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Application of Geo-Information Techniques in Mapping the Spatial Incidence of Malaria in Calabar South Local Government Area, Cross River State, Nigeria.

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Abstract

This study applied geo-information technique in mapping the incidence of malaria in Calabar South Local Government Area of Nigeria. Consequently, the research identified the potential breeding environment of mosquitoes, establishing a relationship between residential distance, frequency of malaria incidence and the breeding location of the vector by creating a malaria risk map. The Global Positioning System (GPS) was used in collecting readings for location and other environmental variables, while an open-ended questionnaire was used in collecting data and information, aimed at achieving other study objectives. A total of 300 copies of the questionnaire were distributed, through stratified and simple random sampling technique. Arc GIS 9.3 software was used in analyzing geo-information parameters, The result of the study indicated that the closer the distance to the identified breeding point, the higher the incidence of malaria and the farther the distance, the less the incidence level of malaria . Hence, there is a relationship between distance from mosquito breeding points and malaria incidence in the study area. Thus, this has resulted in observed high level of malaria incidences among residents living in close proximity to breeding points. Due to the high incidence, there is invariably higher loss in occupational man –hour, as well as death toll, especially among infants from the malaria disease. It is recommended that more researches should be sponsored in with the aim of further finding more effective solutions.

Keywords :Geo-Information, Malaria, Incidence, Breeding Point,

1. Introduction

Malaria is a serious infectious disease that has become the number one public health problem in the tropical world (Colluzi, 2002, WHO, 2008). Malaria has been with man from ancient time to the present civilization. The malignant and intermittent fever observed in ancient time in China, India, Mesopotamia, Greece and Rome were likely the same disease conditions as observed in our times (Loban and Polozok, 1985).Malaria is defined as an acute infectious disease caused by *plasmodium* species and transmitted by mosquitoes of the genus *plasmodium* (FMOH, 2001). Similarly, Cunningham *et al* (2005) defined malaria as an acute and sometimes chronic infectious disease caused by a protozoan parasite of the *plasmodium* species (*plasmodium malariae, plasmodium ovale, plasmodium vivax* and *plasmodium falciparum*)

Malaria is a life threatening parasite disease transmitted by mosquitoes. During the time of Hippocrates, about 450 BC, ‘Miasma Theory’ was used to explain the occurrence of disease epidemics. Thus malaria means “Bad Air” (Akpala, 1994). In 1880, Scientists discovered that the real cause of malaria is a one cell parasite called “*plasmodium*”. Later, they discovered that the parasite is transmitted from one person to another through the bite of a female Anopheles mosquito, which requires blood to nurture her eggs. Today, approximately 40% of the poorest countries are at risk of malaria (WHO, 2008).

The disease was widespread throughout the world, but it was successfully eliminated from many countries within the temperate climates during the mid 20th century. Today, malaria is found throughout the tropical and sub-tropical regions of the world and results in 300-500 million clinical cases per year. It is also responsible for one million deaths annually (WHO, 2008). Malaria kills about twice as many people as does AIDS (Acquired Immune Deficiency Syndrome). As many as half a billion people worldwide are left with chronic anemia, due to malaria infection (Malaria Foundation, 2006)

More so, ninety percent of deaths due to malaria occur in Africa, south of the Sahara, mostly among children (WHO, 2008). It kills an African child every thirty (30) seconds. Many children who survive an episode of severe malaria may suffer from learning impairments or brain damage. Pregnant women and their unborn children are also particularly vulnerable to malaria, which is a major cause of prenatal mortality, low birth weight and maternal mortality, as a result of anemia (WHO, 2008).

In some African countries, people battle up to 40 (forty) or more episodes independently of malaria in their lifetime. The spread of malaria is becoming even more serious as the parasites that cause malaria develop resistance to the drugs used to treat the condition. Its scourge is all encompassing (Center for Disease Control, 2007).

A report from the Roll Back Malaria Control Programme in Nigeria (RBMCP), in 2005, indicates that malaria still constitutes a serious health problem in Nigeria. Nigeria has an estimated population of 140 million, an infant mortality rate of 110 per 1000 and an under-five mortality rate of 183 per 1000 (UNICEF,2002). High levels of malaria endemicity, parasite resistant to affordable drugs, breakdown in public health infrastructural facilities, land use changes such as building of dams, irrigation, deforestation, climatic changes due to global warming and ozone layer depletion help make malaria a leading killer of children, accounting for an estimated 25%-30% of mortality in children under five years or an estimated 300000 deaths each year (Allison 1997, UNICEF, 2008). The WHO (*2004, 2005a, 2005b, 2006a, 2006b, 2007a, 2007b, 2008)* has shown much concern about the malaria challenge, and has made several calculated efforts to solve this emerging and fast evolving problems

Malaria still remains a scourge in marshland environments, especially as a result of bad living conditions in relation to the breeding environment of the mosquito- carrying pathogen (*plasmodium*). The spatial and temporal pattern of malaria transmission at the local level (fixed spatial scale) in Africa has not been well investigated, accurately defined and well documented. Such researches are needed in developing dynamic and area specific risk maps to identify the locations and populations at highest risk for appropriate planning and implementation of targeted goals and epidemiologically sound preventive and control measures, against the malaria disease (Yeshiwondim *et al,* 2009)

The existing malaria maps have limited operational use, to support programmatic activities. They are largely based on expert opinion, climate based models and specific geo-referenced point prevalence data. Researchers have investigated spatial pattern of malaria distribution at household and community levels , in specific sites , and in relation to the proximity of mosquito breeding habitats (ponds, stagnant water bodies, drainages) using non –technological methods. These studies have focused on entomological parameters and population prevalence surveys. In this context, Geographical Information Systems (GIS), Remote Sensing satellite imagery, and geospatial techniques provide new methods and solutions to analyze the epidemiological and ecological context of malaria and other infectious diseases (Yeshiwondim*et al*, 2009).

In his study of the use of GIS for the control of malaria in Latin America, Gustavo (2005) states that large amounts of information are necessary for all malaria control programmes. GIS offers the ability to process quantities of data beyond the capacities of manual systems. Data is stored in a structured digital format, which permits rapid retrieval and use. In another study of the spatial pattern of malaria distribution in Padre-Cocha , Peru, Roper *et al* (2002) states that the application of GPS and GIS technologies in malaria and other vector-borne disease studies , affords the possibility of exploring spatial dimension of disease transmission, not easily examined in the absence of these capabilities.

The non availability of GIS-based malaria risk maps in Cross River State (especially in local communities) has led to a decline in studies showing malaria distribution in relation to mosquito breeding habitats. It is thus, against this background that this research is carried out to map the spatial incidence of malaria, within a sub set of Calabar south local government area (LGA), in relation to mosquito breeding habitats (swamp land with stagnant water bodies and silted drainages) through the application of systematic geo-information techniques, which includes: GIS, GPS, remote sensing and satellite imagery.

This research thus, focuses on identifying the breeding distance of mosquitoes in relation to the living environment of the study population. Three specific communities were studied; Ibesikpo, Mbukpa and Ambo communities. However, the genetic composition, blood group and other pathological characteristics will not be considered in this study.

Since the primary objective of the research is to evaluate the spatial incidence of malarial infection in Calabar South LGA , other objectives include: to establish a relationship between residential housing distance, frequency of malaria incidence and the breeding location of the vector: to recommend measures in ameliorating the spread and consequences of malaria infection in the study area.

2. Study Area

The research area for this study is Calabar South Local Government Area (LGA) of Cross River State, within the Niger Delta region of Nigeria. Calabar South is located in the southern senatorial district of Cross River State and lies between 5^o 32' and $4^o27'$ North of the equator and longitude 7^o 50' and 7^o 57' East of the meridian. It is bounded in the north by Calabar municipality to the south by the Bight of Bonny and the wide expanse of the Atlantic Ocean. To the east the study area is bounded by Great Oua River and westward by Calabar River. Calabar south LGA lies within the tropical region of Nigeria and has both wet and dry season (Akintoye, 1995). The area experiences heavy rainfall, as it is close to the Atlantic Ocean

The climate of Calabar south is a sub equatorial type of climate. The temperature is moderately high (28^oC-33^oC), and the coastal portion of Calabar south exercises a considerable influence on its climate (Nigerian Metrological Agency, 2000). High relative humidity of about 90% is common in this area. The rainfall range is between 1500 mm-3000mm annually. The rainy season usually start in April and lasts till October, while the dry season commences from November and lasts till March (Akintoye , 1995).

The dominant vegetation type in the study area is the mangrove forest, which gives rise to the existence of wetlands; although, there is a high rate of Nypa palm species existence. Animal species found in the area include different species of fishes and other sea foods (periwinkles, snails), and many endemic mammal species and threatened (Okon,2008)

The topography of the study area is characterized by levels of gently undulating features. The elevation varies from 0-50 meters above sea level and increases northward from the coast. Seasonal flooding is a regular feature from the coast (Akintoye, 1995).

The major ethnic group in the study area is the Efik tribe. Industrial activity in the study area is on a low scale, as the major socio economic activity includes: farming, petty trading. Occupational activities include; boat making saw milling and migrant business men from neighboring communities (Okon, 2008).

There are several private and government hospitals, maternities and medical centers within Calabar, but especially in Calabar municipality. Malaria drugs are easily available, even in Chemist shops, as well as herbal preparations, from trado-medical practitioners, which most often result in dangerous self medication.

3. Method of Study

The sampling method adopted by the researcher includes stratified sampling. Geographic Information System (GIS) and Global Positioning Systems (GPS) applications were also utilized in the study. The household heads were the major targets of questionnaire administration to elicit information on the frequency of occurrence of the disease. Since Calabar South LGA is comprised of ten (10) wards and approximately nine (9) major streets that borders its wetland, a total of three streets were randomly selected using a table of random numbers. The copies of questionnaire were distributed randomly on these streets to household heads within the sample area.

3.1 Geo-Information Technique

A global positioning system (GPS) unit was used to obtain data on distance of area of incidence from breeding areas and location of communities and sampled households. Weather tracker was also used to record climatic variables such as heat index, humidity, Pressure etc. The centroid for each street was extracted using Arc GIS 9.3 software to verify data from GPS unit. Other attribute data, on wetlands, vegetation cover, and drainage systems were derived from orthophoto maps and satellite imagery. Digital Elevation Models (DEM) data for the study area were downloaded from the website (http://www.googleearth.com) and extracted using spatial analyst tools of ArcGIS 9.3.

All attributes and datasets were integrated into one geo –database, a data structure used in ArcGIS 9.3 A buffer (50m-250m) was created between the wetland and residential areas, after which each layer was interpolated to become one single layer. Analysis of the relationship between distance from the wetland (an identified breeding point for mosquitoes) and malaria incidence in the sampled residential area was carried out by creating a geo-spatial data base that contains all attribute examined in the study area.

The study area was grouped into clusters based on the distance between data points and this research employed Euclidean distance function to verify the spread of the incidence of the disease.

3.2 Sampling Population

A sampling population of 19,055 inhabitants, living around the wetlands area, was estimated to represent the study population (three selected communities) within Calabar South Local Government Area. A total of 100 household heads were however sampled to elicit information on incidence of occurrence.

4. Result

It is observed from table 1 that a frequency 39.18% level of incidence was recorded for respondents residing within a distance of 50 meters from the pond/ stagnant water body; 23.42% incidence level was recorded for sampled respondents residing 100 meters away from the wetland, while 21.2% incidence level was recorded for the sampled respondents living about 150 meters away from the wetland. For those living about 200 meters away, they had occurrence of 5. 48 %, while 250 meters away was 10.72 %. It is clear therefore, from the data shown that the closer the distance to the identified breeding point, the higher the incidence of malaria and the farther the distance, the less the incidence level of malaria.

5. Discussion of Findings

The study is on the application of geo-information technique in mapping the spatial incidence of malaria in Calabar South LGA, Cross River State. The buffer presents features such as the dominant wetland in the study area, and residential locations within the study area affected by very high, high, moderately high and low malaria incidences. The study shows that there is reduction in malaria incidence with increasing distance from the wetland (a major breeding point of mosquitoes in the study area)

The first buffer of 50 meters shows a very high incidence level of malaria due to its close proximity to the mosquito breeding points. Other buffer created includes; 100m, 150m, and 200m respectively. An altitude was established for the wetland (41 meters above sea level) and residences within the 50m buffer have an altitude of 43m with a difference of 2m from the identified breeding point. The altitude for other residential areas is shown in table 2

In addition to other factors, the major wind direction of the identified breeding point was established, as it supports the flight strength of the mosquitoes. Wind direction was given as “South- East”, to the direction of identified residential areas, as shown in the maps of the study area. Another factor considered in this research is the flight distance covered by a mosquito. Griffith (1970) in his study of *Anopheles quadrimaculalus* in the United states of America established that there is a non-availability of sufficient data showing the mean distance covered by a blood fed or non blood fed mosquito (except in laboratory conditions, which is given as > 1 mile). However, it was established that the flight distance covered by a mosquito is impaired by the elevation of the land. The higher the altitude, the less the distance covered by a mosquito from its take off point. More so, the average heat index (HI) and temperature of residents within the 50m buffer is 33.2 and 29.3^{o}C, is favorable for the breeding of mosquitoes. Arising from these facts, therefore, the results depicts that incidence of malaria relates to distance to breeding ground and other factors such as wind direction and elevation , Figure 1 gives a description of the study area , while figure 2 displays the spatial distribution of malarial incidence with reference to the buffer zones.

6. Conclusion

Geographic Information System (GIS) is versatile tool for analysis of spatial spread of malaria vector as well as other diseases. This tool has been used to create spatial data bases for the spread, management and control of malaria. The technique enhances production of different maps which can be used for surveillance.

The result has demonstrated the diminution of incidence of malaria from the breeding grounds of the vector. Moreover, spatial distribution of vectors and incidence of the disease can then be correlated with other factors as the habits, lifestyle and behavior of the vectors; as well as climatic and other environmental attributes in favour of the growth of the malaria vector.

This application used can also be used for prediction of malaria occurrence based on extrapolations from past and current malaria patterns. It is therefore pertinent for Government, non-governmental organizations and international donors to make available fund for intensive malaria research programmes.

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TABLE 1: MALARIA INCIDENCE DISTRIBUTION (2008-2010)

BUFFER ZONE	RADIUS IN METERS	FREQUENCY OF OCCURRENCE IN %
A	**50**	**39.18**
B	**100**	**23.42**
C	**150**	**21.2**
D	**200**	**5.48**
E	**250**	**10.72**
TOTAL		**100**

SOURCE: Researcher's Fieldwork (2012)

TABLE 2: GEO-INFORMATION PARAMETERS OF THE STUDY AREA
DATE: 07/04/2012
TIME: 4.00pm – 6.00pm **DURATION OF OBSERVATION:** 2 HOURS 2MINS

S/N	LOCATION	LATITUDE	LONGITUDE	ALTITUDE	HUMIDITY	TEMP.	HEAT INDEX	WIND DIRECTION	PRESSURE
1	**STREAM/POND**	N04^{0}55'40.8"	E008^{0}18'42.8"	41	65.9	29.3^{0}C	33.2	South/East	1007.9
2.	**IBESIKPO**	N04^{0}55'41.8"	E008^{0}18'43.8"	43	63.3	29.9^{0}C	33.9	South/East	1007.8
3.	**AMBO**	N04^{0}56'12.9"	E008^{0}18'44.2"	47	64.8	27.8^{0}C	30.3	South/East	1007.2
4.	**MBUKPA**	N04^{0}55'56.5"	E008^{0}18'44.2"	68	62.8	28.2^{0}C	31.9	South/East	1004.8
5	**ANANTIGHA**	N04^{0}54'40.8"	E008^{0}16'42.8"	10	66.1	27.3^{0}C	33.2	South/East	1002.6

Source: Researcher's Fieldwork (2012)

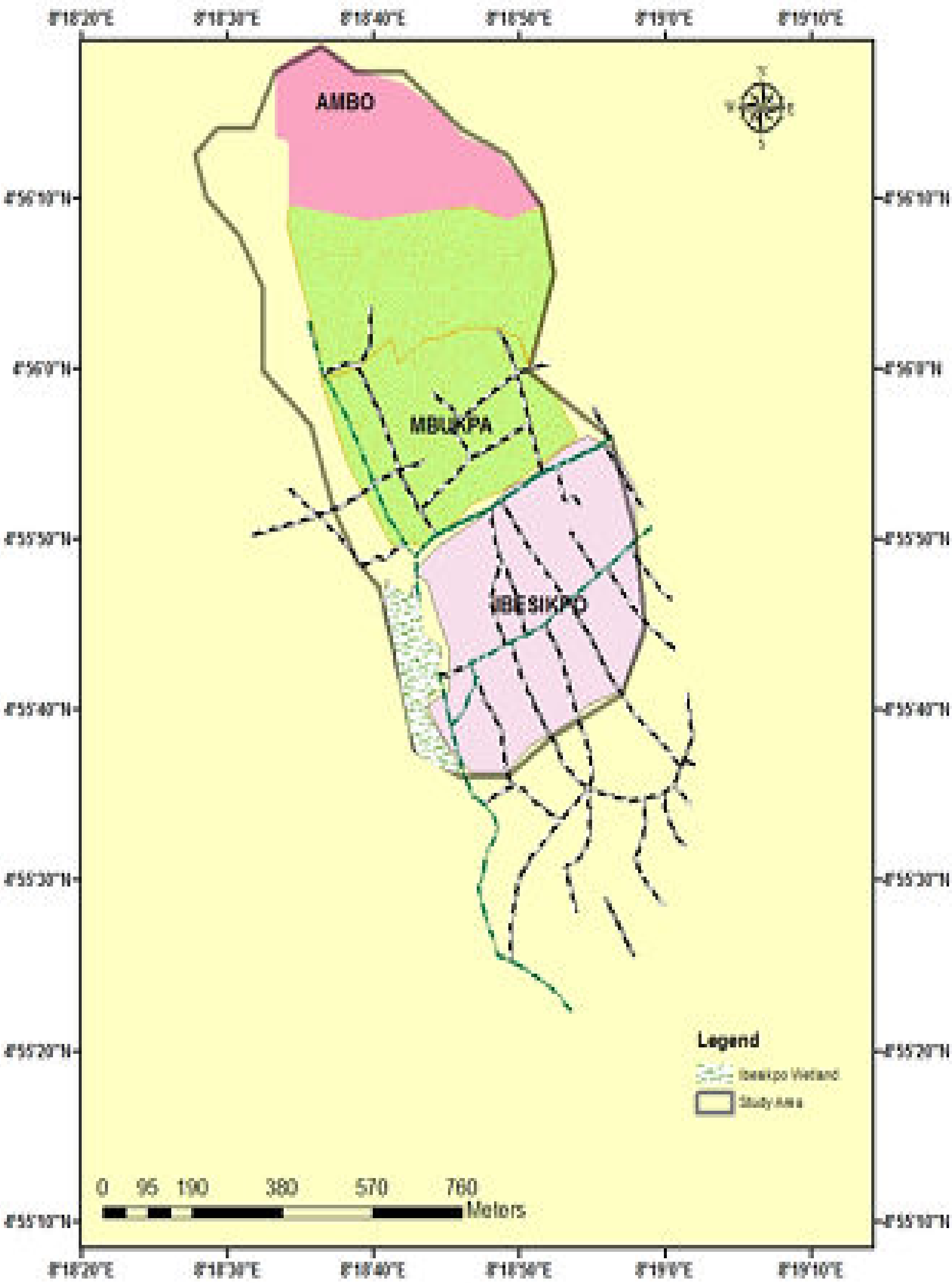

Figure 1: The Study Area
Source: Adapted from Cross River State Survey Map (2012)

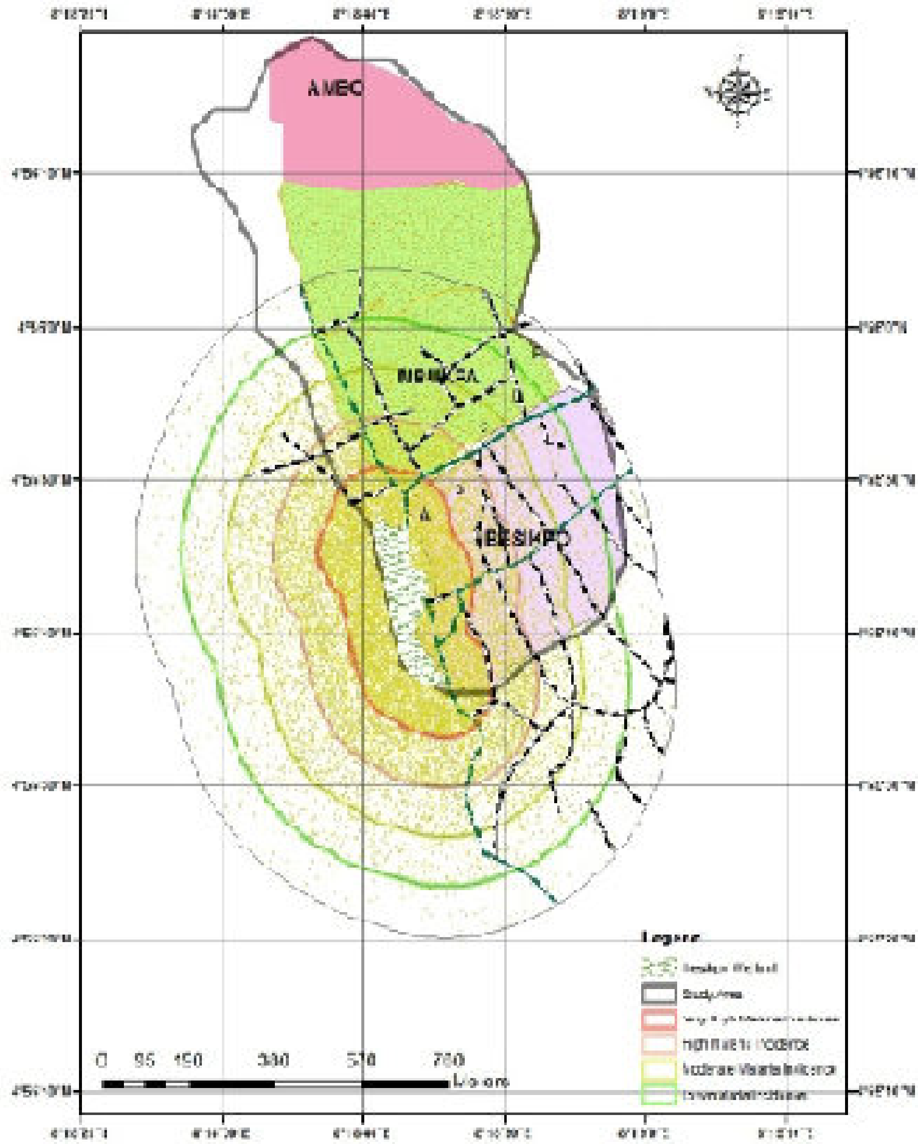

Figure 2: Spatial Distribution of Malaria Incidence in Study Area

Source: Authors' GIS Analysis (2012)