ANALYSIS OF SPATIAL PATTERNS OF MALARIA PREVALENCE IN BORNO STATE, NIGERIA

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ABSTRACT

This paper focuses on the spatial distribution of malaria prevalence between 2011 and 2013 in the twenty four LGAs in Borno State. Data on malaria prevalence within the study period (consisting both outpatients and inpatients) which were categorized into under five years old, above five, pregnant women and numbers of dead in each category within the study period were obtained from Borno State Epidemiological Unit, Maiduguri for this study. A digital map of Borno State showing the twenty four LGAs was also generated using Geographic Information System technique. The data was integrated with the digital map to assess the spatial patterns of prevalence of malaria in Borno State. The prevalence was categorized into very high, high, marginally high and low based on the reported malaria cases in each of the three years of study (2011-2013). The study revealed that in 2011, only Maiduguri Metropolitan Council and Jere LGA recorded very high prevalence. However in 2012 and 2013, Ngala LGA joined MMC and Jere as the third LGA with very high prevalence. Among the pregnant women, MMC and Jere LGAs had very high prevalence while the prevalence was found to be high in Kaga and Ngala LGAs. Very high prevalence of the dead among the pregnant women was found in Bama, Bayo and Dikwa LGAs with high category in Askira Uba, Kwaya Kusar and Mobbar LGAs. In the under-five category, MMC and Jere had very high prevalence while Kaga, Ngala, Gwoza and Bayo were in the high category. However, Damboa and Mobbar LGA was in the very high category in the dead among the under-five with nine other LGAs belonging to the high category. It was recommended that all the LGAs that fall within the very high and high categories should be given higher priorities than those in the lower categories, while the causes of the revealed spatial pattern was recommended for further study.

Keywords: Borno State, spatial pattern, malaria, malaria incidence

INTRODUCTION

The term malaria originated in the 17C in Italy where the death of patient after intermittent Roman fevers was attributed to a bad air (Mal'aria) of the marsh and swamp lands [1]. According to [2] the protozoa was first described in the blood of a patient by Charles Lareran, a French army surgeon stationed in Algeria in 1887, who observed the parasite in an unstained smear of fresh blood, the fever was also recognized in ancient times in China, India and Mesopotamia, but the earliest record was that of Hippocrates in the 5thC B.C., the Greeks and Romans were aware of the association of this fever with marshy lands and conducted one of the earliest health campaigns by drawing out the stagnant water.

In the work of [1] malaria was described as a human disease caused by infection with protozoan parasite belonging to the genus plasmodium, and characterized by chills, fever and in most severe cases, coma leading to death. The parasites are transmitted by the bite of female mosquitoes (the vector of the parasite) of about 60 species belonging to the genus

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Anopheles, which are transmitted into the blood stream of man, are of four species, *Plasmodium Falciparum*, *P ovale* and *Plasmodium vivax.* According to [3], malaria is an infectious disease that, despite being preventable and treatable, threatens the lives of 3.3 million people around the world, for instance, every year, malaria accounts for 243 million cases and 863,000 deaths, 89% of which are in sub-sahara Africa where a child dies every 45 seconds from malaria. [4] also reported that in Africa, nearly three-quarters of the population is at risk to malaria, it is endemic in 90% of African countries, accounting for 16-20% of all hospital admission. According to the latest WHO estimates [5], released in December 2016, there were 212 million cases of malaria in 2015 and 429 000 deaths. The WHO African Region continues to carry a disproportionately high share of the global malaria burden. In 2015, the region was home to 90% of malaria cases and 92% of malaria deaths. Some 13 countries – mainly in sub-Saharan Africa – account for 76% of malaria cases and 75% deaths globally.

Malaria endemic in Nigeria has been an issue of concern to all the stake holders. For instance, [6] reported that malaria is a major public health problem in Nigeria where it accounts for more cases and deaths than any other country in the world, according to him, malaria is a risk for 97% of Nigeria's population, the remaining 3% of the population in Nigeria live in malaria free highlands. They concluded that there was an estimate of 100 million malaria cases with over 300,000 deaths per year in Nigeria, compared to the 215,000 deaths per year from HIV/AIDS, which means that malaria is more deadly in Nigeria than HIV/AIDS. In Borno State, numerous works have been carried out especially on causes, effect and management of malaria endemic in the state. Several reports have been made that malaria incidence is the highest ranking among the causes of morbidity throughout Borno state, and that for a long period of time, malaria contributes immensely to the hospital attendance and was also responsible for a significant mortality rate in the state ([7, 8, 9 and 1].

The need to study the spatial pattern of malaria incidence emanates from the fact that malaria incidence is not evenly distributed in a geographical area but heavily depends on both environmental and socio economic factors [10]. Among the environmental factors are [10] presence of bushes and stagnant water around homes, rainfall, a warm-humid with temperature between 16˚ and 40˚C, low altitude, presence of still or standing water, vegetation that can provide shade for the mosquitoes to hide during the day and digest the blood in the previous night favor the breeding of malaria vectors, as well as parasite reproduction within them. [11] also reported that housing conditions, standard of living, increased urbanization are some of the socio-economic factors that can aid the rate of Anopheles breeding.

Some programmes have been put in place to reduce the incidence of malaria in Nigeria in general and Borno state in particular. Among them are the distribution of treated mosquito nets, administration of free malaria treatment especially among the infants and pregnant women among others. However, despite all these efforts, the incidence of malaria is still very high in Borno State [1]. To this end, [12] reported that malaria control in endemic areas rely on the case management on the use of insecticide treated nets and vector control, but none of these has proved fully efficacious for controlling the infection. One of the reasons responsible for this ineffectiveness in the control of malaria is the non availability of data in most areas, and where available, most of them are in analog format which are always difficult to keep and extract information for quick visual impression and comparative studies. Therefore, this study focused on the use of Geographic Information System (GIS) techniques to generate digital maps and database management to analyze malaria endemic in Borno state where the severity of malaria among the twenty seven LGAs can easily be visualized and analyzed comparatively. The most severe LGAs of the endemic among the under five and

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above five years as well as the number of dead in both outpatients and inpatients categories, which might be difficult to manually generate, can easily be determined. The generated maps and database would serve as guide for the management of malaria endemic, while efforts can be more concentrated on the identified severe LGAs rather than the entire state.

OBJECTIVES

The specific objectives of the study are:

(i) To analyze the spatial pattern of malaria incidence among the twenty seven LGAs in Borno state.

(ii) To make comparative analysis of malaria incidence among the LGAs.

THE STUDY AREA

Borno State came into being in 1976 when Nigeria was divided into nineteen States. The State was created when the then North-Eastern State was split into Bauchi, Borno and Gongola States. However, in 1991, the western part of Borno State now called Yobe State was carved out of Borno State (Fig.1). Borno State today is the most easterly located State in the Lake Chad Basin area. It is located between latitudes 10˚ 0' 13.473"N and 13˚ 44' 40.23"N and longitude 11˚ 26' 20.555"E and 14˚ 34' 11.581"N.

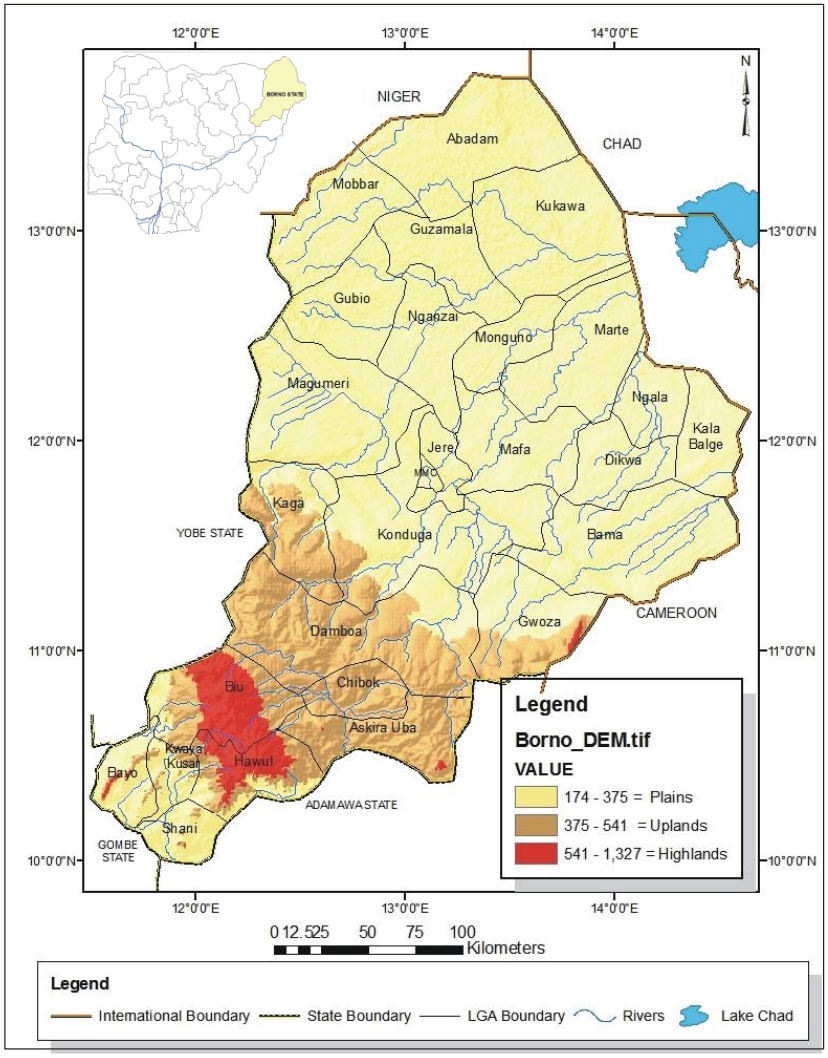

Fig. 1. The Study Area

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The State shares international boundaries with three countries, that is, Republics of Cameroon in the East, Chad in the North East and Niger in the North. Borno State also has boundaries with three States: Adamawa State in the South, Gombe State in South-West and Yobe State in the West. The present Borno State consists of twenty seven (27) LGAs. The Hills and Mountains occupy the southern and South-Eastern regions of Borno State, precisely the central parts of Biu, the northern parts of Hawul and a small portion of Gwoza and Askira-Uba LGAs (Fig.1) According to [13], the areas classified under this category comprise rugged features like mountain ranges, plateau, hills, ridges, escarpments, volcanic cones, inselbergs and other related features.

The plains of Borno State constitute the largest portion of the landmass of the State extending southwards from the Lake Chad, and covering the whole Borno North Senatorial District comprising the following LGAs: Abadam, Gubio, Guzamala, Kaga, Kukawa, Magumeri, Marte, Mobbar, Monguno and Nganzai, as well as almost all the LGAs in the Borno Central Senatorial Zone comprising Bama, Dikwa, Jere, Kala/Balge, Konduga, Mafa, MMC and Ngala. Borno state has few rivers among them are River Komadugu Yobe at the extreme north western part, River Yedzeram which runs from south and empties into Lake Chad. Rivers Ngadda, Ngaddabum, Hawul and Shallangwa are other rivers in the state. The swamps of Lake Chad bounded the state in the north while the Konduga swamp is located at the central portion of the state.

MATERIALS AND METHODS

Types and Sources of Data

Three years data (2011-2013) on malaria incidence in Borno State was collected from Borno State Epidemiological Unit, Ministry of Health, Maiduguri. Each of the annual data was classified into three:

(a) Outpatients

(i) Under five years cases

(ii) Five years and above cases

(iii) Pregnant women cases

(b) Inpatients

(i) Under five years cases

(ii) Five years and above cases

(iii) Pregnant women cases

(c) Deaths

(i) Under five years

(ii) Five years and above

(iii) Pregnant women

The numbers of dead among the pregnant and the under five children were obtained by using the percentages of dead from the total number of cases, which was better than using the ordinary numbers of dead. Borno state map, that is, the base map was acquired from Macmillan Nigeria Secondary Atlas [14] which is one of the recent Atlases in Nigeria and which contains all the boundaries of all the LGAs in the region.

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Data Capture

The acquired Borno State map was scanned and exported to ArcGIS 10.2 software at where the map was carefully georeferenced and the interested features such as international and states boundaries and each of the twenty four LGAs were digitized.

The graduated colour module of the quantity menu of the properties of the layer in ArcGIS was used for the classification and mapping of the malaria cases in each of the categories across the 27 LGAs in the state. This software has the automated capability of breaking data into as many classes as desired using the mean, the median and the standard deviation of the population of each item. However, in this study, the data were categorized into four: that is, very high, high, and marginally high and low as shown in Fig. 2. This has a great advantage over the use of manual method for feature classification because it has the capability of classifying the data automatically into the desired classes which makes the map creation to be faster and accurate with high visual impression.

DISCUSSION OF RESULTS

Spatial Analysis of Malaria Cases in Borno State

The spatial distribution of each of the items such as under 5, above 5 and the pregnant women among the outpatients, inpatients and the dead as well as the total number of malaria cases in each of the three study years (2011, 2012 and 2013) can be generated using ArcGIS software. However in this study, only the following were assessed:

(i) The total malaria cases in each of the three selected years (total number of under 5, above age 5 and pregnant women among the outpatients, inpatients and the dead in each of the 2011, 2012 and 2013 years.

(ii) The total number of pregnant women with malaria between 2011 and 2013.

(iii) The total number of dead among the pregnant women with malaria between 2011 and 2013.

(iv) The total number of under five children with malaria between 2011 and 2013.

(v) The total number of dead among under five with malaria between 2011 and 2013.

Spatial Analysis of total malaria cases in Borno State in 2011

The total malaria cases (outpatients, inpatients, pregnant women, under five and above five years) in 2011 is presented in Fig. 2.

Fig. 2 revealed that in 2011, MMC and Jere LGAs recorded very cases of malaria incidence in the state. The high number of malaria cases in these two LGAs could be attributed to the high population of these two LGAs. According to [15], the population census of the two LGAs had 12.9 and 5.01% respectively of the total population of the state. Ngala, Kaga and Gwoza LGAs were found to record high malaria cases. While the case of Ngala LGA could be attributed to high population [5.67% of the total population of the state [13], In year 2011, except Nganzai LGA, all the northern part of the state recorded low malaria cases which might have occurred because of sparse vegetation cover and scanty rivers in these LGAs. The extreme southern parts comprising Hawul, Kwaya Kussar and Shani LGAs also had low malaria cases in 2011. [16] reported that changes in temperature, humidity, altitude, population density of humans, and deforestation are just a few ecological factors that each play essential parts in the transmission of malaria. Therefore it can be concluded that the general low malaria incidence in northern Borno State could be attributed to extreme high temperature and low humidity which have direct effect on the longevity of the mosquito.

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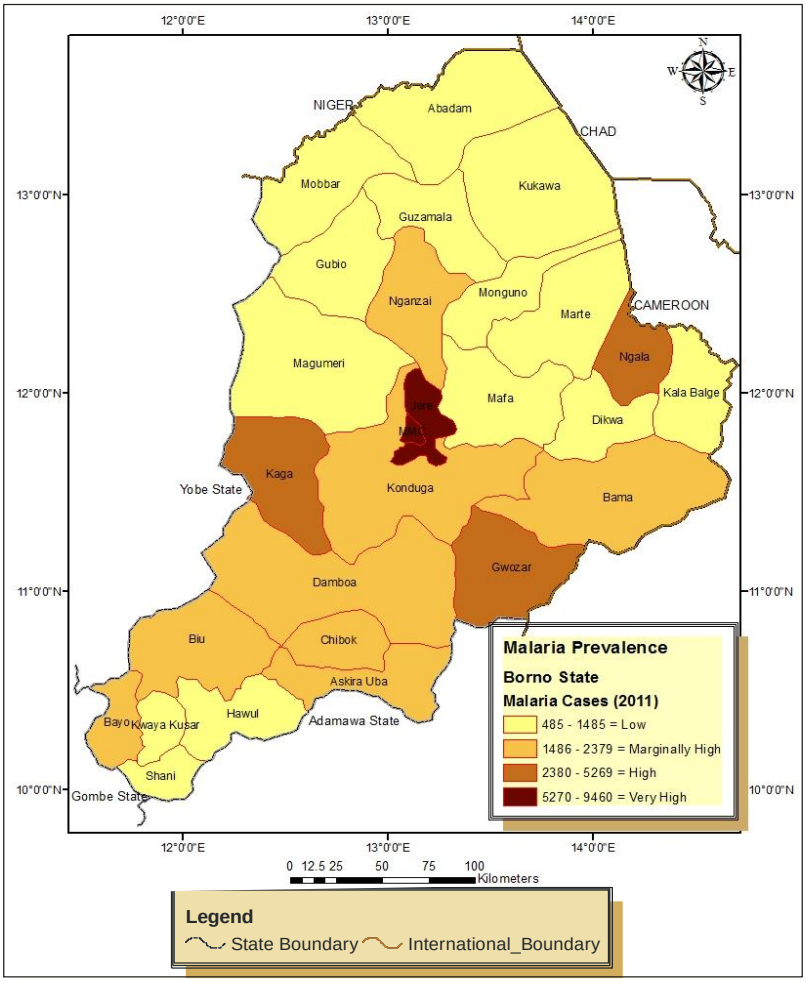

Fig.2. Spatial pattern of Malaria Cases in Borno State (2011)

Each species can thrive at an optimal level as a result of ecological adaptation. From the report of [16], the spread of malaria requires that conditions are favorable for the survival of both the mosquito and the parasite. Temperatures from approximately 21°-32°C and a relative humidity of at least 60% are most conducive for maintenance of transmission. In northern Borno State, the temperature is well above the range of 21-32°C, while the humidity is always below the required 60%.

Spatial Analysis of total malaria cases in Borno State in 2012

The total malaria cases (outpatients, inpatients, pregnant women, under five and above five years) in 2012 is presented in Fig. 3.

In 2012, it was observed that higher cases of malaria incidence were recorded in the state. For instance, Ngala joined MMC and Jere LGAs as those with very high cases in 2012. Moreover, except Magumeri, Mafa and Kala Balge, all other LGAs in the northern part of the state that had low malaria cases in 2011, have changed to marginally high cases in 2012. Moreover, while Hawul LGA remained the only LGA that still maintained low number of cases, more LGAs such as Konduga, Askira Uba, Biu, Chibok and Bayo were discovered to have changed their malaria incidence status from marginally high in 2011 to high in 2012.

The spread of high malaria cases into so many LGAs within this period (2012) could be attributed to the effect of the insurgency. The periods of 2012 to 2014 were recorded as the peak of insurgency in the state which leads to the closure of so many health centers, brain drain, and inaccessibility to some health centers. This finding have also been reported by [17] that high insecurity, difficult terrain and lack of health workers, medicines, equipment and

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basic amenities such as safe water are making access to essential, life-saving health care extremely difficult for people in Borno State which was the base of the conflict-affected areas. Moreover, [18] also reported that health care services have collapsed in Borno State as doctors, nurses and pharmacists flee for their lives from the brutal violence unleashed by the Boko Haram militants. She concluded by a question; how can health care be effective in northern Nigeria if there are no health care workers?

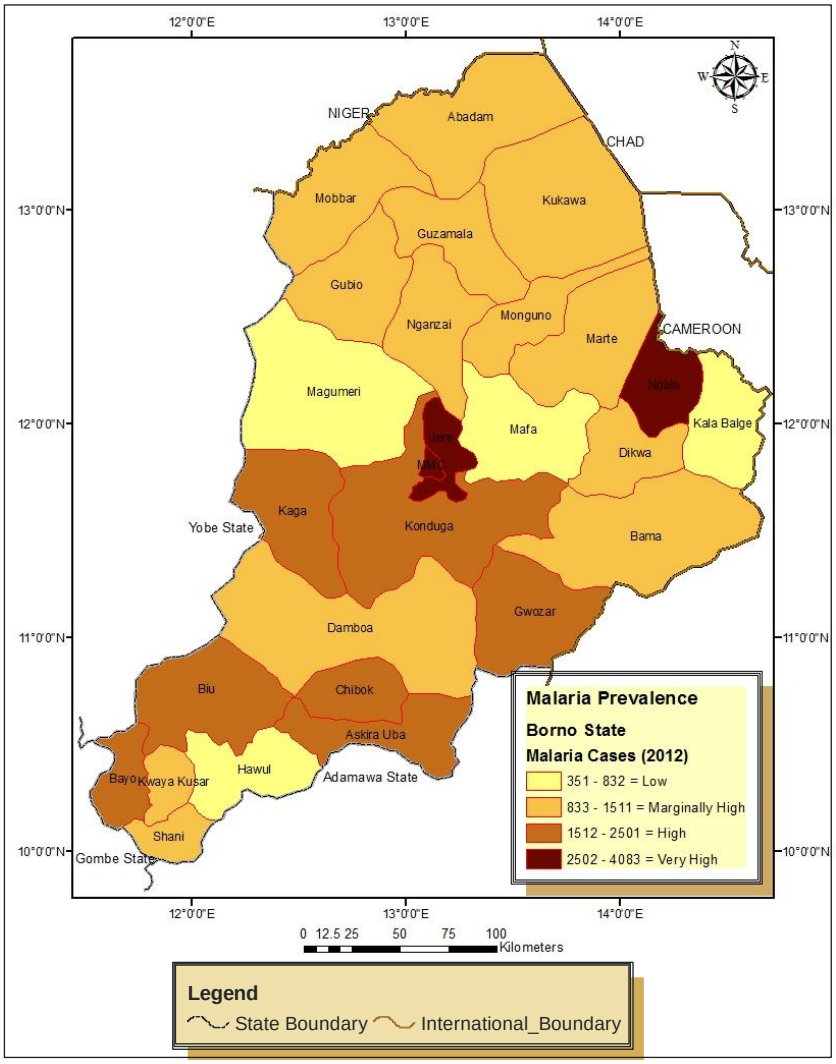

Fig.3. Spatial pattern of Malaria Cases in Borno State (2012)

Spatial Analysis of Total Malaria Cases in Borno State in 2013

The total malaria cases (outpatients, inpatients, pregnant women, under five and above five years) in 2013 is presented in Fig. 4.

In 2013, the spatial distribution of malaria cases was discovered to be low in six LGAs in the northern part and two in the extreme southern region of the state. However, the three LGAs (Jere, Mafa and Ngala) that recorded very high malaria cases in 2012 were still the same LGAs with very high status in 2013. In this year 2013, Kukawa LGA became one of the LGAs with "high" malaria cases. The reason could be attributed to the fact that during this period, most of the LGAs in the extreme north had migrated to Kukawa LGA in general and Baga town in particular which was believed to be more secured because of the large population and market that were more protected by the security agents than the rural areas with either no or less presence of security agents,

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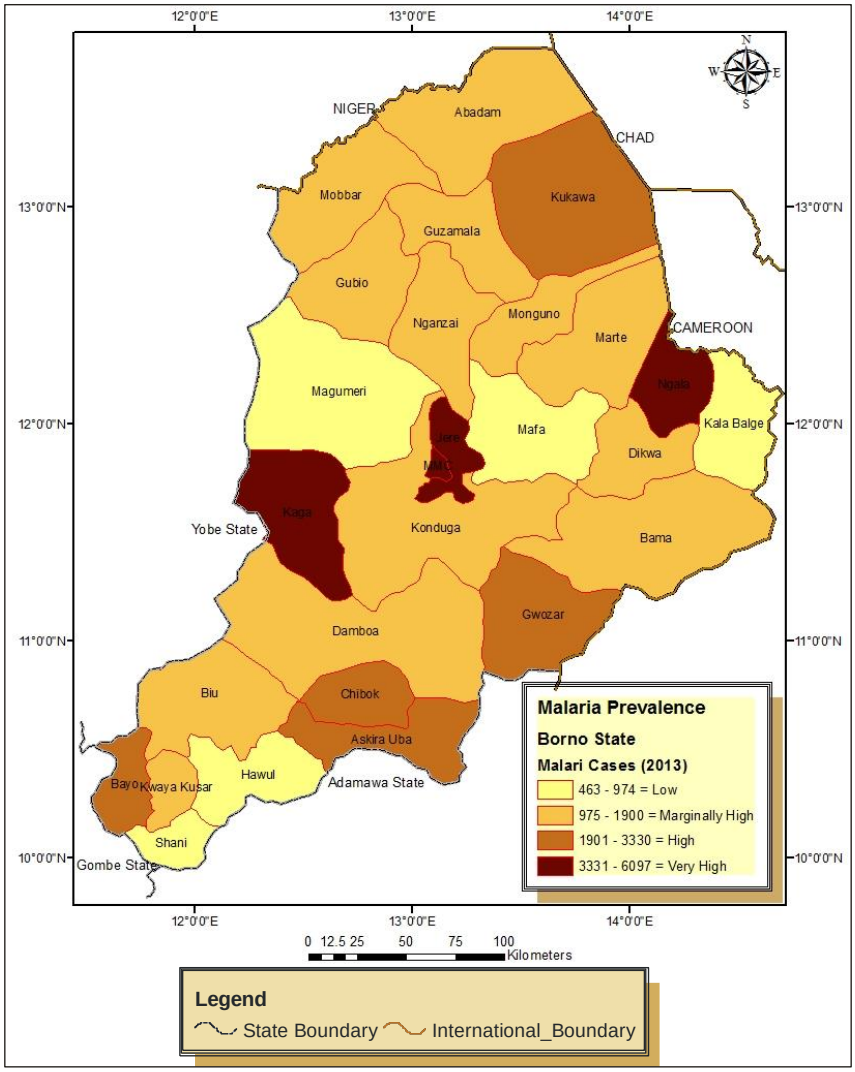

Fig.4. Spatial pattern of malaria cases in Borno State (2013)

The summary of the malaria incidence among all the LGAs from 2011 to 2013 is presented in table.

Table 1. Summary of the malaria incidence among all the LGAs from 2011 to 2013

Status	2011	2012	2013
Very High	Jere, MMC	Jere, Ngala and MMC	Jere, Ngala, Kaga and MMC
High	Gwoza, Kaga and Ngala	Askira Uba, Bayo, Biu, Chibok, Gwoza, Kaga and Konduga	Askira/Uba, Bayo, Gwoza, and Kukawa
Marginally High	Nganzai, Bama, Konduga, Biu, Chibok, Askira Uba, Damboa, and Bayo	Abadam Mobbar, Nganzai, Guzamala, Gubio, Monguno, Marte, Kukawa, Dikwa, Bama, Damboa, Shani, Kwaya Kusar	Biu, Kwaya Kusar, Chibok, Damboa, Bama, Dikwa, Konduga, Marte, Nganzai, Guzamala and Abadam
Low	Mobbar, Abadam, Kukawa, Kala Balge, Guzamala, Monguno, Marte, Mafa, Dikwa, Magumeri, Gubio, Hawul, Kwaya Kusar and Shani	Magumeri, Mafa, Kala Balge and Hawul	Hawul, Shani, Monguno, Magumeri, Gubio, Mobbar,Mafa and Kala Balge

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Spatial Analysis of total malaria cases in Borno State between 2011 and 2013

The spatial distribution of the total malaria cases in 2011-12 and 2013 is presented in Fig. 5.

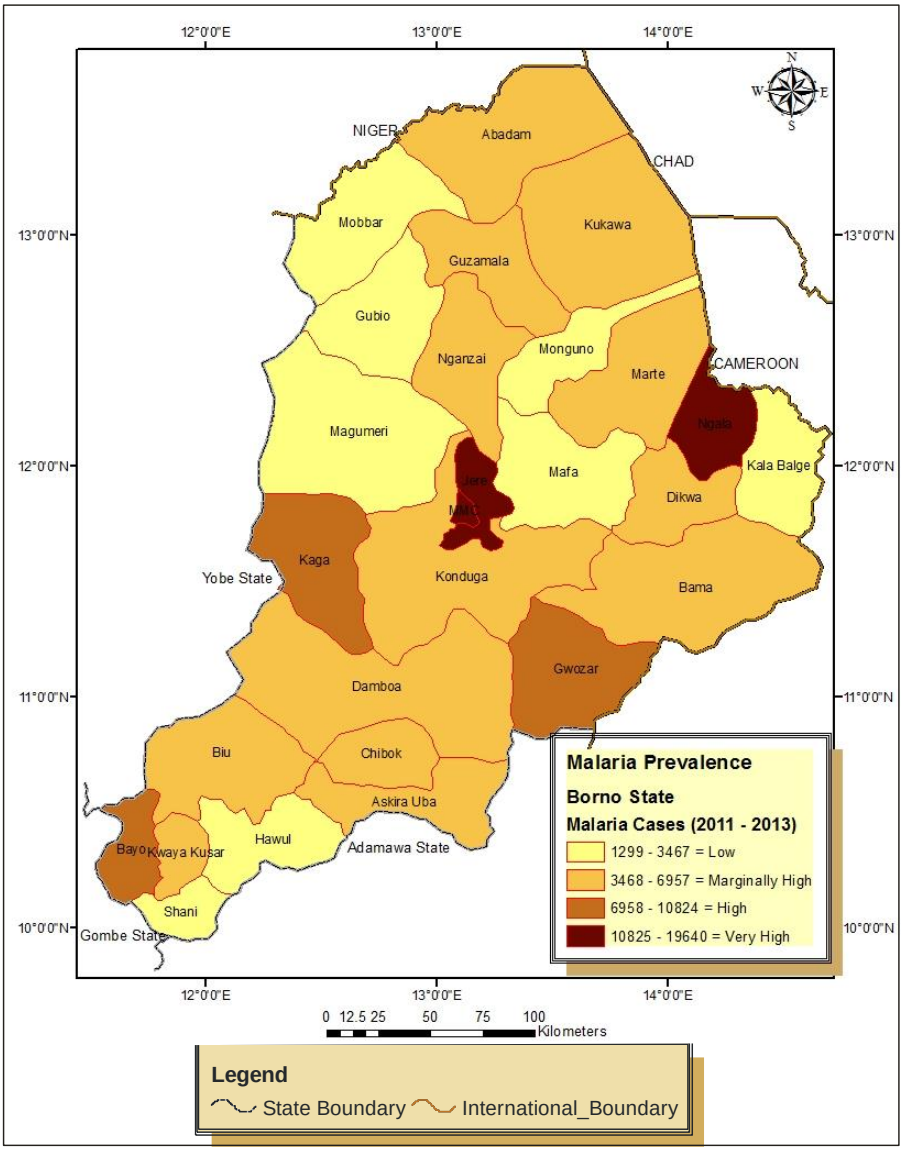

Fig.5. Spatial pattern of total malaria cases in Borno State (2011 and 2013)

Fig. 5 shows the spatial distribution of the total malaria incidence from 2011 to 2013. MMC, Jere and Ngala were seen as the three LGAs with very high incidence of malaria within the three years. The high reported cases of malaria in these three LGAs could be as a result of high population. According to the 2006 National Population and Census results the four LGAs with highest population are MMC (12.95% of the Borno State population), Gwoza (6.3%), Bama (6.48%) and Ngala (5.67%). The LGAs with either very or relatively high cases of malaria incidence were found in the agrarian LGAs where the woodlands are cultivated or where irrigation farming is practiced like Ngala and Kukawa. The impact of deforestation and irrigation agriculture on malaria incidence have been reported by [12] that cleared tropical forest is typically converted into grazing pastures, agricultural plots, and human settlements. These ecological disturbances allow for the proliferation of mosquitoes that prefer human habitation to natural settings.

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Spatial distribution of malaria prevalence among pregnant women and under five

Spatial distribution of malaria prevalence among pregnant women

Fig. 6 shows the spatial distribution of the total malaria incidence among the pregnant women from 2011 to 2013.

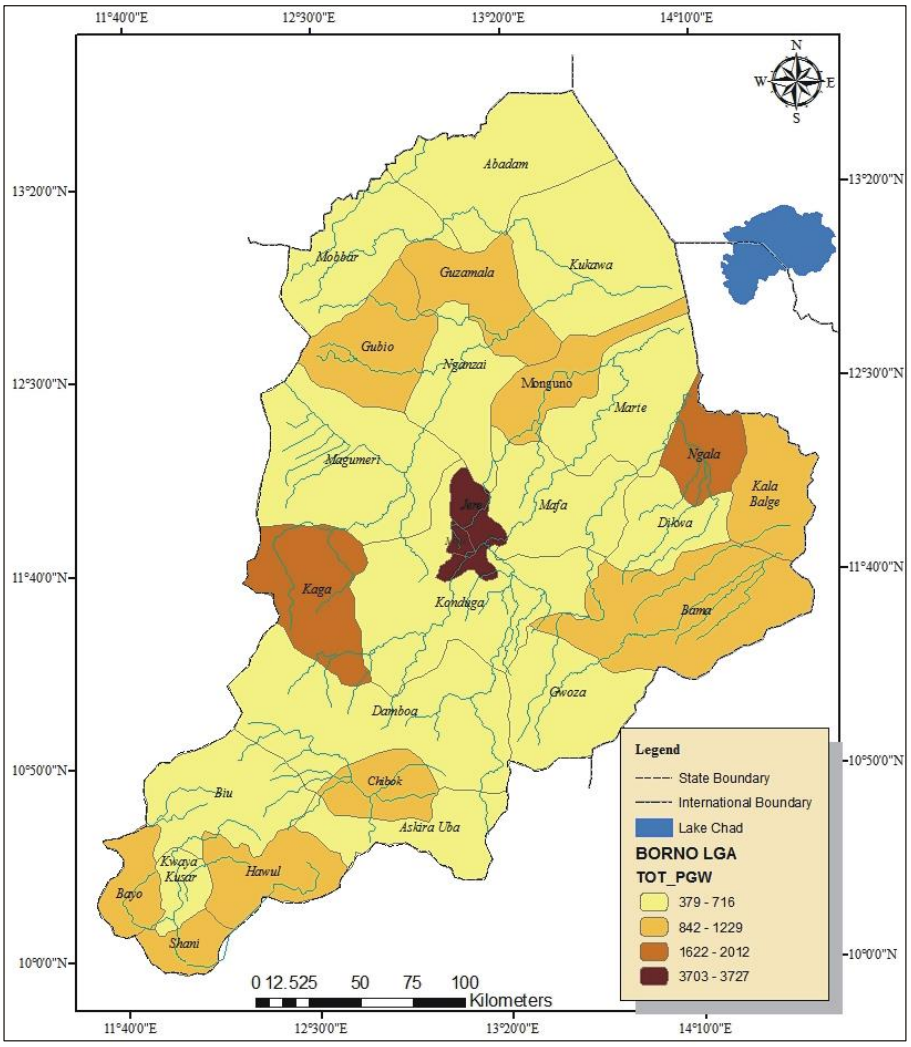

Fig. 6. Spatial pattern of malaria incidence among the pregnant women from 2011 to 2013

The pattern of the spatial distribution is similar to that of the total spatial distribution where MMC, Jere, Ngala and Kaga LGAs were seen as the four most affected LGAs. This shows that these four LGAs need special attention on malaria and malaria related cases in the state.

5.2.3 Spatial distribution of dead among the pregnant women with malaria cases

Fig. 7 revealed that Bama, Bayo and Dikwa were the three LGAs that recorded highest dead cases among the reported pregnant women with malaria cases.

Mobbar, Askira Uba and Kwaya Kusar were also discovered to have high cases of dead among the pregnant women. The Borno State government was reported to have known the spatial distribution of dead among the pregnant women and have since been taking drastic measures to reduce the incidence in the state. For instance, [19] reported that Borno State has emerged best performing state in the eradication of Malaria in the northeastern zone of the country and fourth overall in Nigeria.

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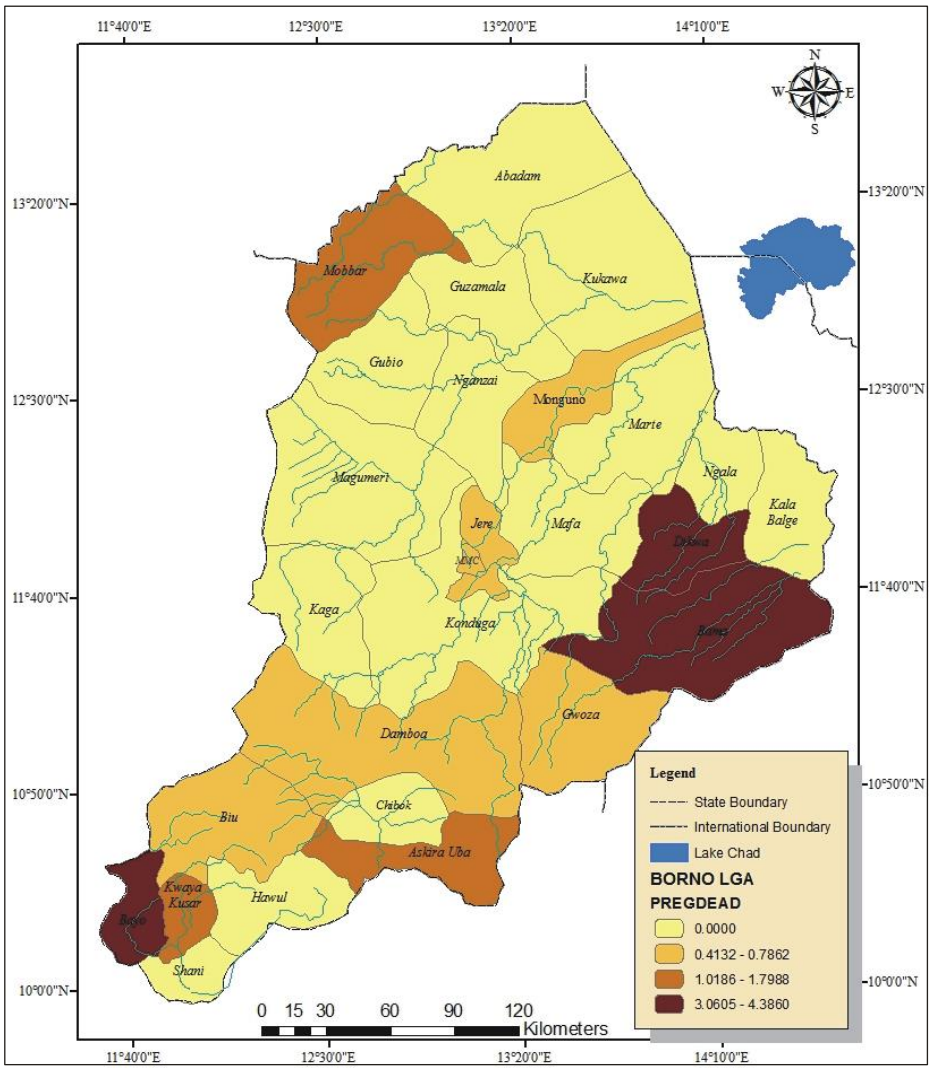

Fig. 7. Spatial distribution of dead among the pregnant women with malaria cases

He concluded that the state recorded 519 deaths from 406,000 reported cases of malaria, but added that cases of the disease had reduced drastically due to measures put in place by the state government. The Borno State government has also trained well over 1,300 health workers to ensure healthy society in Borno. 810 health care providers on malaria commodity logistics system have been trained, and also 405 health workers on malaria case management have also been recruited. The government had also included distribution of about 20,000 long lasting insecticide nets (LLINs) during flood intervention in Mobbar LGA (one of the LGAs highly affected in Fig.7), IPDs activities on pregnant women during routine ANC as well as distribution of about 200,000 ACTs RDTs to 405 health facilities to about 47 private clinics.

Spatial distribution of malaria prevalence and dead among the under five years

Figs. 8 and 9 show the spatial distribution of malaria prevalence among the under five years and dead among the under five years respectively.

Like the previous examined cases, the prevalence of malaria among the under five was found to be very high in MMC and Jere, and high in Kaga, Gwoza, Bayo and Ngala LGAs. However, in dead reported cases, Mobbar and Damboa had the highest number of cases while Abadam, Askira Uba, Bama, Chibok, Dikwa, Kala Balge, Kukawa, Marte, Monguno and MMC also have high reported number of cases but not as high as that of Mobbar and Damboa LGAs. The choice of Mobbar LGA as the venue for the launching of the distribution

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of anti malaria items by the Borno state commissioner of health in 2013 was justified in this study as Mobbar was found to record high number of dead among the pregnant women as well as among the under-five.

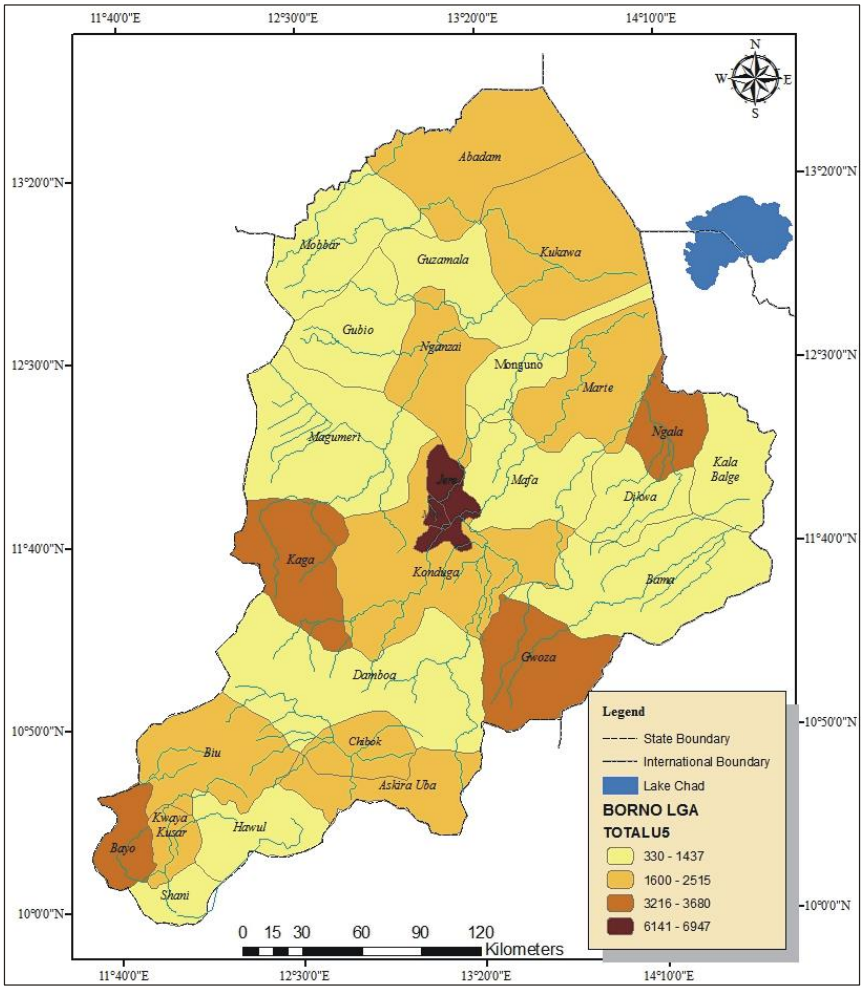

Fig. 8. Spatial distribution of malaria prevalence among the under five years

Nationally, the government has been trying to minimize this incidence as reported by [20] that Nigeria has recorded a 35 per cent decline in malaria cases in five years with only 25 per cent of children under the age of five testing positive for the disease in 2015 compared to 40 per cent in 2010. The results of the 2015 Nigeria Malaria Indicator Survey (NMIS) by the National Malaria Elimination Programme (NMEP), National Population Commission and the National Bureau of Statistics (NBS) show a marked decrease in prevalence of the disease among children under five, and major improvements in prevention and treatment. According to the report, the decrease corresponds with the expanded malaria prevention interventions. Ownership of insecticide-treated mosquito nets (ITNs) has also increased over eight fold since 2008 when only 8% of households owned an ITN.

CONCLUSION

The spatial distribution of malaria prevalence in among the twenty four LGAs in Borno State has been demonstrated in this paper. The spatial assessments include the total reported malaria cases in each year between 2011 to 2013, the reported number of pregnant as well as the dead among the pregnant women and finally reported cases of under five and the dead among the under five. MMC, Jere, Ngala, Kaga, Gwoza, Mobbar and Bayo were found to be

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most affected by malaria prevalence. These seven LGAs needed more attention than the other LGAs in terms of control and management of malaria prevalence in the state. Moreover, while Damboa and Mobbar LGAs were more affected by under five dead, Bama, Dikwa and Bayo LGAs had the highest numbers of dead among the pregnant women. The use of digital maps for spatial assessments has also proven to be more visually impressed than other methods like tables, charts or figures because the generated maps give effective visual impressions that can aid quick assessments, analysis, comparisons and quick decision making. Therefore the use of digital maps for spatial distribution assessments should be encouraged. The course of the patterns of the spatial distributions of malaria prevalence among the LGAs in Borno State is recommended for further studies.

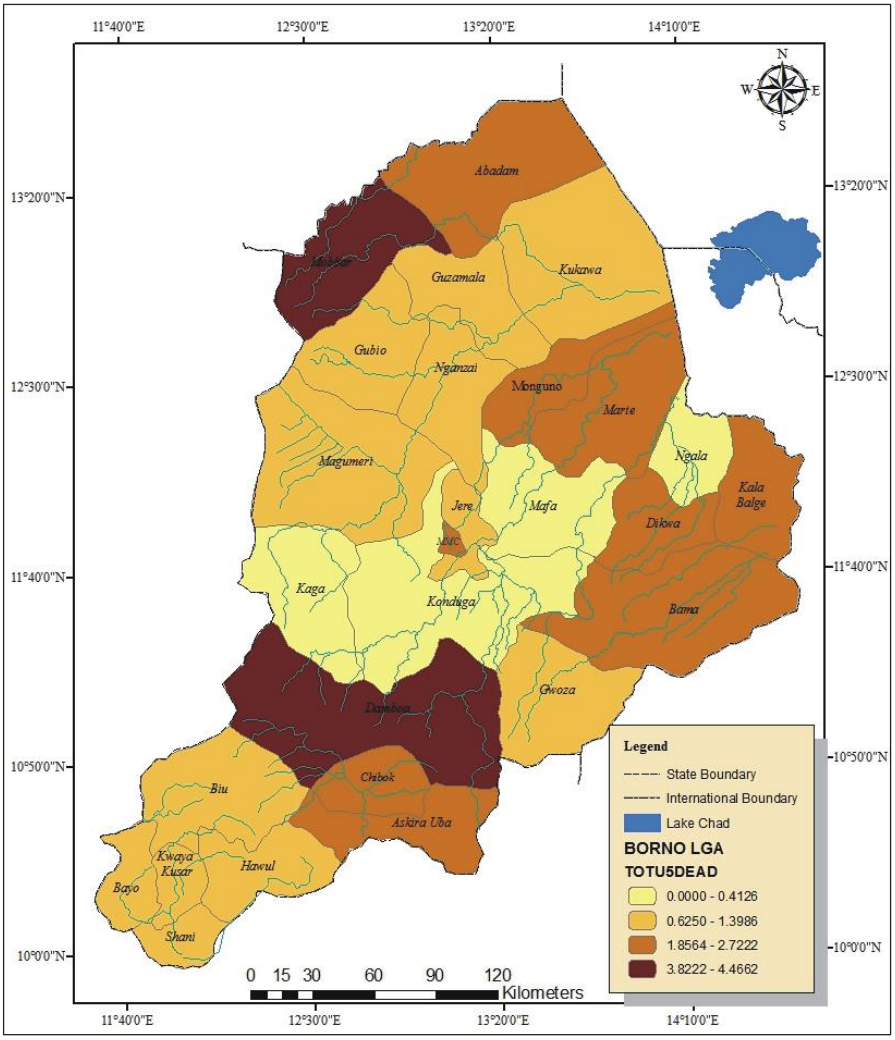

Fig. 9. Spatial distribution of dead cases among the under five years

RECOMMENDATIONS

Since this study has highlighted the prevalence of malaria among the various LGAs in the state, it is recommended that all the LGAs that fall within the very high and high categories should be given higher priorities than those within the lower categories.

GIS should be used to present information that requires spatial patterns as the visual impression enables quick understanding and comparisons among the units which can aid quick decision making.

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