# GIS and data tools for estimating domestic self-supply groundwater use in urban Africa

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## Estimating domestic self-supply groundwater use in urban continental Africa

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### Abstract

Self-supply of groundwater for domestic use in urban sub-Saharan Africa (SSA) is common, but the extent to which it is practiced is unknown. We developed an open data based GIS method for continental Africa (without islands) using groundwater storage, depth to groundwater, aquifer productivity, and population density data. Furthermore, we developed proxies for public supply network coverage and socio-economic status, incorporating restriction measures for groundwater use. Our results indicate that in 2015 about 369 million urban inhabitants (~79% of the total urban population) of continental Africa could potentially supply themselves with groundwater. However, the likely number of urban inhabitants using groundwater obtained via self-supply was less: about 150 million (~32% of the total urban population). With the novel GIS based methodology presented here, the urban population using self-supply groundwater for domestic use can be determined, which is essential to inform policy and practice, and to influence public investment.

- https://doi.org/10.1088/1748-9326/ab9af9

## Background
# Self-supply dependence

- Self-supply of groundwater for **domestic use** in urban sub-Saharan Africa (SSA) is common, but the extent to which it is practiced is unknown.

- The objective of this research is to present a method and estimates for the **Urban population Using Groundwater obtained via Self-supply** (UUGS) for the entire African continent (without islands).

# Method- *Process*

## Maximum urban population to use groundwater obtained via self-supply (continental)

$$G_M = F_M U$$

$F_M$ → Conditional algorithm considering **groundwater storage**, **depth to groundwater** and **aquifer productivity** in continental Africa (MacDonald et al., 2012)

$U$ → Urban population per km$^2$

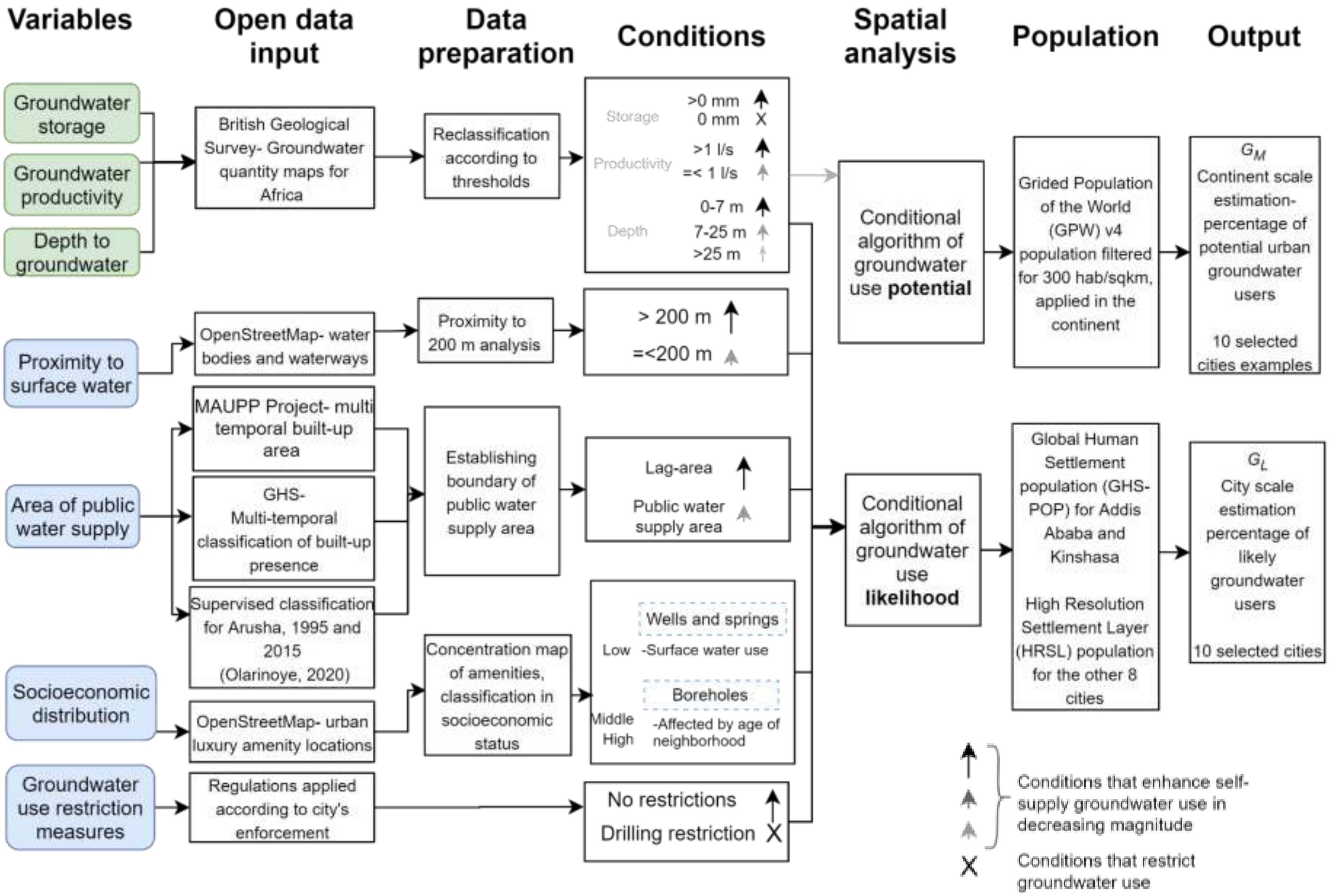
## Likely urban population to use groundwater obtained via self-supply (10 sample cities)

$$G_L = F_L U$$

$F_L$ → Conditional algorithm as maximum proportion but includes **proximity to surface water**, **socio-economic status**, **lag area of the public water supply**, and **imposed groundwater use restriction measures.**

| | |
|---|---|
| Low | 0-0.35 |
| Average | 0-0.65 |
| High | 0-0.95 |

# Method- *Process*



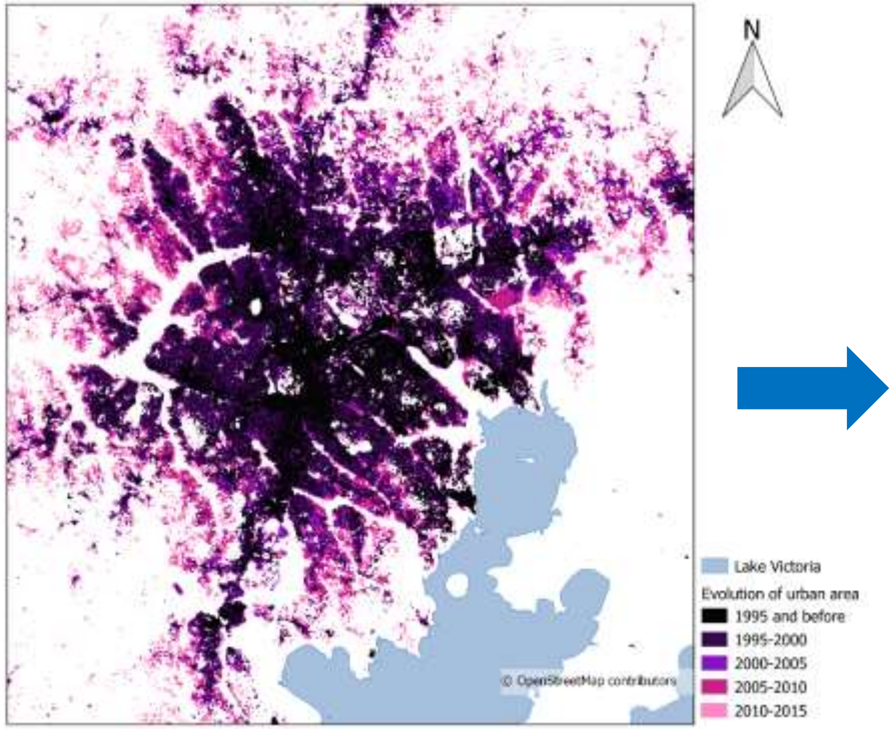
# Proxies- *Lag-area of the public water supply*

Gather data on water supply coverage for all cities

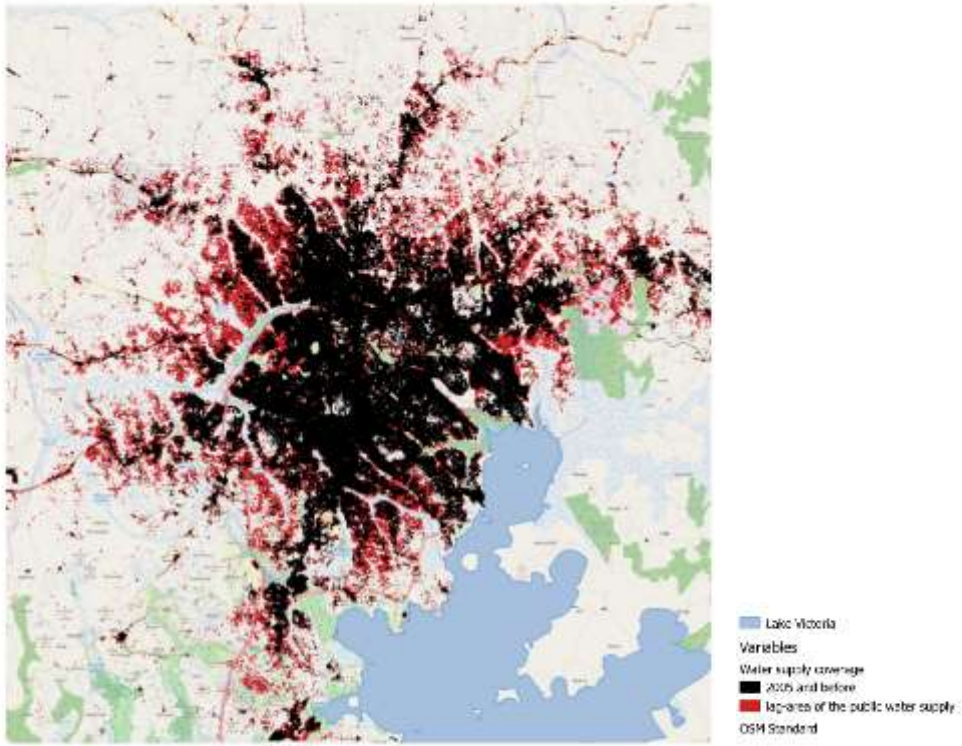
**(% of population with service)**

Calculate number of people served based on the 2015 (or closest available) population of the city

Define temporal-dependent urban boundaries where water supply service is assumed to occur




*Evolution of urban area in Kampala 1995-2015 in 5 year intervals. (Data of Shimoni, 2015)*

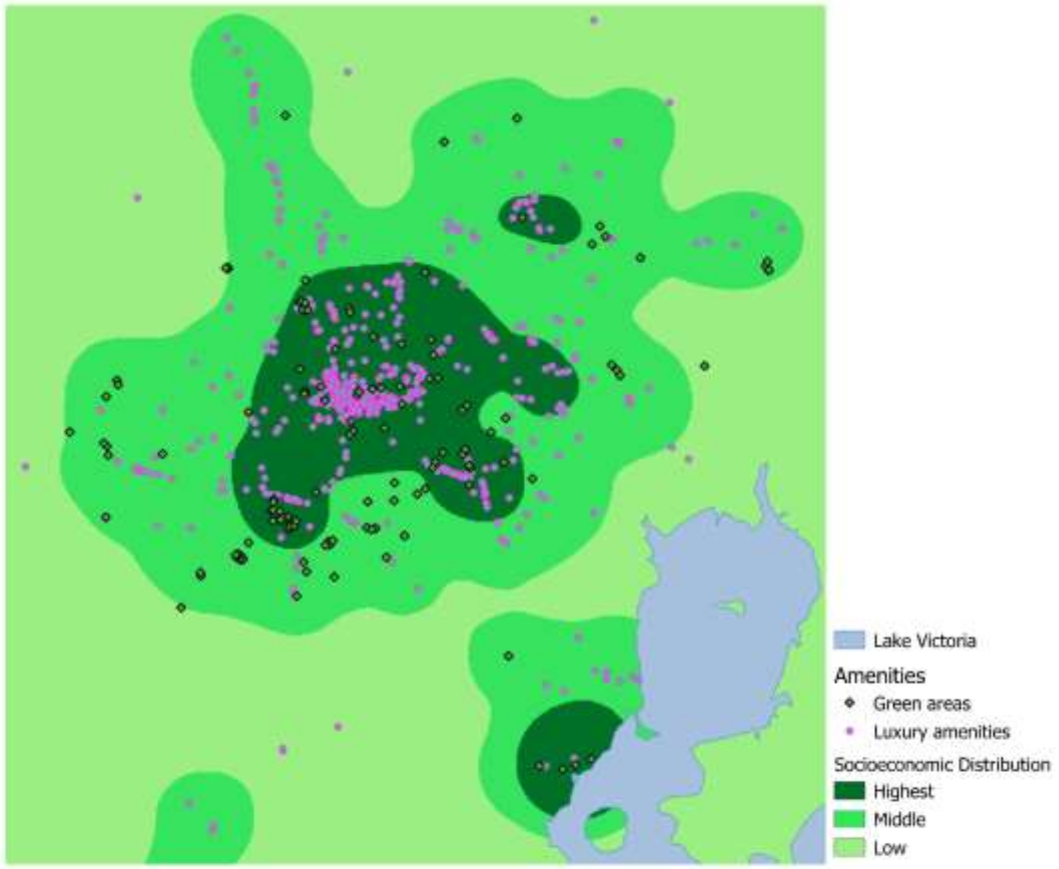



*Lag area of the public water supply (Data of Shimoni, 2015)*

# Proxies- *Socioeconomic Distribution*

Spatial concentration (Kernel density) of luxury amenities and green areas (OpenStreetMap) → Country income distribution → Define socioeconomic boundaries within the city

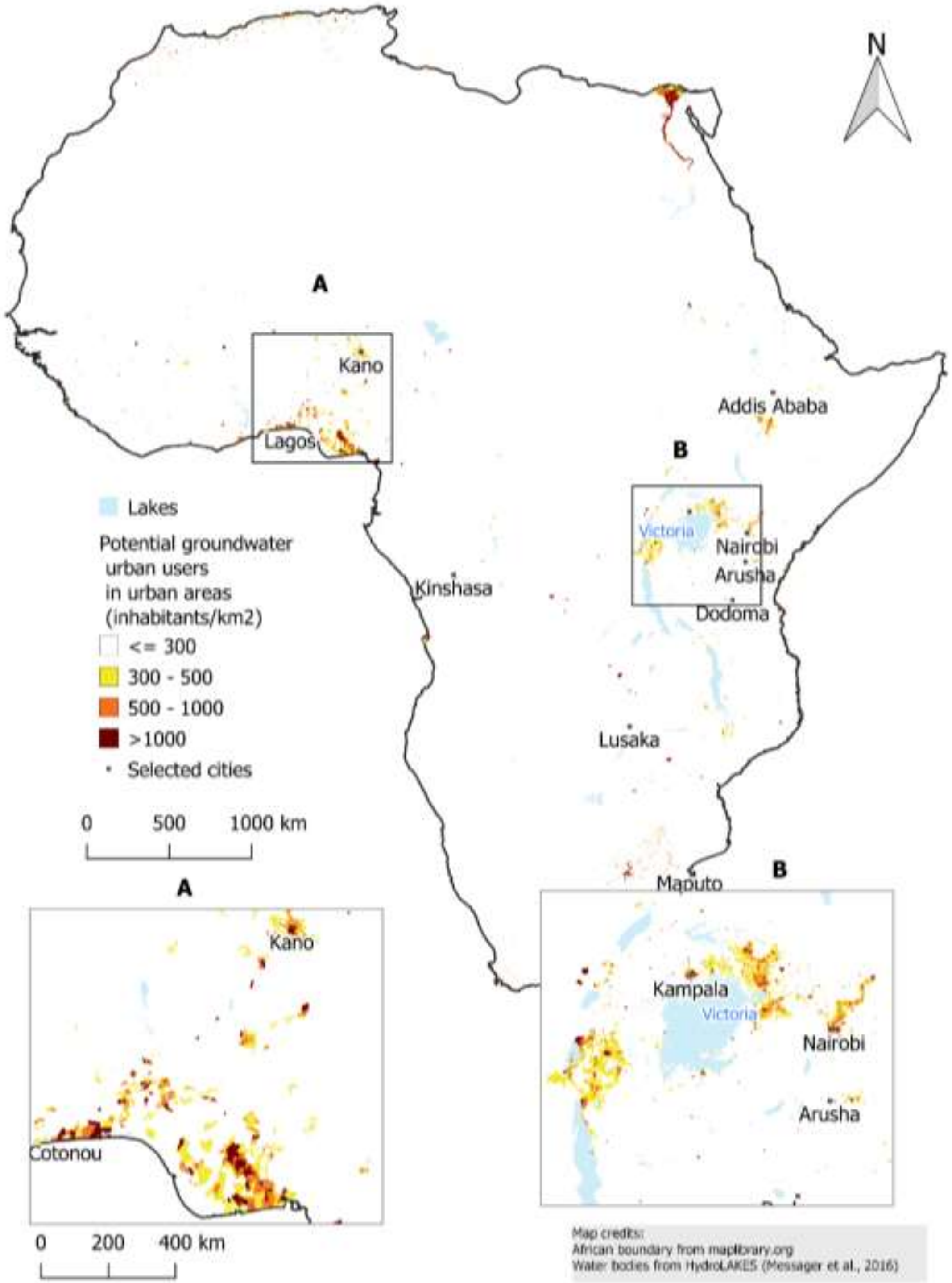
- Socioeconomic distribution will affect which technologies people use to acces groundwater.
- In the method this links socioeconomic distribution with groundwater variables
  - Aquifer productivity → boreholes → higher socioeconomic distribution
  - Groundwater depth →hand-dug wells →lower socioeconomic distribution



# Results-

## *Potential self-supply groundwater use*

Approximately **79%** of the total urban population could potentially use groundwater to meet their domestic needs.



# Results- *Self-supply groundwater use likelihood*

| City | $G_{M\%}$ | $G_{L\%}$ | | | Actual UUGS (PMA) |
|---|---|---|---|---|---|
| | | $F_{L\_min}$* | $F_L$ | $F_{L\_max}$ | |
| Arusha | 90% | 24% | 48% | 71% | 65% ± 15%** |
| Kampala | 75% | 8% | 17% | 25% | 25% ± 3% |
| Kano | 71% | 27% | 52% | 76% | 83% ± 1% |
| Addis Ababa | 90% | 9% | 18% | 27% | 3% ± 1% |
| Kinshasa | 63% | 7% | 19% | 29% | 18% ± 1% |
| Lagos | 89% | 5% | 36% | 56% | 61% ± 1% |
| Nairobi | 77% | 13% | 30% | 44% | 6% ± 1% |
| Average | 79% | | 31% | | |
| Maputo | 52% | 8% | 21% | 32% | n.a.*** |
| Dodoma | 89% | 21% | 44% | 65% | " |
| Lusaka | 76% | 16% | 36% | 53% | " |

*: $F_{L\_min}$ : 0 - 0.35; $F_L$: 0 - 0.65; $F_{L\_max}$: 0 - 0.95;

**: based on Komakech and de Bont, 2018;

***: n.a.: not available;

Extrapolating, we estimate that around **32%** of the urban African population, are *likely* to use groundwater obtained via self-supply.

Earlier studies estimated that more than 30% of the urban population depends on wells, boreholes or springs as their principal source of drinking water.

# Limitations

Full groundwater potential is often not used- 'groundwater awareness' is missing

Local deviations or water governance arrangements not captured in simplified urban analysis

Hydrogeological input data has a resolution of 5 square kilometers

# Implications

- This paper helps us to understand the scale and magnitude of *potential* and *likely* groundwater use in urban sub-Saharan Africa.
- Clearly, household investments are significant and that they should be recognised as such.
- In many urban African contexts, self-supply using groundwater for domestic water supplies is here for the foreseeable future.

# Thanks!

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