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# 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 mosquitos 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 estimates that there were 2.7 million cases and 5.4 thousands 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 death 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 nine hydroelectric dams with twelve more large hydroelectric projects planned.
- Scholarly literature has found a statistically significant relationship between distance to reservoirs, the result of large hydroelectric dams and malaria risk (Lautze et al. 2007, Yewhalew et al. 2009)

## Background

- Remote sensing offers health researchers an alternative technique for studying the geography of disease.
- Remote sensing enables researchers to acquire information about a location without physical 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 Gebresalassie 2016).
- Multiple variables have been found to contribute to malaria prevalence. These include:
  - Land Surface Temperature, Slope, Elevation, Landuse/Landcover type, healthy vegetation, and stagnant water bodies (Ebhuoma and Gebresalassie 2016).
- Risk Assessment mapping using remote sensing data has been used to located areas and populations at varied levels of risk (Minale and Alemu 2018).

## Study Area

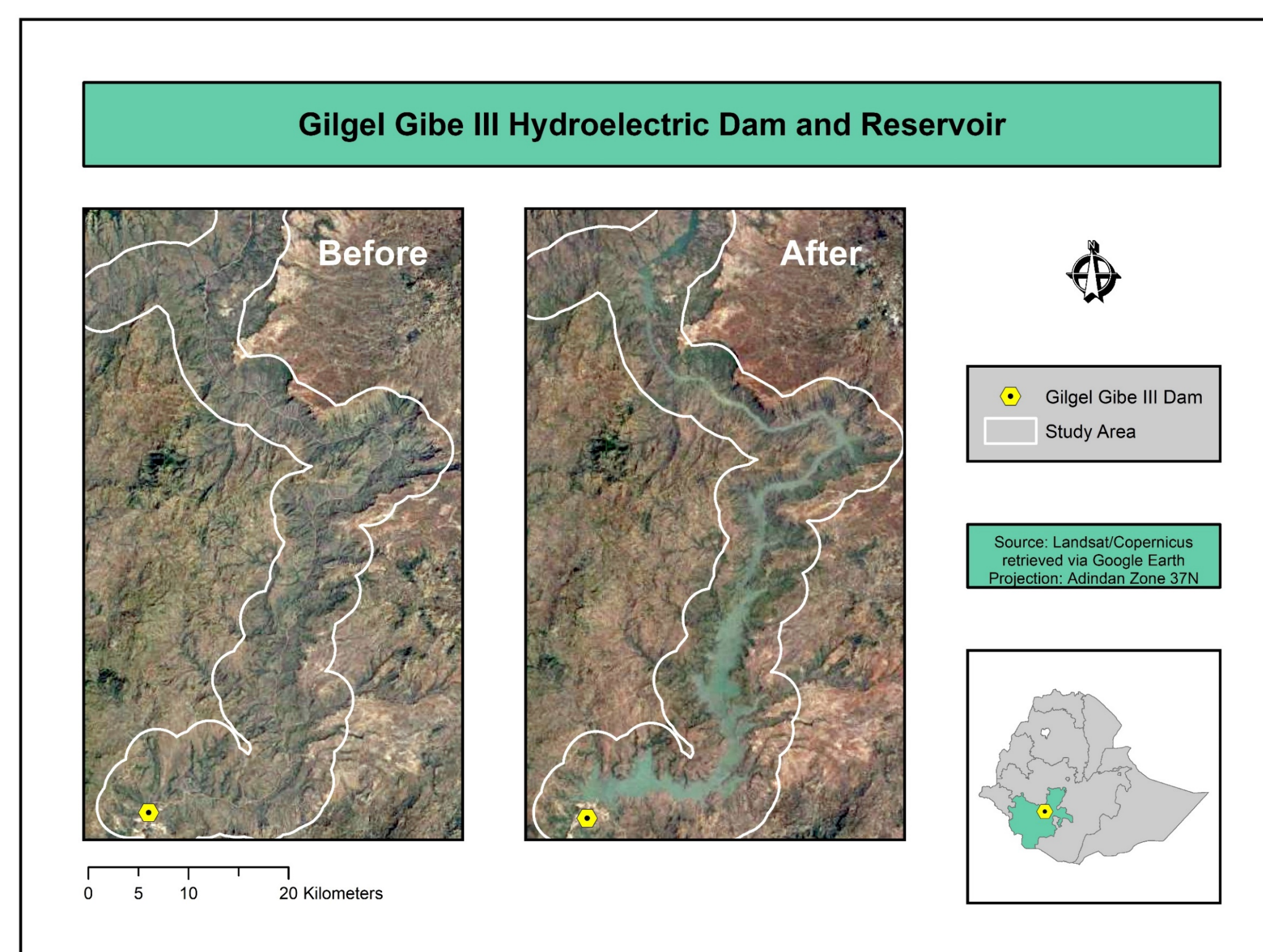


Figure 1: Shows how much the Gilgel Gibe III Hydroelectric Dam has changed the landscape of the Lower Omo River Valley featured.

- The Gilgel Gibe III Hydroelectric Dam is located in the Southern Nations, Nationalities, and Peoples' Region in southwestern 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 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 m<sup>3</sup> of water (Poindexter, 2015). Construction began on the dam in 2006 and it began generating power in 2015.

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## Research Objectives

- Utilize remote sensing techniques to locate mosquito breeding habitats
- Quantify how the Gilgel Gibe III Hydroelectric Dam has changed mosquito breeding habitats
- 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 total 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).

## Data

Model Input Variables		
Specific Input	Source	Purpose
Band 4	Landsat 8 (USGS)	To calculate Land Surface Temperature (LST)
Band 5	• Before (12/11/14)	
Band 10	• After (12/3/17)	
Band 3	Landsat 8 (USGS)	To calculate Modified Normalized Difference Water Index (MNDWI)
Band 6		
DEM	STRM (USGS)	To calculate slope and elevation
Shapefile of the Gilgel Gibe III Reservoir	Manually created using Sentinel 2 (USGS)	To extract input variables to the study areas
Population Data		
Used to investigate Research Objective 3	Landsat (Oak Ridge National Laboratory) • 2017	To quantify populations at greater risk of malaria

Table 1: Describes the data used in this study.

## Weighted Overlay Criteria, Rating, and Weights

Criteria	Low Risk (1)	Low/Medium Risk (2)	Medium Risk (3)	Medium/High Risk (4)	High Risk (5)	Assigned Weight
Slope	> 20.1		15.1 - 20	7.1 - 15	< 7	7%
LST (Celsius)	< 16°, > 40°		16° - 24°, 28° - 40°		24° - 28°	41%
Elevation (Meters)	> 2500		1500 - 2500		< 1500	11%
MNDMI	< 0.1		0.2 - 1		0.1 - 0.2	41%

Table 2: Describes the criteria, rating, and weights used to determine mosquito breeding suitability. Variables and scale values were determined based on expert opinion and scholarly literature. Weights were assigned based on Expert Opinion and an Analytical Hierarchical Process calculator.

## References

- Centers of Disease Control and Prevention. 2018. "Malaria." Page Last Updated: October 5<sup>th</sup>, 2018. Accessed: October 18<sup>th</sup>, 2018. <https://www.cdc.gov/parasites/malaria/index.html>
- Ebhuoma, Osadolor, and Michael Gebresalassie. 2016. "Remote Sensing-Driven Climatic/Environmental Variables for Modelling Malaria Transmission in Sub-Saharan Africa." *International Journal of Environmental Research and Public Health*, Vol 13, Iss 6, p 584 (2016), no. 6: 584. <https://doi.org/10.3390/ijerph13060584>.
- Kibret, Solomon, Jonathan Lautze, Matthew McCartney, G. Glenn Wilson, and Luxon Nhamo. 2015. "Malaria Impact of Large Dams in Sub-Saharan Africa: Maps, Estimates and Predictions." *Malaria Journal* 14 (1): 339. <https://doi.org/10.1186/s12936-015-0873-2>.
- Lautze, Jonathan, Matthew McCartney, Paul Kirshen, Dereje Olana, Gayathree Jayasinghe, and Andrew Spielman. 2007. "Effect of a Large Dam on Malaria Risk: The Koka Reservoir in Ethiopia." *Tropical Medicine & International Health* 12 (8): 982-89. <https://doi.org/10.1111/j.1365-3156.2007.01878.x>.
- Otten, Mac, Maru Aregawi, Wilson Were, Corin Karema, Ambachew Medin, Daddi Jima, Worku Kebede, et al. 2009. "Initial Evidence of Reduction of Malaria Cases and Deaths in Rwanda and Ethiopia Due to Rapid Scale-up of Malaria Prevention and Treatment." *Malaria Journal* 8 (1): 14. <https://doi.org/10.1186/1475-2875-8-14>.
- Minale, Amare Sewnet, and Kalkidan Alemu. 2018. "Mapping Malaria Risk Using Geographic Information Systems and Remote Sensing: The Case of Bahir Dar City, Ethiopia." *Geospatial Health*, Vol 13, Iss 1 (2018), no. 1. <https://doi.org/10.4081/gh.2018.660>.
- Poindexter, Gregory B. 2015. "Power Generation Begins at 1,870 MW Gilgel Gibe III Hydroelectric Project in Ethiopia." *Hydro Review*. World Health Organization. 2018. "Ethiopia." Accessed: March 22<sup>nd</sup>, 2019. [https://www.who.int/malaria/publications/country-profiles/profile\\_eth\\_en.pdf?ua=1](https://www.who.int/malaria/publications/country-profiles/profile_eth_en.pdf?ua=1)
- Yewhalew, Deleenasaw, Worku Legesse, Wim Van Bortel, Solomon Gebre-Selassie, Helmut Kloos, Luc Duchateau, and Niko Speybroeck. 2009. "Malaria and Water Resource Development: The Case of Gilgel-Gibe Hydroelectric Dam in Ethiopia." *Malaria Journal* 8 (January): 21. <https://doi.org/10.1186/1475-2875-8-21>.

## Results: Mosquito Breeding Habitats

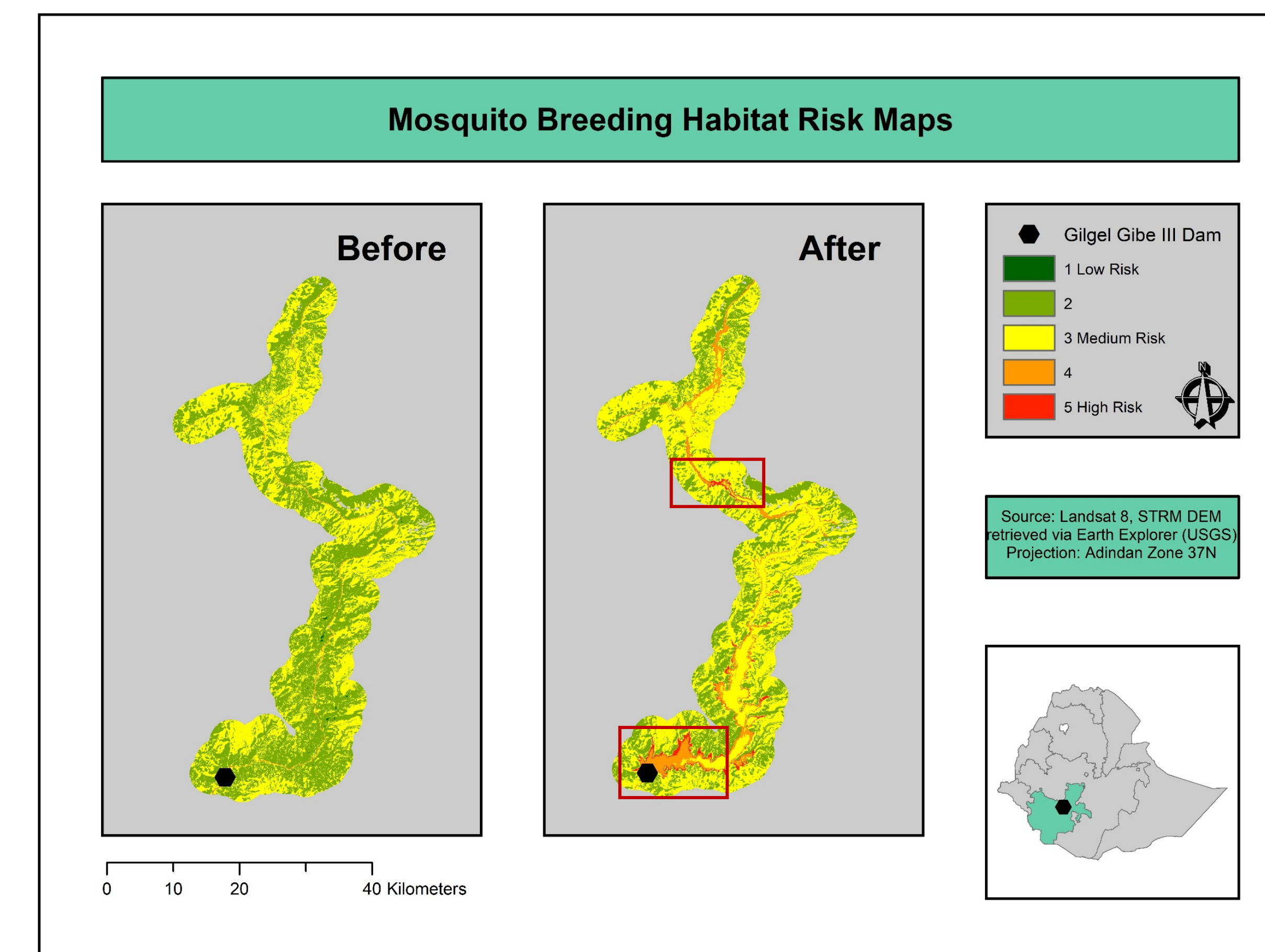


Figure 2: Features the results of the model from Figure 2.

- 22,780 more pixels are classified as being High Risk for mosquito breeding habitats after the Gilgel Gibe III Hydroelectric Dam was completed.
- Before the dam was completed, only 0.31% of the Study Area is classified as High Risk.
- After the dam was completed, 2.37% of the Study Area is classified as High Risk.
- The High Risk areas occur along the edges of the Omo River with two main concentrations.
  - One occurs close to the dam and the other occurs approximately midway in the reservoir, as denoted by the red boxes in the After map.

Pixel Classification	Before (# of Pixels)	After (# of Pixels)
5 High Risk	3,424	26,204
4 Medium/High Risk	4,325	59,212
3 Medium Risk	507,837	648,735
2 Low/Medium Risk	588,992	371,416
1 Low Risk	1,004	15

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

## Results: Populations at Greater Risk of Malaria

- Technique 1 identifies all populations living within 3 km of the Gilgel Gibe III Hydroelectric Dam as being a greater risk.
  - 29,418 more people than Technique 2
- Technique 2 only considers populations living within 3 km of the two areas of High Risk pixel concentration in the After map in Figure 2.

	Estimated Populations at Greater Risk
Technique 1	51,987
Technique 2	22,569

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

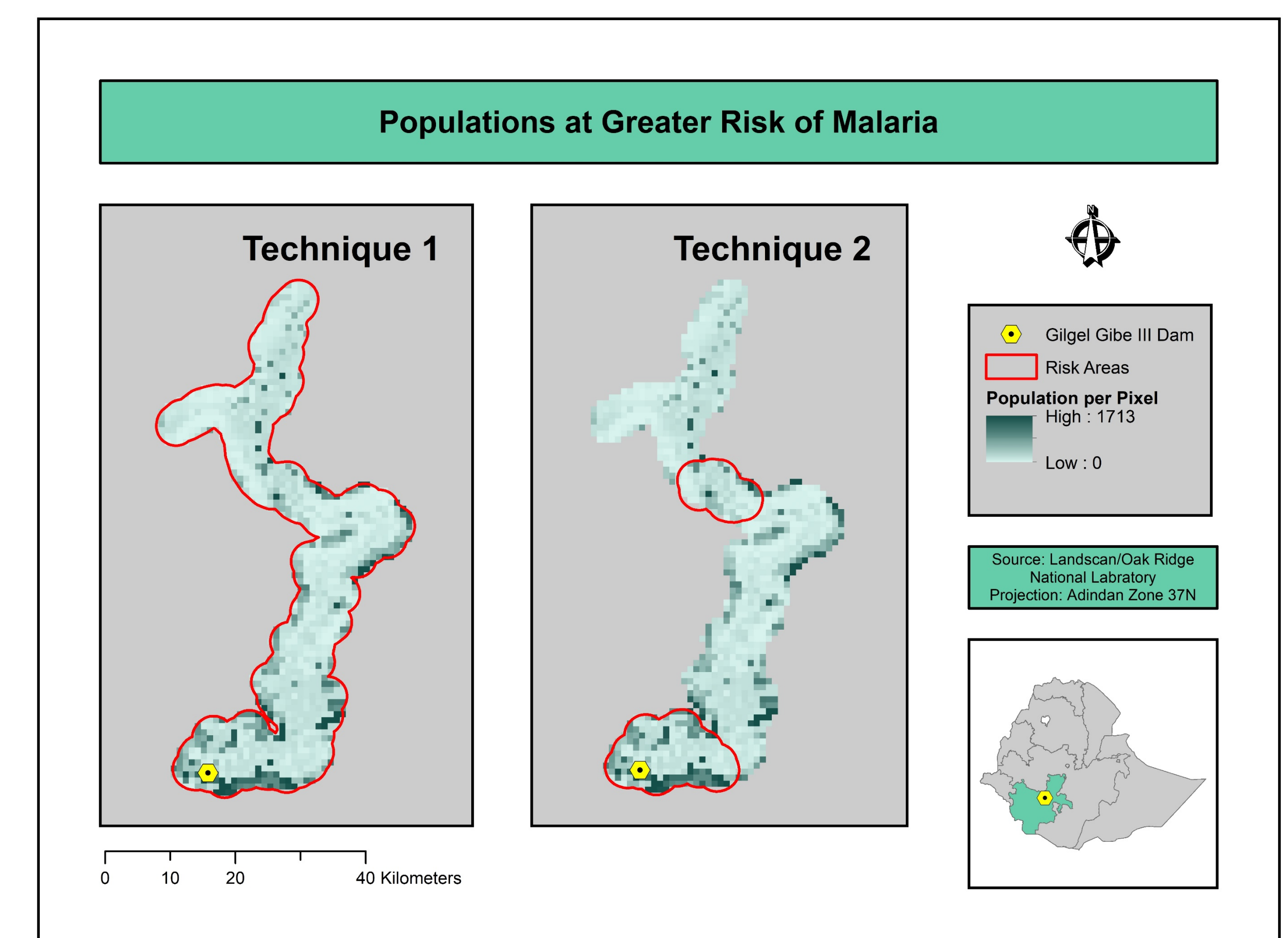


Figure 3: Features the population groups identified by each technique.

## Conclusion

- This study suggests that mosquito breeding habitats are not equally distributed throughout the Gilgel Gibe III Reservoir. This causes certain populations to be at a greater risk of malaria than others. In countries with limited economic capital and resources, the populations are at the greatest risk of malaria should be identified and prioritized.
- The model presented in this research can be applied to other study areas as long as researchers obtain all of the necessary input data listed in Table 1. All of remote sensing data used in this study is free to download or is able to be created with minimal input.