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Malaria Distribution Pattern of Taraba State.

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ABSTRACT
This research is a TETFUND sponsored research as malaria is known since time immemorial as the cause of many deaths: it is a disease caused by the parasite known as the plasmodium spp, which is transmitted through the bite of an infected mosquito. The study seeks to describe malaria distribution pattern of Taraba State while using rainfall, minimum and maximum temperature as determining variables focussing on finding out if any relationship exists between them using GIS. Simple Random Sampling technique was used to arrive at the choice of the randomly sampled local governments (Ibi and Karim Lamido) from the 16 local governments that make up the state. Furthermore, at least five health centres from the sampled local governments were randomly selected and the hand held GPS was used to take their location where archival data of malaria patients for 9 year was obtained from each health centres located in the study area. Climatic data was downloaded from the worldclim data base and GIS soft ware such as ArcMap, Arccatalog and ERDAS were used to process and analyse both the hospital and climatic data. The hospital data were overlaid on the climatic data to find out if any relationship really exist between them while establishing the distribution pattern it was discovered that significant relationship exist between rainfall, temperature and malaria in Taraba State Nigeria. it was then recommended more climatic data should be employed in future in other to validate the findings of this work also government and none government agencies should study the distribution pattern map so as to sensitize members of the public on how malaria is distributed so as to manage the environment in such a manner that breeding spaces for mosquitoes would be reduced and as such reducing the incidence of malaria infections

Keywords: Malaria, Distribution, Rainfall, Temperature, Relationship, GIS Techniques, Health centres, Patients, Mosquitoes.

I. INTRODUCTION

According to the report of World Health Organization (2016), there were 212 million new cases of malaria worldwide in 2015 and up to 90% of these cases occurred in Tropical Africa. In the same year according to the report, there were an estimated 429,000 malaria deaths worldwide and most (92%) of these deaths occurred in the African region.

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The world malaria report 2019 also states that “malaria infection in pregnancy compromises the mother’s health and can lead to her death, in 2018 an estimated 11 million pregnant women living in 38 countries with moderate to high transmission in sub Saharan Africa was infected with malaria (11 million accounts for 29% of global pregnant women). The report further shows that malaria in pregnancy also impact the health of the foetus which can lead to preterm birth and low birth weight, major contributors to neonatal and infant mortality. In 2018, an estimated 872000 children in 38 countries of Africa were born with a low birth weight due to malaria in pregnancy”. In Nigeria alone malaria is the cause of one in every four deaths recorded in infants and young children and worse still, for every ten women that die around child birth, one is caused by malaria. About half of Nigerian adults have one episode of malaria each year while malaria occurs in younger children up to 3-4 times a year (Ayanlade A., Nathaniel O.A. & Oyekanmi B. 2010). Breeding area for mosquitoes is boosted mostly by temperature, precipitation and human activities and sometimes aided by relief. Malaria disease is endemic in tropical Africa where our Nigeria society belong and of course Taraba state and because of presents issues of climate change there is likelihood that malaria spread is on the increase thereby leading to

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higher morbidity and mortality among people and this could further exacerbate the problem of the economy with man-hour loss.

The environment we live in act as host to all biotic and the none biotic elements that live in it and malaria vectors are not of any exception, like other vector-borne diseases the endemic nature is determined by the local environment where mosquitoes and humans resides. Geographical difference of climate, location and vegetation occur in our environment and is responsible for malaria vector distribution the more the environment is suitable as a breeding space for mosquitoes the more the possibility of malaria infection. Malaria endemicity distribution pattern on a global scale was first undertaken in 1968 by Lysenko and Semashko. This represented the major historical record map of various malaria metrics like parasite rate, vector distributions, entomological inoculation rate, sickle cell incidence etc. Problems that are climate related are varying in range and not limited only to malaria as they are constantly occurring and re- occurring in the past few years and the consequences of these climatic activities range from drought in some areas to flooding and inundation of coastal lands and in other areas affecting food production and health situation of people and also devastating the ecosystem. Climatic issues are now topical issue that is been recognised at both national and international fora as a threat to sustainable development (Adebayo, 2005). According to IPCC (2007) and (2010) effects of climate and climate change may simply be seen as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be attributed to both natural and anthropogenic causes. Human induced factors account for short term variations in climate over the last decades, such as the emission of green house gases and aerosols, changes in land use and the depletion of the ozone layer through various human activities such as industrialization, urbanisation, and even agriculture. Taraba state is an agrarian community which is mainly rain fed which means that farmers are not involved in mechanised farming and any exposure to disease like malaria infection could lead to a great loss of productivity due to morbidity as asserted by Jimoh (2003), using the production function approach to quantifying a disease burden in order to evaluate the malaria burden on Nigerian agricultural sector shows that the economic burden of malaria in terms of lost of agricultural output may be as high as millions of naira for every reported case of malaria per 100,000 persons. An increase in this overburden figures should be unacceptable. In Nigeria, malaria prevalence is as high as 80% and is the most common cause of outpatient visits to health facilities. With a case of mortality rate ranging from 8-12.5% in infants and children, malaria accounts for 30% of child mortality in the country and is consistently recorded as one of the five leading causes of childhood mortality (WHO, 2010). Understanding the seasons (wet and dry seasons) in Taraba state and adapting to all its attendant characteristics is very critical in overcoming the threats and damages of malaria throughout a given year because evidence is emerging for a link between extreme climate events such as the anomalously hot 2003 summer and the biting cold in 2007 due to ocean/atmosphere interaction in the tropical Atlantic related to wetter than average conditions (Obada and Olago, 2005). The rapid increase of human impact on the environment through the use of machines and other environmental incompatibles as continuously led to a further deterioration of the atmosphere thereby changing the atmospheric phenomenon. The creation of green house gases has helped to modify the atmosphere negatively. Human activities also helped in the increase of surface water especially in the city centres and these can only help to increase the breeding space for mosquitoes**.** In recent times evidence of climate change is noticed in most part of northern Nigeria leading to flooding, drought, desertification, crop failure and increase in vector borne diseases. There is therefore no better time to embark on this study in Taraba state. That is to look at the impact of climate (rainfall and temperature) on malaria distribution in Ibi local government of Taraba state. Any increase of vector borne disease malaria inclusive can be narrowed down to its devastating effect on the economy. That is to say that there could be reduced productivity amongst the adult population where farmers cannot produce effectively due to morbidity, civil servant cannot contribute meaningfully to improve GDP. Children becomes so weak and sick that they cannot go to school or even play and when health cases are neglected it leads to death especially among children and pregnant women (WHO, 2010). The use of GIS as a tool for generating climatic data has not been extensively employed in attaining research information in this part of the country. Difficulties in accessing detailed and accurate climatic data from the various weather stations in the country coupled with lack of facilities in the various hospitals especially diagnostic facilities are issues of great concern. The researcher will therefore employ the use of GIS to collect and process all relevant data for this work and these include current world clim and digital elevation data to measure if there are relationships between rainfall, temperature, relief and malaria.

II. MATERIALS AND METHODS

The data used were both primary and secondary data, the primary data were: settle radar topographic mission digital elevation, surface temperature and rainfall data downloaded from the United State Geological Survey (USGS) and World Clim data base respectively while the secondary data include the map of Taraba State which was obtained from the office of the surveyor general of the state. Data about malaria was obtained from the state ministry of health headquarters in Jalingo. Software and their application for this study were: ArcGis version 9.2 for map making, modelling and analysis, Winrar version 4.5 was used for unzipping the Archive images, Erdas imagine version 9.1 was used for image processing and Excel was used for conversion of malaria distribution data while the hand held GPS was used for capturing the location of the Health Centers. The random sampling technique was used during the data collection process. In the first place the 16 local governments that make up Taraba State were divided into three senatorial districts the north, south and central senatorial district. The northern senatorial district has six local governments while the south and the central have five local governments each. In each senatorial district, the names of each senatorial district was written on a piece of paper and each was wrapped after which two (the southern senatorial district and the northern senatorial district) senatorial districts were randomly picked, the researcher further wrote the names of the local government found in these senatorial areas these local governments includes Takum, Wukari, Ibi, Ussa and Donga in the south where Ibi was randomly picked while Ardo Kola, Karim Lamido, Lau, Yorro and Zing in the north and Karim Lamido was randomly picked. Surface Temperature and Rainfall data based on the sampled local government was downloaded and treated accordingly. Furthermore, at least five health centres of the local governments were randomly sampled and the hand held GPS was used to take their location where archival data of malaria patients for 9 years was obtained from each health centre located in study area. The nine years malaria data was divided by nine to arrive at an average frequency which was overlaid on the climatic data. The SRTM digital elevation (1 arc second), surface temperature image/data and rainfall image/data of the study area was projected from Geographic Coordinate System to Projected Coordinate System (UTM/WAS 84) using ArcGis 9.2. The images (Temperature data and Rainfall data) was then imported into Erdas imagine where the location of the study area on the images was subsetted or clipped. The images' brightness, contrast and appearance were enhanced (known as radiometric correction). Finally the images were classified based on the ranges of their values. The map of Taraba State was obtained in shape file format and imported into Arc Map Workstation where the location of the study areas (Ibi and Karim Lamido) was digitised and represented using polygon. Point feature was used to locate the major towns/villages of the local governments (L.G). The frequencies and rates of malaria distribution of each of the affected area was modelled with quantities/proportional symbols and represented against the affected places. In other to understand the relationship between the frequency of the disease with altitude, temperature and rainfall, the frequency of disease was overlaid on the subsetted maps.

1. Temperature map of the Study Area
2. Rainfall map of the Study Area

And the three different maps produced for Ibi local government namely

1. Overlaid map of malaria distribution and minimum temperature of the study area
2. Overlaid map of malaria distribution and maximum temperature of the study area
3. Overlaid map of malaria distribution and rainfall of the study area

The Multiple Regression Analyses

The multiple regression technique was used to estimate the impact of relief, rainfall and temperature (minimum and maximum temperature) on malaria infection. The four functional forms were used in order to select the equation that is most succinct. The functional forms are;

i) Linear function

$Y= b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + ei$

ii) Exponential function

$\text{In } Y=b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + ei$

iii) Semi logarithm

$Y = \text{in } b_0 + b_1 \text{ In } X_1 + b_2 \text{ In } X_2 + b_3 \text{ In } X_3 + b_4 \text{ In } X_4 + ei$

iv) Double log function

$\text{In } Y = \text{In } b_0 + b_1 \text{ In } X_1 + b_2 \text{ In } X_2 + b_3 \text{ In } X_3 + b_4 \text{ In } X_4 + ei$

$Y= F(X_1 + X_2 + X_3 + X_4 + ei)$

Where

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Y= Frequency of malaria infection
X_1= Height above sea level (relief)
X_2= Rainfall
X_3= Minimum temperature
X_4= Maximum temperature
b_0.....b_4= Coefficient of the independent variables
ei= Error term.
The exponential function was fund to be most succinct.

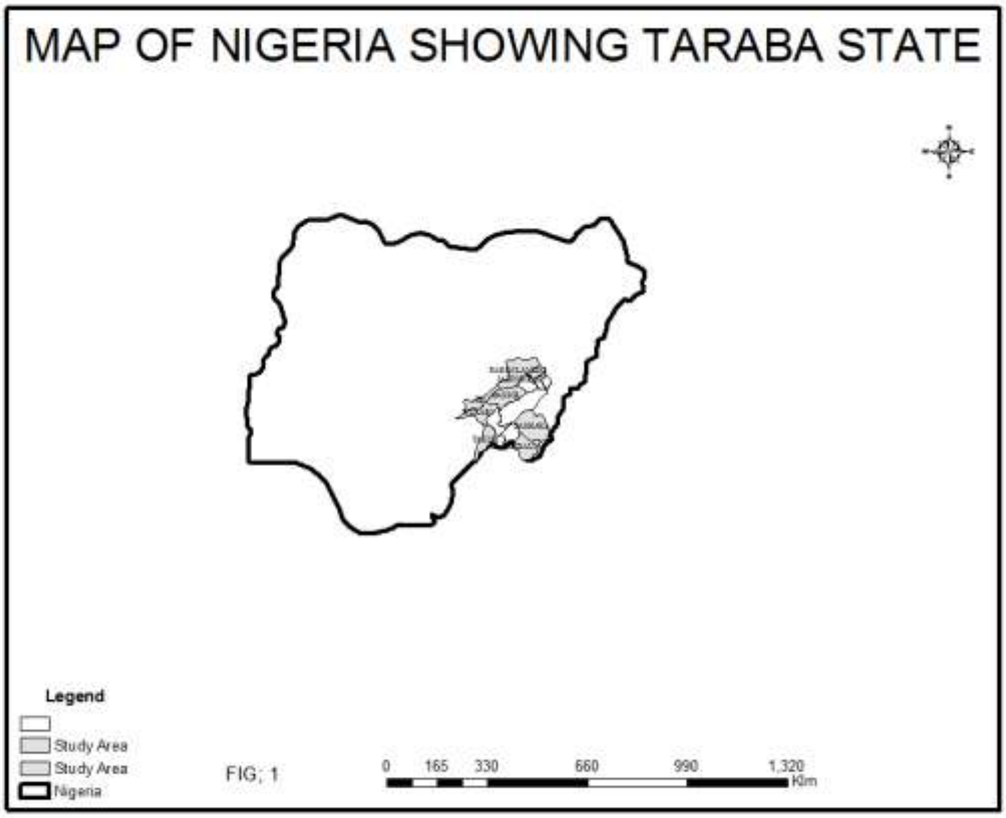


Fig: 1 Map of Nigeria Showing the Study Area

Table 1 show average mean rainfall of 87.4 mm throughout the year for Karim Lamido Local Government while it is 102.4mm for Ibi Local Government of Taraba State with little or no rainfall in most of January up to March and most of November to December also records least amount of rainfall for the two areas under discussion. Malaria infections mostly occur as shown on tables 1 and 2 in the months of August, September and October as the leading month with 15% in Karim Lamido occurred in September while August with 11% occurrence was the highest in Ibi. The month of December accounts for the lowest amount of infections in Karim Lamido and the lowest infection in Ibi southern Taraba occurred in February as shown on the table. It should be noted that the frequencies of incidence of infection is higher in Ibi than in Karim Lamido as each Local Government is treated differently.

Table 1 Showing Monthly Average Rainfall, Minimum / Maximum Temperatures and Malaria Distribution in Karim Lamido LGA

Months of the year	Rainfall mm	Minimum Temp. ^{0}C	Maximum Temp.^{0}C	Monthly Total Malaria Infection Karim L. (2011-2019)	% Total of Malaria Infections
January	0	17	35	3955	6%

February	0	19	37	6003	9%
March	7	23	39	4900	7.5%
April	51	25	39	5530	8.5%
May	108	25	36	3950	6%
June	160	23	33	7537	11.6%
July	173	23	31	5736	8.8%
August	205	22	30	8200	13%
September	195	22	31	9800	15%
October	150	22	31	5700	8.8%
November	0	19	35	3001	5%
December	0	16	35	399	0.6%
Average mean total	87.4mm	21.3^{0}C	34.3^{0}C	64711	100%

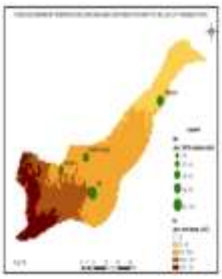
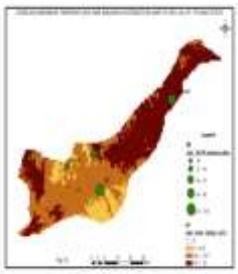
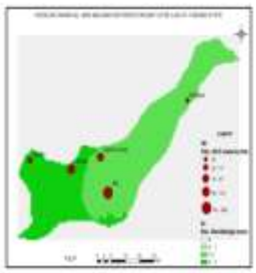
Source; worldclim. data base and Taraba State Min. of Health, 2019.

Table 2 Showing Monthly Average Rainfall, Minimum / Maximum Temperatures and Malaria Distribution in Ibi LGA

Months of the year	Rainfall mm	Minimum Temp. ^{0}C	Maximum Temp.^{0}C	Monthly Total Malaria Infections of Ibi (2011-2019)	% Total of Malaria Infections
January	2	19	35	7745	7%
February	2	21	37	7542	7%
March	20	24	37	9950	9%
April	74	24	36	5540	5%
May	143	23	32	8200	7.7%
June	170	23	31	9338	9%
July	208	22	30	8360	8%
August	228	22	30	11454	11%
September	223	22	30	9955	9%
October	150	21	32	11040	10%
November	8	19	33	8114	8%
December	1	16	35	8061	8%
Average mean total	102.4mm	21.3^{0}C	33.1^{0}C	105299	100%

Source; worldclim. data base and Taraba State Min. of Health, 2019.

PRESENTATION OF DATA OF IBI DURING THE DRY SEASON

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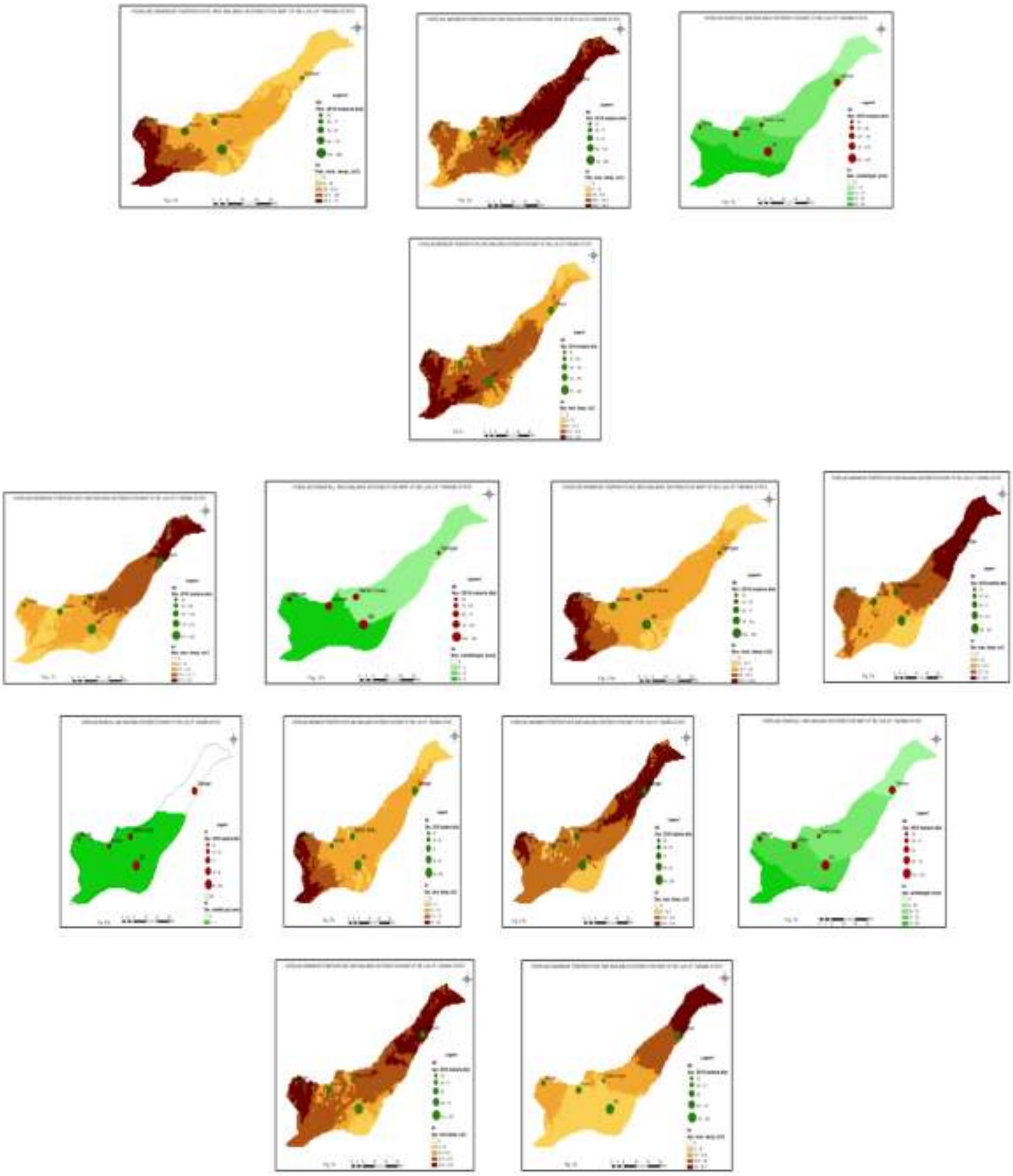

Source: worldclim data base and Taraba state ministry of health, 2019

Maps:1a to 18a showing relationship between rainfall, temperature (minimum and maximum temperature) and malaria distribution in Ibi local government area (LGA) of Taraba State in the months of January to April and November to December 2019.

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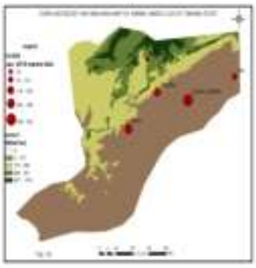
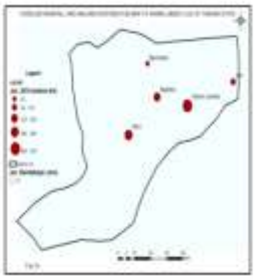
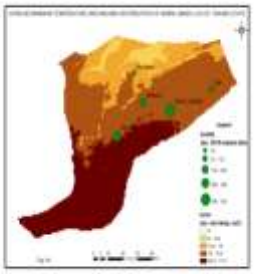
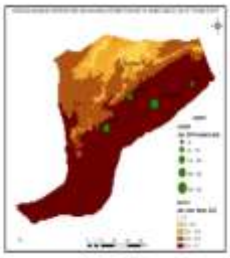
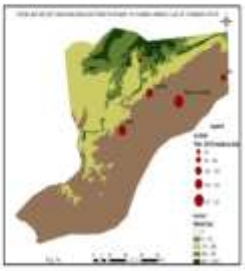
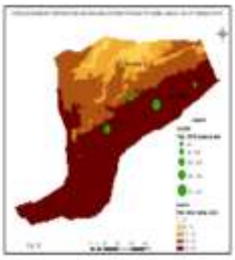
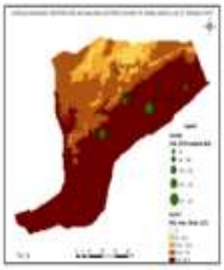
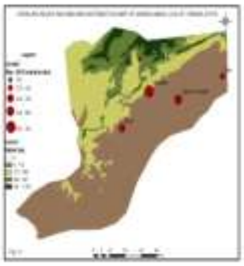
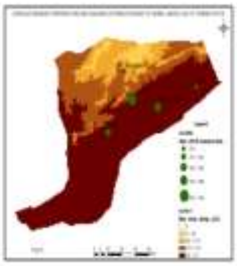
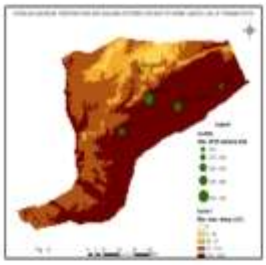
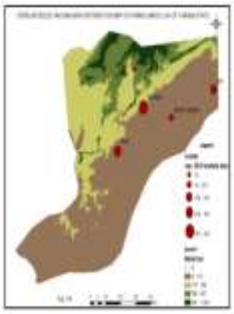
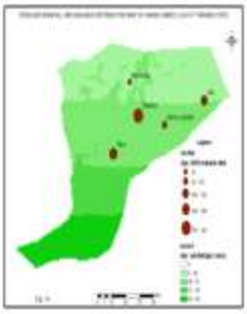
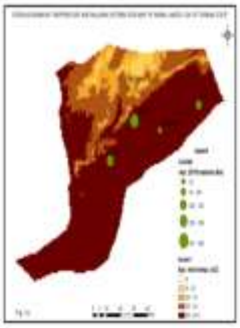
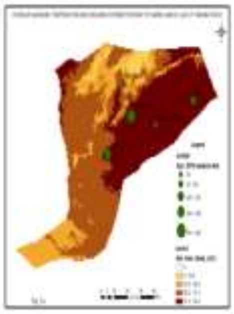
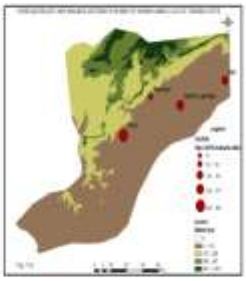
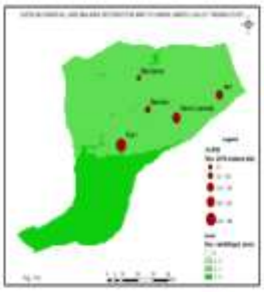
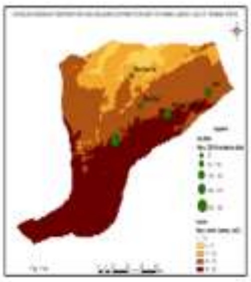
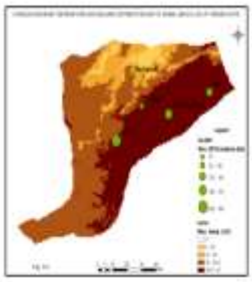
PRESENTATION OF DATA OF KARIM LAMIDO DURING THE DRY SEASON

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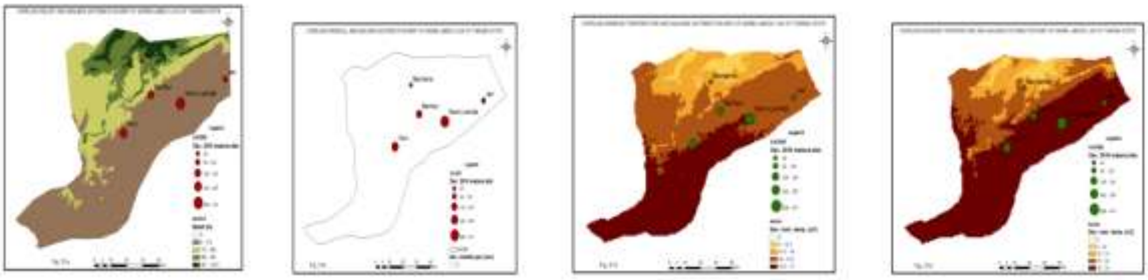
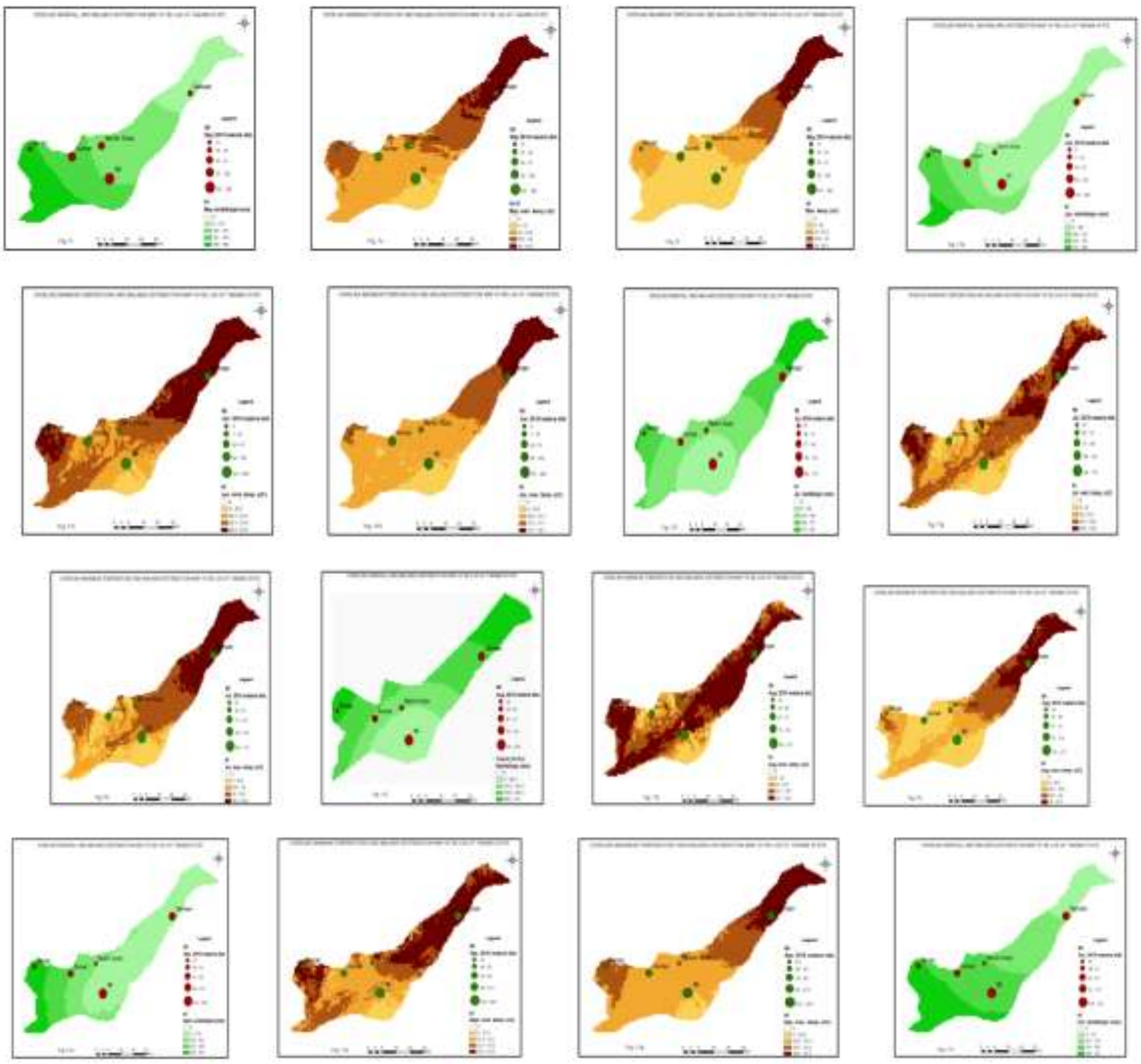


Figs. 1a to 1d, 1e to 1h, 1i to 1l, 1m to 1p, 11u to 11x and Fig 21a to 21d showing relationship between relief, rainfall, temperature (minimum and maximum temperature) and malaria distribution in Karim Lamido local government area (LGA) of Taraba State in the months of January, February, March, April November and December 2019.

PRESENTATION OF DATA OF IBI DURING THE WET SEASON



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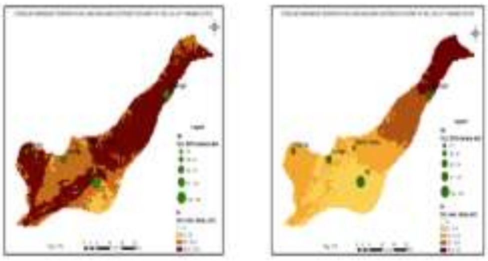
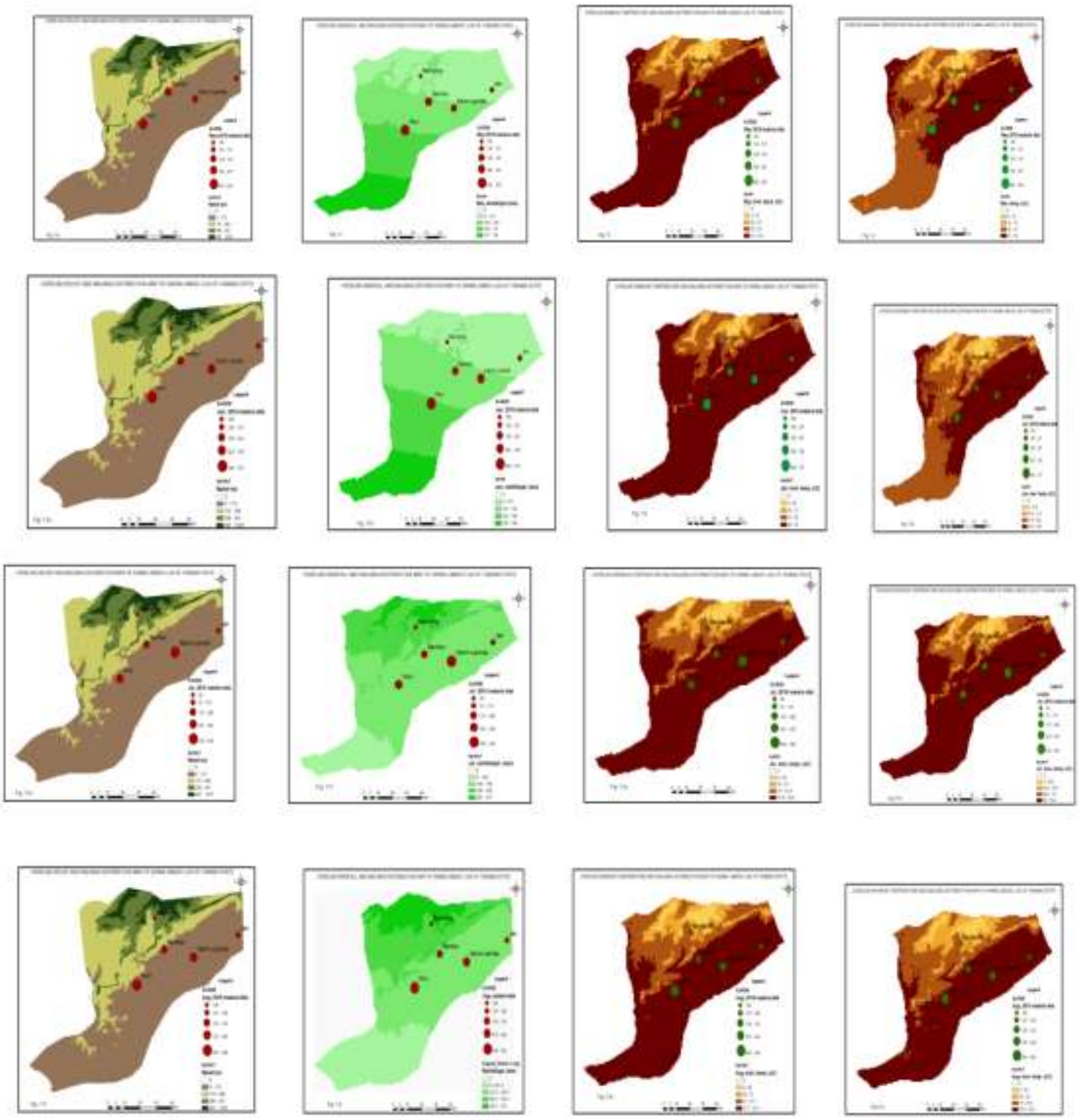


Source: worldclim data base and Taraba state ministry of health, 2019

Maps:1b to 18b showing relationship between rainfall, temperature (minimum and maximum temperature) and malaria distribution in Ibi local government area (LGA) of Taraba State in the months of May to October 2019.

PRESENTATION OF DATA OF KARIM LAMIDO DURING THE WET SEASON



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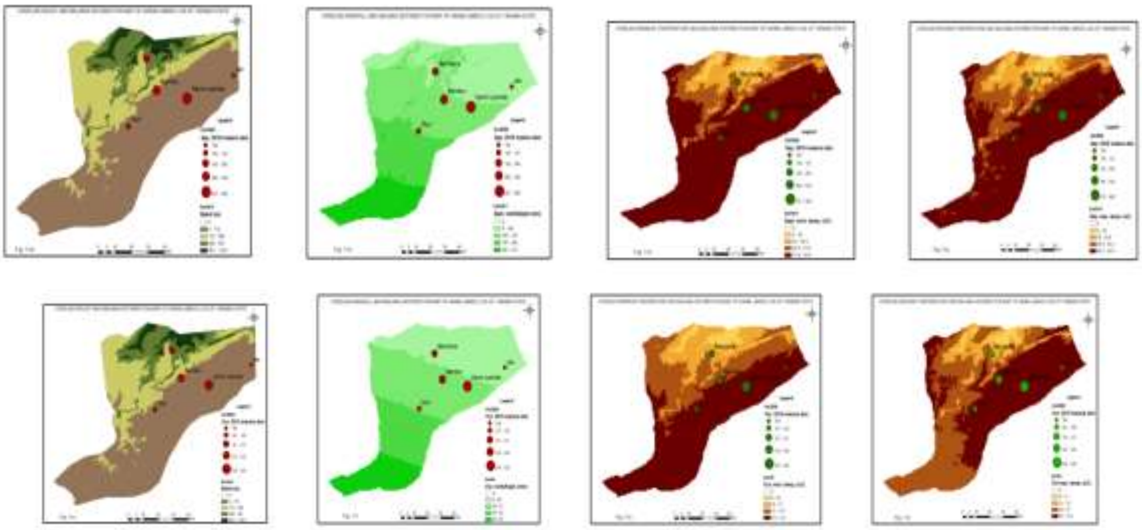

Figs. 1q to 1t, 11a to 11d Figs. 11e to 11h, 11i to 11l, 11m to 11p and 11q to 11t showing relationship between relief, rainfall, temperature (minimum and maximum temperature) and malaria distribution in Karim Lamido local government area (LGA) of Taraba State in the months of May, June July, August September and October 2019.

III. DISCUSSION OF RESULTS

This session discusses the impact of rainfall on malaria, and the impact of minimum and maximum temperature on malaria infection in Taraba state. The researcher sought to find out the impact of rainfall on malaria distribution in the study area of Taraba State using regression analysis where rainfall was defined as X2 and malaria distribution as Y. The outcome shows that there is a significant impact or relationship between rainfall and malaria distribution at 5%. This means that an increase in rainfall would statistically lead to an increase in the distribution of malaria infection in Taraba State. This finding corresponds with the works of, Ayanlade et al 2010, Adebayo et al 2005, Obada et al, 2005 etc. We also tried to find the impact or relationship between minimum temperature and malaria distribution in Taraba state using regression analysis where minimum temperature was defined as X3 and malaria distribution as Y. The outcome shows that there is a statistically significant impact or relationship between minimum temperature and malaria distribution at 5%. This means also that an increase in minimum temperature would lead to an increase in malaria distribution in Taraba State. This findings corresponds with the work of Ayanlade et al 2010, Adebayo et al 2005, Obada et al, 2005 etc. Finally we sought the impact or relationship between maximum temperature and malaria distribution using regression analysis where maximum temperature was defined as X4 and malaria distribution as Y. The outcome shows that there is significant impact or relationship between maximum temperature and malaria distribution at 5% significance. This simply means that an increase in maximum temperature would statistically increase the incidence of malaria infection in the state. This corresponds with the works of Ayanlade et al 2010, Adebayo et al 2005, Obada et al, 2005 etc even though the literatures showed that there is significant relationship between temperature and malaria there was no specific mention of maximum or minimum temperature having relationship with malaria distribution.

The summary of the major findings are presented below:

The general trend of rainfall amounts indicates a gradual decrease from the northern part to the southern part of the state. Rainfall amount in the southern part with about 350 mm in the month of September this also coincides with the work of (Udo, R.K. 1970). Generally speaking temperatures are always very high in the northern part of Taraba state especially the extreme north of the state than the southern part and that the range of temperatures are higher in the northern part too. Harmattan is also an important component of the climatic type of Taraba state and this occurs in the months of December and January and this coincides with the movement of the north east trade wind of the Sahara desert. The Harmattan period also coincides with the periods of minimum temperature with the lowest temperatures (17^0C)

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recorded in the local government of the state this also coincides with the findings of (Udo, R.K. 1970). Incidence of malaria is higher in the southern part of the state than in the north. The moist nature of the southern part of state along with sufficient temperatures makes it most succinct for its spread as also established in a work done by Ayanlade et al (2013) where he states that there is relationship between rainfall, temperature and malaria distribution.

Regression Analysis;

Table 2; Exponential Multiple Regression result of Relationship between Relief, Rainfall Minimum, Maximum Temperature and Malaria Distribution.

Variables	Estimated parameters	Coefficients	Standard Errors	T-Values	Significant Levels
Constant	X_0	3.624024	0.117463	30.85254	0.0000**
Relief	X_1	1.95E-05	1.91E-05	1.024598	0.3060NS
Rainfall	X_2	0.003018	0.000150	20.08397	0.0000**
Min. Temp.	X_3	0.015522	0.003065	5.0664427	0.0000**
Max. Temp.	X_4	0.044044	0.002700	16.31427	0.0000**

Diagnostic Statistics
R^2=0.610
F-Value=0000
N= 539
Source: Field study 2015; *=1% significant level, **=5% significant level and ***=10% significant level. NS= not statistically significant.

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