Irrigation Detection and Estimation of the Effects of Productive Electricity Demands on Energy System Planning

Terence Conlon[1], Yuezi Wu[2], Simone Fobi[3], Chris Small[4], Hasan Siddiqui[5], Edwin Adkins[6], Vijay Modi[7]

Research question: Can we find locations that exhibit dry season photosynthetic crop growth?

- Motivation: Identifying these locations provides information about which areas can sustain electricity demand for irrigation.

Methodology: We use labeled administrative data from California and Catalonia, along with hand-labeled polygons in Ethiopia to train a land-cover classifier.

- By combining imagery and labels across multiple regions, we deploy a transfer-learning based approach that allows our model to learn generalizable combinations of input layers for accurate predictions.

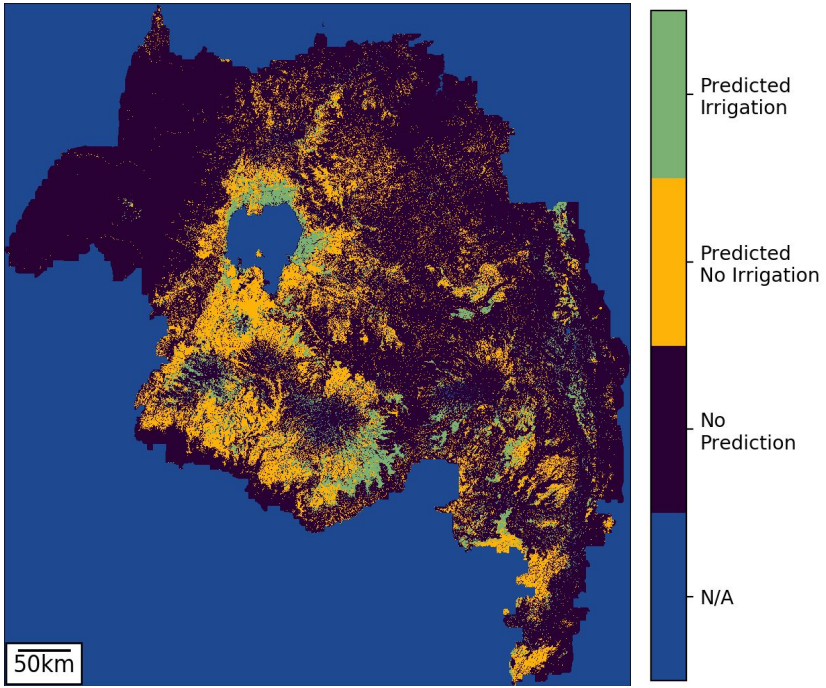

Figure: Predicted irrigation over the Amhara region of Ethiopia.

[1]tmc2180@columbia.edu, [2]yw3054@columbia.edu, [3]sf2786@columbia.edu, [4]csmall@columbia.edu, [5]hss2152@columbia.edu, [6]jea98@columbia.edu, [7]modi@columbia.edu

Moving from predicted irrigation polygons to energy system modeling

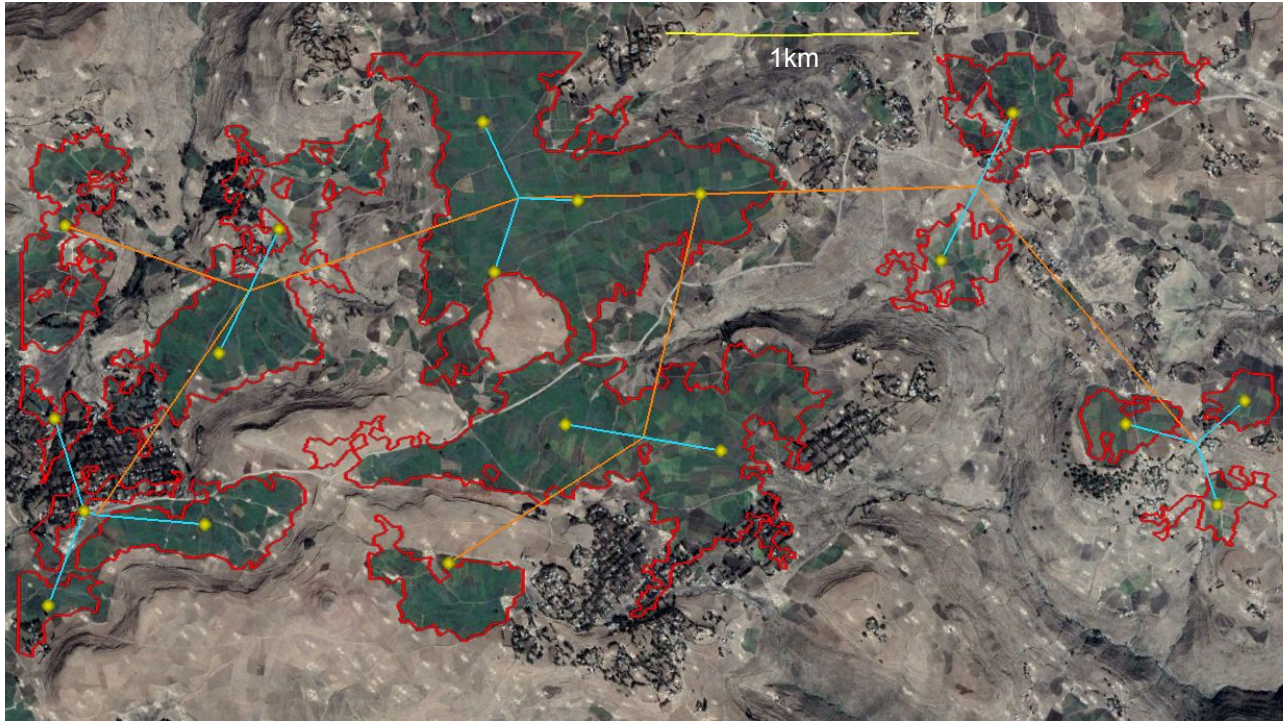

Figure: Proposed electric grid network with MV (orange) and LV (blue) lines serving irrigation zone centroids (yellow), near Gedebge, Ethiopia. Predictions made with Sentinel-2 imagery (taken from the Descartes Labs Platform) and presented on an Airbus image taken from Google Earth Pro.

After obtaining predicted polygons, we simulate electricity loads associated with each identified area.

Research question: Can we find least-cost generation (solar + diesel) and storage (battery) systems to meet productive (irrigation-related) and non-productive (household) electricity demands? How do these optimal systems change under different configurations?

Summary of findings:

1. Prediction accuracy on MODIS-derived features across California, Catalonia, and Amhara ranges between 0.74 and 0.99 based on class and location.
    - Classifier is trained on all three regions' data. Training on a single region's data results in higher accuracy in said region, but worse generalizability.

2. Trained classifier is applicable to multiple sources of input data at different temporal and spatial scales (biweekly MODIS-derived layers and monthly Sentinel-derived layers).

3. Solar-diesel-battery minigrids provide the most cost effective option for meeting electricity demand at the irrigation zone-level (300m radius). Linking irrigation zones reduces cost only if grid power is available.

Figure: Acacia irrigation project, Senegal [Jack Bott, QSEL (2016)]