



Mapping of *Anopheles* mosquito Breeding Habitats in Malaria Endemic Communities of Dutse, Jigawa State, Nigeria

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<https://doi.org/10.67601/njbls.v3i2c.68>

Article info

Date received

14/08/2026

Date accepted

20/09/2026

Available online

30/09/2026

Keywords

Anopheles mosquito, GIS tool, Sakwaya, Larvae, Mapping.

Abstract

Mapping of *Anopheles* mosquitoes breeding sites using the Geographic Information System (GIS) will immensely improve the control and management of mosquito vectors transmitting diseases through Collecting information from field surveys will give an insight about the density and distribution pattern of mosquito vector species. As part of the study to map *Anopheles* mosquito breeding habitats using Geographical Information System, sampling locations were analyzed with entomological variables. Larval surveillance were conducted three times in each of the communities to determine the abundance of *Anopheles* mosquito larvae, breeding habitats physicochemical parameters and abundance of breeding habitats. The study shows that *Anopheles* mosquito larvae were collected from three (3) communities with Sixty nine (69) breeding sites respectively. The breeding sites (Sakwaya, Madobi and Limawa) are located few kilometers away from Dutse metropolis, Madobi and Limawa are semi urban settlements while Sakwaya is a rural settlement. Majority of people in the communities are subsistence farmers with some participates in fishing, Animal husbandry, irrigation operations and small businesses. Most of the inhabitants in the study village lives in concrete and mud dwellings. The breeding sites in these communities were located at 3-8 m from human habitations except in Limawa with 200-400m. Map of communities shows that higher number (103,638) of *Anopheles* mosquito larvae were found in the three (3) study communities. Sakwaya Madobi and Limawa. 69,132(66.7%) in Sakwaya community, 33,851(32.7%) in Madobi community and 655(0.6%) in Limawa Community respectively. The distribution of temperature in the *Anopheles* mosquito larval breeding habitats of the Larval Source Management (LSM) intervention communities in Dutse, Jigawa State indicates that the temperature pattern of the breeding habitats in the map reveals that the *Anopheles* larvae breeding habitats in Sakwaya community are characterized with very low temperature (Dark blue), however in Madobi and Limawa communities *Anopheles* mosquito larvae breeding habitats are characterized with very high temperature (Dark pink) respectively. Based on the distribution of PH in the *Anopheles* mosquito larvae breeding habitats of Larval Source Management (LSM) intervention communities in Dutse LGA results shows that Sakwaya Community breeding habitats was characterized



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with very high pH (dark pink zone) followed by Madobi community breeding habitats characterized with very low pH (Dark blue zone) while the Limawa community breeding habitats was characterized with a low pH (Orange colour zone) respectively. This study reveals that there is need for expanding the use of GIS tools with the aim of developing entomological surveillance studies in Jigawa State and Nigeria at large. The use of GIS tool for mapping *Anopheles* mosquito vectors will inform adequate planning, management and control of endemic malaria vector diseases in Nigeria.

Introduction

Malaria is deadly and one of the most prevalent disease globally (Ahmad et al 2011). In 2022 the African region was a home to 95% of all malaria cases and 96% deaths. Children under 5 years of age accounted for roughly 80% of all malaria deaths in the region. Four African countries account for almost half of malaria deaths worldwide and the greatest was in Nigeria (31.9%), Congo DR (13.2%), Tanzania (4.1%) and Mozambique (3.8%) (WHO, 2022). Evidence indicates that malaria transmission is high across Nigeria, the higher transmission occurs in the rural communities and communities near water bodies such as rivers and irrigation sites in the northern part of the country (NMSP, 2020)

The effort to eliminate malaria reducing it to at least 10%, Nigeria implement Malaria Indicator Survey (MIS) by the National Malaria Elimination Program (NMEP) of the Federal Ministry of Health (FMOH) there by providing population based estimates on Malaria indicators including malaria prevention, case management and prevalence of malaria to inform strategic planning and programmed evaluation (MIS, 2021).

In Nigeria, mosquitoes are widely distributed throughout the country, the most prevalent species discovered belong to the genera *Anopheles*, *Culex* and *Aedes*. The most problematic species that have been involved with the transmission of diseases such as malaria, yellow fever, and filariasis are *Anopheles gambiae*, *An. arabiensis*, *Aedes aegypti* and *Culex quinquefasciatus* (Yayock et al., 2015). Mosquitoes become the main adversaries of people due to the enormous spread of suffering and death generated by the diseases they transmit (Afolabi et al., 2019). Female *Anopheles* mosquito distribute malaria parasites, the plasmodium, after uptake of blood meal when they bite humans. It remains a

critical and severe public health issue affecting most of the developing countries including Nigeria (Binuyo et al., 2022). The members of these species comprise of *Anopheles gambiae* s.s. *Anopheles arabiensis*, *Anopheles merus*, *Anopheles melas*, *Anopheles bwambe* and *Anopheles quadranulatus* (Coetzee, 2000).

Anopheline mosquitoes remain successful in their ability to adapt to their changing natural environments, expanding opportunities for the propagation of their species. The majority of these adaptive processes comes at a cost to both the mosquitoes and their hosts as they serve as vectors of various human pathogens including malaria parasites, filarial worms and arboviruses (arthropod-borne viruses) (Adeogun et al., 2023)

To eliminate malaria in Nigeria, the larval source management should be in-cooperated with the existing vector control measures. Larval source management which substantially control malaria vector density by limiting appropriateness of mosquito larvae habitats is acknowledged as an effective and supplemental strategy for malaria control (Gowelo et al., 2020). Larval source management comprises the adjustment, manipulations and control of water sources that host the larvae of malaria vectors which leads to the reduction of adult mosquito populations (Constantianus et al., 2021). However, due to the difficulty involve in larval sampling from numerous aquatic habitats in the field especially if the larval habitats are non-permanent, the new tools like the Geographic Positioning System (GPS) and Geographic Information System (GIS) technologies are now used in mapping *Anopheles* mosquitos breeding sites (Ahmed et al., 2021).

This study aims to map the *anopheles* mosquitos breeding sites by the use of Remote Sensing (RS)

and GIS technologies in malaria control program by observing the distribution of vectors in malaria endemic communities and determining the association between environmental variables and the distribution of *Anophele* larval in the varying breeding habitats.

Methods

Study Area

The study was carried out in Sakwaya (Lat:11°40'58.45512N Long: 9°14'11.39904E) located at about 14 km west of Dutse, Madobi (Lat:11°41'21.5N Long: 9°24'31.3 E) located about 9 km south of Dutse and Limawa (Lat:11°7'50.833 N and Long:9°33'39.833E) which are located at about 3 km North of Dutse respectively (Figure 1). Most of the population of the studied villages live in mud and concrete buildings. In Sakwaya the houses are arranged in linear array although some are scattered with no concrete roads and gutters. In Madobi the houses are scattered but in linear array with two asphalt overlay road within the town, in Limawa community the houses are scattered with rocky terrain surrounding the village. The prevalence of malaria in these communities may likely be due to the presence of adequate mosquito breeding habitats near human habitations.

Malaria control Programme is controlled by National Malaria Elimination Programme of the Federal Ministry of Health and Social Welfare Nigeria and the State Ministry of Health.

Larval Surveillance

The *Anopheles* mosquito larval collections were conducted so as to determine the types and abundance of habitats that harbors potential vectors. Larval collection and different site mapping were conducted every month on three occasions between April 2025 and December 2025. All possible breeding sites of *Anopheles* mosquitoes were observed within and surrounding areas of the three (3) communities. All potential breeding habitats were inspected to check for the presence of *Anopheles* mosquito larvae, a standard dipper method was used, soup ladle methods were also used to collect the larvae by lowering it gently into the water. Samples were brought to laboratory and the live *Anopheles* mosquito larvae were transferred

to a plastic container covered by perforated plastic cover to allow the passage of air into the container. The larvae collected were reared in the insectary in white plastic tray on a diet of Cabin biscuit and yeast tablets.

Identification of *Anopheles* mosquito larvae collected

The Adults reared from the field collected larvae were first identified by the digital microscope and the morphological keys by Coetzee (2020). About 80% of the larvae collected from the field survived to adult while the rest about 20% were not used and are therefore discarded.

Determination of Temperature and pH of the Breeding Sites

All the possible habitats were checked for the presence of *Anopheles* mosquito larvae. Different sites in the assessed locations were sampled by utilizing the standard dipping method; if mosquito larvae were present 20 dips were taken using 350ml standard dipper and soup ladle in both natural and artificial mosquitoes breeding sites. The physicochemical characteristics pH and Temperature were also recorded. Thermometer was dipped into the water containing *Anopheles* mosquito larvae in the field, the reading of the temperature of the water was taken. The same procedure was conducted for the pH using pH meter.

Mapping of *Anopheles* mosquito populations

The selected communities were inspected before and after the LSM interventions. The locations of the malaria mosquito larval habitats were recorded using a GPS essential software [GarminGPSMAP® 60CSx] and processed with MapSource® software in all the three communities. Coordinates of habitat containing mosquito larvae were later integrated to a GIS database using software ArcGIS 9.3 (Ndiaye et al., 2020).

Data Analysis

The coordinates of habitat containing mosquito larvae were processed with MapSource® software. *Anopheles* mosquito larval habitat were analyzed using descriptive statistics.

Results

Distribution of *Anopheles* mosquito larvae breeding habitats from the total of 69 breeding habitats identified in Dutse LGA

The distribution of *Anopheles* mosquito larvae from the total of 69 breeding habitats identified in Dutse LGA was presented in Table 1, A total of 69 breeding habitats were identified and *Anopheles* mosquito immature stages were collected from the breeding sites identified in Dutse LGA. The results revealed that the number of breeding habitats identified in Sakwaya Community was 41(59.42%) where 6 of the breeding habitats are clean water, 25 are cloudy and 10 are muddy all distributed in ground pool respectively.

The number of breeding habitats identified in Madobi Community was 22(31.88%) where 5 breeding habitats are clean water 10 are cloudy and 5 are muddy; they are also distributed in ground pool.

The breeding habitats identified in Limawa Community are 6(8.70%) in which 4 are clean water breeding habitats and 2 are cloudy, all in the rice field breeding habitats respectively.

Mapping of *Anopheles* mosquito larvae breeding locations and their productivities across LSM intervention communities in Dutse LGA, Jigawa State

The distribution of larval productivity across LSM intervention communities in Dutse LGA, Jigawa State was presented in Figure.2 the map shows that there is variation in the larval density in the three communities of Sakwaya, Madobi and Limawa. Sakwaya was characterized with very high larval productivity (Dark pink zone) followed by Madobi community with high larval productivity (Dark brown zone) while the least was Limawa community having a very low larval productivity (Dark blue zone). This finding indicates that there are many *Anopheles* mosquito larvae breeding habitats in the three communities of Dutse LGA.

Distribution of Temperature in the breeding habitats of LSM intervention communities in Dutse LGA, Jigawa State

The distribution of temperature in the *Anopheles* mosquito larval breeding habitats of the LSM intervention communities in Dutse, Jigawa State was presented in Figure.3. The temperature pattern of the breeding habitats in the map reveals that the *Anopheles* larvae breeding habitats in Sakwaya community are characterized with very low temperature (Dark blue). However, Madobi and Limawa communities *Anopheles* mosquito larvae breeding habitats are characterized with very high temperature (Dark pink) respectively.

Distribution of PH in the breeding habitats of LSM intervention communities in Dutse LGA, Jigawa State

The distribution of PH which was measured with pHmeter in the *Anopheles* mosquito larvae breeding habitats of LSM intervention communities in Dutse LGA was presented in Figure.4. The map showed that Sakwaya Community breeding habitats was characterized with very high pH (dark pink zone) followed by Madobi community breeding habitats characterized with very low pH (Dark blue zone) while the Limawa community breeding habitats was characterized with a low pH(Orange colour zone) respectively.

Discussion

Mapping of malaria vector using GIS is a suitable tool used for identification of *Anopheles* mosquito breeding sites especially in malaria endemic communities like Sakwaya, Madobi and Limawa Communities. This study is in line with the findings of (Oduola et al., 2024) who combined entomological data and Satellite image to inform larval source management (LSM) in Nigeria. The findings of (Rezvan et al., 2026) reveals that the use of google earth engine reveals about 94% *Anopheles* mosquito larvae breeding habitats. Similarly, the work of (Palaniyandi et al., 2025) confirmed that mapping of mosquito breeding sites is very vital particularly if the traditional field surveillance is limited to access and lack of resources.

The distribution of Temperature in the *Anopheles* mosquito breeding habitats in the three communities indicates that the mapping of a particular breeding habitats varies in terms of temperature, Sakwaya has very low temperature

while a very high temperature was observed in Madobi and Limawa communities respectively. This finding is in accordance with the findings of (Amadi et al., 2018) when mapping potential *Anopheles gambiae* larval distribution using remote sensed climatic and environmental variables, they

observed *Anopheles* larvae low temperature, vegetation cover and wetland environments. On the other hand, the most vital factor for mosquito vectors density using satellite images and fuzzy software were found to be temperature, humidity and rainfall (Sarfraz et al., 2024).

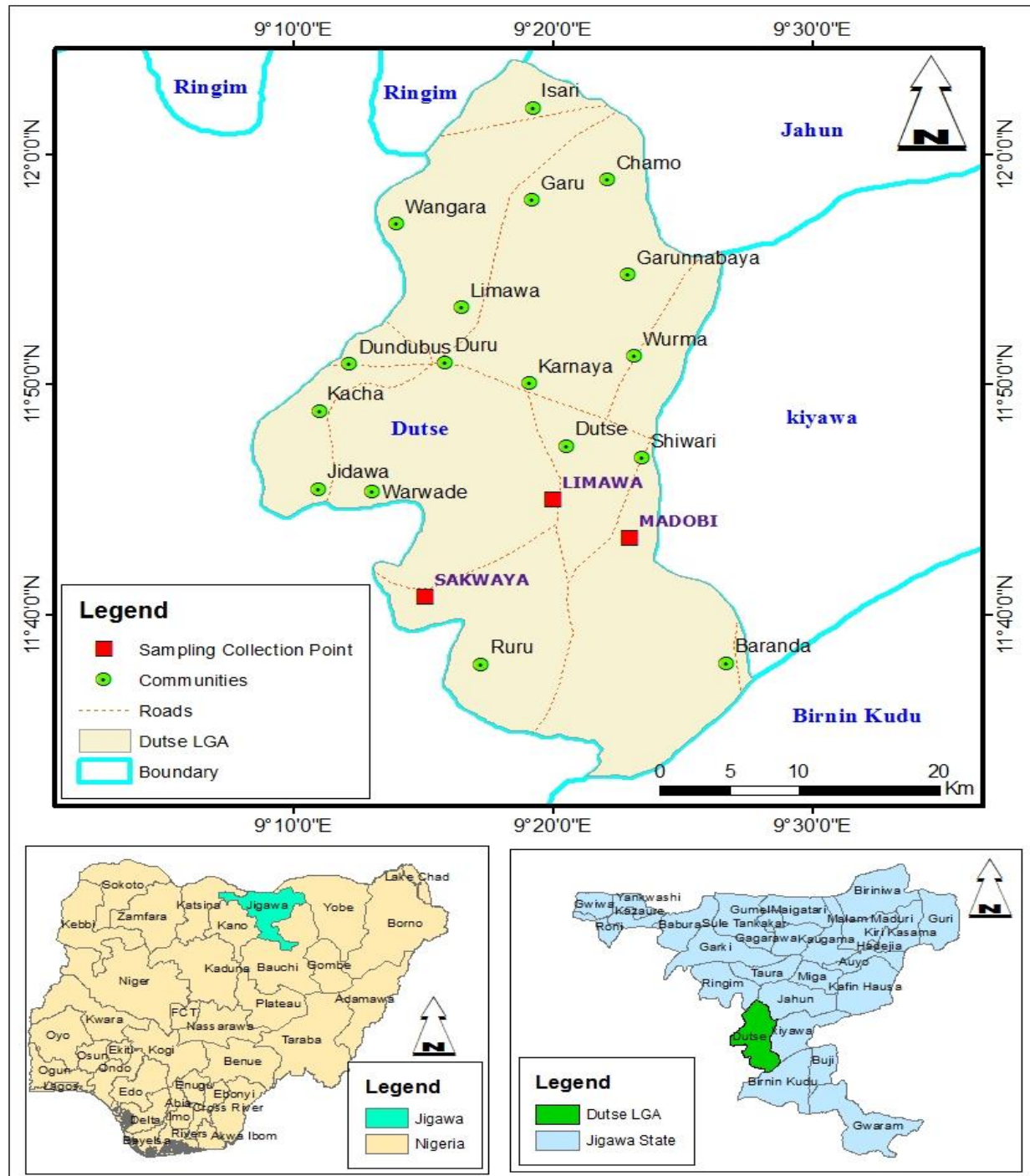
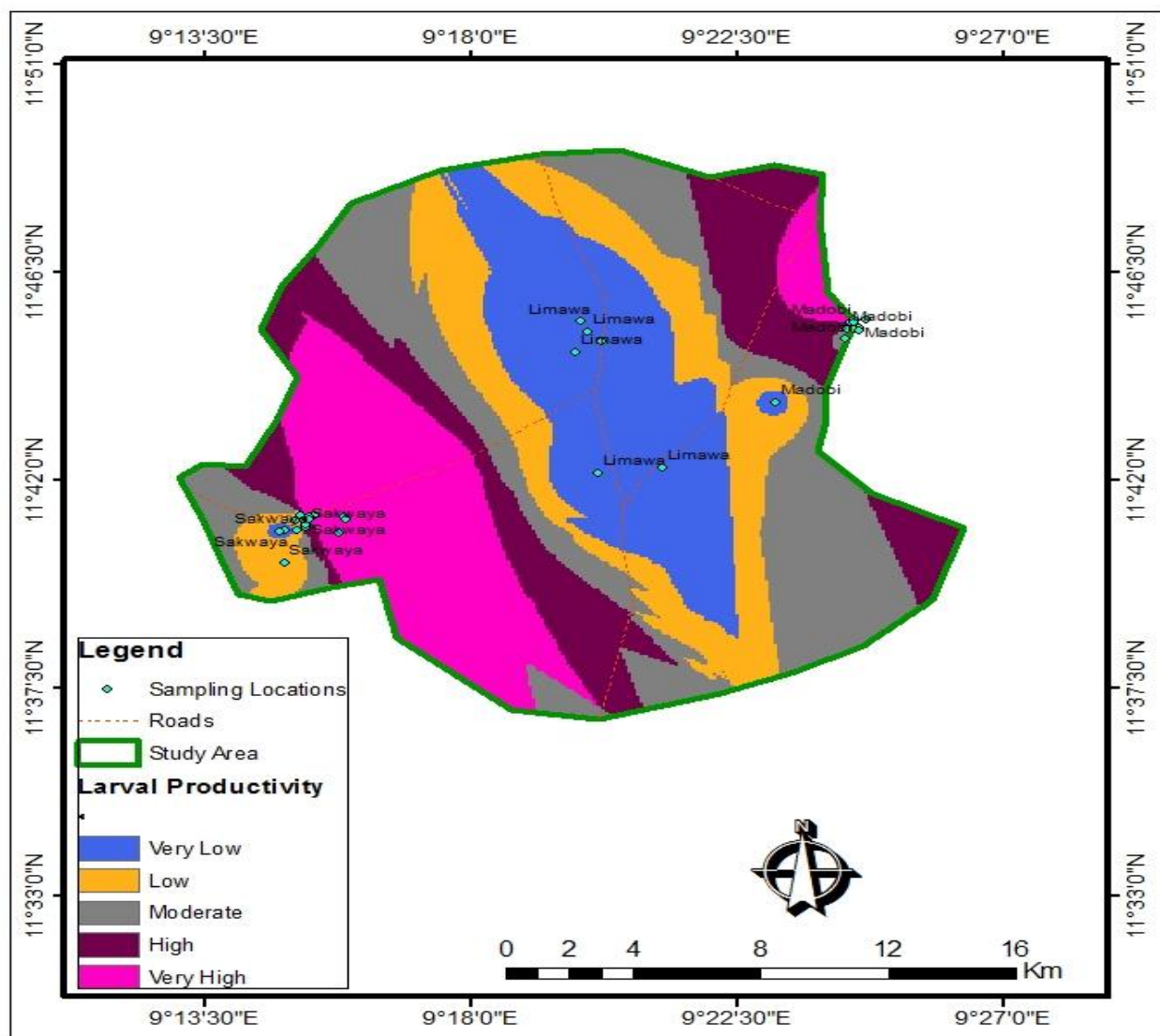


Figure 1: Map of Dutse LGA Jigawa State Showing Study Area.

Table 1: Distribution of Anopheles mosquito larvae breeding habitats from the total of 69 breeding habitats identified in Dutse LGA

Habitat type	Substrate type	Larval habitat group					
		Clear Ground	Cloudy pool	Muddy	Clear Rice	Cloudy field	Muddy
Presence of <i>Anopheles</i> larvae in Sakwaya community	Number of Habitat 41(59.42%)	6	25	10	0	0	0
Presence of <i>Anopheles</i> larvae in Madobi community	22(31.88%)	5	10	5	2	0	0
Presence of <i>Anopheles</i> larvae in Limawa community	06(8.70%)	0	0	0	4	2	0
Total	69(100%)	11	35	15	6	2	0

**Figure 2: Map of Study Area Showing the Distribution of Laval Productivity.**

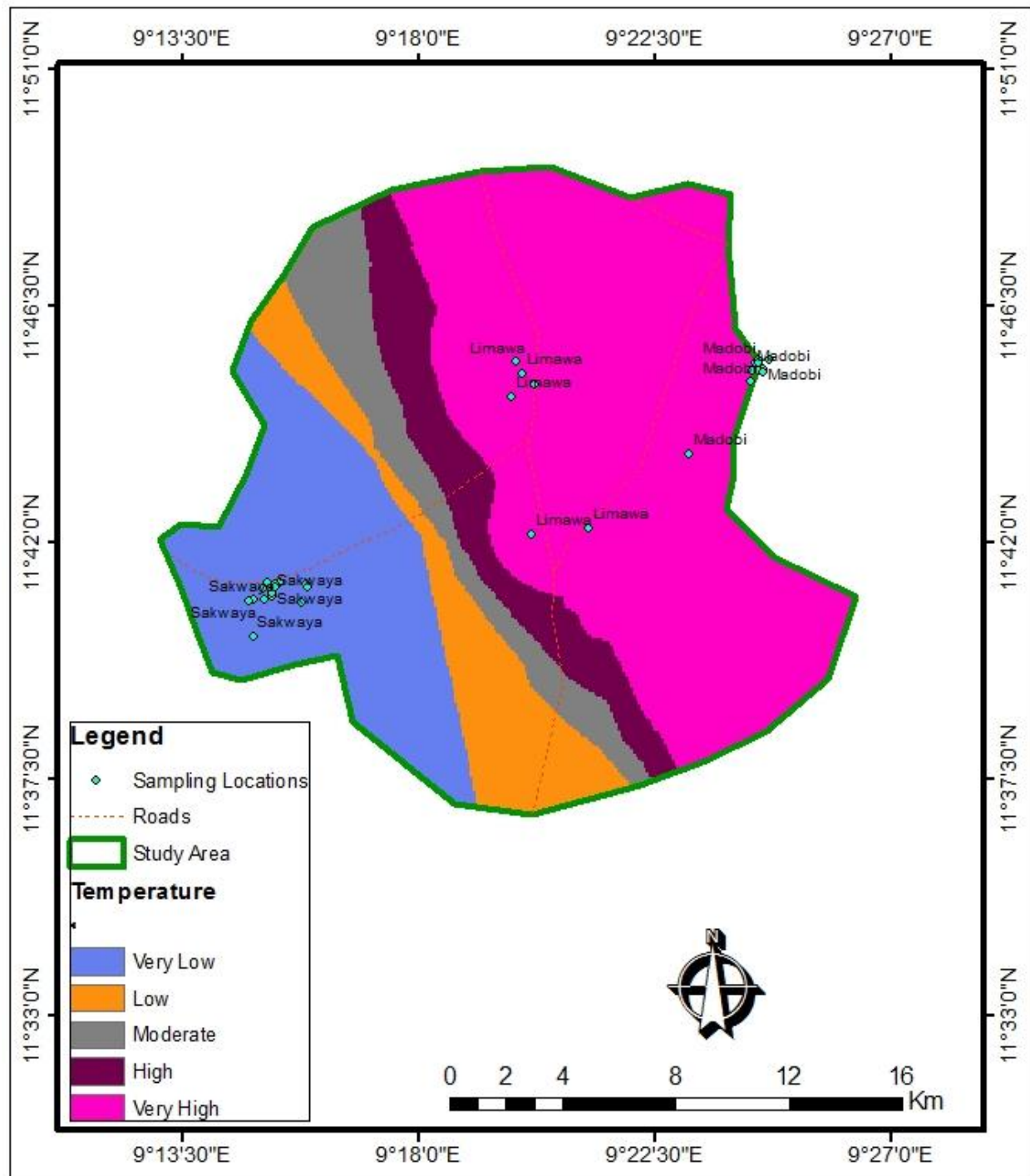


Figure 3: Map of Study Area Showing the Distribution of Temperature.

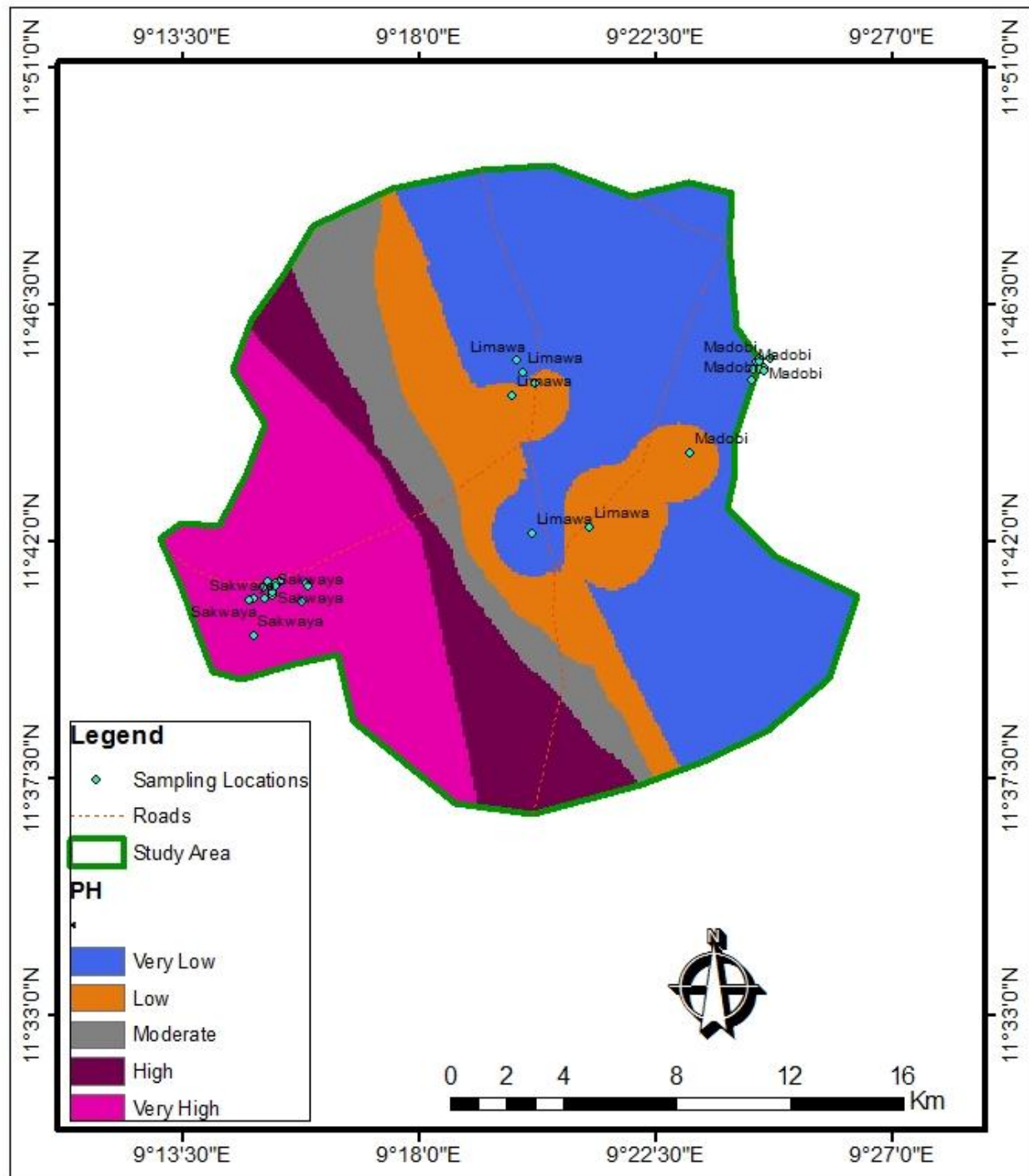


Figure 4: Map of Study Area Showing the distribution of PH Values.

The larval density in the communities of Dutse is associated with the pH of the breeding habitats with most mosquitos vector larvae proliferate in neutral to alkaline water environment, the present study is in line with that of (Adugna et al. 2025) who studies density and species composition of

Anopheles mosquito larvae along lake tana, north west Ethiopia concludes that several factors such as habitat types, vegetation types water pH served as predictor for the presence of larvae in the area. Coulibaly et al. (2025) reports that environmental parameters such as water clarity, surface area and

pH strongly influence the *Anopheles* mosquito larvae density. In another study by (Massa et al., 2026) revealed that the physicochemical properties of *Anopheles* mosquito larval habitat such as pH and Temperature are significantly associated with positive water collection of *Anopheles* mosquito larvae.

Conclusion

This study indicates that the temperature and pH in the several mosquito breeding habitats varies from high, low, very high or very low temperature and pH, there is immediate needs of expanding the use of GIS tools for the aim of enriching aspect of entomological surveillance studies in Jigawa State and Nigeria at large. The use of GIS tool for mapping malaria vectors will inform a sustainable planning, management and control of endemic vector diseases in Nigeria. Mapping of *Anopheles* mosquito breeding habitats will inform us about the ecological factors that leads to the proliferation of mosquito larvae in their various breeding sites.

Acknowledgement:

The Authors acknowledge the communities Larval Source Management Groups, Village Heads, Jigawa State Ministry of Health and Jigawa State Ministry of Environments.

Authors Contribution

TS and MMD were responsible for conceptualization, initiating and selection of the study communities. AKA and TS carryout and supervise the implementation of the methodology, TS recorded observations and clean the data. BJB conducted the data Analysis. Original manuscript was prepared by TS., MMD, contributes to the reviewing and editing the manuscript. All Authors have read and approved the final copy of the manuscript for publication.

Conflict of interest

The authors declare no conflict of interest.

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