Sci-Afric Journal of Scientific Issues, Research and Essays Vol. 2 (5), Pp. 238-247, May, 2014. ***(ISSN 2311-6188)***
http://www.sci-afric.org

Review

Epidemiological study of tropical diseases using Geographic Information Systems (GIS) and Remote Sensing (RS).

*[1]**Oladejo** S.O, [1]**Nandi** I., and [2]**Ajibola** B.

1. Department of Biology, Alvan Ikoku Federal College of Education, P.M.B 1033, Owerri, Imo State.Nigeria.
2. Department of Zoology, University of Ibadan, Oyo State, Nigeria.

* Corresponding Author E-mail: sundayoladejo001@yahoo.com

Accepted May 05th, 2014

ABSTRACT

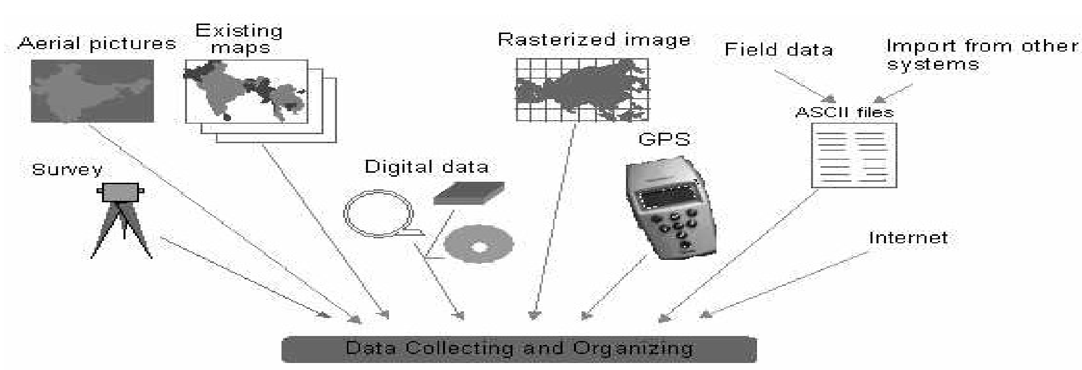
Geographic Information Systems (GIS) and Remote Sensing are providing new tools which allow collation, mapping and analysis of empirical survey of infection data for tropical disease management. Although the geographic approach has long been integrated into tropical disease control programs, the linkage between geography and health in general have only come to the fore in recent decades. This paper seeks to examine the meanings, principles involved and the relevant examples of the use of GIS and RS in the control of tropical diseases. Information was sourced from the internet, text books, WHO Technical Reports and journals. The write-up therefore provides the current information about tropical disease control using GIS and Rs with specific examples.

Key words: Geographic Information Systems (GIS), Diseases, Mapping, Survey and Analysis.

INTRODUCTION

The advent of geographical information system as a new technology for graphical representation and spatial analysis of data bases offers a new approach for planning and managing the control of tropical diseases (Mott et al, 995). Although the geographic approach has long been integrated into tropical disease control programs (WHO 1965), the linkage between geography and health in general have only come to the fore in recent decades (Verhasselt 1993). For tropical disease control, these links are particularly relevant as refugee movements, the continuous population flux between rural and urban areas, and environmental changes influence the distribution of vectors, reservoir animals, and the human population, and determine the transmission of diseases (Ruto and Karuga 2009, and Mott et al, 1995). Data collection/input remains the most expensive and time-consuming aspect of setting up a major GIS facility. Experience indicates that data collection accounts for 60-80% of the total cost (time and money) of a fully operational GIS as shown in the figure below.

Figure 1: Integrated data collection sources in GIS process.



The GIS Process includes the following:

Project formulation, i.e. what's the question?

- Develop a specific question. Write it down.
- Evaluate whether GIS is the appropriate tool. Give reasons.
- Evaluate what data you need, its availability and its usefulness. Make a list.
- Evaluate whether there is a faster, cheaper, and easier way. Always double check.
- Plan a course of action. Get started.

Data acquisition, i.e. getting the data/ Data comes from many sources.

- Paper maps
- Field collections, with or without GPS
- Aerial photography and satellite imagery
- Existing sources, over the Internet or from researchers, etc.

Pre-processing, i.e. getting the data to work together.

- Map projections define the geographic coordinate system of the data.
- All the data layers need to be in the same coordinate system to overlay.
- All the data need to be in a format compatible with your GIS (i.e. Arcview)

Data management, i.e. keeping yourself and your data organized.

- Good notes and metadata are essential.
- Organization of files and folders.
- Regular back-ups of on-going work.
- Keeping a clean workspace (in the computer)

Manipulation and analysis, i.e. Distance/Area Measurements.

Overlay Operations: In overlay analysis, location is held constant and several variables are simultaneously evaluated (Avery and Berlin, 1985).Figure 2.

Spatial Modeling

Product generation, i.e. pretty pictures to answers

- Designing maps (and tables and charts) to convey the meaning you desire
- Output devices e.g Printers, plotters, and the Internet produce results of your analysis
- Preparing datasets for distribution

The needed GIS tools/components.

HARDWARE: These are used for the acquisition, storage, processing and display of geospatial data. They include; (a) The data acquisition hardware (e.g. GPS, total station, digital image processing hardware, analytical/digital photogrammetric stereo-plotter, digitizer and Scanner); (b) the host computer for processing, manipulation and storage; and (c) the output hardware (such as graphic screen, printer and plotter).

The choice of the hardware is normally guided by the application of interest.

SOFTWARE: There are many GIS software that could be used to perform the GIS operations in a particular application. A GIS software is a collection of four interrelated software subsystems namely: (a) Data collection and input software, (b) Data storage and retrieval software, (c) Data manipulated and analysis software (for topologic overlay, buffer generation, adhoc query and modelling e.t.c), and (d)Visualisation and presentation software

The softwares are of many types. GIS Software Choices includes the following; ESRI (Environmental Systems Research Institute), ARC/INFO, Arc View, Arc GIS, Intergraph, Erdas, GRASS, MapInfo, CAMRIS, IDRISI etc.

GIS, RS AND DISEASE MAPPING

Geographic Information System/Remote Sensing (GIS/RS) in the study of Parasitic Diseases

The advent of Geographic Information Technology, particularly Geographical Information System, provides common ground for dialogue between Zoologists, Veterinarians, Medical Public Health Workers, Agriculturists, Geologists, Botanists, Engineers (Clarker, 1995; Brooker, 2007; Ekpo, 2008, Oladejo et al, 2011 and Oladejo et al,2013). At present,Geographic information system/Remote sensing (GIS/RS) is gradually becoming popularly applied in many researches including epidemiology, and has been an indispensably available instrument of environmental resource management and programming (Brooker et al., 2001; 2002a; 2002b; Ekpo, 2008; Simoonga et al, 2008).

Remote sensing is the science (and to some extent, art) of acquiring information about the earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information (Fabiyi 2001; Salami.2006a; Mengistu and Salami, 2007). Within the scope of this study, the focus of remote sensing is the measurement of emitted or reflected electromagnetic radiation, or spectral characteristics, from a target object by a multispectral satellite sensor. A multispectral sensor is characterized as a passive sensor. Passive sensors record energy that is naturally reflected or emitted from a target. In contrast, active sensors supply their own source of energy, directing it at the target in order to measure the returned energy (Brandon and Bottomley, 1998). This technology is based on the fact that every object or phenomenon reflects and emits energy at specific and distinctive wavelengths of the electromagnetic spectrum (Chima, 2002). Scientists have been able to study both biotic and abiotic components of the earth using remotely sensed data. Changes in these components have been mapped from space at many temporal and spatial scales since 1972 (Beck et al., 2000). In most contemporary land use studies which employ remote sensing imagery from multispectral sensors, the foremost task is the observation of spectral characteristics of measured electromagnetic radiation from a target or landscape. Analysts develop signatures based upon the detected energy's measurement and position in the electromagnetic spectrum. The various uses into which satllite images could be put into in the sustainable environmental management are highlighted below (Table 1).

A geographic Information System (GIS) is an information system for capturing, storing, analyzing, managing and presenting data which are spatially referenced (linked to location) (Bergauist, 2000, Buroffice, 2006). It integrates maps, charts, tables, and data into a coherent system that is related logically, quantitatively and spatially. Typically, GIS systems are employed to organize and present information that has both geometric structures (e.g., maps, blueprints, photographs as well as quntitative structures (e.g., population, area and density) (Berguist, 2000). GIS applications are tools that allow users to create interactive queries (user created searches), analyze spatial information, edit data, maps, and present the results of all these operations(Brooker and Hay, 2002; 2002a; 2002b; Scott, 2003 Ekpo, 2008; Simoonga et al, 2009). Geographic Information System Technology can be used for scientific investigations, resource management, asset management, environmental impact assessment, urban planning, cartography, criminology, geographic history, marketing, and logistics to name a few. GIS might be used to find wetlands that need protection from pollution, or GIS can be used by a company to site a new business location to take advantage of a previously underserved market (Brooker et al., 2001; Brooker and Hay, 2002; Scott, 2003 Ekpo, 2008; Simoonga et al, 2009).

Table 1: Satellites Imageries and the Environmental Variables Associated with them

Mission	Sensor	Swath (km)	Applications
Orbview-3	Orbview-3	8	Urban and sub-urban areas, refugee camps, land planning and infrastructure.
Ikonos	Ikonos	11	Urban and sub-urban areas, refugee camps, land planning and infrastructure.
SPOT 5a&5b	HRG	60	Land coverage and land-use classification maps, vegetation and water bodies.
Landsat-7	ETM+	185	Land coverage and land-use classification maps, vegetation and water bodies
Landsat-5	TM	185	Land coverage and land-use classification maps, vegetation and water bodies
Spot-5a	Vegetation	2200	Vegetation and water bodies
NOAA-M	AVHRR	3000	Vegetation monitoring, LST, water bodies
Meteostat-2 generation	SEVIRI	Hemisphere	Rainfall estimation, LST
Radarsat-1	SAR	45-500	Forest, water bodies

Source: Ceccato et al. (2005).

The abundant data and the technology of Remote Sensing, image processing and analyzing provide the information useful for detecting the status and inversing the flux of the earth's surface, and investigating the multiformity and variational rule of geographical factors, such as the vegetation, soil, physiognomy (WHO, 1999; Hay; 2004; Salami, 2006b; Adediji and Ajibade, 2008), and Land Cover/Land Use. GIS/RS provide the important pledge of gaining surface characteristic parameters (emphasis particularly on humidity and temperature of soil, vegetable coverage, etc) of schistosomiasis endemic areas, fitting these parameters with snail density, and establishing the exact and credible forecast model of schistosomiasis, (Hay, 2000 and Ekpo et al, 2008).

The epidemiology of schistosomiasis is rapidly changing and new apprioaches are required to promote its prevention and control towards sustainable environmental management (Hay, 2000 and Zhou, 2001). Risk mapping studies and predictions of schistosomiasis transmission was carried out by Brooker et al. (2000) in Tanzania and in Sub-Saharan Africa (Brooker et al., 2001). Zhou., et al (2001) assessed the spatio-temporal distribution and abundance of Schistosoma japonicum, he ascertained the efficiency of GIS/RS for future control programme in three Gorges dam project in China. Ta Tong et al (2002) in Philippines used the combination of the Landsat MSS data with the climate data of temperature, rainfall and to forcast the endemic areas for schistosomiasis. Brooker et al.,(2007) and Simooga et al. (2008) emphazised the relevance of GIS/RS and the spatial analysis for epidemiology and ecology of schistosomiasis in Africa.

Raso et al., (2005) did the first application of Bayesian Geostatistics Risk Mapping in Africa. He concluded that GIS/RS is a good instrument for analysing the epidemiology of schistosomiasis. Ekpo et al, (2008) produced risk model map of urinary schistosomiasis in Ogun State as observed and predicted through logistic regression using GIS. Environmental parameters that affect disease epidemiology can be presented in a multi-layered fashion, or the data sets merged into probability maps of vector distribution that directly depict the risk of human infection using GIS/RS (Zhou et al. 2001; Eisele et al., 2003;Omumbo et al. 2005; Jia-Gang et al., 2005; Sabesan et al.,2006; Ekpo et al., 2008).

Risk maps are outcomes of transmission models in which environmental information has been merged with data from the fields of epidemiology and vector biology (Kitron, 2000). Bretas (1996) ascertained that mapping as an instrument aids visualization of differences, clustering, heterogeneity or homogeneity within data. Spatial patterns can be perceived and correlations visualized through the use of maps, also symbols and colours can communicate detail or the relative importance of certain features. Mapping of population densities to restructure parasite control is useful for planning integrated intervention targets in tropical diseases control. GIS/RS applications are used for the following as shown in figure 2;

Mapping of locations: GIS can be used to map locations with the use of GPS. GIS allows the creation of maps through automated mapping, data capture, and surveying analysis tools.e g Spatial autocorrelation using ordinary kriging interpolation method .(Figure 2, 11)

Mapping quantities: Quantities are mapped to find out the most and least, to find places that meet certain criteria and take action, or to see the relationships between places. This gives an additional level of information beyond simply mapping the locations of features. (Figure 3)

Mapping densities: While concentrations can be seen by simply mapping the locations of features, in areas with many features it may be difficult to see which areas have a higher concentration than others. A density map allows the measurement of the number of features using a uniform areal unit, such as acres or square miles, so that the distribution can be clearly seen. (Figure 4, 8, 9)

Finding distances: GIS can be used to find out what's occurring within a set distance of a feature. (Figure 5, 10)

Mapping and monitoring change: GIS can be used to map the change in an area to anticipate future occurences thus enhancing sustainable descision making meeting future conditions, decide on a course of action, or to evaluate the results of an action or policy. (Figure 6, 7, 12a, 12b, 13).

Figure 2: The predicted P. falciparum prevalence in East Africa (an example of a risk map). Green areas: high risk; blue areas: malaria near water; yellow areas: malaria-free. **(Source: Omumbo et al. (2005)).**

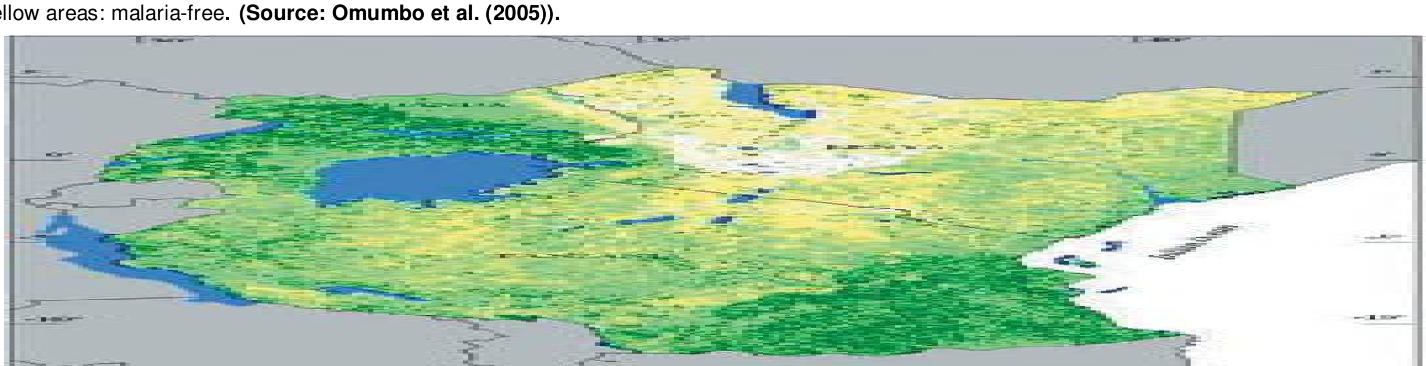


Figure 3: The predicted urban forced prediction with ecological zone stratification. Legend: white ¼ 0–<5%, yellow ¼ 5–<25%, light green ¼ 25–<75%, dark green ¼ ‡75% parasite ratio. Blue areas are water bodies. **(Source: Omumbo et al. (2005))**

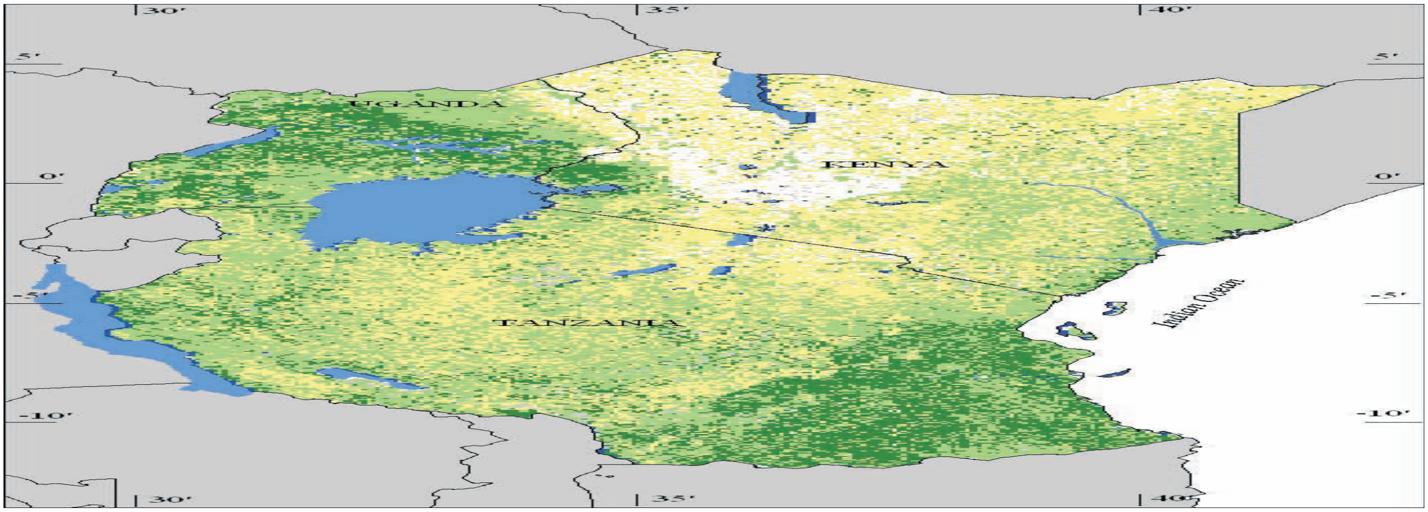


Figure 4: The villages with high prevalence of Schistosoma japonicum in the Poyang Lake area Dark blue: suspected snail habitats; pink: buffer zone within 1200m; Red points: villages. **(Source: Jia-Gang et al., (2005)).**

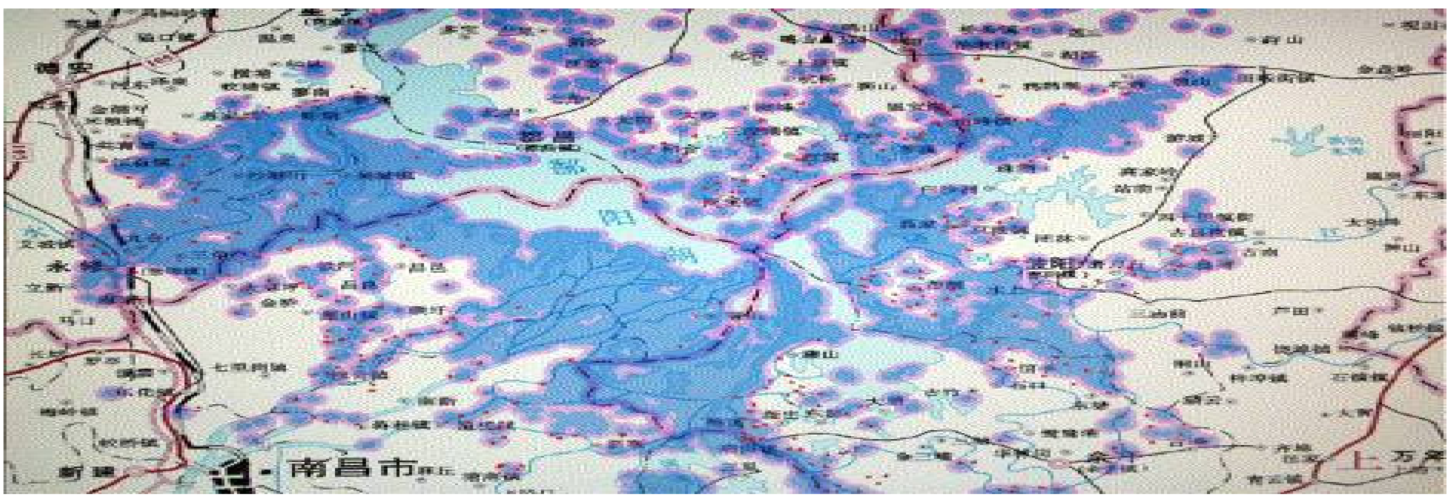


Figure 5: The range of different environmental variables associated with the transmission of filariasis in Tamil Nadu, India. The model was found to be 100% sensitive and 67.3% specific. **(Source: Sabesan et al., (2006))**

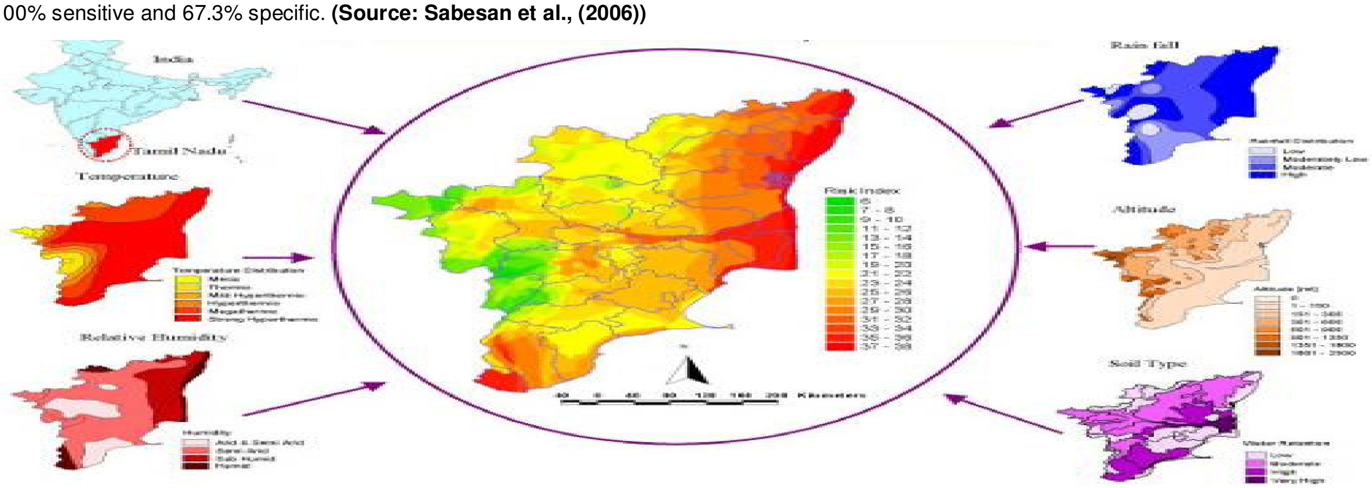


Figure 6: Climate-based forecast of schistosomiasis risk for Jiangsu province using 30-year-average monthly data from 18 climate stations. The forecast was based on the growing degree day concept, water budget analysis and reported development requirements of S. japonicum in O. hupensis. Index value contours 900 indicate suitable areas for transmission. **(Source: Zhou et al. (2001))**

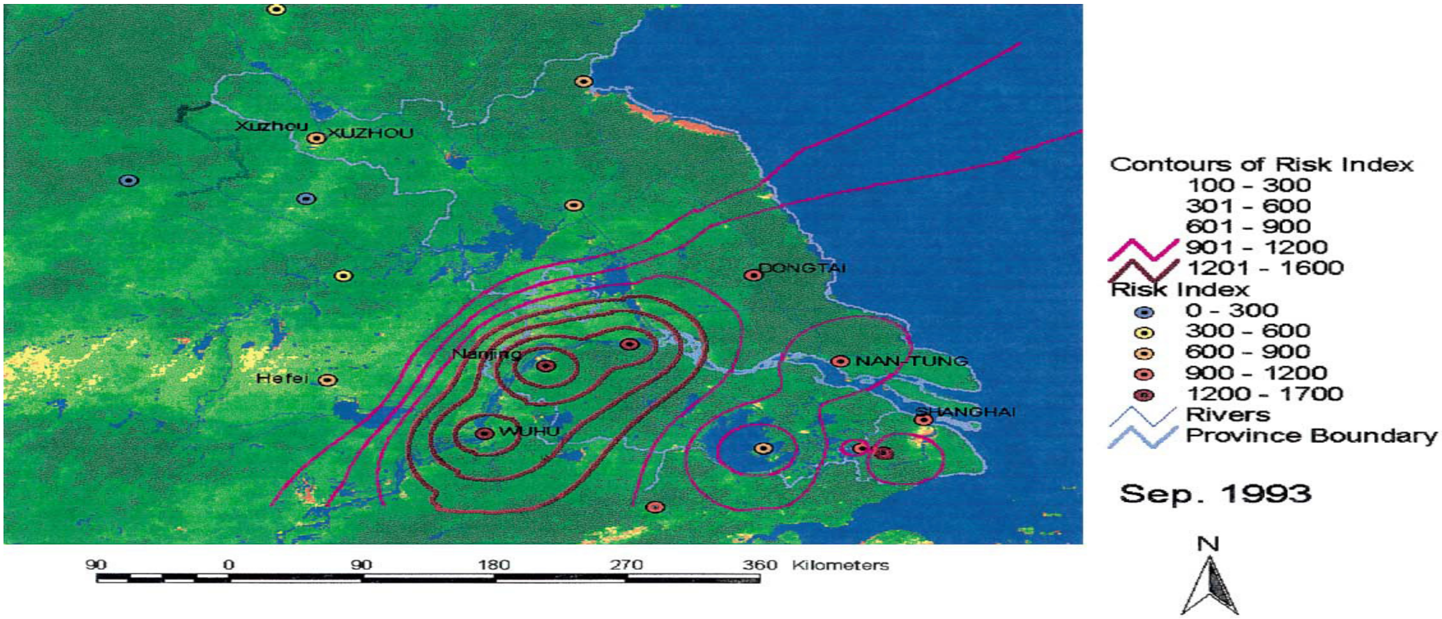


Figure 7: Risk model map of spatial distribution of urinary schistosomiasis in Ogun State as observed and predicted through logistic regression **(Source: Ekpo et al., (2008))**

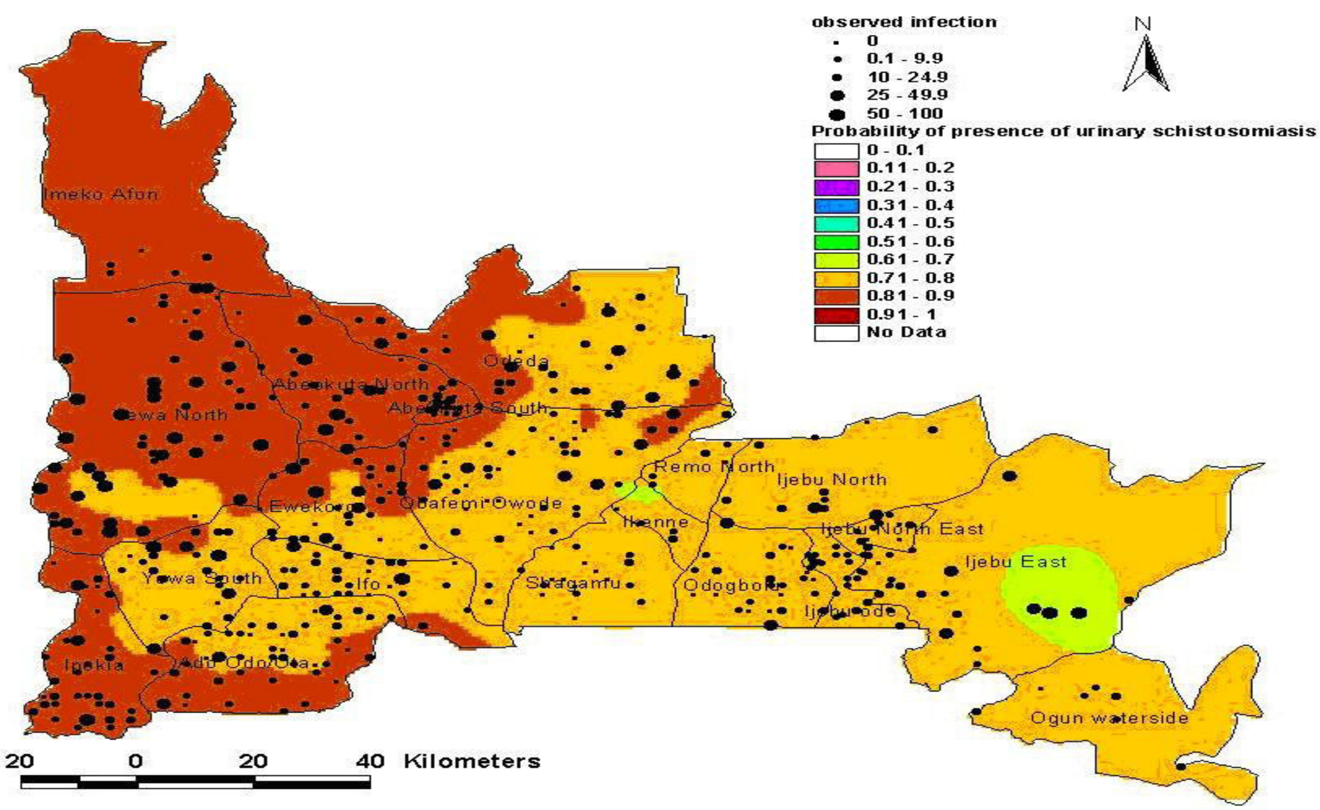


Figure 8: Land cover map of the Xichang area based on IKONOS and DEM data **(Source: Xu, et al., (2006))**

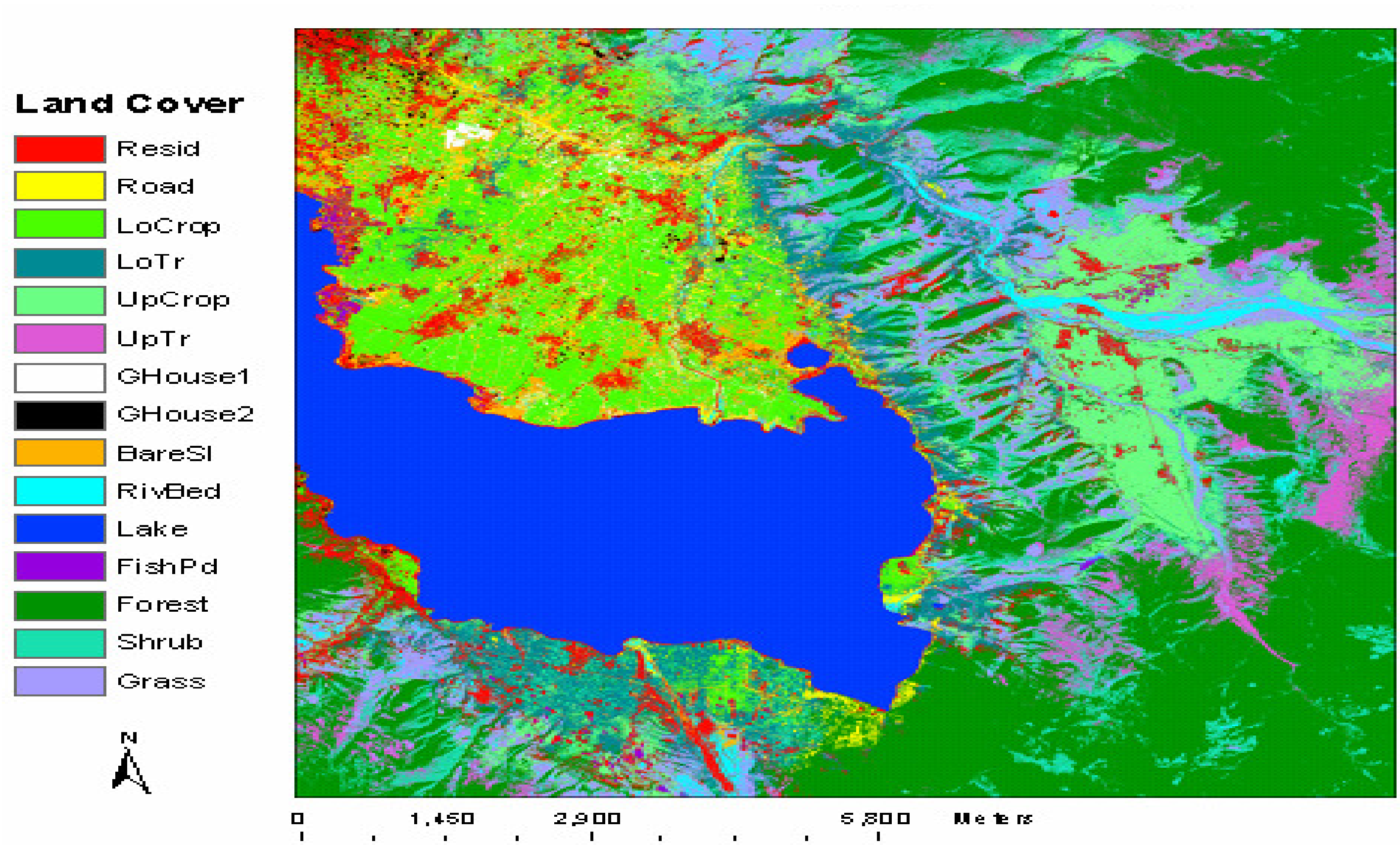


Figure 9: Snail density map of the study area estimated with land cover fraction data **(Source: Xu, et al., (2006))**

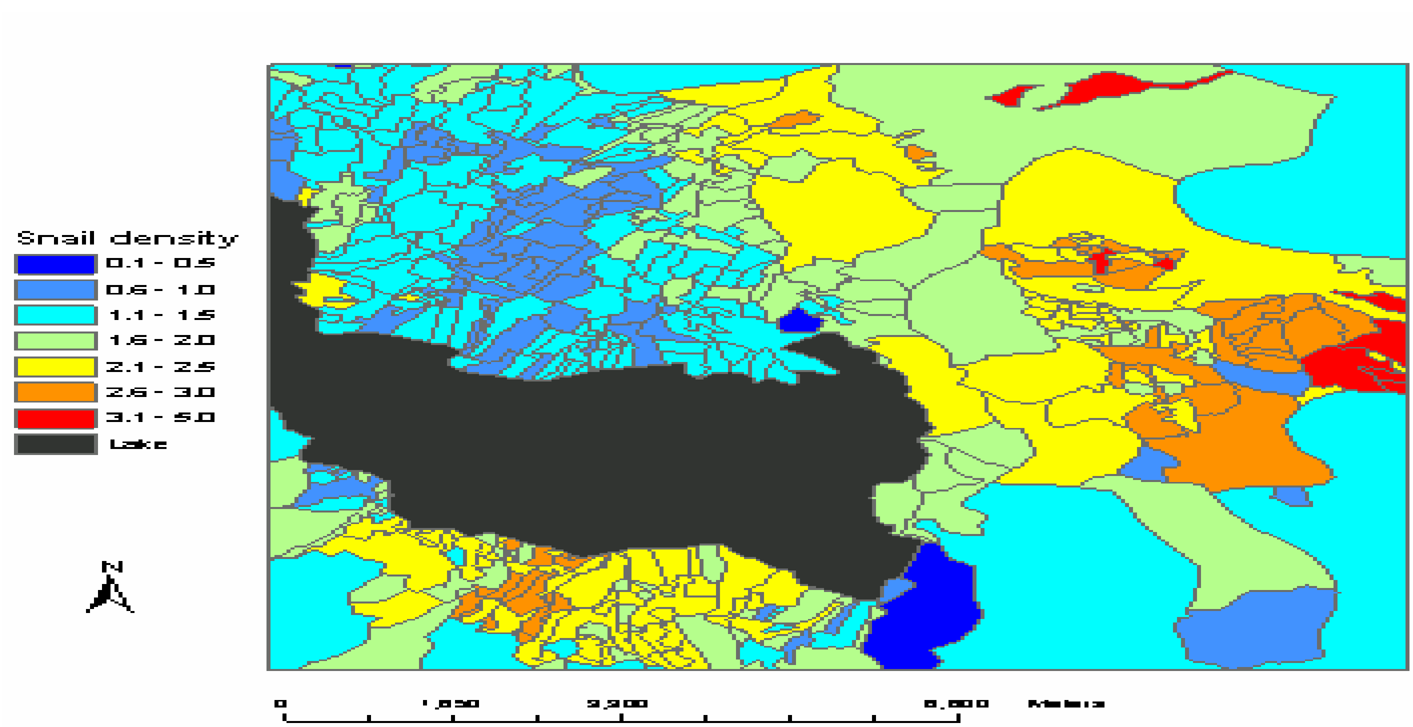


Figure 10: Images were taken with a digital camera at points within Kisumu and Malindi during field-based data collection. Latitude and longitude were also recorded at these points using GPS. Six of these images, coupled with their respective GPS coordinates, were used to assist with the interpretation of NDVI values at five meter resolution within selected grid cells. **(Source: Eisele et a.l, (2003))**

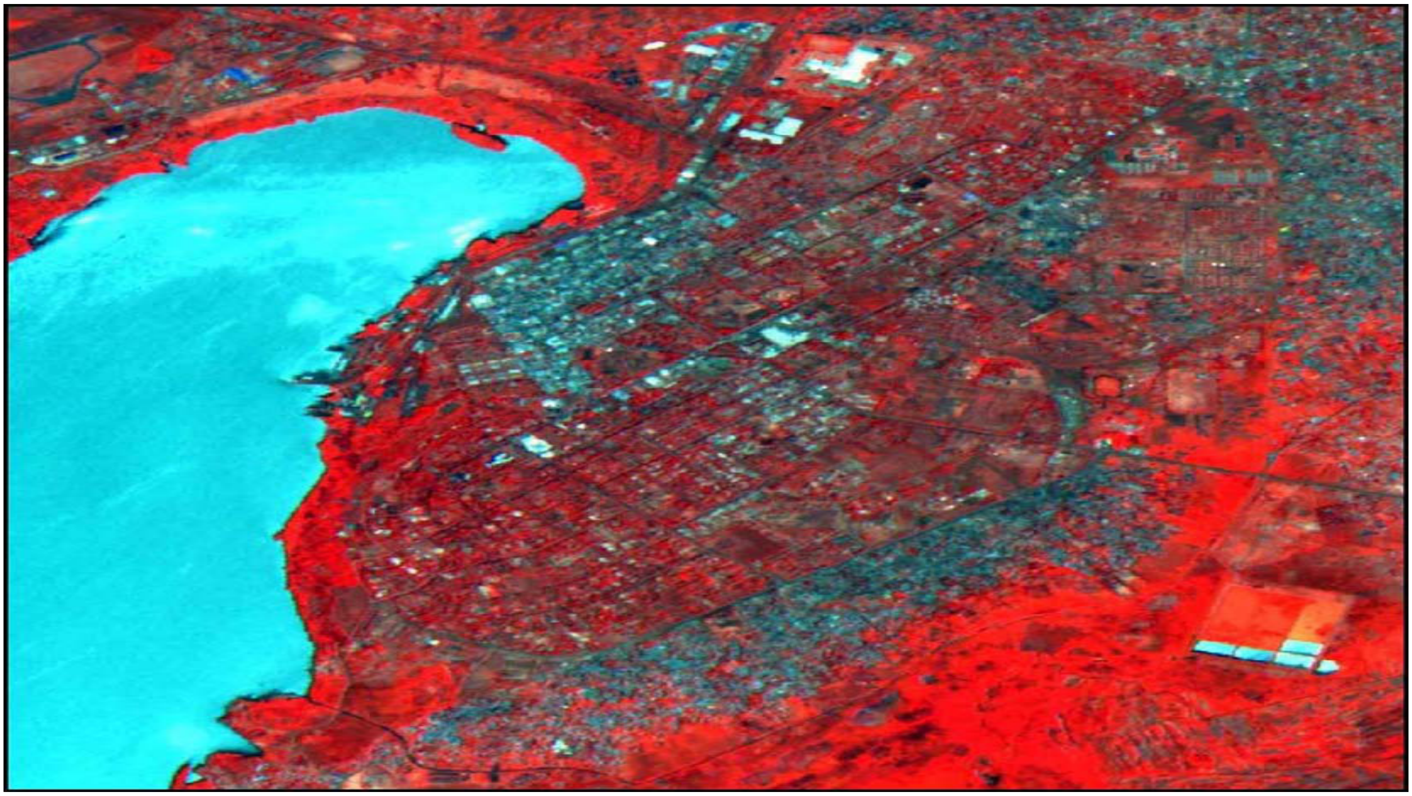


Figure 11: Infrared colour composite derived from the MTI data for the area of Kisumu, Kenya. **(Source: Eisele et al., (2003))**

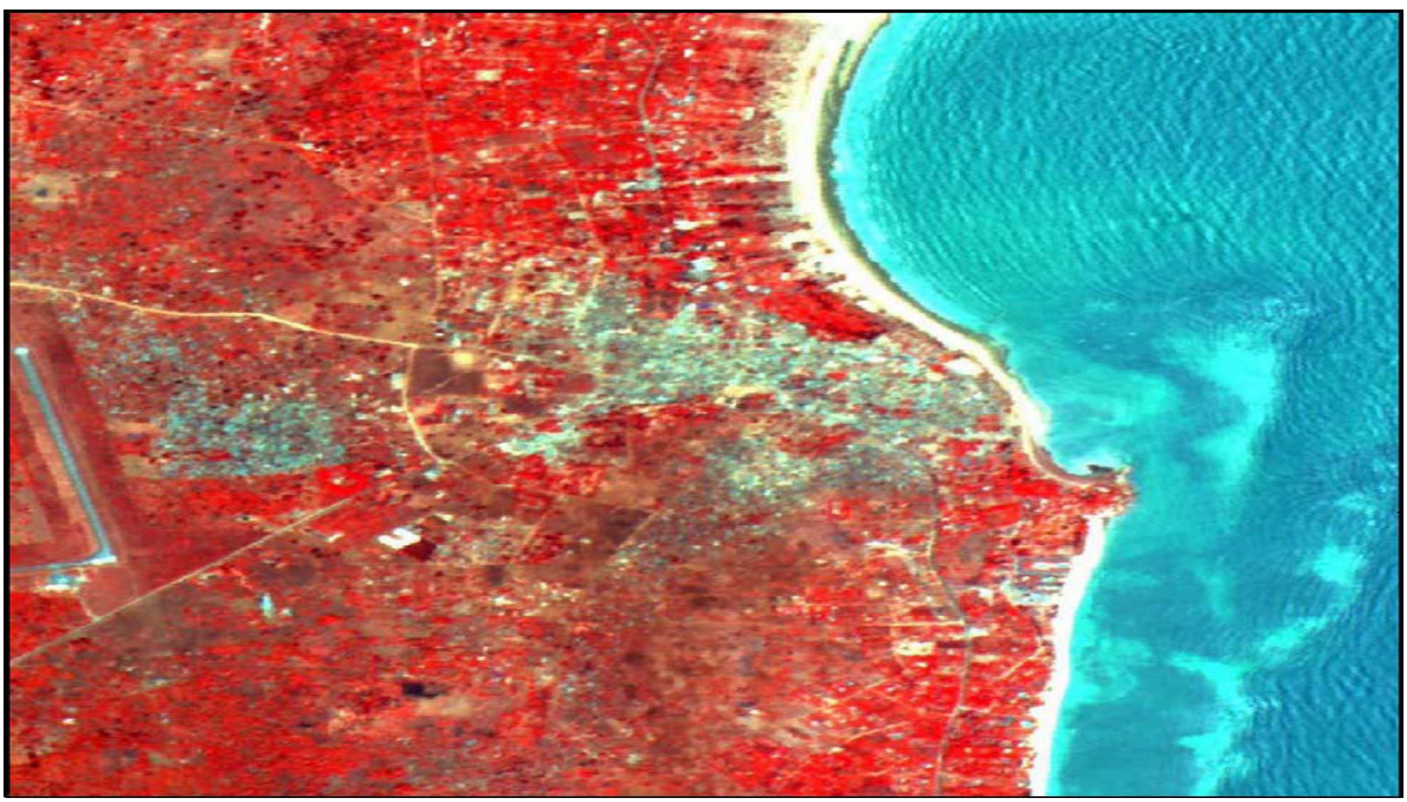


Figure 12a: Land Use/ Land Cover Map of the Communities bordering Erile/Owala Reservior based on LandsatTM 1991. **(Source: Oladejo et al., (2013))**

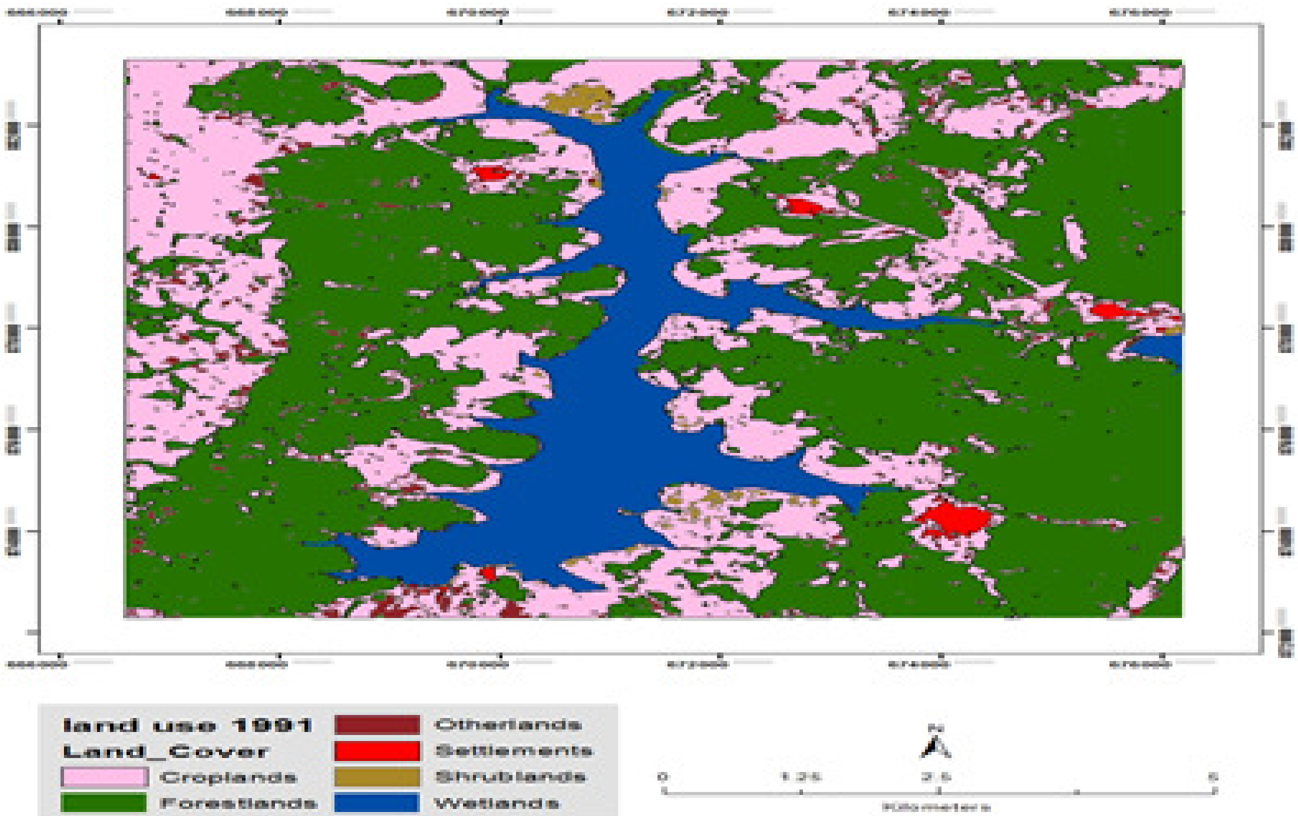
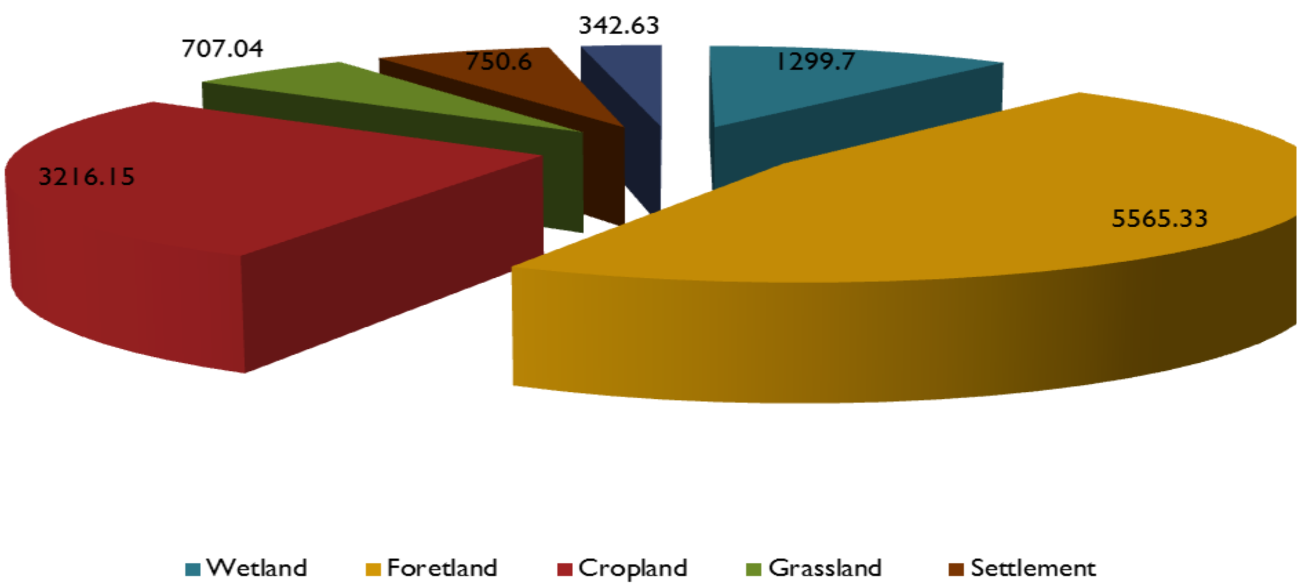
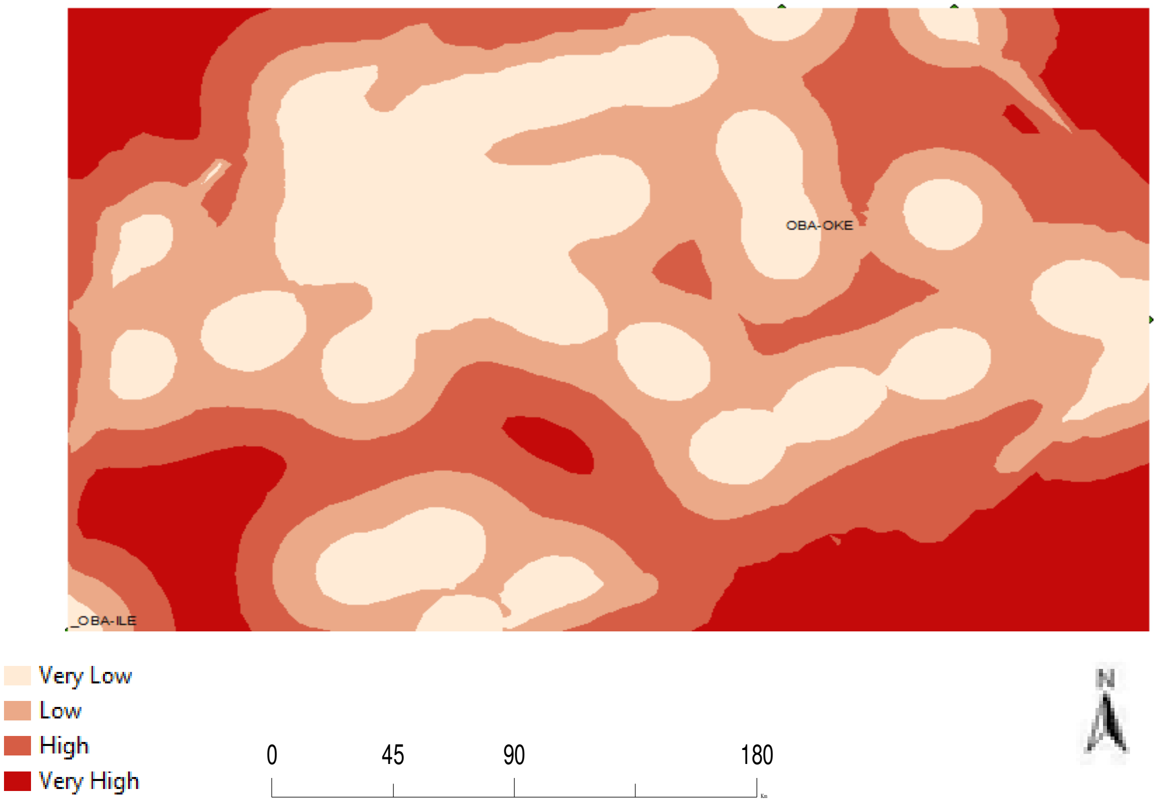


Figure 12b: Land Use/ Land Cover Map of the Communities bordering Erile/Owala Reservior based on LandsatTM 1991, **(Source: Oladejo et al., (2013))**



Rem

Figure 13: Prediction Map of the Prevalence and Human Water Contact Patterns of Urinary Schistosomiasis in Oba-Ile and Oba-Oke, Osun State, Nigeria (Standard Error Map). **(Source: Oladejo et al., (2013))**



CONCLUSION

The review therefore provides the curent information about the use of GIS as a means for evaluating monitoring and planning sustainable conrol of tropical diseases.

REFERENCES

Adeoye,NO.(2007) Deforestation and Land Use Dynamics In Ijesa-Ekiti Region Of Southwestern Nigeria.Ph.D Thesis,University of Ibadan.pp30-49.

Akinbami, FFK., Salami, AT. and Siyanbola, WO. (2003). “An Integrated strategy for Sustainable forest-energy –environment interactions in Nigeria” Journal of Environmental Management, 69 (2): 115-128.

Akinyede JO. (2003). Nigeria and its Space Mission International, 17 (2): 13-15.

Akinyede JO. (2004) Geoinformation Acquisition for National Development: The Role of Nigeria Sat- 1. NASRDA News, 1 (1): 6-21.

Ayeni, B (1998), Training Manual, Workshop on Geographic Information Systems and Environmental Monitoring. The Federal Environemntal Protection Agency, Abuja Nigeria.

Balogun O.(2003).Senior Secondary Atlas (Second Edition).Lagos Longman Nigeria Plc.

Beck, LR; Lobitz, BM. and Wood, BL (2002) Remote Sensing and Human Health: Neio sensors and New Opportunities.

Boroffice,RA. (2006). Press Conference Address at International Stakeholders`Workshop on Geo-Information System-Based forest monitoring in Nigeria (GEOFORMIN), March 27-30,2006 at NUC Auditorium, Maitama,Abuja.

Bretas, G. (1996). Geographic Information Systems for the study and control of malaria. GIS for health and the Environment: Study and Control of malaria. http://www.idrc.ca/books/focus/766/bretas.html.

Ceccato, P; Connor, SJ; Jeanne, J; Thomson, MC. (2005). Application of Geographical Information Systems and Remote Sensing technologies for assessing and monitoring malaria risk. Parassitologia 47:81-96.

Chima, MA. (2002). Urban Defection From remotely Sensed Data of Ikeja Area, Lagos. M. Sc Thesis Obafemi Awolowo University Ile-Ife.

Daash, A. Srivastava, A. Nagpal, B.N. Saxena, R. & Gupta, S. K.(2009) Geographical information system (GIS) in decision support to control malaria-a case study of Koraput district in Orissa, India. Journal of Vector Borne Diseases.Volume 46 Number1 (2009).

Davis, GM., T. Wilke, Y. Zhang, XI., Xu., GP. Qiu. C. Spolskyk,

DC. Qiu, YS Li, MY. Xia, and Z. Feng, (1999) Snail Schistosoma paragonimus intereactions in China: Population ecology, genetic diversity, coevolution and emerging diseases, malacolgia 41 (2): 355-377.

deMers, MN. (1997) Fundamentals of Geographic Information Systems. John Wiley and Sons.

Dongus,S;Nyika,D;Kanady, K; Mtasiwam,D;Mshinda, H;Fillinger,U; Drecher, A.W; Tanner,M;Castro,M. Cand Killeen, G. F. (2007) .Participatory mapping of target areas to enable operatiohal larval source management to suppress malaria vector mosquitoes in Dar es Salam, Tanzania,International Journal of Health Geographics 6;27.

Dozie, INS, Onwuliri, COE. and Nwoke, BEB. (2004). Onchocerciasis in Imo State Nigeria. Community Knowledge and Beliefs about transmission, treatment and prevention. Public Health. 118:128-130.

Dozie, INS., Chukuwocha, UM., Nwoke, BEB, Anosike, JC, Ukaga, C., Obiukwu, CU., Onwuliri, COE, Chikwendu, CI., NWanguma, BC., Njemanze, PC. and Okoro, JC. (2007). Satellite Technology and the control of parasitic diseases in Africa: An Overview. Nigerian Journal of Parasitology 28(1) pp 47-53.
Eastman JR.(2001).IDRISI Guide to GIS and Image Processing Vol.1, Worcester M.A.,USA,Clark Labs,Clark University.p. 17-34.
Eckert, ST. Kellenberger, and K. Iten. Accuracy assessment of automatically derived digital elavation models from ASTER data in remote, mountainous terrain, International Journal of Remote Sensing in press.
Erharuyi,N.(2000) Geographic Information System 9(GIS):GIS Fundamentals" A paper presented at the 1ST Regional Workshop On Remote Sensing Applications , April 10-14,2000.
Fabiyi, S. (2001) Geographic Information Systems Techniques and Methods. Research Support Services Ibadan, Nigeria. Vol.1.
Flazell, JC. and Magrath U. (1992). A Supervised Thematic Mapper Classification with a Purification of Training Samples. International: Journal of Remote Sensing. 13 (11): 2039-2049.
Hay, SI., (2000). An overview of remote sensing for epidemiology and public health application. Advances in parasitology, 47:1-35.
Hay, SI., Myers, MF., Maynard, MN., and Rogers D. (2002). Remote Sensing to relevant Sensing in Human Health. Journal Photogrametric and Remote Sensing 109-120.
NASRDA (2004), Nigeriasat -1: A Solution to sustainable National Development Challenges, NASRDA News, 1 (3): 8-12.
Nayak, S. and Bakuguna, A. (2001), "Application of remote sensing data to monitor mangroves and other coastal vegetation of India", India Journal of Marine Sciences, 80 (9): 1208-1213.
Oladejo SO;Morenikeji OA and Salami AT(2011). Application of Geographic Information System(GIS) in the assessment of human water contact patterns in relation to schistosomiasis infection in five rural communities in Osun State,Southwest Nigeria. NISEB Journal Vol.II,N 2 ; 129-134.
Oladejo SO, Morenikeji OA and Salami AT. 2013). Spatial Pattern of Human Water Contact Activities and Schistosoma haematobium in Owalla/Erinle Reservoir, South-West, Nigeria" In Proc. Tropentag 2013, Conference on congress Iowa, crop science society of America, Inc., International Research on Food Security, Natural Wisnconsin U.S.A., pp: 773-778. Resource Management and Rural Development
Oladejo, S.O. (20013). Fundamental of Ecology, ISBN 978-38436-5-6, Katolad Publisher 13 Itedo- Oluwas Street, Ogo-Oluwa, Osogbo, Osun State, Nigeria
Rogers, DJ. and S.E. Randolph (1991). Mortality rates and population density of tsetse flies correlated with satellite imagery, Nature, 351:739-741.
Rogers, DJ., SI., Hay, MJ. Packer, and GRW. Wint, (1997). Mapping land –cover over large areas using multi-spectral data derived from the NOAA-AVHRR: A case study of Nigeria, International Journal of Remote Sensing, 18 (15): 3297-3303.
Rutto, JJ. and Karuga JW.(2009) Temporal and spatial epidemiology of sleeping sickness and use of geographical information system (GIS) in Kenya. Journal of Vector Borne Diseases. Volume 46 Number 1 (2009).
Sabesan, S. Raju, HK., Srividya, A. and Das, PK. (2006). Delimitation of lymphatic filariasis transmission risk areas: a geo-environmental approach. Filaria Journal 5: 12.
Salami, AT. (2006) "A Potientials of Nigeriasat-1 for Sustainable Forest Monitoring in Africa: A case Study from Nigeria", A paper presented at DFG Research Group 510 on 'Ecological and cultural change in West and Central Africa,' Goethe Institute Yaounde, Cameroon. March 5-7, 2006.
Salami, AT. (2006). Imperatives of Spaces Technology for Sustainable Forest Management In Nigeria Proceedings of An International Stakeholders' Workshop Sponsor by National Space Research and Development Agency, Abuja.
Sood C. And Bhagat RM.(2005) Interfacing geographical information system and pesticides models.Current Science,Vol 89,No.8,25.
Tambulini,G (2002) Children health and environmemt.A review of evidence.A joint report from the European Environment Agency and WHO Regional Office for Europe,Copenhagen European Environment Agency (2002) environment Issues Report,29,4447.
Tayo, MA. and Jewsbury JM. (1978).Malumfashi edemic diseases research project IV: Changes in snail population following the
Thomas,PE,Keating J. Swalm C. Charles MM. Andrew KG. James KR. John IG. Linda A. Communication diseases surveillance and Response. Protection of the Human Environment. Roll Back malaria. Geneva. WHO/SDE/OEH/0401.
World Health Organization. (2002). Tropical diseases fact sheet. WHO, Geneva.
Yang, G; Vounatsou, P; Xiao-Nong, Z., Utzinger, J; Tanner, M. (2005). A review of geographic information system and remote sensing with applications to the epidemiology and control of Schistosomiasis in China. Acta Tropica 96, 2-3: 117-129.
Zhi-Ying, Z., De-Zhong, X, Xiao-Nong, Z., Yun, Z abd Shi-Jun, L. (2005) Remote sensing and spatial statistical analysis to predict the distribution of Oncomelaria hupensis in the marshlands of China. Acta trpoica 96 (2-3) pp 205-212.