Chapter 42
Modelling the Spatial Distribution of the Anopheles Mosquito for Malaria Risk Zoning Using Remote Sensing and GIS:
A Case Study in the Zambezi Basin, Zimbabwe

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ABSTRACT

Remote Sensing and Geographic Information System was used to develop a spatial risk malaria distribution model based on environmental suitability for survival of the Anopheles gambie sp. Complex (A. arabiensis and A. gambae), the vector known to transmit malaria in Zimbabwe (Masendu, 1996). Employing geostatistical techniques, spatial analysis of environmental factors that contribute to the spread of the malaria vector was conducted to develop a malaria risk model that could be used in effective malaria control planning in Zimbabwe. The study was conducted in the Piriwiri, Umfuli and Magondi communal lands of Zimbabwe. A model was developed that defined malaria hot spots in the communal lands where attention must be given in developing plans and strategies for malaria control. Environmental data collected from satellite images and validated by fieldwork were used in the study. Based on expert knowledge, specific environmental factors favourable for Anopheles malaria vector were identified. This information was then used to predict the suitability of the area for the Anopheles

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mosquito using Indicator Kriging Algorithm (Isaacs et al., 1989). This method calculated the probability of exceeding an environmental indicator threshold (this allowed the prediction that a particular area (location) in the communal lands is suitable for the survival and spread of the Anopheles) and integrated them into a potential vector distribution model for the area. This model was used to determine areas that are potentially risky for malaria. Again the spatial distribution of malaria was calculated, based on clinical malaria data and accessibility to the clinics, and compared with the potential vector distribution zones to determine areas with high malaria risk. Except a few areas in Umfuli that were highly favourable for the Anopheles mosquito, most of the communal lands were not suitable for anopheles to survive indicating that malaria incidences are generally associated with highly favourable areas for the vector. Combining GIS and remote sensing applications with geostatistical analysis is a promising approach to define malaria risk areas in Zimbabwe. However, further quantitative research is necessary to validate the relationships within the malaria transmission system, especially on the vector and the human environment aspects.

INTRODUCTION

Malaria is a life threatening disease affecting the world's under-developed countries (WHO report, 2011) and is one of the top priority diseases targeted for elimination by the World Health Organization (Alemu et al., 2013). It is a major cause of mortality in Africa especially, in sub-Saharan Africa (WHO report). The incidence of malaria worldwide is estimated to be 216 million cases per year, with 81% of these cases occurring in sub-Saharan Africa. Malaria kills approximately 655,000 people per year; 91% of deaths occur in sub-Saharan Africa (WHO report, 2011). It is a major epidemic in Zimbabwe.

In Zimbabwe Malaria is caused by *Plasmodium falciparum* (Chandiwana et al., 1994) and is transmitted by the *Anopheles gambiae* species complex (WHO, 1982; Coetzee et al., 1993; Masendu, 1996). It is an important communicable disease contributing to about 20-30% of out-patient attendance, especially patients in the age group above 5 years (MOH & CH, 1993). Malaria epidemic is observed to occur especially in the seasonal zones among unprotected, non-immune populations experiencing a high incidence rate of about 400 cases per 100,000 people during the transmission season between December and April (MOH & CH, 1993; Mbizvo et al., 1993). Malaria control planning in Zimbabwe hitherto depended on previously stratified malaria zones which were mainly based on temperature. However, in order to effectively address the issue of Malaria control a good understanding of the epidemiology (Kleinschmidt et al., 2002) and transmission potential in time and space is needed (Alemu et al., 2013). As demonstrated by other researchers, targeting heterogeneity at all levels of transmission intensity could improve malaria intervention strategies and control measures (Coleman et al., 2009; Haque et al., 2009; Mboera et al., 2010; Wen et al., 2011). Advancement of technology and availability of GIS and remote sensing techniques have created the possibility of such detailed analysis. Scholars from across the globe have addressed the issue of malaria control using a variety of approaches (Fobil et al., 2012; Hanafi-Bojd et al., 2012; Wembley et al., 2012; Alemu et al., 2013; Ayele et al., 2013; Coulibaly et al., 2013; Ganser & Wisely, 2013; Jones et al., 2013). Nonetheless, till date there is scarce evidence of study addressing the issue of malaria in Zimbabwe especially, studies examining the spatial distribution of malaria or factors causing malaria (Hartman et al., 2002; Ebi et al., 2005; Mabaso et al., 2005). This study conducted as part of a thesis research fills in this important void and paves the way for future such studies that use modern technology to examine spatial distribution of malaria. The study aimed at developing a malaria

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