EFFECTS OF CLIMATE VARIABILITY AND OTHER FACTORS ON THE OUTBREAK AND SPREAD OF NEWCASTLE DISEASE IN SUNEKA DIVISION OF KISII COUNTY

BY

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NOVEMBER, 2014
DECLARATION

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

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DEDICATION

This work is dedicated to the Lord Jesus and my parents, Mary and the late Joseph who laid the foundations of my education.
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DEFINITION OF TERMS

**Disease:** Illness of one or more of the body organs or tissues caused by the pathogens or germs.

**Ecto-parasites:** External parasites such as lice, fleas

**Endo-parasites:** Internal parasites such as worms

**Free range:** System of farming where chicken are kept in natural conditions, scavenge on any available food and can move around freely

**Indigenous chicken:** Local or native birds

**Newcastle disease:** Highly infectious and contagious viral disease characterized by coughing and sneezing, nasal discharge, waterly yellow diarrhoea and paralysis of wing and legs.
ABBREVIATIONS AND ACRONYMS

AIDS: Acquired Immune Deficiency Syndrome

APMV-1: Avian Paramyxovirus Type 1

CBS: Central Bureau of Statistics

FAO: Food and Agriculture Organisation

FRIC: Free Range Indigenous Chicken

GDP: Gross Domestic Product

GOK: Government of Kenya

HIV: Human Immuno Deficiency Virus

IB: Infectious Bronchitis

IC: Indigenous chicken

IICAB: Institute for International Cooperation in Animal Biologics

IPCC: Intergovernmental Panel on Climate Change

LIFDCs: Low Income Food –Deficit Countries

KNBS: Kenya National Bureau of statistics

MDGs: Millennium Development Goals

MOA: Ministry of Agriculture

MAM: March April May

MOLD: Ministry of Livestock Development

ND: Newcastle Disease

NDV: Newcastle Disease Virus

OND: October November December

OIE: Office of International des Epizootics
**SANDCP:** Southern Africa Newcastle Disease Control Project

**SSA:** Sub-Saharan Africa.
ABSTRACT

Newcastle Disease (ND) is a common occurrence in Suneka Division. ND is caused by Avian Paramyxovirus Type 1, is one of the most significant diseases for poultry producers around the world. This poultry disease is influenced directly or indirectly by weather as it affects the timing and the intensity of an outbreak. This thesis examined the factors influencing the outbreak and the spread of Newcastle disease in Suneka Division of Kisii County. The objectives of study were; to investigate the relationship between the weather variables and the occurrence of Newcastle Disease (ND) in Free Range Indigenous Chicken, to investigate factors other than weather variables that influence the outbreak and spread of ND, to assess the socio-economic impacts of ND on the poultry farmers and to assess the adaptive and mitigation measures used by farmers to manage ND in Suneka Division. The study used a descriptive design with both qualitative and quantitative approaches. The sample size was 200 households and respondents were poultry farmers. Veterinary officers were key informants. Primary data was collected using questionnaires and interview schedules. Secondary data on rainfall, temperature and relative humidity was collected from the Kisii meteorological station for 2007 and 2011. Data was analysed using measures of central tendency such as means and mode. They were presented using frequency tables. Karl Pearson coefficient of correlation was used to test the null hypothesis that there was no relationship between the climate variables and the occurrence of ND at 5% level of significance. The study revealed that ND occurs during the months of July-August and December-January. It was generally found out that this disease occurs after the long March, April and May (MAM) and short rains October November and December (OND). There was a positive Pearson Correlation between humidity and ND for the month of August ($r = 0.328$) and December ($r = 0.596$). However, in the months of July ($r = -0.576$) and January ($r = -0.418$) the relationship was negative. It was also found out that there was a positive Pearson Correlation between rainfall and ND in the months of August ($r = 0.286$) and December ($r = 0.275$). However, there was a negative relationship in the months July ($r = -0.549$) and January ($r = -0.144$). Concerning temperature, there was a positive Pearson Correlation between temperature and ND in August ($r =0.772$), July ($r = 0.683$) and January ($r = 0.159$). However, in the month of December there was a negative Pearson Correlation ($r = -0.546$). In relation to factors that influence the outbreak of ND, 83.5% of the farmers interviewed reported that ND is caused by infected live chicken, 13% infected poultry products, 2% other animals like dogs and 1.5% all the above factors. Poultry farmers used various methods to control ND. These included use of traditional herbs, selling, eating, burying and vaccination. To curb the ND menace and increase productivity of free range indigenous chicken, the research recommended that there was need for farmers to monitor weather changes by obtaining data from the meteorological weather stations. Educate small-scale farmers on how to adopt hygienic and bio-safe poultry rearing methods to minimize loss of chicken through diseases, pests and predation.
CHAPTER ONE

1.0 INTRODUCTION

This section deals with the background of the study, statement of the problem, objectives, questions, hypothesis, justification and significance of the study and scope and limitations.

1.1 Background of the study

Poultry plays a key role in the lives of the poor rural population in developing countries. This is especially so in Sub-Saharan Africa (SSA) where they provide income, capital assets, and fertilizers (Millar et al., 2008). In Kenya both hybrid and indigenous poultry are reared. Indigenous poultry production presents a significant portion of the economy and a source of income to small scale farmers (Kaingu et al., 2010). Most farmers in rural areas rear chicken because they are raised with relatively low capital, space and readily available household labour. They are also hardy, adapt well to the rural environments, survive on low inputs and adapt to fluctuations in the available feed resources (Gichoni and Maina, 1992). Chicken roam in the yard, around the boxes in the garbage in search of grain, greenery, crickets, termites, ants, insects and other feeds.

FRIC play a vital role in the improvement of the nutritional status and income of many poor rural households. They are also a global asset for many millions who live below the poverty line (Alders and Spradbrow, 2001). It provides scarce animal protein in form of meat, eggs and provides the owners with a form of
saving which can help in times of need to meet essential family expenses such as medicines, clothing and school fees. Families also increase their income by taking advantage of seasonal peaks in poultry demand, such as at religious festivals or celebrations. Other benefits include pest control, provision of manure, contribution to traditional ceremonies and cleanliness and hygiene as FRIC feed on leftover foods (Johnson et al., 1991).

Despite their importance, FRIC are faced by many challenges. These include: predation by snakes and birds of prey, poor housing, poor nutrition, climate variability, attack by pests and diseases and lack of adequate assistance from extension services (Moreki, 2006).

Climate variability can alter poultry’s relationship with parasites and vectors. These variations can influence where parasites and vectors thrive, making certain geographical regions more amenable to them. Climate can determine how vectors are distributed, transmitted and evolve and can influence the factors associated with emerging poultry diseases and how birds respond to these diseases (Sabuni, 2011).

Newcastle disease (ND), caused by Avian Paramyxovirus Type 1 (APMV-1), is one of the most significant diseases for poultry producers around the world (Okwor and Eze, 2011). This poultry disease is influenced directly or indirectly by weather and climate. These may be spatial with climate affecting distribution or
temporal with weather affecting timing of an outbreak and both relate to the intensity of an outbreak. Outbreaks are often associated with alternating heavy rainfall, drought and high temperatures (Perry et al., 2002). Higher temperatures may increase the rate of development of certain pathogens or parasites that have one or more life cycle outside the animal host. This may shorten generation times and possibly increase the total number of generations per year leading to higher pathogen or parasite population sizes (Harvel et al, 2002).

The disease is widely distributed throughout the world; in 2008, 73 countries reported presence of the disease to the Office of International des Epizooties (OIE, 2009). Additionally, numerous nations in Asia, Africa, Central America, and South America have endemic or frequent outbreaks caused by virulent Newcastle Disease Virus (NDV) and there are sporadic outbreaks of the virus worldwide (OIE, 2009). ND is the most serious epizootic poultry disease in the most low income food-deficit countries (LIFDCs). It occurs every year and kills on average 70% to 80% of the unvaccinated FRIC (Gueye, 2002). ND was enzootic in much of Africa and caused mortalities of all age groups from chicks to adults. Outbreaks of ND reported to World Animal Health information Database showed higher cases of ND outbreak in Ghana as compared to Kenya from 2005-2008 (Robyn, 2009).

In Suneka division, Kisii County poultry industry is the second in priority ranking in the livestock enterprise. Local birds are the most dominant (Ministry of
Livestock Development, MOLD, 2008). This enterprise is always affected by seasonal outbreaks of ND which is commonly known as “Omosando” leading to greater economic losses to farmers due to its high rates of mortalities (MOA, 2010).

Despite the awareness that disease emergence may be related to ecological change, few studies have vigorously analyzed environmental drivers of the dynamics of disease emergence (Riana et al., 2008). Therefore more research into causes and methods of disease control is needed not only to reduce countrywide disease prevalence, but also to combat poverty and hunger in the nation. This in turn will enable the Government of Kenya to achieve one of its Millennium Development Goals (MDGs) of eradicating extreme hunger and poverty.

The study aimed at finding out the effects of climatic variables and other factors on the seasonal variation of ND in FRIC and its socio-economic implications to the livelihoods of farmers in Suneka Division.

1.2 Statement of the problem

Indigenous chicken in Kenya are about 76 percent of the total poultry population and produce about 55 percent and 47 percent of the total meat and eggs respectively. Despite this contribution, poultry production is constrained especially among small scale farmers due to Newcastle Disease (ND) (Kingori et al., 2010).

In Kenya, research done in the lowlands, midlands and highlands revealed that parasites are a common health problem on FRIC and agro-climate influenced their
distribution (Kaingu et al., 2010). These parasites in turn cause disease on FRIC. ND is the most prevalent and fatal disease in poultry in Kenya (MOLD, 2006). This disease leads to great economic losses through deaths.

Despite the occurrence of many losses due to ND, efforts being made to address this problem are not adequate. Consequently, the study investigated the underlying climatic variables and other factors that contributed to the seasonal outbreak and spread of ND in Suneka Division. It also examined the socio-economic impacts of ND to the small scale poultry farmers and various strategies that had been put in place to manage this disease.

1.3 Research Objectives

The main objective of the study was to investigate the effect of variations in climatic factors and other factors on the outbreak and spread of ND in Suneka Division.

1.3.1. Specific Objectives

The specific objectives of the study were:

i) To investigate the relationship between climatic variables and the occurrence of Newcastle Disease in free range indigenous chicken (FRIC) in Suneka Division.

ii) To investigate factors other than climate variables that influences the outbreak and spread of Newcastle Disease.
iii) To assess the socio-economic impacts of Newcastle Disease to the poultry farmers.

iv) To assess the adaptive and mitigation measures put in place to manage Newcastle Disease.

1.4 Research Questions

The research was guided by the following research questions:

i) What is the relationship between climatic variables and Newcastle Disease in FRIC in Suneka Division?

ii) What factors other than climatic variables influence the outbreak and spread of Newcastle Disease?

iii) What are the socio-economic impacts of Newcastle Disease to the poultry farmers?

iv) What are the adaptive and mitigation measures that have been put in place to control Newcastle Disease?

1.5 Research hypothesis

The research was based on the following hypothesis:

**Ho.** There is no significant relationship between the climatic variables and the outbreak and spread of Newcastle Disease.
1.6 Justification and significance of the study

FRIC are the dominant form of poultry kept in Kenya (Kaingu et al., 2010). They are a natural resource whose potential is not fully exploited for the welfare of the rural populations. Being the second priority ranking livestock enterprise in Suneka Division, (GOK, 2009) indigenous chicken play a role in poverty alleviation. Income from the sale of eggs and live chickens help boost the family income (MOLD, 2008). Therefore, increasing the productivity of these chickens will make significant contribution towards increasing their food security and secure their livelihood.

Over the years, farmers in Suneka Division have experienced huge losses due to deaths of chicken caused by seasonal outbreaks of ND (GOK, 2009). Though the disease is a menace in the whole country, the research was done in Suneka Division. This is because little has been done concerning disease emergence and climate in this area. In addition to this, the enterprise is gaining momentum because of scarcity of land that is caused by high population density hence many people have embarked on rearing of indigenous chicken as it requires small space (GOK, 2009).

The research provides a comprehensive and valuable technical guide for those in government or agencies who wish to embark on projects that exploit the potential of small scale poultry production to improve the livelihood of the rural poor. It
will also help farmers to predict the outbreak of the disease and take early precautionary measures.

1.7 Scope and limitations

The study was limited to Suneka Division, though the disease is wide spread all over the country. This is because land size is small (GOK, 2009) and many farmers have embarked on this enterprise as it requires small space. It examined the influence of rainfall, temperature and humidity on the outbreak and spread of ND. These climatic elements were selected due to their effect on poultry production. While temperature is indicative of thermal stress, relative humidity affects breathing and food intake and utilization. Rainfall affects both the quality and quantity of feeds consumed. It also examined other factors that were attributable to the spread of the disease in Suneka Division. The research covered a period of five years from 2007-2011.

The research encountered the following limitations: time, financial constraints and muddy roads which were caused by rains and efforts were made to overcome these challenges. This was through limiting the study to cover a period of five years and efforts were made to reach all the areas through wearing gum boots, jackets and carrying umbrellas.
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This section examines the literature that is relevant to the study and also identifies the knowledge gaps which this study sought to fill.

2.1.1 Benefits and challenges facing poultry in Kenya.

Free Range Indigenous Chicken (FRIC) are most significant livestock species in terms of the level of ownership, access to animal protein and the potential for earning income (SANDCP, 2005). In SSA, 85 percent of all households keep FRIC, with women owning 70 percent of them (Gueye, 1998). Poultry provides approximately 20 percent of protein consumed in the developing countries (Jensen and Dolber, 2003).

Free Range Indigenous Chicken play a vital role in the improvement of the nutritional status and income of many poor rural households and are a global asset for many millions who live below the poverty line (Alders and Spradbrow, 2001). It provides scarce animal protein in form of meat, eggs and provides the owners with a form of saving which can help in times of need to meet essential family expenses such as medicines, clothing and school fees. Families can also increase their income by taking advantage of seasonal peaks in poultry demand, such as at religious festivals or celebrations. Other benefits include pest control, provision of manure, contribution to traditional ceremonies and festivals and cleanliness and...
hygiene (Johnston et al., 1991). FRIC feed on remains of foods which could have otherwise rotten and increase dirt in homesteads.

In Kenya Poultry keeping is one of the most popular livestock enterprises due to its low capital and space requirements. The poultry sector contributes about 55 percent to the livestock sector and 30 percent of the agricultural gross domestic product (GDP) or 7.8 percent of the total GDP (GOK, 2007). In the year 2006, Kenya had an estimated 37.3 million birds, of which free-range indigenous birds comprised 84.1 percent or 31.4 million birds, 8.4 percent were layers or 3.1 million birds, 5.7 percent or 2.1 million birds were broilers. Other poultry species (ducks, turkeys, pigeons, guinea fowl and quails) accounted for 1.8 percent or 0.7 million (MOLD, 2007).

Despite their importance, FRIC are faced with many constraints and challenges. These range from diseases to predators, theft, feeding, marketing, ecto and endo parasites (Danda et al., 2006). The diseases affecting indigenous chicken (IC) include ND, fowl typhoid, Gumboro, coccidiosis and eye infection. Danda et al., (2006) singled out ND to be the most significant source of economic losses in IC. Direct estimation of economic losses from ND by household rounded up to a mean of seasonal loss of 40 birds per year in the coastal lowlands of Kenya. Newcastle Disease (ND) is a highly infectious viral disease caused by a paramyxovirus which mainly affects poultry. The ND virus can infect through the respiratory tract, the ocular mucous membranes and the digestive tract. The incubation period usually
ranges from 2 to 15 days depending on the strain of virus (Alders and Spradbrow, 2001).

The virulence of the disease depends on the particular strain of the virus. Of the highly virulent strains, which are particularly common in South-East Asia and Africa, some grow in the gut (viscerotropic), while others grow mainly in the central nervous system (neurotropic strains). The most common indication of a serious outbreak of a neurotropic strain of the disease is seen in a nervous symptom exhibited in infected birds where neck twist right back and the chickens simply fall and die (Alders and Sprawbrow, 2001). Less virulent strains, such as those that are endemic in Australia, affect only the respiratory system, with varying degrees of severity. Symptoms may include loss of appetite, a dramatic drop in egg production, increased respiration, and coughing, gasping and even rapid death without exhibition of other symptoms (Spradbrow, 1999).

2.2. Effects of climate on the outbreak and spread of Newcastle Disease.

Weather and Climate change is a phenomenon that currently can be recognized by many indicators and its impacts affect not only species and ecosystems but also human economy and society (IPCC, 2007). Newcastle poultry disease is affected directly or indirectly by weather and climate. These links may be spatial with climate affecting distribution, temporal with weather affecting timing of an outbreak or relate to the intensity of an outbreak. Outbreaks are often associated with alternating heavy rainfall, drought and high temperatures (Perry et al., 2002).
A study conducted by Njagi et al., (2010) revealed that Newcastle Disease Virus (NDV) was significantly higher (17.8 percent) in the dry hot zones compared to the cool wet zone at 9 percent showing climate as a risk factor in the occurrence of NDV in FRIC. Also Sonaiya (1999a) reported that the major outbreak of Newcastle disease regularly occur at the peak of the rain (June/July) and the dry season (January/February) during which mortality reaches 70 – 100% in Nigeria. Reports from Kenya (Anonymous 1996) and Ethiopia (Sonaiya 1999b) indicated that severity of this disease reached the peak in wet season but in dry season in West Africa (Mukiibi–Muka 1992; Gueye 1998). Unfortunately the period of high demand in dry season coincided with high incidence of Newcastle disease thus increasing its spread (Kuzonga et al., 2008). This high demand for FRIC in December/January for Christmas and New Year Celebrations is a major factor for its spread in Nigeria. Also a study done by Olabode et al., (2012) in Ilorin Kwara state in Nigeria revealed seasonal distribution of the disease indicated a higher occurrence in the dry season (October-March). Therefore pathogens or parasites that are sensitive to moist or dry conditions may be affected by changes in precipitation, soil moisture and frequent floods.

In relation to temperature, the virus can survive for more than 8 weeks in hot dry areas at temperatures of 40°C (Warner, 1989), for about 3 months at 20°C to 30°C and even longer at cooler temperatures (Lancaster, 1966). At 23°C -29°C, the virus (APMV-I) is reported to survive in contaminated litter for 10 to 14 days and 20°C in soil for 22 days (Institute of International Co-operation in Animal Biologics,
IICAB, 2005). When temperatures are just above freezing point (1-2°C) the virus is reported to survive on chicken skin up to 160 days and in bone marrow for nearly 200 days. APMV-1 can be inactivated by heat of 56°C for three hours or 60°C for 30 minutes (IICAB, 2005).

Airborne spread of ND was considered to be of major significance during the early outbreaks of 1970-1972 epidemics in Great Britain, but little significance is attached to airborne spread in reports from many countries (Alexander, 1988). High relative humidity and rainfall induce the outbreak of disease in poultry through the creation of a conducive breeding environment for disease pathogens (Obayela and Andeniyi, 2006). Overheating or chilling becomes a serious stress factor, which pre-disposes the bird to the disease. This brings in the climatic conditions such as the wet season when frequent rainfall affects the environment or the dry season when the temperatures may be high (Dontwi et al., 2011).

Newcastle Disease was first recognized in Indonesia in 1926 and has persisted as the major disease affecting poultry. Although little systematic research has been conducted on the epidemiology of ND in Indonesia, it is reputed to affect both indigenous and imported species of poultry throughout the country on what would appear to be a seasonal basis. Highest mortalities have been reported towards the end of the dry season for the months between July-September, the period which farmers refer to as 'musim penyakit' or the 'disease season' (Kingston and Creswell, 1982).
From the above discussion it is evident that climate influences the outbreak and spread of Newcastle disease, hence the need to determine its influence on FRIC in Suneka Division.

2.3 Other factors influencing the outbreak and spread of Newcastle Disease.

Studies have revealed that the level of performance of poultry does not only depend on inherited capacity but also to a greater extent upon the environment (Campell and Lasley, 1975). Among the factors contributing to the endemicity of Newcastle Disease (ND) in free range indigenous chicken include the age structure and immunity, concurrent infections, environmental factors which facilitate the spreading of the virus and affect the susceptibility of birds. According to Byarugaba et al (2012), epidemiological factors that maintain the spread of the disease include: uncontrolled contact between birds from different background, frequent introduction of birds from the market, contact with wild birds and selling of sick birds during outbreaks.

Outbreaks of ND may also occur as a result of movement of infected live (caged) birds (Clavijo et al., 2000), transmission from infected water fowl (Takakuwa, et al., 1998), contaminated people or equipment, infected poultry products (meat, feathers, blood, faeces, bones and poultry scraps), contaminated poultry feeds, drinking water and vaccines (Alexander, 1997). However, the greatest risk of the spread of NDV comes from the movement of people and equipment. Due to the centralization of many processes in the poultry industry there is intensive traffic of
personnel and vehicles (feed and chicken trucks, egg collectors, advisors, helpers, veterinarians and neighbours) moving from one flock to another (Kouwenhoven, 1993).

Further, wild birds can be the source of ND in FRIC. In Nigeria Velogenic, Mesogenic and Lentogenic strains of NDV have been found in wild birds and these were considered reservoirs and a source of dissemination of the virus to susceptible village poultry (Olabode et al., 1992). Also Hanson, cited by Higgins and Shortridge (1988), identified two wildlife reservoirs of NDV, chicken virulent NDV among migratory water fowl of temperate zones and chicken virulent NDV among tropical jungle birds. Other poultry species can also be infected with NDV and may play a role in the spread of NDV in intensively managed poultry. These birds include ducks, geese, turkeys, doves, guinea fowl and peacocks (Higgins and Shortridge, 1988; Warner, 1989, Martin 1992). In addition to this, animals such as dogs, cats, foxes and rodents shed their faeces 72 hours after having eaten infected fowl carcasses, thus they act as transient reservoirs of NDV due to their contact with village poultry and the village environment (White and Jordan, 1963).

Movement of people and equipment, movement of poultry products, contaminated feeds and water are probably the major source of infecting poultry. Farmers in Kenya try to sell their hens as soon as they show signs of disease (Musiime, 1992). This favours the introduction of NDV to other susceptible populations. The role of infected carcasses and poultry products are well recognised in the spread of
disease in commercial poultry (Alexander, 1988). In rural areas, sick birds are normally eaten by farmers and the viscera from birds fed to poultry, dogs and cats (Martin, 1992). The usual practice is to throw the viscera into the field where they are eaten by poultry and other animals, resulting in the spread of infection.

2.4 Socio-economic impacts of Newcastle Disease to poultry farmers

Newcastle Disease (ND) is an important limiting factor in the productivity of village poultry which results in great economic losses (Martin, 1992). According to Gueye (2002) and Byarugaba et al., (2012) ND occurs every year and kills on average 70% to 100% of unvaccinated FRIC in LIFDCs. In Tanzania, the mortality rate in affected flocks may reach 90 percent and the disease sometimes devastates entire flocks during outbreaks (Alders et al., 2000). In Kenya, ND is the most devastating disease in free range indigenous chicken (Awan et al., 1994). The disease results in great economic losses which come as a result of high mortality rates (Martin, 1992).

According to Bennett (2003), disease in poultry has seven main economic impacts, namely: i) reduction in the level of marketable outputs, ii) reduction in output quality, iii) waste or higher level of use of inputs, iv) resource costs associated with disease prevention and control, v) human health costs associated with disease or disease control, vi) negative animal welfare associated with disease and vii) international trade restrictions due to disease and its control. In addition, FAO (2001), considers poultry disease an example of invasive species, and categorizes
six areas of their impact namely, production effects, market and price effects, trade effects, impact on food security, human health and environment and financial costs. From the above literature, it is evident that ND causes great economic losses through deaths of chicken, lowers egg production since chicken lose appetite and causes conjunctivitis to human beings. NDV is a human pathogen and most common sign of infection is conjunctivitis that develops within 24 hours of NDV exposure to the eyes (Swayne and King, 2003).

2.5. Adaptive and mitigation measures used to manage Newcastle Disease

In order to control ND, the farmers use different approaches. Some use local treatments such as; use of “omo” washing detergent with food or water, using grounded garlic mixed with water, use of car battery water and grounding aloe put in drinking water (Dontwi et al., 2011). Aloe species is arguably the most important, as it is found in many geographical regions and is believed to be effective against a wide range of range of diseases and ailments. Okitoi et al., (2007) found that most poultry farmers in Western Kenya commonly use Aloe vera extracts to manage Newcastle disease.

Diseased birds and in some cases dead birds are eaten and some farmers bury the remains after eating and non-eaten chicken in pits. In addition to this, farmers sell their birds as quickly as possible when the signs of ND appear. In Uganda, birds usually die during the dry season due to disease outbreak. Therefore, most farmers start selling off their stocks just before the dry season, often when the birds are in
the incubated phase of ND (George, 1992). Farmers also take hygiene measures such as cleaning and disinfecting of poultry houses, observing personal hygiene when handling chicken such as removing shoes when entering poultry houses and washing hands before handling chicken. Other farmers also control parasites by deworming using traditional herbs such as garlic and administering drugs such as Ascarex D (Moreki, 2006). Some farmers also vaccinate their chicken using vaccines that are available at district and divisional veterinary offices and from local agro vets (Ondwassy et al., 1999).

From the literature review above the following knowledge gaps were identified.
### Table 2.1 Identified knowledge gaps

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Theme</th>
<th>Summary of findings</th>
<th>Gap identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danda et al.</td>
<td>2006</td>
<td>Characterization of the indigenous chicken sub-sector in the coastal lowlands of Kenya</td>
<td>Indigenous poultry production is faced by common diseases such as ND, fowl typhoid and eye infection</td>
<td>Did not examine the season of occurrence</td>
</tr>
<tr>
<td>Moreki</td>
<td>2006</td>
<td>Family poultry production</td>
<td>Chicken play an important role in poverty alleviation. ND was the major constraint in family poultry production</td>
<td>Did not address the influence of climate on the outbreak and spread of ND</td>
</tr>
<tr>
<td>Obayela and Andenyi</td>
<td>2006</td>
<td>The effects of climate on poultry productivity in Ilorin Kwara State, Nigeria</td>
<td>Diseases are common between May and October when relative humidity and rainfall are high.</td>
<td>The research did not examine the disease control methods</td>
</tr>
<tr>
<td>Kingori et al.</td>
<td>2010</td>
<td>Indigenous chicken production in Kenya. A review.</td>
<td>Indigenous chicken contribute to the national egg production despite their low productivity. Also ND was the most prevalent and fatal disease in Kenya</td>
<td>It did not examine the influence of climate variables on ND and season of occurrence.</td>
</tr>
</tbody>
</table>

### 2.6. Conceptual framework

From the literature review a conceptual framework was established (Figure 1). This was adopted from Wilcox and Colwell’s (2005) model on emerging and re-
emerging of infectious diseases. According to this model environmental change can affect the outbreak and spread of diseases in three ways: increasing the range or abundance of animal reservoirs or insect vectors, prolonging transmission cycle and increasing the importation of vectors or animal reservoirs, for example by air, to new regions which cause the establishment of disease in the region.

**Independent variable**

Weather parameters

**Dependent variable**

Newcastle disease

![Diagram](https://via.placeholder.com/150)

**Figure 2.1:** Conceptual Framework showing the relationship between climate, other factors, intervening variables and ND.

**Source:** Adopted and modified from Wilcox and Colwell, (2005).
In the conceptual framework, seasonal weather (temperature, rainfall and humidity) provide conducive conditions for the survival of the virus and therefore influences the outbreak of ND. Wind on the other hand, influences the spread of the disease from one region to another. Extraneous factors such as humans, dogs, general hygiene and size of the flock influences the spread of ND, hence the severity of this disease. Intervening variables such as sensitization about the disease, poultry policy on vaccination and research can reduce or increase the spread and severity of the disease. Sensitization can be done through seminars and workshops so as to educate small scale poultry farmers on various aspects of poultry keeping including how to manage different diseases. Further government policies such as vaccination and quarantine can aid in the control of the disease, hence reduce the severity of the disease.
CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design, variables, study area, target population, sample size and sampling technique, research instruments and data collection methods.

3.2 Research Design

The study adopted a descriptive research design that aimed at determining the seasonal occurrence of ND in relation to the elements of climate. It incorporated both primary and secondary methods in gathering information on the effect of climate variables and other factors on ND in free range chicken in Suneka Division, Kisii County.

3.3 Variables

This research took ND as the dependent variable and temperature, rainfall and relative humidity as the independent variables. The climatic elements were selected due to their effect on poultry production. Temperature is indicative of thermal stress, relative humidity affects breathing and food intake and utilization. Rainfall affects both the quality and quantity of feeds consumed (Obayela and Adenyi, 2006).
3.4 Study area

The study was conducted in Bomorenda, Iyabe and Riana locations in Suneka Division in Kisii South District, Kisii County (Figure 2). Kisii South District was curved out of the larger Kisii Central District and is one of the districts that make up Kisii county. The district is bordered by Gucha South district to the south, Rongo District to the west, Homabay District to the north, Kisii Central district to the east and Gucha district to south east. This area lies between latitude 0° 30’ S and 0° 54’S and longitude 34° 38’ E and 35° 02’E as shown in Figure 3.1 and occupies a total of 76.9 km².
Figure 3.1: Study Area, Suneka Division

Source: Modified from Kisii District Development plan, 2009
It is characterized by undulating and hilly topography and lies approximately 1500m above sea level (GOK, 2009). The overall slope of the area is towards the west; therefore the general drainage is in that direction.

The district exhibits a highland equatorial climate resulting into long and short rainfall pattern with an average annual rainfall of 1500mm and 60 percent reliability (800 mm in the short rains and 1200 mm in the long periods). Temperature ranges between 16\(^\circ\)C and 27\(^\circ\)C, with the coldest months being June, July and August while the hottest months are December and January (GOK, 2009).

Kisii South District had a population of 66,303 and 13,911 households according to 2009 census (MOA, 2010; GOK, 2009). About 90 percent of the land is arable. Crop farming and livestock keeping are the main economic activities. Poultry industry is the second priority ranking livestock enterprise in the district and indigenous or local birds are dominant (MOLD, 2008). The enterprise contributes about 40,569 trays of eggs and 36,532 kilograms of meat yearly (GOK, 2009).

### 3.5 Target population

The target population was small scale poultry farmers in Suneka Division. The area has a population of 66,303 people in 13,911 households found in three locations of Suneka Division (KNBS, 2010) as displayed in Table 3.1. The respondents were poultry farmers who had reared indigenous chicken for the last five years.
Table 3.1: Population distribution in the three location of Suneka Division.

<table>
<thead>
<tr>
<th>Location/sub location</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Households</th>
<th>Area in sq km</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOMORENDA</td>
<td>11,855</td>
<td>13,194</td>
<td>25,049</td>
<td>5,354</td>
<td>18.4</td>
<td>1,365</td>
</tr>
<tr>
<td>Bomakombi</td>
<td>3,399</td>
<td>4,026</td>
<td>7,425</td>
<td>1,504</td>
<td>6.0</td>
<td>1,235</td>
</tr>
<tr>
<td>Bomwancha</td>
<td>1,599</td>
<td>1,768</td>
<td>3,367</td>
<td>693</td>
<td>2.5</td>
<td>1,334</td>
</tr>
<tr>
<td>Bonyanchaire</td>
<td>3,697</td>
<td>4,034</td>
<td>7,731</td>
<td>1,759</td>
<td>4.4</td>
<td>1,746</td>
</tr>
<tr>
<td>Bonyaoro</td>
<td>3,160</td>
<td>3,366</td>
<td>6,526</td>
<td>1,398</td>
<td>5.4</td>
<td>1,210</td>
</tr>
<tr>
<td>IYABE</td>
<td>9,800</td>
<td>10,691</td>
<td>20,491</td>
<td>4,275</td>
<td>27.2</td>
<td>752</td>
</tr>
<tr>
<td>Bokeire</td>
<td>3,292</td>
<td>3,611</td>
<td>6,903</td>
<td>1,461</td>
<td>8.4</td>
<td>821</td>
</tr>
<tr>
<td>Bomokora</td>
<td>6,502</td>
<td>7,080</td>
<td>13,588</td>
<td>2,814</td>
<td>18.8</td>
<td>722</td>
</tr>
<tr>
<td>RIANA</td>
<td>9,789</td>
<td>10,974</td>
<td>20,763</td>
<td>4,282</td>
<td>31.3</td>
<td>664</td>
</tr>
<tr>
<td>Bogitaal</td>
<td>4,888</td>
<td>5,486</td>
<td>10,374</td>
<td>2,203</td>
<td>16.4</td>
<td>635</td>
</tr>
<tr>
<td>Nyamwari</td>
<td>4,901</td>
<td>5,488</td>
<td>10,389</td>
<td>2,079</td>
<td>14.9</td>
<td>696</td>
</tr>
</tbody>
</table>

Source: National population census, (KNBS, 2009)

3.6 Sampling techniques and sample size

3.6.1 Sampling techniques

The research used simple random and purposive sampling methods. The randomly chosen locations were: Bomorenda, Iyabe and Riana locations of Kisii South. Further, the study divided the location into sub locations. Farmers were chosen using snow balling sampling technique.
3.6.2 Sample size

The sample size was 200 households which were calculated as shown below.

Mathematical formula suggested by Nassiuma (2000) was used to determine the sample size.

\[ n = \frac{NC^2}{C^2 + (N - 1)e^2} \]

Where \( n \) = sample size

\( N \) = population, 13911 in this case

\( C \) = co-efficient of variation, assumed to be 70.9 % for most survey research

\( e \) = standard error assumed to be 0.05 in this case

Substituting these values in the equation, estimated sample size was:

\[ n = \frac{13911(0.79)^2}{0.79^2 + (13911 - 1) 0.05^2} \]

\[ n = 200 \]

Sample sizes for each location were calculated as follows:

**Table 3.2: Sample sizes for each location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Calculation of number of households per location</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bomorenda</td>
<td>5354/13911(200)</td>
<td>77 households</td>
</tr>
<tr>
<td>Iyabe</td>
<td>4275/13911(200)</td>
<td>61 households</td>
</tr>
<tr>
<td>Riana</td>
<td>4282/13911(200)</td>
<td>62 households</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>200 households</strong></td>
</tr>
</tbody>
</table>
Sample size for each location = (Number of household per location / number of households in the three locations) × total sample size. i.e Sample size for Bomorenda location = 5354/13911 ×200 =77 households. The total number of respondents interviewed was 200 households. In every sub-location sample sizes were arrived as shown in table 3.3 below.

**Table 3.3: Sample sizes for each sub-location**

<table>
<thead>
<tr>
<th>Location/ sub-location</th>
<th>Calculation of no. of households per sub-location</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOMORENDA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bomakombi</td>
<td>1504/5354((77)</td>
<td>22</td>
</tr>
<tr>
<td>Bomwancha</td>
<td>693/5354(77)</td>
<td>10</td>
</tr>
<tr>
<td>Bonyancharie</td>
<td>1759/5354(77)</td>
<td>25</td>
</tr>
<tr>
<td>Bonyaoro</td>
<td>1398/5354(77)</td>
<td>20</td>
</tr>
<tr>
<td>IYABE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bokeire</td>
<td>1461/4275(61)</td>
<td>21</td>
</tr>
<tr>
<td>Bomokora</td>
<td>2814/4275(61)</td>
<td>40</td>
</tr>
<tr>
<td>RIANA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bogitaa</td>
<td>2203/4282(62)</td>
<td>32</td>
</tr>
<tr>
<td>Nyamwari</td>
<td>2079/4282(62)</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>
3.7 Data collection tools

Both primary and secondary data were collected. Primary data was collected from poultry farmers using questionnaires (Appendix 1). It had both open-ended and closed questions. Interview schedules (Appendix 2) were used for veterinary officers. Data collected included, season of ND occurrence over 2007-2011, mortality of FRIC, socio-economic impacts of ND to poultry farmers and mitigation and adaptive measures put in place to manage ND. Data from the farmers was collected from September to December 2012. Table 3.4 shows data collected for each objective and the measurable variables.

Secondary data on climatic variables (temperature, humidity and rainfall) on monthly basis was collected from Kisii Meteorological Department for 2007-2011. The climatic elements were selected due to their effect on poultry production and ND. Temperature is indicative of thermal stress, relative humidity affects breathing and food intake and utilization. Rainfall affects both the quality and quantity of feeds consumed by the birds (Obayela and Adenyi, 2006).
Table 3.4: Objectives and measurable variables

<table>
<thead>
<tr>
<th>Objective</th>
<th>Data required</th>
<th>Measurable variables</th>
<th>Methods of data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.To investigate the relationship between climatic variables and the occurrence of ND</td>
<td>• Rainfall&lt;br&gt;• Temperature&lt;br&gt;• Humidity&lt;br&gt;• Season of occurrence of ND&lt;br&gt;• Number of deaths</td>
<td>Rainfall&lt;br&gt;Humidity&lt;br&gt;Temperature&lt;br&gt;Deaths</td>
<td>Mean, Karl Pearson correlation method</td>
</tr>
<tr>
<td>2. To investigate factors other than climate that influence the outbreak and spread of ND</td>
<td>• Other factors</td>
<td>Other factors</td>
<td>Measures of central tendency (mode), frequency table</td>
</tr>
<tr>
<td>3. To assess the socio-economic impacts of ND to Poultry farmers</td>
<td>• Socio-economic impacts</td>
<td>Number of deaths</td>
<td>Percentiles&lt;br&gt;Mean</td>
</tr>
<tr>
<td>4. To assess the adaptive and mitigative measures put in place to control ND</td>
<td>• Vaccination&lt;br&gt;• Government support&lt;br&gt;• Other methods of disease control</td>
<td>Methods of disease control</td>
<td>Percentiles</td>
</tr>
</tbody>
</table>

3.8 Pilot Study

Pilot study is important in ensuring that the study reasonably adopts a plan and approach that will significantly guarantee the purpose of investigation (Gay,
A pilot study was done before the commencement of data collection to test on the suitability of the data collection tools. The pilot study was done in Bonyando sub location, Bogiakumu location of Kisii County. Five poultry farmers were interviewed during the month of September 2012. Two research assistants were hired to aid in administering the questionnaires. The pilot study allowed for reformatting of the questionnaire so as to achieve the desired objectives of the study. This also ensured the validity of the instrument on the structure and content.

3.8.1 Validity of the instruments

Validity refers to the degree in which a test or other measuring device is truly measuring what we intended it to measure. It should be based upon careful analyses by several specialists of instructional objectives and of actual subject matter studied. The questionnaire and interview schedule for this study were prepared and submitted to experts in the School of Humanities and Social Sciences at Kenyatta University for advice on the structure and content.

3.8.2 Reliability of the instruments

According to Mwiria and Wamahiu (1995), a research instrument is reliable to the extent it measures what it is supposed to measure consistently. The degree of consistency between the test scores, responses or observations is called reliability (Denscombe, 1998). In this study, test and re-test method was adopted to assess reliability (Mugenda and Mugenda, 2003). In this approach, questionnaires were administered twice to the same poultry farmers. Data from poultry farmers was
collected from the start and at the end of September 2012 using the same questionnaire. The correlation of reliability was found to be 0.9. This showed a high reliability hence the instrument was reliable.

3.9 Methods of data analysis

Descriptive data was analysed by objectives and hypothesis. Climatic variables were analysed using the arithmetic mean for the five years. Hypothesis testing was done using the Karl Pearson Coefficient of Correlation. The Statistical Package for Social Sciences (SPSS) was used in testing of hypotheses and in the analysis of empirical data. The significance level for each hypothesis was invariably decided at 5% level of significance because this is a social research where humans are social beings. The analysed data was presented using frequency tables.

The Karl Pearson coefficient of correlation method was used to test the hypothesis; \( H_0: \) There is no significant relationship between climatic variables and the outbreak and spread of Newcastle Disease. It is a method of measuring the degree of relationship between two variables. The coefficient assumes the following:

i) That there is a linear relationship between two variables.

ii) That one variable is independent and the other is dependent.

iii) A large number of independent causes are operating in both variables so as to produce a normal distribution.

Karl Pearson Coefficient of Correlation \( (r) = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{n \sigma_x \sigma_y} \)

Where:
\( x_i = \text{\(i^{th}\) value of x variable} \)
\( x = \text{mean of x} \)
\( y_i = \text{\(i^{th}\) value of y variables} \)
\( y = \text{mean of y} \)
\( \sigma_x = \text{standard deviation of x} \)
\( \sigma_y = \text{Standard deviation of y} \)

The \( r \) value lies between \( \pm 1 \).

\( r^2 = \text{coefficient of determination (\% of the dependent explained by the independent variables)} \)

Positive value of \( r \) indicates positive correlation between the two variables and a negative value indicates a negative relationship while zero, shows no relationship (Kothari, 1996, Shaw and Wheeler 1985).
CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter interprets and explains the findings with regard to the stated research objectives and hypothesis.

4.2 Demographic characteristics of households

Findings revealed that 51 percent of the FRIC farmers interviewed were female while 49 percent were male (Table 4.1)

Table 4.1: Gender of the respondents

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>102</td>
<td>51.0</td>
</tr>
<tr>
<td>Male</td>
<td>98</td>
<td>49.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The higher number of female can be attributed to prevailing cultural traditions where women are more involved in household and food production chores. This includes rearing of indigenous chicken, which is seen more of a woman’s than man’s enterprise.

In relation to age 89 percent of the respondents were between the ages of 19-54 and 11 percent were 55 and above (Table 4.2).
Table 4.2: Age of respondents

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-35</td>
<td>66</td>
<td>33.0</td>
</tr>
<tr>
<td>35-54</td>
<td>112</td>
<td>56.0</td>
</tr>
<tr>
<td>55 and above</td>
<td>22</td>
<td>11.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The implications are that most of these people are in their productive age 19-54, hence, they can engage in activities to enhance income generation and food security. Therefore, they can undertake FRIC keeping activities to eke a living.

Findings also showed that in education levels, at least 40 percent of the respondents had reached tertiary level of education, 36 percent secondary, 22 percent primary and 3 percent had no formal education (Table 4.3).

Table 4.3: Educational level of the respondents

<table>
<thead>
<tr>
<th>Level</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No education</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Primary</td>
<td>44</td>
<td>22.0</td>
</tr>
<tr>
<td>Secondary</td>
<td>70</td>
<td>36.0</td>
</tr>
<tr>
<td>Higher</td>
<td>80</td>
<td>40.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The farmer’s level of education influences the way a person searches and responds to information received. According to Morgan and Munton (1972), young and highly educated farmers are more prepared to take risks in order to try out new ideas than elderly farmers. The level of education of a farmer is also important in
understanding the basic concepts in indigenous and modern methods of weather forecasting and making choices on vaccination.

In relation to the family size, result showed that 21 percent of the respondents had six members and above, 60 percent had between four and five, and 19 percent between one and three members (Table 4.4). This was an indication of a higher population; hence need for more food resources.

**Table 4.4: Family size of the respondents**

<table>
<thead>
<tr>
<th>Number of persons</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>13.0</td>
</tr>
<tr>
<td>4</td>
<td>58</td>
<td>29.0</td>
</tr>
<tr>
<td>5</td>
<td>62</td>
<td>31.0</td>
</tr>
<tr>
<td>6 and above</td>
<td>42</td>
<td>21.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Among the people interviewed, 56.5 percent were small-scale farmers, 19.5 percent commercial farmers, 12 percent teachers, 11 percent civil servants and one percent others (Table 4.5).

**Table 4.5: Occupation of the respondents**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small-scale farmer</td>
<td>113</td>
<td>56.5</td>
</tr>
<tr>
<td>commercial farmer</td>
<td>39</td>
<td>19.5</td>
</tr>
<tr>
<td>Teacher</td>
<td>24</td>
<td>12.0</td>
</tr>
<tr>
<td>Civil servant</td>
<td>22</td>
<td>11.0</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>
A larger number of small-scale farmers indicated the need for many small economic activities to sustain their living.

In order to know the type of livestock activity carried out in Suneka Division, respondents were asked the type of livestock farming they engaged in. The findings revealed that at least every person interviewed kept livestock. Seventy six percent of the respondents kept livestock and poultry, 23 percent kept poultry only and 1 percent kept only livestock (Table 4.6).

**Table 4.6: Type of Animal kept**

<table>
<thead>
<tr>
<th>Type of Animal kept</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Poultry</td>
<td>46</td>
<td>23.0</td>
</tr>
<tr>
<td>Both</td>
<td>152</td>
<td>76.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

This implies that poultry and livestock are interdependent on, in that wastes from each can be used as food. For example free range indigenous chicken feed on cow dung and faeces from chicken is a nutritive source of mineral to the cattle. Also the remains are used as manure in the farms. From these findings, it shows that almost all households engage in chicken rearing. This shows the importance of this activity to the households. Indeed 99 percent of the respondents keep chicken and only one percent did not. This agrees with Kingori *et al.* (2010) who found out that FRIC was of importance to many rural populations and contributed to the national egg production.
Findings also revealed that 76 percent of the respondents reared indigenous chicken. This is because FRIC are hardy, adapt well to the rural environments and adapt to fluctuations of feed resources. Twenty two percent of the respondents reared indigenous and hybrid chicken and 2 percent only the hybrid (Table 4.7).

**Table 4.7: Types of chicken kept**

<table>
<thead>
<tr>
<th>Chicken Type</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous</td>
<td>152</td>
<td>76.0</td>
</tr>
<tr>
<td>Hybrid</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>(Broilers and layers)</td>
<td>44</td>
<td>22.0</td>
</tr>
<tr>
<td>Both</td>
<td>44</td>
<td>22.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

This agrees with responses from veterinary officers that FRIC was the most common type of chicken kept in the area which were about 118,871 birds.

This implies that people prefer FRIC which scavenge on the local environment hence reduces the expenses of purchasing commercial feeds. Further, the small land sizes of land which are less than one acre (Table 4.8), in this division have contributed to FRIC keeping as it requires less space. Hybrid types of chicken kept included broilers and layers.

**Table 4.8: Land size**

<table>
<thead>
<tr>
<th>Land size</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than one acre</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>
When asked about the number of FRIC kept, it was found out that 52% kept 31 and above birds, 28% kept 11-30 while 19% had less than 10 chicken (Table 4.9).

**Table 4.9: Number of indigenous chicken kept in each household**

<table>
<thead>
<tr>
<th>Number of chicken</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>38</td>
<td>19.0</td>
</tr>
<tr>
<td>11-30</td>
<td>56</td>
<td>28.0</td>
</tr>
<tr>
<td>31-50</td>
<td>28</td>
<td>14.0</td>
</tr>
<tr>
<td>51-99</td>
<td>32</td>
<td>16.0</td>
</tr>
<tr>
<td>100 and above</td>
<td>44</td>
<td>22.0</td>
</tr>
<tr>
<td>Total</td>
<td>198</td>
<td>99.0</td>
</tr>
</tbody>
</table>

This implied that productivity is low, since 61 percent keep less than 50 chickens. Therefore, there is need to improve productivity through adapting modern methods of poultry rearing such as foster brooding.

**4.3 Socio-economic impacts of Newcastle Disease to poultry farmers**

Poultry keeping plays an important role in the lives of small scale farmers. Most of the respondents (100%) reported that chicken gave them quick returns as compared to other livestock. The benefits enjoyed by these farmers included food (meat and eggs), income, manure and feathers that are used for decorations as reported by the farmers. Some farmers kept the chicken as pets. This agree with Kingori *et al* (2010) who found out that FRIC played an important role in the improvement of the nutritional status and income of many poor rural households who live below the poverty line.
When asked on the reasons for raising FRIC, 83 percent was for regular consumption, 69 percent serving guests, 48 percent regular sale, 21 percent cultural ceremonies, 14 percent consumption during holidays, 20 percent sale of eggs and 1 percent other functions such as pets (Table 4.10). This agrees with Kingori et al., (2010) who found out that poultry provides protein consumed in the developing countries especially Kenya and Robyn, (2009) who also found that FRIC played a role in provision of food and income to farmers in Tanzania.

Table: 4.10 Reasons for raising free range indigenous chicken among households in Suneka Division

<table>
<thead>
<tr>
<th>Reason</th>
<th>% of households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular consumption</td>
<td>83</td>
</tr>
<tr>
<td>Serving Guests</td>
<td>69</td>
</tr>
<tr>
<td>Regular sale</td>
<td>32</td>
</tr>
<tr>
<td>Cultural Ceremonies</td>
<td>21</td>
</tr>
<tr>
<td>Consumption in Holidays</td>
<td>14</td>
</tr>
<tr>
<td>Sale of eggs</td>
<td>20</td>
</tr>
<tr>
<td>Other functions such as pets</td>
<td>1</td>
</tr>
</tbody>
</table>

On average, a chicken was sold for Ksh. 400, with a cockerel fetching Ksh. 600. This money was then used to purchase household goods and services. Further chicken represented the easiest source of high quality proteins.
However, there were also challenges mentioned in poultry keeping by all the farmers. These were identified as, lack of enough feeds, predation by wild birds and animals such as dogs, theft and diseases especially “Omosando” or Newcastle. Free Range Indigenous Chickens were left to scavenge for food on their own from the local environment. Often they did not gather enough, resulting to slow growth and reduced productivity. Further, as they searched for food, they were predated by wild birds like eagles, mongoose, and dogs. Respondents also reported theft as the serious problem in the area. Chickens were stolen during the day when nobody was found in the homestead and also during the night. This agreed with veterinary officers who reported that FRIC farmers faced the following challenges diseases especially ND, high cost of feeds and poor management skills. This is in agreement with Robyn, (2009) who found that in Mozambique FRIC farmers were affected by ND, predators, fleas, internal parasites theft and shortage of feeds.

ND was the major disease that affected small scale farmers in this area as reported by the veterinary officers. The ND virus could be infected through the respiratory tract, the ocular mucous membrane and digestive tract as reported by the veterinary officer. This implied that ND was a major challenge and therefore monitoring of the disease dynamics was necessary especially in relation to weather changes in order to control it.

When asked whether FRIC were affected by ND for the last two years, 99% of the farmers agreed while only 1 percent reported of no attacks (Table 4.11).
Table 4.11: Responses of farmers on ND attacks

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>198</td>
<td>99.0</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

This agrees with Okwor and Eze (2011) who found out that ND was a menace to local chickens in South East Savannah Zone in Nigeria.

4.3.1 Effects of Newcastle Disease outbreaks to the farmers

ND outbreak caused huge losses to farmers. Among the reported effects included loss of income, lower egg production and lower prices of chicken in the market. All the farmers reported that outbreaks of ND reduced prices of chickens and egg production. ND reduced the chickens’ appetite for feed and this reduced egg production. The disease affected all age categories of chicken and all types of chickens including FRIC, broilers, brooders and layers as reported by farmers (Table 4.12). This agrees with Chantal, et al., (2013) in Nigeria who found that chicken were more infected than any other birds. It also agrees with Robyn, (2009) who found that ND caused mortalities to all age groups of chicken from chicks to adults.
Table 4.12: Categories of chicken affected by ND

<table>
<thead>
<tr>
<th>Category affected by ND</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicks</td>
<td>43</td>
<td>21.5</td>
</tr>
<tr>
<td>Broilers</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>All</td>
<td>151</td>
<td>75.5</td>
</tr>
<tr>
<td>Layers</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Brooders</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

During ND outbreaks, every farmer sold their flock before the attack became severe so as to fetch some income. This led to higher supply of chicken which eventually lowered the prices of chicken by almost half the price as reported by the farmers.

Further, outbreaks of ND increased the production expenses as farmers needed to purchase drugs to treat the sick chicken. Farmers had to pay for the vaccine at between Ksh. 10 and 5 per chicken. This agrees with IICAB, (2009) who found that in United States ND epidemic in 2002-2003 resulted in the death of more than three million birds and caused the industry losses estimated at $5 million.

4.4 Relationship between climatic variables and the occurrence of Newcastle Disease in FRIC in Suneka Division

Climate variability can affect poultry both directly and indirectly (Mcpeak, 2006). Direct effects are from air temperature, humidity and rainfall which influence poultry performance, growth and egg production. Indirect effects include climatic
influences on severity and distribution of poultry diseases and parasites (Seo and Mendelsohn, 2006).

In relation to ND, changes in temperature, humidity and rainfall influenced the outbreak and severity of the disease in FRIC. When respondents were asked if changes in climatic variables had influence on the outbreak and spread of ND, 98.5 percent agreed that it had while 1.5 percent had no knowledge about it. This is in agreement with Dontwi et al., (2011) who found out that wet season or dry season predisposes the FRIC to diseases.

Further, when respondents were asked the months in which ND occurred, 74 percent reported that it occurred in July-August, 24 percent December- January and only 2 percent were not sure (Table 4.13). This agrees with Olabode (2012) who found that ND occurrence was higher in the dry season between October and March with the peaks in November and December in Nigeria.

**Table 4.13: Responses on season of occurrence of ND in Suneka Division**

<table>
<thead>
<tr>
<th>Season</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>July-August</td>
<td>149</td>
<td>74.5</td>
</tr>
<tr>
<td>Dec-January</td>
<td>47</td>
<td>23.5</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Relating these months to temperature, rainfall and humidity, it was found out that temperature for July was the lowest for the five years. The temperatures recorded
in the month of August were higher than July for the five years. Also temperatures were higher in January than December (Table 4.14).

**Table 4.14: Mean Monthly Temperature in °C for the years 2007-2011**

<table>
<thead>
<tr>
<th>Year/ Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>20.9</td>
<td>21.4</td>
<td>21.8</td>
<td>21.3</td>
<td>20.9</td>
<td>19.8</td>
<td>19.5</td>
<td>19.9</td>
<td>20.5</td>
<td>20.7</td>
<td>20.5</td>
<td>20.8</td>
</tr>
<tr>
<td>2008</td>
<td>21.5</td>
<td>21.9</td>
<td>21.3</td>
<td>20.3</td>
<td>20.7</td>
<td>19.7</td>
<td>18.9</td>
<td>20.0</td>
<td>20.9</td>
<td>20.4</td>
<td>20.6</td>
<td>21.5</td>
</tr>
<tr>
<td>2009</td>
<td>23.4</td>
<td>22.0</td>
<td>22.4</td>
<td>20.7</td>
<td>20.3</td>
<td>20.6</td>
<td>20.4</td>
<td>20.9</td>
<td>21.1</td>
<td>21.1</td>
<td>21.1</td>
<td>20.8</td>
</tr>
<tr>
<td>2010</td>
<td>21.6</td>
<td>22.0</td>
<td>21.1</td>
<td>21.6</td>
<td>20.9</td>
<td>20.7</td>
<td>20.1</td>
<td>20.7</td>
<td>20.4</td>
<td>20.8</td>
<td>21.0</td>
<td>20.7</td>
</tr>
<tr>
<td>2011</td>
<td>21.5</td>
<td>22.3</td>
<td>21.6</td>
<td>21.3</td>
<td>20.9</td>
<td>20.1</td>
<td>19.7</td>
<td>19.9</td>
<td>20.3</td>
<td>19.8</td>
<td>19.9</td>
<td>21.1</td>
</tr>
<tr>
<td>Mean</td>
<td>21.8</td>
<td>21.9</td>
<td>21.6</td>
<td>21.0</td>
<td>20.7</td>
<td>20.2</td>
<td>19.7</td>
<td>20.3</td>
<td>20.6</td>
<td>20.6</td>
<td>20.6</td>
<td>21</td>
</tr>
</tbody>
</table>

*Source: Kisii Meteorological Department, 2014*

The mean temperature for the five years was in January was 21.8 °C while for December was 21°C, July was 19.7 °C while in August 20.3 °C. Generally July recorded the lowest temperatures while January was among the second highest after February. The mean annual temperatures are higher for the four months. This agrees with Njagi *et al* (2010) who found out that NDV was significantly higher in drier zones.
Table 4.15: Total monthly rainfall in mm for the years 2007-2011

<table>
<thead>
<tr>
<th>Year/ Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>188.6</td>
<td>179.5</td>
<td>151.1</td>
<td>172.3</td>
<td>246.7</td>
<td>191.4</td>
<td>139.3</td>
<td>70.7</td>
<td>158.9</td>
<td>125.4</td>
<td>97.5</td>
<td>96.6</td>
</tr>
<tr>
<td>2008</td>
<td>30.8</td>
<td>59.5</td>
<td>304.1</td>
<td>291.1</td>
<td>118.5</td>
<td>136.0</td>
<td>220.6</td>
<td>191.7</td>
<td>168.9</td>
<td>241.0</td>
<td>154.3</td>
<td>82.1</td>
</tr>
<tr>
<td>2009</td>
<td>120.8</td>
<td>54.7</td>
<td>252.2</td>
<td>242.0</td>
<td>311.1</td>
<td>183.1</td>
<td>70.0</td>
<td>213.0</td>
<td>145.3</td>
<td>94.1</td>
<td>133.4</td>
<td>310.0</td>
</tr>
<tr>
<td>2010</td>
<td>108.6</td>
<td>106.5</td>
<td>217.7</td>
<td>244.6</td>
<td>375.7</td>
<td>252.3</td>
<td>80.3</td>
<td>178.1</td>
<td>256.7</td>
<td>256.9</td>
<td>109.3</td>
<td>170.3</td>
</tr>
<tr>
<td>2011</td>
<td>101.0</td>
<td>44.7</td>
<td>141.9</td>
<td>228.4</td>
<td>235.1</td>
<td>94.4</td>
<td>99.1</td>
<td>226.4</td>
<td>226.0</td>
<td>209.2</td>
<td>312.6</td>
<td>220.2</td>
</tr>
<tr>
<td>mean</td>
<td>110</td>
<td>89</td>
<td>213.4</td>
<td>235.7</td>
<td>257.4</td>
<td>171.4</td>
<td>121.9</td>
<td>176</td>
<td>191.2</td>
<td>185.3</td>
<td>161.4</td>
<td>175.8</td>
</tr>
</tbody>
</table>

Source: Kisii Meteorological Department, 2014

The mean annual rainfall for five years in January was 110 mm; July was 121 mm, August 176 mm and December 175.8 mm. This shows that ND occurs after the long rains MAM and short rains OND.
Table 4.16: Monthly Relative Humidity (%) For The Years 2007-2011

<table>
<thead>
<tr>
<th>Year/month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>67</td>
<td>60</td>
<td>57</td>
<td>63</td>
<td>65</td>
<td>70</td>
<td>68</td>
<td>65</td>
<td>62</td>
<td>62</td>
<td>63</td>
<td>59</td>
</tr>
<tr>
<td>2008</td>
<td>59</td>
<td>47</td>
<td>31</td>
<td>73</td>
<td>70</td>
<td>67</td>
<td>70</td>
<td>66</td>
<td>52</td>
<td>61</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td>2009</td>
<td>40</td>
<td>40</td>
<td>48</td>
<td>68</td>
<td>66</td>
<td>68</td>
<td>48</td>
<td>57</td>
<td>52</td>
<td>63</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>2010</td>
<td>52</td>
<td>45</td>
<td>57</td>
<td>63</td>
<td>67</td>
<td>68</td>
<td>62</td>
<td>70</td>
<td>37</td>
<td>65</td>
<td>72</td>
<td>70</td>
</tr>
<tr>
<td>2011</td>
<td>55</td>
<td>60</td>
<td>69</td>
<td>66</td>
<td>70</td>
<td>66</td>
<td>62</td>
<td>61</td>
<td>67</td>
<td>66</td>
<td>59</td>
<td>60</td>
</tr>
<tr>
<td>Mean</td>
<td>54.6</td>
<td>50.4</td>
<td>52.4</td>
<td>66.6</td>
<td>67.6</td>
<td>67.8</td>
<td>62</td>
<td>63.8</td>
<td>54</td>
<td>63.4</td>
<td>66.8</td>
<td>63.4</td>
</tr>
</tbody>
</table>

Source: Kisii Meteorological Department, 2014

The relative humidity was 54.6% in January, 62% in July, 63.8% in August and 63.4 % in December. July to August is classified as the coldest months as July recorded the lowest temperatures for the five years while December and January are the hottest months (G.O.K, 2009). When asked which element of weather influenced the outbreak of ND, most of the respondents reported that changes in rainfall and temperatures caused the outbreak and its spread. This agrees with Olabode (2012) who found that ND occurrence was higher in the dry season between October and March with the peaks in November and December in Nigeria.

Dontwi et al, (2011) and Obayela and Andeniyi, (2006) who found that the dry and wet season can create conducive breeding environment for disease causing organisms. During these two periods, there were losses of chicken through deaths of chicken. When respondents were asked on the number of deaths, 33 percent
gave a range of 1-30, 61 percent, 31-99, 3 percent 100 and above and 3 percent would not recall the number that had died (Table, 4.17).

Table: 4.17: Number of deaths caused by ND per year

<table>
<thead>
<tr>
<th>No. of deaths</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>12</td>
<td>6.0</td>
</tr>
<tr>
<td>11-30</td>
<td>54</td>
<td>27.0</td>
</tr>
<tr>
<td>31-50</td>
<td>78</td>
<td>39.0</td>
</tr>
<tr>
<td>51-99</td>
<td>44</td>
<td>22.0</td>
</tr>
<tr>
<td>100 and above</td>
<td>6</td>
<td>3.0</td>
</tr>
<tr>
<td>Not recall</td>
<td>6</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

This implies that outbreaks of ND cause losses to the farmers particularly through death of the chicken. This agrees with Alders et al (2000) who found out mortality rate in flocks affected by ND was about 90% in Tanzania. The following were the responses on Monthly deaths due to ND:
### Table 4.18: Monthly deaths

<table>
<thead>
<tr>
<th>Month</th>
<th>Deaths</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1-10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>11-30</td>
<td>21</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>31-50</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>51-99</td>
<td>33</td>
<td>16.5</td>
</tr>
<tr>
<td></td>
<td>100 and above</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>July</td>
<td>1-10</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>11-30</td>
<td>29</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>31-50</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>51-99</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>100 and above</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>August</td>
<td>1-10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>11-30</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>31-50</td>
<td>11</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>51-99</td>
<td>13</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>100 and above</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>December</td>
<td>1-10</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>11-30</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>31-50</td>
<td>7</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>51-99</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>100 and above</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
A correlation between monthly deaths due to ND and the climatic variables showed the following:

**Table 4.19: Correlation between Monthly Deaths and Relative humidity for the month of August**

<table>
<thead>
<tr>
<th>Monthly Deaths for August</th>
<th>Pearson Correlation</th>
<th>Sig.(2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.328</td>
<td>.590</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation ($r = 0.328$) between humidity and ND for the month of August. The null hypothesis that there is no significant relationship between humidity and ND for the month of August is not rejected ($p = 0.590$) at 5% level of significance. The coefficient of determination $r^2 = 10.76\%$ means that relative humidity contributed to 10.76% of the monthly deaths of chicken in the month of August.

**Table 4.20: Correlation between Monthly Deaths and Relative humidity for the month of December**

<table>
<thead>
<tr>
<th>Monthly Deaths for December</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.596</td>
<td>.288</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation ($r = 0.596$) between humidity and ND for the month of December. The null hypothesis that there is no significant
relationship between humidity and ND for the month of December is not rejected (p = 0.288) at 5% level of significance. The coefficient of determination $r^2 = 35.52\%$ means that relative humidity contributed to 35.52% of the monthly deaths of chicken in the month of December.

**Table 4.21: Correlation between Monthly Deaths and Relative humidity for the month of July**

<table>
<thead>
<tr>
<th>Monthly Deaths for July</th>
<th>July Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>-.576</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.309</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a negative Pearson Correlation ($r = -0.576$) between humidity and ND for the month of July. The null hypothesis that there is no significant relationship between humidity and ND for the month of July is not rejected (p = 0.309) at 5% level of significance. The coefficient of determination $r^2 = 33.18\%$ indicating that relative humidity contributed to 33.18% of the monthly deaths of chicken in the month of July.

**Table 4.22: Correlation between Monthly Deaths and Relative humidity for the month of January**

<table>
<thead>
<tr>
<th>Monthly Deaths for January</th>
<th>January Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>-.418</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.048</td>
</tr>
<tr>
<td>N</td>
<td>5</td>
</tr>
</tbody>
</table>
There is a negative Pearson Correlation ($r = -0.418$) between relative humidity and ND for the month of January. The null hypothesis that there is no significant relationship between humidity and ND for the month of January is rejected ($p = 0.048$) at 5% level of significance. The coefficient of determination $r^2 = 17.47\%$ suggesting that relative humidity contributed to 17.47% of the monthly deaths of chicken in the month of January.

Table 4.23: Correlation between Monthly Deaths and Rainfall for the month of July

<table>
<thead>
<tr>
<th>July Deaths for</th>
<th>Monthly Pearson Correlation Sig. (2-tailed)</th>
<th>July Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-0.549</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.338</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

There is a negative Pearson Correlation ($r = -0.549$) between rainfall and ND. However, the null hypothesis that there is no significant relationship between rainfall and ND in the month of July is not rejected ($p = 0.338$) at 5% level of significance. The coefficient of determination, $r^2 = 30.14\%$ meaning that rainfall contributed to 30.14% of the monthly deaths of chicken in July.

Table 4.24: Correlation between Monthly Deaths and Rainfall for the month of August

<table>
<thead>
<tr>
<th>Monthly Deaths for August</th>
<th>Pearson Correlation Sig. (2-tailed)</th>
<th>August Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.286</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.641</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>
There is a positive Pearson Correlation ($r = 0.286$) between rainfall and ND. However, the null hypothesis that there is no significant relationship between rainfall and ND in the month of August is not rejected ($p = 0.641$) at 5% level of significance. In August, the coefficient of determination, $r^2 = 8.18\%$ implying that rainfall contributed to 8.18% of the monthly deaths of chicken.

Table 4.25: Correlation between Monthly Deaths and Rainfall for the month of December

<table>
<thead>
<tr>
<th>Monthly Deaths for December</th>
<th>Pearson Correlation Sig. (2-tailed)</th>
<th>December Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r = 0.275$</td>
<td>$p = 0.654$</td>
</tr>
<tr>
<td></td>
<td>$N = 5$</td>
<td>$r^2 = 7.56%$</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation ($r = 0.275$) between rainfall and ND. However, the null hypothesis that there is no significant relationship between rainfall and ND in the month of December is accepted ($p = 0.654$) at 5% level of significance. During the month of December, the coefficient of determination, $r^2 = 7.56\%$ meaning that rainfall contributed to 7.56% of the monthly deaths of chicken.
Table 4.26: Correlation between Monthly Deaths and Rainfall for the month of January

<table>
<thead>
<tr>
<th>Monthly Deaths for January</th>
<th>Pearson Correlation</th>
<th>January Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>-.144</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>.817</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

There is a negative Pearson Correlation (r = -0.144) between rainfall and ND. However, the null hypothesis that there is no significant relationship between rainfall and ND in the month of January is accepted (p = 0.817) at 5% level of significance. The coefficient of determination in January was 2.07%, implying that rainfall contributed to 2.07% of the monthly deaths of chicken.

Table 4.27: Correlation between Monthly Deaths and Temperature for the month of July

<table>
<thead>
<tr>
<th>Monthly Deaths for July</th>
<th>Pearson Correlation</th>
<th>July Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.683</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>.020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation (r = 0.683) between temperature and ND. However, the null hypothesis that there is no significant relationship between temperature and ND in the month of July is rejected (p = 0.020) at 5% level of significance. In the month of July $r^2 = 46.65\%$, implying that temperature predicted monthly deaths for chicken by 46.65%.
Table 4.28: Correlation between Monthly Deaths and Temperature for the month of August

<table>
<thead>
<tr>
<th>Monthly Deaths for August</th>
<th>Pearson Correlation</th>
<th>August Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.772</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>.126</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation ($r = 0.772$) between temperature and ND. However, the null hypothesis that there is no significant relationship between temperature and ND in the month of August is accepted ($p = 0.126$) at 5% level of significance. During the month of August $r^2 = 59.60\%$, implying that temperature predicted monthly deaths for chicken by 59.60%.

Table 4.29: Correlation between Monthly Deaths and Temperature for the month of December

<table>
<thead>
<tr>
<th>Monthly Deaths for December</th>
<th>Pearson Correlation</th>
<th>December Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>-.546</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>.0341</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a negative Pearson Correlation ($r = -0.546$) between temperature and ND. However, the null hypothesis that there is no significant relationship between temperature and ND in the month of December is rejected ($p = 0.0341$) at 5% level of significance. In the month of December $r^2 = 29.81\%$, indicating that temperature predicted monthly deaths for chicken by 29.81%.
Table 4.30: Correlation between Monthly Deaths and Temperature for the month of January

<table>
<thead>
<tr>
<th>Monthly Deaths for January</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.159</td>
<td>.798</td>
<td>5</td>
</tr>
</tbody>
</table>

There is a positive Pearson Correlation ($r = 0.159$) between temperature and ND. However, the null hypothesis that there is no significant relationship between temperature and ND in the month of January is accepted ($p = 0.798$) at 5% level of significance. In the month of January $r^2 = 2.53\%$, implying that temperature predicted monthly deaths for chicken by 2.53%.

### 4.5 Other factors that influence the outbreaks of Newcastle Disease

Other than climate, findings showed that there were other factors influenced the outbreak of ND. These included infected live birds, infected poultry products (meat, feathers, blood and faeces), contaminated poultry feeds and drinking water as the findings revealed (Table 4.31).

Table 4.31: Other factors that cause the outbreak and spread of ND

<table>
<thead>
<tr>
<th>Other causes of ND</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infected poultry products</td>
<td>26</td>
<td>13.0</td>
</tr>
<tr>
<td>Other animals</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>Infected live birds</td>
<td>167</td>
<td>83.5</td>
</tr>
<tr>
<td>All</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>
Thirteen percent of the respondents reported that ND was spread by infected poultry products; 83.5 percent by infected live chicken. This finding agrees with Byrarugaba et al. (2012) who found that outbreaks of ND occur as a result of uncontrolled movement of live birds from different background. Two percent of the respondents reported that ND was spread by other animals such as dogs and cats and 1.5 percent all the above factors. It was found out that ND spreads throughout the flock through contact with the sick live birds when taking feeds and also staying together in the same room. The study revealed that ND spreads faster when there are larger numbers of chicken because the contact rate with each other is very high than when they are fewer.

Chickens roam in the yard, around the boxes in the garbage in search of grain, greenery, crickets, termites, ants, insects and others. In the course of doing this, they can feed on feces put by dogs that had fed on dead chicken or on remains of sick chicken, which enhanced the quick spread of the disease. The research found out that sick birds were normally eaten by farmers and the viscera from birds were often fed to poultry, dogs and cats (Plate 1). The usual practice was to throw the viscera into the field for this purpose where they were eaten by poultry and other animals, resulting in the spread of infection.
Plate 4.1: A dog feeding on a dead chicken that died of ND in the village

ND can spread very fast within the flock if fed with contaminated feeds. This ranges from food remains as these chickens scavenge for food freely in the environments. People on the other hand, can aid in the spread of the disease through visiting sick chicken houses and then visiting health chicken. Their shoes and clothes can aid in the spread of this disease. The introduction of new flocks without inspection to the existing flocks can also aid in the spread of the disease. Further, transportation of sick live chicken near healthy flock can also lead to spread of the disease since the disease is viral and can be spread via the inhalation of contaminated air.

4.6 Adaptive and mitigation measures

Farmers were asked to report on the adaptive and mitigation measures that were put in place to deal with ND. An interesting fact emerged revealing that 99 percent
of the farmers were aware of the signs of ND which included, coughing and sneezing, nasal discharge, watery yellow diarrhoea, twisted wings and paralysis of wings and legs. Only 1 percent of the farmers did not know the signs ND.

Findings revealed that farmers used various methods to control ND summarised in Table 4.32.

**Table 4.32: Farmers responses on methods of disease control**

<table>
<thead>
<tr>
<th>Methods of disease control</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional herbs</td>
<td>28</td>
<td>14.0</td>
</tr>
<tr>
<td>Selling</td>
<td>18</td>
<td>9.0</td>
</tr>
<tr>
<td>Eating</td>
<td>8</td>
<td>4.0</td>
</tr>
<tr>
<td>Burying</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Vaccination</td>
<td>18</td>
<td>9.0</td>
</tr>
<tr>
<td>Traditional herbs and Selling</td>
<td>14</td>
<td>7.0</td>
</tr>
<tr>
<td>Sell, eat and bury</td>
<td>30</td>
<td>15.0</td>
</tr>
<tr>
<td>All</td>
<td>82</td>
<td>41.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The findings revealed that 15 percent sold, ate the sick chicken and buried the ones that had died; 14 percent used traditional herbs such grounded garlic mixed with water, grounded aloe mixed with water and fresh milk; 9 percent used vaccines; 9 percent sold their chicken once an outbreak occurred; 7 percent used both
traditional herbs and also sold some; 4 percent ate the sick birds; 1 percent buried the ones that had died and 41 percent of the poultry farmers used all the above method. This agreed with Dontwi et al. (2011) who found that farmers used traditional herbs to control diseases and Byrarugaba et al. (2012) who found that farmers sell their birds during outbreaks which maintain the disease within the flock.

Farmers used traditional herbs especially aloe, because it is locally available and was believed to be effective against a wide range of diseases and ailments. The leaves were harvested, cleaned with water and crushed before they were mixed with drinking water for chickens. The ‘medicated’ water was offered to all birds until they showed signs of good health. However, not all the chickens could be cured. Farmers also used fresh milk as they believed that it cleansed the swap from the throat of the sick chicken. It was noted that the use of traditional herbs was of great importance in the smallholder farmers in Suneka Division at the expense of conventional drugs as they were readily accessible and inexpensive.

Farmers used vaccines such as ND vaccine and infectious bronchitis (IB) vaccine to control the disease. However a few farmers were aware of this vaccine. This was done by veterinary officers who formed an integral part in disease control. Findings revealed that about 9 percent of the farmers were not aware of the veterinary services in the area, while 91 percent of the of the chicken farmers were aware of the veterinary services, however they visited it occasionally as it had
monetary attachment to get the services. Further the veterinary offices were distant from the farmers’ residential areas and this hindered the frequent use of the services (Table 4.33).

**Table 4.33: Proximity of veterinary offices to the poultry farmers**

<table>
<thead>
<tr>
<th>Distance</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 km</td>
<td>23</td>
<td>11.5</td>
</tr>
<tr>
<td>2 km</td>
<td>28</td>
<td>14.0</td>
</tr>
<tr>
<td>3 km</td>
<td>49</td>
<td>24.5</td>
</tr>
<tr>
<td>4 km</td>
<td>34</td>
<td>17.0</td>
</tr>
<tr>
<td>5 km</td>
<td>34</td>
<td>17.0</td>
</tr>
<tr>
<td>6 and above</td>
<td>32</td>
<td>16.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

It also emerged that there were only four veterinary officers in the district and was deemed inadequate given the size of the population of farmers in the area. This made control of the disease difficult as they could not reach every farmer on time.

Further, when farmers were asked how frequent they visited the veterinary offices, 80.5 percent reported that they used the veterinary offices when need arose, 7.5 percent, weekly, 1 percent, monthly and 11 percent have never made use of the veterinary services (Table 4.34).

**Table 4.34: Responses on the frequency of using the veterinary services**

<table>
<thead>
<tr>
<th>Visits</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly</td>
<td>15</td>
<td>7.5</td>
</tr>
<tr>
<td>Monthly</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>When need arises</td>
<td>161</td>
<td>80.5</td>
</tr>
<tr>
<td>Never</td>
<td>22</td>
<td>11.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The implication is that the veterinary services that offer vital services to farmers are not being utilized adequately. Hence farmers are missing out the necessary services of disease control.

Sensitization was another method that was employed by veterinary officers to control the disease. Sensitization involved teaching the farmers on methods of disease control, methods of increasing productivity, modern methods of poultry farming and services they offered. This was done through workshops, seminars, field demonstrations and barazas as reported by the veterinary officers.

When farmers were asked on how often they attended workshops and seminars, only 31 percent had attended, while 69 percent had never attended. This was attributed to lack of proper dissemination of information to farmers and lack of proper cooperation between administration especially chiefs and veterinary officers as reported by one of the veterinary officers. The implication is that not all farmers got the necessary information on disease control hence disease control becomes difficult.

Farmers also reported that they used other disease control methods such as observing hygiene and controlling internal and external parasites. Fourth one percent observed hygiene and control of parasites, 36.5 percent observed hygiene while 22.5 percent controlled parasites (Table 4.35).
Farmers cleaned the poultry houses on daily basis, disinfected them with disinfectants, and observed personal hygiene when handling chickens such as washing hands when handling chickens and their products and wearing protective clothing when handling chicken.

Internal parasites were controlled using traditional drugs such as crushed garlic mixed with water. Farmers believed that garlic was sour and therefore could destroy internal parasites such as ringworms. External parasites were controlled by pouring hot water in poultry houses and spraying powdered drugs such as “Sevin” or “Dudu dust”. The control of these parasites formed an essential part of controlling diseases, as they weaken the immunity of the chickens if not controlled. This was in agreement with Moreki (2006) who found out that control of internal and external parasites helped in controlling the outbreaks and spread of diseases.

<table>
<thead>
<tr>
<th>Control measures</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of parasites</td>
<td>45</td>
<td>22.5</td>
</tr>
<tr>
<td>Observing hygiene</td>
<td>73</td>
<td>36.5</td>
</tr>
<tr>
<td>Both</td>
<td>82</td>
<td>41.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>
Further the study found out that government support also formed an integral part of disease control and improving productivity. When respondents were asked if the government gave any support to the poultry farmers, 79 percent reported that the government does not give any support while 21 percent agreed that the government supported the sector (Table 4.36).

**Table 4.36: Reponses of poultry farmers on the government support to the poultry sector**

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>158</td>
<td>79.0</td>
</tr>
<tr>
<td>Yes</td>
<td>42</td>
<td>21.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Even though there were a greater percentage of farmers who were not aware of the government support, a report from veterinary officer revealed that there was. This was through the Ministry of Livestock Development which had employed extension and veterinary officers. The extension officers were responsible for educating poultry farmers on methods of improving productivity and giving general advice as far as poultry is concerned. On the other hand veterinary officers vaccinated poultry and taught farmers different poultry diseases, signs and symptoms and methods of disease control. The veterinary officers also procured drugs on behalf of the government to vaccinate the chickens. Further, the government had started a project of small scale indigenous poultry improvement project through the Ministry of Livestock Development. Currently there 16 groups
which have benefited from this project. These groups include women groups, youth group and self help groups comprising of between 14-48 people and are registered with the Ministry of Social Services. The government has built poultry houses, purchased improved indigenous chicken from Naivasha, gave them to the groups and also provided feeds until they started laying eggs. From there, the groups took full management of the chickens.
CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarises the findings of the study, draws conclusions and makes recommendations necessary for formulation and the way forward.

The study set out to achieve the following objectives:

i) To investigate the relationship between climatic variables and the occurrence of Newcastle Disease in free range indigenous in Suneka Division.

ii) To investigate other factors other than climate that influences the outbreak and spread of ND.

iii) To assess the socio-economic impacts of ND to poultry farmers.

iv) To assess the adaptive and mitigation measures that had been put in place to control ND.

To achieve the above objectives, primary and secondary data collected from the field were used. Data for rainfall, temperature and relative humidity for 2007-2011 were obtained from the Kenya Meteorological Department, Kisii. To analyse climatic data, mean for temperature and rainfall were calculated for the months when Newcastle Disease had occurred. Karl Pearson Correlation method was used to determine the relationship between season of occurrence and the deaths caused by ND. Primary data was collected from poultry farmers in Bomorenda, Iyabe and Riana Locations of Kisii South District, Kisii County. A total of 200 poultry farmers administered with questionnaires. This data was processed, analysed and
presented using descriptive statistics. Tools of analysis for climatic and primary data were Social Package of Social Sciences (SPSS) and Microsoft Excel.

5.2 Summary of findings

5.2.1 Household characteristics

Survey results showed that out of the 200 poultry farmers interviewed, 51 percent were female while 49 percent were male. The research revealed that 89 percent of the interviewees were of age between 19-54 years while 11 percent were 55 years and above. In relation to the family size of the interviewees, it was found out that percent 52% had five people and above while 48 percent less four people. At least 40 percent of the poultry farmers interviewed had tertiary education, 36 percent secondary education, 22 percent primary education and 3 percent no formal education.

5.2.2 Farming practices

The research revealed that 56.5 percent of the farmers interviewed were small-scale farmers and 23 percent were employed by the government. Further, 76 percent reared indigenous chicken only while 22 percent reared both indigenous and hybrid breeds. All the farmers interviewed had less than one acre of land hence had taken the option of keeping Free Range Indigenous Chicken (FRIC) as it requires less space and low income. The study revealed that 52 percent reared 50 and above free range indigenous chicken, while 28 percent, 11-30 and 19 percent less than ten. Since there were a higher percentage of respondents who were
farmers, there is need to pool resources together by forming farmers cooperative societies which can advance loans so as to improve the FRIC production in the area.

5.2.3 Relationship between climatic variables and the occurrence of Newcastle Disease

The research found that Newcastle Disease outbreaks were experienced in the months of July to August and December to January. The mean annual temperature for the five years in January was 21.8 °C while for December was 21°C, July was 19.7 °C while in August 20.3 °C. Generally July recorded the lowest temperatures while January was the second highest after February. There was a positive Pearson Correlation (r =0.772) between temperature and ND in August, a negative correlation (r = -0.546) in December, a positive correlation (r = 0.683) in July and a positive correlation (r = 0.159) between temperature and ND in January.

The mean annual rainfall for five years in January was 110 mm, July was 121mm, August 176mm and December 175.8 mm. This shows that ND occurs after the long rains MAM and short rains OND. There was a negative Pearson Correlation (r = -0.549) between rainfall and ND in the month of July. There was a positive correlation (r = 0.286) in August, a positive correlation (r = 0.275) in December and a negative correlation (r = -0.144) between rainfall and ND in January.
The relative humidity was 54.6% in January, 62% in July, 63.8% in August and 63.4 % in December. The Pearson correlation between the monthly deaths caused by ND and the climatic variables showed that there was a positive Pearson Correlation \( r = 0.328 \) between humidity and ND for the month of January. In July there was a negative Pearson Correlation \( r = -0.576 \), a positive Pearson Correlation \( r = 0.596 \) in the month of December and a negative Pearson Correlation \( r = -0.418 \) between relative humidity and ND for the month of January.

### 5.2.4 Other factors that influence the outbreak of Newcastle Disease.

Other than climate, the research found out other factors such as infected live birds and poultry products, contaminated poultry feeds and drinking water can influence the outbreak of ND disease. Animals such as dogs and cats enhanced the spread of the disease through feeding on the remains of sick chicken. About 86% of the respondents agreed that ND was spread by infected live birds, 13 percent infected poultry products, 2 percent other animals like dogs and 1.5 percent all the above factors. This called for stern measures to be put in place to control the diseases such as; proper disposal of infected chicken remains, quarantine and using clean feeds.

### 5.2.5 Socio-economic impacts of Newcastle Disease to the poultry farmers.

Poultry farmers got many benefits from keeping of free range indigenous chicken. This included income, food (eggs and meat) and also source of self employment.
The study revealed that 83 percent kept free range indigenous chicken for regular consumption, 69 percent serving guests, 32 percent regular sale, 21 percent cultural ceremonies, 14 percent consumption during holidays such as charismas and 20 percent sale of eggs.

In spite of this, free range indigenous farmers were faced with the following challenges; lack of enough feeds, predation and frequent outbreaks of diseases such as ND. 99 percent of the farmers interviewed agreed that ND occurred every year.

Due to its occurrence, farmers incurred many losses. These included huge losses resulting from deaths, reduction in egg production and fluctuation of prices of chicken in the market. It had also led to the increase in production costs through purchase of drugs and vaccination.

In relation to the farmers’ health, farmers were not aware of any effect of ND. But, from the literature review it was found out that it causes mild conjunctivitis.

5.2.6 Adaptive and Mitigation measures that were put in place to manage Newcastle Disease.

From the study, it was found out that farmers use different methods to control the disease. These include use of traditional herbs such as grounded garlic mixed with water; grounded aloe mixed water, fresh milk and grounded mangoes.
Fourteen percent of the poultry farmers interviewed use traditional herbs, 9 percent sell the chicken during the outbreak of the disease, 15 percent sell, eat and bury those that have died and 4 percent eat the sick chicken. Fourth one percent of the farmers use all the above mentioned methods.

Other methods used to control the disease included observing hygiene measures such as cleaning and disinfecting of poultry houses, observing personal hygiene when handling chicken such as removing shoes when entering poultry houses and wearing protective clothes, washing hands before handling chicken and controlling internal and external parasites.

5.3 Conclusion

The following conclusions were drawn from the study based on the objectives; the research found that Newcastle Disease outbreaks were experienced in the months of July to August and December to January. The mean annual temperature for the five years was in January was 21.8 $^\circ$C while for December was 21$^\circ$C, July was 19.7 $^\circ$C while in August 20.3 $^\circ$C. Generally July recorded the lowest temperatures while February recorded the highest. There was a positive Pearson Correlation between temperature and ND in August, January and July. However, there was a negative correlation in December.

The mean annual rainfall for five years in January was 110 mm; July was 121 mm, August 176 mm and December 175.8 mm. This shows that ND occurs after the long rains MAM and short rains OND. There was a negative Pearson Correlation
between rainfall and ND in the month of January and July. However, in the
months of August and December the relationship was positive.

The relative humidity was 54.6% in January, 62% in July, 63.8% in August and
63.4 % in December. There was a negative Pearson Correlation between relative
humidity and ND in the month of January and July. However, in the months of
August and December the relationship was positive.

5.3.1 Other factors that influence the outbreak of Newcastle Disease.

Other than climate, the research found other factors such as infected live birds and
poultry products, contaminated poultry feeds and drinking water can influence the
outbreak of ND disease. The research concludes that there is a relationship
between climate variables and ND

5.3.2 Socio-economic impacts of Newcastle Disease to the poultry farmers.

Poultry farmers got many benefits from keeping of free range indigenous chicken.
These included income, food (eggs and meat) and also source of self employment.
Among the challenges facing FRIC included; lack of enough feeds, predation and
frequent outbreaks of diseases such as ND. ND occurred every year and its effects
included: huge losses resulting from deaths, reduction in egg production,
fluctuation of prices of chicken in the market and increase in production costs
through purchase of drugs and vaccination.
5.3.3 Adaptive and Mitigation measures that were put in place to manage Newcastle Disease

From the study, it was found out that farmers use different methods to control the disease. These include use of traditional herbs such as grounded garlic mixed with water; grounded aloe mixed water, fresh milk and grounded mangoes.

5.4 Recommendations

On the basis of the findings of this study, the following are the recommendations that would improve the production in free range indigenous chicken, prediction and control of Newcastle disease.

i) Decentralize weather stations to location levels to enable monitoring of changes in temperature, rainfall and humidity so as to predict the occurrence of this disease and take early precautionary measures.

ii) The government should employ more extension officers and decentralize veterinary offices to the sub-location levels so as to bring services to the farmer. This will enable farmers to get technical assistance without travelling long distances.

iii) Establish quarantine system to curb the spread of the disease and also establish a slaughter house to allow inspection. This will ensure that only healthy chicken are sold to consumers.

iv) Government to provide free drugs for vaccination and reduce the cost of feeds in order to reduce the cost of production for the poultry farmers.
v) Farmers should keep poultry records especially on disease occurrence, season in which they occur, number of chicken that died and control measures. This will enable them to monitor the epidemiology of the disease and take early precautionary measures.

vi) Government to educate small-scale farmers on how to adopt hygienic and bio-safe poultry rearing to minimize loss of chicken through diseases, pests and predation. This can be done through ensuring good housing system to protect chickens from strong winds and rains.

vii) The government should facilitate improvement of productivity of indigenous chicken by commercializing the enterprise in order to improve food security and improve household incomes. This can be done through improving on the breeding management of indigenous chicken through purchase and distribution of improved breeding stock to farmers

5.5 Areas for further study

Following this study, the following are possible research areas that need to be undertaken in order to improve productivity in free range indigenous chicken.

i) More research needs to done to investigate the influence of climate variability on other poultry diseases such as fowl pox and Gumboro.

ii) The extent to which traditional herbs are effective in controlling Newcastle Disease.
REFERENCES


Institute for International Cooperation in Animal Biologics (2008). Newcastle Disease. Avian paramyxovirus-1, Goose paramyxovirus infection. College of Veterinary Medicine, Iowa State University


a Tool in Poverty Eradication and Promotion of Gender Equality –
Proceedings of a Workshop. Accessed on 07/07/2012 from
Newcastle disease in migratory waterfowl populations. Japanese journal of
veterinary research. 45(4), 207-215.
Epidemiology, pp73-76. Elsevier: Amsterdam.
Baillaire, Tindall & Cox ltd: London.
as an inter disciplinary paradigm. Ecohealth vol. 2(4) pp.244-257.
Disease Outbreaks: A Review. Geneva.
Appendices

Appendix 1: Farmer’s questionnaire

Hello. My name is Norah Moige Nyaiyo a postgraduate student in Kenyatta University. I’m undertaking a research on the effect of climate and other factors on Newcastle Disease in Bomorenda, Iyabe and Riana locations of Suneka Division of Kisii County. This research is meant to help stakeholders and farmers to predict the outbreak of this disease and take early precautionary measures. I humbly request for your contribution.

A. Demographic characteristics

1. Sex [ ] F [ ] M

2. Age [ ] 12-18 [ ] 19-35 [ ] 36-54 [ ] 55+

3. Occupation: [ ] None [ ] Small-scale farmer [ ] Commercial farmer [ ] Teacher [ ] Civil servant

4. Level of education: [ ] None [ ] Primary [ ] Secondary [ ] Higher.

5. Family/household size [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6+

6. Farm size (acres) [ ] 0-1 [ ] 2-4 [ ] 5-7 [ ] 8-10 [ ] 11+

7. Do you keep livestock? [ ] Yes [ ] No

8. Which type of livestock? [ ] Cattle & others [ ] poultry [ ] both

9. Do you keep chicken? [ ] Yes [ ] No

10. Which type of chicken? [ ] Indigenous [ ] Commercial [ ] Both

11. How many in number? [ ] 1-10 [ ] 11-30 [ ] 31-50 [ ] 50-99 [ ] 100+
B. Benefits and challenges

1. i) What benefits have you enjoyed from keeping chicken?

........................................................................................................................................................................

ii) How much does your chicken cost before the outbreak of diseases?

2. What challenges/constraints do you face in keeping indigenous chicken?

........................................................................................................................................................................

........................................................................................................................................................................

........................................................................................................................................................................

3. Have your chicken ever been infected by Newcastle Disease for the last two years?

☐ Yes  ☐ No

4. Which season/months of the year did it occur?

........................................................................................................................................................................

5. To your own assessment what was the cause of the disease?

a) Infected live birds

b) Infected poultry products

c) Other animals like dogs and cats

d) Human beings

6. Do changes in climatic variables influence the occurrence of ND?  ☐ Yes  ☐ No

7. If yes, how?

C. Socio-Economic impacts

1. i) How many chickens died because of ND for the last two years?

........................................................................................................................................................................
ii) Which month did the deaths occur?

iii) Approximately how chicken died that month?

2. Which category of chicken was most affected?  
   - ☐ Chicks  ☐ Broilers  
   - ☐ All  ☐ Layers  ☐ Brooders

3. When the chicken are infected with ND:
   a) How does it affect the prices?
   b) How does it affect production?
   c) How does it affect the farmers’ health?

4. What other effects do you experience when there is the outbreak of ND?
   """
   """

5. How did you control the disease?
   a) Using traditional herbs
   b) Selling
   c) Eating
   d) Burying
   e) Vaccination

6. Apart from the methods mentioned above, what other methods did you employ?

D. Awareness and sensitization

1. Have you ever attended a seminar on ND disease?  ☐ Yes  ☐ No

2. If yes, how often?
   """
3. Is your community sensitized on poultry issues? ☐ Yes ☐ No

4. Are your community leaders aware of the diseases that attack chicken?
   ☐ Yes ☐ No

5. If yes, to which extent do they sensitize the community?

6. Are you aware of the signs and symptoms of ND?

E. Veterinary Services

1. Are you aware of veterinary services for poultry in this community? ☐ Yes ☐ No

2. If yes, how often do you visit the veterinary offices?

3. How far is the veterinary office/officer from your poultry farm?

5. Have your chicken been vaccinated against ND there before? ☐ Yes ☐ No

6. How often do you do it? ☐ After three months ☐ when disease occurs. ☐ Never

7. How much does it cost for treatment/vaccination per hen?

   Maximum

   Minimum

8. To your own opinion, does the government give any support to the poultry farmers? ☐ No ☐ Yes

9. If yes, how? ........................................................................................................................................

10. What can you recommend to be done so as to improve indigenous poultry keeping?

   ........................................................................................................................................................

THANK YOU FOR YOUR CONTRIBUTION.
Appendix 2: Veterinary officer’s interview schedule

1. What are the main regulations and policies governing poultry in this country?
2. What is the importance of the poultry sector in this area?
3. What type of poultry is most commonly kept in this area and why?
4. What is the total number of indigenous chicken kept in this area?
5. What challenges are faced by indigenous poultry farmers in this area?
6. How often do you get complaints from indigenous chicken farmers?
7. How do you help farmers to overcome these challenges?
8. Have the indigenous chickens in the area been infected by ND for the last two years?
   □ Yes □ No
9. If yes, in which seasons/months of the year did the disease occur?
10. How many indigenous chicken died for the period of two years?
11. How do you control the disease?
12. What challenges do you face in controlling the disease in indigenous chicken?
13. How do you overcome these challenges?
14. How often do you have seminars with the poultry farmers?
15. What challenges do you face in organising these seminars?
16. From your own experience; does climate influence the outbreak of ND? □ Yes □ No
17. If yes, how?
18. What is the impact of ND to the livestock economy?
19. Other than ND what other problems do indigenous chicken farmers face?
20. How do they overcome them?
21. What should be done to improve indigenous poultry keeping in the area?

22. What can you suggest in order to improve the farmers’ preparedness to ND disaster in our country in general?

THANK YOU.
Appendix 3: Data on Rainfall, Temperature and Relative Humidity

## Monthly Rainfall in Millimeters (mm) for the Years 2008-2013

<table>
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## Monthly Relative Humidity in Percentage (%) for the Years 2008-2013

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## Monthly Temperature in Degree Celsius °C for the Years 2008-2013

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Appendix 4: Research Permit

CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two (2) four (4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

Republic of Kenya

Research Clearance Permit

(Conditions see back page)