50 % practice temporal nomadism, 5.00 % do go for destocking while others practice more than one of these. Those who do not change their production method either do not have the means (25.30 %) or have no idea (74.70 %). Estimating the annual cost on treatment and prevention of cattle diseases (Figure 4.15), result showed that 57 of the 152 respondents spend no more than GMD1000.00, 30 spend between GMD1001 and 2000, 14 from GMD2001 to 3000, 7 between GMD3001 and 4000, 12 spend from GMD 40001 and 5000 and 32 expense more than GMD5000 annually.

There were gender effects for both questions “Have you change production system due to climate variability” (X^2 (1, N = 184) = 41.03, $p < 0.001$) and “If yes, what have you done” (X^2 (7, N = 101) = 17.63, $p = 0.014$). The gender effect on the question “If yes, what have you done” is significant (F 7,93 = 2.809, p-value = 0.011) such that males practiced feed conservation while women are buying feed supplement. The Post hoc test on the question “Have you change production system” was not conducted because there were fewer than three groups. There was a significant sex response to annual cost on cattle treatment X^2 (5, N = 152) = 25.01, $p < 0.001$. The significance difference between groups (F 5, 146 = 5.751, $p < =0.001$) was such that females are most likely to spend no more than GMD3000 compared to males who could spend over GMD5000 annually.

Table 4.21 Frequency response to question relating to change of management system

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P - value
Have you change cattle management system due to climate variability? (n = 184)						
Yes	78	23	101	41.03	1	0.000
No	25	58	83			
If yes, what have you done? (n = 101)						
Feed conservation	22	0	22	17.63	7	0.014
Buy feed supplement	16	12	28			
Herd wet and dry seasons	7	0	7			
Frequent treatment	13	6	19			
Temporal nomadism	15	3	18			
Destocking	3	2	5			
Buy, conserve and cut fodder	1	0	1			
Supplement and nomadism	1	0	1			
If no, why not? (n = 83)						
No means	7	14	21	0.138	1	0.710
No idea	18	44	62			

Source: Author’s field work (2017)

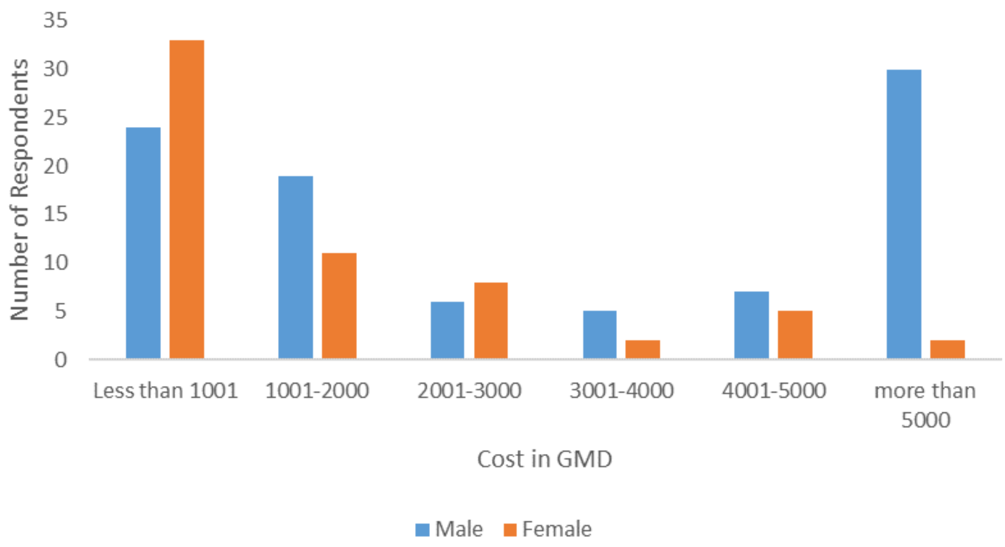


Figure 4.15 Estimated annual cost on disease control

GMD = Gambian Dalasi

These results are corroborated by the results obtained from the focused group discussion. As showed in Table 4.22, the least practiced copping strategies by women were herd both wet and dry seasons and feed conservation while the most common practice of the males were feed conservation, herd both wet and dry season and buy feed (Table 4.23)

Table 4.22 Pairwise Ranking of Adaptation Strategies for Women's Group

Variables	Destocking	Treat Frequently	Temporal Nomadism	Feed Conservation	Buy Feed Supplement	Herd Dry and Wet Seasons	Score	Rank
Destocking		Treat Frequently	Destocking	Destocking	Buy Feed Supplement	Destocking	3	3rd
Treat Frequently			Treat Frequently	Treat Frequently	Buy Feed Supplement	Treat Frequently	4	2nd
Temporal Nomadism				Feed Conservation	Buy Feed Supplement	Herd dry and Wet Seasons	0	6th
Feed Conservation					Buy Feed Supplement	Feed Conservation	2	4th
Buy Feed Supplement						Buy Feed Supplement	5	1st
Herd dry and Wet Seasons							1	5th

Source: Author's field work (2017)

Table 4.23 Pairwise ranking of adaptation strategies for men's group

Variables	Destocking	Treat Frequently	Temporal Nomadism	Feed Conservation	Buy Feed Supplement	Herd Dry and Wet Seasons	Score	Rank
Destocking		Treat Frequently	Destocking	Feed Conservation	Destocking	Herd dry and Wet Seasons	2	4th
Treat Frequently			Treat Frequently	Feed Conservation	Treat Frequently	Treat Frequently	4	2nd
Temporal Nomadism				Feed Conservation	Buy Feed Supplement	Herd dry and Wet Seasons	0	6th
Feed Conservation					Feed Conservation	Feed Conservation	5	1st
Buy Feed Supplement						Herd dry and Wet Seasons	1	5th
Herd dry and Wet Seasons							3	3rd

Source: Author's field work (2017)

"*One has to change production method or risk facing very high cattle mortality or even losing your herd*". These were words from some of the respondents and group members during the questionnaire administration and the focused group discussions. Although the Spearman's correlation tests revealed that temperature is more influential to the occurrence of most of the common diseases, the respondents' views suggested that variability in rainy season was the most felt of all climate parameters variability and feed availability was the most challenging problem. This is demonstrated by the fact that almost all practiced coping strategies were aimed at solving feed problem. However, respondents noted that the end effect of feed shortage is poor cattle health and consequently high disease prevalence. The cattle management system, which is mainly traditional, characterised by low input investments and high dependence on natural vegetation explained the reason for these coping strategies. Respondents practice feed conservation techniques, buy feed supplement and cut fodder trees to reduce the effects of feed shortage. Similar coping strategies were reported by Kima (2010) who recounted that farmers used crop residues to feed their livestock.

Another suggestion of these results is that coping or adaptation strategies is largely influenced by the socio-economic condition of the individual or the means available to them. As showed in the result, most women do not practice feed conservation. This is because what is required of this activity cannot be provided by most women. One female respondent mentioned "*feed conservation requires cart, donkey/horse and huge labour, which we do not have. Those of us who have little money will buy cakes and other feed supplements and those who do not will leave everything with Allah".* This is an indication of how women are disadvantage and substantiated the proclamation made by WFP *et al*.

(2009) cited by Kimaro and Chibinga (2013) that women are one of the groups that are at greatest risk to suffer from potential impacts of climate change because women have fewer capabilities and resources than men.

4.4.4.3 Likelihood of stopping cattle production

On whether cattle production would be stopped for other activities due to climate variability (Table 4.24), only 17 out of 184 respondents said yes and the others, 167 respondents said no. Fourteen out of 17 respondents suggested to go for small ruminant production, two chose to go for petit trading and one respondents opted to save money in the bank instead of going for cattle production. Ninety-nine out of 167 respondents remarked that because of the role cattle production plays in ensuring food security, they are not leaving cattle production for any other activity. While 32 respondents felt have no idea of what to do other than cattle production, 7 are of the view that there is no better substitute for cattle production. Twenty-seven respondents regarded cattle production as form of culture and prestige thus will not stop cattle production and only two said disease control is easy.

Although the Pearson chi-square test on the question "Are you likely to stop cattle production due to climate variability" was not significantly associated with gender (X^2 (1, N = 184) = 3.19, p = 0.07), gender responses on the questions "If yes, for which activity" X^2 (2, N = 17) = 7.47, p = 0.024 and "If no, why not" X^2 (5, N = 167) = 25.47, $p < 0.001$ were both significant. Post hoc test could not be performed for the statement on "activities to do if cattle production were to be stopped" because one group has fewer than two cases. The Post hoc test for gender response on the question "If no, why not" revealed significant difference between the respondents who mentioned "Food security" and "No idea" and between those who lamented "Culture and prestige" and "No idea" ($F_{5,161}$ = 5.795, p – value = 0.0005) The statistically significant difference between means was such that males regarded cattle production as a form of maintaining food security and culture and prestige while women have no idea of what to do.

Table 4.24 Frequency response to the question relating to stopping cattle production

Variable	Male	Female	Total	Pearson chi-square	Degree of freedom	P-value
Are you likely to stop cattle production due to climate variability? (n = 184)						
Yes	13	4	17			
No	90	77	167	3.19	1	0.074
If yes, for what activity? (n = 17)						
Petty trading	1	0	1			
Small ruminant production	12	2	14	7.47	2	0.024
Banking	0	2	2			
If no, why not? (n = 167)						
Food security	64	35	99			
Easy to control diseases	0	2	2			
Culture and prestige	15	12	27	25.47	5	<0.001
No idea	6	26	32			
No better substitute	5	2	7			

Source: Author's field work (2017)

Despite the enormous challenges faced in cattle production due to climate variability, cattle producers are still not willing to give up cattle production. This is evident by the fact that only 17 out of 184 respondents are likely to stop cattle production. This is an indication of the pivotal role cattle production plays in livelihood improvement. The role cattle production plays in ensuring food security can be linked to the mixed crop-livestock production system praticed in The Gambia. Livestock especially cattle production enhanced crop production by providing the much needed farm labour as well as fertilizing soils in the farm lands. Furthermore, when crop failure occurs, livestock particularly cattle are sold to buy food stuff. This was also mentioned by Yaffa (2013).

4.5 Important diseases

On diseases, Figure 4.16 showed that HS was the most mentioned disease (124), followed by tryps (67) and the BQ (34). While CBPP was mentioned 30 times, LSD and FMD were mentioned each seven times and tick infestation only four times. The results of the focused group discussion in Sare Demba Toro, Sandu District were to some extent similar to the results obtained from individual respondent. As in Table 4.25, haemorrhagic septicaemia (HS), contagious bovine pleuropneumonia (CBPP) and trypanosomiasis were ranked first, second and third, respectively by the male group. This was followed by Black quarter (BQ) and then Lumpy skin disease. In Table 4.26, the women group ranked HS as the most important followed by tryps. Contagious Bovine Pleuropneumonia, Lumpy skin Disease and tick infestation were ranked third, fourth and fifth respectively. In the Kantoro and Wuli East, women do not recognize individual disease, though recognized sick cattle.

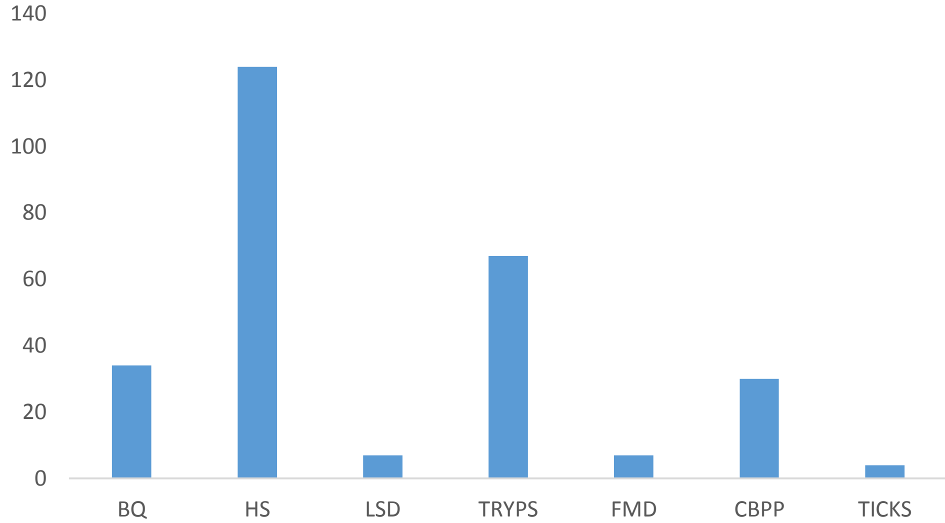


Figure 4.16 Listed important disease

BQ- Black Quarter, HS – Haemorrhagic Septicaemia, LSD- Lumpy Skin Disease,

TRYPS- Trypanosomiasis, FMD – Foot and Mouth Disease, CBPP – Contagious Bovine Pleuropneumonia

Table 4.25 Ranking of Common Cattle Disease in Sare Demba Toro, Sandu District (Men)

Diseases	***CBPP***	***HS***	***BQ***	***TRYPS***	***LSD***	***SCORE***	***RANK***
CBPP		HS	CBPP	CBPP	CBPP	3	2nd
H/S			HS	HS	HS	4	1st
BQ				TRYPS	BQ	1	4th
TRYPS					TRYPS	2	3rd
LSD						0	5th

Source: Author's field work (2017)

BQ- Black Quarter, HS – Haemorrhagic Septicaemia, LSD- Lumpy Skin Disease,

TRYPS- Trypanosomiasis, FMD – Foot and Mouth Disease, CBPP – Contagious Bovine Pleuropneumonia

Table 4.26 Ranking of common cattle disease in Sare Demba Toro, Sandu District (women)

Diseases	*CBPP*	*HS*	*TRYPS*	*LSD*	*TICKS*	*SCORE*	*RANK*
CBPP		HS	TRYPS	CBPP	CBPP	2	3rd
H/S			HS	HS	HS	4	1st
TRYPS				TRYPS	TRYPS	3	2nd
LSD					LSD	1	4th
TICKS						0	5th

Source: Author's field work (2017)

BQ- Black Quarter, HS – Haemorrhagic Septicaemia, LSD- Lumpy Skin Disease,

TRYPS- Trypanosomiasis, FMD – Foot and Mouth Disease, CBPP – Contagious Bovine Pleuropneumonia

The ranking of the common diseases according to the most important was based on occurrence and mortality rates. The rising temperatures, inadequate feed and increasing wind speed may have induced high incidence of haemorrhagic septicaemia, which is regarded as the most cattle disease.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Base on the observed results, the following conclusion were made

1. This research results established that all the common cattle diseases occurrence in Upper River Region, The Gambia are statistically significantly correlated to at least one of the climate variables. This is amply demonstrated by the Spearman's correlation tests and the regression analyses revealed variability in these climate variables in most cases lead to increase in the occurrence of the common diseases. This will unequivocally affect cattle owners' income and as well as threaten food security as cost on disease control and cattle mortality are most likely to increased.

2. There are significant dissimilarities between men and women regarding their perception, impact and adaptation to climate change. Unfortunately, women are most of the time if not always been disadvantaged. This implies women are more likely to be prone to the negative impacts climate variability.

3. It is unequivocal that climate variability does exists and to a great extent as results of the research showed. Although the Mann Kendall test revealed the existence of trend for rainfall only, the anomaly index exposed both annual and monthly variations in all climate variables. Unfortunately, most of these variabilities are found to be negative, for instance, temperature is increasing and rainy season decreasing in length and its onset getting late. These variabilities have negative impact on the health of cattle, consequently impacting cattle production in Upper River Region, The Gambia.

5.2 Recommendations

In view of these observations, the following recommendations were made:

1. The results of the research have established that temperature is increasing. Since most of the common cattle diseases have correlation with temperature, a lot needs to be done to curb further outbreaks of diseases. Although continual exposure of cattle to increasing temperatures could affect cattle immunity and their response to vaccination, vaccination against these diseases should still be carried out on a regular and timely basis.

2. In addition, the cattle management system that is characterized by free extensive management should be improved. Reducing the high dependence on natural vegetation could go a long way towards ensuring feed availability, thus reducing stress on cattle and consequently increase their immunity.

3. Furthermore, any intervention to curb climate variability impacts must be gender sensitive. A common approach to reduce effects of climate variability for both male and females might be disadvantageous to one group, most likely, the females. Since perception, impacts and adaptation to climate variability vary with gender, interventions to address the problems brought by climate variability should also vary.

4. Massive awareness campaign should also be stepped up to improve climate variability awareness and several forms such as the use of radio, training and school children should be tried. The use of local knowledge particular from elder could be meaningful.

5. Finally, the complexity of disease occurrence, transmission and distribution is unquestionable. In view of this, a further research is recommended with the factoring of

other variables like cattle population. This is deemed necessary because of the low R^2 values in the regression analyses.

REFERENCES

Abdela, N. & Jilo, K. (2016). Impact of Climate Change on Livestock Health: A Review. *Global Veterinaria*, 16(5), 419–424. http://doi.org/10.5829/idosi.gv.2016.16.05.10370

Accurate, N. (1997). Respiratory disease in cattle. *National Animal Disease Information System (NADIS) Health Bulliten*, (Fig 1), 4–6.

Adamu, J. Y., & Aliyu, M. M. (2007). Prevalence of contagious bovine pleuropneumonia in Borno State, Nigeria. *Nigerian Veterinary Journal, 27*(2), 14–22.

Aguilar, L. (2006). Gender and Climate Change. *International Union for Conservation of Nature (IUCN),* 6. https://doi.org/10.1017/S1743923X06232100

Alexandersen, S., Zhang, Z., Donaldson, A.., & Garland, A. J... (2003). The Pathogenesis and Diagnosis of Foot-and-Mouth Disease. *Journal of Comparative Pathology*, *129*(1), 1–36. http://doi.org/10.1016/S0021-9975(03)00041-0

Alwis, M. C. L. D. E. (1992). Haemorrhagic Septicaemia-A General Review Serotype distribution. *British Veterinary Journal*, *148*(2), 99–112.

Amanfu, W. (2009). Contagious bovine pleuropneumonia (lung sickness) in Africa. *The Onderstepoort Journal of Veterinary Research*, *76*, 13–17.

Amanfu, W., Masupu, K. V, Adom, E. K., Raborokgwe, M. V, & Bashiruddin, J. B. (1998). An outbreak of contagious bovine pleuropneumonia in Ngamiland district of north-western Botswana. *The Veterinary Record*, *143*(2), 46–48. https://doi.org/10.1136/vr.143.2.46

Authié, E. (1994). Trypanosomiasis and trypanotolerance in cattle: A role for congopain? *Parasitology Today*. http://doi.org/10.1016/0169-4758(94)90252-6

Bagley, C. V. (1997). Bovine Respiratoty Diseases, *Animal Health Fact Sheet*, AH/Beef/04, 4 pp.

Benkirane, A., & De Alwis, M. C. L. (2002). Haemorrhagic septicaemia, its significance, prevention and control in Asia. *Veterinarni Medicina*, *47*(8), 234–240.

Bett, B., Kiunga, P., Gachohi, J., Sindato, C., Mbotha, D., Robinson, T., … Grace, D. (2016). Effects of climate change on the occurrence and distribution of livestock diseases. *Preventive Veterinary Medicine*. Elsevier B.V., 47 (8), 234–240. https://doi.org/http://dx.doi.org/10.1016/j.prevetmed.2016.11.019

Brownlie J, Clarke Mc, Howard Cj, Pocock Dh. Pathogenesis and Epidemiology of Bovine Virus Diarrhoea Virus Infection of Cattle. Annales de Recherches V´et´erinaires, INRA Editions, 1987, 18 (2), pp.157-166. <hal-00901705>

Chatikobo, P., Choga, T., Ncube, C., & Mutambara, J. (2013). Participatory diagnosis and prioritization of constraints to cattle production in some smallholder farming areas of Zimbabwe. *Preventive Veterinary Medicine*, *109*(3–4), 327–333. https://doi.org/10.1016/j.prevetmed.2012.10.013

Claxton, J. R., Leperre, P., Rawlings, P., Snow, W. F., & Dwinger, R. H. (1992). Trypanosomiasisin cattle in Gambiae: Incidence, prevalence and tsetse challenge. Acta Tropica, 50, 219–225.

Cox, M., Gardner, W. C., & Fraser, L. H. (2015). Rangeland Ecology & Management A Survey-Based Assessment of Cattle Producers' Adaptation to Climate Change in British Columbia, Canada ☆. *Range Ecology & Management*, *68*(2), 119–130. https://doi.org/10.1016/j.rama.2015.01.004

Daffeh, K,2001. The influence of Climate Factors on the Incidence of Infectious Diseases in Cattle in The Gambia (Black quarter and Haemorrhagic). Thesis. (MSc). Fondation Universitaire Luxembourgeoise, Belgium

Daffeh, K. (2010). Sustainable Management of Globally Significant Endemic Ruminant Livestock in West Africa (POGEBE) Gambia Baseline Report, 2010. Banjul.

Das, R., Sailo, L., Verma, N., Bharti, P., Saikia, J., Imtiwati, & Kumar, R. (2016). Impact of heat stress on health and performance of dairy animals: A review. *Veterinary World*. https://doi.org/10.14202/vetworld.2016.260-268

Davies, G. (2002). Foot and mouth disease. *Research in Veterinary Science*, *73*(3), 195–199. https://doi.org/10.1016/S0034-5288(02)00105-4

de Gruijl, F. R., Longstreth, J., Norval, M., Cullen, A. P., Slaper, H., Margaret L. Kripke, f Y., & H, T. g and J. C. van der L. (2012). Modelling Fluorescence in Clinical Photodynamic Therapy. *Photochemical & Photobiological Sciences*, *12*(1), 203–13. https://doi.org/10.1039/c2pp25271f

Demetriades, J., & Esplen, E. (2008). The Gender Dimensions of Poverty and Climate Change Adaptation. *Ids Bulletin-Institute of Development Studies*, *39*(4), 24. https://doi.org/10.1111/j.1759-5436.2008.tb00473.x

DLS, (2016). Department of Livestock Services – Contagious Bovine Pleuropneumonia 2015 Mass Vaccination Report. 16 pp

FAO (2012). Food and Agricultural Organisation- Final Report on Livestock Sector Review, The Gambia

Gay, K., Stubbs, E., & Galindo-gonzalez, S. (2016). Matrix Ranking: A Tool for Decision-Making and Prioritization, University of Florida, Institute of Food and Agricultural Sciences, pp 2–5.

GBoS (2013). Gambia Bureau of Statistic- The Gambia Population and Housing Census Preliminary Results, pp 12-15

GCCPD (2016). Gambia Climate Change Policy Document – Ministry of Environment, Climate Change, Forestry, Water and Wildlife

GoTG (2007) Government of The Gambia- Gambia National Adaptation Programme of Action (NAPA). Department of State for Forestry and The Environment, Banjul, 97p

GoTG (2016). Government of The Gambia-Adapting Agriculture to Climate Change, Review of Past Experiences and Lessons Related to Cattle, Small Ruminant and Poultry Management Practices in The Gambia.

Gouro, A., Hamadou, S., Soara, A. & Guerrini, L. (2008). Climate Change in West Africa: Impact on livestock and strategies of adaptation. In: P. Rowlinson, M. Steel & A. Nefzaoui, eds. Proceedings International Conference: Livestock and Global Climate Change. Rowlinson, P., Steele, M & Nefzaoui, A (eds). British Society of Animal Science, 68-70

Gruenberg, W. (2016). Overview of Salmonellosis, *Veterinary Manual* Retreived April 19, 2017, from http://www.msdvetmanual.com/digestive-system/salmonellosis/overview-of-salmonellosis

Gupta, A., Birhman, K., Raheja, I., Sharma, S. K., & Kar, H. K. (2016). Space-time analysis of human brucellosis considering environmental factors in Iran. *Asian Pacific Journal of Tropical Disease*, *6*(3), 248–252. http://doi.org/10.1016/S2222-1808(15)61024-6

Harvell, C. D., Mitchell, C. E., Ward, J. R., Altizer, S., Dobson, A. P., Richard, S. O., Samuel, M. D. (2014). Climate Warming and Disease Risks for terrestrial and marine biota, *2158*(2002). http://doi.org/10.1126/science.1063699

Ifejika, S, C. (2010). Drought Coping and Adaptation Strategies: Understanding Adaptations to Climate Change in Agro-pastoral Livestock Production in Makueni District, Kenya. European Journal of Development Research, 22(5), 623–642. https://doi.org/10.1057/ejdr.2010.39

INDC (Intended Nationally Determined Contribution) of The Gambia (2017). The Gambia: Department of Water Resources, Ministry of Environment, Climate Change, Forestry, Water and Wildlife.

IPCC, 2001: Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp.

IPCC (2007). Climate Change 2007: *Synthesis Report. Contribution of Working Groups I, II and III to the Forth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)], Geneva, 104 pp.

IPCC, 2014: *Climate Change 2014: Synthesis Report*. *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

Jaiteh M.S & Sarr B. (2011). Climate Change and Development in the Gambia: Challenges to Ecosystem Goods and Services. A Technical Report, 57pp.

Jaiteh Malanding, S. (2010). Climate Change and Development in the Gambia Challenges to Ecosystem Goods and Services, (May 2011), 57. https://doi.org/10.13140/2.1.1731.1040

Jallow, B.P., Toure, S., Barrow, M. and Mathieu, A.A. (1999) 'Coastal zone of The Gambia and the Abidjan region in Côte d'Ivoire: sea level rise vulnerability, response strategies, and adaptation options', Climate Research, Vol. 12, Nos. 2–3, pp.129–136.

Karmeshu, N. (2012). Trend Detection in Annual Temperature & Precipitation Using the Mann Kendall Test- A Case Study of Assess Climate Change on Select States in the Northern United States. Thesis (MSc). University of Pennsylvania

Kawale, J., & Chatterjee, S. (2011). Anomaly construction in climate data: Issues and challenges. *NASA Conference on Intelligent Data Understanding (CIDU) 2011*, 1–15. Retrieved from http://climatechange.cs.umn.edu/docs/sahel.pdf

Kima, S. A, 2014. Assessment of the Impact of Climate and Land Use Changes on Pastoral Livestock Farming in Boulgou Province, South-Eastern Burkina Faso. Thesis (MTech). Federal University of Technology, Minna, Nigeria

Kimaro E G and Chibinga O C 2013**:** Potential impact of climate change on livestock production and health in East Africa: A review. *Livestock Research for Rural Development. Volume 25, Article #116.* Retrieved August 10, 2017, from http://www.lrrd.org/lrrd25/7/kima25116.htm

Ly, M., Traore, S. B., Agali, A., & Sarr, B. (2013). Evolution of some observed climate extremes in the West African Sahel. *Weather and Climate Extremes*, *1*, 19–25. http://doi.org/10.1016/j.wace.2013.07.005

MacGregor, S. (2010). "Gender and climate change": from impacts to discourses. Journal of the Indian Ocean Region, 6(2), 223–238. https://doi.org/10.1080/19480881.2010.536669

Magyar, T., Ujvári, B., Szeredi, L., Virsinger, N., Albert, E., Német, Z., … Biksi, I. (2017). Re-emergence of bovine haemorrhagic septicaemia in Hungary. *Acta Veterinaria Hungarica*, *65*(1), 41–49. http://doi.org/10.1556/004.2017.004

Mandleni, B. (2011). Impact of Climate Change and Adaptation on Cattle and Sheep Farming in The Eastern Cape Province of South Africa. *Agricultural Systems*, *101*(October), 113–127. https://doi.org/10.1016/j.agsy.2009.05.002

McGranahan, G., Balk, D., & Anderson, B. (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization*, *19*(1), 17–37. http://doi.org/10.1177/0956247807076960

Megersa, B., Markemann, A., Angassa, A., Ogutu, J. O., Piepho, H. P., & Valle Zárate, A. (2014a). Livestock Diversification: An Adaptive Strategy to Climate and Rangeland Ecosystem Changes in Southern Ethiopia. Human Ecology, 42(4), 509–520. https://doi.org/10.1007/s10745-014-9668-2

Megersa, B., Markemann, A., Angassa, A., Ogutu, J. O., Piepho, H., & Valle, A. (2014b). Impacts of climate change and variability on cattle production in southern Ethiopia: Perceptions and empirical evidence. *Agricultural Systems*, *130*, 23–34. https://doi.org/10.1016/j.agsy.2014.06.002

Mertz, O., Mbow, C., & Reenberg, A. (2009). Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management*, *43*, 804–816. https://doi.org/10.1007/s00267-008-9197-0

Moenga, B. O., Muchemi, G. M., Kang'ethe, E. K., Kimenju, J. W., Mutiga, E. R., & Matete, G. O. (2013). The impact of climate change on the incidence of cattle diseases in a pastoral area of Kenya. *Livestock Research for Rural Development*, *25*(4).

Moore, S., Shrestha, S., Tomlinson, K. W., Vuong, H., Colwell, R. R., Pascual, M., … Baylis, M. (2012). Predicting the effect of climate change on African trypanosomiasis: integrating epidemiology with parasite and vector biology. *Journal of the Royal Society, Interface / the Royal Society*, *9*(70), 817–30. https://doi.org/10.1098/rsif.2011.0654

Mueller, K. (2007). Urinary tract disease in cattle. *UK Vet.*, *12*(6), 37–45. http://doi.org/10.1111/j.2044-3870.2007.tb00125.x

Mugalavai, E. M., Kipkorir, E. C., Raes, D., & Rao, M. S. (2008). Analysis of rainfall onset, cessation and length of growing season for western Kenya. Agricultural and Forest Meteorology, 148(6–7), 1123–1135. https://doi.org/10.1016/j.agrformet.2008.02.013

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., & Bernabucci, U. (2010). Effects of climate changes on animal production and sustainability of livestock systems ☆. *Livestock Science*, *130*(1–3), 57–69. http://doi.org/10.1016/j.livsci.2010.02.011

Nyariki, D. M., Mwang, W., & Thompson, D. M. (2009). Land-Use Change and Livestock Production Challenges in an Integrated System: The Masai-Mara Ecosystem, Kenya. *Journal of Human Ecology*, *26*(3), 163–173.

OIE. (2008). Office International des Epizooties - *Contagious Bovine Pleuropneumonia*. *OIE Terrestrial manual*. pp 712 – 721 https://doi.org/10.1079/9780851990125.0069

Okoh, E. (1980). An outbreak of pasteurellosis in Kano Zoo. *Journal of Wildlife Diseases*, *16*(1), 3–5.

Olmos, S. (2001). Vulnerability and adaptation to climate change: concepts, issue, assessment methods. *Climate Change Knowledge Network Foundation Paper*, (July), 20.

Patz, J. A., Graczyk, T. K., Geller, N., & Vittor, A. Y. (2000). Effects of environmental change on emerging parasitic diseases. *Int J Parasitol*, *30*(12–13), 1395–1405. http://doi.org/S0020-7519(00)00141-7 [pii]

Robinson, T.P., Thornton P.K., Franceschini, G., Kruska, R.L., Chiozza, F., Notenbaert, A., Cecchi, G., Herrero, M., Epprecht, M., Fritz, S., You, L., Conchedda, G. & See, L. 2011. Global livestock production systems. Rome, Food and Agriculture Organization of the United Nations (FAO) and International Livestock Research Institute (ILRI), 152 pp.

Rowlinson P (2008) Adapting livestock production systems to CC – temperate zones. In: Rowlinson P, Steele M, Nefzaoui A (eds) Proceedings of the international conference livestock and global CC, 17–20 May 2008. BSAS, Hammamet, Tunisia, pp 61–63. Available at www.mashreq-maghreb.org/documents/LGCC_pro- ceedings.pdf

Secka A, Ceesay A, Bojang M, J. B. and C. S. (2015). CBPP T 1 44/T 1 SR VACCINE INDUCED IMMUNE RESPONSE IN VACCINATED CATTLE. *Bulletin of Animal Health and Production in Africa*, *2*(2337), 53–58.

Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C., eds., 2015. Climate Change Impact on Livestock: Adaptation and Mitigation. New Delhi: Springer

Shivachandra, S. B., Viswas, K. N., & Kumar, A. (2011). A review of haemorrhagic septicaemia in cattle and buffalo. *Animal Health Research Reviews / Conference of Research Workers in Animal Diseases*, *12*(1), 67–82. https://doi.org/10.1017/S146625231100003X

Sivakumar, T., Thennarasu, A., & Rajkumar, J. S. I. (2012). Effect of season on the incidence of infectious diseases of bovine in Tamilnadu. *Meteorology*, *47*, 8874–8875.

Smit, B., Burton, I., Klein, R. J. T., & Wandel, J. (2000). An Anatomy of Adaptation to Climate Change and Variability. *Climate Change*. https://doi.org/10.1023/A:1005661622966

Smithers, J. & Smith, B. (1997). Human adaptation climatic variability and change. *Global Environmemtal Change*, 7(2), 129–146. PII: s0959-3780(97)00003-4.

Sobrino, F., Saiz, M., Jimenez-Clavero, M. A., Nunez, J. I., Rosas, M. F., Baranowski, E., & Ley, V. (2001). Foot-and-mouth disease virus: A long known virus, but a current threat. *Veterinary Research*, *32*(1), 1–30. https://doi.org/10.1051/vetres:2001106

Steverding, D. (2008). The history of African trypanosomiasis. *Parasites & Vectors*, *1*(1), 3. https://doi.org/10.1186/1756-3305-1-3

Sujakhu, N. M., Ranjitkar, S., Niraula, R. R., Pokharel, B. K., Schmidt-Vogt, D., & Xu, J. (2016). Farmers' Perceptions of and Adaptations to Changing Climate in the Melamchi Valley of Nepal. *Mountain Research and Development*, *36*(1), 15–30. https://doi.org/10.1659/MRD-JOURNAL-D-15-00032.1

Taruvinga, A., Muchenje, V., & Mushunje, A. (2013). Climate change impacts and adaptations on small-scale livestock production. *International Journal of Development and Sustainability*, *2*(2), 664–685.

Thiaucout F.; Van Der Lugt, J. J. and Provost, A. (2004). Contagious bovine pleuropneumonia. In R.C. Coetzer, J.A.W.; Tustin (Ed.), Infectious disease of livestock (Vol. 3 2nd). Cape Town: Oxford University Press.

Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know. *Agricultural Systems*, *101*(3), 113–127. https://doi.org/10.1016/j.agsy.2009.05.002

Unger R.K. & Crawford, M. (1993). Commentary: Sex And Gender- The Troubled Relationship between Terms and Concepts. *Psychological Science* 4(2), 122–124

Useh, N. M., Ibrahim, N. D. G., Nok, A. J., & Esievo, K. A. N. (2006a). Relationship between outbreaks of blackleg in cattle and annual rainfall in Zaria, Nigeria. *The Veterinary Record*, *158*(3), 100–101. https://doi.org/10.1136/vr.158.3.100

Useh, N. M., Nok, A. J., & Esievo, K. A. N. (2006b). Blackleg in ruminants. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*, *1*(40), 8 pp. https://doi.org/10.1079/PAVSNNR20061040

Van den Bossche, P & A W Coetzer, J. (2008). Climate change and animal health in Africa. *Revue scientifique et technique (International Office of Epizootics).* 27. 551-62.

Watson, C. (1994). Proportional piling in Turkana: A case study: Rapid Rural Appraisal (RRA) Notes (1994), Issue 20, pp.131–132, IIED London

Wikse, S. (2005). Management of Infectious Reproductive Disease in Beef Cattle Herds, Proceedings, Applied Reproductive Strategies in Beef Cattle, Texas A & M University, College Station

XLStat Addinsoft, (2015). Getting started manual XLStat. pp 104

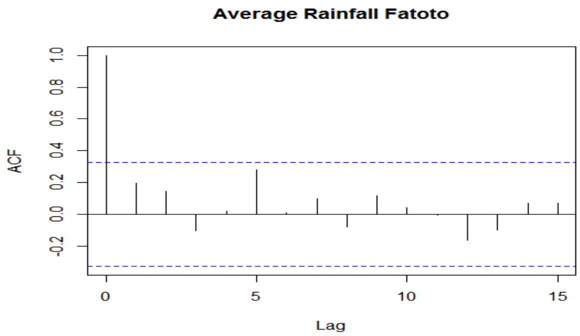
Yaffa, S. (2013). Coping measures not enough to avoid loss and damage from drought in the North Bank Region of The Gambia. International *Journal of Global Warming*, 5(4), 467–482. https://doi.org/10.1504/IJGW.2013.057286

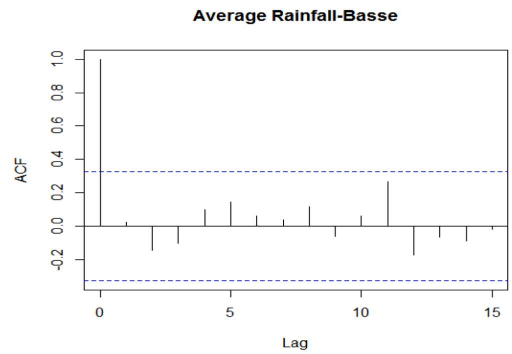
Zavoloka, A. (1988) Diagnosis of livestock diseases in countries with Tropical Climate (booklet written in Russian).

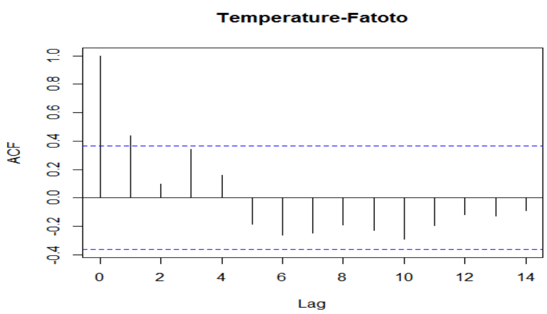
Zhang, Y., Bi, P., & Hiller, J. E. (2010). Climate variations and Salmonella infection in Australian subtropical and tropical regions. Science of the Total Environment, 408(3), 524–530. http://doi.org/10.1016/j.scitotenv.2009.10.068

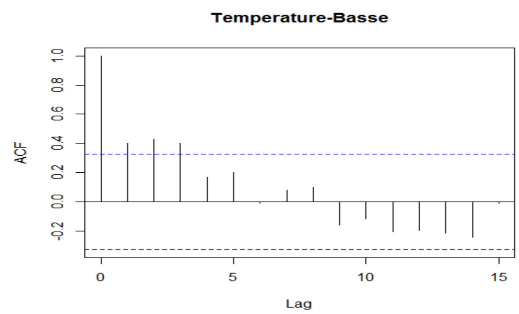
APPENDICES

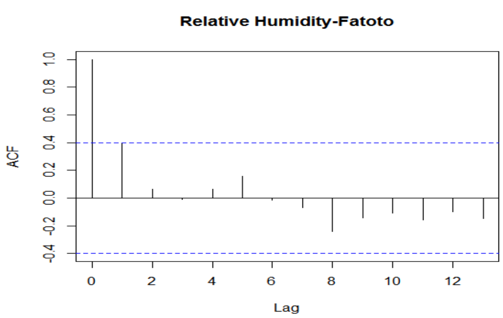
APPENDIX A: Autocorrelation test of climate variables

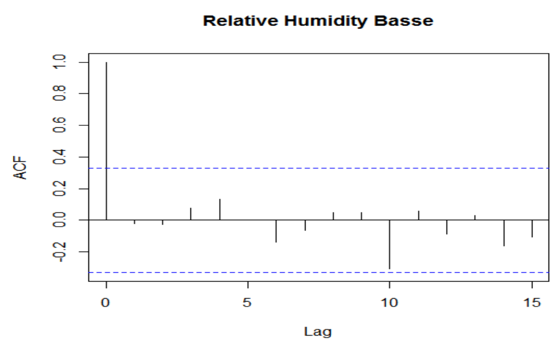


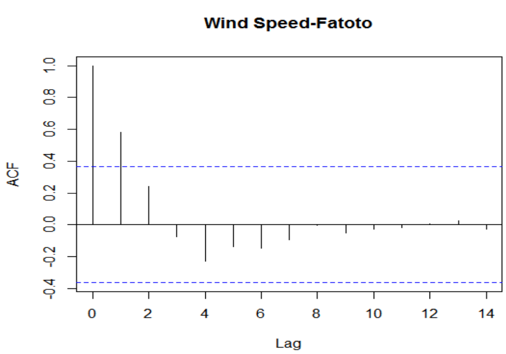


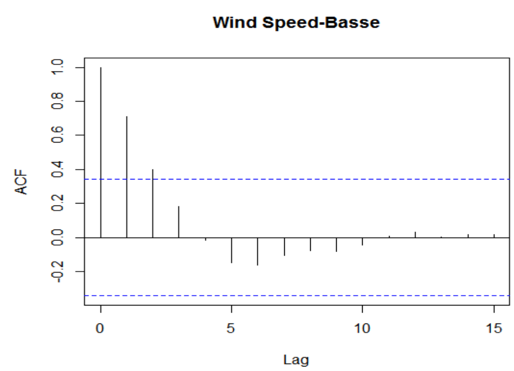




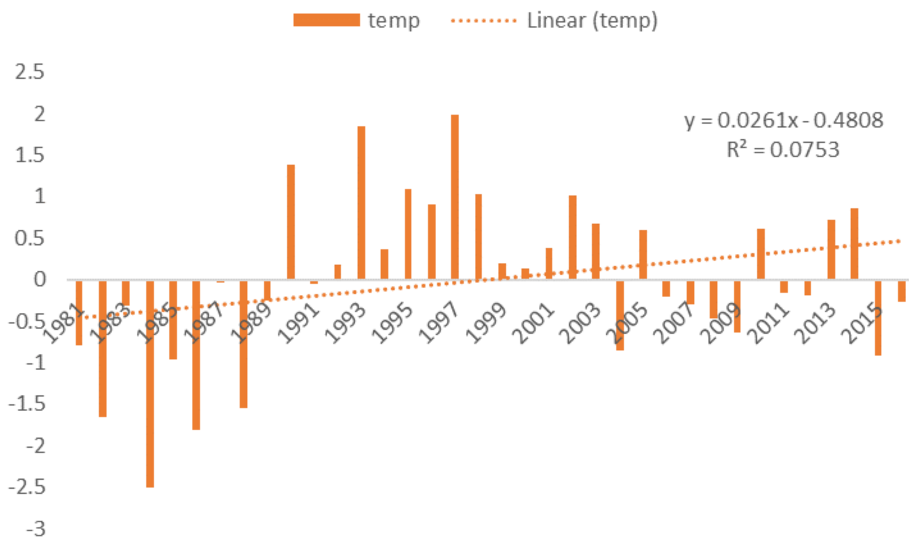




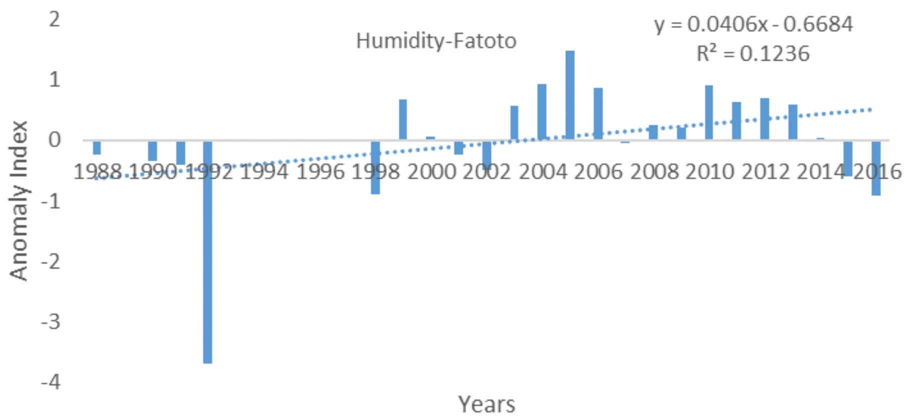


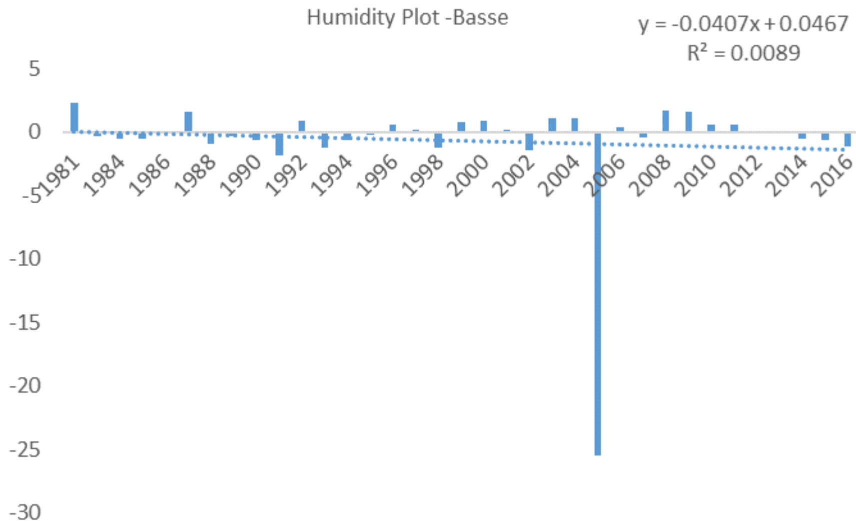


APPINDEX B: Annual temperature standardized anomaly for Upper River Region

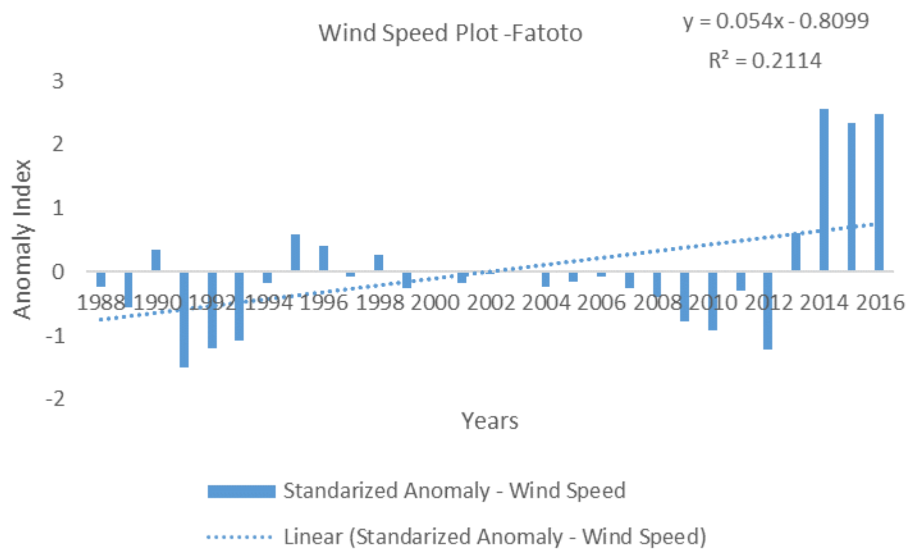


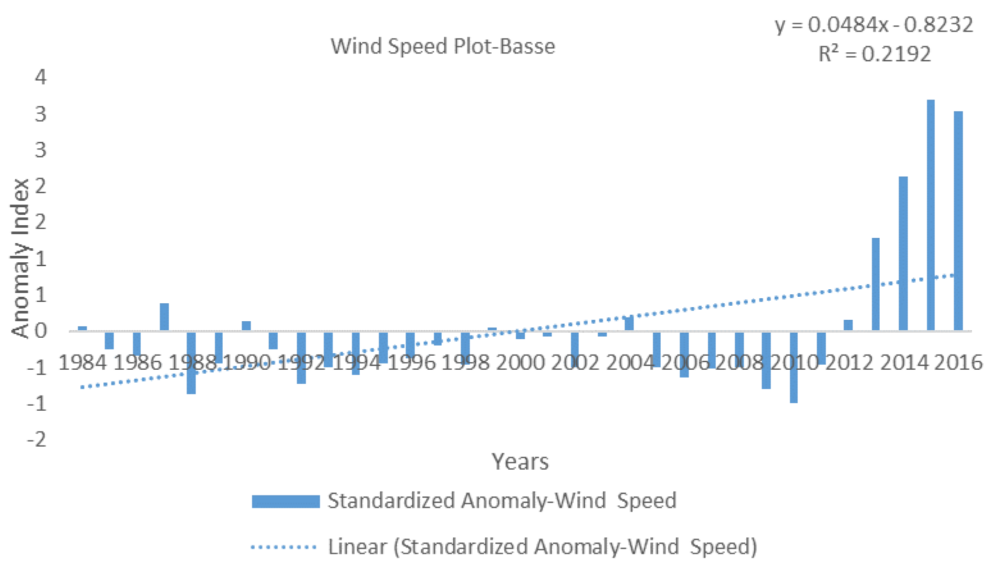
APPENDEX C: Annual standardized anomaly of relative humidity of Basse and Fatoto





APPENDIX D: Annual standardized anomaly of wind speed of Basse and Fatoto





Appendix E: Reproductive and urinary tract and gastro intestinal tract infections regression matrix – Fatoto

Model		Unstandardized	Standard Error	Standardized	t	p	Collinearity Statistics Tolerance	VIF
1	intercept	-1.565	2.143		-0.730	0.466		
	Minimum temperature	0.100	0.091	0.091	1.095	0.275	0.857	1.167
	Rainfall	0.011	0.004	0.254	3.063	0.003	0.859	1.164
	Wind Speed	0.253	0.092	0.214	2.764	0.006	0.982	1.018

Dependent variable: Reproductive urinary tract infections

Model		Unstandardized	Standard Error	Standardized	t	p	Collinearity Statistics Tolerance	VIF
1	intercept	-2.877	5.345		-0.538	0.591		
	Average temperature	0.515	0.181	0.247	2.838	0.005	0.955	1.047
	Humidity	0.176	0.081	0.189	2.172	0.032	0.955	1.047

Dependent Variable: Gastro intestinal tract infections

Source: Author’s field work (2017)

Appendix F: Reproductive and urinary tract infections regression matrix – Basse

Model		Unstandardized	Standard Error	Standardized	t	p	Collinearity Statistics	
							Tolerance	VIF
1	intercept	1.848	0.726		2.547	0.012		
	Rainfall (mm)	0.006	0.003	0.164	2.020	0.045	0.948	1.055
	Wind Speed (knots)	0.122	0.060	0.165	2.025	0.045	0.948	1.055

Dependent Variable: Reproductive and Urinary Tract Infections

Source: Author's field work(2017)

Appendix G: A female respondent in Madina Balla during questionnaire administration

Appendix H: Conducting matrix scoring during focused group discussion

Appendix I: Questionnaire

RESEARCH QUESTIONNAIRE

The research topic, "The Impact of Climate Variability on the occurrence of Common Cattle Diseases" aims at determining the degree to which climate variability impacted on cattle production in the study area. One of its objectives is to compare between men and women cattle farmers' perception, impact and adaptation of climate variability. In this regard, these questionnaires are drawn to be able to meet the said objective.

The product of this work is to help one of the leading researchers of this work to accomplish his Master's Thesis, which is a requirement for graduation. However, it can be useful to policy makers in designing and developing projects or programmes geared towards improving cattle farmers' livelihoods

Enumerator's Name: …………………………………………

Tel. Number……………………….... Date………………..

Respondent's Name (Optional)………………………………………………….

Tel. Number…………………………….

Question	**Code of Answer**	**Answer**
Sex	Male = 1 Female =2	
Age	Give figure in years	
Number of Cattle in Household	Give Figure	
How long have you been in cattle production	Give figures in years	
Village	Give Name	
District	Give Name	
Educational Level	Non Formal = 1, Primary = 2, Secondary = 3, Tertiary =4	

Part I: Perception on Climate Variability

Question	Answer Code	Answer
What is the trend of the rainy season	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
What is the trend of the rainy season	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
What is the situation with the frequency of floods	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
What is the situation with the frequency of Droughts	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
How about the length of dry spells in the rainy season	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
Onset of rainy season has been changing	Increasing = 1, Decreasing =2, No change =3, No Idea = 4	
Do you notice any climate variability?	Yes = 1, No = 2, No Idea = 3	
If yes, what , what is/are the cause(s) of the variability (explain)		
Have you received information regarding climate variability?	Yes = 1, No = 2	
If yes from where?	Radio = 1, Television =2, Training =3, Others = 4 (Specify)	

Part II: Impact of Climate Change

Questions	**Answer Codes**	**Answer**
Do rainfall changes affect your livestock production?	Yes = 1, No = 2, No Idea = 3	
If yes, how? (Explain)		
To what extent have rainfall changes negatively affect livestock health?	None = 1, Moderate = 2, Severe, Low = 4, No idea =5	
Do temperature changes affect your livestock production?	Yes = 1, No = 2, No Idea = 3	
If yes, how? (Explain)		
To what extent has rainfall variability negatively affect livestock health?	None = 1, Moderate = 2, Severe, Low = 4, No idea =5	
Do wind changes affect your livestock production?	Yes = 1, No = 2, No Idea = 3	
If yes, how? (Explain)		
To what extent have wind variability negatively affect livestock health?	None = 1, Moderate = 2, Severe, Low = 4, No idea =5	
To what extent has wind variability affected disease spread	None = 1, Moderate = 2, Severe, Low = 4, No idea =5	
To what extent has wind variability affected cattle mortality	None = 1, Moderate = 2, Severe, Low = 4, No idea =5	

ANIMAL HEALTH

What are the common diseases/conditions affecting your cattle in the last 10 years? Rank them in order of economic importance, and mention the season of occurrence.

Disease	Rank	Periods of occurrence	Remarks

Part III: Adaptation Measures

Questions	**Answer Codes**	**Answer**
Have you done anything to deal with rainfall variability?	Yes = 1, No = 2	
If yes, what did you do? (Explain)/ If no, why not? (Explain)		
Have you done anything to deal with temperature Variability?	Yes = 1, No = 2	
If yes, what did you do? (Explain)/ If no, why not? (Explain)		
Have you done anything to deal with wind?	Yes = 1, No = 2	
If yes, what did you do? (Explain)/ If no, why not? (Explain)		
How do you manage disease outbreak in your herd?	Treat myself = 1, Call veterinary Officer =2, Call private auxiliary = 3, Others (specify) =4	

If you treat how much do you spend annually on average? (give five in Dalasi)		
Did you change your livestock production system to deal with climate variability?	Yes = 1, No = 2	
If yes, what have you done? (Explain)/ If no, why not? (Explain).		
Have you diversified the livestock species you rear due to climate variability?	Yes =1, No = 2	
If yes, from which species to which species?		
Why do you choose that species?		