Leveraging Google Earth Engine to identify possible habitat for *Anopheles* mosquitoes in the Greater Mekong Subregion

Robert J Zupko
Center for Infectious Disease Dynamics, Department of Biology, Pennsylvania State University, USA

Malaria, caused by the *Plasmodium falciparum* parasite and spread by *Anopheles* mosquitoes, continues to be a major global public health concern, causing 241 million cases and 627 thousand deaths in 2020 (WHO, 2021). Within the Greater Mekong Subregion (GMS) the prevalence of malaria has declined dramatically since the early 2000s and the region is progressing towards eradication; although malaria remains associated with forests and forested fringes, the ideal habitat for *Anopheles* mosquitoes. In this study, we explored how Google Earth Engine (GEE) can be used to identify the possible habitat for *Anopheles* mosquitoes via web-based application or using programmatic workflows to export raster data for offline analysis.

METHODS

Using environmental envelopes for *Anopheles* species in the GMS (Obsomer et al. 2012), a workflow was developed for GEE (Fig. 2) that uses precipitation (CHIRPS Pentad), temperature (MOD11A1.061), and imagery (Landsat 7, 8) to identify the possible habitat. The workflow begins by first delimiting the potential habitat based upon the environmental conditions, followed by landcover classification using a manually trained Classification and Regression Tree (CART). Potential habitat that contains forest is then classified as suitable habitat for a given *Anopheles* species. When using the web-based application results are presented to the user directly (Fig. 1); however, when accessing GEE via the Python API, results are saved as a raster in a Google Drive for later retrieval.

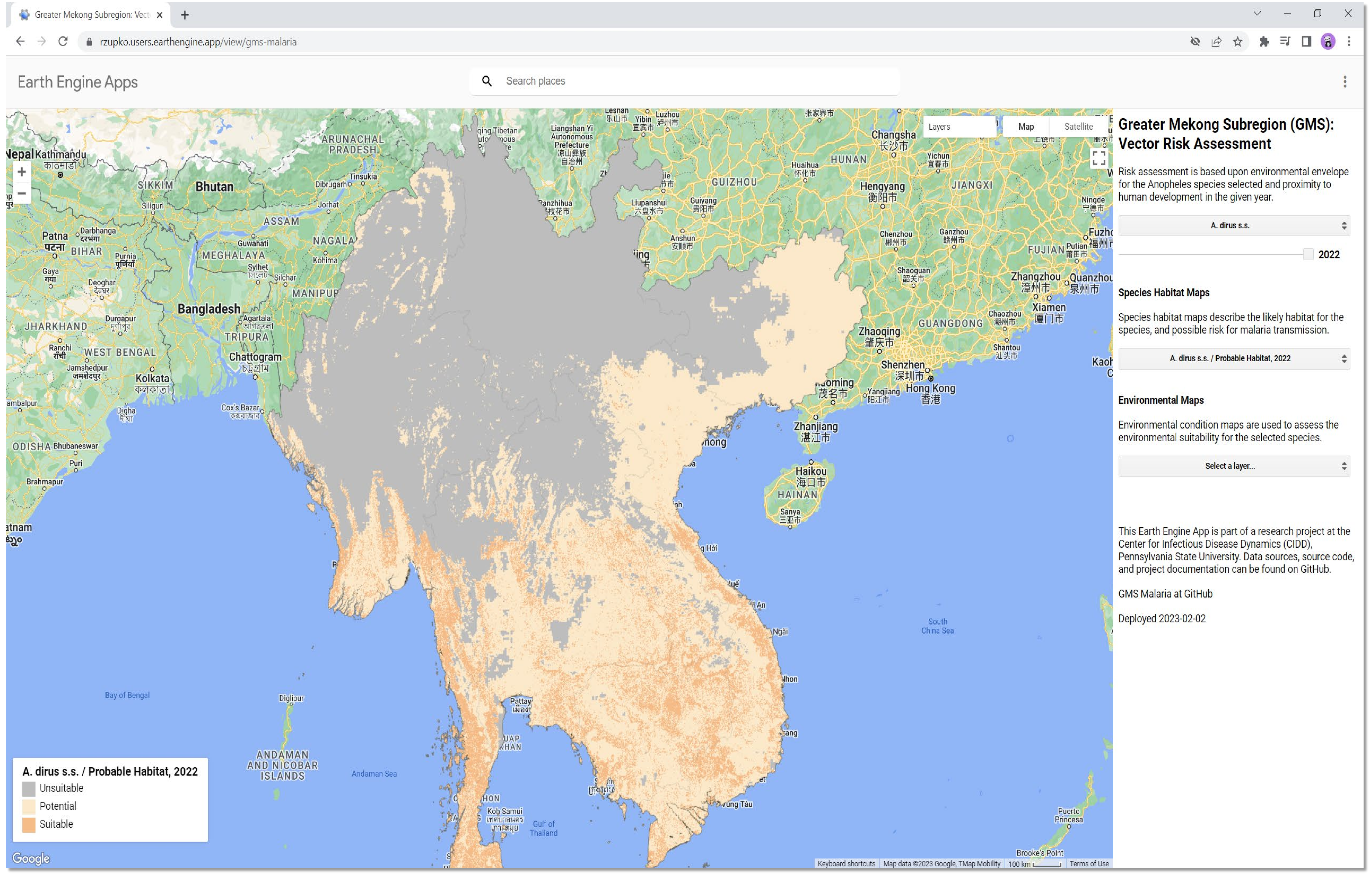

Figure 1. Example of the Earth Engine App during execution. Note that the user has the option of selecting from multiple *Anopheles* species and seeing potential habitat each year.

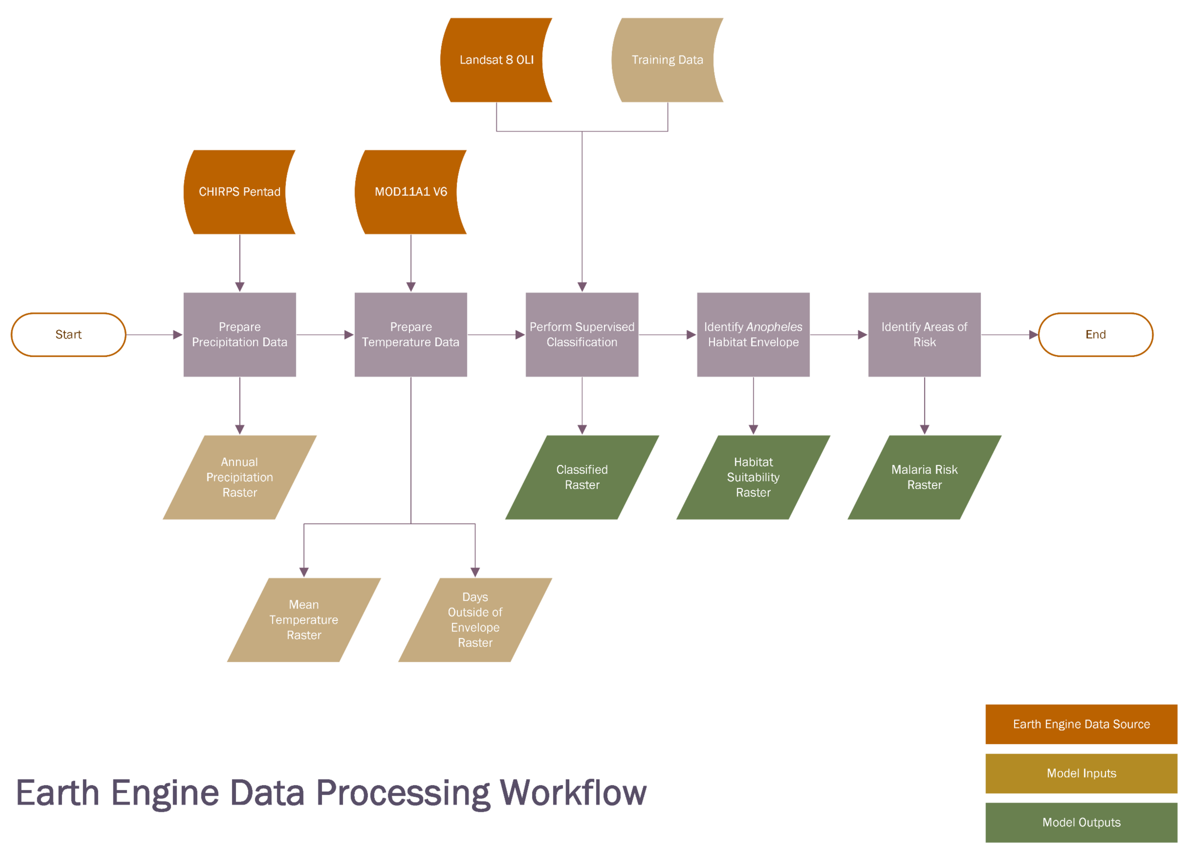

Figure 2. The overall workflow for the project required little change despite a significant amount of iteration taking place to implement the workflow in both JavaScript and Python.

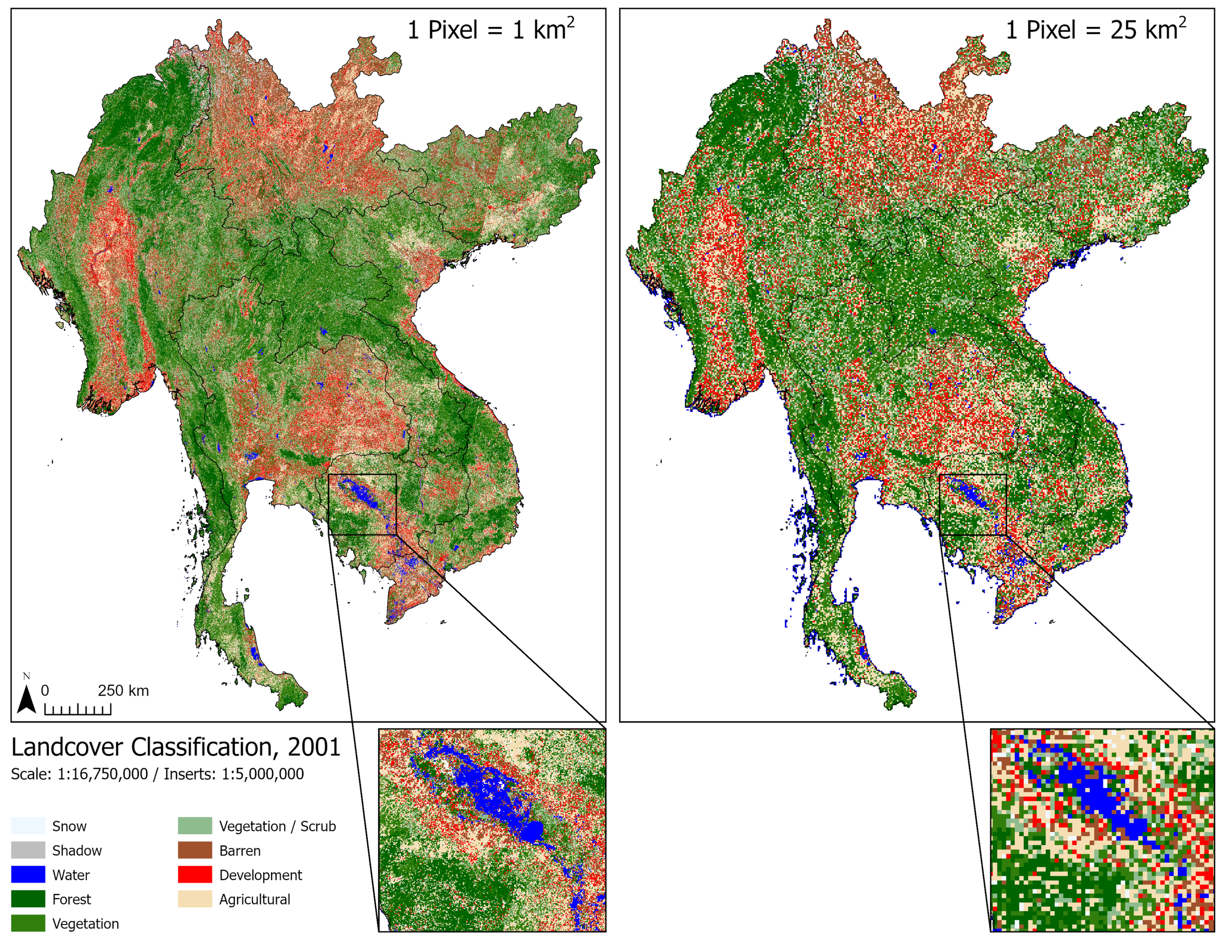

Figure 3. As part of the project, the impact of increasing (or decreasing) the spatial resolution was explored.

RESULTS & DISCUSSION

The habitat identified using GEE is similar habitat identified by Obsomer et al. (2012) although more work is still needed to quantify the differences and evaluate change over time. However, more work is needed to explore uncertainty in the projections and how to communicate them to users given that pixel resolution impacts result (e.g., decreasing pixel resolution from 1 km^2 to 25 km^2 results in an increasing in from 30,712 km^2 to 67,372 km^2; but 443,931 km^2 to 445,275 km^2 for forest). With properly quantified uncertainty and an effective means of communicating it, the GEE app has the potential to be useful to policymakers in the GMS region. Expansion of the GEE app to other parts of the world is possible but will require an expanded workflow to ensure that landcover classification is regionally appropriate.

RESOURCES

Earth Engine App
https://rzupko.users.earthengine.app/view/gms-malaria

GitHub Repository
https://github.com/rjzupkoi/gms-malaria

REFERENCES

Obsomer, V., Defourny, P., & Coosemans, M. (2012). Predicted Distribution of Major Malaria Vectors Belonging to the Anopheles dirus Complex in Asia: Ecological Niche and Environmental Influences. *PLOS ONE*, *7*(11), e50475. doi: 10.1371/journal.pone.0050475

World Health Organization. (2021). *World Malaria Report 2021*. Geneva, Switzerland: World Health Organization. Retrieved from https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021