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Spatial Distribution of Cholera cases in Damaturu Town, Yobe State, Nigeria

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ABSTRACT

Cholera disease appears to be a serious infections disease which bedeviled many locales particularly in developing countries. A single case of cholera is a threat to neighboring areas and a global concern. The distribution of the disease are largely determined by series of environmental factors such as climate, local geography as well as living standards. Similarly, poor sanitation and hygiene are part of the drivers for the disease progression in most affected communities. Based on 10 years data from epidemiological unit, this study undertook the spatial analysis of cholera disease incidences in Damaturu Local government area so as to determine the hotspots of the disease in the area and awareness of the disease among people. Also, six wards were purposively selected and questionnaire were administered to 381 household respondents. Descriptive statistics and GIS tool were used to analyze the data. Results were presented in maps and frequency tables. The findings reveal that there are three highly vulnerable areas, five moderate areas and three low risk areas. The epidemic was concentrated in Nayinawa, Kukareta and Maisandari wards. Nearest to water body and high population density are factors that determine the spread of cholera disease in the study area. Further research is needed especially in the environmental factors influencing the occurrence of cholera in other to prevent and control future outbreak and disaster.

Keywords: *Cholera outbreak, Hotspot maps, Epidemics, Endemic, Damaturu, Yobe State*

1. INTRODUCTION

Cholera is an extremely virulent disease that can cause severe acute watery diarrhea. It takes between 12 hours and 5 days for a person to show symptoms after ingesting contaminated food or water. Cholera affects both children and adults and can kill within hours if untreated (WHO, 2019). It is a serious intestinal disease that has impacted human life for centuries and that leads to severe illness and loss of human life (Ali *eta l*., 2012). Disease mapping technology, has been evolving remarkably, is one of the most important GIS technology (Murad and Khashoggi, 2020). Disease mapping is the most important tool in spatial epidemiology and is used to describe and evaluate the disease area distribution (Xi *et al.*, 2014). In developing countries, cholera is closely related to poor environmental status and lack of basic infrastructure. In West Central African countries, there were 40,779 cholera cases reported in 2012 and also 846 dearth with over half of the reported cases originating in the Democratic Republic of Congo. More than 13,000 people suffering from the disease have been admitted in hospital in Serial Leone and Cameroon (WHO, 2014). In Nigeria, the outbreak is dynamic as the result of the raining season pattern and the major outbreak usually comes up in the third quarters of the year in the north and last quarters in the eastern part of the nation.

Predicting cholera has proven difficult because of a number of factors including multiple strains of bacteria, high levels of case fatalities in some regions of the world and a complex of influences on its distribution in people and environment (Fleming *et al.*, 2005). Several studies on cholera outbreak have been recorded all over the world. The studies of (Emmanuel, 2009) reveals that respondent's good knowledge of cholera, high perception of its severity and positive attitude in the mitigating effort during an outbreak offered windows of opportunity in the control of cholera outbreak. Studies of Emmanuel *et al* (2012) showed that most reported cases of water borne diseases were due to environmental factors including poor environmental sanitation and topography. Furthermore, other research shows that in endemic regions, cholera outbreaks are often associated with climatic events in some part of Africa, outbreaks occur during the dry season or right after heavy rainfalls (Codeco, 2001). Perline (2002) reveal that cholera epidemics are unpredictable and may reoccur in either the raining or dry season. Bertuzzo., *et al* (2008) studies shows that spatial distribution plays a fundamental role which is usually neglected in the existing cholera models. Damaturu has witnessed cases of cholera outbreak in the past years. In 2010, the death toll of 42 persons in the state came after taking contaminated water drawn from wells and ponds (Shuibu, 2013). The disease occurred mostly in the densely populated areas of the study area. This

study aims at mapping the prone areas of the disease using past records of incidences in other to prevent and control future outbreak of cholera in the study area. In addition, there is need to understand the people's awareness of the condition in which they live in relation to the disease because a single cholera case is a threat to future outbreaks. In view of the above, despite several studies on cholera all over the world, limited research and documentation have been done in Damaturu LGA of Yobe state. This study therefore examines the spatial distribution with respect to cholera and level of awareness of its causes and prevention in other to prevent and control future cholera outbreak in the study area. The findings of the study may also provide baseline data for future studies in the field.

2. MATERIALS AND METHODS

2.1 Study Area

Damaturu is located in between latitude 11º 39' 30'' to 11º 47' 00'' N and longitude 11º 54' 00'' to 12º 02' 00'' E. Damaturu LGA is the capital of Yobe state and has a total land area of 2,360 kilometers. It is bordered by Tarmuwa L.G.A , to the east by Kaga L.G.A of Borno state, to the south by Gujba L.G.A and to the west by Fune L.G.A respectively (Ahmed, 2013).

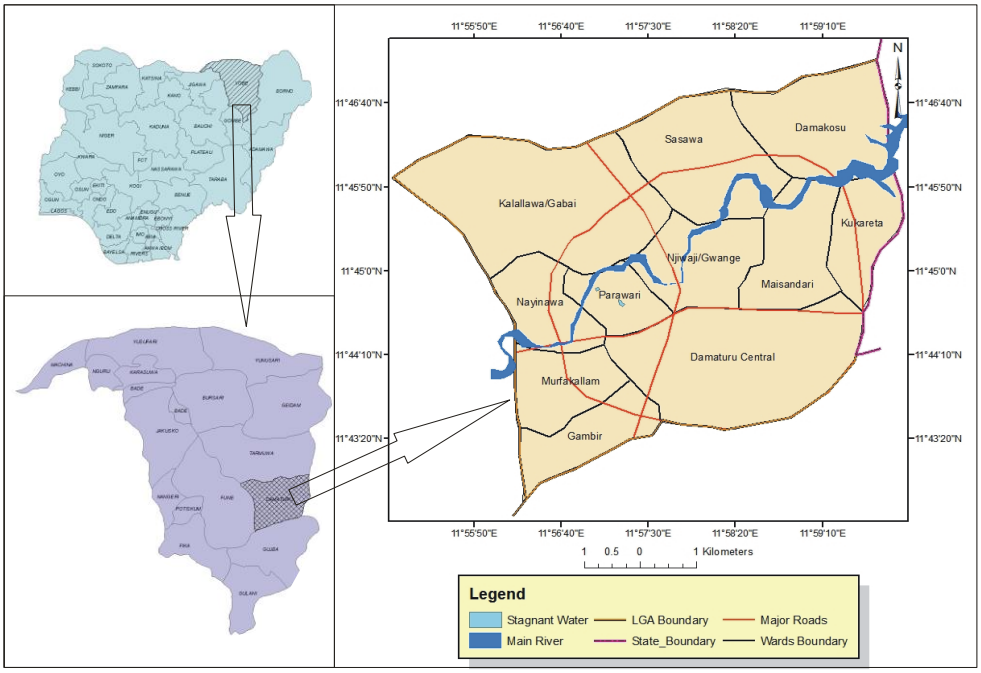

Figure 1. The location map of the Study Area

The Soil of Damaturu is mainly Sandy in nature typical of the semi-arid region. It is pourers and contains a lot of air spaces and with high alkaline content Alluvial soil is also found in Damaturu which are suitable for the cultivation of crops. Damaturu itself lies in the flood plain and is prone to flood in those years with heavy rainfall (Oruonye and Garba, 2008). The Soil of Damaturu is mainly Sandy in nature typical of the semi-arid region. It is pourers and contains a lot of air spaces and with high alkaline content Alluvial soil is also found in Damaturu which are suitable for the cultivation of crops.

2.2 Relief and Drainage

Damaturu is part of a vast open plain development on young sedimentary rocks of Chad formation which is made up of clay and sand horizon. The basin has an average depression of between 45 to 75 meters and separated from Benue valley by Biu, Plateau. The topography of the town is plain with open valleys running on north South-west axis through the town. During raining season, this acts as stormy water drainage flowing to the North-East. Water divide is found about few meters below the area. (Ayuba, 2013). Damaturu is not drained by any river, hence absence of surface water resources. The town depends mainly on underground water resources which are usually accessed through drilling of boreholes and artesian wells. Damaturu is a water deficit region with very low surface water during the raining season. All the boreholes and cement wells were regarded as Potable and used for domestic purpose by the residents of the area (Aji, 2014). Nature of relief and drainage also determines cholera outbreak of an area because warm air temperature with Low River flows and creates favourable environmental conditions for growth of cholera bacteria.

2.3 Climate

Damaturu is located in the semi -arid region of Nigeria with tropical continental climate. The climate is characterized by short wet season (June-August) and long dry season (October-May) which is usually low between 500-1000mm while evapotranspiration is high.

2.4 Soil and Vegetation

Damaturu is under the Sudan Savannah and it is characterized by short grass lands and shrubs, apart from shrubs, there are some tropical trees like Baobab, Acacia and Tamarind which cover the land mass. The vegetation is largely a reflection of the human impact of man and livestock which include direct deforestation or over grassing (Aji, 2014). The Soil of Damaturu is mainly Sandy in nature typical of the semi-arid region. It is pourers and contains a lot of air spaces and with high alkaline content Alluvial soil is also found in Damaturu which are suitable for the cultivation of crops. Damaturu itself lies in the flood plain and is prone

to flood in those years with heavy rainfall (Oruonye & Garba, 2008). According to Clement (2012), areas of low relief are susceptible to seasonal flooding. This shows that soil and vegetation plays a role in cholera outbreak.

2.5 People and Population

According to the National Population Commission, the study area Damaturu Local Government has a projected population of 124,500 people NPC (2009). The people of the area engage in different administrative and commercial activities. They engage in buying and selling of different agricultural products and other trade. The major language spoken in the town is Hausa, Kanuri and Fulfulde respectively. Understanding the people and population of the study area is very important in this study. The population of the study area will determine the number of people at risk to cholera outbreak. According to Jahan (2016), population density, urbanization and overcrowding also influence cholera transmission.

2.6 Data Source

The data collected for this study includes information on number of cholera cases (2016 to 2020) and list of areas where cholera outbreak occurs yearly from the records of the Ministry of Health, Hospital and epidemiological unit Damaturu LGA; demographic data of respondents such as age, occupation, sex, educational background and marital status and family size of the victim.

Data for this study was obtained from both primary and secondary sources. The primary source includes field observation of the environmental conditions of the areas, administration of interview to head of households. The secondary sources include records of cholera cases, year of outbreak and related information, Maps as well as population of the study area from National Population Commission, Ministry of land and survey, Epidemiological unit in Damaturu LGA.

2.7 Data and Collection procedure

The target population for this research was the household heads living in Damaturu LGA defined to include six wards which were all be purposely selected out of eleven wards. Purposive sampling technique was used in selecting six wards with past incidence of cholera cases from the study area. Thereafter systematic random sampling was employed to administer questionnaires to 381 household head. The 381 questionnaires was distributed purposively according to the population of each wards within the study area. Data was generated through administration of questionnaire

2.8 Data analysis

Descriptive statistics and GIS tools were used to analyze the data collected. The descriptive techniques involve the use of frequency tables to describe the demographic characteristics, people's awareness and perception of cholera disease. The GIS tool was used in producing thematic maps which were used to show the cholera distribution and hotspot area.

3. RESULTS

3.1 Spatial Distribution of Cholera Disease in Damaturu

As the study is aimed at exploring the spatial distribution of Cholera disease distribution and the awareness of the disease among people. The findings of the study confirm that population is higher around areas of Nayinawa, Pawari, Ngiwaji/Gwange and Damaturu Central wards. This is shown in figure 4.1 were it reveals the high, medium and low population areas. The high population areas have 16470 to 155, 50 number of population. Figure 4.2 shows the population density of the area with the highest ranging from 71 to 136 in 2006 to 2016. Figure 4.3 shows the highest number of households at 7, 46 to 10,796 in the study area. Spatial distribution of male cholera cases are shown in figure 4.6. Similarly figure 4.5 shows the spatial distribution of female cholera cases. As from 2006 to2016, there were 80 to 181 cases of cholera disease in the study area shown in figure 4.6. Relief of the study area shows the presence of river valley with about 300 to 373mm. it also show the upland and the lowland areas. It also shows the lowlands and he high lands areas. This can be seen in figure 4.6. Drainage pattern of most areas plays an important role in cholera studies. Figure 4.8 shows the drainage pattern of the study area where it shows presence of stream around the hotspot areas of cholera cases of the area.

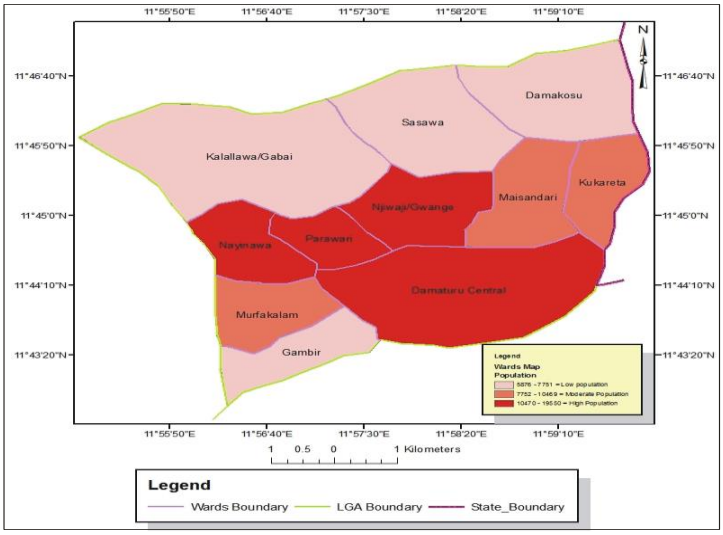

Figure 2. The Distribution of the Population in the Study area

Determining the population distribution is important in cholera studies. In Figure 4.1, the red colour represent the high population areas which are areas of Nayinawa, Pawari, Njiwaji/Gwange and Damaturu Central wards. The findings also shows that low population of Gambir, Kalallawa/Gabai, Sasawa, Damakosu wich is shown as the pink colour in the map. The orange colour depicts areas of moderate population which are areas of Maisandari, Kukareta and Murfakalam.

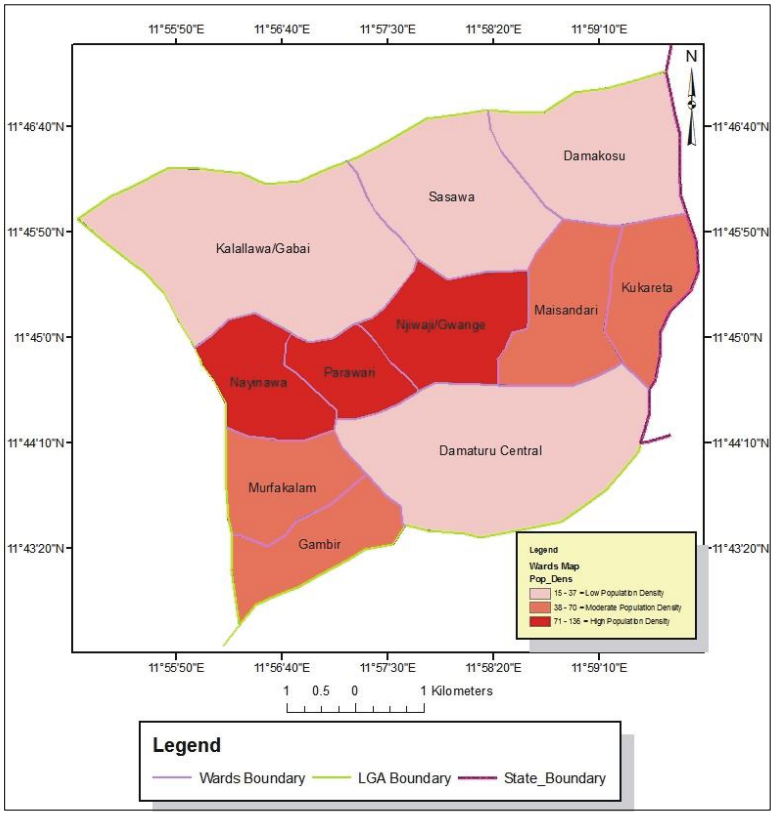

Figure 3. The population Density of the Study area

Figure 4.2 present above depicts the population density of the study area. The red color represents areas of high population density and these area Nayinawa, Pawari, Ngiwajo/Gwange wards. The remaining two colour represent areas of low and medium density which are Damaturu Central, Kalallawa/Gabai, Sasawa and Damakosu, Maisandari and Kukareta areas. Figure 4 below depicts distribution of Number of households in the study area. The result was revealed in Figure 3 were it shows the highest and medium number of household in red and orange colour. Damaturu Central, Nayinawa, Njiwaji/ Gwange, Damaturu Central, Nayinawa and Njiwaji/ Gwange wards. The pink colour represent areas of low number of households. that 7543 to 1076 high number of household in areas of Damaturu Central, Nayinawa and Njiwaji/ Gwange. Low number of household represented in pink colour have about 754 to 2411 households and are found in areas of Gambir, Murfakalam, Kukareta, Damakosu, Kallawa/ Gabai and Sasawa.

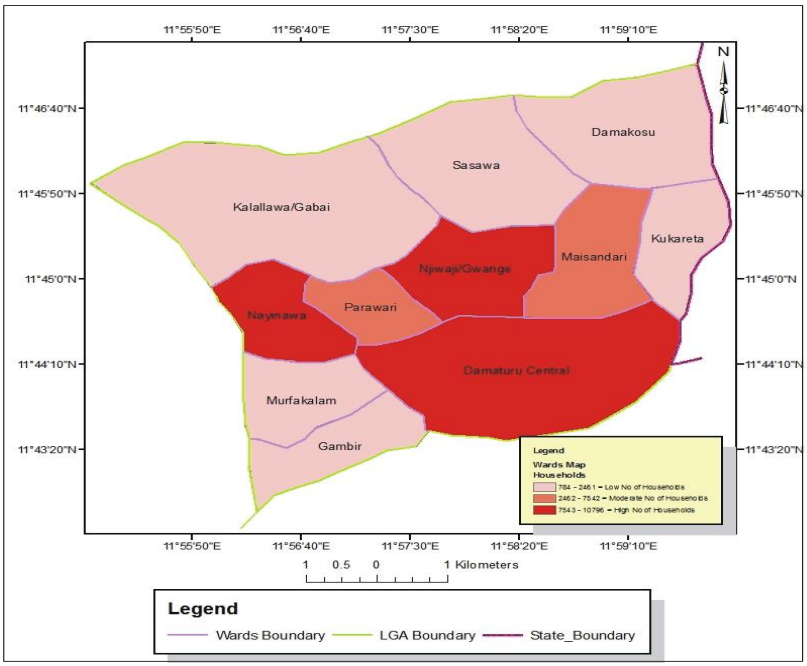

Figure 4. The distribution of households in the study area

The pattern of cholera cases shown in figure 5 below reveals that cases of cholera occurrence are higher in Nayinawa, Murfakalam and kukareta represented in red colour. Gambir, Pawari, Njiwaji/ Gwange, Maisandari and Damakosu ward have a moderate cases of 17 to 45 which is shown in orange colour on the map. Damaturu Central, Sasawa and Kalallawa/ Gabai ward have lower number of the disease cases shown in pink color.

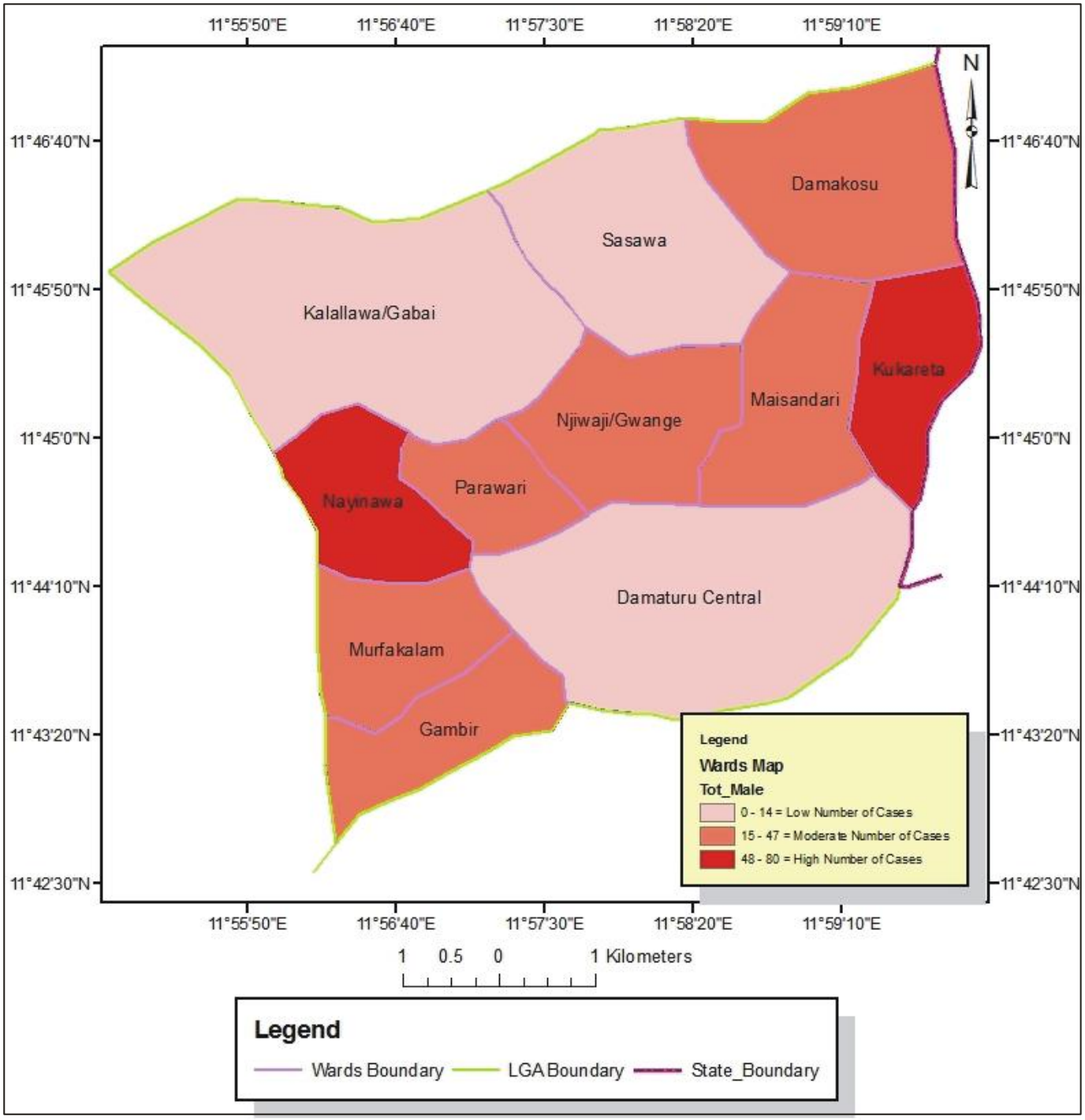

Figure 5. Spatial distribution of Male Cholera cases in the study area

Higher cholera cases among men are found in Kukareta and Nayinawa ward with 48 to 80 number of cases represented in red colour in the map. Moderate number of 15 to 47 number of male cases are found in areas of Gambir, Murfakalam, Maisandari, Njiwaji/ Gwange and Pawari wards which are presented in orange colour. The pink colur depicits lower number of male cases are found in Damaturu Central,Kalallawa/Gabai and Sasawa wards.

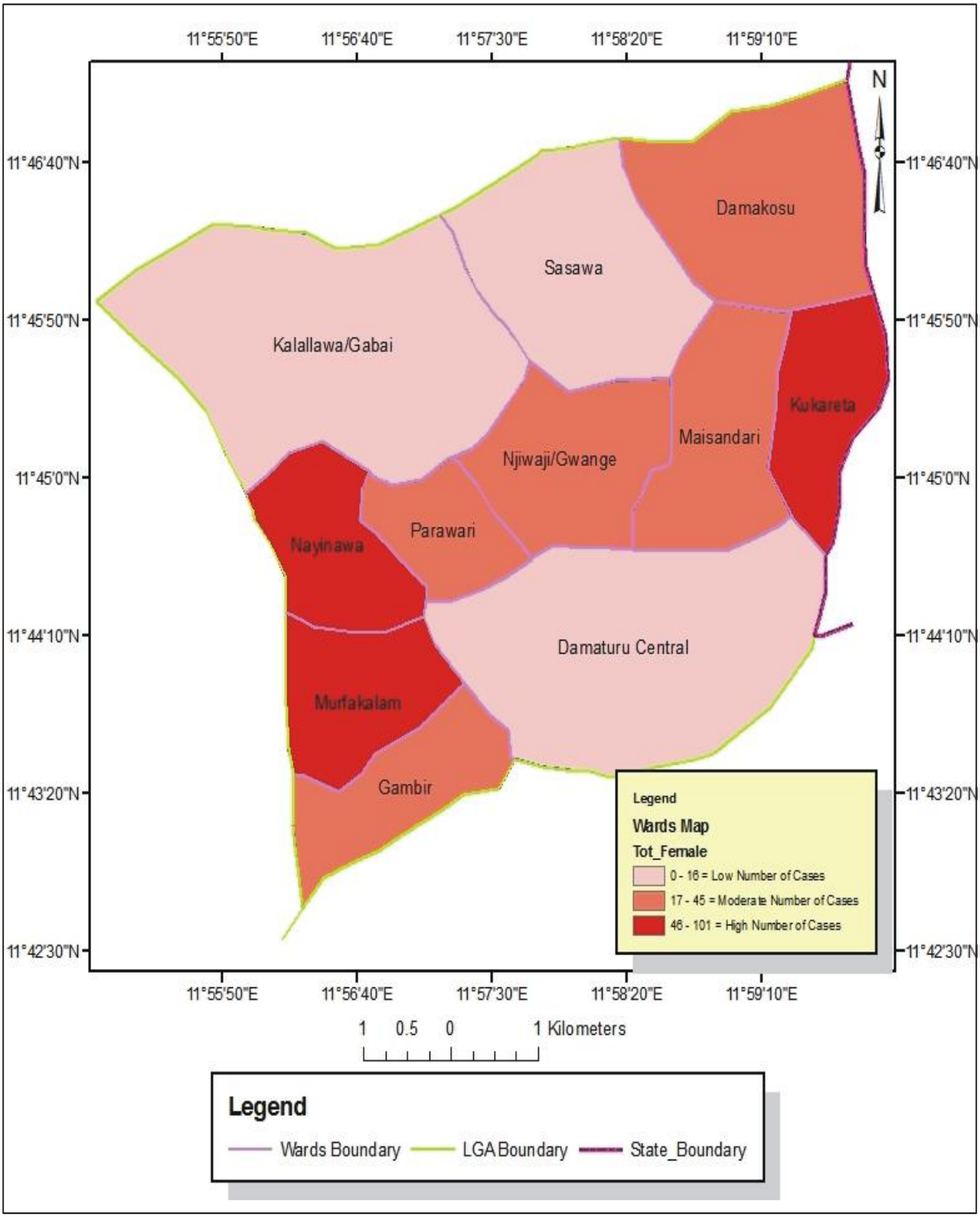

Figure 6. Spatial distribution of Female Cholera cases in the study area

The pattern of cholera cases shown in fig 4 reveals that cases of cholera occurrence are higher in Nayinawa, Murfakalam and kukareta represented in red colour. Gambir, Pawari, Njiwaji/ Gwange, Maisandari and Damakosu ward have a moderate cases of 17 to 45 which is shown in orange colour on the map. Damaturu Central, Sasawa and Kalallawa/ Gabai ward have lower number of the disease cases shown in pink colur.

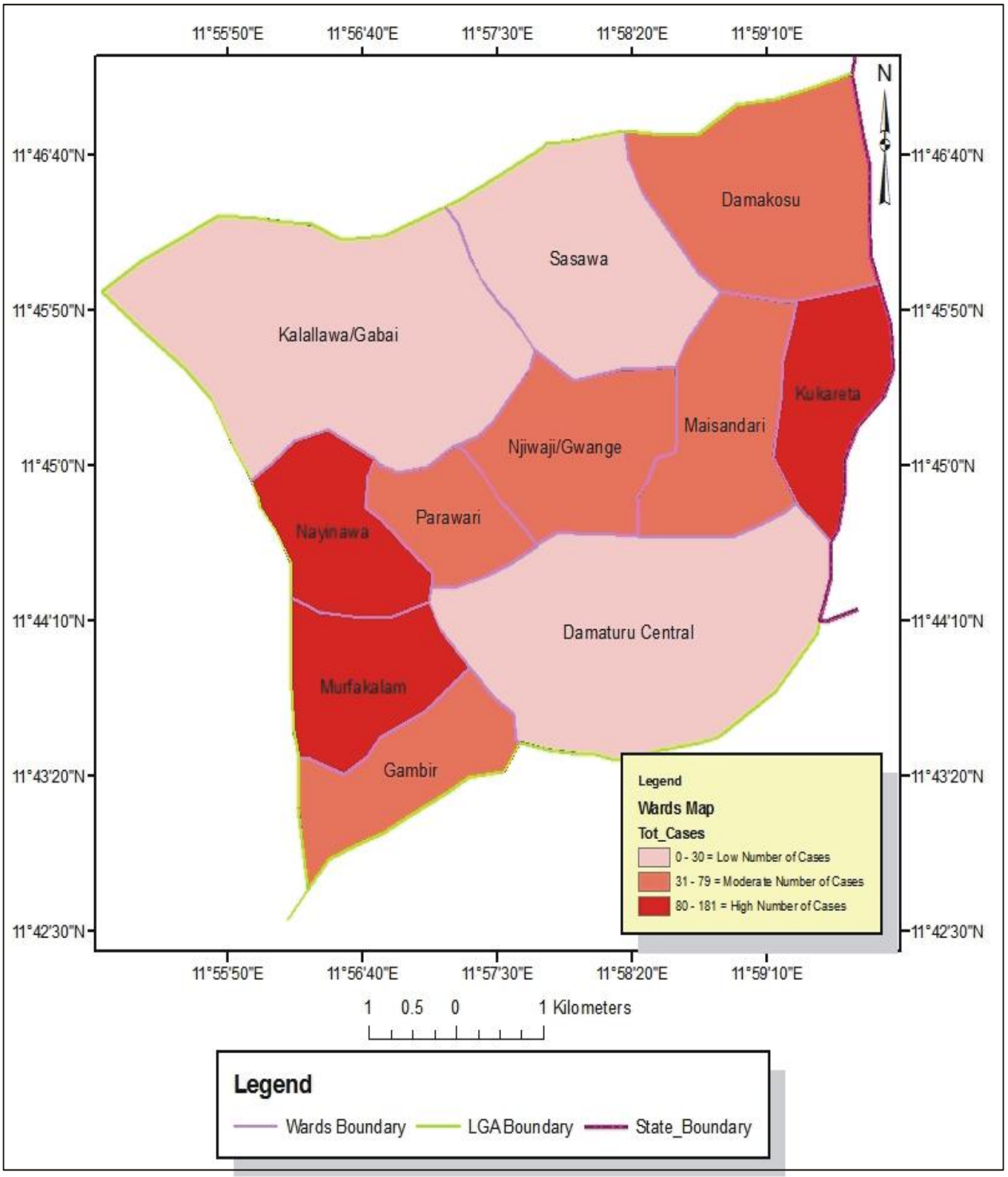

Figure 7. Spatial patterns of total population cases

It has been observed from the findings that total cholera cases recorded are higher in Nayinawa and Kukareta Ward where it shows total of 80 to 181 cases between 2010 to 2020 this is well represented in red colour on the map. The pink colour represent the areas with low cases of cholera in Damaturu Central ward where it has 0-30 total cholera cases. Other wards of Maisandari, Gwange and Pawari have moderate number of cases of 31 – 79 which is represented in orange colour on the map.

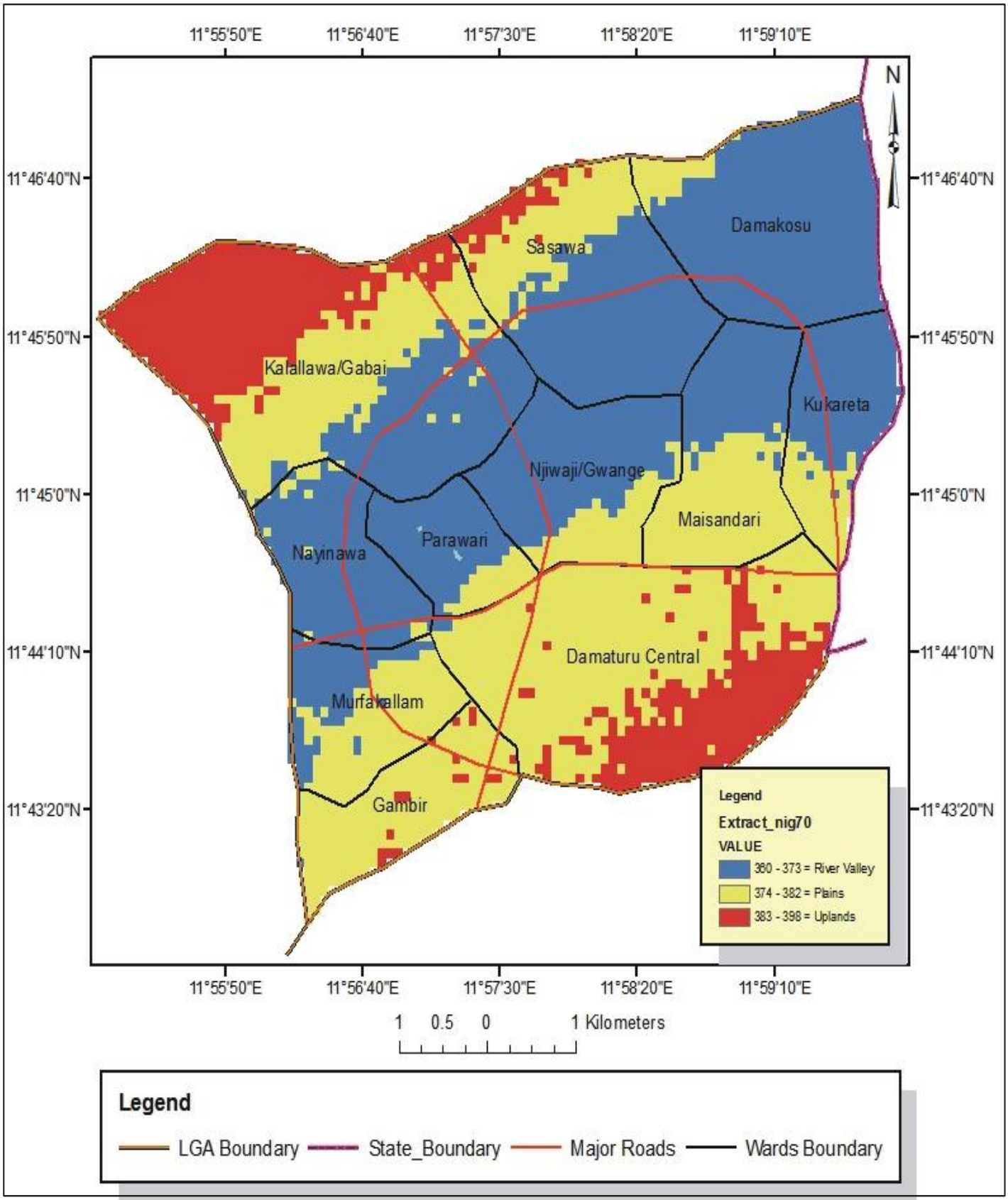

Figure 8. General relief of the study area

According figure 4.7, the blue colour depicts river valley which shows presence of water around the area. The yellow colour represent the lowland areas and the have 374 382m plains. Lastly, the red colour represent the upland areas and has 383 398m as shown in the in figure above.

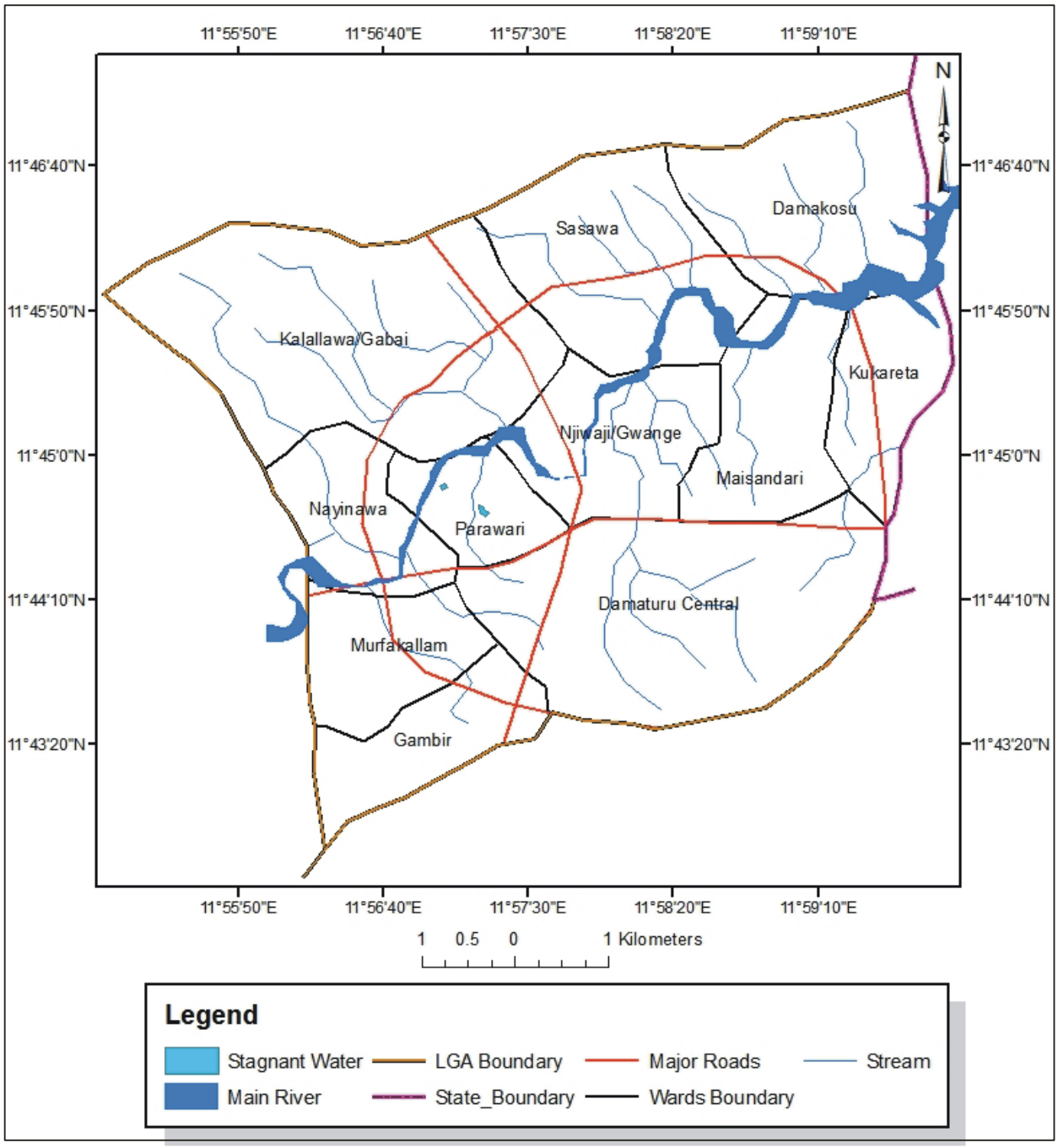

Figure 9. The drainage patterns of the area

It can be seen that the stream passes through areas of cases of cholera outbreak in the study area. It also shows that the high intensity of the flow of the stream is higher in Nayinawa and Kukareta. Furthermore, it also shows that areas of lower cases of cholera shown in figure 4.6 are areas where the stream did not flow into The presence of the stream in the study area supports an important role of transmission in the dynamics of cholera epidemic in Damaturu local government area. It can also be seen that Kukareta and Nayi-nawa are liable to flooding and can result in cholera outbreak.

3.2 Social and Demographic Characteristics

Table 4.1 presents the age, marital status, educational level of respondents and households size. It shows that 44.0% fall between the ages of 41-50 which represents the majority of the respondents. It also presents the marital status of the respondents which shows that 68.5% of the respondents were married while 32.0% of the respondents were single. The table also presents the educational level of respondents; literacy is very important variable in hygiene; it influences attitude of people on environmental condition towards reduction of disease generally. It can be seen from table that 34.0% of the respondents have attained tertiary education level, 38.3% have attained secondary level; 19.1% have attended primary school while 9.0% have informal education. This reveals that the level of education in the study area is fair. Results further show that most of the houses (41.5%) contain 3-4 households sharing the same compound, only 2.6% of the houses contain between 7 households and above. Others are 30.4% with 1-2 households and 25.5% contain 5-6 households living together. This indicates that most of the houses in the study area are occupied by more than one family.

Table 4.1 Socio-Demographic Characteristics of Respondents

Age	No. of Respondents	Percentage %
20 – 30	21	5.51
41 – 50	168	44.10
51- 60	78	21.47
61 and above	114	29.92
Total	381	100.0
Marital Status		
Single	120	31.50
Married	261	68.5
Total	381	100.0
Educational Level		
Primary	73	19.10
Secondary	146	38.30
Tertiary	129	34.00
Informal	33	9.00
Total	381	100.0
Number of people in the households		
1-2	116	30.4
3-4	158	41.5
5-6	97	25.5
7 and above	10	2.6
Total	381	100

Source: Field Survey 2016

3.2.1 Knowledge of Cholera outbreak among respondents in the Study Area

It can be deduced from table 4.1, that majority of the respondents (89.0%) were aware of occurrence of cholera in the study area and that 50.7% were aware through listening to radio, 25.0% through friends, 19.0% through television and 6.0% from personnel experienced**.** From the findings it shows that only 11% are not aware of cholera disease.

Table 3.2: Have you heard of Cholera diseases

Status	No. of Respondents	Percentage (%)
Yes	339	89.0
No	42	11.0
Total	381	100

Source: Field Survey, 2016

If yes, what is your source of information about Cholera Outbreak?

Status	No. of Respondents	Percentage (%)
Television	62	18.0%
Radio	172	50.7%
Friend	85	25.0%
Personal experience	20	6.0%
Total	339	100%

Source: Field Survey, 2016

3.2.3 Causes of Cholera Occurrence among Respondents

Table 4.2 reveals that majority of the respondents believe that poor hygiene is the cause of cholera occurrence in the study area, about 13.1% said it is the act of god, 31.0% said contaminated water and 22.0% said eating contaminated food.

Table 4.3: Causes of cholera occurrence in the area

Respondents View	No. of Respondents	Percentage (%)
Contaminated water	118	31.0%
Poor hygiene habit	132	34.6%
Eating contaminated food	81	22.0%
Act of God	50	13.1%
Total	381	100%

4. DISCUSSION

The age of population plays a significant role in the socioeconomic life of the people, with regards to the ages of the respondents; more than 70% of them are adults. Since it is expected that the questionnaire was completed by the household heads. By

implication, population with dominantly active age group will be in position to make important decisions on cholera occurrence and prevention. From the study it reveals that majority of the respondents were married couples which greatly influences the population of the household been that the family size of married household is higher than the unmarried or singles. The most basic demographic characteristic of a household. Large family size influences the waste generated and if not carefully handled may lead to unhygienic condition and related diseases like cholera.

In addition, population distribution plays an important role in the occurrence of cholera in the study area (see fig 4.1 and fig 4.6). Hotspot areas of cholera incidence especially Nayinawa, Pawari and Njiwaji/Gwange are areas of high population distribution. Hence, the study confirms that population distribution contributes to cholera occurrence in Damaturu LGA. This is in line with the study of Agbor (2014), where he reveal that average temperature, distance to streams, population distribution and latitude are statistically significant predictors of increased cholera cases. Likewise, results show that population density contributed to cholera incidence in the study area. This is reveal in fig 4.6 and fig 4.2 where hotspots areas of Nayinawa, Pawari and Njiwaji/Gwange wards are areas where population density were found to be high. Therefore, increased population density causes increased in cholera incidence in Damaturu LGA. Study of (Ndidi et al, 2013) confirms with these findings were they stated that was population density was included as a pre indicator variable because it may exert strong influence on cholera occurrence and spread.

Furthermore, it is clear from the findings that number of household might not be connected to the occurrence of cholera in the area since Damaturu central ward that has lower number of cholera cases is also having high number of household (see Figure 4.3). The result therefore shows that increased number of household is not related to increase cholera incidence in the study area. Hence, this study disagree with the findings of Daryl domain (2018) were he reveals that nearly 80 percent of the cholera transmission in Dhaka occurred between people who shared a household.

Epidemiological unit data collected shows that the occurrence of cholera between 2010 and 2020 was not uniform across the wards of Damaturu LGA. Kukareta, Nayinawa and Murfakalam wards recorded very high cases of cholera (see Figure 4.6). Highest occurrence was recorded in Kukareta ward with 181 cases in the eleven year period. This is about three times the occurrence of the disease in Bindigari/Pawari, Damakosu and Gambir/Moduri wards. It is interesting to note that there was no reported case of the disease recorded throughout the period of investigation in Sasawa/Kabary ward while Damaturu Central recorded the least with only 14 cases. On the whole, female were slightly higher than males in contracting the disease. Females were the most affected in nine out of the eleven wards of the LGA. It was only in Gambir/Moduri ward that males were observed to have higher number of cases than females.

Similarly, the relief map of figure 4.7 shows that there is a land/stream difference in the distribution of cholera incidence in the study area. Areas along the streams have higher cases of cholera incidence and these areas can be detected in figure 4.6 were it shows areas of Kukareta, Nayinawa and Murfakalam. Lowland areas that also have moderate number of cholera disease which might be as a result of the areas been close to the stream and lack of environmental hygiene. This is confirm with the study of Ameer (2017) where he noted that the causes of the disease are the contamination of water by improper drainage management, effluent contamination of water sources, over population and the lack of awareness among residents about water bone diseases. Similarly, the study of Wang and Yang (2021) were they reveals that cholera epidemic was likely to break out near water areas. They also noted that humid and lowland areas were most likely to have cholera epidemic. In addition, it is revealed from Fig. 4.8 that a river passes through the six wards of the study area. The presence of this river might not be unconnected to the cases of cholera in the study area especially in Nayinawa and Kukareta ward were the volume of the water is higher.

Similar finding also noted that in lakes and rivers, aquatic reservoirs of vibrio cholera have been evocated (Rebaudet *et al*., 2013). In addition, findings of (Salubi and Elliot 2021) noted that households using surface water was the significant predictor of the observed spatial variations in cholera incidence. It can be seen that the stream passes through areas of cases of cholera outbreak in the study area. It also show that the high intensity of the flow of the stream is higher in Nayinawa and Kukareta. Furthermore, it also show that areas of lower cases of cholera shown in figure 4.6 are areas where the stream did not flow into. The presence of the stream in the study area supports an important role of transmission in the dynamics of cholera epidemic in Damaturu local government area. It can also be seen that Kukareta and Nayinawa are liable to flooding and can result in cholera outbreak.

Looking at results regarding the knowledge of cholera occurrence, it reveals that the people are aware and they believe it emerge as a result of improper hygiene. (Rajasingham *et al.*, 2011), reported that cholera outbreak typically arise in settings where water, sanitation, and hygiene infrastructures are inadequate. Similar study of (Merten *et al*., 2013) in their study of local perceptions of cholera and anticipated vaccine acceptance in Katanga province reported that most of the respondents perceived contaminated water and food were considered most effective measures of cholera outbreak.

5. CONCLUSION

In conclusion, the result of this research suggested that closeness to the river and plains were found to be the most important predictors of cholera incidence in the study area. Lack of awareness on the disease causes and prevention has also contributed to cholera incidence. This research is one of the few of its kind in Damaturu LGA. Hence, there is a need for more detailed research to consider factors like climate, access to safe drinking water and availability of good drainage systems.

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