Amplifying Progress toward Multiple Development Goals through Resource Recovery from Sanitation

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Rabat, Morocco

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Guest Research Group
ENGINEERING FOR SUSTAINABILITY

John Trimmer

Roland Cusick

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The U.S. Government's Global Hunger and Food Security Initiative

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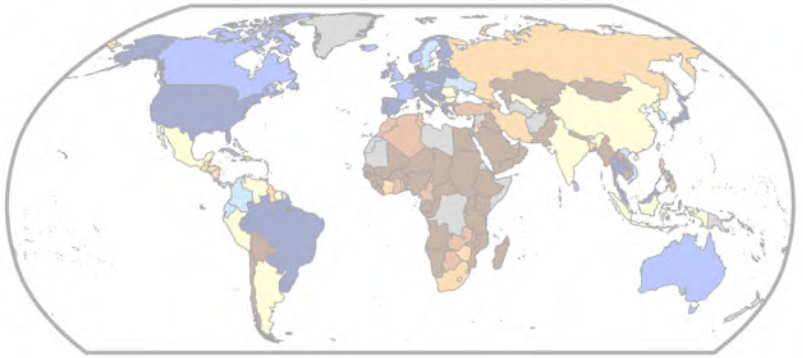
ENGINEERING FOR SUSTAINABILITY

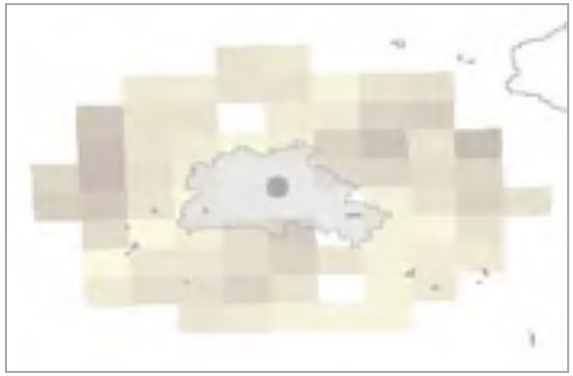
Today I'll focus on opportunities to leverage human excreta to advance sanitation and development.

incentivizing safe management of human excreta

understanding the resource potential



prioritizing large-scale implementation



Countries with low sanitation coverage also have limited access to agricultural inputs and clean energy.

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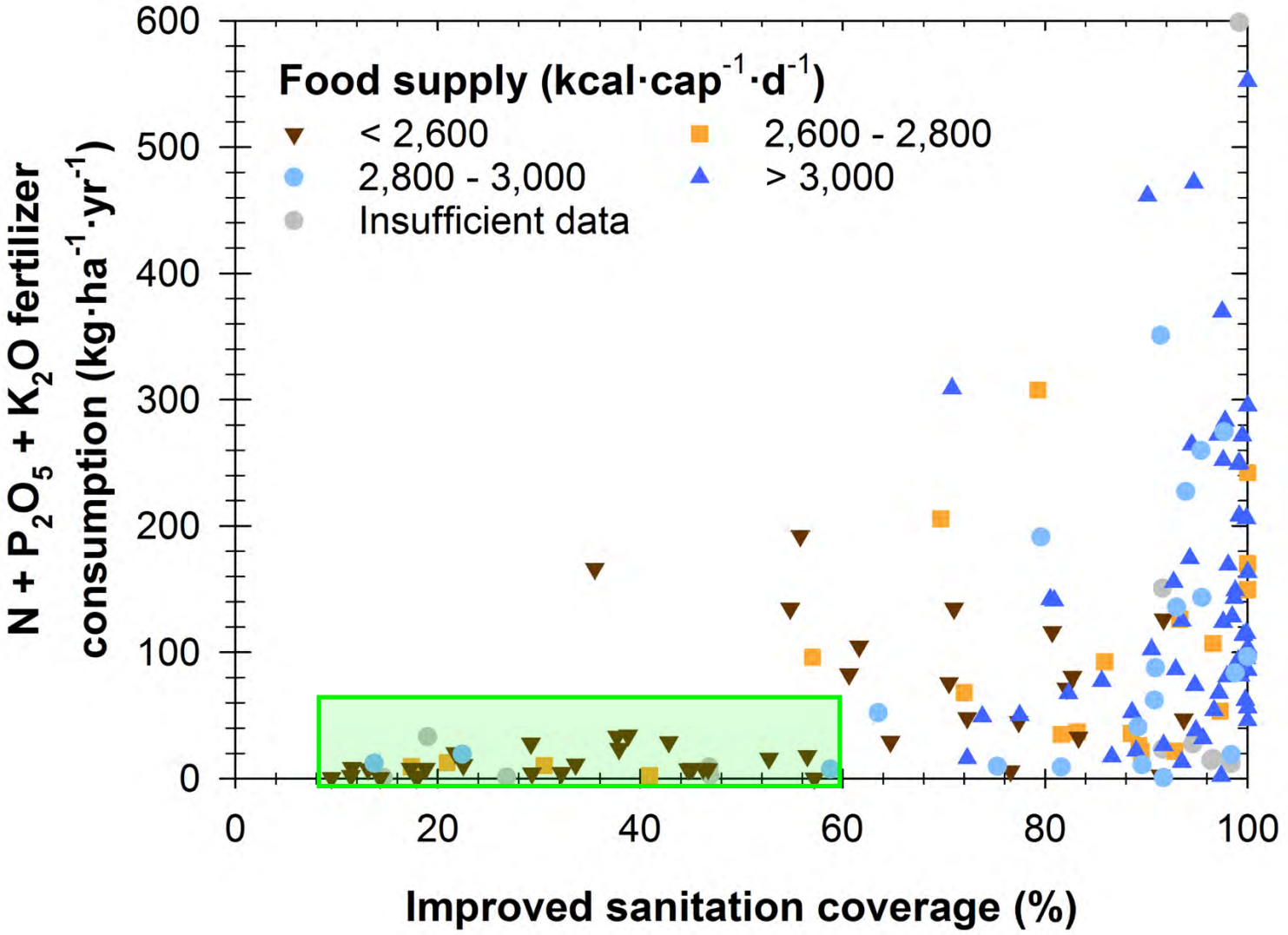
sanitation

agriculture

energy



[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

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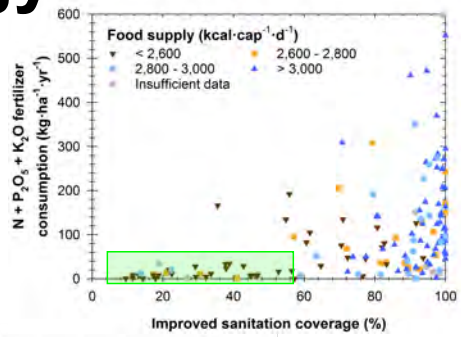
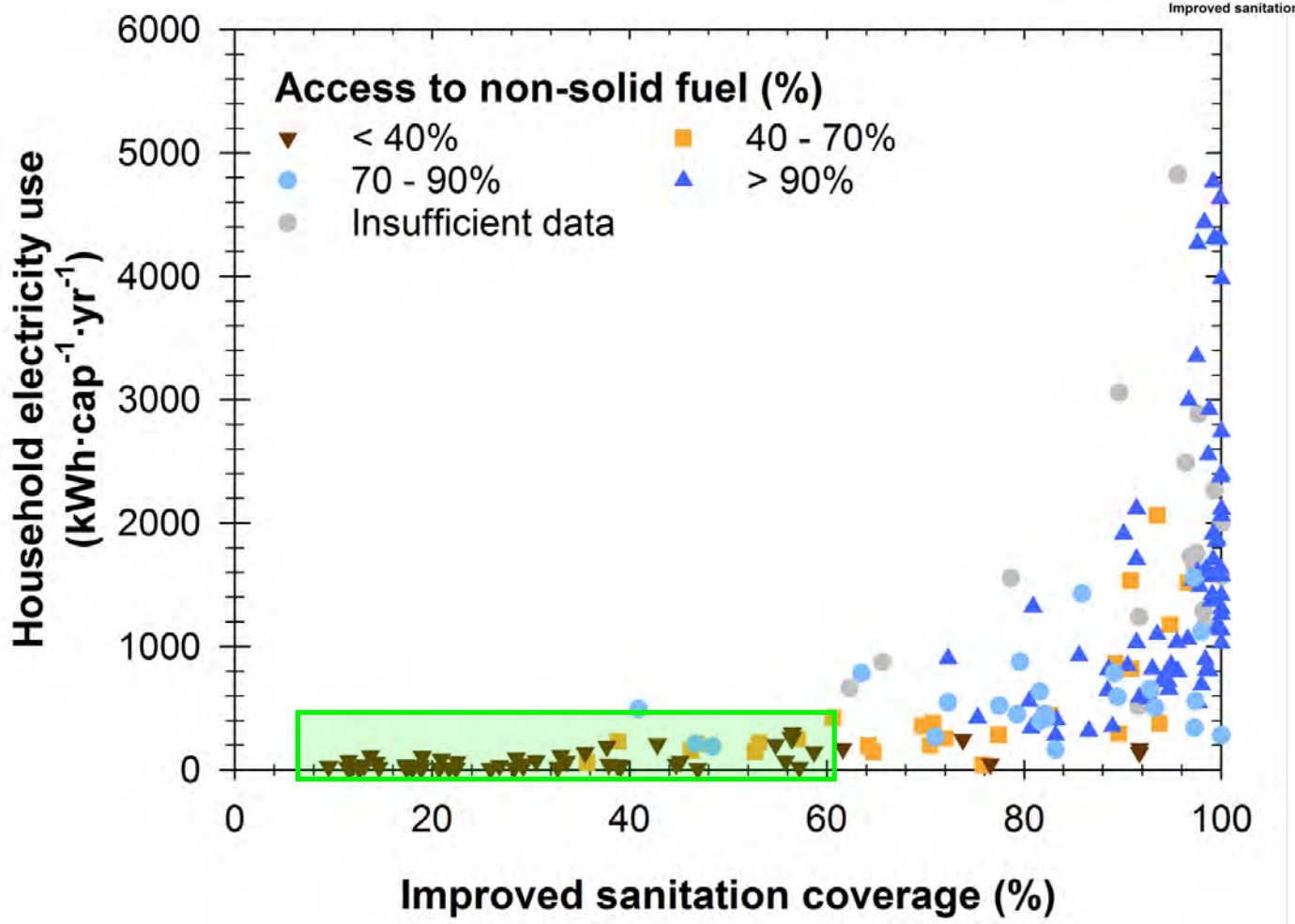




[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Can resource recovery from sanitation amplify progress toward multiple SDGs at regional, national, and global scales?

Universal access to safe drinking water and sanitation

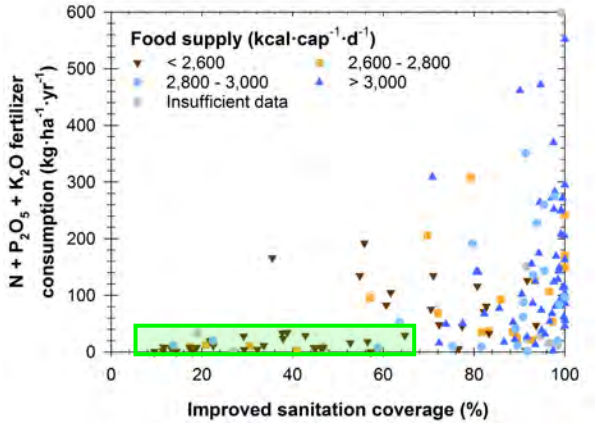
6.2 Universal and equitable access to sanitation

6.3 Halve proportion of untreated wastewater

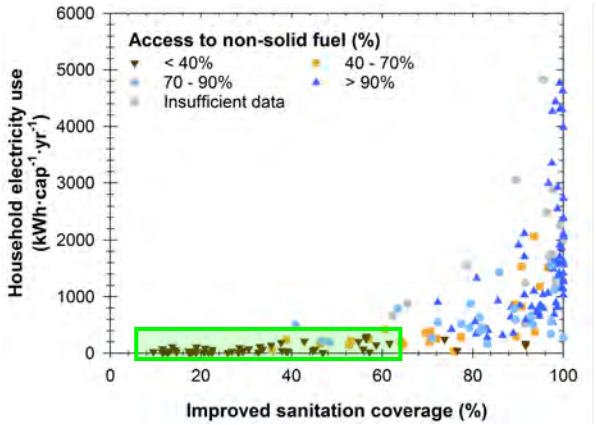
End hunger and promote sustainable agriculture

Ensure access to affordable, reliable, sustainable energy

nutrients for agriculture

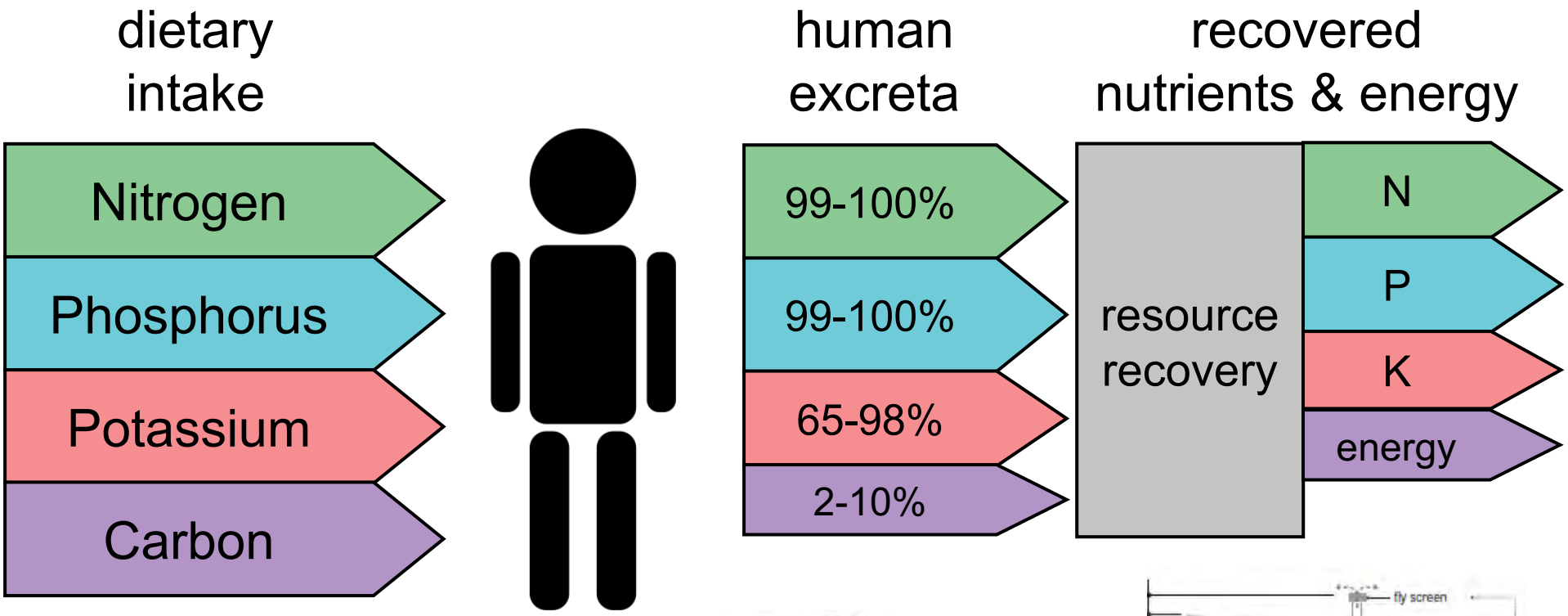


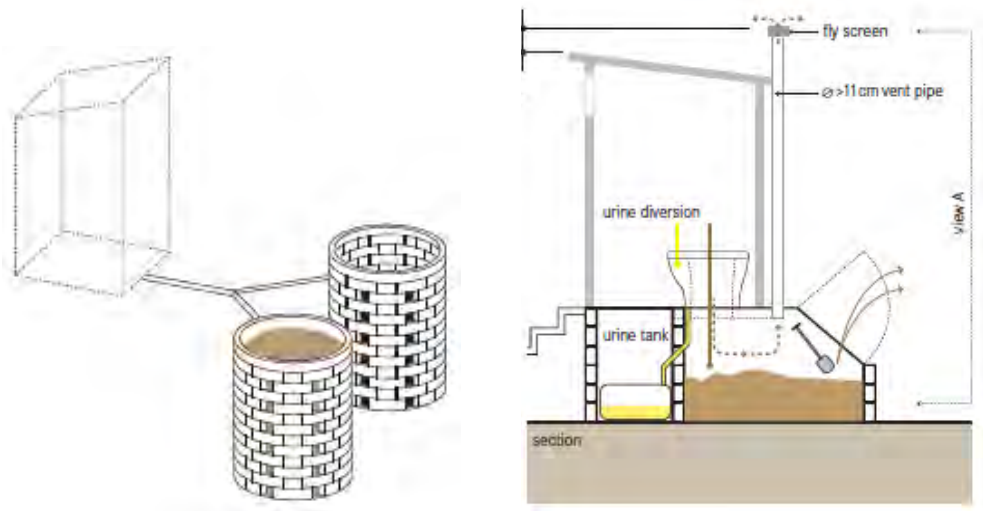
household energy



[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Technologies exist to recover resources from human excreta, but vary in their relative sustainability.

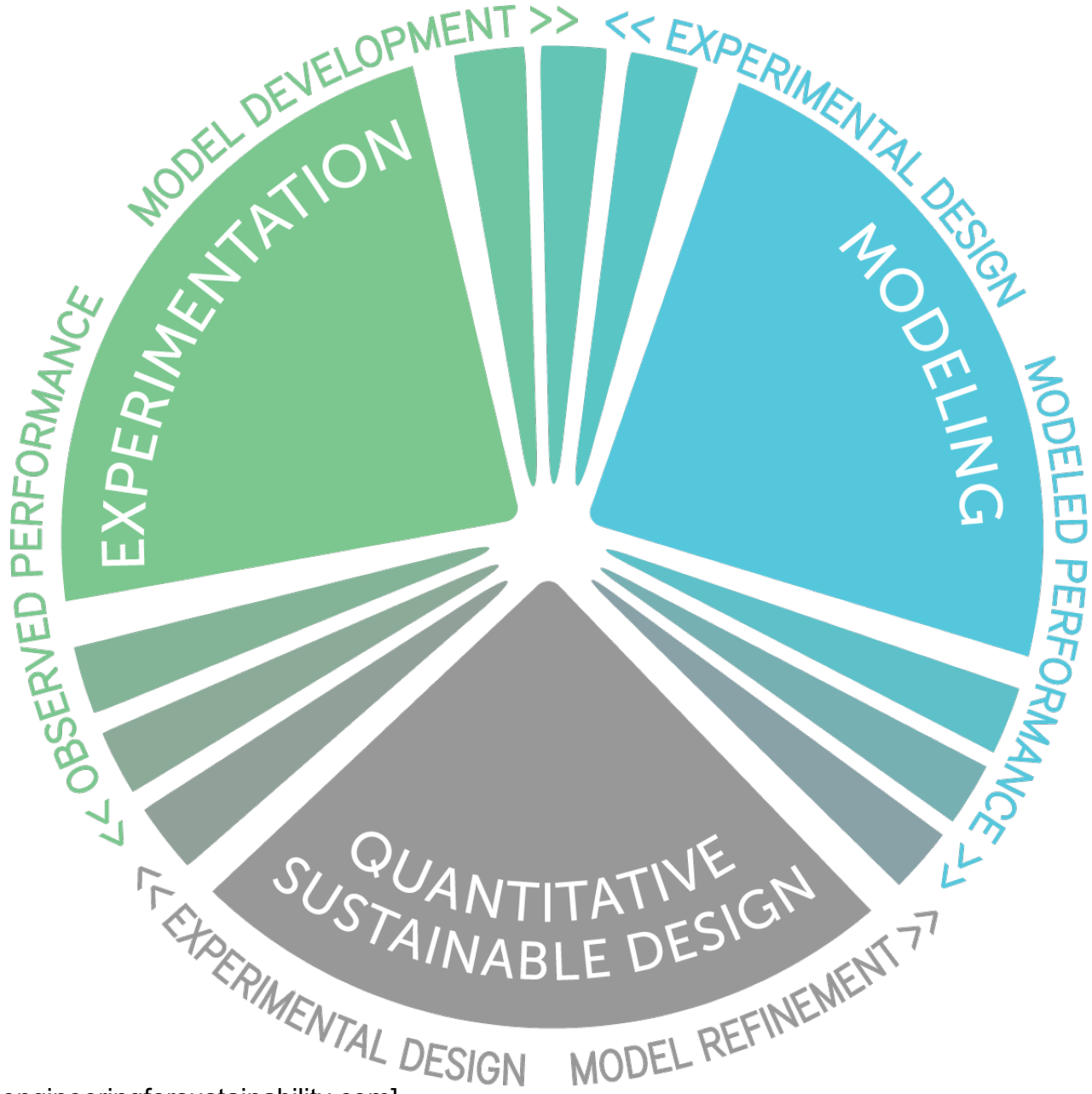




[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

[Tilley et al. Compendium of Sanitation Systems and Technologies, Eawag, 2008.]

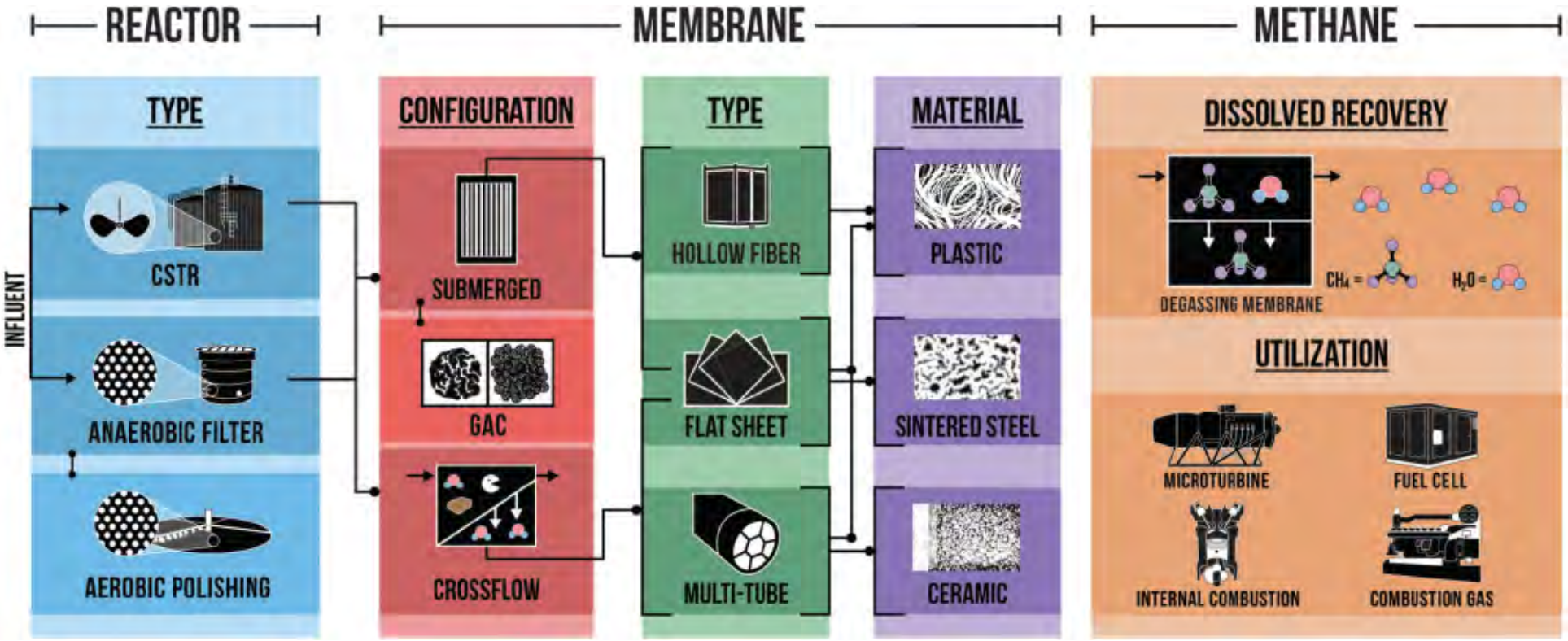
We integrate experimentation, modeling, and quantitative sustainable design (QSD) for technology development.

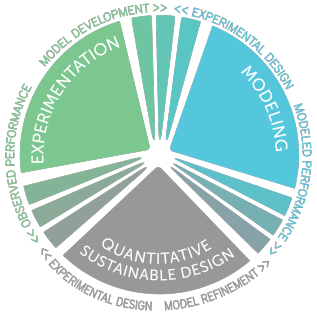


[Guest Research Group; engineeringforsustainability.com]

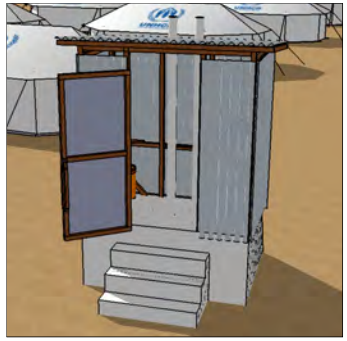
We integrate techno-economic analysis (TEA) and life cycle assessment (LCA) to prioritize research and development.

anaerobic membrane bioreactors (AnMBRs)





We are performing similar analyses for WASH in refugee settlements



[Shoener et al. *Energy Environ. Sci.*, 2016, 9(3): 1102-1112.]

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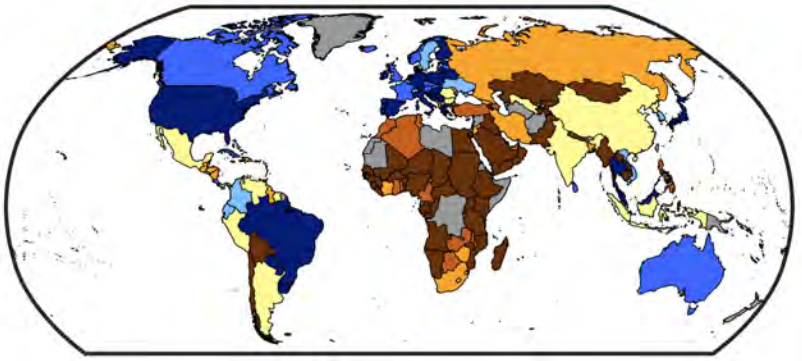
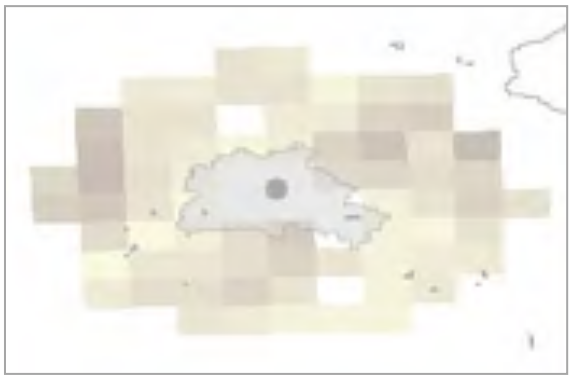


prioritizing large-scale implementation



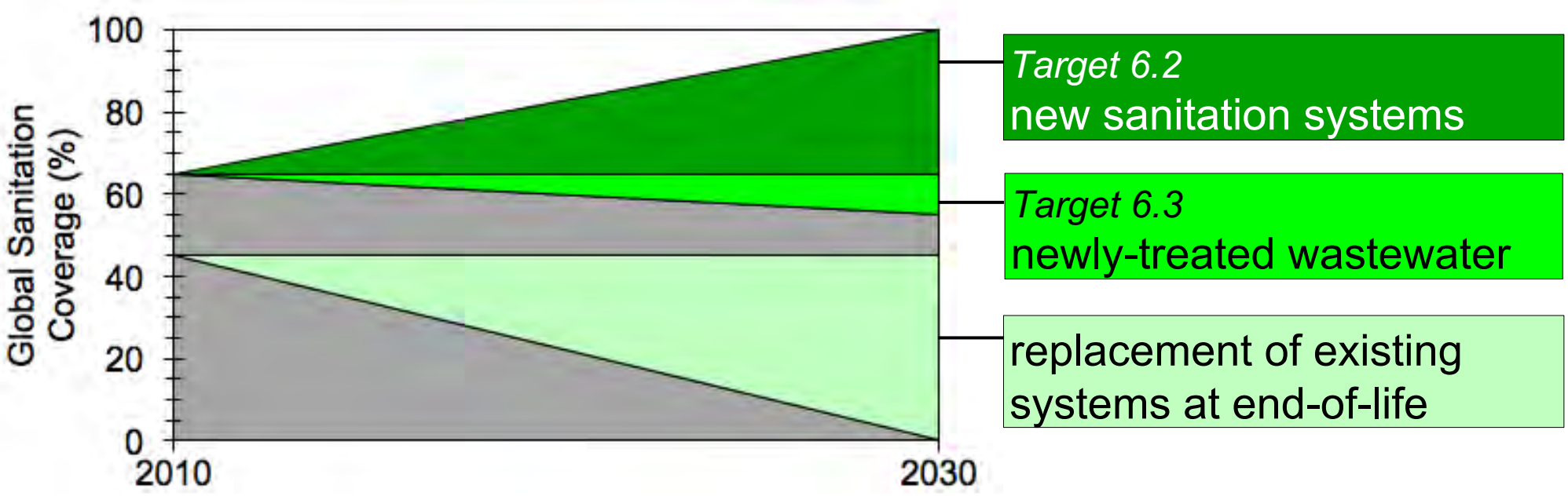
The impacts of meeting SDG Targets 6.2 and 6.3 with resource recovery technologies were evaluated.

2010 → 2030

recent datasets

Population growth and urbanization (*UN, 2014*)
Food supply and dietary intake (*FAO, 2008*)
Fertilizer (N, P, K) consumption (*FAO, 2008)*
Household electricity consumption *(linear extrapolation*)

SDG time horizon

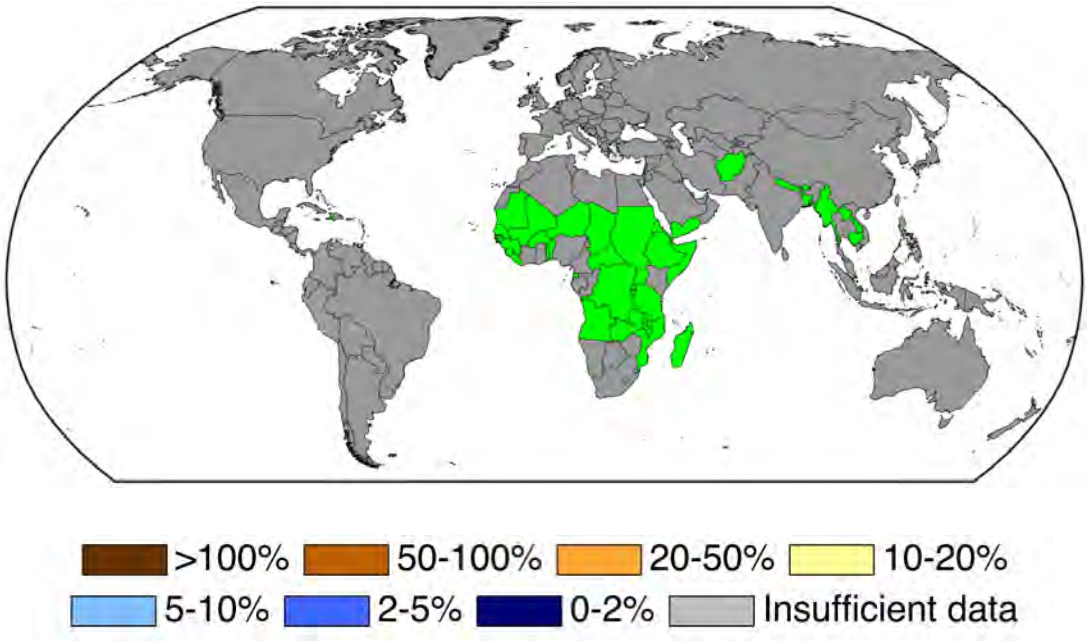


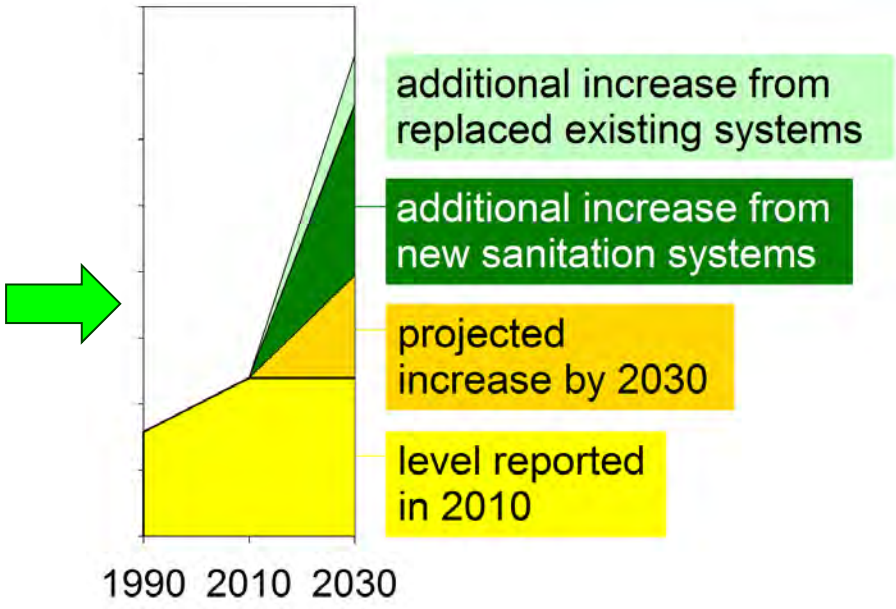
+ sensitivity & uncertainty analyses

[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Resource recovery impacts relative to projected 2030 resource availability were estimated at the national scale.

an illustration:





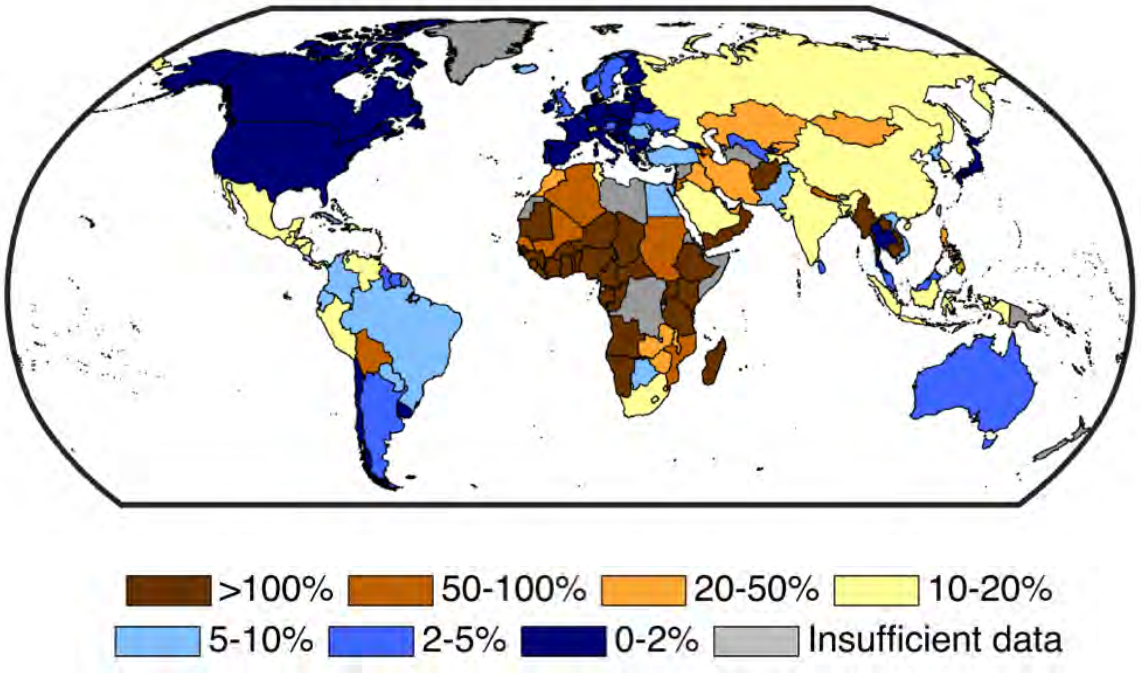
averages across least-developed countries (LDCs)

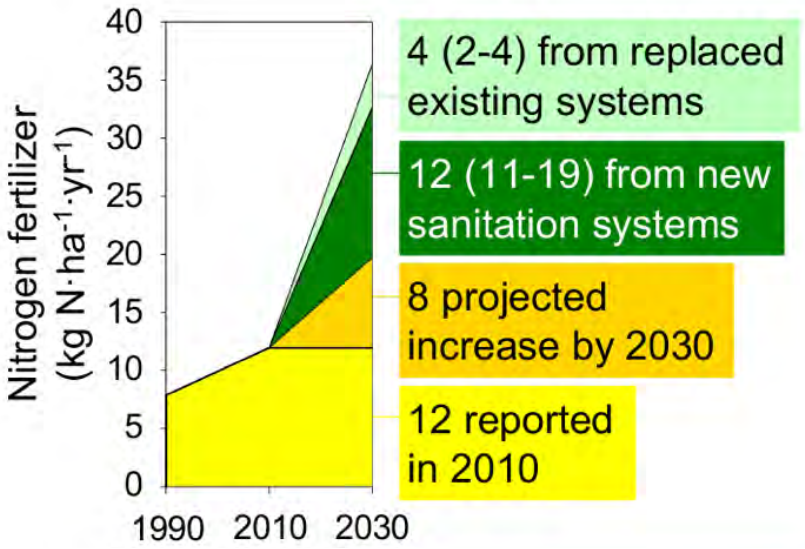
$$\textbf{Impact} = \frac{\text{(increase from resource recovery)}}{\text{(projected consumption in 2030)}} \cdot 100\%$$

[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Recovery from new and upgraded sanitation systems can increase global N fertilizer availability by 11% (9-16%).

Nitrogen

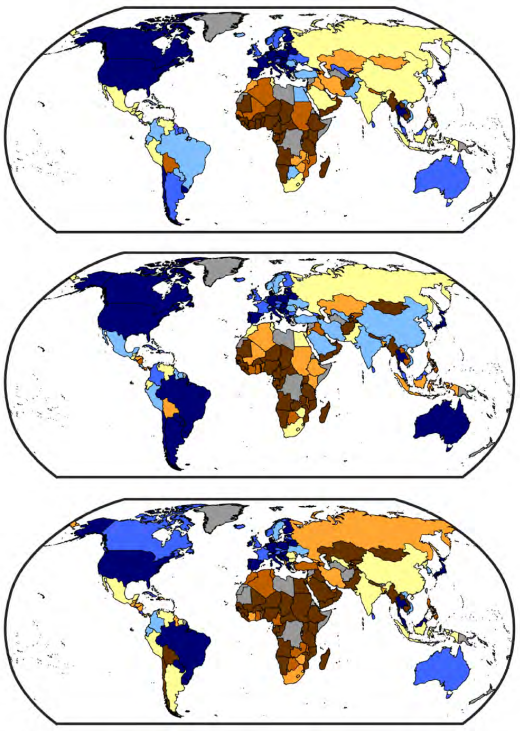


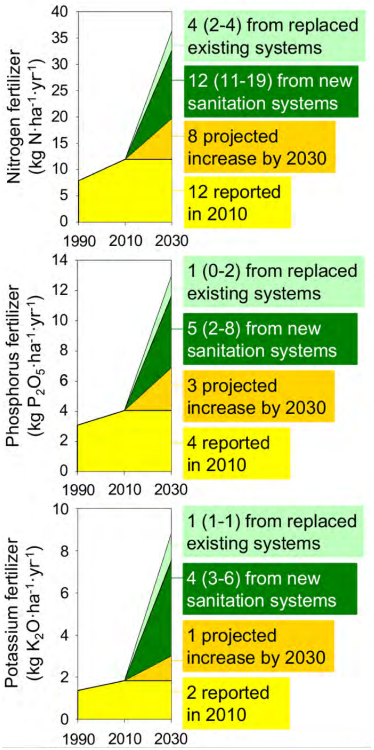


averages across least-developed countries

[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Resource recovery could dramatically increase access to potassium, in particular.

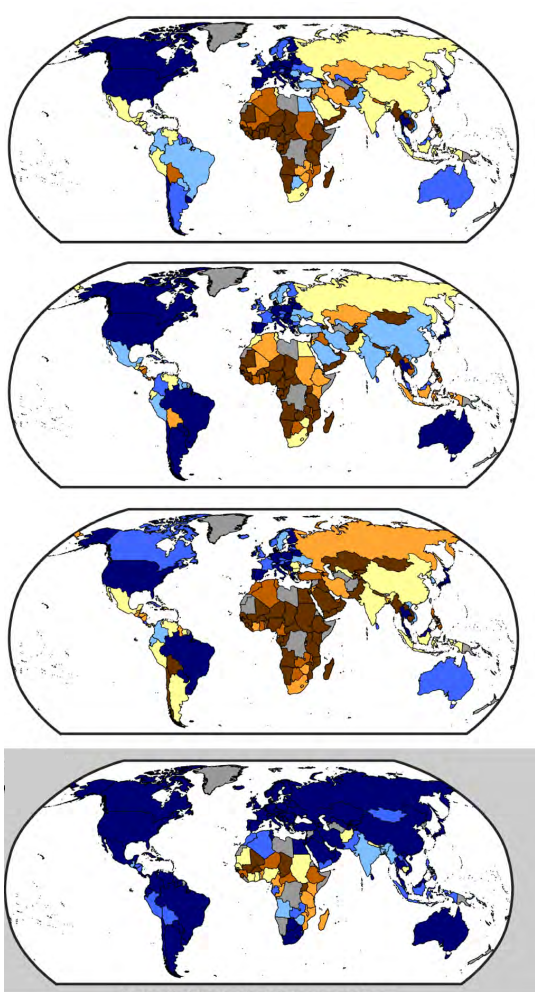


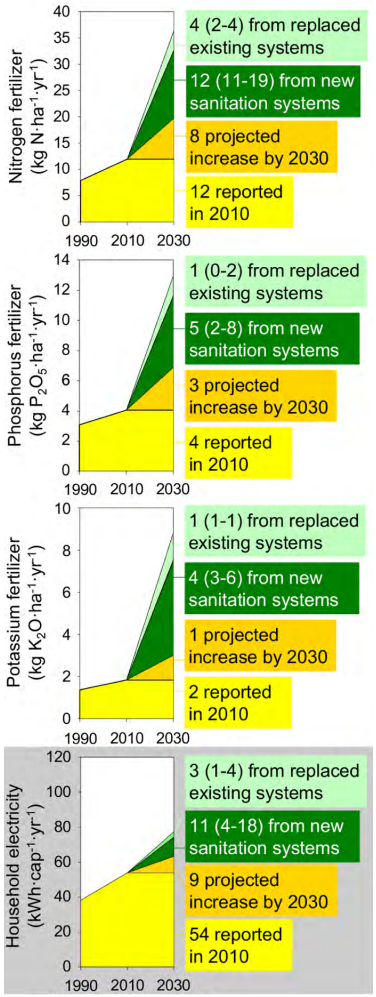


	Global	LDCs
Nitrogen	**11%** (9-16%)	**65%** (55-94%)
Phosphorus	**9%** (5-15%)	**68%** (35-113%)
Potassium	**12%** (10-16%)	**149%** (114-193%)

[Trimmer et al. *Environ. Sci. Technol.*, 2017, 51(18): 10765-10776.]

Energy recovery was limited to 1% (0-2%) of global electricity use, but could be impactful in specific LDCs.





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Potassium	**12%** (10-16%)	**149%** (114-193%)
Electricity	**1%** (0-2%)	**17%** (7-28%)

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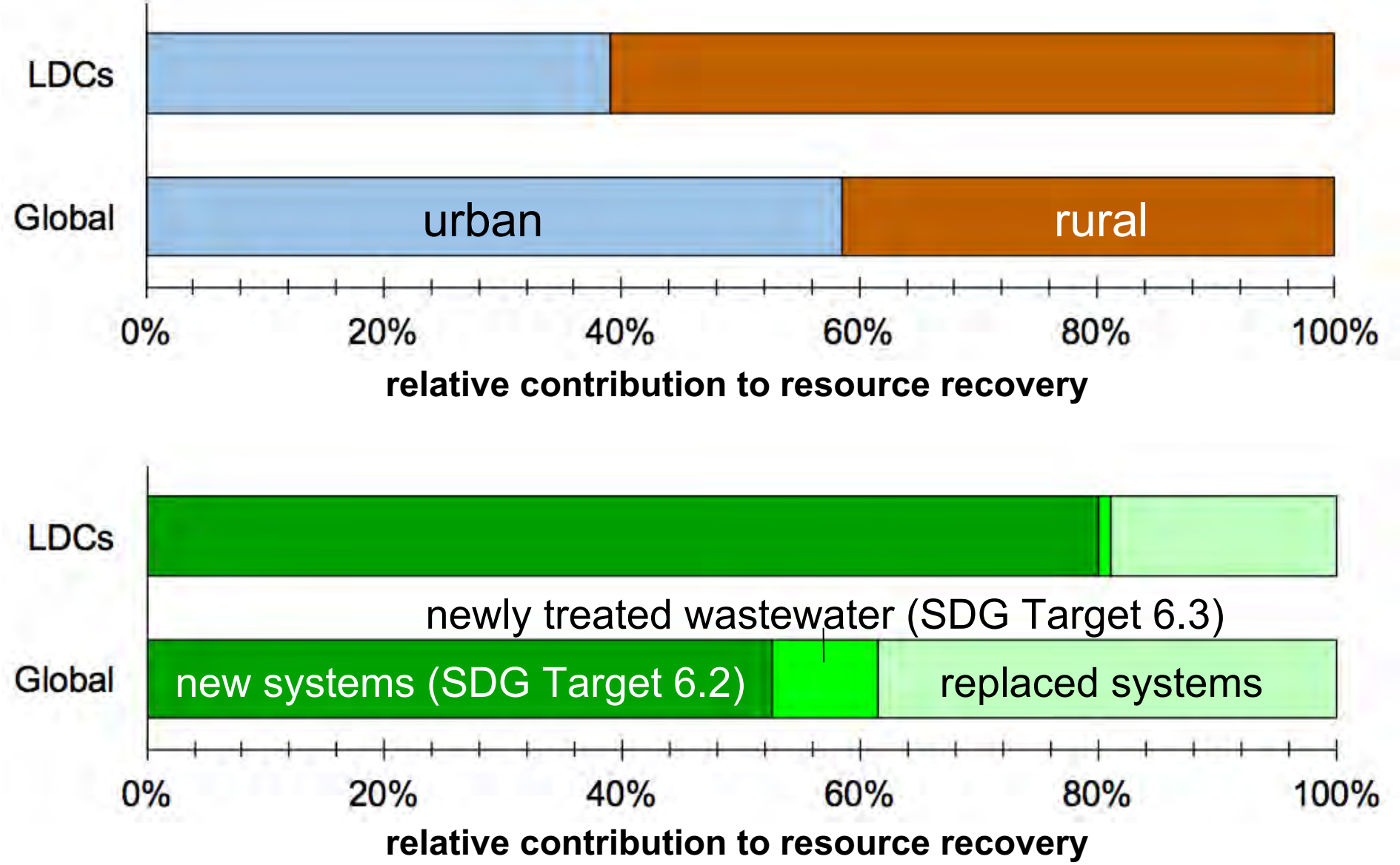
Especially in rural areas, newly-installed systems will be critical to resource recovery in the LDCs.



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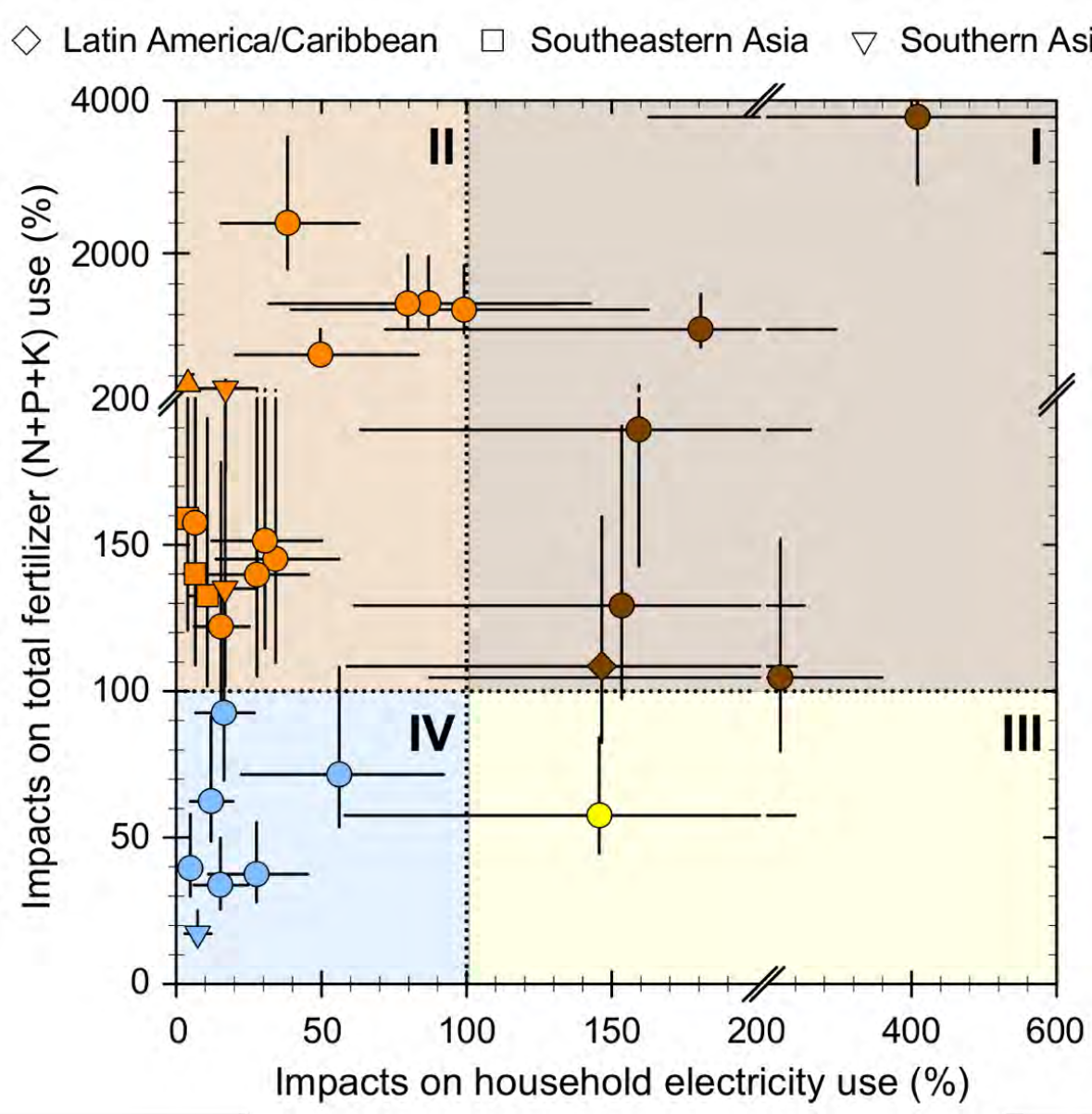
Beyond overarching trends, this analysis provides country-level data relevant to local decision-makers.



Zone I	Burkina Faso, Chad, Guinea-Bissau, Haiti, Sierra Leone, Uganda
Zone II	Afghanistan, Angola, Benin, Cambodia, Central African Republic, Guinea, Lao People's Democratic Republic, Madagascar, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Senegal, United Republic of Tanzania, Yemen
Zone III	Mali
Zone IV	Bangladesh, Ethiopia, Lesotho, Malawi, Sudan, Togo, Zambia

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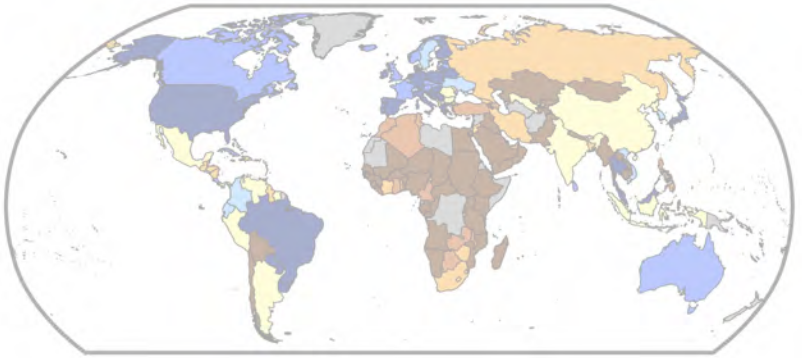

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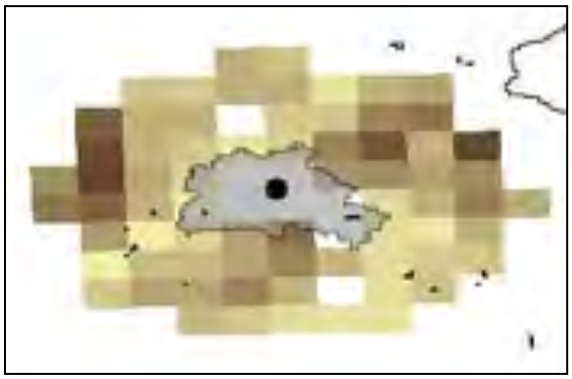
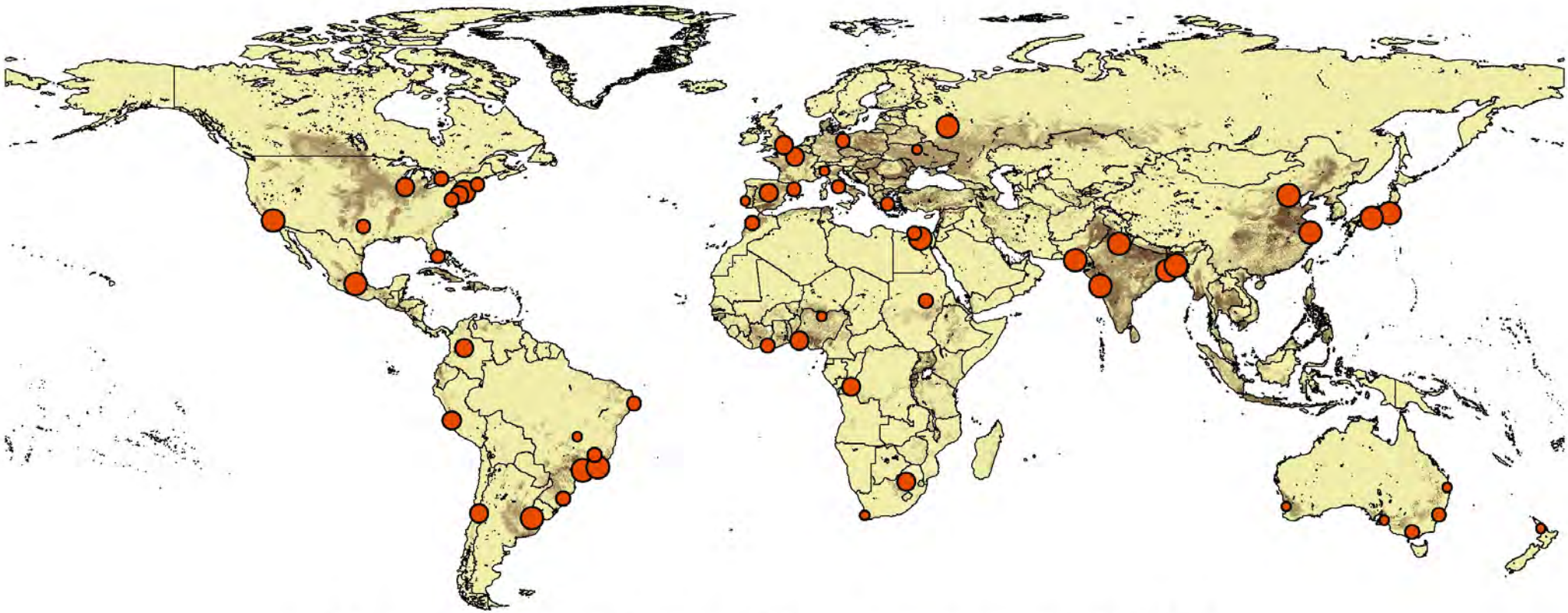


Urbanization trends are expected to continue, making cities the largest source of human-derived nutrients.



City population and crop nitrogen requirements in 2000

Population of 10 largest cities on each continent

- < 3 million
- 3 - 5 million
- 5 - 10 million
- > 10 million

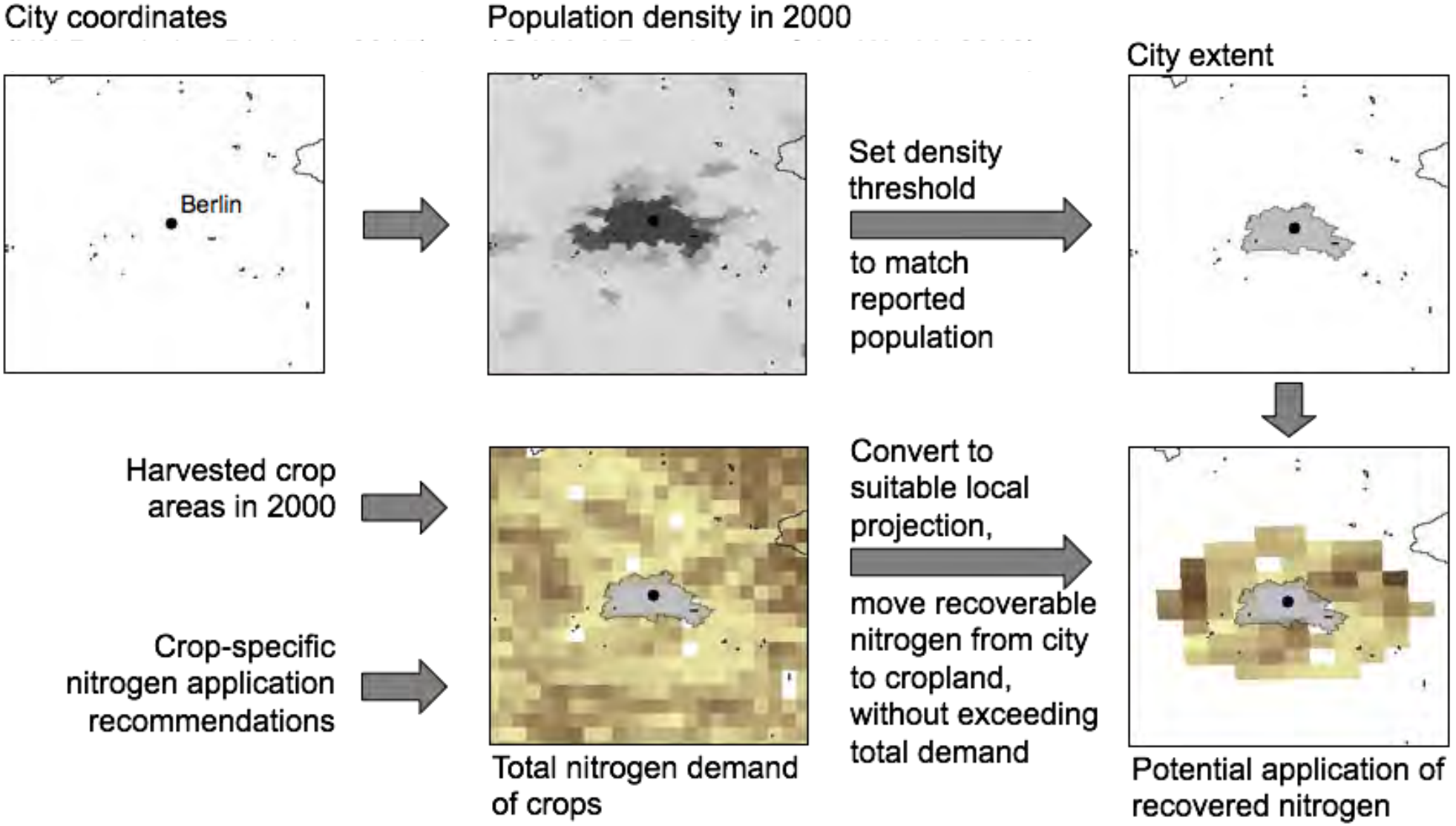
Crop nitrogen requirement (kg N/ha total cell area)

- < 10
- 10 - 30
- 30 - 60
- 60 - 100
- > 100

Details will be provided in upcoming manuscript:
[Trimmer and Guest, *In preparation*.]
Contact jsguest@illinois.edu for additional information.

We established geographic boundaries and identified N, P, and K demands for crops surrounding each city.

Nitrogen from Berlin



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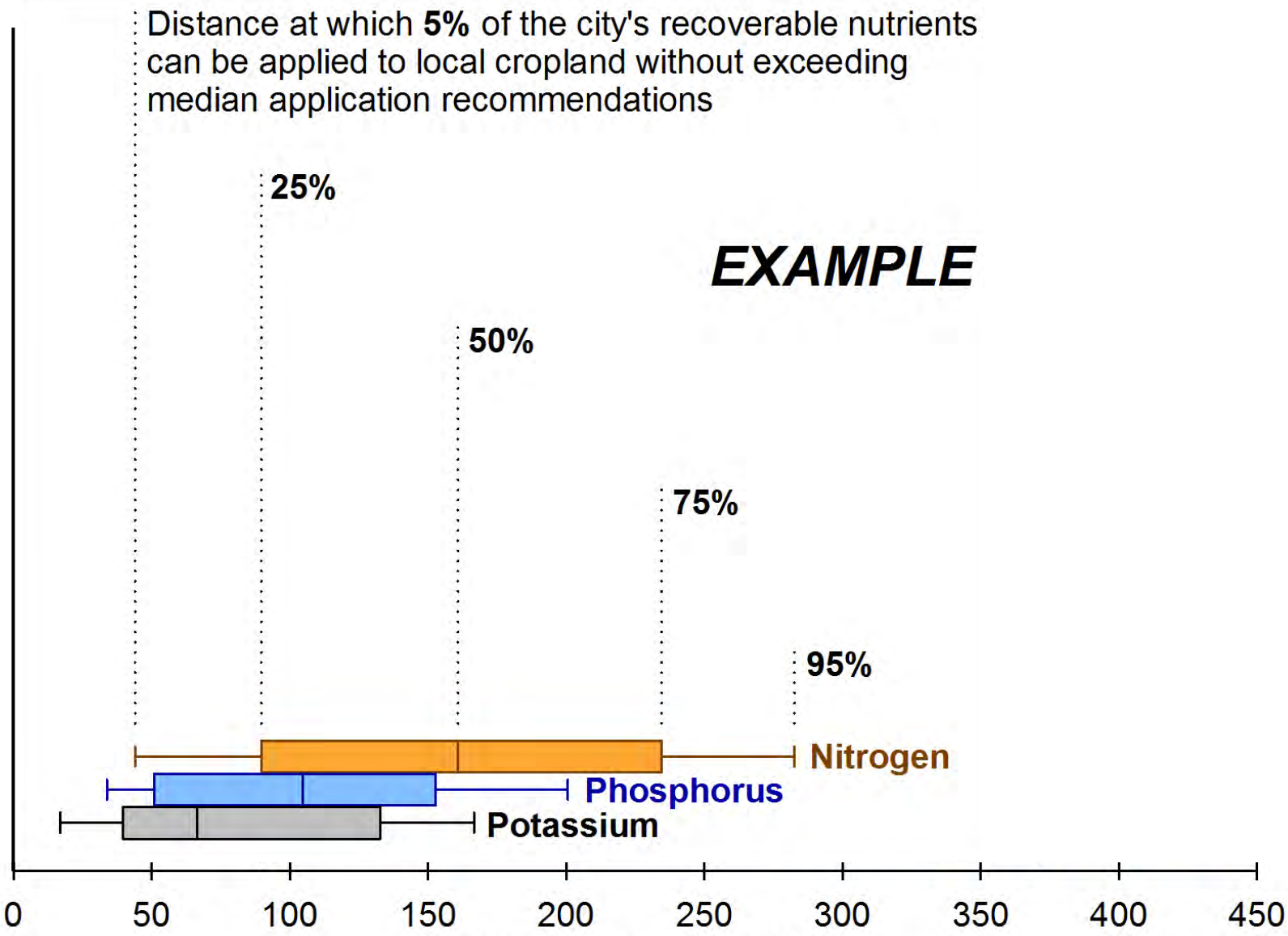
We then determined how far nutrients would need to be transported to be used in agriculture.



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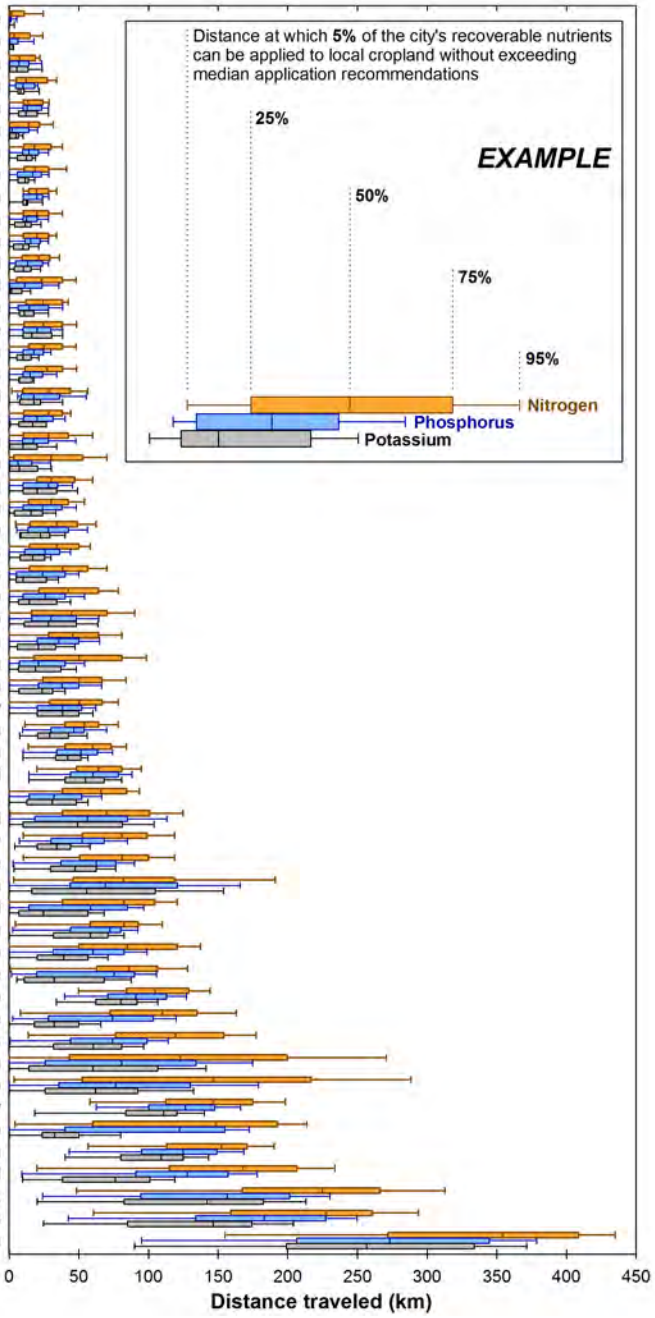
Transport distances vary by city, with N. America and Oceania requiring the longest.



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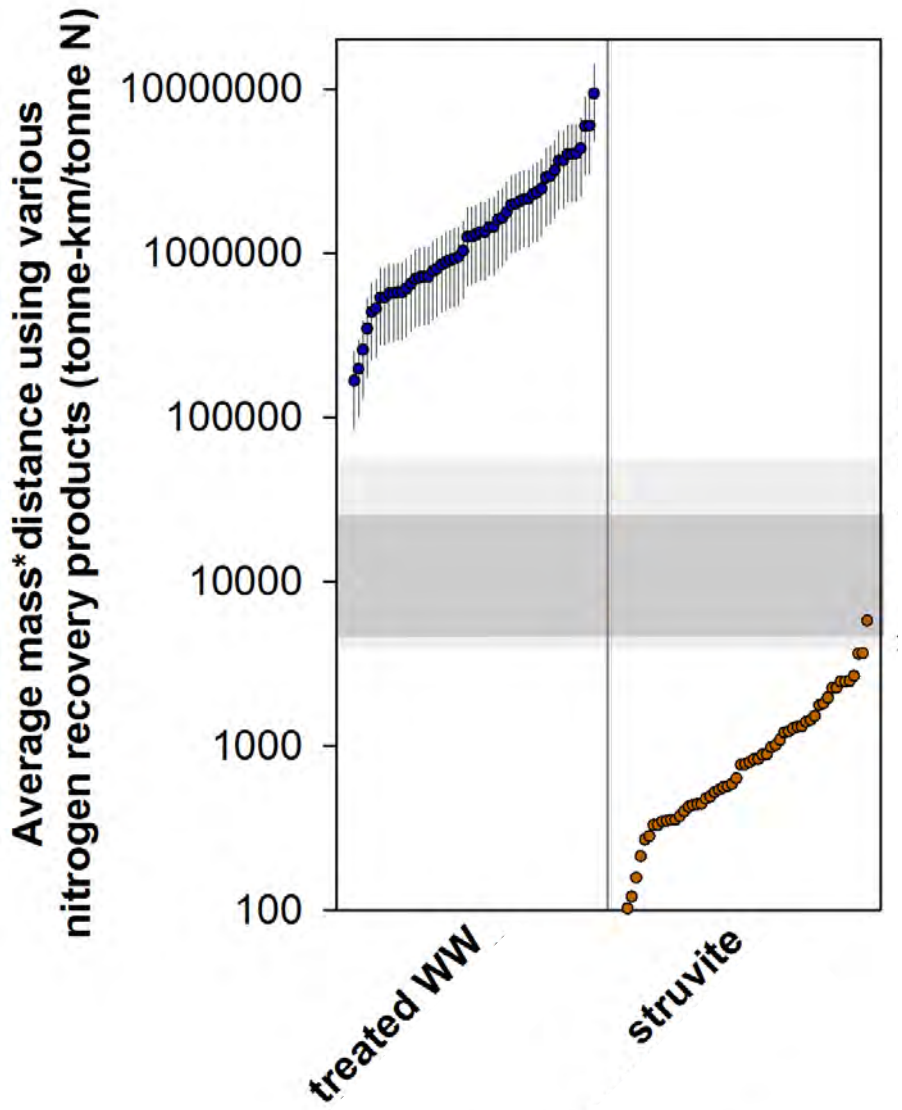
Large-scale recovery will necessitate the recovery of more concentrated forms of nutrients.



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In conclusion, resource recovery may incentivize sanitation deployment and financing, but technologies and service delivery should be tailored to a given locality.