Published: March 2016

Application of geo-spatial technology in schistosomiasis modelling in Africa

Tawanda Manyangadze - PhD Student in the School of Nursing and Public Health Medicine at UKZN.
Moses John Chimbari - Professor and College Dean of Research at College of Health Sciences, UKZN.
Michael Gebreslasie - Geographer based at UKZN.
Samson Mukaratirwa - Professor in Parasitology and Dean and Head of School of Life Sciences at the UKZN.

Schistosomiasis also known as bilharzia is a parasitic disease caused by *Schistosoma haematobium* and *Schistosoma mansoni.* This disease mainly affects under-resourced communities, especially in rural areas and is often not prioritized in national budgets in sub-Saharan African countries (1). Despite the efforts to control schistosomiasis in sub-Saharan Africa, 90% of the global, total number of individuals infected with schistosomes still lives in Africa (2). The spatial and temporal distribution of schistosomiasis is mainly determined by the distribution of the intermediate host freshwater snail species. This is well-known, but the distribution is difficult to predict. The development of geospatial technology including GIS and remote sensing or earth observation (EO) has facilitated the progress made in predicting or modelling schistosomiasis in Africa. GIS and Remote sensing/EO are defined as follows:

- GIS involves efficiently capturing, storing, updating, manipulating, analysing, and displaying spatial information (3) including remote sensing data.
- Remote sensing or EO refers to the acquisition of information of an object or phenomenon from a distance using a real-time sensing device which is, for example, mounted on an aircraft or a satellite (4).

In this article we outline the developments in geo-spatial technology focussing on progress and challenges encountered as well as the way forward in the application of geo-spatial technology in mapping and/or modelling schistosomiasis in Africa.

Progress and challenges in geo-spatial technology application in schistosomiasis modelling in Africa

The past 30 years have seen developments in GIS and EO models to predict the distribution of schistosome infections in Africa. Geo-spatial technology has also provided invaluable tools to better understand the determinants. The annual number of publications on remote sensing and GIS with application to schistosomiasis in Africa generally increased over the years as shown in Figure 1. This indicates the increased appreciation and usefulness of geospatial technology in schistosomiasis control and management through mapping, modelling or prediction. Spatial technologies have been useful in understanding the spatial distribution of parasites and intermediate hosts snails depicted in maps showing the interplay with spatial and temporal features of the environment as well as the distribution of human schistosome infections. The use of GIS and EO in the predictive models has contributed to improved control programmes at different spatial scales mainly in East Africa through showing the distribution of the disease and identifying vulnerable populations for mass drug administration (MDA). This made it possible to allocate the limited resources available in a more cost-effective way.

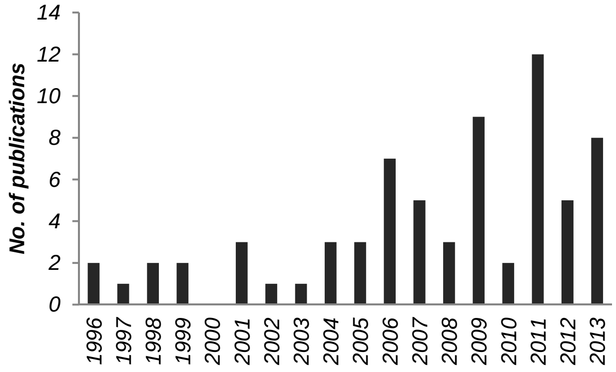

Figure 1. Number of publications reporting on remote sensing and GIS applied to schistosomiasis in Africa 1996 to 2013 [updated from (4])

Although EO has been providing data such as rainfall, temperature and vegetation for developing schistosomiasis distribution models, there are still challenges inhibiting the full adoption and application of GIS and remote sensing technology in schistosomiasis control programmes. The major challenge has been resistance to the uptake of EO technology, especially in the early stages, mainly due to the costs involved in the acquisition and processing of EO data and the equipment. This has also been worsened by limited capacity in terms of skills to process and use EO data, especially in Africa. In this regard, the prediction models in Africa have been weakened by many factors, including:

- Statistical uncertainty in variable selection criteria and methods used in the models. This has impacted on the applicability and transferability of these models to other areas.
- Low spatial resolution, as the high resolution data have been expensive. Therefore the models have been at national and regional levels, and not at e.g. village level, and hence lack relevance to local communities.
- The models have not utilized the temporal domain of EO to model the temporal or seasonal aspect of schistosomiasis considering the distribution of the intermediate host snail species.
- Lack of vigorous validation due to lack of baseline data, hence some of the models have remained theoretical and lack practical application in control programmes.

Future research priorities

Despite the above mentioned challenges or weaknesses, geo-spatial technologies are promising in order to be able to rapidly and accurately identify and map high-risk communities in a cost-effective manner. Although schistosomiasis treatment with praziquantel might be affordable, resources are limited in Africa necessitating the use of spatial models to identify exposed and vulnerable communities. These models require disease data, climatic, environmental and socio-economic factors, therefore we propose the theoretical framework below for schistosomiasis predictive modelling (Figure 2).

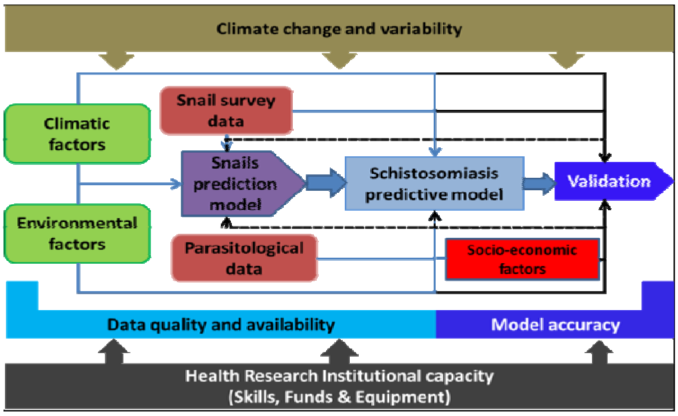

Figure 2: Theoretical framework for schistosomiasis modelling

The framework considers four phases: 1) data collection (climatic, environmental and socio-economic factors, snail survey and human parasitological data); 2) snail prediction modelling; 3) schistosomiasis predictive modelling; and 4) validation of the models which are based on data quality and availability as well as the need for model accuracy. The climatic and environmental factors mainly determine the spatial and temporal distribution of the intermediate host snail species, hence they are inputs in the snail prediction models, which are also proxies for the distribution of schistosome infections in human populations. In addition to human parasitological data and socio-economic factors, the snail prediction model outputs can also be inputs in the schistosomiasis infection distribution models. Socio-economic factors including religion, availability of toilets at home, toilet use, places of bath and laundry, access to improved water supply and sanitation may determine the spatial distribution of schistosomiasis infections especially at local scale. The whole modelling system is sustained by health research institutional capacity including: skills, funds and equipment to generate high quality data to achieve desirable model accuracy.

Although remote sensing has proved to be a reliable source of climatic and environmental data, there is need to consider satellites with high spatial resolution such as SPOT-6 as opposed to low spatial resolution imagery of 1km and 8km for MODIS and AVHRR respectively. The EO technology could offer higher spatial and spectral data, more frequent coverage at a lower cost (5). However, specialized skills and expertise are a pre-requisite to realize the full potential of these developments.

There is need to develop skills and more and better methods through further research and refinement of schistosomiasis predictive models to meet the needs of the communities. There is need for investing more time and resources in the development, application and use of the spatial technology in epidemiology in general. This may be achieved through an interdisciplinary approach in which epidemiologists collaborate with geographers and software programmers and promote the use of high-quality EO and field measured data. This may allow detailed research and refinements of the modelling techniques and also processing of remote sensing data to improve accuracy and efficiency of these models. Furthermore, there is need for studies to focus on local scale for the model outputs to be useful in control and management of schistosomiasis at community level. However, climate change may keep on suppressing the system (Figure 2) giving much pressure on the status quo as the whole system may change requiring further research into these changes and interactions between all the factors highlighted. Moreover, field and laboratory studies are still required to generate high quality data, including climatic and environmental factors, for calibration of EO data and validation of the predictive models. This may help to realize the usefulness of these models in community health and climate change decision making processes especially at local levels in Africa.

Tawanda Manyangadze *- PhD Student in the School of Nursing and Public Health Medicine at University of KwaZulu-Natal. Areas of interest: Application of GIS and remote sensing in modelling the spatial and temporal distribution of diseases and the effects of climate change.* manyangadze.tawanda@gmail.com

Moses John Chimbari *- Professor and College Dean of Research at College of Health Sciences, University of KwaZulu-Natal. His research focus is on vector-borne diseases, in particular schistosomiasis and malaria. Much of his research applies Ecohealth principles that address health in the context of socio-ecological dimensions and climate change effects.* chimbari@ukzn.ac.za

Michael Gebreslasie *- Geographer based at University of KwaZulu-Natal, with emphasis in Geospatial methods pursue a multidisciplinary research agenda that focus on the spatio-temporal Remote Sensing for environmental change detection and monitoring, forestry (vegetation) inventory and assessment using Remote Sensing, and Spatial epidemiology including modelling the spatio-temporal patterns of environmental disease transmission and forecasting.* gebreslasie@ukzn.ac.za

Samson Mukaratirwa *- Professor in Parasitology and Dean and Head of School of Life Sciences at the University of KwaZulu-Natal. Research interests: a variety of parasitic diseases of economic and public health importance and a passion on "Neglected Parasitic Zoonoses" affecting the resource-poor communities in Africa with special interest in the geospatial distribution and burden of vector-borne diseases and parasitic zoonoses.* mukaratirwa@ukzn.ac.za

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