

Canada's Esri Young Scholar

ARCGIS AND THE FIGHT AGAINST MALARIA

Using GIS and remote sensing to compare malaria control interventions in Tanzania

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THE PROBLEM

Insecticide-treated nets (ITNs) and indoor residual spraying (IRS) remain the two major intervention strategies that target *Anopheles* mosquitoes, the exclusive vectors of malaria parasites. Yet, insufficient funding for these critical control methods hinders many countries' abilities to meet publicly-endorsed deadlines for malaria elimination. With a critical need to allocate limited resources to most at-risk areas, how do ITN and IRS coverages compare when targeting *Anopheles* mosquito distributions across Tanzania?

TANZANIA AS A STUDY AREA

The study area consists of Tanzania and its islands in the Indian Ocean (Fig. 1A), located on the east coast of Africa and occupying 886,160 km². Malaria is the leading cause of morbidity and mortality in the country, particularly in children under five. In 2014, nearly 100% of Tanzanians were at risk of malaria. The relationship between ITN ownership and *Anopheles* habitat suitability in Tanzania has been recently assessed using Geographic Information Systems (GIS), remote sensing and ecological niche modelling. Yet, IRS coverage has not been explored using similar techniques.

USING ARCGIS

ArcMap and ArcGIS were used to process satellite imagery, create a relative habitat suitability map, and compare ITN and IRS coverages. The process involved several steps: 1. Data Collection: Gathering satellite imagery and vector control data. 2. Pre-processing: Correcting for atmospheric and geometric distortions. 3. Analysis: Using GIS tools to overlay and analyze the data. 4. Output: Generating maps and reports.

UNEXPECTED RESULTS

Similar to a previous analysis of ITN ownership across households in Tanzania, the current analysis revealed that the average number (Fig. 3A) and proportion of children (Fig. 3B) under the age of five using ITNs across Tanzania had weak but significant ($p < 0.05$) negative correlations with mosquito habitat suitability ($IR = 0.079$ and $IR = 0.087$, respectively) (Fig. 3A and 3B, respectively). Unlike ITN ownership and use, which have a generally widespread coverage across the country, IRS applications only target certain regions of Tanzania (Fig. 4C). This may explain why IRS applications showed a relatively strong significant positive correlation with mosquito habitat suitability at the countrywide scale ($IR = 0.319$) (Fig. 5C). Analysis was done using Ordinary Least Squares (OLS) regression (green line, respectively, in Fig. 5) as well as in the 0.1 and 0.9 quantiles (the red and purple lines, respectively, in Fig. 5) to explore possible trends in the populations within the 10% highest and lowest coverages of ITNs, use in children therefore appears to decrease as mosquito habitat suitability and thus malaria risk, increases. IRS, however, showed an opposite, more promising trend, with increasing coverage towards higher risk areas in the 0.1 and 0.9 quantiles. Considering the widespread use of ITNs across Tanzania relative to IRS, these results are unexpected and suggest that ITN better targets areas most at risk of malaria.

ArcMap and Maxent

used the Maxent program (Version 3.3.3K) a species habitat modeling software, to create the *Anopheles* habitat suitability output (Fig. 1B). Environmental inputs (Fig. 2) were projected, re-sampled, clipped, and snapped to the same spatial extent in ArcMap 10.3.1 for input into Maxent. Maxent then correlated geo-referenced locations where the mosquitoes were sampled with the environmental characteristics of that area to present a relative habitat suitability map (a purple-to-red map) for suitability relative to other pixels on the map.

The R-ArcGIS bridge

Using the R-ArcGIS bridge, I was able to directly access my ArcMap layers of ITN and IRS coverages, used the 'tidy' pipes and 'raster' packages to create clipped buffer zones in the ArcMap layers around each location where people were surveyed about their use of ITNs and IRS. These buffer zones were created due to the randomly-shifted locations of the survey points for privacy reasons (Fig. 3). Survey locations were shifted randomly by up to 1 km in urban areas and up to 10 km in rural areas but could not be shifted across district locations (shown by the white lines in Fig. 3). Therefore, the buffer zones to these districts (Fig. 4) and correlated the resulting buffer areas of ITN and IRS use to the underlying mosquito habitat suitability (Fig. 5).

WHAT NEXT?

The combined spatial analysis of ITN and IRS coverages in relation to *Anopheles* habitat suitability in Tanzania presents a different picture of how well malaria control strategies target mosquitoes than analyzing either method separately. For future analyses, important questions include the following: Within the targeted local areas of IRS coverage, does IRS still target mosquito hot spots? How do ITN coverages compare at similar scales? These analyses are critical to informing malaria control programs allocating limited resources to highest-risk areas as well as helping countries meet malaria elimination deadlines.

Evaluating Badland Susceptibility in Basilicata, Italy through the Integration of GIS and Multicriteria Decision Analysis

Sean Leipe
 School of Geography and Earth Sciences, McMaster University

CONTROLS ON ROCKFALL-TALUS PROCESS-RESPONSE SYSTEMS IN KANAWASIA, CANADIAN ROCKIES

Prasamsa Thapa

High-Resolution Hydrological Modelling of the Lower Foulson River Basin, Manitoba, Canada

Rajtantra Lihare

Flood Modelling Using Flooding Patterns and Spatial Autocorrelation

Dongchul Lee

The figure displays five abstracts of research papers. Each abstract includes a title, author name, and a brief summary of the study. The papers cover topics such as badland susceptibility, rockfall-talus systems, hydrological modeling, and flood modeling. Each abstract is accompanied by a small figure or map related to the research.

Flood Modelling Using Flooding Patterns and Spatial Autocorrelation

Dongchul Lee, Applied Modelling and Quantitative Methods, Trent University

High-Resolution Hydrological Modelling of the Lower Foulson River Basin, Manitoba, Canada

Rajtantra Lihare, Natural Resources and Environmental Studies, University of Northern British Columbia

The figure shows two research papers. The first paper, 'Flood Modelling Using Flooding Patterns and Spatial Autocorrelation', discusses the use of GIS and remote sensing to model flooding patterns. The second paper, 'High-Resolution Hydrological Modelling of the Lower Foulson River Basin, Manitoba, Canada', describes a hydrological modeling approach for a specific river basin. Both papers include text, figures, and tables.

Exemplary Work in Geospatial Sciences

The Esri Young Scholars Award program was launched in 2012 by Esri in cooperation with its international distributors to recognize the exemplary work in geospatial sciences of students around the world. The award includes registration, transportation costs, hotel and per diem to attend the **Esri Education GIS Conference** and **Esri User Conference** in San Diego.

In Canada, the young scholar applicants are judged based on a poster and paper that demonstrate their use of Esri technology. The top submissions in 2017 included:

- Emily Acheson, PhD student in Geography at the University of British Columbia (Winner)
- Dongchul Lee, Masters student in Applied Modelling and Quantitative Methods at Trent University
- Sean Leipe, undergraduate student in Geography at McMaster University
- Rajtantra Lihare, PhD student in Natural Resources and Environmental Studies at the University of Northern British Columbia
- Prasamsa Thapa, Masters student in Geography at the University of Calgary

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