Spatiotemporal Characterization of Wetlands in the Ethiopian Highlands using Landsat, SRTM and MODIS Data

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Introduction

Tropical wetlands provide important ecosystem services but also serve as habitats for malaria-transmitting mosquitoes. Wetland maps are therefore critical tools for management decisions by public health agencies. We developed a wetland map of our study region in the Ethiopian highlands using a random forests decision tree model. We tested three models with (1) topographical indices from 30 m SRTM data, (2) individual reflectance bands and multispectral wetness indices from Landsat TM/ETM+ imagery, and (3) combined spectral and topographic data. Integrating reflectance data, multispectral wetness indices, and topographic derivatives produced the most accurate wetland map. We explored seasonal and interannual variability of actual evapotranspiration (ETa) over a ten year period (2001-2010) for three land use/land cover classes (cropland, permanent wetland and seasonal wetland “musk”) using MODIS time series data. We observed differences in land surface phenology after the major rainy season across three land use/land cover classes: permanent wetlands, croplands, and seasonal wetlands. Information about the spatial extent and temporal dynamics of wetlands in Amhara region can help to monitor malaria risk because wetlands near human populations are potential natural reservoirs of mosquitoes.

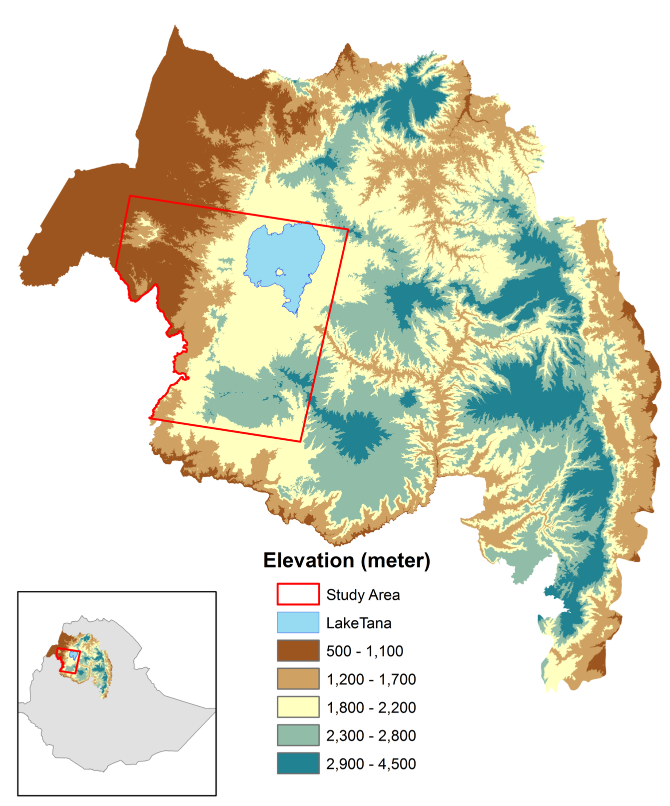

Figure 1. Study area in the Amhara region of Ethiopia. Exploratory field work documented mosquito breeding habitats in seasonal and permanent wetlands.

Research Questions

- Will integration of high resolution Google Earth imagery, Landsat TM/ETM+ and SRTM topographic derivatives improve the accuracy of wetland maps?
- Are there different seasonal patterns of surface moisture on different land cover types during critical phases of the malaria transmission season?
- What are the interannual patterns of surface moisture on different land cover types and what are their implications for malaria transmission?

Modeling Framework

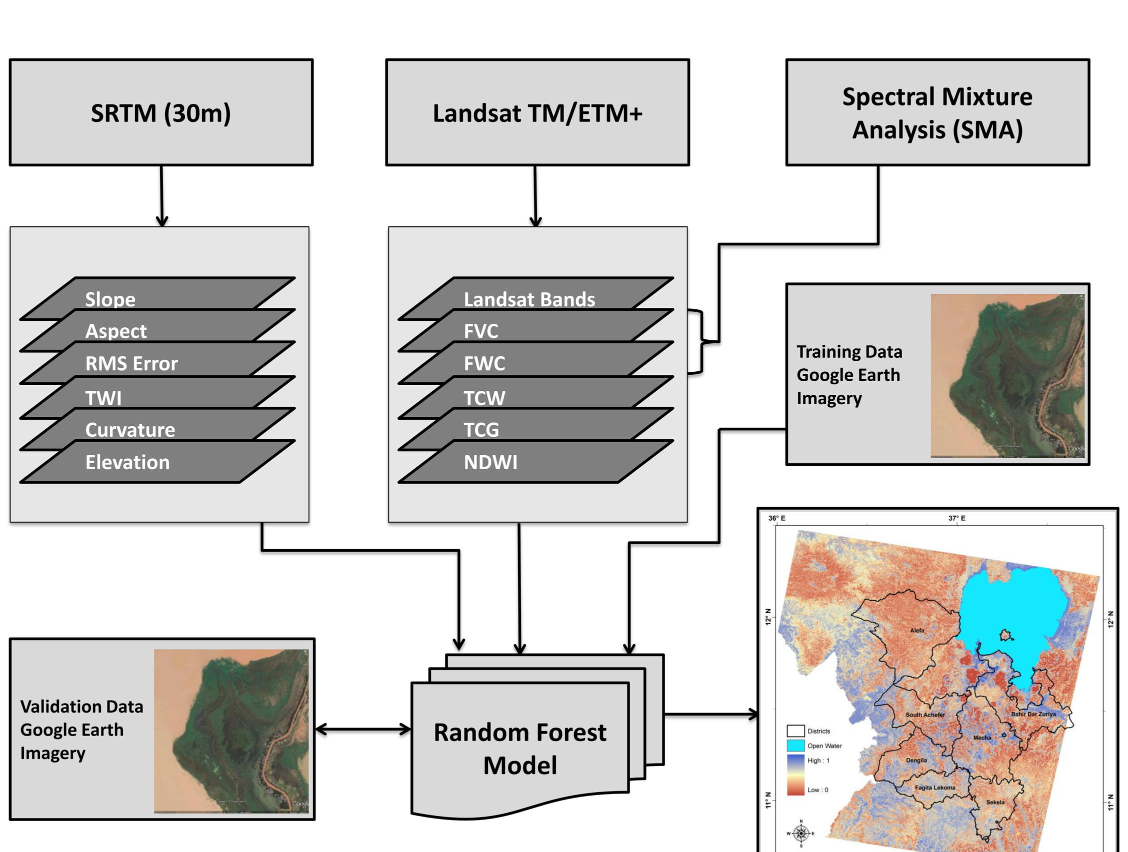

Figure 2. Conceptual Model for Wetland Mapping

Random Forest Model

Table 1. Validation statistics for the Random Forest models.

	Model 1 (Topographical)	Model 2 (Spectral)	Model 3 (Integrated)
Producer’s Accuracy (%)	85.20	81.22	88.35
User’s Accuracy (%)	76.26	87.46	88.96
Overall Accuracy (%)	80.32	85.51	89.23

- Model validation was based on independent data from Google Earth (2788 Training and 2795 Validation points from 22 sample blocks).
- Validation results indicate that the integrated model (Model 3) outperformed the other two models (Table 1).

Wetland Map

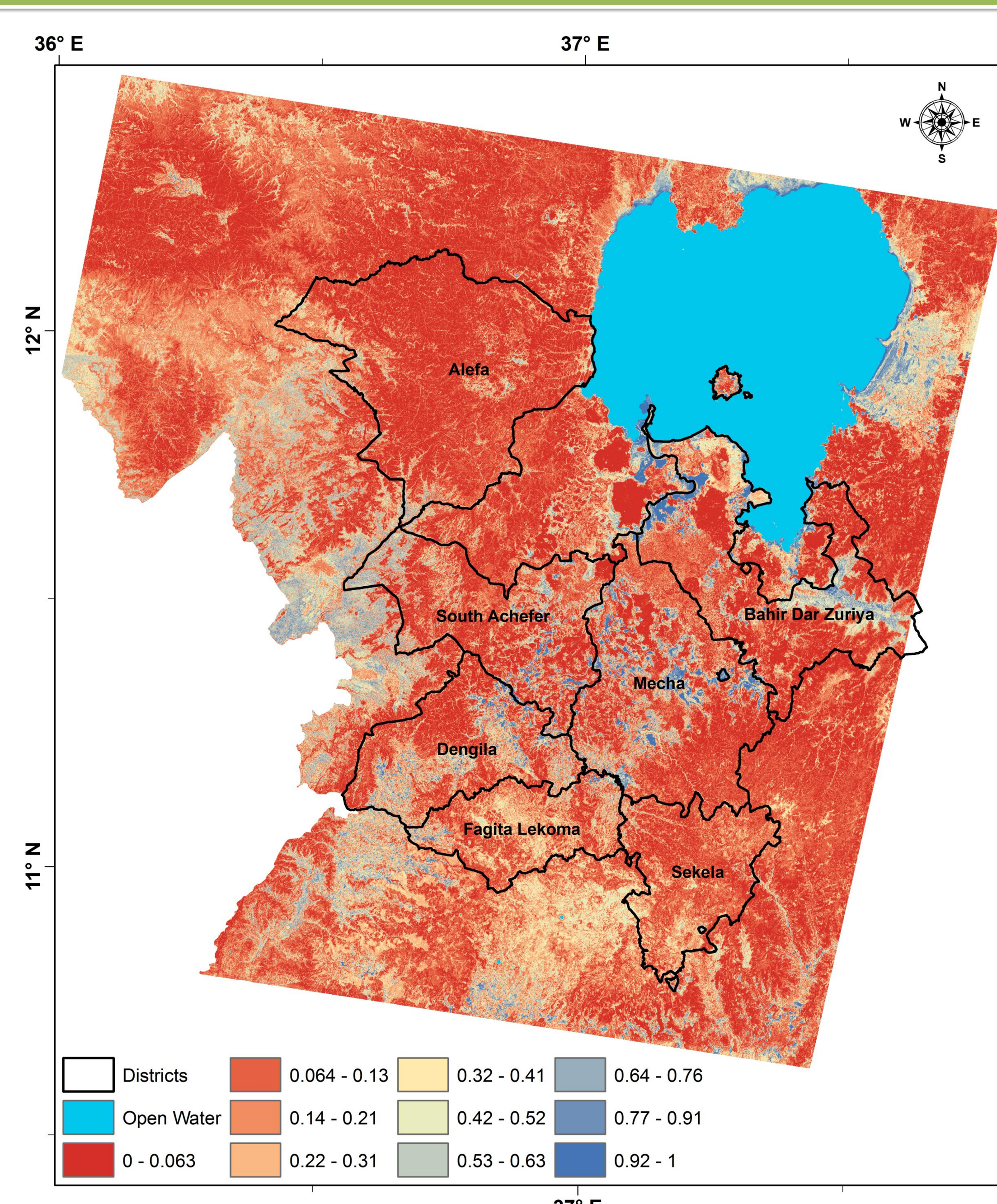

Figure 3. Wetland probability map from Model 3 (integrated model). The color ramp represents the gradient of wetland.

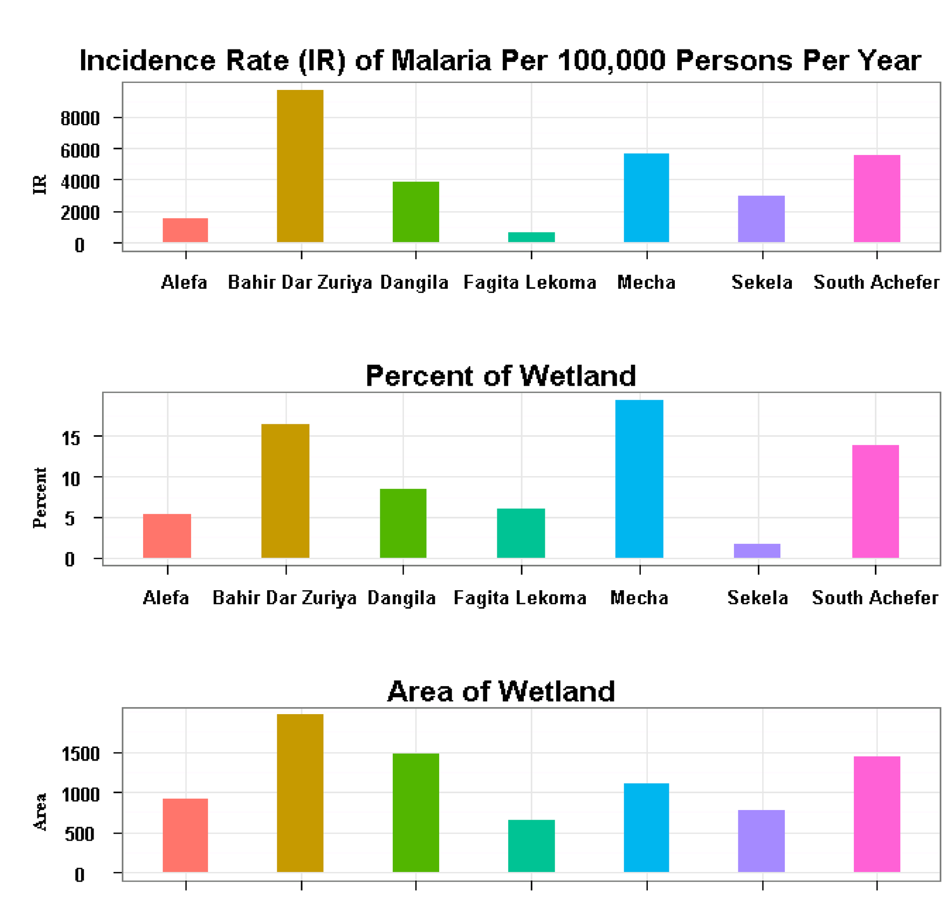

Figure 4 . Wetlands versus malaria association for seven districts of the Amhara region. Incidence rates were calculated using data from 2001-2010.

- Districts with higher malaria incidence had higher percent and area of wetlands (Figure 4).
- Mapping these wetland area at a regional level can help public health decision making to prioritize high risk areas.

Intra-annual and Interannual Variability

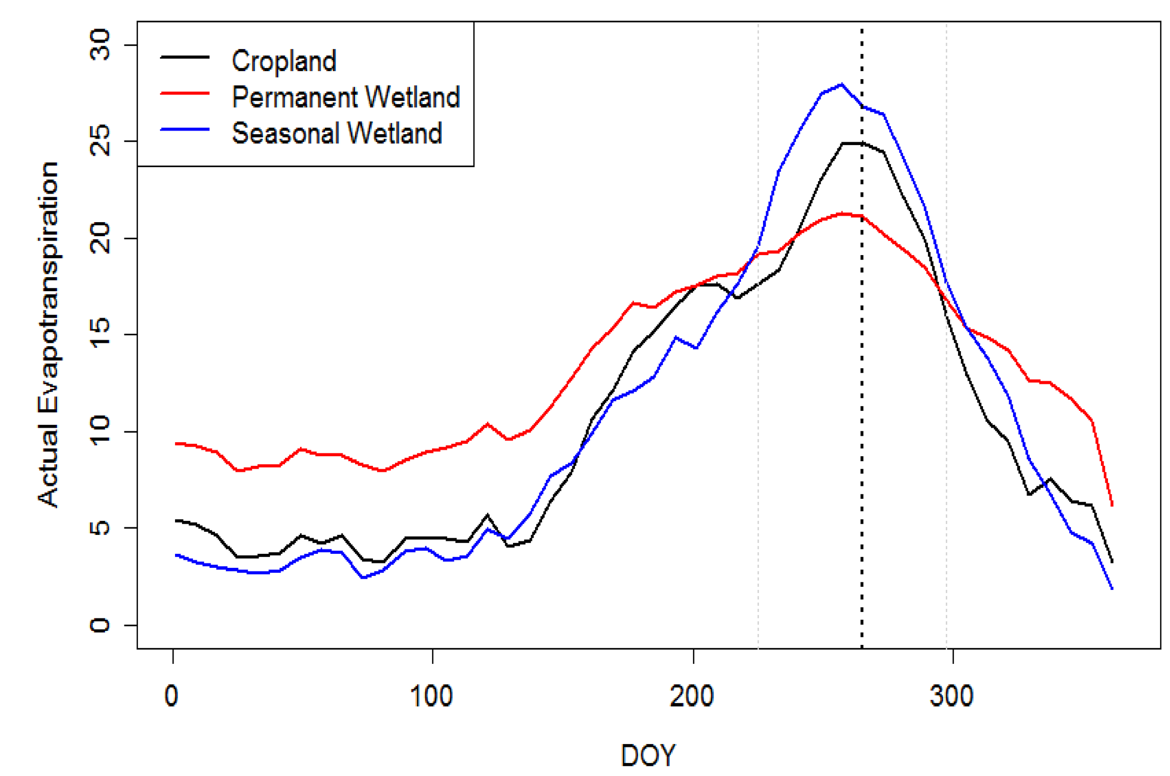

Figure 5 Mean seasonal variability in ETa (mm/8 days) from the MODIS Global Evapotranspiration Product (MOD16) summarized over 2001-2010

- We summarized mean ETa over 10 different sites for each land cover land use: croplands (34.71 km^2), permanent wetlands (28.29 km^2), and seasonal wetlands (5.18 km^2).
- Seasonal wetlands showed the highest peak after the major rainy season while permanent wetlands were higher during the dry season (Figure 5).
- Cropland showed an increasing trend during the main growing season over the ten year period (Figures 6 and 7).

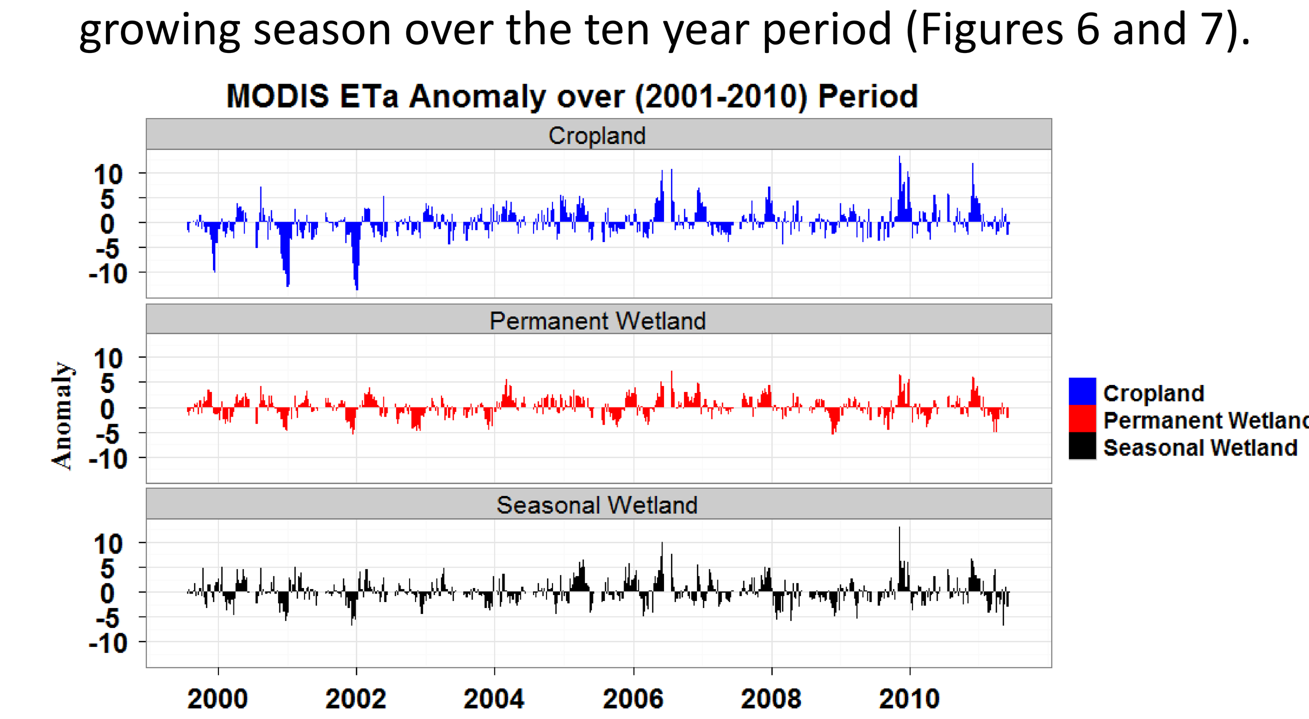

Figure 6. Seasonal ETa (mm/8days) anomalies over the 2001-2010 period from the MODIS Global Evapotranspiration Product (MOD16).

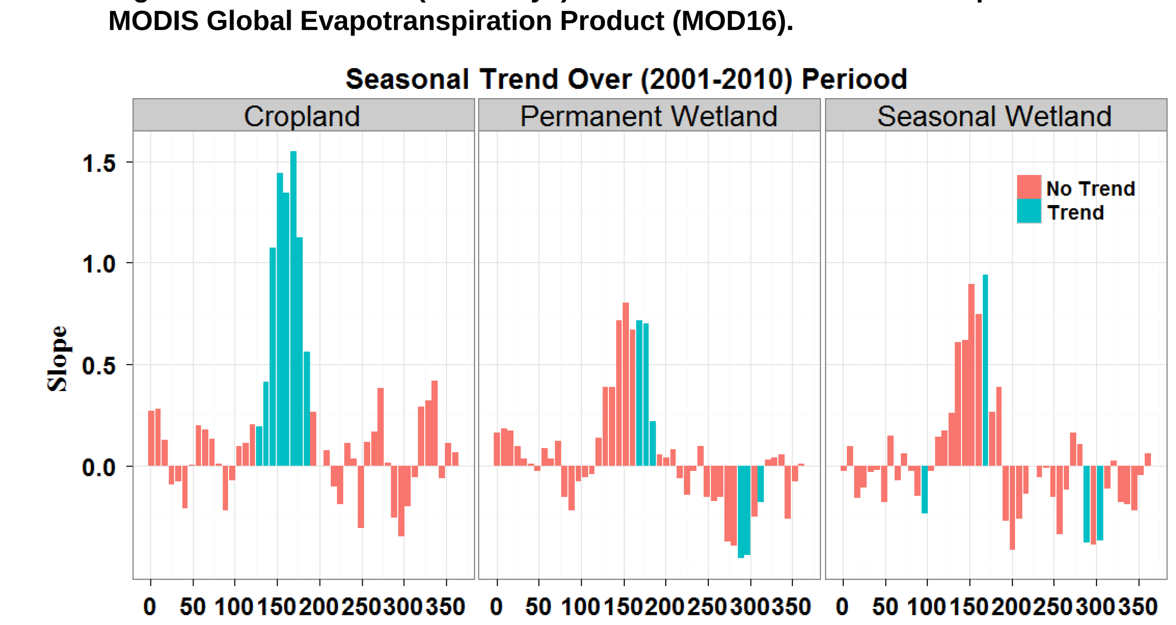

Figure 7. Results of Mann-Kendall tests for seasonal trends in ETa from 2000-2010.

Summary

- Integration of high resolution Google Earth imagery, Landsat TM/ETM+ and SRTM topographic derivatives produced accurate wetland maps.
- Districts with a high percentage of wetland cover were associated with elevated malaria incidence.
- Permanent wetlands had the highest moisture during the dry season and may serve as reservoirs for mosquitoes.
- Seasonal wetlands had the highest moisture before the major malaria transmission season.

Acknowledgments

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