APPLIED GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND REMOTE SENSING: PREDICTING THE CURRENT AND FUTURE DISTRIBUTION OF MALARIA HAZARD USING THE ECOLOGICAL NICHE MODELS

Farai Madzimure*

Abstract

The main objective of this study was to map the current as well as future distribution of malaria hazard areas in the SADC countries using the ecological niche models. To achieve this, the current malaria hazard areas were modelled using the ecological niche models. The ecological niche models were used to predict the current distribution of anopheles gambiae as a function of current records of mean annual temperature and precipitation. Secondly, the future distribution of malaria hazard areas was also modelled. This was achieved through predicting how the projected changes in temperature and rainfall will affect future environmental niche requirements for the anopheles gambiae. The climate data used was obtained from CSIRO Global Circulation Model. The climate change scenario used was the a2a (the worst case scenario) for the year 2080. Results indicated that malaria hazard areas are currently located closer to the Indian Ocean. As distance from the Indian Ocean increases, malaria hazard tend to be low. Countries such as Madagascar and Mozambique are currently at a greater risk in terms of malaria hazard as these areas have suitable environmental niches for the anopheles gambiae mosquito specie. The anopheles gambiae tend to shun high altitude areas and as well as arid areas like the Kalahari and the Namib Deserts. Results also indicated that by the year 2080, most Southern African countries will be prone to malaria hazard as the niche requirements for the anopheles gambiae increases from the countries closer to the Indian Ocean to inland areas. Malaria hazard will also encroach into high altitude areas. However, results presented here are not conclusive as the ecological niche model only uses vector biology without taking into cognicence other complex socio-

* **Lecturer: Zimbabwe Open University**

economic factors such as the health delivery systems. Future studies are therefore recommended to assess the adaptive capacity of these countries to malaria hazard by assessing their health delivery systems and other socio-economic factors.

Key words: ecological niche model, Climate Commonwealth Scientific and Industrial Research Organisation (CSIRO), Global Circulation Model (GCM) , Bio- climatic envelope, climate change, climate scenario

Introduction

Climate change is one of the hottest topics at the moment as it affects all aspects of human well being. Intergovernmental on Panel Climate Change (IPCC) projections indicate that global temperatures may rise by 1.4 - 5.8^{0}C by the year 2100 (Gwitira 2013). The changes in global climate are linked to the increased concentrations of the following gases which result from anthropogenic activities: carbon-dioxide, methane, nitrous oxide, hydro fluorocarbons, chlorofluorocarbons, aerosols and sulphur dioxide (Murwira 2013). Much is known about the effects of climate change on health. Inter-annual and inter-decadal variability in climate will have a direct influence on the epidemiology of vector borne diseases (Haines 2006). Temporal and spatial changes in temperature and precipitation will affect the ecology of vectors and the risk of disease transmission (Partz 2005). However, exploring the impacts of climate change on malaria using the ecological niche models and climate change scenarios within the SADC region remains largely unexplored. Understanding the effects of climate change on malaria hazard is critical for purposes of vulnerability assessment.

Study area

The study area constitutes the following countries: Zimbabwe, South Africa, Zambia, Angola, Lesotho, Namibia, Mozambique, Swaziland, Madagascar, Malawi and Botswana.

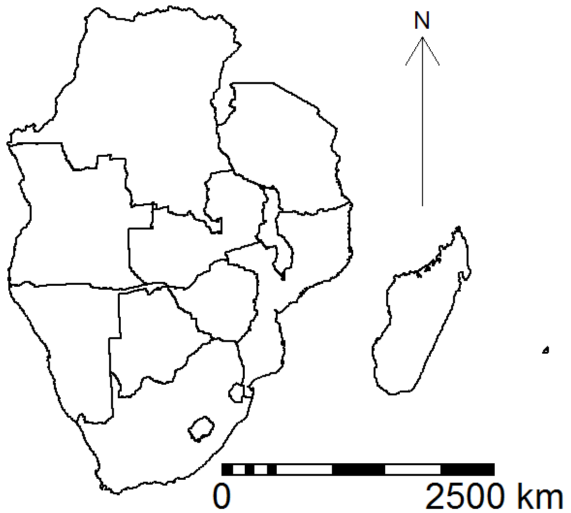


Figure 1: Location of study area

Modelling malaria hazard for Southern Africa

Method

Data collection

The study was based on ecological niche model projections over the CSIRO GCM and one climate change scenario or green house gas scenario which is the a2a or the worst case climate scenario. The projected climate change was for the year 2080. Anopheles gambiae occurrences were obtained from the Bio clime model which is an envelope style technique which shows the distribution of species in relation to environmental variables. The Bio climatic envelope style specifies the model in terms of percentiles. The SADC country boundary data used in this study are shape files in GIS format.

Predicting current distribution of malaria hazard

DIVA GIS software was used for data analysis. In the DIVA GIS, current rainfall and temperature data from the climate data base for all the active points in the shape file (which are the SADC countries) was extracted. The ecological niche concept was used to predict how the mosquito vector is currently distributed in relation to environmental niche such as rainfall and temperature.

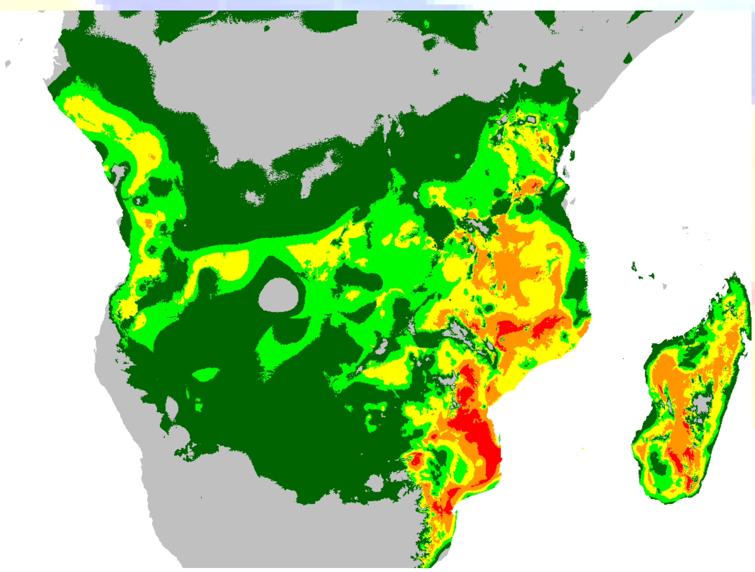
Predicting future distribution of malaria hazard

The ecological niche concept was used to predict how the geographical distribution of the anopheles gambiae may change under the CSIRO GCM 2080 a2a climate change scenario.

Results

Current malaria hazard prediction within the SADC Region

Figure 1 illustrates the distribution of malaria hazard under the current climatic conditions. It can be observed from figure 1 that the SADC countries lying closer to the Indian Ocean ranks high in terms of malaria hazard as they satisfy the environmental niche for the malaria vectors. These include Madagascar, Mozambique and Malawi. Most highlands are not even suitable for malaria vector survival under the current climatic conditions. Examples of such areas are the Lesotho since it is a mountainous country. The desert areas, Namib Desert, and Kalahari are not suitable for the malaria vector. Countries like South Africa have low malaria hazard.



Key

- Not suitable
- Low (0-2.5 percentiles)
- Medium (2.5-5percentiles)
- High (5-10 percentiles)
- Very high (10-20 percentiles)
- Excellent (20-36 percentiles)
- No data

Figure 2: Current distribution of malaria hazard in SADC countries.

Predicted future distribution of malaria hazard under the CSIRO GCM 2080 a2a climate change scenario.

Figure 2 illustrates that the projected changes in temperature and precipitation will have an impact on the distribution of the malaria in SADC countries. Most countries will have excellent niches for mosquitoes by the year 2080. The malaria vector will not thrive well in South Africa. Some parts of the Kalahari Desert and the Namib Desert will not be excellent in terms of malaria hazard.

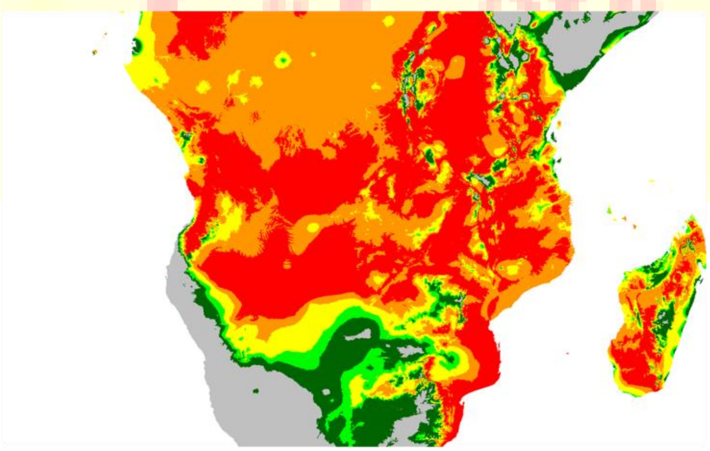


Figure 3: Projected future distribution of malaria hazard in SADC countries.

Key

Not suitable

Low (0-2.5 percentiles)

Medium (2.5-5 percentiles)

High (5-10 percentiles)

Very high (10-20 percentiles)

Excellent (20-36 percentiles)

No data

Discussion

Results of this study indicated that malaria hazard can be mapped using the ecological niche models. This study has also demonstrated that the ecological niche models can be used to predict the current and future distribution of the anopheles gambiae. This is not surprising as the survival of mosquito species largely depends on temperature and precipitation characteristics of an area. The results are quite consistent with (Lafferty 2009) who noted that continued warming will expose millions of people to the risks of diseases such as malaria. (Martens 1995) observed that the survival and geographic distribution of the malaria parasite and its vector are sensitive to climate changes, mainly temperature and rainfall. (Peterson 2009) noted that warming climates will cause a shift in the niche for the anopheles gambiae specie. (Peterson 2009)`s results were however based on GCMs from the Hadley Centre and the Canadian Centre. Hence, this is for the first time that CSIRO GCM and the 2080 a2a climate change scenario have been used to map the current and future malaria hazard in the SADC countries.

Conclusions

The main objective of this study was to model current and future malaria hazard areas using the CSIRO GCM in SADC countries using the ecological niche models. We conclude that climate change may affect the distribution of the malaria vector within the SADC countries. However, the use of the ecological niche concept alone cannot offer conclusive results on the vulnerability of an area to climate change and malaria since it only considers vector biology without taking into cognicence complex socio- economic factors such as level of medical technology such as malaria control programmes. Hence, future studies should further the study by assessing vulnerability of the SADC countries to malaria by considering socio-economic factors in order to come up with a comprehensive conclusion.

References

Gwitira, I. (2013) Climate Change and Health. University of Zimbabwe.

Haines, A. (2006) Climate Change and Human Health: Impacts, Vulnerability and Public Health. Journal of Science Direct 120:583-596.

Lafferty, K. (2009) The Ecology of climate change and infectious diseases. Ecology 90:888-900.

Martens, W. J. (1995) Potential Impact of Global Climate Change on Malaria Risk. Environmental Health Perspectives 103:458-464.

Murwira, A. (2013) Climate Change. University of Zimbabwe.

Partz, J. A. (2005) Impacts of Regional Climate Change on Human Health. International Weekly Journal of Science.

Peterson, A. T. (2009) Shifting suitability for malaria vectors across Africa with warming climates. B.M.C Infectious Diseases 9:59.