International Journal of Scientific Engineering and Research (IJSER)
www.ijser.in
ISSN (Online): 2347-3878, Impact Factor (2014): 3.05

Application of Remote Sensing and GIS Techniques in the Malaria Control Program of Katsina State Nigeria

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Abstract: ***Malaria is an acute infectious disease spread to humans by the female anopheles mosquito. Effective control and management of the disease principally required accurate data on the disease and the knowledge of the spatial location of the major existing and highly potential mosquito breeding habitats. It also requires the knowledge of the proximity of health service centers and other land use /land cover of the area under consideration. Thus there is a need for thematic maps showing the configuration of the land area, couple with modeling and Geographic Information System (GIS) as major decision making tools, to articulate and achieve desirable results. Paradoxically past efforts by the Katsina State Government of Nigeria to contain the disease in the State neglected this associated environmental control measures and therefore proved less effective. For effectiveness and costs reduction strategies, this study attempts the application of the Remote Sensing, Land Survey and the GIS techniques for the Malaria Control Programme of Katsina State. Katsina metropolis as case study was used to highlight the challenges involve and the potentials for the state wide application. The result may facilitates an improve malaria epidemic understanding and help its abatement.***

Keywords: Katsina, Mosquito, Malaria GIS, Remote Sensing

1. Introduction and Background

Malaria Control program is one of the various disease control programs set up by the Katsina State Government of Nigeria. The disease is an acute infectious disease spread to humans by the female anopheles mosquito. Itis an epidemic in the state responsible for about 2, 959, 806reported cases and 12, 668recorded death in the last eight years (2001 – 2008)(Table 1), among the State's 6, 329, 706 people [1].

Control of malaria is known to be a formidable task comprising a multifaceted series of measures that often complement one another.Basically it involves the control of 3 living beings, Man (the host), Plasmodia (the agent), and Anopheles mosquito (the vector) and their environment. A number of measures adopted to contain the negative impact of the disease in Katsina State include the introduction of the Free Malaria Drug Program in all the State's hospitals, intermittent Insecticide Spray, the distribution of insecticide treated bed nets, etc. Despite these laudable efforts, the incidence of Malaria is on the increase in the state. Records of the State's Ministry of Health show that from the year 2001, Malaria cases rose from 250, 218 reported cases with 375 deaths 1n 2001 to 600, 286 reported cases and 4, 100 deaths in the 2008. As indicated in Table 1, Chart1 and chart 2 below.

Table 1: Malaria cases and morbidity

Summary of Reported Malaria Cases and Death due Malaria in Katsina State (2001-2008)			
S/N	Year	Cases	Deaths
1	2001	250, 218	375
2	2002	198, 423	342
3	2003	189, 423	571
4	2004	344, 018	1119
5	2005	392, 563	1701
6	2006	495, 736	1699
7	2007	489, 139	2758
8	2008	600, 286	4103
	Total	2, 959, 806	12668

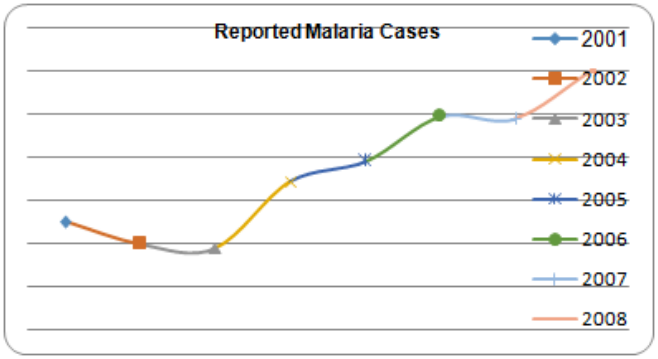

Chart 1: Reported Malaria Cases 2001-2008

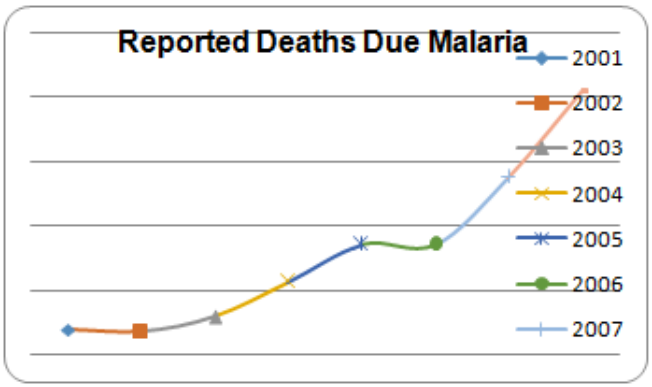

Chart 2: Reported Deaths due Malaria 2001-2008

In [2] it was reported that, the social and economic burden of malaria on the people in form of treatment cost, prevention and loss of work time in the State has lead to the reconsiderations and review of the past approaches to contain the disease. It was realized that there is a need to factor in the environmental management measures that integrate the use of map and other geospatial information.

Paradoxically, the associated environmental factor that integrates the use of map and other geospatial information was hitherto not employed in the State's malaria control program. Consequently to help gain an accurate understanding of the situation and improve the awareness for strategic planning in the malaria control and administration efforts, the Office of the State's Surveyor-General partnered with other organizations in the State such as the National Population Commission, Ministry of Health, E.P.O Unit (SPHCDA) and Katsina Local Government Health Department to provide geospatial information critical to the control of the epidemic in Katsina metropolis.

Tables2, 3 and 4 below are brief descriptions and summary of the State's geo-political, vital statistics and general heath indicators respectively, as contained in the year 2009 report of a baseline study conducted by the Support to the Nigeria Malaria Programme (SuNMaP). SuNMaP is a 5-year (2008 – 2012) programme funded by the UK Department for International Development (DfID). The programme is aimed at working with the Government and people of Nigeria to strengthen the national effort to control malaria. The baseline study which took place from the 14th – 16thDecember 2009 was aimed at the assessing the capacity for Malaria Control at the State and Local Government Area (LGA) Levels in Katsina State [3].

Table 2: Geo-political data of Katsina State

No of LGAs	34
Districts in the state	54
No of political wards	361
No of village heads	570
Major ethnic groups	Hausa and Fulani
Urban population	30%
Rural population	70%
Bordering country	Niger
Bordering States	Kano, Kaduna, Zamfara, Jigawa
Predominant religion	Islam
Workforce in the public sector	predominantly male

Table 3 Some Vital statistics of Katsina State

Total population	6, 329, 706
Total less than 5 years (20%)	1, 265, 942
Total under 1 year (4%)	253, 188
Women of Child Bearing Age (22%)	2, 392, 536
Pregnant women (5%)	316, 486
Rate of increase between 2003 and 2007	12.3%

Table 4: General Health Indicators of Katsina State

Incidence of Malaria	**77/1000 population**
Maternal Mortality Ratio (MMR)	1, 000/100, 000 Live Birth (Highest MMR for Nigeria)
Neonatal Mortality Rate	55/1, 000 Live Birth
Infant Mortality Rate	114/1, 000 Live Birth
U5 MR	269/1, 000 Live Birth
Average Fertility	7.2
ANC attendance	about 55%
Delivery in HF by skilled attendants	about 10%.

Earlier in its 2008 Fact Sheet for the North West Zone of Nigeria, the 2008 Nigeria Demographic and Health Survey (NDHS), provided an up to date information on population and health situation in Nigeria [4]. The following key points on Fertility, Family Planning, Maternal and Child health, Malaria, Housing condition, and Education status, relevant to this paper were highlighted among others. These were as shown in Table 5 below.

Past studies including [5], [6] has demonstrated the efficacy of the application of GIS in malarial control studies. This paper attempts integrating the geo-spatial information componentscritical to the control of the epidemicby exploring the application of modern technology of Remote Sensing (RS) and Geographic Information system (GIS) in a Malaria Control programme of Katsina State of Nigeria.

It suffices this presentation that Remote sensing (RS) be consider as a process of obtaining information about an object, area or phenomena without making physical contact with the object[7], [8], while GIS integrates hardware for capturing managing, analyzing and displaying all forms of geographically referenced information [9]and [10]. RS generally enhances the ability to generate data while GIS can analyze landscape level relationship of vectors and diseases [11].

Table 5: Summary of Population and Health Situation in Katsina relative to Nigeria

Fertility	Katsina State	Nigeria
1. Total fertility rate	7.2	5.7
2. Women age 15-19 who are mother or now pregnant (%)	65%	23%
3. Birth that occur less than 2 years after preceding birth (%)	28%	24%
Family Planning		
Current use of any modern Method (currently Married women)	1%	10%
Maternal and Child Heath		
Maternity Care		
1. Women who gave birth in the last 5 years who received antenatal care a skilled provider[1] (%)	14%	58%
2. Birth assisted by a skilled provider (%)	5%	39%
3. Birth delivered in a heath facility (%)	4%	35%
Child Immunisation		
1. Children 12-23 months fully immunised[2] (%)	1%	23%
2. Children12-23months with no immunisation (%)	58%	28%
Malaria		
1. Household with at least one insecticide-treated net (ITN) (%)	2%	8%
2. Children <5 years who slept under an ITN the night before the survey (%)	1%	6%
3. Pregnant women who slept under an ITN the night before the survey (%)	1%	5%
4. Pregnant women who received 2+ doses of SP / Fansider as IPT during antenatal care (%)	1%	5%
5. Among the children with fever percent who received anti malarial drugs the same or next day (%)	22%	15%
Housing Conditions		
1. Households with an improved souse of drinking water (%)	38%	56%
2. Households with electricity (%)	30%	50%
3. Households with an improved toilet facility (%)	47%	27%
Education		
1. Literate (women15-49years/men15-49 years (%)		
2. No education (women15-49years/men15-49 years (%)		

[1] Skilled provider includes Doctor, Nurse/Midwife, or Auxiliary nurse/midwife
[2] Fully immunised includes BCG, Measles and three doses each of DPT

Katsina Metropolis due to its political status and also being major urban centre in the State was chosen for a pilot study to highlights the challenges and the possible benefits to be achieved by incorporation of RS and GIS technologies in the State malaria control programme.

Malarial Situation and Health Service Provision

Malarial Situation

Katsina State is among the states in Nigeria adjudged as Malaria endemic State. Two main types of mosquitoes, an. Gambiae and an. Funestusin the wet season and dry season respectively are identified as the most predominant malaria vectors in the State. Transmission of the disease is all year round with seasonal peaks. From the records of the State's Ministry of Health (KTSMOH 2010), the disease is rated first among 10 noticeable diseases in the state (75 % of out-patient consultations). All age groups are affected and in pregnancy it is responsible for a large share of maternal deaths (at least 11%).The record also shows that there is more severe malaria in children and this appears to be increasing.

Health Service Provision

The health services in Katsina state are being provided at three levels (a), Federal, (b) State and (c) Local Government levels respectively. The respective available facilities are as follows: 1 Federal Medical Centre in Katsina town; 21 General hospitals and specialist hospitals run by the Hospital Services Management Board; 22 Comprehensive Health Centres and 1427 health clinics and dispensaries which are operated by the 34 LGAs and the State Primary Health Care Development Agency (SPHCDA).In addition to these there are also institutional health facilities. Table 6below is the summary list of the health Service centres as of December 2009.

Table 6: List of Health Service Centre in Katsina (December 2010)

Primary Health Care (PHC) Facilities	Total
1. PHC Centers	100
2. Maternal and Child Health clinics	154
3. Health Clinics	518
4. Dispensaries	460
Hospitals	
1. General hospitals(incl.Turai Yar'Adua maternal & child Hospital	21
2. Mental asylum	1
3. Federal Medical Centre	1
Private Service Delivery Points (SDPs)	
1. Private hospitals & clinics	50
2. Pharmaceutical stores	21
3. Patent Medicine Stores	1703

2. The Study Area

Katsina lies between latitude 12° 51'51" - 13°00'40" N and longitude 07°34' 02 - 07° 34'11" E. It is currently the State capital of Katsina State of Nigeria and also the headquarters of Katsina Local Government Area. 1 and 2 are the administrative boundaries maps of the State and of the Katsina Metropolis respectively.

Figure 1: Administrative Map of Katsina State

Figure 2: Administrative ward boundaries Katsina Metropolis

3. Objectives

The objective of this work is the establishment of a simple GIS:

1. Torelate different information regarding the effects and impacts of malaria in a spatial context and to promote better malaria control program management.
2. Tofacilitate an accurate understanding of the situation and enlarge the awareness for a tactical planning in the malaria control and administration efforts of the State.
3. To provide spatial data map showing administrative boundaries, roads, rivers. Schools, market places and healt service facilities, etc on which to display the malaria data in a GIS, for scientific investigation and for a better decision making.

Figure 3: Enhanced Satellite Image of Katsina

Figure 4a: Aerial Photograph of part of Katsina Metropolis

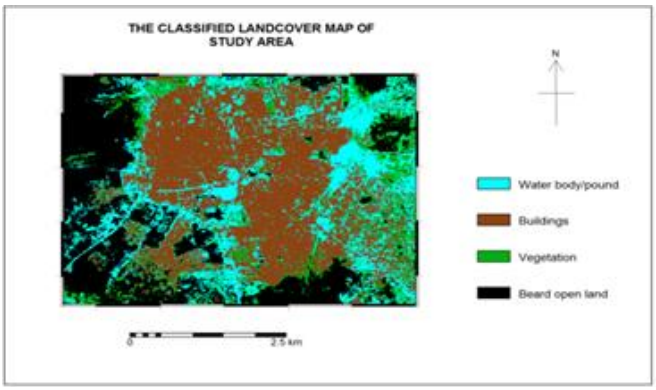

Figure 5: Classified land use map of Katsina Metropolis

4. Materials and Data

The hardware utilized comprises of 2 laptops, and 2 desktops computers with their accessories and one A3 printer. The software used consists of assorted Remote Sensing and GIS software's together with Computer Aided Design (CAD) software all coupled in a Window based environment.

The data set was derived from the field Surveys under taken and from the existing records of the Epidemiological (E.P.I.D**)** unit of the State's Ministry of Health (MOH), the State Ministry of Lands and Surveys (MLS), office of the Surveyor General of the Federation (OSGOF) Katsina, State Environmental Protection Agency (SEPA) and the Disease control unit of Katsina Local Government Health office (LGHO). This data set includes; Topographic map

sheet, Aerial Photographs (Fig3a) and Coordinates of some Ground control points, from the MLS, Satellite imagery (Fig3) from OSGOF. The data on insecticide spray (date and location) from SEPA and the malarial situational records from E.P.I.D. and the LGHO.

5. Methodology

The approach adopted for this work was centered on three main entries comprising data collection and collation, basic analysis and presentation of an output for further analysis. In the absent of adequate formal address system in Katsina metropolis, its existing ward administrative structure (Fig 2), was used to develop the spatial infrastructure. The four wards are Arewa, kudu, Yamma and Gabas respectively. Using the existing topographic map as base map, additional ground control points were established for accurate delineation of these administrative boundaries using a Differential GPS (DGPS) instrument. The topographic map and the aerial photographs were scanned and geo-referenced in the computer system. Similarly for the Satellite imagery image analysis and classification (Figure 6) were made. Ground truthing involving a field trip was made to verified classified details. A hand held Global Position System (GPS) receiver was used.

Furthermore a GPS receiver was used during the field survey to provide the locations of the various health service centers (public and private) in the metropolis(Table7 below), also recorded were the locations of large crowd gathering points that includes Markets, Worshiping places and schools were registered as Waypoints. The burrow pits, ponds, irrigation sites, streams and rivers, defined as potential mosquito breeding habitats were indentified. The RS products Fig3 and Fig3a above (satellite imagery and aerial photographs) simplified identification of these vector habitats.

The data gathered were utilized to create attribute database and for the development of different layers which were used to form various thematic maps. Respective Layers for the Wards (administrative), Vector's habitat, Schools, Markets, Places of Worships and Health service centres (HSC) etc within the metropolis were created.

Table 7: List of some Health Service Centres in Katsina Metropolis (Dec 2009)

Field Id	Name	Address	X COORDS	Y COORDS
1	Nigerian Chinese Medical Center	Nagogo RD, G.R.A	352564	1431372
2	Ikhwaan eye and Medical Center	Filin Samji	349618	1437149
3	Maternal and child health center	Kofar Sauri	349095	1438171
4	College of health Science	Yar Kutungu Market	348747	1437599
5	Psychiatric hospital katsina	Yar Kutungu Market	348762	1437519
6	Rahusa Medical Diagnostic Lab	Behind General Hospital	348467	1437320
7	General Hospital Katsina	Moh'd Dikko Rd	348343	1437354
8	Katsina Medical Diagnostic Lab	Moh'd Dikko Rd	348269	1437295
9	State Primary Health Care Devp Agency	Sani Abacha Square K/ Guga	347641	1436895
10	Maternal and child health center	Tudun Hidda	346762	1437612
11	Maternal and child health center	K/Guga Jibia Rd	346673	1436336
12	Federal Medical Center	Murtala Moh'd Way	346733	1435850
13	General Hospital Babbar Ruga	Batsari Rd Katsina	344438	1432616
14	Maternal and child health center	Waziri Zayyana Rd Rafin Dadi	347726	1435513
15	Rafin Dadi Dispensary	Waziri Zayyana Rd Rafin Dadi	347726	1435555
16	Nad-da Diagonistic Center	Murtala Moh'd Way	347864	1434828
17	Ikon Allah Clinic	Yahaya Madaki Way	348076	1434651
18	Vetenary Clinic	Opp Central Market	348032	1434483
19	First Millennium Clinic	Ahmadu Bello Way	348265	1435553
20	Modern Police Hospital	Police compound	348556	1435743
21	Amana Clinic and Maternity Home	Sabuwar Kasuwa	348885	1435892
22	Maternal and child health center	K/ Kaura	349093	1435120
23	Okmos Clinics and Hospital	K/ Kaura	349145	1435055
24	Alheri Hospital	Lawrence Onoja Rd	350123	1434896
25	Sauki Clinic and Maternity Home	K/ Marusah	349565	1436009
26	Maternal and child health center	K/ Marusah	349448	1436067
27	Allah Bamu Lafiya Clinic	Maiduguri street Kerau Qtrs	349142	1436669
28	Sura clinic	Kerau Qtrs	349201	1436719
29	Full Care Dental Clinic	Daura Rd	351390	1436861
30	EU-Prime Dispensary	Kwado	353286	1435636
31	Allahu Shafi Medical Diagonistic Lab	W T C R/About Mani Rd	351193	1435226
32	Nursing Home	Hassan Usman Rd	351076	1435405
33	Mukhtar Bello Islamic Center	K/ Kaura Layout	350832	1434970
34	Hamdala Surgery	Hassan Usman Rd	351162	1434712
35	Turai Yar Adua Maternity and Children Hosp	Gidan Dawa	351767	1434138
36	Amfani Clinic and Maternity	Funtua Crescent K/ Kaura Layout	351238	1433838
37	Katsina Steel Rollings Clinic	Hassan Usman Rd	351292	1433492

The power of GIS emanating from its ability to relate different information in a spatial context was exploited. I the GIS combinations of related mapped variables together with their attributes and other data set was achieved. This allows analysis of the spatial dynamics of malaria incidence and prevalence within the metropolis to be conducted in a digital environment. For example the linking of the administrative, the land use and the Health Service centre layers with data set of reported cases of malaria obtained from the EPID Unit generated a visual display of areas high clusters of malaria cases vis-à-vis the areas that were adequately serve or under served with provision of HSC.

The variables output generated comprises set of thematic maps, charts and other statistics reports. There is also the facilitation for some spatial queries and manipulation, analysis and modeling with data. Distances between points of reported incidence, the HSC and the identified potential vector habitat were analyzed. The spatio temporal relationship of insecticide spray (dates and locations) and the malarial incidences on a chosen time scale were analyzed.

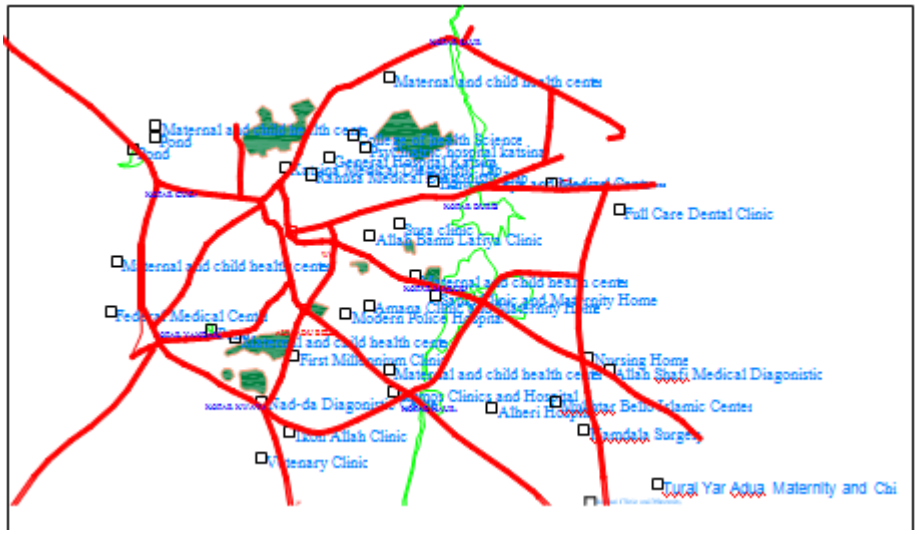

Figure 6: Map of the locations potential mosquito Breading areas andSomeHealth Centres in Katsina Metropolis Dec. 2009

6. Discussions

Challenges

The challenges of GIS for malarial Control programme have been fully by [12]. A peculiar case that posed a major challenge to this pilot project at the onset (Year 2010) has to do with fact that there were no existing GIS in Katsina. There was a problem in the way and manner of disease reporting in the State. Most people do not go to Hospital for malaria treatment; they often resort to self medication. There is reluctance and failure of most private clinics to report malaria cases to the relevant authority. Technically this results in data limitation. Other challenges include the lack of technical infrastructures and specialists to give training to the field staff or to perform the analysis. Thus this pilot project for the application of remote sensing and GIS in the State's malaria control program was initiated.

Some of the additional challenging factors for the project include the need to;

1. Increase improve data integrity and quality
2. Increase speed of information distribution
3. Prevent duplication of efforts
4. Investigate the spatial dynamics of malaria transmission
5. Estimate the spatio- temporal magnitude of the disease.
6. Provide avenue of assessing the effectiveness of the control measures
7. Create condition for an efficient planning, implementation and evaluation of the resources
8. Minimize cost

Achievements

Some of the major achievements of this work include:

a) The establishment of a malarial database in a spatial context for analysis**.**
b) Incorporation of the modern techniques of Remote Sensing and GIS into the State's Malaria Control Programme
c) Providing clearer means of identification of the areas of high incidence and prevalence of the disease
d) Increasing awareness and further capacity buildings
e) Enabling the provision of accurate and up to date information for the MCP management and planning application.
f) Establishment of unified standard for documentation and information dissemination

By creating a map covering the entire Metropolis in a digital format, it is now possible to accurately define the locations, proximity and extents of the identified high potential mosquito breeding, malaria incidence and prevalence areas, as well as the locations of the various gathering centers of large crowd of people such as Market places, Primary and Secondary schools and the health service facilities in the metropolis. The map makes it possible to learn which areas are served, not served and

underserved in the provision of health service delivery service within the metropolis. It also enable the accurate identification of the vector habitat within the metropolis which makes a significant contribution to the disease control effort as it facilitates ease of targeting of eggs and larva of the vector.

The visual display of spatial clusters of malaria cases and their corresponding tabular records of the disease in the computer based GIS platform, provide powerful analytical tools to establish and confirm spatial relationships among the various data sets and the selection of priority areas. These allow for trends analysis and tactical planning for effective resource allocation and hence cost reduction.

7. Results and Conclusions

The results of this pilot study confirmed the usefulness of the application of the Remote Sensing (RS)and Geographic Information System (GIS) technology as a possible cost effective way to improve evaluation of the malaria, its vector and the disease's spatial distribution in a given study area.

Remote sensing data serves as a tool for surveying large areas to identify vector habitats, areas of high malarial incidences, and help direct control measures. The data when made available in digital format could easily be amenable for computer analysis and integration with other digital databases in a GIS.

The spatially analyzed outputs provided by this approach are of direct assistance to the evaluation of malaria control programs. The final map produced and the statistical analysis carried out could provide a platform for effective control and strategic planning based on reliable geospatial information.

The controls include issues relating to the suitable choice of water ways and ponds to be filled or drained and the densification considerations for hospitals and clinics where there is critical need, also, Time scheduling for the insecticide re-spraying and other monitoring and evolutions.

Thus understanding the relationship between location and malaria incidences can significantly help us in understanding, controlling and preventing the disease, and in better Malaria Control programme planning, with more efficient and effective resource utilization. This should ultimately lead to better healthcare outcomes and improved health for everyone.

However due to numerous constrains ranging from insufficiency of the required data, data flow and its transparency, inadequate infrastructures, skilled staff to manned the GIS and funding limitation, the Statewide application of this approach, as of now, is not warranted.

It suffices to recommends that some of the other major urban centres of the State (Funtua, Malumfashi, Daura, and Dutsin-Ma) respectively, could be consider in the future efforts towards spatially enable malaria control strategy for the State.

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