INFLUENCE OF CLIMATE VARIABILITY ON THE OCCURRENCE OF CATTLE REPRODUCTIVE AND URINARY TRACT INFECTIONS

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Abstract

The inadequate study on the intersection between climate change and livestock in The Gambia coupled with high abortion rates in cattle that are manage under the extensive management system prompted this research. The research was conducted in Upper River Region, The Gambia due to its high cattle population. Frequency, Spearman's correlation and regression analyses were carried out between climate variables (rainfall, temperature, wind speed and humidity) and the monthly occurrence of reproductive and urinary tract infections (RUT). The research revealed that in the Upper River Region, The Gambia, monthly occurrence of reproductive and urinary tract infections is positively significantly correlated to average monthly minimum temperature, relative humidity, wind speed and monthly total rainfall at $p < 0.05$. However, using the Backward method of the regression analysis, it was found that with the highest possible coefficient of determination (R^2) value of 0.346 and lowest variance inflation factor (VIF) of 1.018, rainfall, minimum temperature and wind speed provided the best equation that statistically significantly predicted the occurrence of reproductive and urinary tract infections.

KEYWORDS: Reproductive and Urinary Tract Infection; Climate variability; Cattle; The Gambia

INTRODUCTION

The contribution of the livestock sector to The Gambia economy is huge. Even though its contribution to enhancing crop production (fertilising the agricultural lands and providing the much needed labour in pulling the sine hoe and seeder) are not accounted for, the livestock sector still contributes about 8.6 % of the National GDP and almost 30 % of the Agricultural Gross Domestic Product (FAO, 2012). To the rural farmer, livestock is not only a means of saving wealth to ensure food security, but serves as a form of prestige and honour in society. As population and urbanization continue to increase, these benefits are expected to increase. Despite its immense contribution, livestock, especially cattle production in The Gambia, is still traditional, depending largely on natural vegetation and water bodies for feed and water respectively, thus making it prone to climate variability. In the traditional management system, increasing herd size is often the priority of the herdsman. However, this is seriously challenged by high abortion rates. Prevalence of abortions or immature births and long calving intervals are many in livestock particularly in cattle.

Although one of the least contributors to global greenhouse gases emission, less than 0.01 % (INDC, 2017), The Gambia is still seriously challenged by the consequences of climate variability. There are already catalogue of droughts, floods, increased temperature and sea level rise (Jaiteh and Sarr, 2011; Yaffa, 2013), which are expected to increase in the future. These changes will in no doubt affect the agricultural system particularly the livestock sector. For instance, with variations in both the length and onset of rain, herders resort to unregulated transhumance as means of minimising the effects of feed and water shortage. This leads to the introduction and re-emergence of diseases. In spite of all the benefits and the magnitude of the changes that are likely to befall livestock systems, the claim made by Thornton *et al*. (2009) that intersection of climate change and livestock in developing countries is a relatively neglected research area is particularly true for The Gambia. There is very little research done on climate change and livestock in The Gambia. These concerned issues are a motivation to find out the impacts of climate variability on livestock.

One of the challenges affecting the desire of cattle owners to increase their herd size may be high abortion rates. According to Wikse (2005) the seven pathogens; *Brucella abortus*, *Leptospira hardjo-bovis, Campylobacter fetus*, Infectious Bovine Rhinotracheitis (IBR) virus, Bovine Viral Diarrhoea (BVD), *Tritrichomonas foetus* and *Neospora caninum* are of worry to beef cattle herd as these pathogens cause lots of damages including embryonic deaths, stillbirths and weak calves. The survival and distribution of these pathogens and many others could be influenced by some climate variables (Aune *et al*., 2012). In Iran, Gupta *et al*. (2016) discovered that incidence of human Brucellosis, a disease characteristics of abortion is positively correlated to monthly average temperarure and wind speed and negatively associated to monthly average precipitation. Mai *et al.* (2013) also suggested that the prevalence of genital Campylobacteriosis and Trichomonosis that are characterised by infertility, embryo mortality and abortion were higher in zero-grazing herds.

Amongst other factors, climate, herd confinement, and feeds were responsible for the difference in regional occurrence of infectious diseases causing bovine abortion and foetus loss (Barr and Anderson, 1993). Albeit the findings that pathogens survival and distribution could be influenced by climate variables and the fact that human Brucellosis is associated with temperature, wind speed and precipitation, there is not much evidence to associate climate variability and reproductive and urinary tract infections in cattle raised under the extensive management system. Thus, this article seeks to find out the relationship between variability in climate parameters (temperature, humidity, wind speed and rainfall) and reproductive and urinary tract infections in cattle reared under an extensive management system.

METHODOLOGY

The study area: The Gambia has a tropical climate characterized by a seven-month long dry season (November - May) and a five-month rainy season stretching between June and October. In the dry season, temperatures range between 18^0 and 30^0 Celsius while it ranges from 23^0 to 33^0 Celsius in the wet season. According to GCCPD (2016), temperature has been rising in the order of 0.5^0 Celsius per decade, recording the lowest mean temperature of 25.8^0 Celsius in 1947 and the highest mean temperature of 28.2^0 Celsius in the year 2000. The annual rainfall amounts have decreased by 30 % from 1950 to 2000 (Jaiteh, 2010).

The Upper River Region, the second largest region in the country occupying about 2000 Square Km was the focus of the study (Figure 1). It is located in the eastern part of the country with latitude and longitude of 13.42570 N and 14.00720 W, respectively (GBoS, 2013). The Agro ecological zone of Upper River Region is characteristics of a growing period of over 135 days and the start of the growing season falls around the first half of June. The cumulative rainfall is between 700 to 800 mm per annum. The natural vegetation in this zone consists of grasslands with scattered trees. The vegetation in this zone has been heavily modified through human interference in the form of cultivation and bush fire. Cattle production is a major activity practiced in Upper River Region where 500 households are reported to own over 70,000 cattle. However, cattle production is still traditional, depending mainly on the natural vegetation as source of feed. This natural vegetation is communally owned and the rules guiding its usage and management are not enforced.

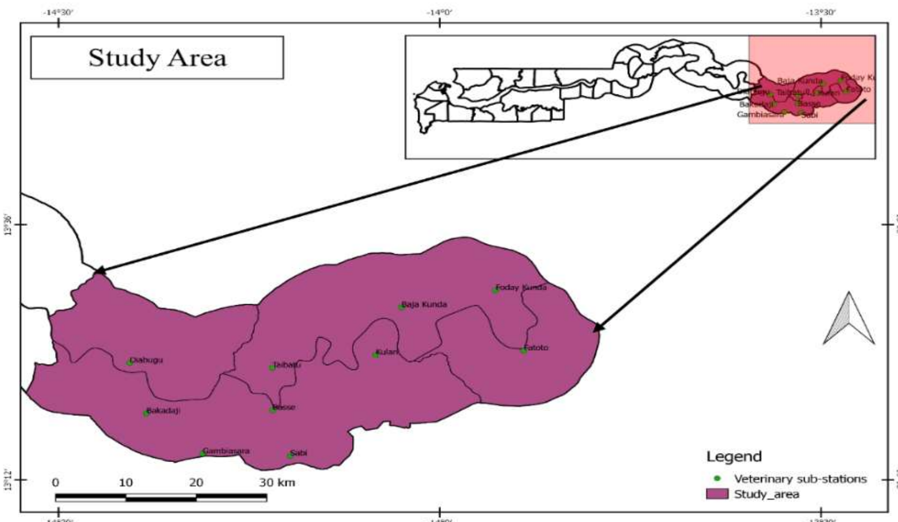

Figure 1 Map of the Study Area

Data collection: Meteorological data of the Basse Meteorological Stations including average monthly minimum and maximum temperatures, humidity, wind speed and total monthly rainfall were collected from the Department of Water Resources (DWR). The data were from January 1981 to December 2016.

Veterinary Clinic Records from 1995 to 2016, which was a little over 75 % complete were collected from the Regional Veterinary Office in Basse. The data consist of compiled monthly reports of trained staff of the Department of Livestock Services (DLS) called Livestock Assistants who are posted across the length and breadth of the Region. The dataset contains only the number of cases reported to the livestock assistants by the farmers, which the livestock assistants compiled as their monthly reports. The Regional Veterinary Officer in turn compiles the reports from the various sub-stations at district level as the Regional monthly report. The dataset contains several years but is not detailed enough to show date of occurrence, age and sex of cattle and specific villages where the outbreaks occurred.

Data Analysis Mann-Kendall test: Mann Kendall test was used to statistically detect the trend in temperature, rainfall, humidity and wind speed for Basse Meteorological Data. Mann Kendall test was used because it does not require the data to be normally distributed and moreover have low sensitivity to abrupt breaks due to non-homogenous time series (Karmeshu, 2012). The null hypothesis (H_0) of this test assumed that there is no trend, that is, the data is independent and randomly ordered. The H_0 is tested against the alternative hypothesis (Ha) that assumed that there is a trend (Karmeshu, 2012). The Excel plugin XLSTAT 2015 was used to conduct this test.

Frequency, Spearman's Correlation and Regression Analyse: The frequency analysis of the monthly occurrence of reproductive and urinary tract infections was carried out. Spearman's correlation tests were performed between the veterinary clinic data (monthly occurrence of RUT infections) and the monthly climate variables of the Basse Meteorological stations. The data were initially tested for stationarity using the Dickey-Fuller Method, which uses the null hypothesis (H_0) p = 1 and the alternate hypothesis (Ha) as |<1.

Multiple linear regression analysis was performed, monthly RUT infections as the dependent variable and minimum and maximum temperatures, rainfall, humidity and wind speed as the independent variables. To ensure the assumptions were not violated, diagnostic tests of multicolinearity, homoscedasticity and normality distribution of the residuals were performed. To reduce the collinearity effects, maximum temperature, which was not correlated with RUT infections, was removed from the regression analysis. All these tests were performed using statistical software JASP.

RESULTS AND DISCUSSION

Climate variables trend: The Mann-Kendall test was performed to determine the trends in climate variables. The Mann-Kendall test demonstrated that there were statistically significant monotonic trends in rainfall (Kendall's tau = 0.248, p = 0.034) and minimum temperature (Kendall's tau = -0.367, p = 0.005) of the study area. Maximum temperature, humidity and wind speed have not showed any monotonic increase or decrease (Table 1). Fitted trend lines revealed an upward trend in rainfall and a downward trend in minimum temperature (Figures 2 and 3).

As illustrated by the Mann-Kendall test result (Table 1), climate variability does exists and to a great extent. The variabilities in both rainfall and minimum temperature is monotonic. Variabilty in these climate variables could suggest threats to cattle health. For instance, changes in rainfall pattern may influence the expansion of vectors (Thornton *et al.*, 2009) and provide favourable conditions for many pathogen (Kimaro and Chibinga, 2013; Abdela and Jilo, 2016). The increasing rainfall may cause floods, which are favourable conditions for survival and proliferation of many pathogens.

Table 1 Mann-Kendall Test Result

Variable	**Kendall's tau**	**S**	**p-value**	**Alpha**
Rainfall	0.248	156.000	0.034	0.05
Humidity	0.190	50.000	0.220	0.05
Wind Speed	0.181	67.000	0.203	0.05
Maximum Temperature	0.253	76.000	0.080	0.05
Minimum Temperature	-0.367	-149.000	0.005	0.05

S – Mann-Kendall Statistics

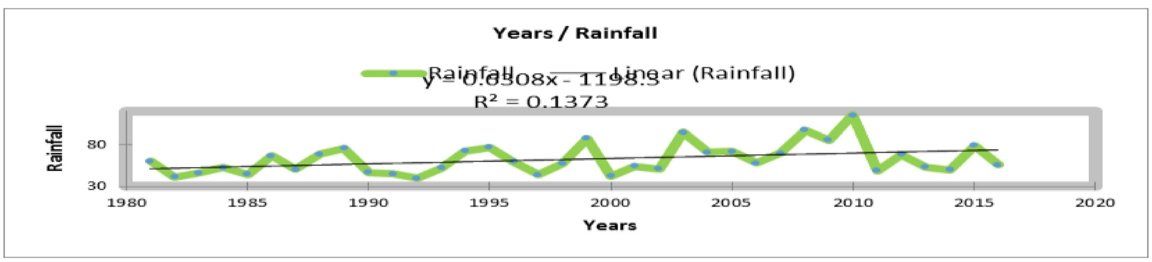

Figure 2. The Rainfall Trend

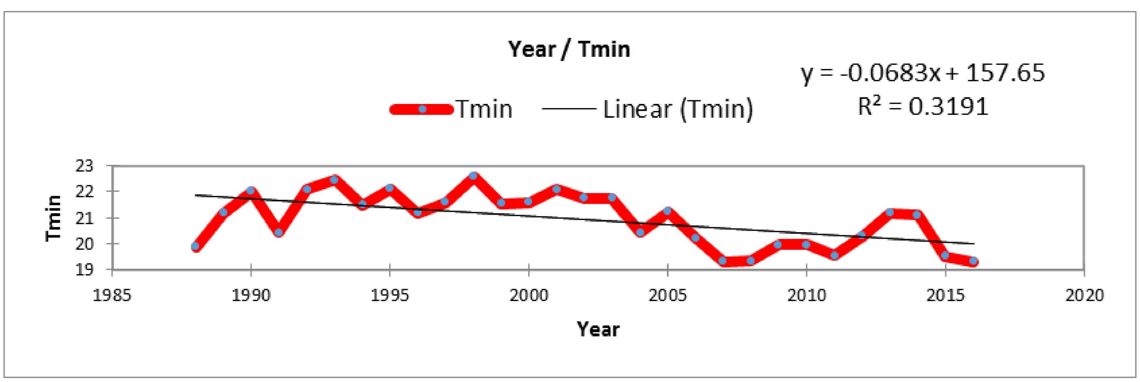

Figure 3 Minimum Temperature Trend

RUT occurrence: From January 1995 to December 2016, 551 cases of reproductive and urinary tract infections were reported with a mean of 3.555 and standard deviation (3.950). Most of these cases (52 %)

occurred in the rainy season, that is, from June to October (Figure 4) and on a monthly basis, the highest cases of RUT were reported in August and the lowest number of cases were received in November (Figure 5).

The disease surveillance system in most countries in Africa is challenged by under reporting (Mshelia *et al*., 2010; OIE, 2017). The reported RUT infection cases of only 551 for more than a decade in Upper River Region, The Gambia may have verified this statement. An explanation for the under reporting of diseases by farmers could be their inability to pay for drugs and veterinary services. As farmers are unable to pay for drugs and veterinary services, they may regard it unnecessary to report cases to veterinary officers. Another contributing factor is the difficulty in accessing veterinary officers. The livestock assistant to farmer ratio is huge such that it can reach 1 : 1500. Some farmers may have to travel for more 10 km to access a veterinary assistant. The inadequate access to veterinary services coupled with the inability to pay for drugs are eminent contributing factors to disease under reporting

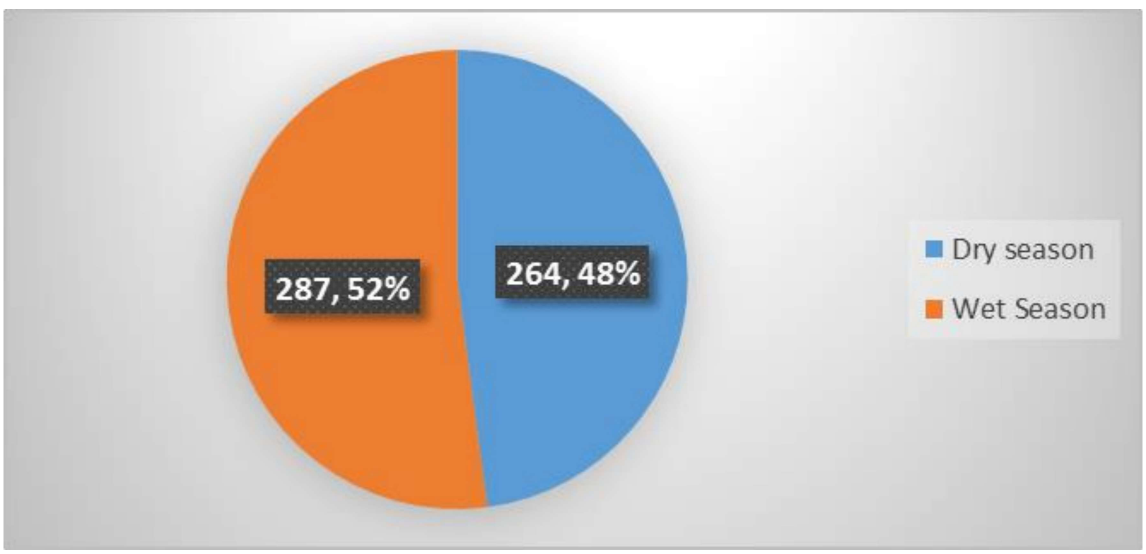

Figure 4 Seasonal Occurrence of Reproductive and Urinary Tract Infections

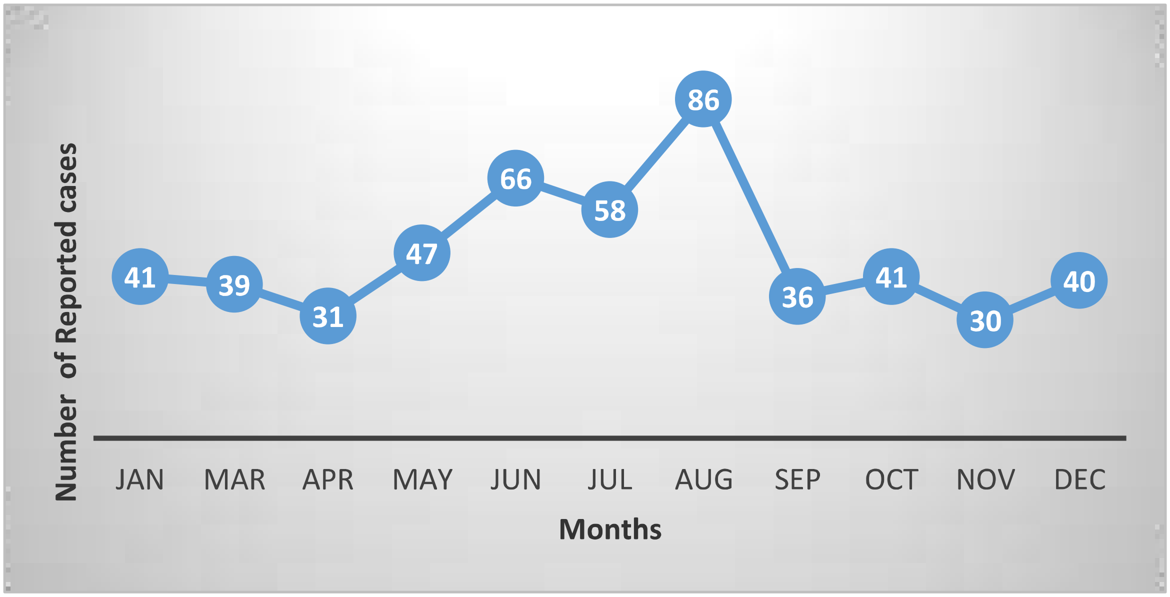

Figure 5 Monthly occurrence of reproductive and urinary tract infections

RUT and climate variables correlation: To determine the association between the occurrence of reproductive and urinary tract infections and variabilities in climate variables of the Region, Spearman correlation test was performed. This analysis revealed that average monthly minimum temperature (r = 0.218, p = 0.007), wind speed (r = 0.158, p = 0.041), humidity (r = 0.185, p = 0.041) and total monthly rainfall (r = 0.263, p < 0.001), were all positively correlated to the monthly occurrence of RUT infections. However, there was no statistically significant association between monthly maximum temperature (r = -0.088, p = 0.382) and the monthly occurrence of RUT infections average (Table 2).

This study establihsed that occurrence of reproductive and urinary tract infection is strongly associated with minimum temperature, rainfall, humidity and wind speed. This is in line with the study of Gupta *et al.* (2016) who suggested correlation between rainfall and human Brucellosis, which is characteristics of abortion. However, while Gupta *et. al.* (2016) revealed a negative correlation, this study discovered a positive association. Their result which established that Brucellosis in human is positively associated to wind speed and humidity is similar to the result of this study, which indicated that wind speed and humidity are positively in association with monthly occurrence of RUT infections.

Disease transmission and distribution is very complex as there are several factors that are responsible. However, the positive correlation between RUT infections and these climate variables could be linked to a number of factors that occur in the Region. One possible explanation could be attributed to high infestation of endo-parasites (worms) during the rainy season. In the Upper River Region, herdsmen practice early morning grazing with the intent to produce more milk. Incidentally, worms are very active during this period, thus worms infestation load become heavier. This problem is further aggravated by the lack of routine deworming programmes. Farmers mostly react to disease outbreak situations rather than adopting preventive practices and commonly seek for veterinary services only when the lives of their animals are endangered. It is not characteristics of cattle owners to carry out routine deworming of their cattle, thus exposing cattle to the effects of high worm infections. Another reason that could be related to the positive correlation between rainfall and RUT, is the traditional form of cattle management system practiced. In the study area, as a result of the traditional cattle rearing system, there is no proper disposal of dead cattle. Aborted foetuses and placentas are not properly dispose but allowed to decay in grazing lands, cattle tracks and watering points, potentially allowing these places to be reservoirs of infections (Daffeh, 2001). Furthermore, with heavy rainfalls, some grazing areas are flooded rendering it inaccessible to cattle. As herders practice temporal nomadism especially to reduce this impact, cattle from different areas are gathered in a grazing area, enhancing the transmission of RUT infections.

Another possible cause for the positive correlation between RUT infections and wind, humidity and rainfall is the influence these variables have on pathogens and animals. According to Kimaro and Chibinga (2013), there are a number of pathogens that are sensitive to humidity and temperature changes. Humidity and wind speed have great abilities to influence the development and spread of pathogens. In the Gambia, cattle are rarely housed especially under the extensive management system. The continual exposure of cattle to increasing temperature, high humidity and strong wind may add stress thus supressing cattle immune system (Abdela and Jilo, 2016; Bett *et al*., 2016), making cattle prone to infections.

Table 2 Correlation Matrix of RUT infections and Climate Variables

Variable	Spearman's rho	p- values
Minimum temperature	0.218**	0.007
Rainfall	0.263***	< 0.001
Wind Speed	0.158*	0.050
Humidity	0.185*	0.041
Maximum temperature	-0.088^{ns}	0.382

*p < .05, **p < .01, ***p <.001, ns – not significant

In addition, Backward multiple linear regression analysis (Table 3) was calculated to ascertain the capacity to which minimum temperature, rainfall, wind speed and humidity can predict the occurrence of reproductive and urinary tract infections in cattle. The assumption of normality, multicollinearity, homoscedasticity and existence of outlier were ensured not to be violated by conducting the assumption tests. In model 1, which took into account all the variables (minimum temperature, rainfall, wind speed and humidity), 33.9 % of the variance was described. Although the overall model was statistically significant (F4, 117 = 3.797, p = 0.006), by individual contribution, wind speed (p = 0.006) was the only statistically significant variable.

In the second model where humidity was controlled, the explained variance was reduced by 0.001 but both rainfall and wind speed were statistically significant in the prediction. The model established that minimum temperature, rainfall and wind speed statistically significantly predict RUT occurrence ($F_{3,118}$ = 5.059, p = 0.002). In the third and final model, after controlling for minimum temperature and humidity, rainfall and wind speed were both statistically significant in predicting RUT occurrence ($F_{2,119}$ = 6.768, p = 0.002), with R^2 value of 0.320.

Considering the highest possible R^2 value and the lowest Variance Inflation Factor (VIF), minimum temperature, rainfall and wind speed presented the best model to predict the occurrence of monthly RUT infections in cattle in the Upper River Region, The Gambia ($F_{3, 118}$ = 5.059, p < 0.002, R^2 = .338). Although the contribution of minimum temperature was not significant (Beta = 0.117, t = 1.254, Sig = 0.212), the contributions of rainfall (Beta = 0.224, t = 3.2.405, Sig. = 0.018) and wind speed (Beta = 0.254, t = 2.847, sig = 0.005) to the prediction of RUT infections were both statistically significant (Table 4). An increase of 1.0 % in the monthly occurrence of RUT infections in the

Upper River Region would occur with a millimetre (mm) increase in the monthly total rainfall. On a bigger scale, one knot increase in the average monthly wind speed will likely increase the monthly occurrence of RUT infection in the region by 28.8 %. The equation for RUT, with the highest possible R^2 Value of .338 and the lowest possible variance inflation factor of 1.059 is represented as;

RUT = -2.385 + .010 x RF + .288 x WS + .129 x T Min,

where RUT refers reproductive and urinary tract infections, RF is rainfall, WS stands for wind speed and T Min meaning minimum temperature.

CONCLUSION AND RECOMMENDATION

Based on the outcomes of this study, there are strong indications that rainfall, minimum temperature, humidity and wind speed variabilities clearly influence the occurrence of reproductive and urinary tract infections in cattle that are manage under the extensive management system. The influence rainfall for instance has on the availability of feed and water availability looks crucial to the epidemiology of reproductive and urinary tract infections. Low rainfall leads to inadequate feed and water prompting herders to practice temporal nomadism. Similarly, with heavy rains, flood may occur preventing cattle from accessing some grazing areas, which may also prompt temporal momadism.

Although there is need to distinguish the individual diseases that make up the reported RUT infections, it is evident that climate variability strongly influences the monthly occurrence of RUT infections. As rainfall, wind speed and humidity are expected to continue to increase, the occurrence of RUT is equally expected to increase except much more efforts are done. This will inturn hinder farmers' desire to increase their herd sizes. The strong association between reprductve and urinary tract infection may have negetive impact on farmers income level and food security. Increase abortion rates would not only reduce milk production but would as well threaten food security.

It is thus recommended that management systems be improved and more efforts be excerted on early disease diagnosis and treatment to reduce losses.

Table 3 RUT Regression Matrix

Model	Variables	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t	Sig	VIF	df	f	Sig of model	R^2
	Constant	-2.812		-1.021	0.31					
	TMin	0.12	0.11	1.136	0.258	1.231	4			
1	Rainfall	0.008	0.185	1.298	0.197	2.698	117			
	Humidity	0.011	0.055	0.355	0.723	3.148	121	3.797	0.006	0.339
	Wind speed	0.3	0.265	2.797	0.006	1.185				
	Constant	-2.385		-0.966	0.336					
2	TMin	0.129	0.117	1.254	0.212	1.167	3			
	Rainfall	0.01	0.224	2.405	0.018	1.154	118	5.059	0.002	0.338
	Wind speed	0.288	0.254	2.847	0.005	1.059	121			
	Constant	0.405	-	0.376	0.707		2			
3	Rainfall	0.011	0.262	2.963	0.004	1.033	119	6.768	0.002	0.32
	Wind speed	0.268	0.236	2.678	0.008	1.033	121			

t = student t test, df = degree of freedom, f = f statistics, Sig = Significance value, TMin = Minimum temperature

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