Quest Journals
Journal of Medical and Dental Science Research
Volume 9~ Issue 9 (2022) pp: 109-116
ISSN(Online) : 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Geospatial Mapping of the Burden of Malaria in Port Harcourt Metropolis, Niger Delta, Nigeria

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Received 12 Sep., 2022; Revised 26 Sep., 2022; Accepted 28 Sep., 2022 © The author(s) 2022. Published with open access at ***www.questjournals.org***

I. Introduction

Malaria is a major public health problem in many developing countries. It is one of the world's most deadly and life threating parasitic disease especially in the tropical and subtropical areas (Adefioye et al 2007; Okonko et al 2009; Idowu et al 2009; Olasehinde et al 2010' Abah and Tample 2015). it is an ancient disease and a major public health concern in Africa. Approximately 3.2 billion people remain at risk of contracting malaria. Recently it is assumed that mosquitoes occurrence, and existence of breeding sites is associated with human population density, land cover and land use as the most important spatial determinant of malaria prevalence (Edillo et al 2002; Shiliho et al 2003; Kreuels et al 2008; De-Souza, Kelly-Hope, Lawson, Wilson and Boakye 2010). Research also shows that areas with highest malaria risk are often found within just few hundred meters of such larva habitats and due to the fact that malaria is insect vector transmitted, the environment is a key determinant of the spread of the infection (Edillo, Toure, Lanzaro, Dolo and Taylor 2002).

Globally, the determinants of malaria vary on many scales in their effects as well as their occurrence. In many regions, one could argue that there is little justification for considering malaria at a continental scale; often the differences within a continent are too great and diverse. But for Africa, a good case can be made: the vector species are limited in number but widely spread across the continent, and malaria itself has a relatively coherent epidemiology throughout much of sub-Saharan Africa. In particular, because Africa is the home of the most efficient anopheline transmitters of malaria and because transmission reaches much higher levels than elsewhere in the world, the characteristics of African malaria are more extreme than observed elsewhere. In addition, the responses to changes in determinants may be different, or more subtle, than may be suspected elsewhere.

Geo-climatic factors such as temperature, moisture, therefore are outlined as determinants of Anopheles breeding sides, vector densities, adult mosquito survival rate, and longevity and vector capacity. This is attributed to the fact that the transmission and prevalence of vector borne disease such as malaria are highly influenced by spatial and temporal changes in the environment in association with environmental behaviour and scocio-economic factors which are likely to modify malaria risk and transmission. Munga et al 2006; Minakawa et al 2005; Hi-STAR 2002; Patz, Graczyk, Geller and Vittor 2002; Afrane, Ahou, Lawson, Gilheko and Yan (2007), identified cultivated areas, and dirty environment as environmental factors associated with malaria risk since they both breed conditions favourable for the formation of small puddles that are preferred breeding sides for Anopheles. Hence according to Patz, Graczyk, Geller, Vittor, (2000) distribution of malaria is determined by climate and other geographic factors that influence the development of mosquitoes and Plasmodium at a given time, but it is also influenced by environmental alterations over time. Ecosystem changes resulting from natural phenomena or human interventions, on a local or global scale, can alter the ecological balance and context in which vectors and their parasites develop and transmit the disease (Patz, Graczyk, Geller, Vittor, 2000).

Temperature is said to affects the development of malaria as the parasite does not develop below 18^C and over 40^C (Paajmans, Blandford, Bell, Blandford, 2010). The highest proportion of vectors surviving the incubation period is observed at temperatures between 28^C and 32^C (Alemu, Abebe, Tsegaye, Lemu, 2011). Precipitation is another key player in malaria occurrence; increased precipitation can provide more breeding sites for mosquitoes, but excess rain can also destroy breeding sites (Parham, Michael, 2010; Kfrefis, Schawrts, 2011). Altitude can also indirectly influence the distribution and spread of malaria via its effect on temperature (Pagot, 1992). Land cover is seen as another factor in malaria occurrence. In Kenya and Nigeria for instance, the association between land cover type and presence of anopheline larvae was statistically significant (Munga, Yakob, Mushinzimana, Zhou, Ouna, Ouna, Minakawa, Githeko, Yan, G 2009; Ayo, Obafemi , and Ogoro, 2017).

For smaller regions, topography remains the single most important aspect that defines large scale differences in malaria risk because climate variables change little over the limited range of latitude (Ayo, Obafemi , and Ogoro, 2017). The distribution of water bodies is a major factor that influences malaria occurrence and case distributions. Water bodies play a very important role as larval breeding sites for malaria mosquitoes. Therefore, identification of vulnerable sites is a direct indicator for malaria risk occurrences. Hence, the spatial distribution of associated variables, as well as transmission intensity, has become an urgent need, especially in endemic areas.

However, applying chemical insecticides across the environment and in every household will cause great effects on the environment and impact on man. In order to mitigate these effects, new tools such as the Geographic Information System (GIS) technologies which allows or make possible the mapping of potential larval habitats in an environment has been deployed globally (Minakawa, 1999). The use of the GIS tools will allow the forecasting of potential malaria dominant and transmission zones by delineating potential breeding habitats for malaria vectors in an environment. This has made the utilization of satellite imagery in the remote sensing platform and the Geographic Information System (GIS) environment to delineate areas of the environment that allows the habitats of malaria using functions or criteria such as topography, drainage and land cover to show the potential breeding site for mosquitoes breeding and transmission. The topography of a place plays a very vital role as it does not allow or allow the retention of water on the surface to make for the breeding of mosquitoes. Landuse on the other hand defines the level of water stagnation in the environment, though, sometimes subject to its population density, especially in relation to agricultural land uses. With reference to the World Health Organisation (WHO) (2008), 3.3 billion persons approximately which are almost 50% of the population of the world are exposed to malaria. This work therefore identified, map malaria occurrence, its prevalence and transmission risk in Port Harcourt metropolis, Niger delta.

Study Area

Location and extent

The study area was limited to Port Harcourt metropolis and the design consisted of a cross-sectional observational study. The study utilized high-resolution Google earth images to enable the delineation of the urban and its periphery extent of the study area. The information processing and digital and graphic modeling were performed by the Geographic Information System (GIS) in the ArcGIS 10.4 platform. The images and base maps were geo-referenced and digitized in the ArcGIS environment to ensure proper overlaying and analysis. The feature classes required for the analysis were digitized in to their separate layers and shapefiles were created. The Global Position System (GPS) enabled the retrieval of the global position all cases recorded, their locational attributes across the study area.

Metropolis of Port Harcourt is positioned from Latitude $4^0$45'N through Latitude 4^0 55' N, and Longitude 6^0 55' E through Longitude 7^0 05' E as shown in Figure 1. The Atlantic Ocean is found at an approximate distance of 25km from it. The five local governments which the metropolis extends into are the Obio-Akpor, Eleme, Oyigbo, Okrika, Oyigbo and Port Harcourt LGAs. (Figure1).

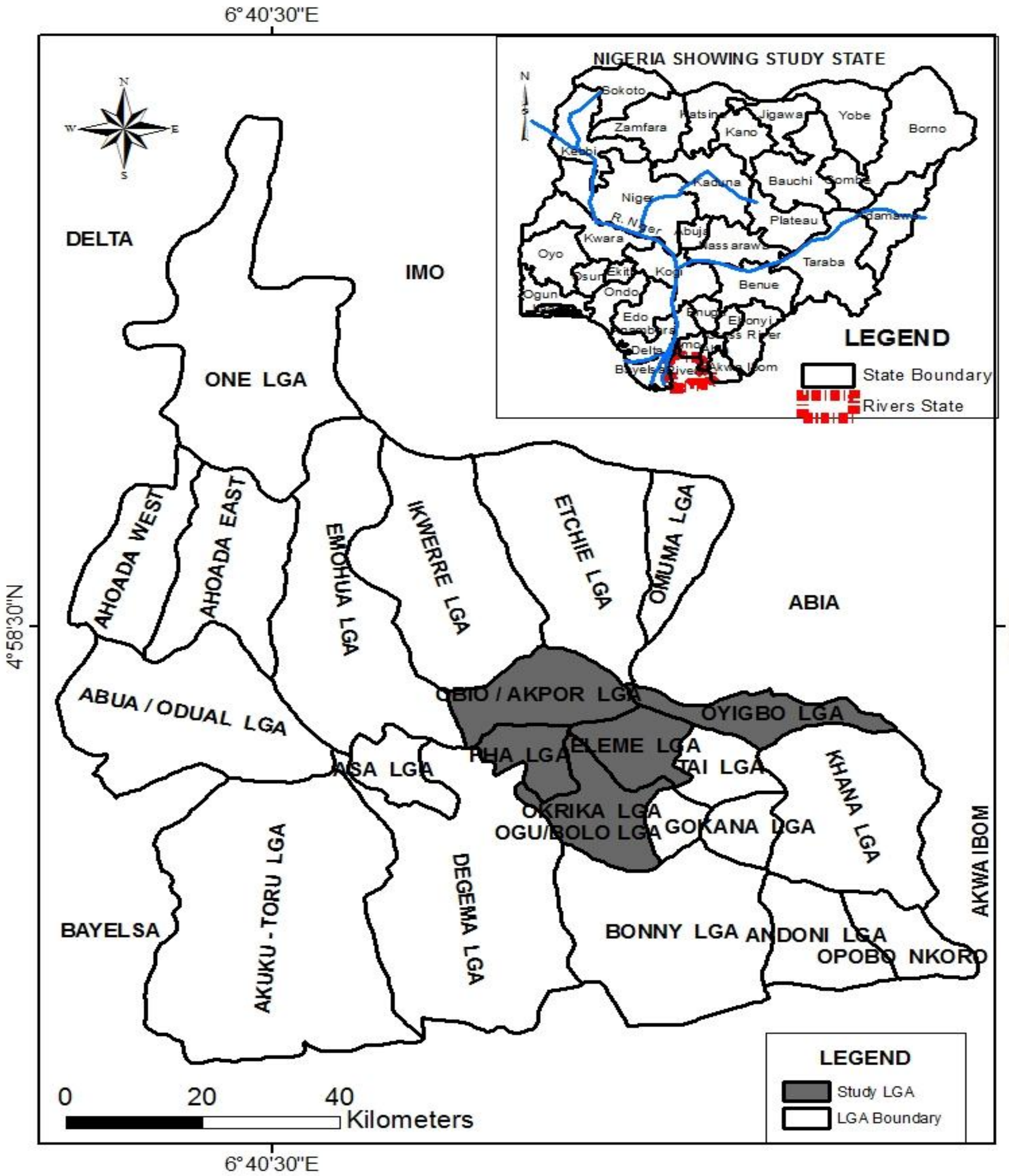

Figure 1. Rivers State Showing Port Harcourt Metropolis

II. Materials and Methods

Geospatial technology, which has been used successfully in other malaria control programs in developing countries, includes among others, the Geographic Information System (GIS), Global Positioning System (GPS), and remote sensing (RS). GIS is defined as an organized collection of computer hardware and software, and geographic data to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information. With GIS it is possible to analyze differences in multiple spatial data layers related to the geographic position of a phenomenon, its attributes, and spatial relationships and to create new spatial information not available by studying the data layers separately. The Geographic coordinates of the incident cases were obtained using the Global Positioning System (GPS).

Where GPS information was not directly available, the location of the visited place attribute and coordinate were obtained using the Google image. Landsat Images were analysied using the Supervised Maximum Likelihood Classification techniques to classify the land cover of the area indicating different land cover classes.

III. Discussion and Findings

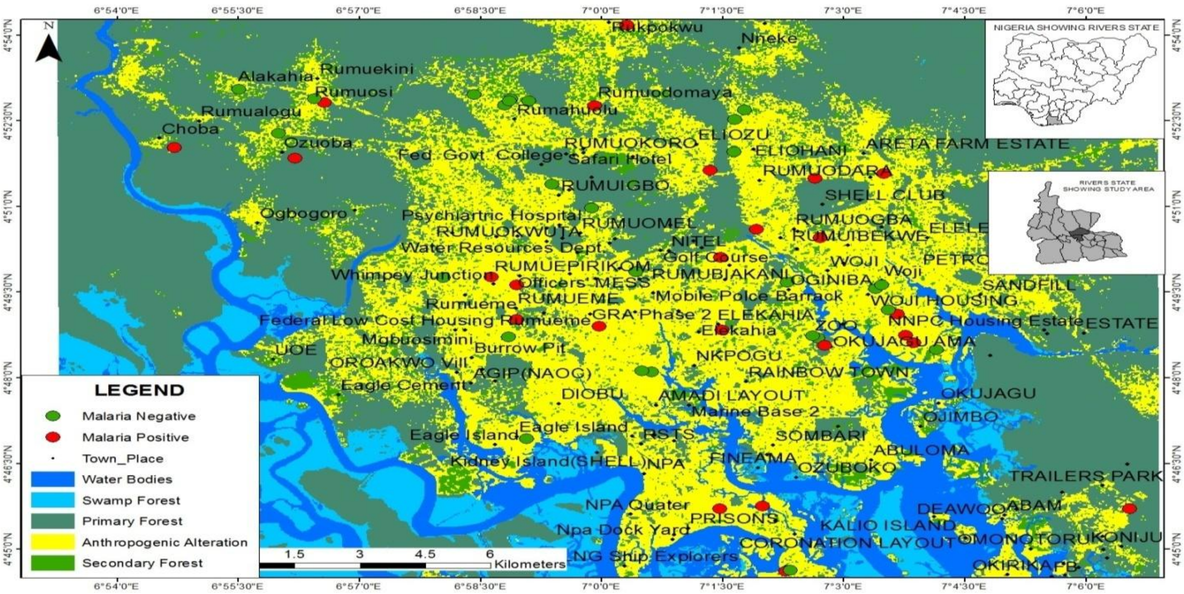

Figure 2 Land Cover and the Incidence of Malaria

Findings from figure 2 examined land cover determinant of malaria using the landcover image data in the Person Product Moment Correlation (PPMC) environment. This gave a positive relationship with a p value of 0.00 for forest cover and the incidence of malaria in the study area.

This is in line with the findings of (Ye-Ebiyo, Pollack, Spieiman 2000; Munga et al 2006; Minakawa 2005) that Cultivation enhances malaria occurrence as they serve as breeding habitats and enhances larva development. Hence, the closeness of vegetation, cultivation to homestead may increase the risk factors of malaria in the study area. This is in line with the findings presented by (WHO 1982, Patz, Graczyk, Geller and Vittor 2000) who affirmed that, the proximity of forest could increase/decrease mosquito abundance mosquitoes and malaria risk.

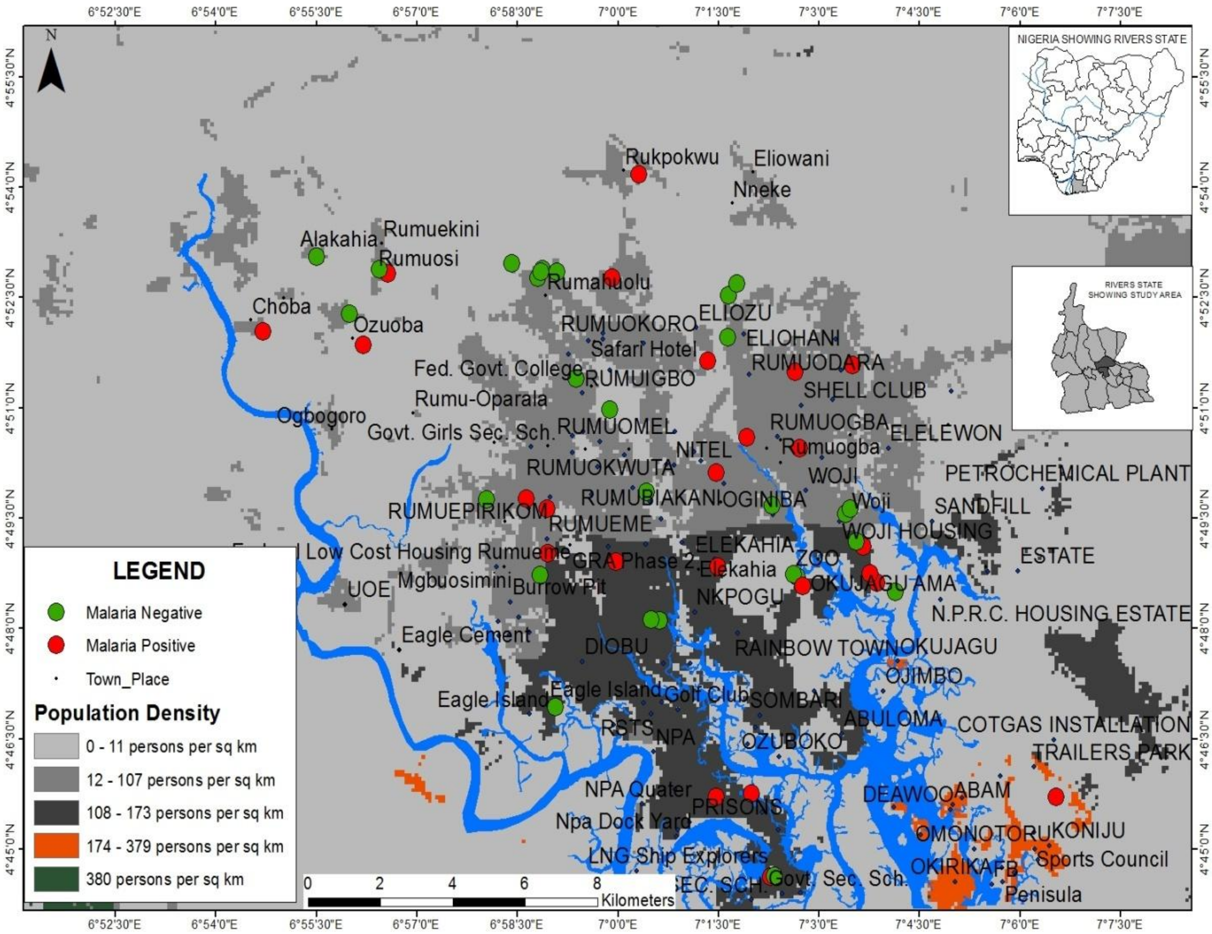

Figure 3 Population Density and the Incidence of Malaria

Analyzing the result in reference to population density, Figure 3 shows the population of the study area in raster form and the overlay of the location of the population sampled for the incidence of malaria as enumerated for the study. From the overlay analysis, the locational occurance of malaria incidence is subject to the population density of the given area as more eaves and puddles are noticed around homes of densely populated neighbourhood this is obviously noticed from the figure 3 that there is high concentration of malaria occurrence in areas with higher population per square kilometers. Areas with 12 to 107 and 108 to 173 persons per square kilometers host most incidence of malaria victims as compared to areas with 0 to 11 persons per square kilometers. Findings from the analysis of population density determinant of malaria incidence as shown in figure 3 using the population data in the Person Product Moment Correlation (PPMC) environment revealed a positive relationship with a p value of 0.04 for high population density and the incidence of malaria in the study area. This is in conformity with the findings of (Ghebreysis et al 2000) that High density area are prone to having household construction which creates open eaves and makes for easy mosquito access to people sleeping inside their homes. This therefore implies that High population density will create hiding spaces/places for mosquitoes**.**

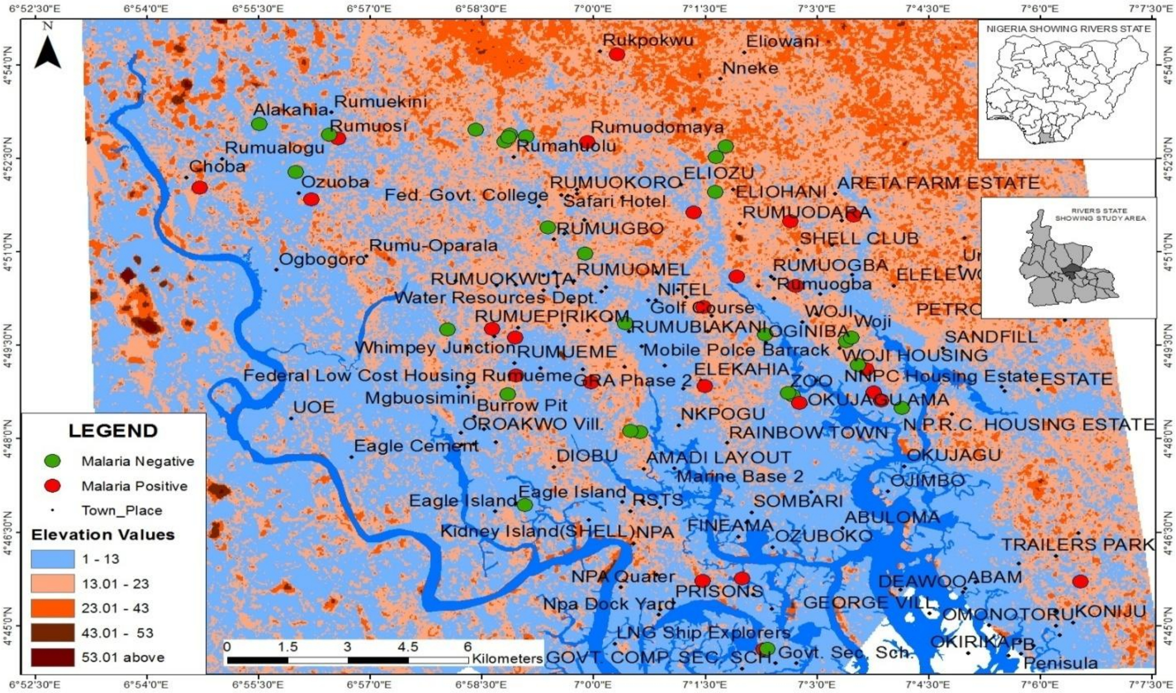

Figure 4 Topography and the Incidence of Malaria

The digital elevation model of the study area shows the area of depression across the study area over-layed with the drainage and community locations across the study area. The light green marked area in the study map represents lower elevation hence avenue for water accumulation as shown in the legend of 1 - 13meters above sea level with a gradual rise to 53 meters above sea level. From the analysis, it is obvious that the potential breeding site cut across the entire study area located in the North Eastern part of the study area. The Topography defined as the predictor of wetness and its potential malaria breed in sites shows from the findings of the analysis of Topography determinant of malaria incidence using the Person Product Moment Correlation (PPMC) analytical tools revealed a positive relationship between topography and the incidence of malaria in the study area. This also is in conformity with the findings of (Edillo, Toure, Lanzaro, Dolo and Taylor, 2002) that Adult vector abundance is positively associated with the availability of aquatic habitats which are most occurring in depressed landforms creation pockets of water storage which necessitate the deposition of eggs.

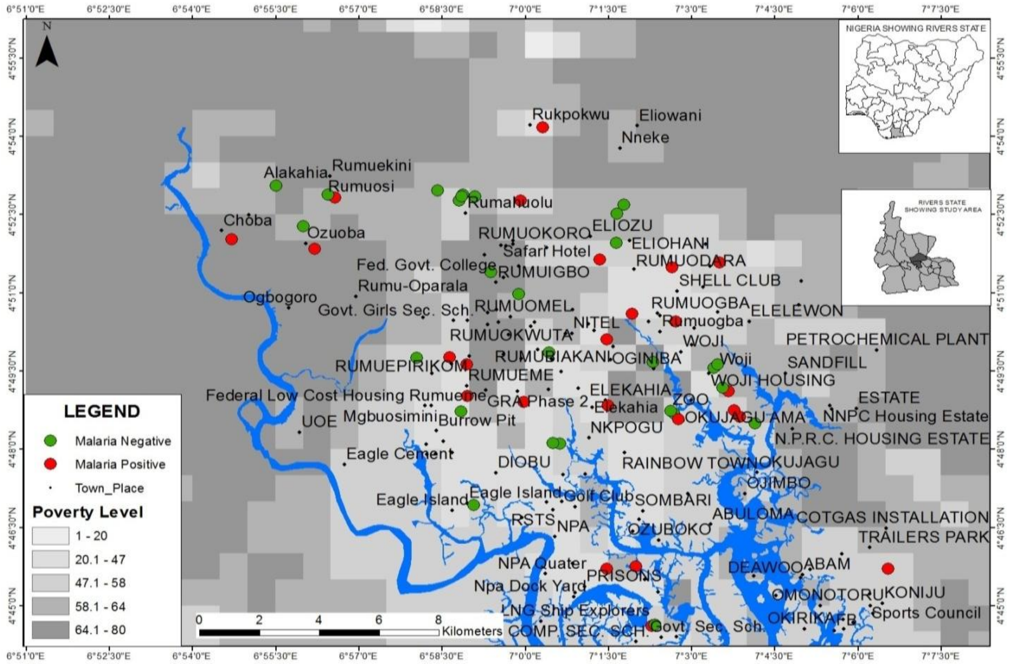

Figure 5 Poverty and the Incidence of Malaria

Understanding the underlying factors favoring malaria prevalence in the study area, revealed that, areas with less than 20 percent of the population living below poverty line based on UN population division estimate, (Alpha version 2010, 2015 and 2020) recorded low malaria incidence as compared to areas of 47.1 to 80 percent of the populations living below poverty line as shown in Figure 5. This reveals that, areas with higher per capita income recorded less malaria incidence compared to areas with population of low per capita income. Findings from the analysis of household wealth (poverty) determinant of malaria incidence using the Person Product Moment Correlation (PPMC) revealed a positive relationship between poverty and the incidence of malaria in the study area. This is in similarity with the findings of (Ifeyinwa Chijioke-Nwauche *et al* 2020) that there is association between household wealth and malaria risk

IV. Conclusion

From the analysis and the results, malaria incidence and mosquitoes are prevalent in the study area. The occurrence has significant relationship with the physical and human environmental (Land cover, Topography, Population density and poverty level).

V. Recommendations

It is therefore recommended that efforts should be incorporated in environmental education in the wake of malaria outburst in the study area. Sanitation exercise should be enhanced and opening up of drain should be prioritized. Urban Planning should be encouraged alongside development control by authorities aimed at enhancing malaria elimination from source and finally, homestead cultivation and constructions should be regulated to eliminate eaves and puddles around homes.

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