Mapping Populations at Greater Risk of Malaria Due to Hydroelectric Dams in Ethiopia: A Case Study of the Gilgel Gibe III Hydroelectric Dam

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Introduction

• Malaria is a parasitic infection that is spread by female mosquitoes of the Anopheles genus.
• It is acutely prevalent in Sub-Saharan Africa where ~90% of all malaria deaths occur—killing approximately 400,000 people each year (Centers for Disease Control and Prevention 2018).
• Ethiopia has historically been impacted by malaria.
• In 2018, the World Health Organization estimated that there were 2.7 million cases and 3.4 thousand deaths attributed to malaria in Ethiopia.
• Two malaria parasites are most common in Ethiopia:
  - Plasmodium falciparum (the most abundant and deadly type in Sub-Saharan Africa)
  - Plasmodium vivax
• Malaria transmission is highly dependent upon environmental conditions.
• Since 2000, many programs have been put into place to combat malaria with a common goal of lessening to global malaria burden.
• These programs have made significant strides in reducing malaria cases and deaths throughout the world (Otten et al. 2009). However, despite all the progress that has been made to combat malaria, anthropogenic environmental alterations are changing the landscape of malaria prevalence.
• Ethiopia, as well as other countries in Sub-Saharan Africa, has been increasing its hydroelectric infrastructure and is planning new hydroelectric projects.
• Ethiopia currently has two hydroelectric dams with twelve more large hydroelectric projects planned.
• Scholarly literature has found a statistically significant relationship between distance to reservoirs, the geographic location, and malaria cases.
• Previous scientific research has studied the relationship between malaria prevalence and climatic/environmental variables (Ebhuoma and Gebresalasie 2016).
• Research has also been conducted on the impact of malaria on the villagers in countries with limited economic capital and resources, the populations are at the greatest risk of malaria should be identified and prioritized.
• Remote sensing enables researchers to acquire information about a location without physically making contact or conducting laborious amounts of field work.
• Previous scientific research has studied the relationship between malaria prevalence and climatic/environmental variables (Ebhuoma and Gebresalasie 2016).
• Multiple variables have been found to contribute to malaria prevalence. These include:
  - Land Surface Temperature
  - Slope
  - Elevation
  - Landuse/Landcover type
  - Healthy vegetation
  - Stagnant water bodies (Ebhuoma and Gebresalasie 2016).
• Remote sensing offers health researchers an alternative technique for studying the geography of disease.

Background

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Study Area

Gilgel Gibe III Hydroelectric Dam and Reservoir

Figure 1: Shows how much the Gilgel Gibe III Hydroelectric Dam has changed the landscape of the Lower Omo River Valley feature.

• The Gilgel Gibe III Hydroelectric Dam is located in the Southern Nations, Nationalities, and Peoples’ Region in southeastern Ethiopia, on the Omo River.
• According to the Federal Ministry of Health in Ethiopia, this region contains almost 50% of Ethiopia’s malaria cases.
• It is a 230-meters tall and generates 1,870 Mega Watts of energy and at capacity, the Gilgel Gibe III’s reservoir can hold 14,700 million m³ of water (Prindiville, 2015). Construction began on the dam in 2006 and it began generating power in 2015.

Results: Mosquito Breeding Habitats

Mosquito Breeding Habitat Risk Maps

Figure 2: Features the results of the model from Figure 2.

Results: Populations at Greater Risk of Malaria

Figure 3: Features the populations groups identified by each technique.

Table 5: Shows the number of pixels classified in each risk category.

Technique 1 identified all populations living within 3 km of the Gilgel Gibe III Hydroelectric Dam as being at a greater risk of malaria.

Technique 2 only considers populations living within 3 km of the two areas of High Risk pixel concentration in the After Map.

Results: Populations at Greater Risk of Malaria

• Technique 1 identified all populations living within 3 km of the Gilgel Gibe III Hydroelectric Dam as being at a greater risk of malaria.
• 29,428 more people than Technique 2 identified.
• Technique 2 only considers populations living within 3 km of the two areas of High Risk pixel concentration in the After Map.

Table 3: Shows the number of people classified in each risk category.

Table 1: Describes the data used in this study.

Table 2: Describes the criteria, rating, and weights used to determine mosquito breeding suitability.

Table 4: Shows the estimated people living in the associated areas.

Table 5: Shows the estimated people living in the associated areas.

Research Objectives

1. Utilize remote sensing techniques to locate mosquito breeding habitats
2. Quantify how the Gilgel Gibe III Hydroelectric Dam has changed mosquito breeding habitats
3. Identify populations at greater risk of malaria due to the Gilgel Gibe III Hydroelectric Dam

Methods

• Create a model in ArcGIS 10.6 ModelBuilder that identifies mosquito breeding habitats using remotely sensed data
  - Evaluate the Study Area both before and after the Gilgel Gibe III Hydroelectric Dam was built
  - Calculate the number of pixels identified at each risk level and compare
  - Identify the estimated population living within the entire Study Area (Technique 1) and compare it populations living near areas of high risk pixel concentrations (Technique 2)

Study Area

Gilgel Gibe III Hydroelectric Dam and Reservoir

• It is 250 meters tall and generates 1,870 Mega Watts of energy and At capacity, the Gilgel Gibe III’s reservoir can hold 14,700 million m³ of water (Prindiville, 2015). Construction began on the dam in 2006 and it began generating power in 2015.

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References

• References

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