Rural Water Availability and the Growth of Cities

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Growth of cities in SSA

- Currently, around 55% of the human population live in urban areas (UN 2018).
- In the last six decades growth of urban areas was largest in Sub-Saharan Africa.
- Yet, 57% of the African population still lives in rural areas (UN 2018).

- Low- and middle-income countries today, urbanize faster and at a much earlier stage of development.
  - (Jedwab & Vollrath 2019, Glaeser 2014, Castells-Quintana & Wenban-Smith 2020)
- Weather anomalies can act as a push factor causing people to migrate from rural to urban areas in Sub-Saharan Africa.
  - (Marchiori, Maystadt & Schumacher 2012, Kaczan & Orgill-Meyer 2020, Zaveri, Russ, Khan, Damania & Jägerskog 2021, Barrios, Bertinelli & Strobl 2006, Brückner 2012)
- With faster urban growth there will be new benefits and challenges to cities, especially in low-income countries (Satterthwaite 2017).

Research contributions and why to we care . . .

Research contributions:

- Estimate a dose-response function of rural water availability and the effects on nearby cities and towns in Sub-Saharan Africa.
  - Allowing non-linearities in the response function of city-level growth (Henderson 2017, Krause et al. 2021).
  - Accounting for heterogeneous effects conditional on the initial size of cities.
  - Applying state-of-the-art methods to identify cities (Peri and Sasahara 2019, Krause et al. 2021).
  - Utilizing the latest hyperlocal remote sensing and climate data.

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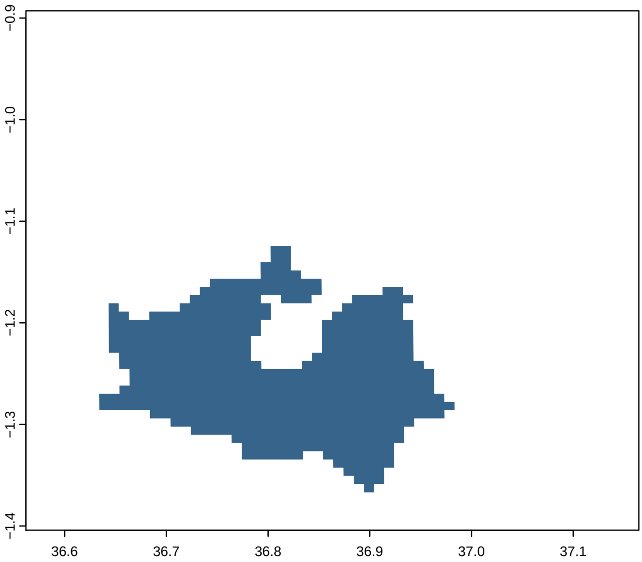
Why do we care?

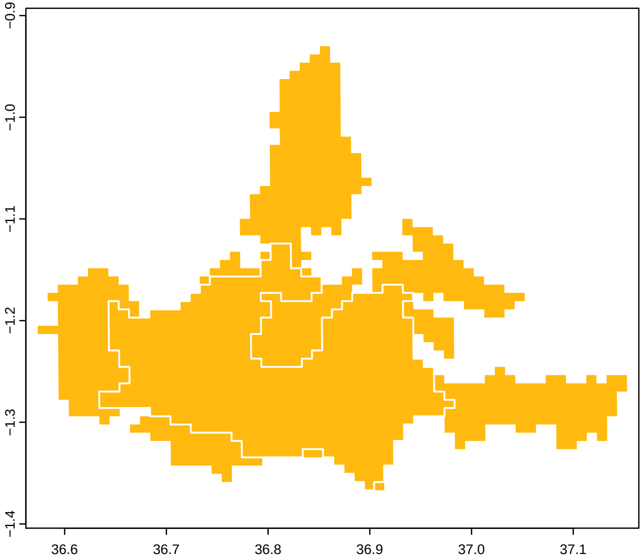
- To address the growth of cities we need to know its causal origin.
- Decision makers need to take the direct and indirect impacts due to market responses of adaptation measures against drought into account.
- Disturbances in water availability become more frequent, longer and intense due to climate change.

Data: Identification of urban boundaries I [Example: Nairobi, Kenya]

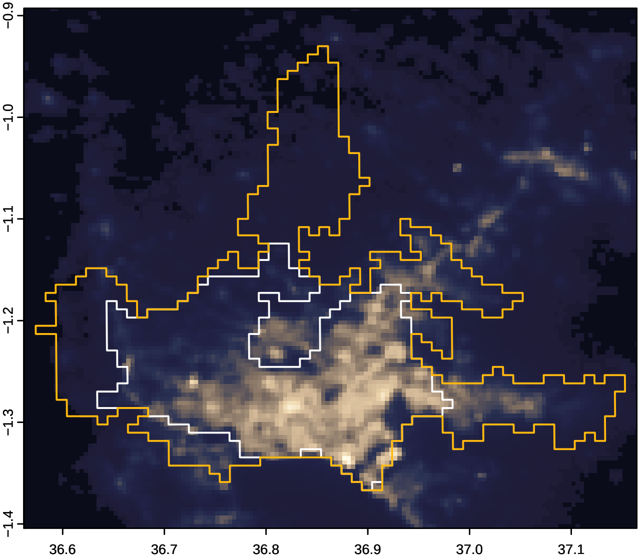
◂ data



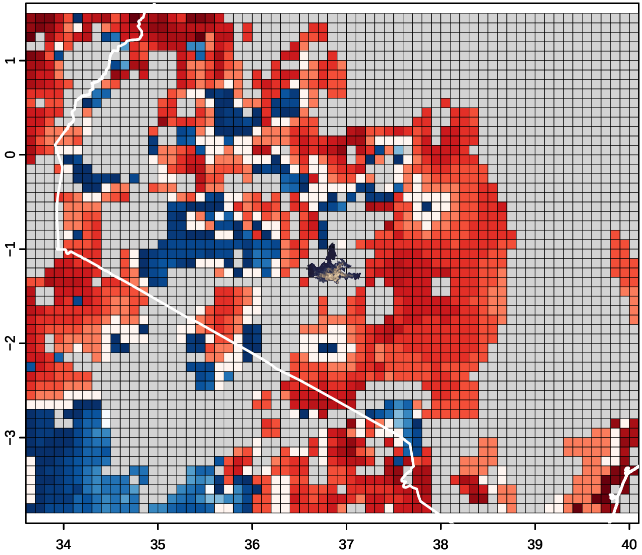
Data: Identification of urban boundaries II [Example: Nairobi, Kenya]



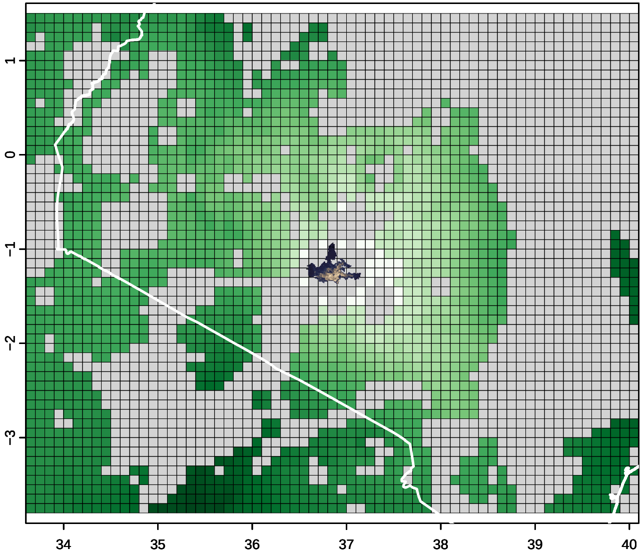
Data: Economic activity and city growth [Example: Nairobi, Kenya]



Data: Agricultural productivity shocks [Example: Nairobi, Kenya]



Data: Moving costs [Example: Nairobi, Kenya]



Data Summary

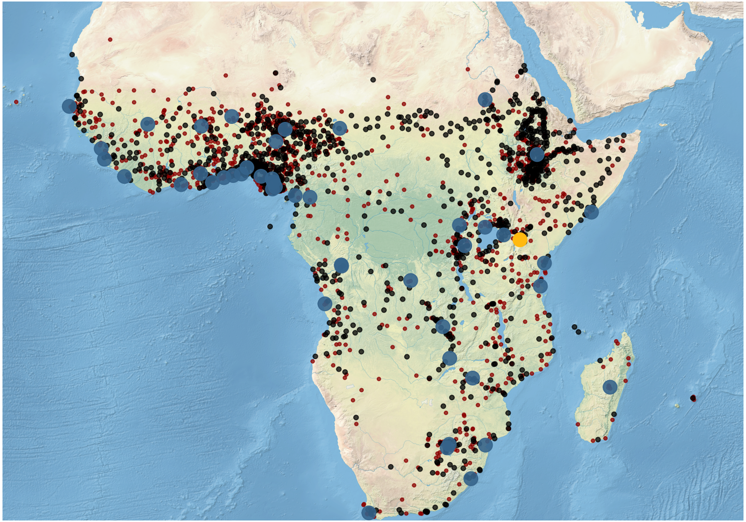


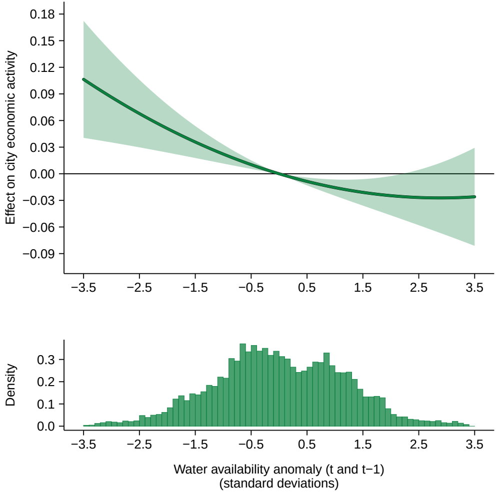
Figure: The location of cities in Sub-Saharan Africa; N= 2,376

Econometric strategy

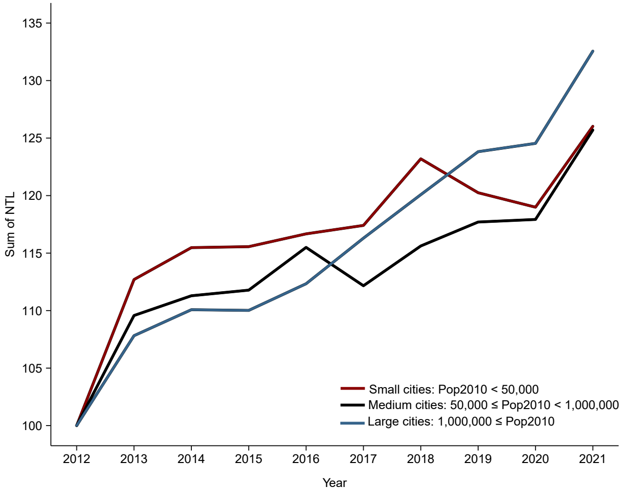
$$log(SNTL_{ct}) = \sum_{p=1}^{2} \Bigg[\underbrace{\beta^{p}_{rural} WA\_rural^{p}_{ct}}_{\textbf{rural water availability}} + \underbrace{\beta^{p,TEMP}_{city} TEMP\_city^{p}_{ct} + \beta^{p,PRE}_{city} PRE\_city^{p}_{ct}}_{\text{city weather}} \Bigg] \tag{1}$$
$$+ \underbrace{\alpha_c + \phi_t}_{\text{fixed effects}} + \underbrace{\mu_c \times \tau}_{\text{trends}} + \epsilon_{ict},$$

- c = city; t = year
- WA_rural = rural, growing season water availability; TEMP_city = city temperature; PREC_city = city precipitation
- Standard errors: clustered at city level
- Identification: Exploit **random natural variation** in **precipitation** and **evapotranspiration** as source for **exogenous** year-by-year realizations of **water availability shocks** during the **growing season** outside the city to explain year-to-year variation in city-level economic activity.

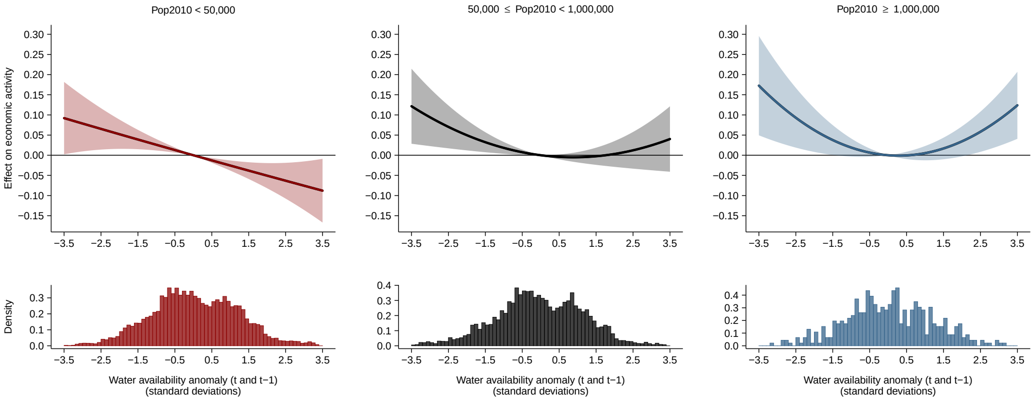
Results I: Agricultural productivity shocks and city growth



City growth in small (red), middle (black), and large (blue) cities



Results II: Heterogenous effects in small, middle, and large cities



Policy implications for sustainable city growth.

- Disturbances in water availability become more frequent, longer and intense due to climate change.
- Dry and wet conditions occurring in rural areas lead to changes in city growth within nearby cities and towns.
- Cities responds non-linearly to these shocks and that different cities respond differently.
  - City growth stronger in larger cities.
- Policy measures for sustainable city growth need to take climate induced rural-to-urban migration into account.
- Next steps:
  - Heterogeneities within cities.
  - Differences in market access and trade exposure.

Thank you!

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BS1: Water Availability

back

Atmospheric water availability (WA): WA

- Combines **water supply** (=*precipitation*) with **water demand** (=*evapotranspiration*) to measure **water availability** (Vicente-Serrano, Van der Schrier, Beguería, Azorin-Molina & Lopez-Moreno 2015, Konapala, Mishra, Wada & Mann 2020):

$$WA_{imt} = Precipitation_{imt} - Potential\ Evapotranspiration_{imt}$$

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Within-year variation of WA: Greenest month

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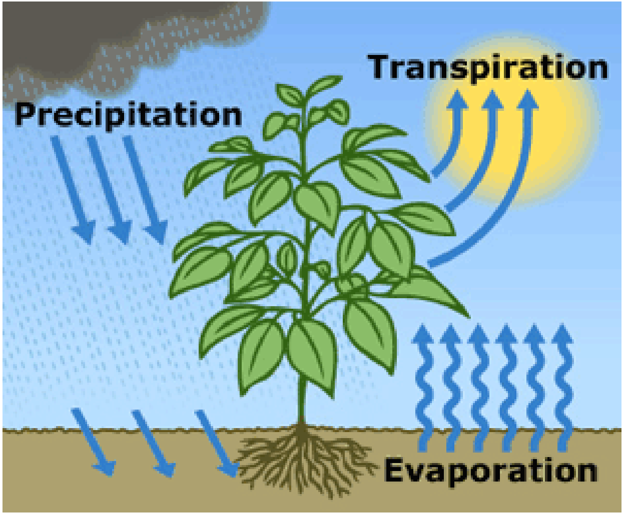
Standardized Water Availability Anomaly (SWAA):

- $SWAA_{it}^{GS} = \frac{WA_{it}^{GS} - \overline{WA_{i}^{GS}}}{\sigma(WA_{i}^{GS})}$
- SDs by which each grid cell's **growing season** WA deviates from long-term norm

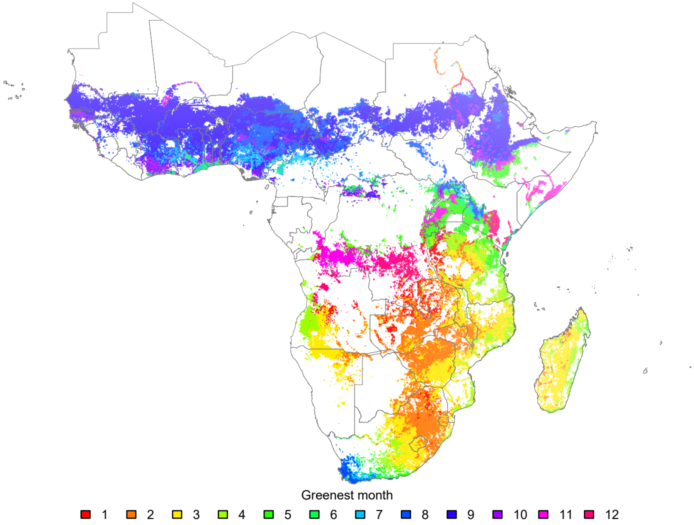
BS2: Evapotranspiration

back



BS3: Greenest month 2001-2021

back



BS4: Data procedure

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1. Identification of urban boundaries.
   - Global Human Settlement Layer (1km resolution, 2010-2020); Source: Schiavina et al. 2022.
   - Open Street Map.
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3. Agricultural productivity shocks.
   - ERA5-Land (0.1° resolution, 1981-2021); Source: Munoz-Sabater et al. 2021, Singer et al. 2021.
   - MODIS/Terra Vegetation Indices (0.05° resolution, 2000-2021); Didan 2021.
   - Global Land Analysis & Discovery (0.025° resolution, 2011); Source: Potapov et al. 2021.