Impact of Urban Expansion on Peri-Urban Agriculture, Hydrometeorology, Food Security and Human Health in East and West Africa: Linking Social Science to Earth Observations and Earth System Modeling

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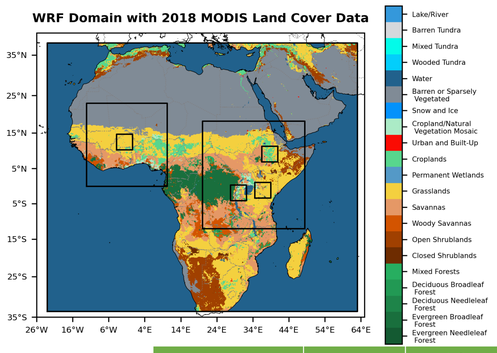
This NASA IDS project brings together climate modeling, remote sensing and geospatial data and methods, and social science expertise to understand how urban and peri-urban agriculture (UPA) contribute to improved food security, reduced hydrometeorological hazards, and water quality in a changing climate and changing landscapes. By capturing and predicting the current and future changes of green space across four African cities - Ouagadougou, Kigali, Addis Ababa, and Nairobi - these potential UPA sites are then connected to locale-specific population and development scenarios. To map current and near-future (~ 2035) changes in these urban areas, we used high- to coarse-resolution imagery and products within the TerrSet model to predict future land-cover/land-use change. At the 500 m and 1 km spatial resolutions, the results showed little change between 2003 and 2019 and therefore predicted little change in the near term. A systematic review of Web of Science food gaps in how LCLUC modeling has been developed and/or applied in the African continent – limiting applicability for UPA landscapes but also creating technology opportunities to improve coupled landscape-climate modeling. Through combined land-cover/land-use change and climate modeling and experiments using the Weather Research and Forecasting (WRF) model at NASA Short-term Prediction Research and Transition Center (SPoRT), we can ultimately determine how vegetated areas affect the local and regional hydrometeorology and urban heat island for these important African cities. Currently, we are using multilevel models to connect yield outcomes and household-level data in Burkina Faso, Rwanda, Ethiopia, and Kenya to determine the changing food security of urban, peri-urban, and rural communities near Ouagadougou, Kigali, Addis Ababa, and Nairobi. From there, we will then understand how children's health is likely to change in the coming decade from these modeled urbanization processes. Finally, results are compared with published African Union sustainable development goals and assessments, and qualitatively assessed by a project team member specializing in African political ecology and political economy studies.

Why Urban Agriculture?

Food production in urban and peri-urban zones can be a significant contributor to the food security of an urban area, absorbing price shocks and **accounting for up to ½ of urban food needs**.

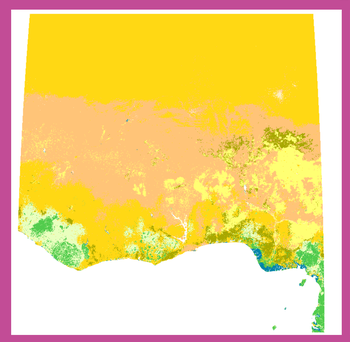
Why Hydrometeorology?

Likely impacts of changing urban vegetation extent on local & regional hydrometeorology (**urban heat islands, extreme temperatures, extreme precipitation, extreme drought**) is critical to urban planning and national policies.



	Continent	East & West Africa	City Metros
Horizontal Resolution	12 km	3 km	1 km
Radiation	RRTMG		
Land Surface Model	Noah-MP (4 soil layers)		
Planetary Boundary Layer	Mellor-Yamada-Janjic (MYJ)		
Microphysics	Morrison 2-moment		
Cumulus Parameterization	Kain-Fritsch	None	
Urban Physics	Urban Canopy Model		

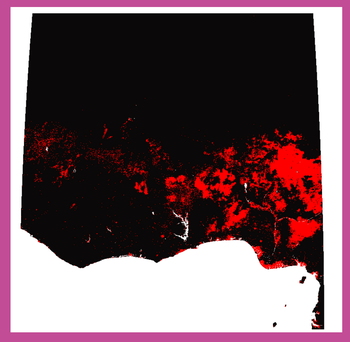
So, turns out modeling future land cover at 500m is hard.

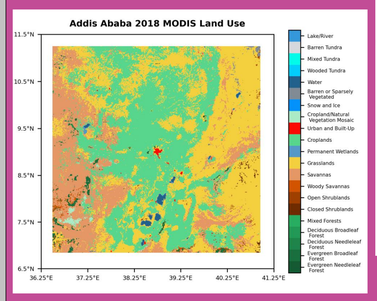


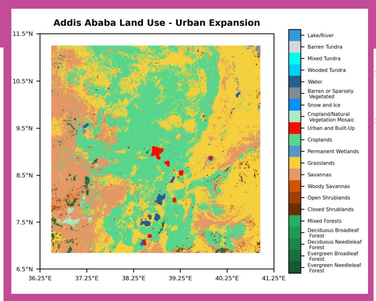
TerrSet LCM finds 3-5% urban growth by 2030 based on 2008-2018 priors.

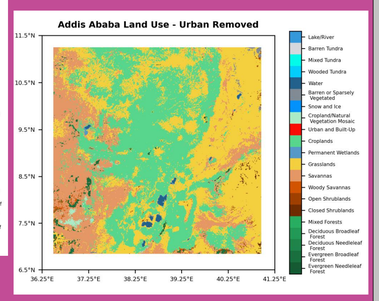
African urbanization rate stood at ~ 44% in 2021 (Statista).

Shift focus to the extremes.







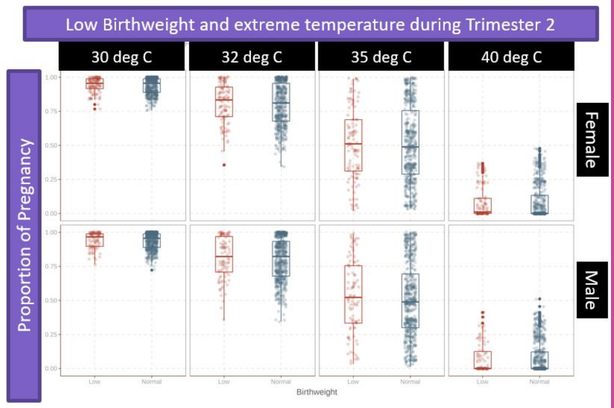


Health Impacts ⟷ Modeling results

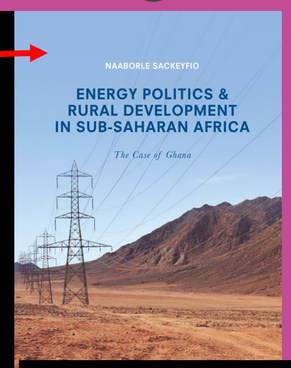
Low birthweight vs normal birthweight
by child sex & different temp bins

Y-axis: proportion of pregnancy with days above that temp threshold

Ouagadougou, Burkina Faso



Linking land use scenarios and futures to *realpolitik*



Why focus on 2030 when African Union's future sights set for 2063?

- Understanding shifting patterns of greenspace across four sub-Saharan African cities allows us to capture prospective outcomes for agricultural productivity, water use and food security.
- Map in compelling ways food security projections supports intergovernmental efforts such as the African Union's SDG objectives for 'inclusive, safe, resilient and sustainable human settlements and cities.'

African Union

SUSTAINABLE DEVELOPMENT GOALS

Climate modeling and EO products align with current IPCC and SDG timelines. But what if answered the timelines set by African policymakers? How do we shift NASA priorities to be flexible to the needs of all?

How has LCLUC been modeled in Africa? A Systematic Review

The English language Boolean query was performed 29 September 2021 on Elsevier GEOBASE and Thomson Reuters Web of Science (Core Collection), hosted by Miami University's King Library (USA).

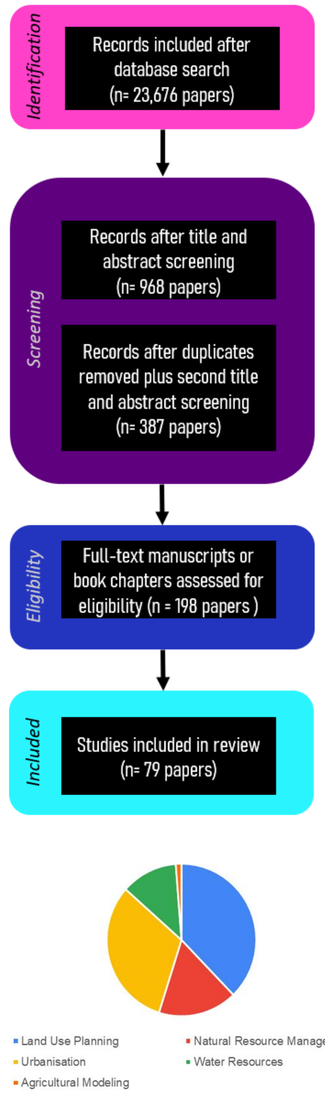
(("Land*" OR "Land cover*" OR "Land use*" OR "Urban* OR "Urban development*" OR "Spatial*" OR "Peri urban*" OR "Agriculture*" OR "Spatio temporal*" OR "Landscape*" OR "Land system*") AND ("Change*" OR "Pattern*" OR "Process*" OR "Change detection*" OR "Assessment* OR "Evaluation*" OR "Forecasting*" OR "Projection*") AND ("Model*") AND ("Africa*"))

Example Boolean query; final version included names of all African countries.

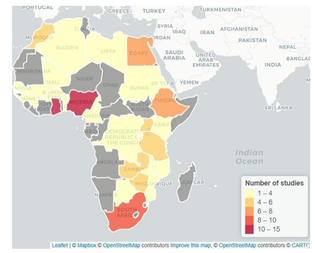
Our Team

Associate Profs
Assistant Prof
PhD-level Researcher
PhD students
Masters-level Researcher
Undergrad Researchers

Approach & Results



GEOGRAPHIC
Only 28 of the 55 African Union countries modeled, with Ghana, Nigeria, South Africa, Egypt, & Ethiopia most studied.



SPATIAL
More than 4 out of 5 studies relied on the freely available 30 m Landsat archive to model LCLUC.

Landsat 8 OLI from January 24, 2016

THEMATIC
Focus on urbanization (35%), land use planning (28%), and natural resource management.

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