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VU VRIJE UNIVERSITEIT AMSTERDAM

Abstract

Global Urban Drought Risk Under Climate Change

Tristian Stolte et al. (in prep.)

EGU General Assembly 2022

Photo by: Shravan K Acharya

About the authors

Tristian Stolte, MSc	-	PhD researcher in global urban disaster risk at IVM-VU
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Research Question

Tristian Stolte et al. (in prep.)

- What is the distribution of drought risk among cities across the globe?
  - Current & future risk patterns
  - Based on methods from global urban water scarcity literature

Scope of the research

Tristian Stolte et al. (in prep.)

- Global scale
  - 264 urban agglomerations
- Hydrological drought
  - Surface water only
- Risk
  - Including components of hazard, exposure, and vulnerability
- Open source data only
- Historical: 1971 – 2010
- Future: 2031 – 2070 (rcp2.6-SSP1 & rcp6.0-SSP3)

Why urban drought?

Tristian Stolte et al. (in prep.)

Many people will think of wilting crops and dried soils when thinking of drought:

Photo by Md. Hasanuzzaman Himel

Photo by Grant Durr

Why urban drought?

Tristian Stolte et al. (in prep.)

But cities are affected just as well:

Although a drought does not necessarily need to happen inside the city for it to have impact…

Why?

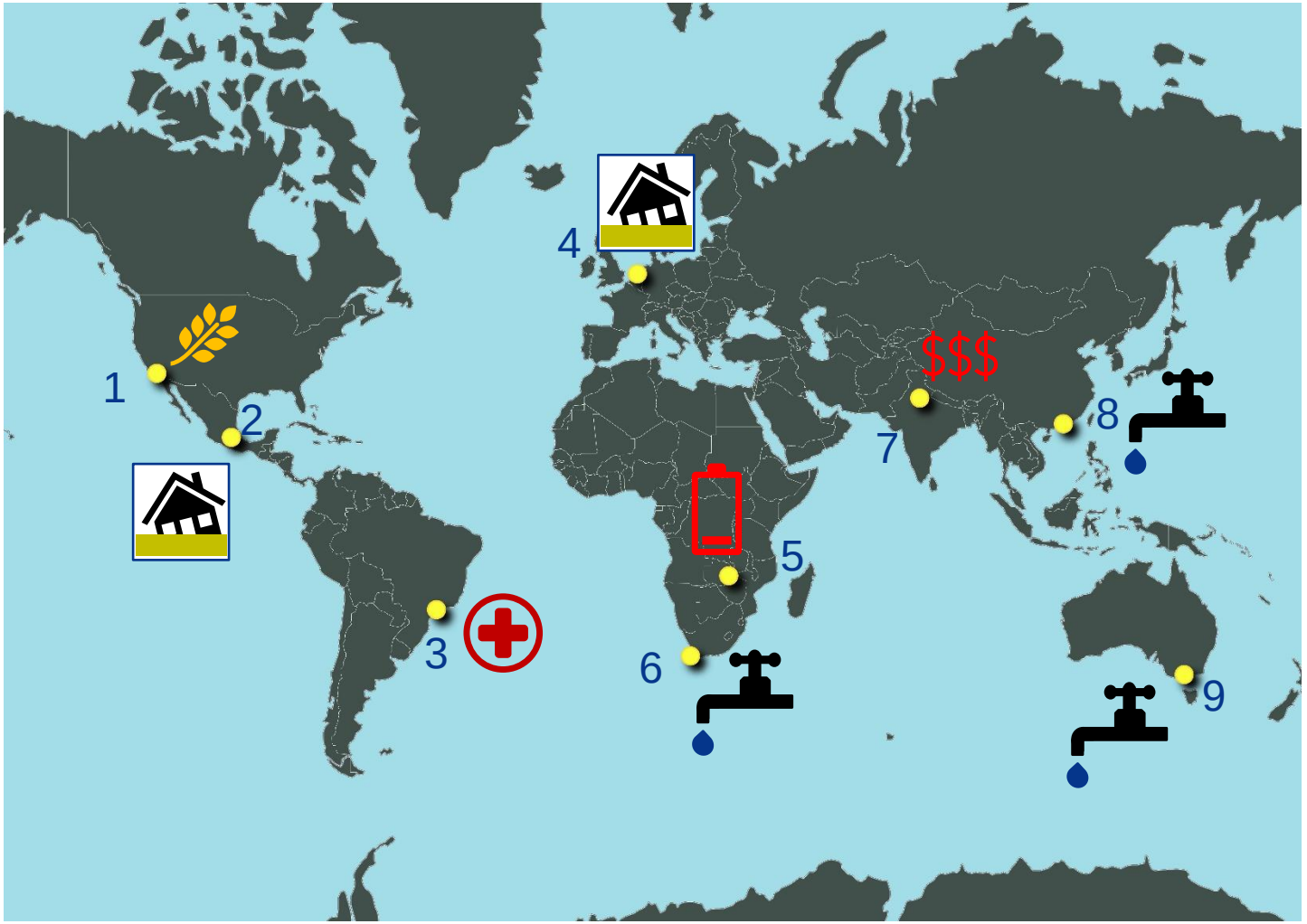
Tristian Stolte et al. (in prep.)

- Most cities obtain their water for consumption and production from either surface water or groundwater sources (McDonald et al., 2014)
- If drought hits a reservoir, cities are impacted, but the drought occurs outside the city boundaries

Several past urban drought events and their impacts

Tristian Stolte et al. (in prep.)

1. Los Angeles – wilting of urban vegetation
2. Mexico City – Sinking buildings
3. São Paulo – Sanitation and health affected
4. Amsterdam – Sinking buildings
5. Lusaka – Reduced hydropower supply
6. Cape Town – Reduced water supply
7. New Delhi – Increased pricing of water
8. Shenzhen – Reduced water supply
9. Melbourne – Reduced water supply



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Note that these are just some examples of cities and impacts; this map is not exhaustive

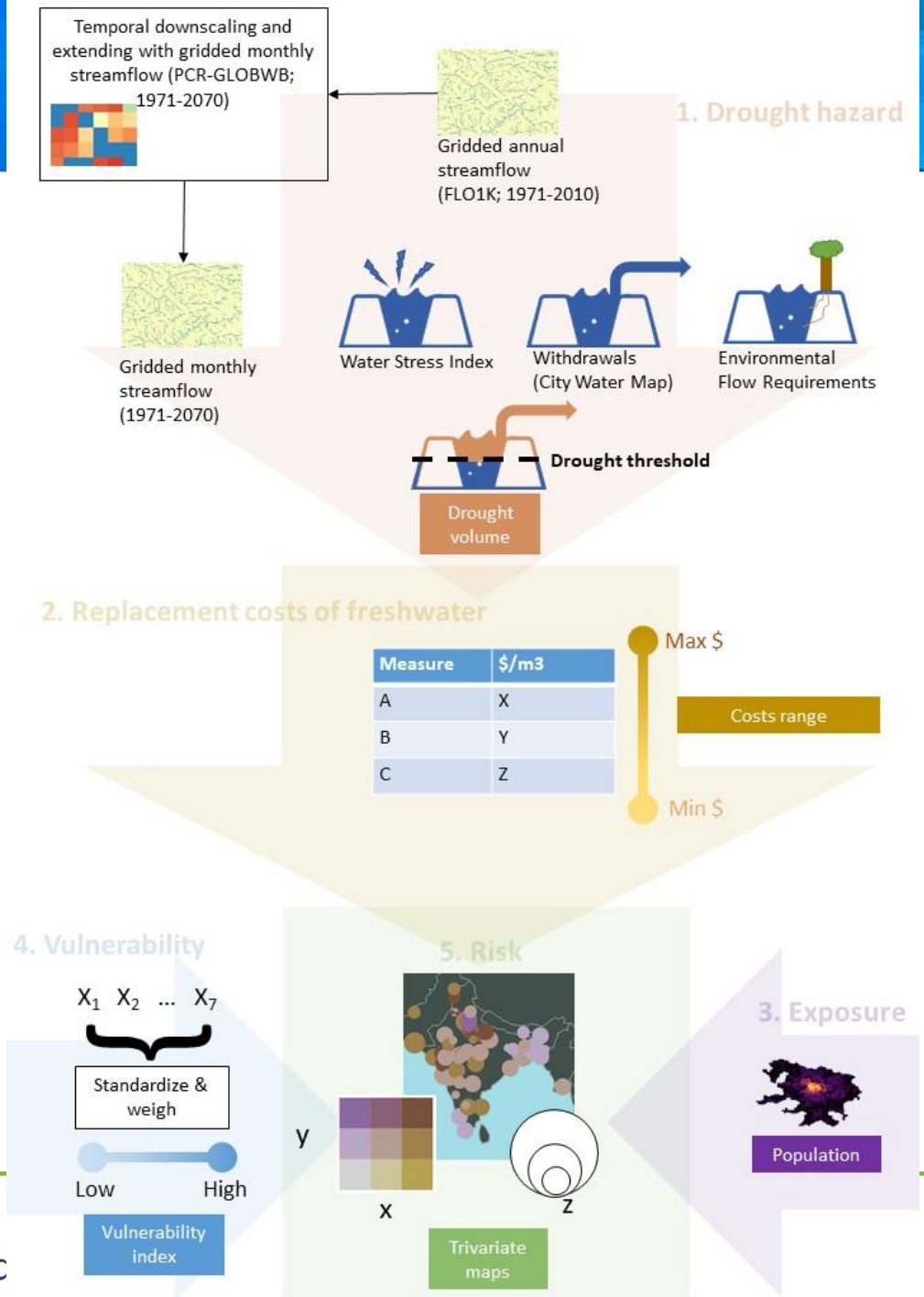
Why global urban drought?

Tristian Stolte et al. (in prep.)

- Drought (or any disaster for that matter) in cities is often studied on a case-by-case basis
- Not a clear vision on which cities need most urgent attention

Our methods

Tristian Stolte et al. (in prep.)



Hazard – an example

Tristian Stolte et al. (in prep.)

Threshold :

660m³/s + 200m³/s = **860m³/s**

For an 80% reduction in mean streamflow:

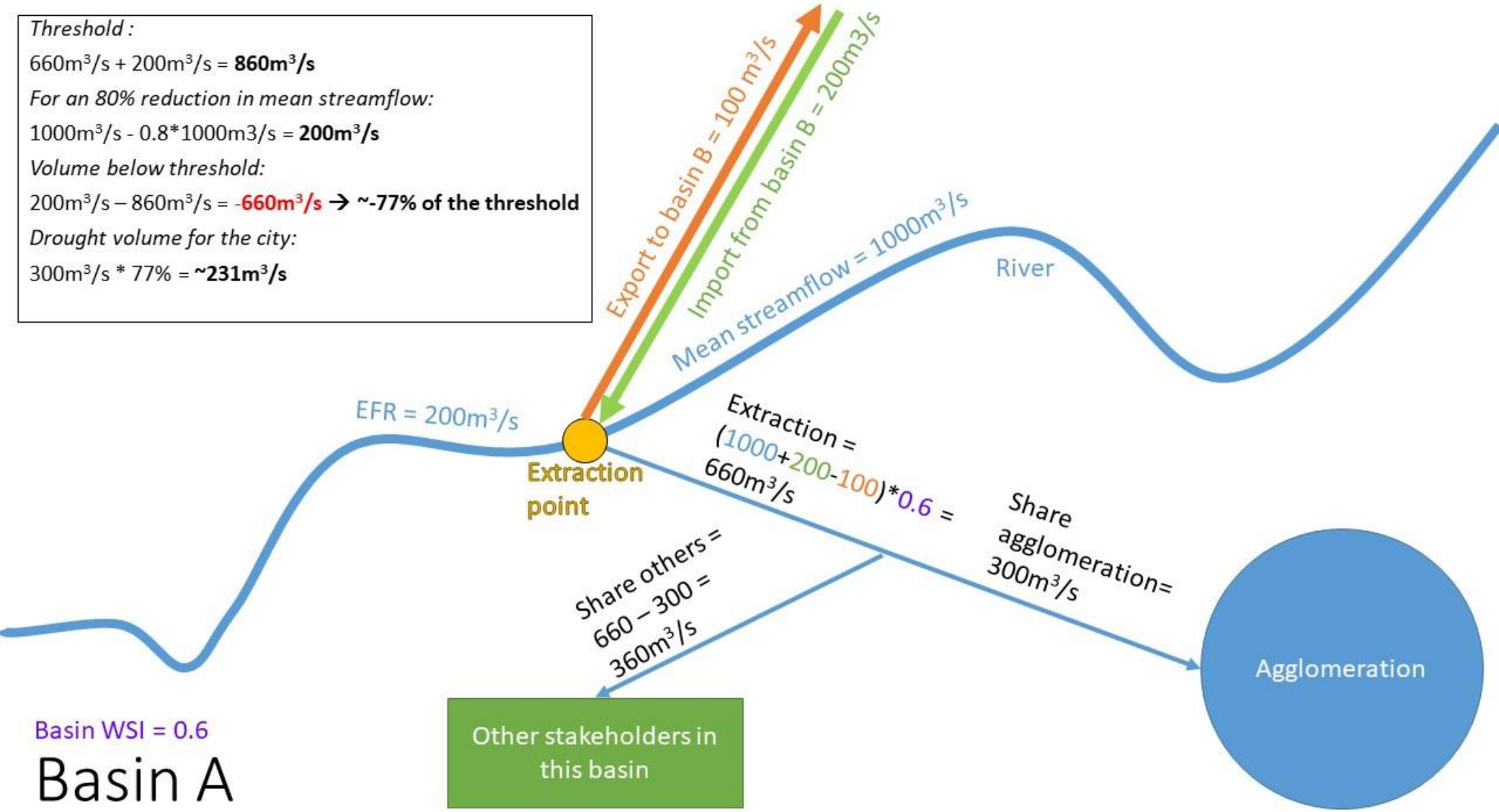
1000m³/s - 0.8*1000m3/s = **200m³/s**

Volume below threshold:

200m³/s – 860m³/s = **-660m³/s → ~-77% of the threshold**

Drought volume for the city:

300m³/s * 77% = **~231m³/s**



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These numbers are not per se representative for any city! They are used for the sake of explanation.

Freshwater replacement costs

Tristian Stolte et al. (in prep.)

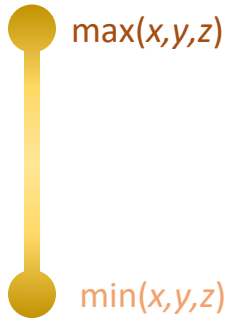
Drought volume

Volume = $v m^3$

Replacement measures

Measure	Unit cost	Total costs
Increase reservoir storage	*a*	*v*a=x*
Reuse urban residential/industrial water	*b*	*v*b=y*
Desalination	*c*	*v*c=z*

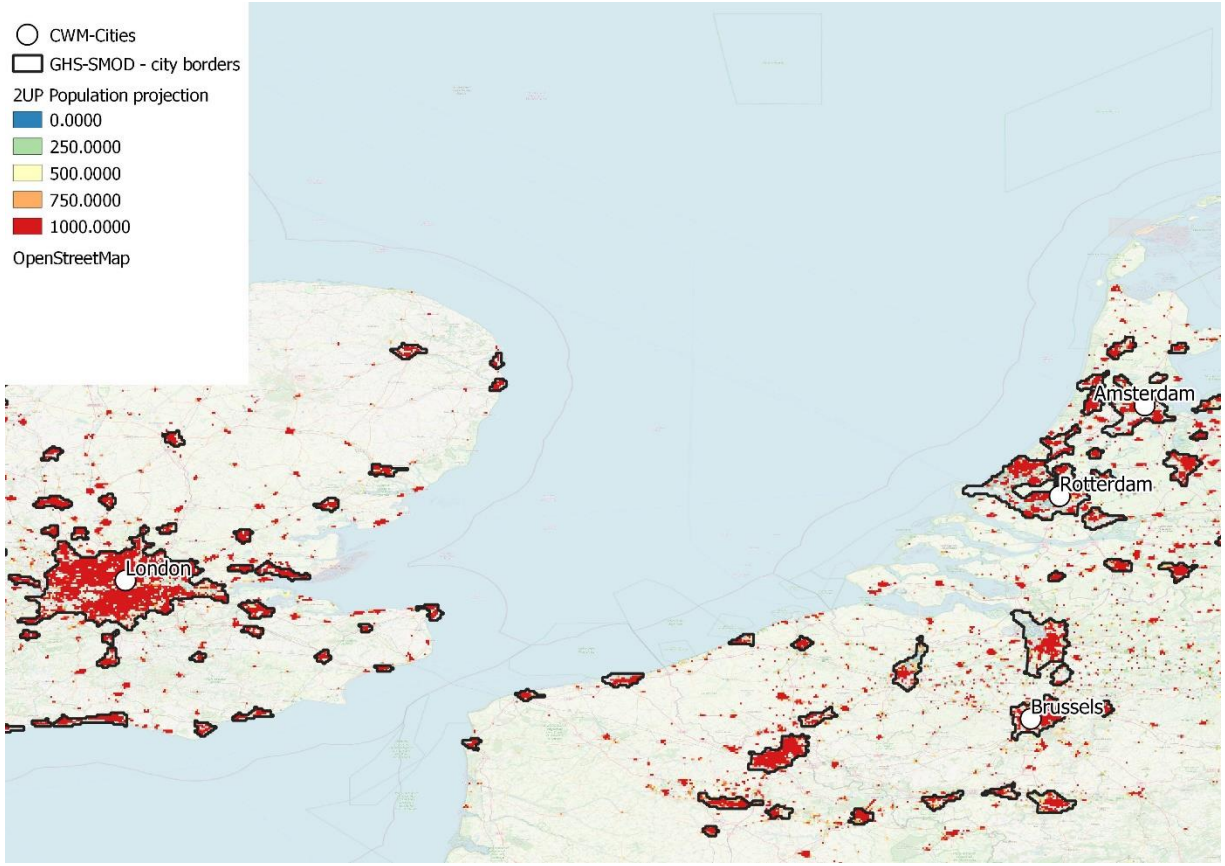
Cost range



Exposure

Tristian Stolte et al. (in prep.)

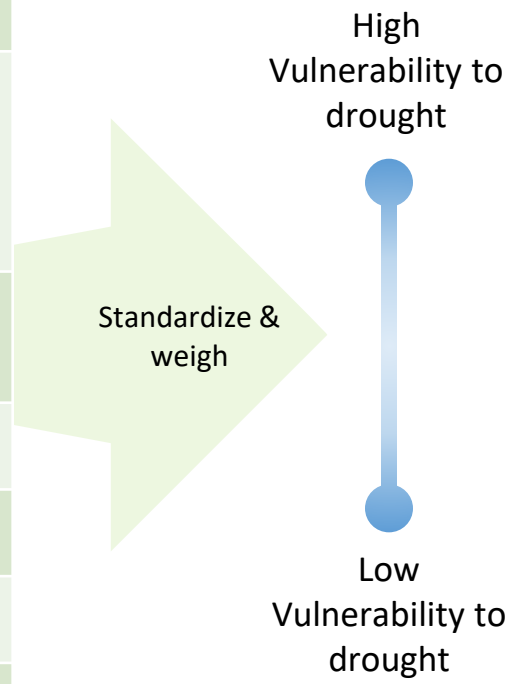
- Physical borders from GHS-SMOD
- 2UP population totals (current, SSP1, SSP3)
- City locations from which we know extraction volumes from City Water Map (CWM)



Vulnerability

Tristian Stolte et al. (in prep.)

Indicator	Variable	Unit	Year
Access to clean water	Unimproved/No Drinking Water	% of population	2015
Poverty	Poverty	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	Most recent value between 1960-2020
Water quality	Untreated Connected Wastewater	% of population	2000-2010
Government Effectiveness	Government effectiveness	-	2020
Conflict & insecurity	Number of conflicts	Count	Sum over 1989-2017
Sanitation	Unimproved/No Sanitation	% of urban population	2020
Groundwater depletion	Groundwater table decline	cm/year	Average change over 1990-2014

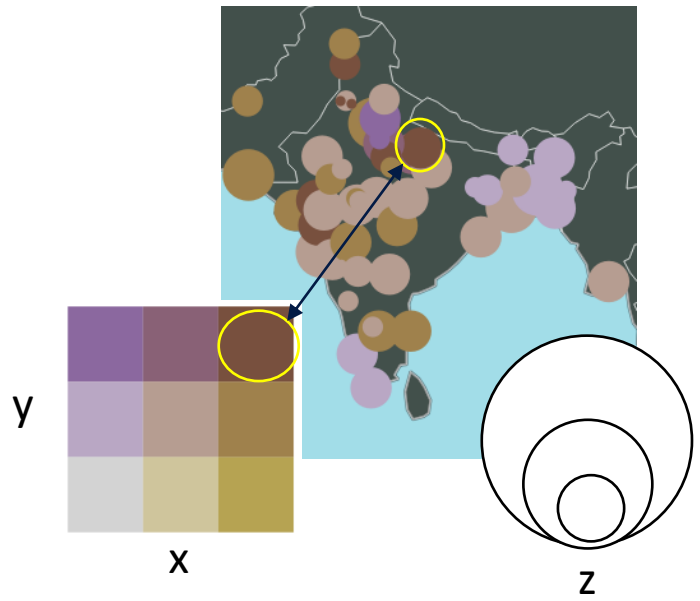


Risk

Tristian Stolte et al. (in prep.)

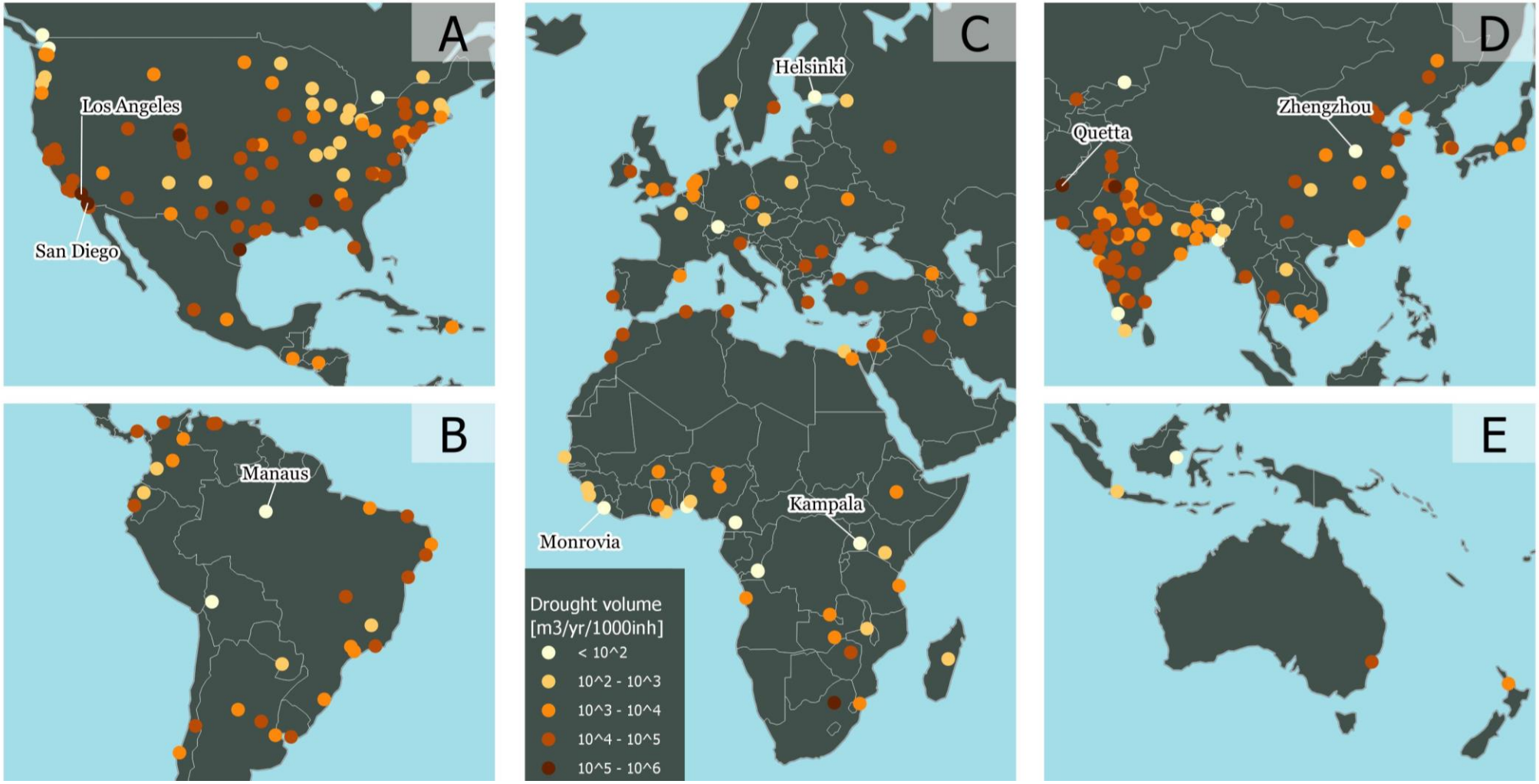
- Trivariate maps → maps with three variables
  - Max freshwater replacement costs (x) → low, medium, and high costs
  - Exposure (z) → point size of each agglomeration
  - Vulnerability (y) → low, medium, and high vulnerability

The city in the yellow circle for instance, has a high replacement costs, and high vulnerability, with medium-large exposure



Results – Hazard (current)

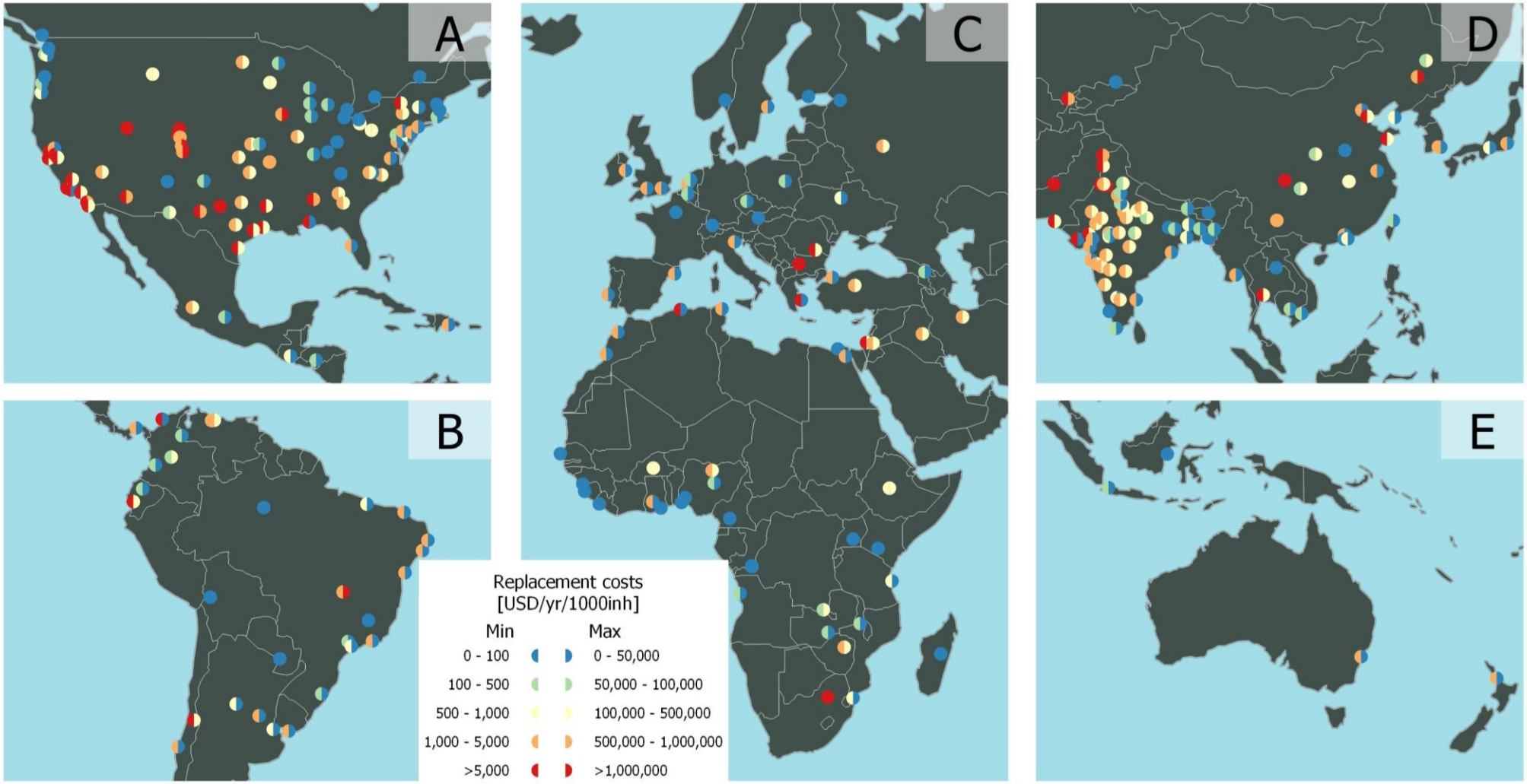
Tristian Stolte et al. (in prep.)



Note that some interesting cities are emphasized with call-outs

Results – Costs (current)

Tristian Stolte et al. (in prep.)



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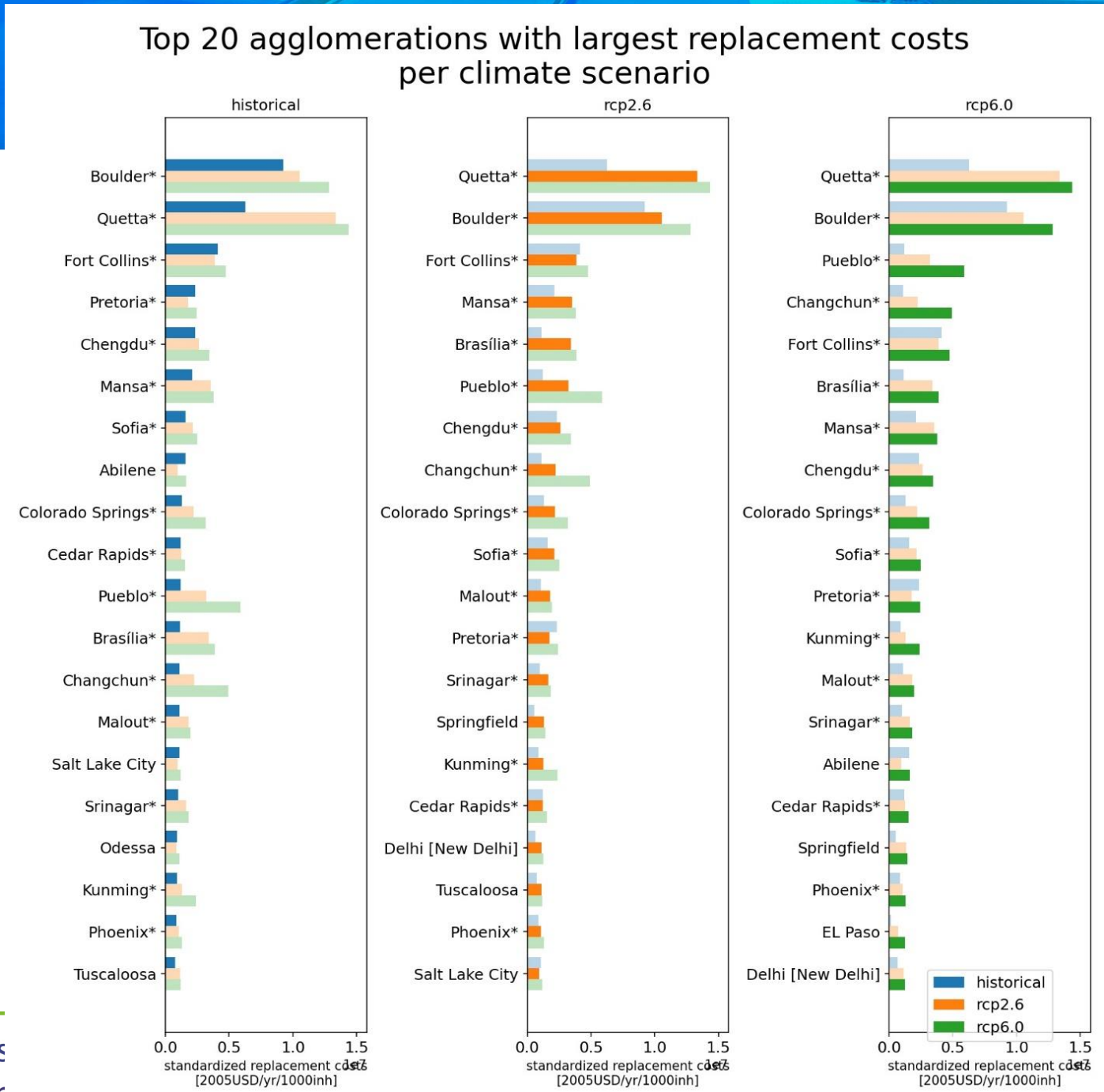

Results – change in hazard and costs

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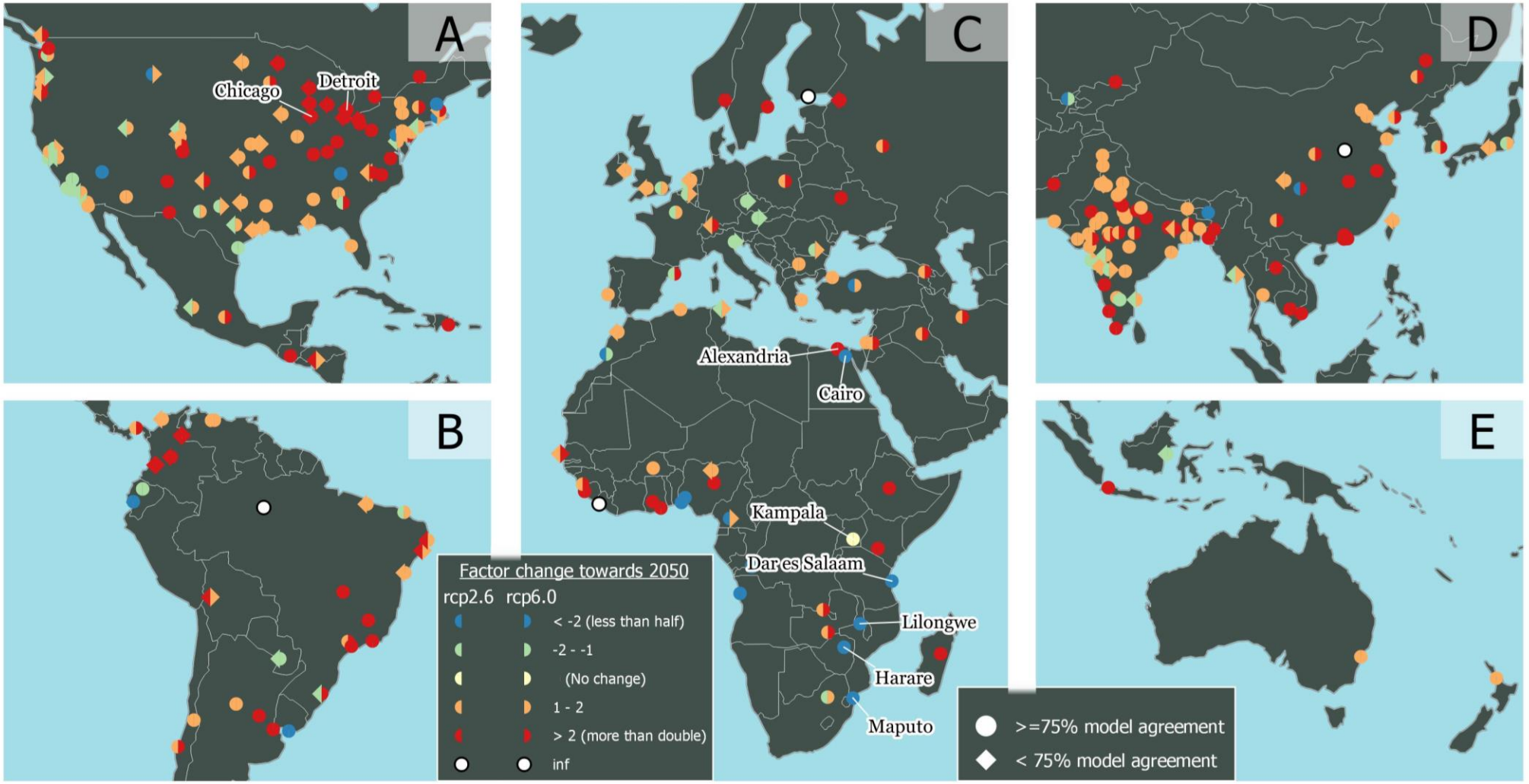

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Results – Vulnerability (static over time)

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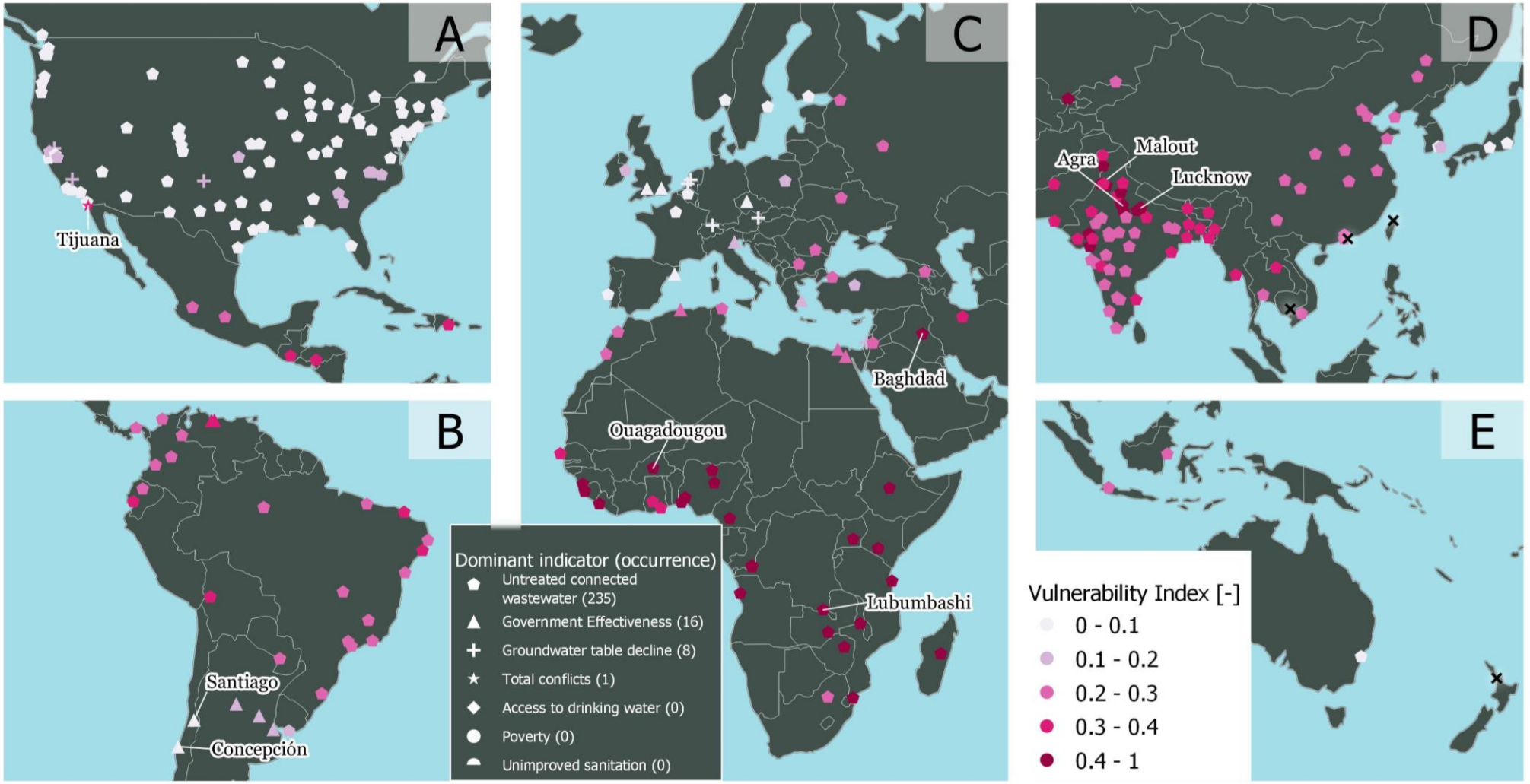

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Result – Risk (current)

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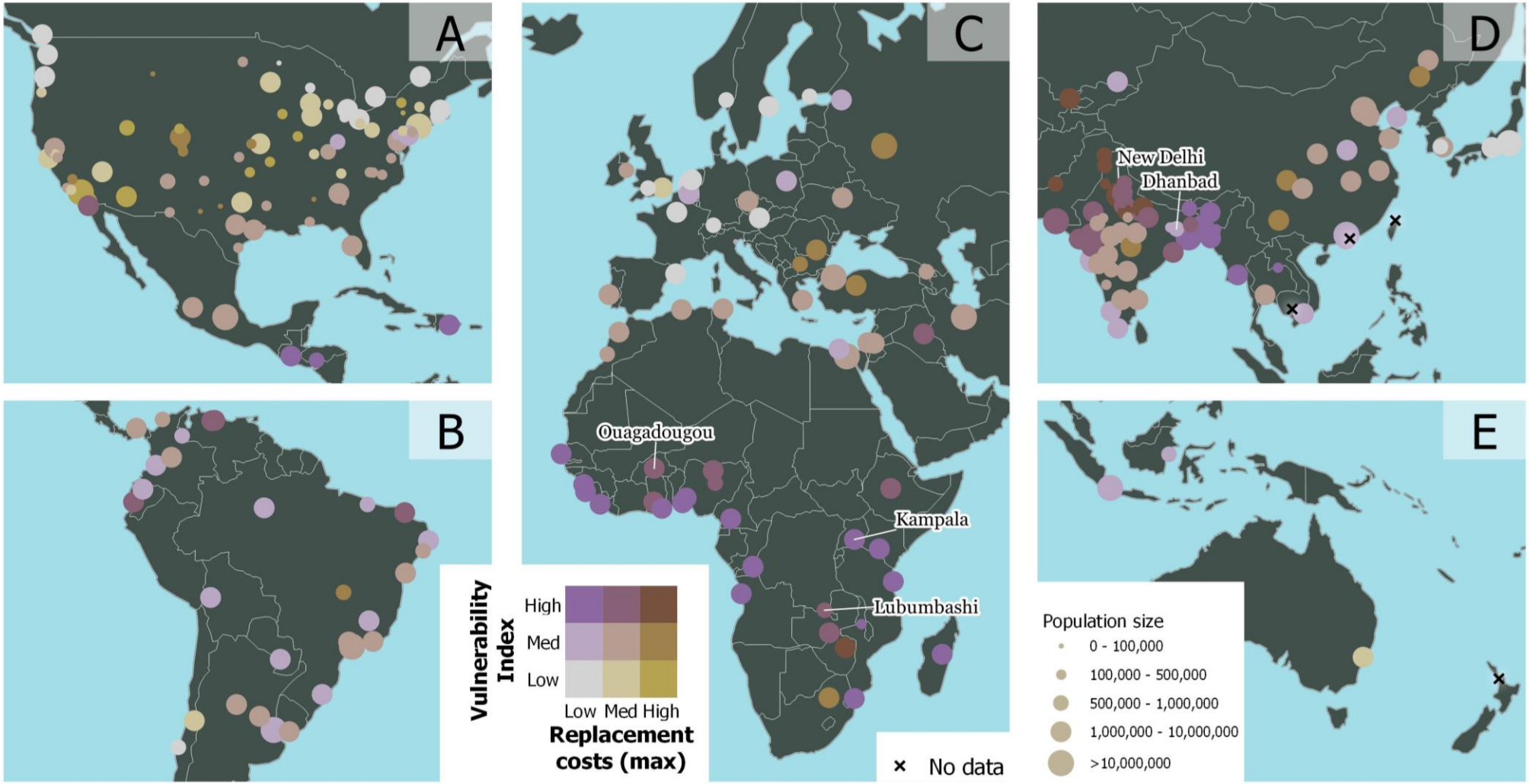

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Result – Risk (rcp2.6-SSP1)

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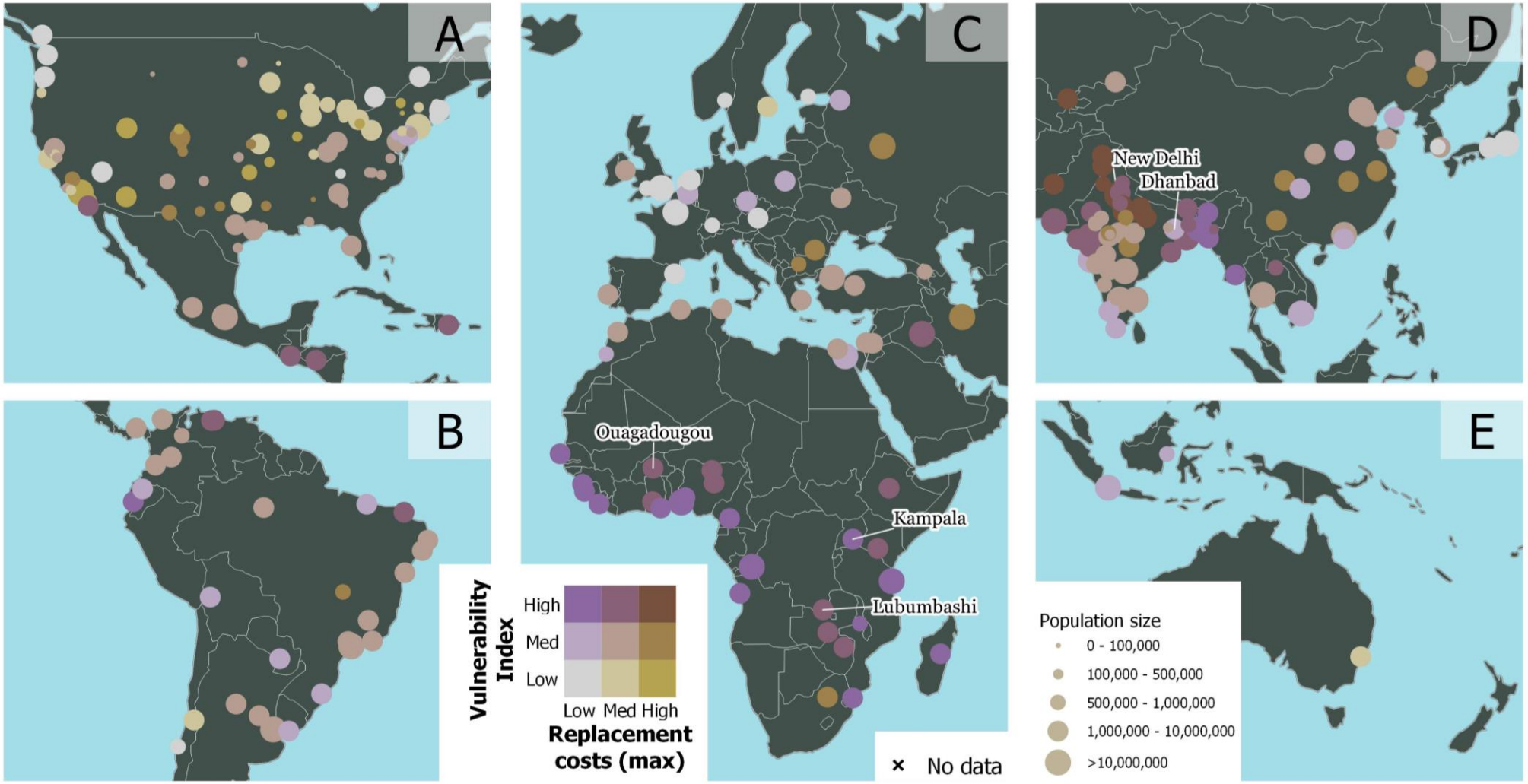

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Note that some interesting cities are emphasized with call-outs

Result – Risk (rcp6.0-SSP3)

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Coming soon!

These results can be used to…

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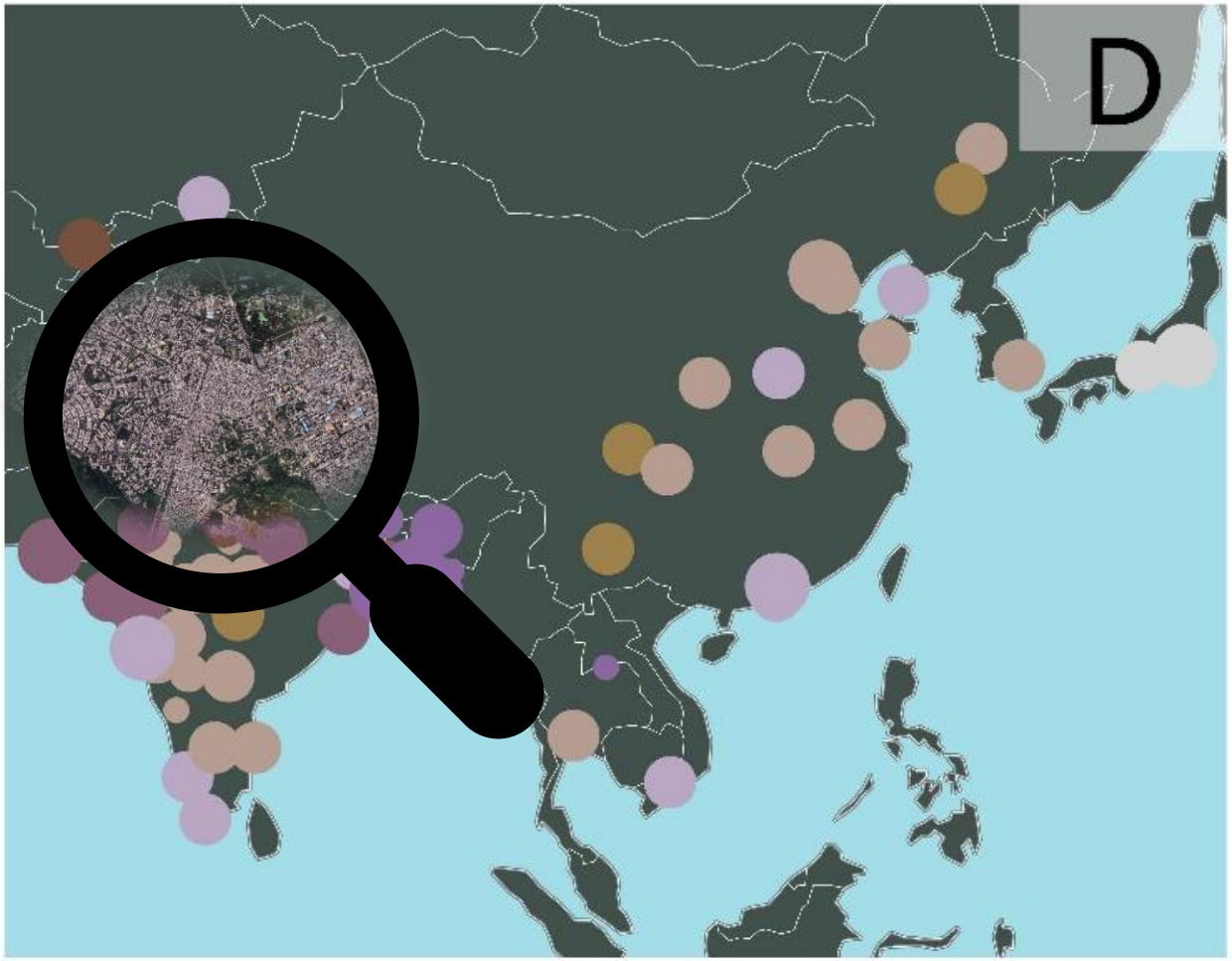


…get a better understanding of which cities we should investigate in more detail

These results can be used to…

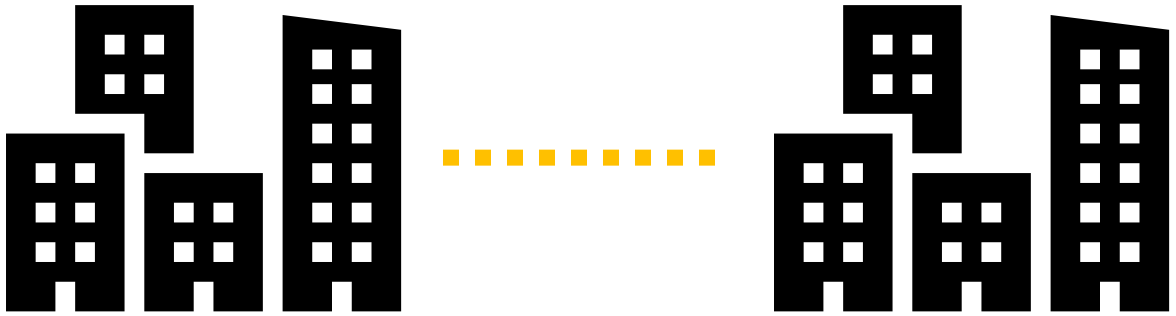
Tristian Stolte et al. (in prep.)

…put drought risk on the agenda for cities in general

These results can be used to…

Tristian Stolte et al. (in prep.)

…explore new city2city learning networks based on similar risk profiles



Changes towards 2050 that we not considered in our model

Tristian Stolte et al. (in prep.)

- Extraction volumes increases → cities will use more water (Wada et al., 2016)
- Groundwater increasingly unsustainably extracted → drought volumes increase (Flörke et al., 2018)

Conclusion

Tristian Stolte et al. (in prep.)

- Droughts can hit urban agglomerations in many different ways
- There are already several hotspots of urban hydrological drought, and the hazard is increasing for most cities in our analysis
- Exposure is also increasing for most cities
- Assuming static vulnerability, we see a rise in urban hydrological drought risk towards 2050 under the RCP2.6-SSP1 and RCP6.0-SSP3 scenarios
- Trends in urban water use and groundwater abstractions reinforce this result.

Thank you!

For more information, please contact:

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Or approach me during EGU22!