Fitting human excreta into a circular nutrient bioeconomy -

Future scenarios, retailer perspectives, and research accessibility in Sweden

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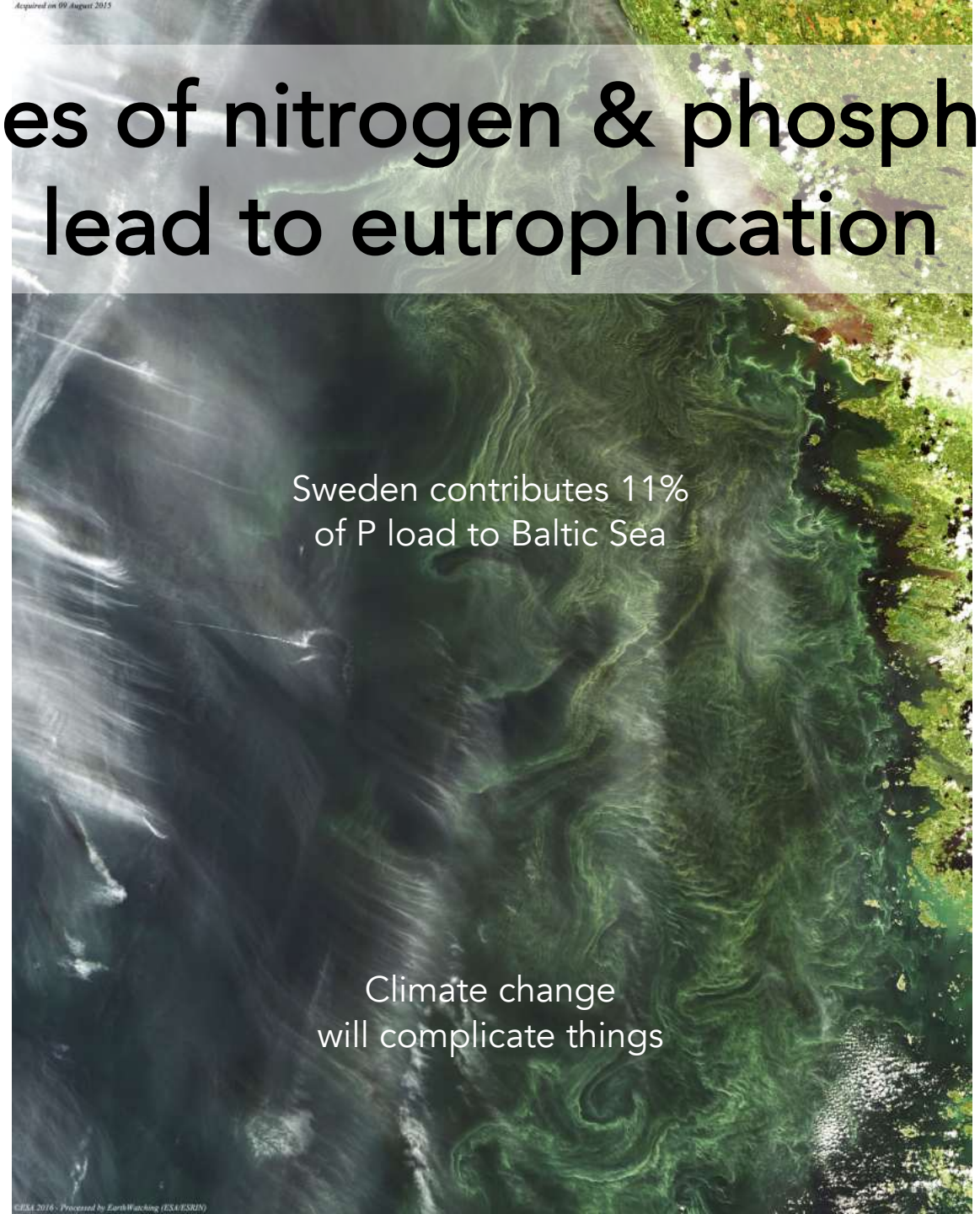
Agriculture requires nutrients
@gmetson

Losses of nitrogen & phosphorus lead to eutrophication



Statistics from HELCOM (2018), 2014 data

Today's project co-authors

Future land use and biobased Sweden


N.H. Quttineh


R. Feiz


A. Sundblad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G Metson

Biogas Research Center

FORMAS

End of Wastewater


R. Harder

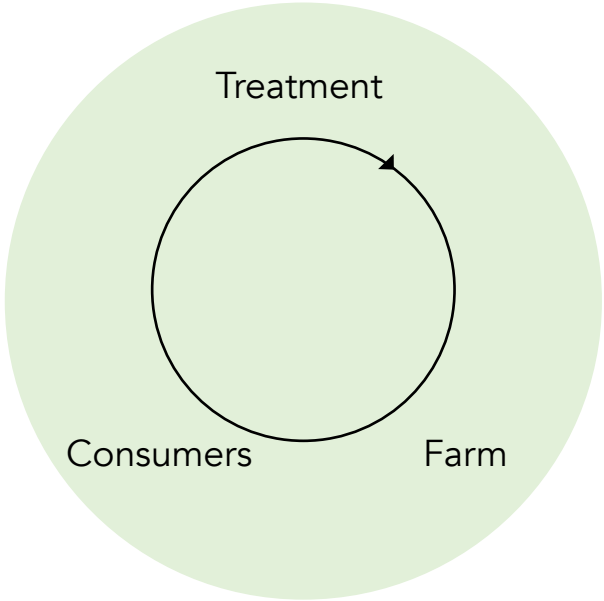

G Metson


J. McConville


B. Macura


S. Johannesdottir

Human excreta nutrients in sustainable food systems



A vision for Sweden's food future

More recycling

Less waste

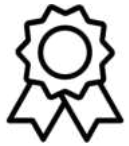
amount

Less meat

amount

Consume local food and energy

where

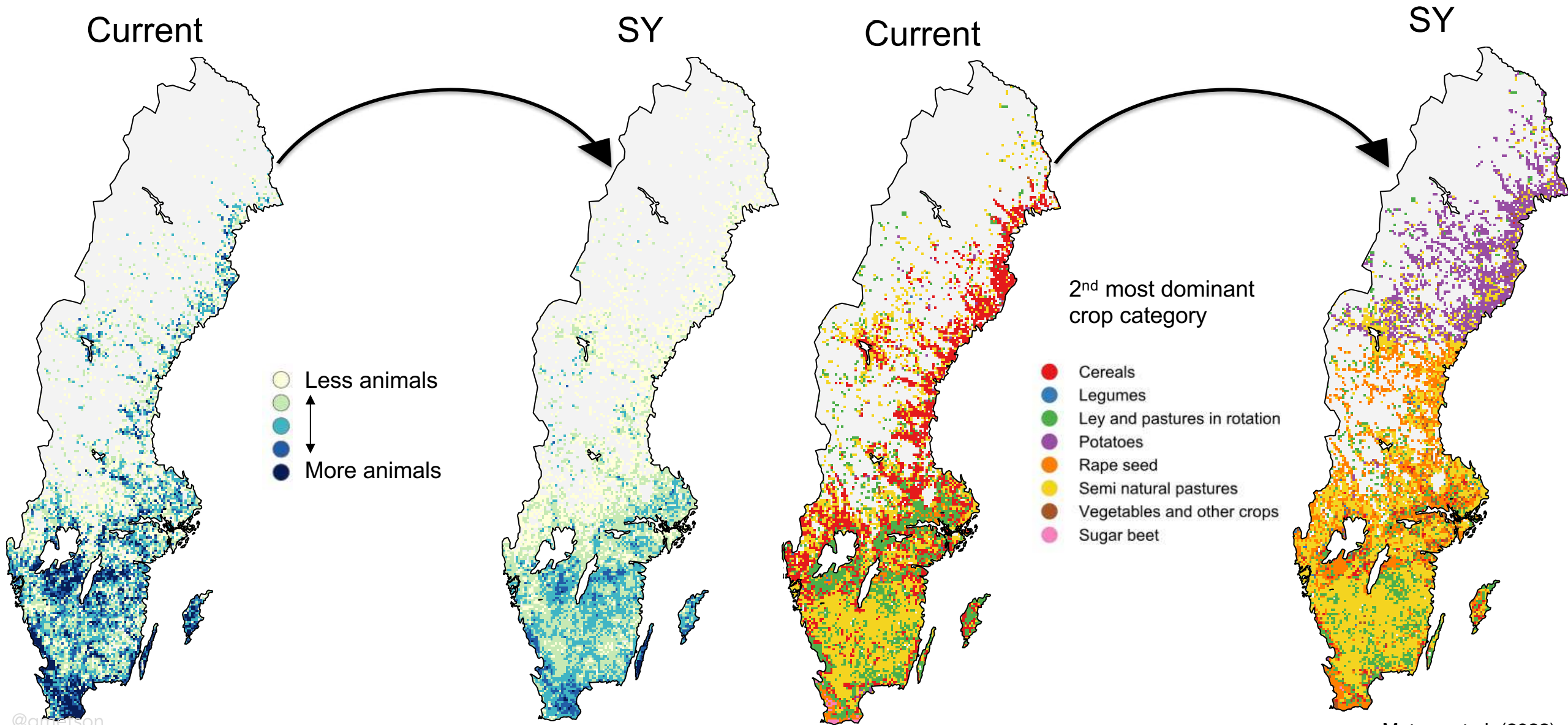


Organic production

use

2030 Vision with stakeholders Karlsson et al. (2018)

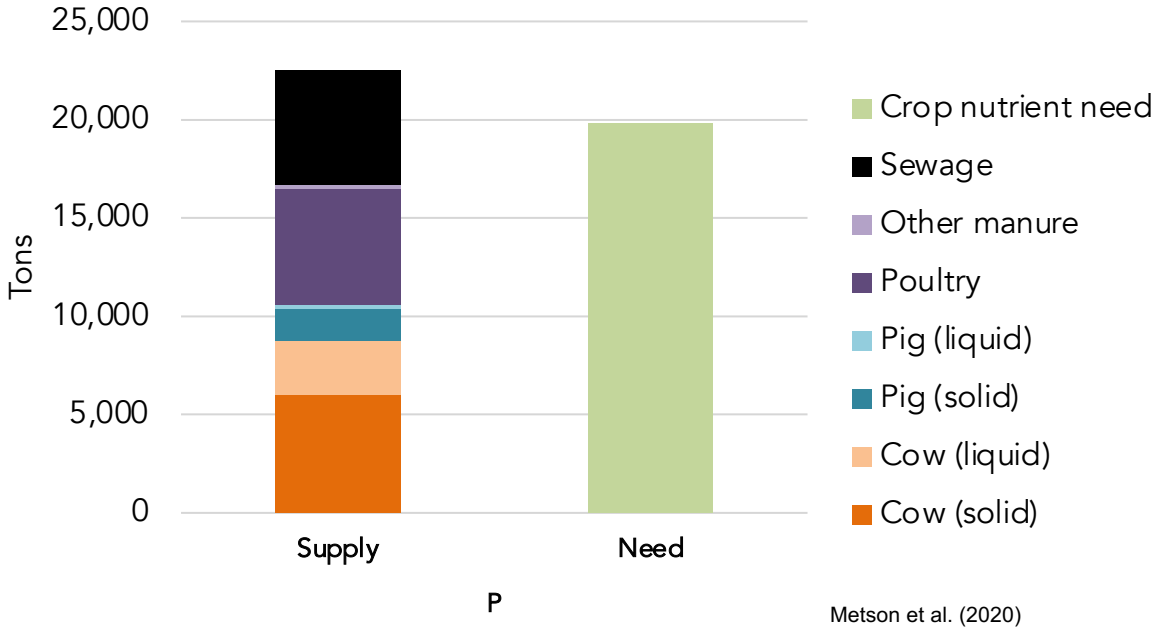
Less animals, more vegetables



Metson et al. (2022)

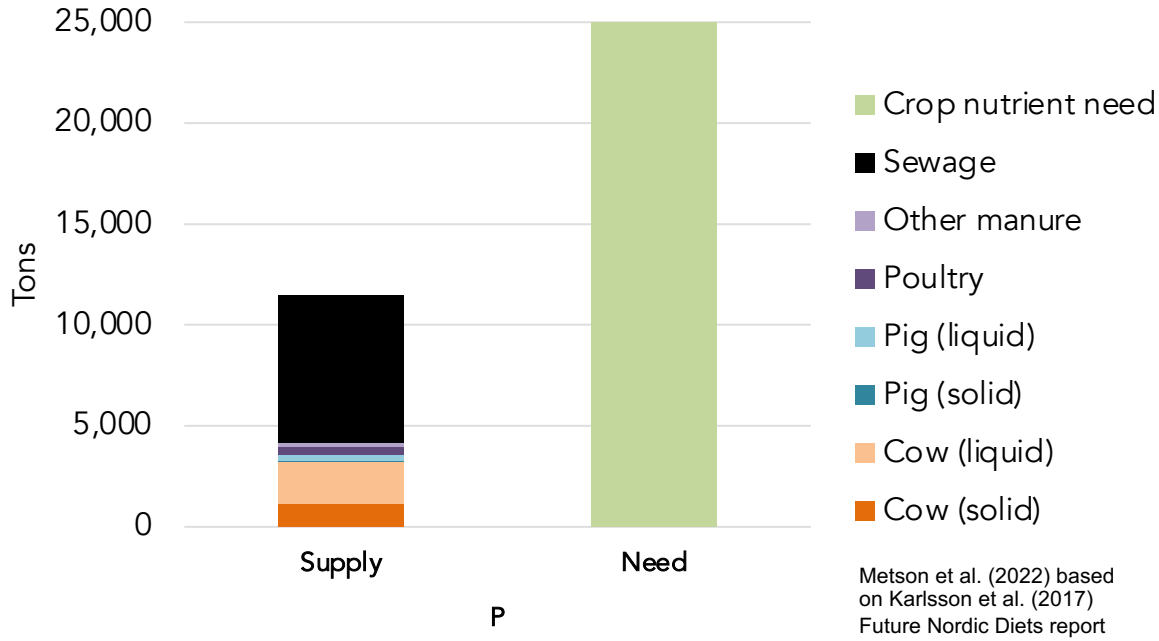
As we become more efficient in agriculture and reduce meat consumption then…

Current Sweden (data avg. 2013-2016)



Metson et al. (2020)

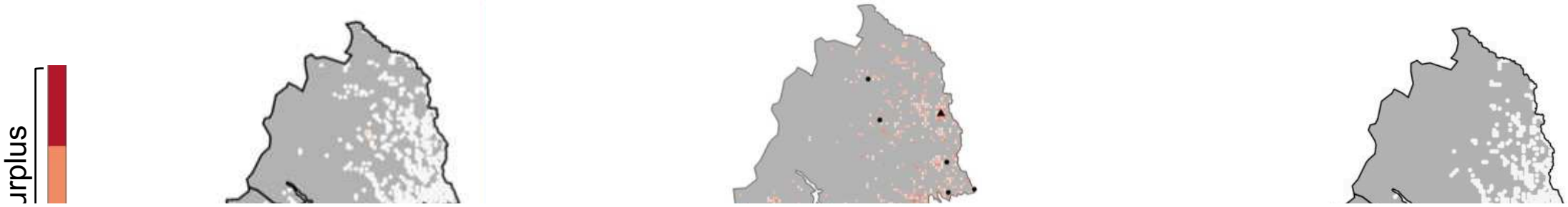
Sweden self-sufficiency (w/pasture animals)



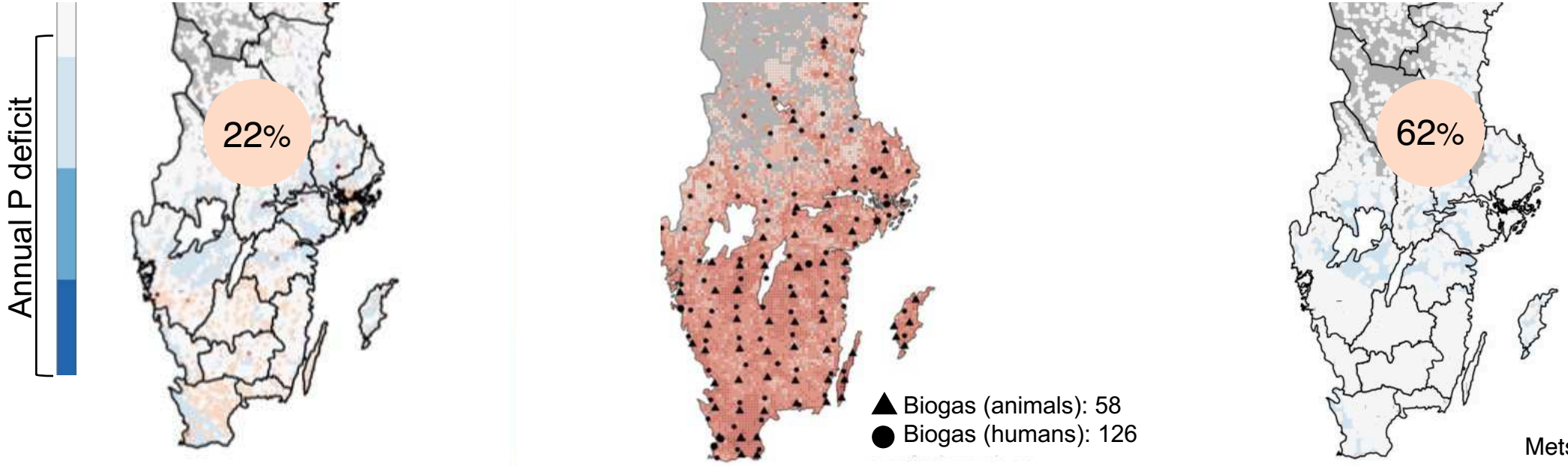
Metson et al. (2022) based on Karlsson et al. (2017) Future Nordic Diets report scenario

Human excreta becomes essential to circular agriculture

Less crop demand is met than currently



Fewer biogas plant locations but similar locations



Metson et al. (2022)

Take home messages – future land use

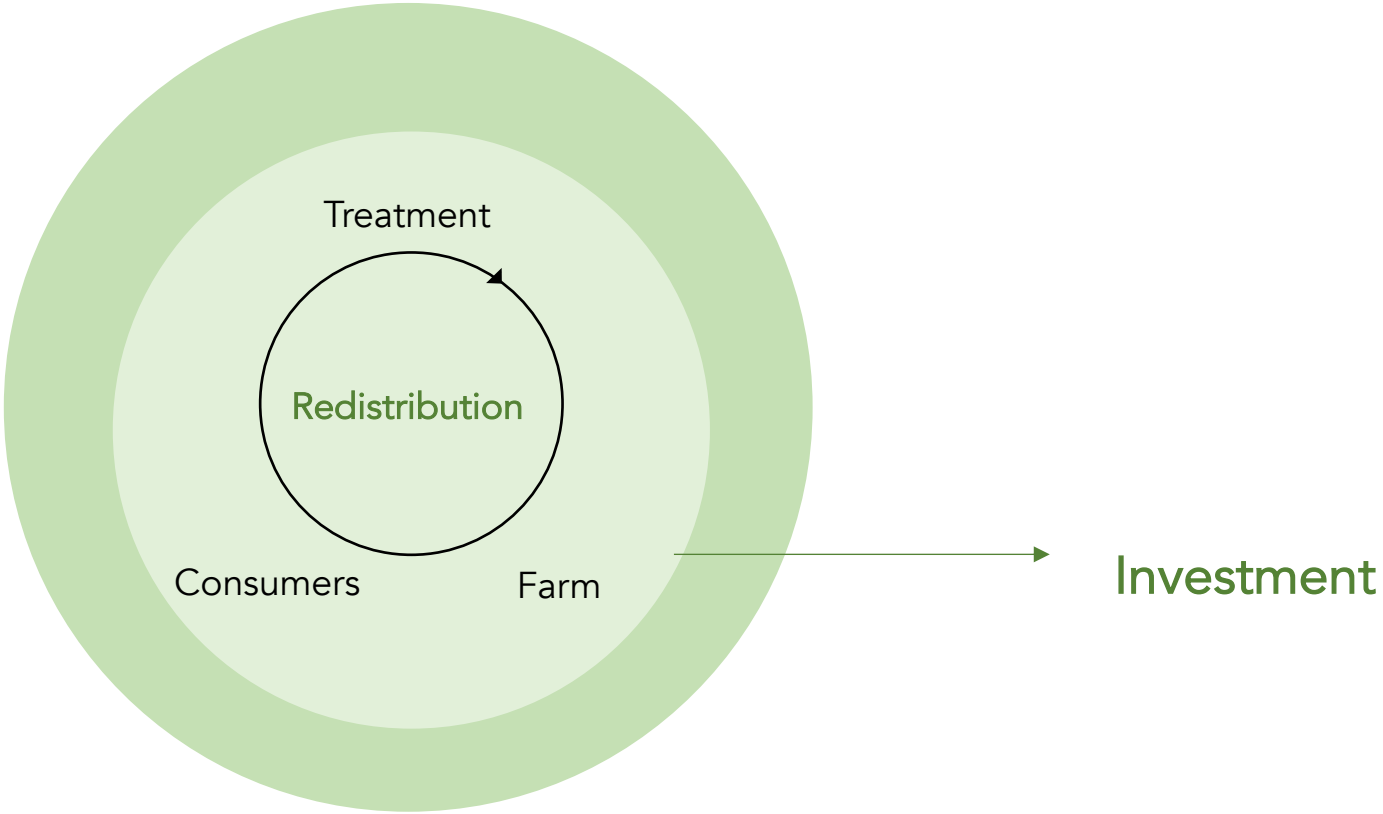
‘Demand side’ measures mean there is less to go around, but make recycling nutrients **more** valuable

Nutrients from human excreta could make up a larger share of resources

Places with the biggest potential for biogas plants today may still be **the same** ones tomorrow – investing in infrastructure makes sense

Regions with few potential plants needed may need more detailed planning before moving ahead

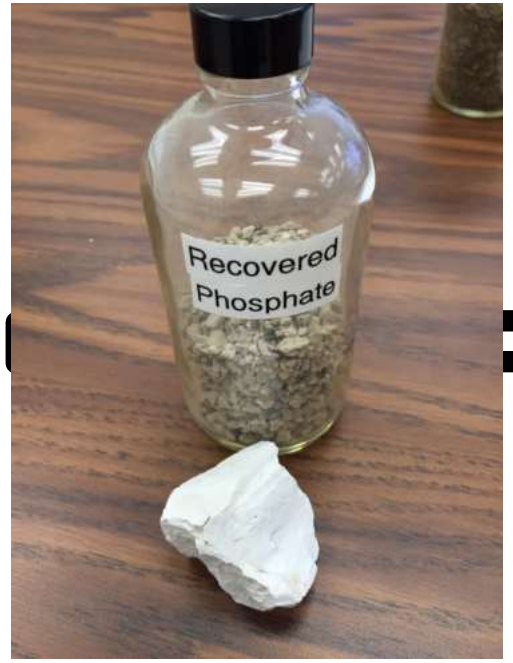
Human excreta nutrients in sustainable food systems



Without social acceptance our options for recycling will be limited

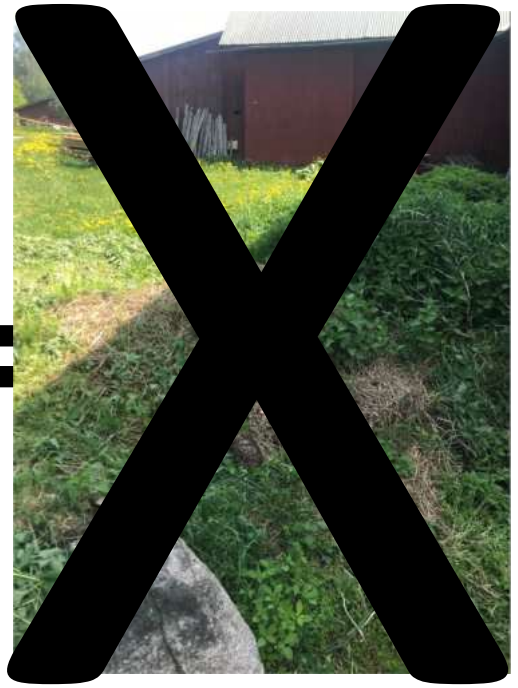
- Swedish commission
  on the ban of sewage sludge
- EU goals
- Organic certification

High tech



Single nutrient products

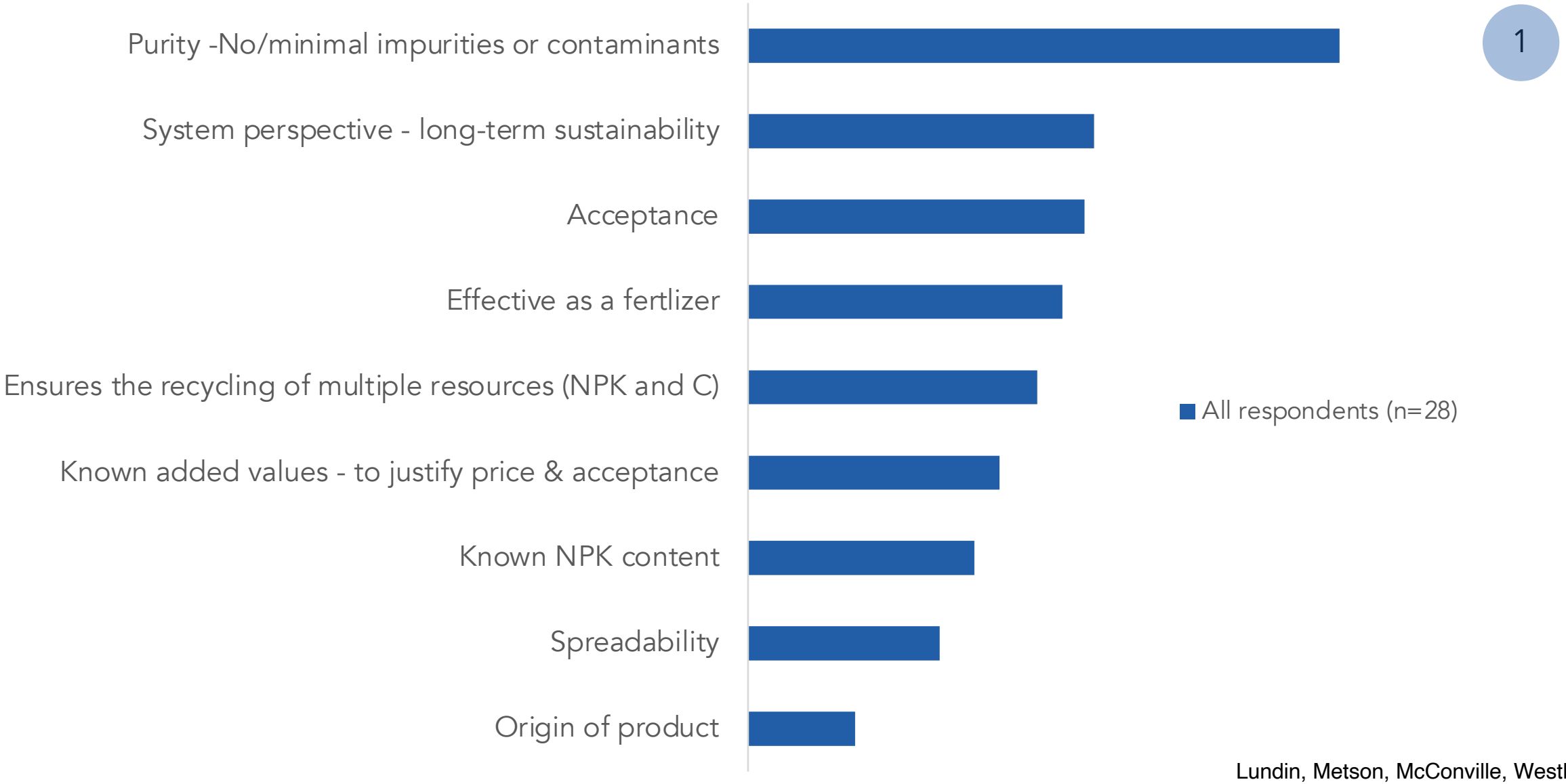
Low tech



2 yrs worth of composted human waste for a village of 30 in Sweden

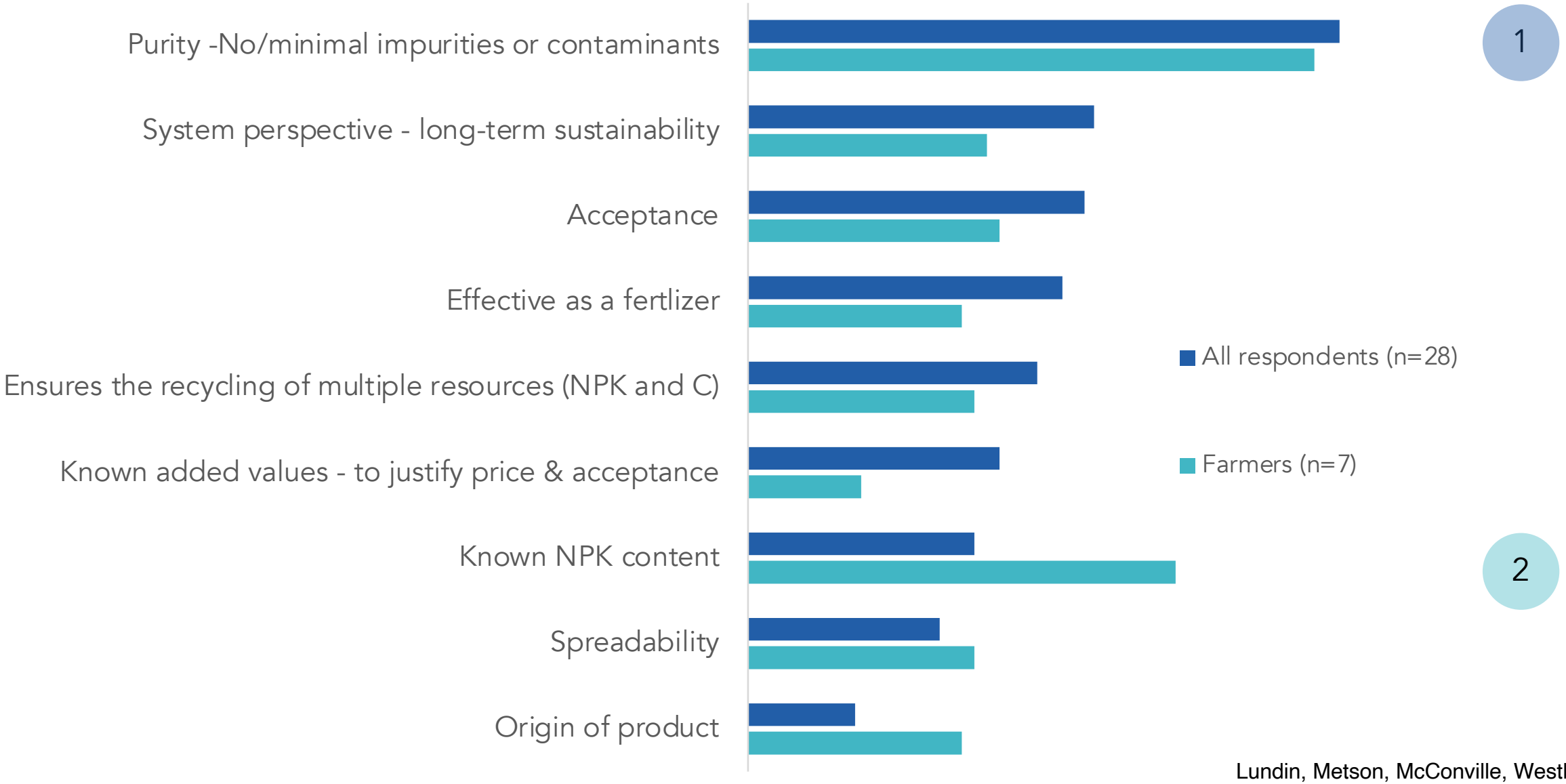
More on current state of sanitation in Sweden:
https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-8809-5.pdf?pid=22471

Safety (no contamination) is a top priority



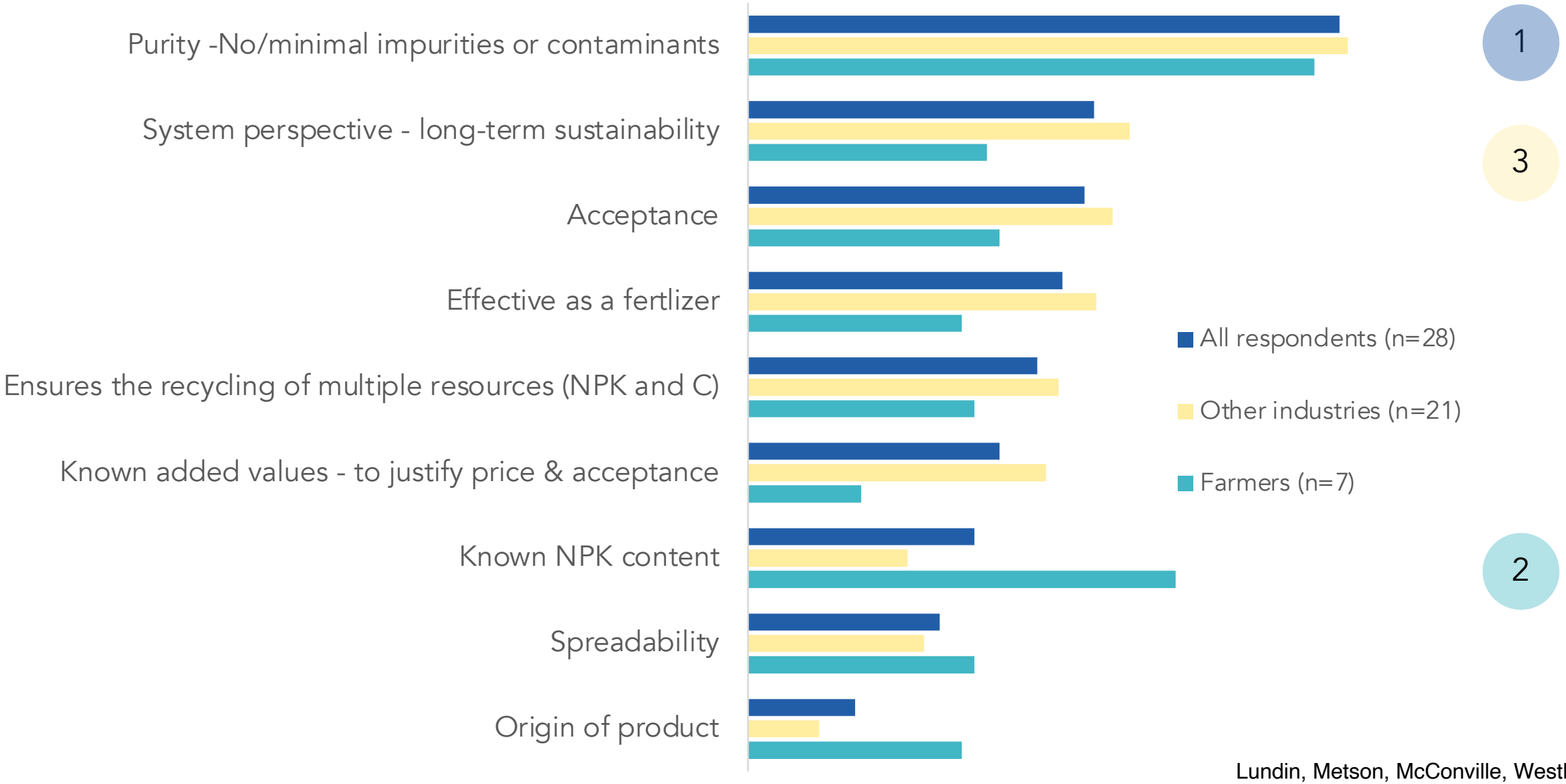
Lundin, Metson, McConville, Westling (2021)

Farmers also need to know nutrient content



Lundin, Metson, McConville, Westling (2021)

Sustainability & acceptance also matter



Lundin, Metson, McConville, Westling (2021)

Take home messages – farmers and wastewater

Safety is a key priority across actor groups

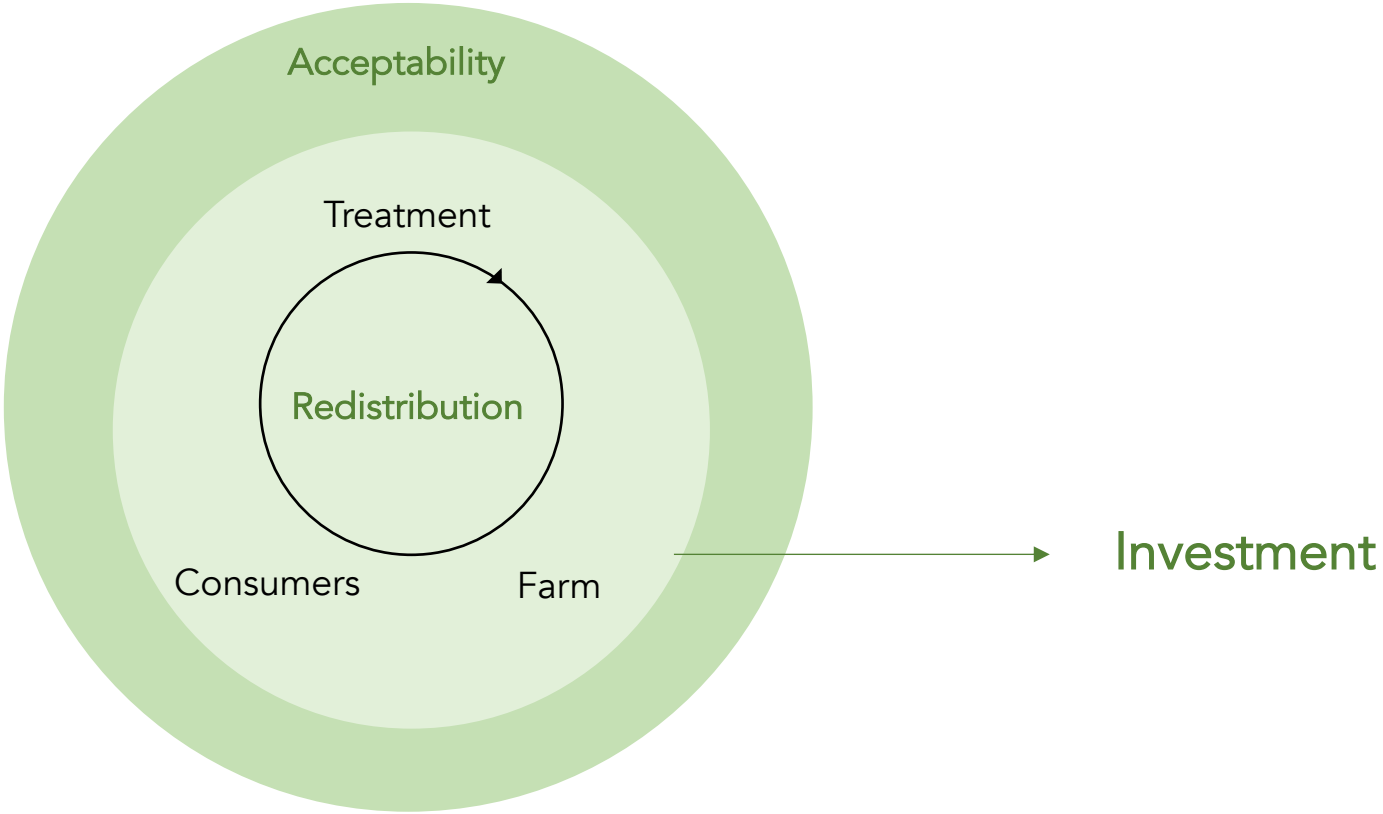
Farmers also need clear nutrient content

Desire for regulatory support, decision support, infrastructure, and **knowledge sharing**

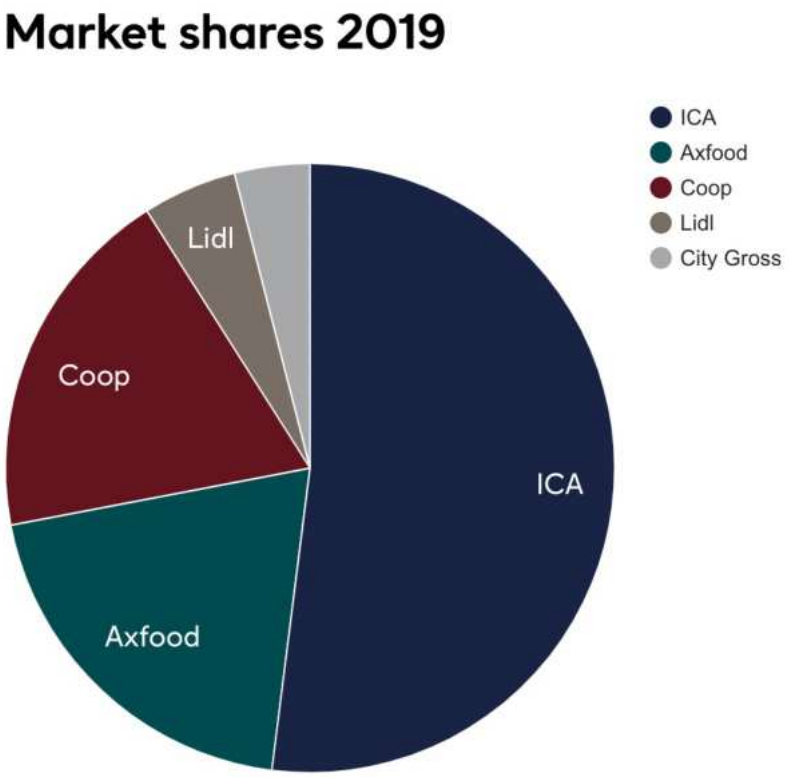
Difficult for people to name actors to take responsibility for changes needed

Agreement of a need to engage with farmers and food sectors

Human excreta nutrients in sustainable food systems



Swedish retailers could be a key actor

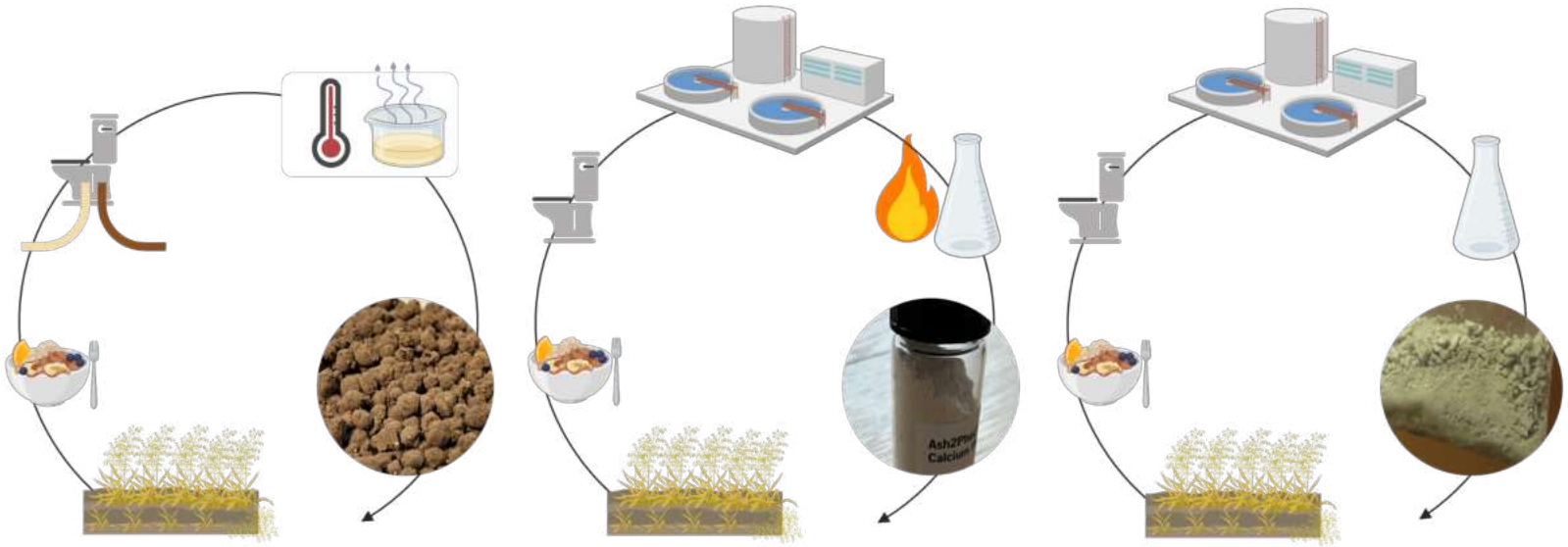


Few actors purchase and stock shelves

↓

Affects farmers and consumers

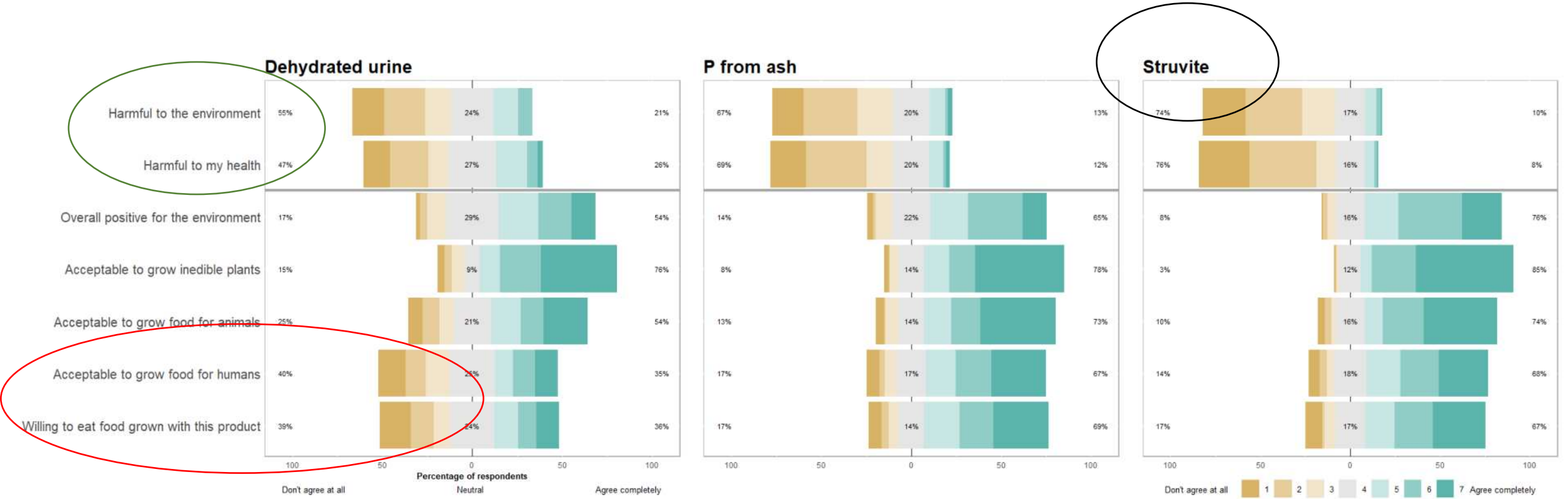
Which product is more acceptable?



Surveyed 127 food retailers (stores)

McConville et al. (under review)
City and Environment Interactions

Further away from human food and more ‘processed’



McConville et al. (under review)
City and Environment Interactions

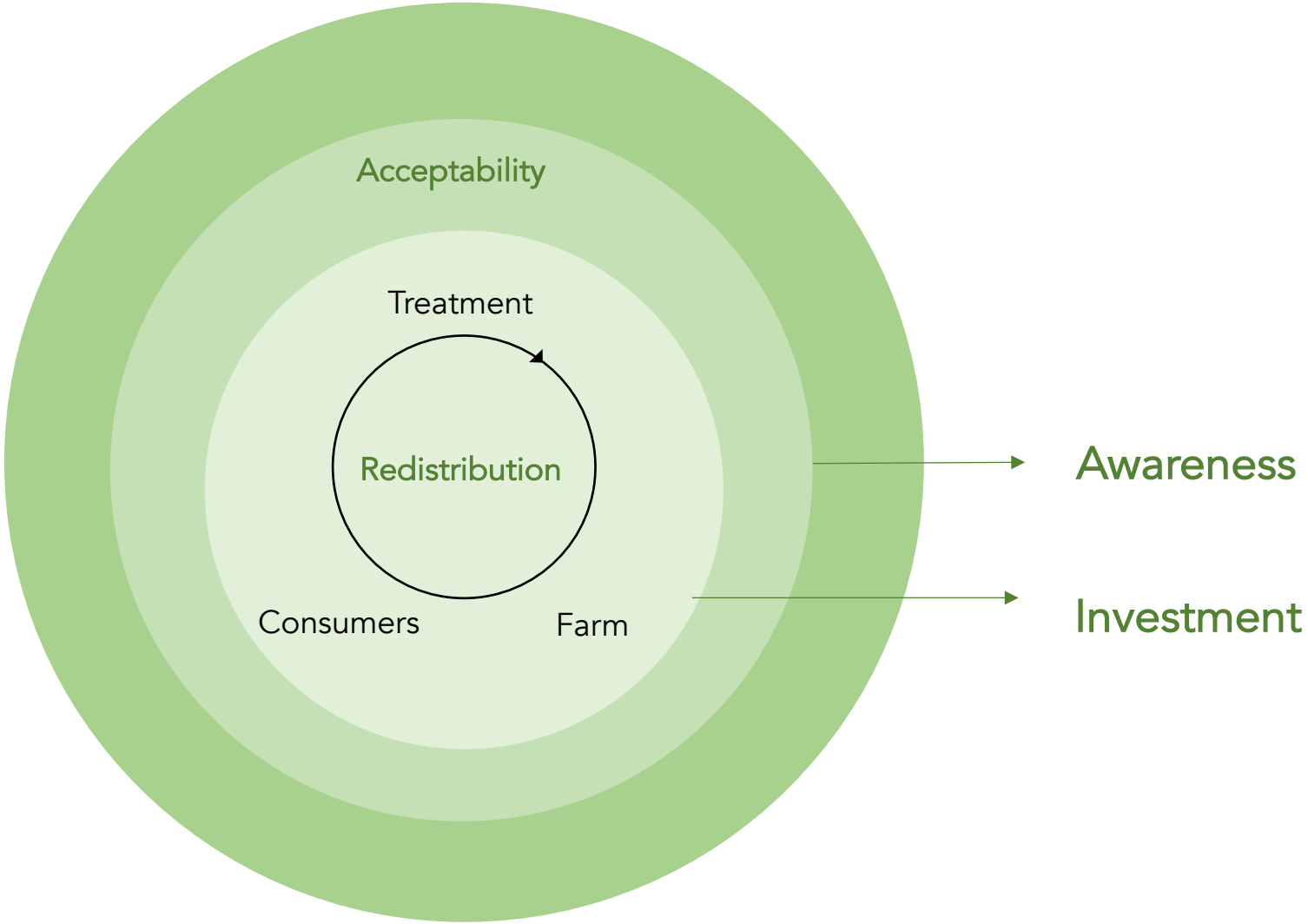
Take home messages – retailer survey

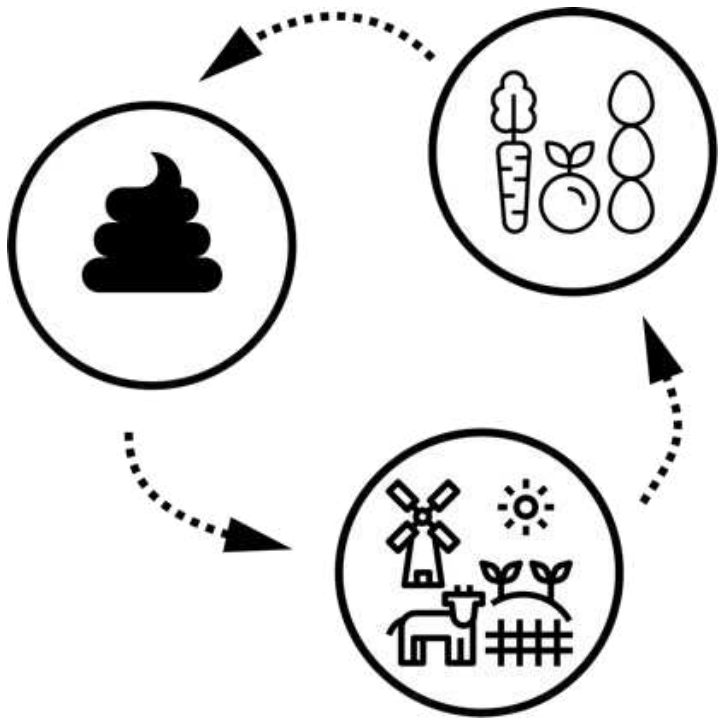
Not negative to reuse generally, but no specific goals on nutrient recycling in sustainability strategies

Perceived risk is central to acceptance

Lack of knowledge hindered people from answering

Human excreta nutrients in sustainable food systems





END-OF-WASTEWATER

2020-2023

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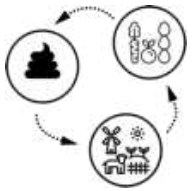
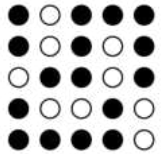
WHY EGESTABASE?



IMAGINE …

you are interested in …

finding publications



hot topics and gaps

temporal evolution

hot spots

exploring options

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FINDING EVIDENCE IS NOT TRIVIAL

CRITICAL REVIEWS IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY
2019, VOL. 49, NO. 8, 695–743
https://doi.org/10.1080/10643389.2018.1558889

Taylor & Francis
Taylor & Francis Group

OPEN ACCESS Check for updates

Recycling nutrients contained in human excreta to agriculture: Pathways, processes, and products

Robin Harder [a,b,c], Rosanne Wielemaker[d], Tove A. Larsen [e], Grietje Zeeman[e], and Gunilla Öberg [c]

Johannesdottir *et al. Environ Evid* (2020) 9:24
https://doi.org/10.1186/s13750-020-00207-7

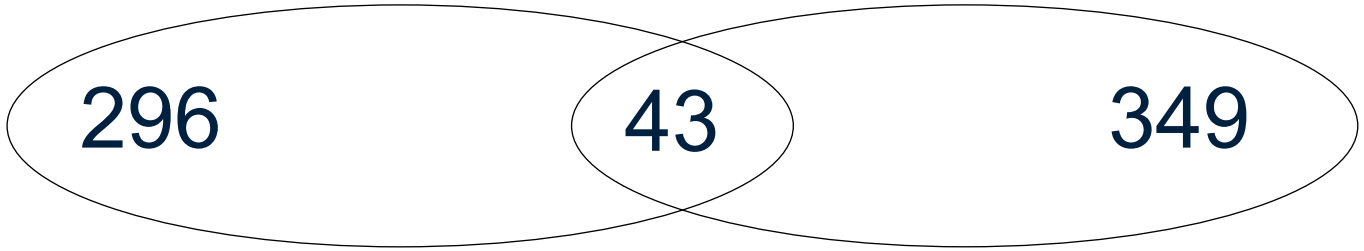
Environmental Evidence

SYSTEMATIC MAP Open Access

What evidence exists on ecotechnologies for recycling carbon and nutrients from domestic wastewater? A systematic map

Solveig L. Johannesdottir[1*], Biljana Macura[2], Jennifer McConville[3], Dag Lorick[2], Neal R. Haddaway[2,4,5], Agnieszka Karczmarczyk[6], Filippa Ek[2], Mikołaj Piniewski[7], Marta Księżniak[8] and Paweł Osuch[7]

SAN2AGRI	TOTAL	BONUS RETURN
339	688	392



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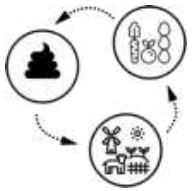
WHAT WE SEEK TO ACHIEVE



Map Evidence

>

Database

Website

<

Co-Design

- on nutrient recovery and reuse from human excreta and domestic wastewater
- from research and practice

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WHAT WE HAVE DONE SO FAR

Methodological Plan (Draft)

Methodological Plan (Final)

Searching, screening, coding

2020 Q3 Q4 | 2021 Q1 Q2 Q3 | 2022 Q4 Q1 | Q2 Q3 Q4 | 2023 Q1

Machine learning

Final Release Egestabase v3

Egestabase v1

Egestabase v2

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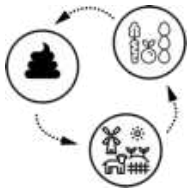
Macura et al. (2021)

THE EVIDENCE DATABASE



SEARCHING Scopus Web of Science

190 000 scientific papers

SCREENING not eligible 120 000 | eligible 10 000

TOPICS:
Recovery Technology
Recycling Fertilizers
Sustainability
User Acceptance

CODING

BIBLIOGRAPHIC METADATA

SOURCE STREAM
ACCESS STREAM
TECHNOLOGY CLUSTER
RECOVERY PROCESS
RECOVERY PRODUCT

TOPIC + EXTENDED METADATA PER TOPIC

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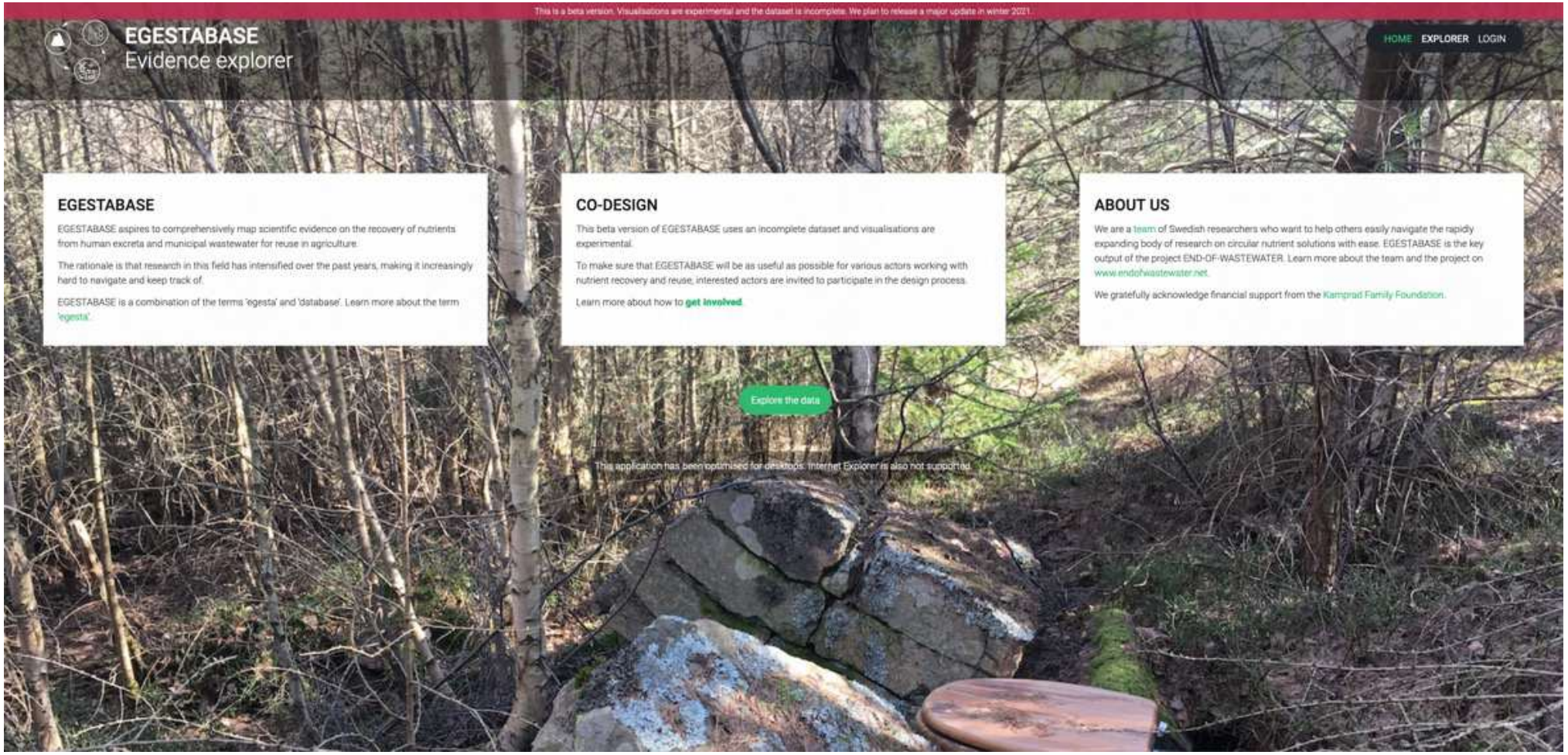
THE EVIDENCE EXPLORER



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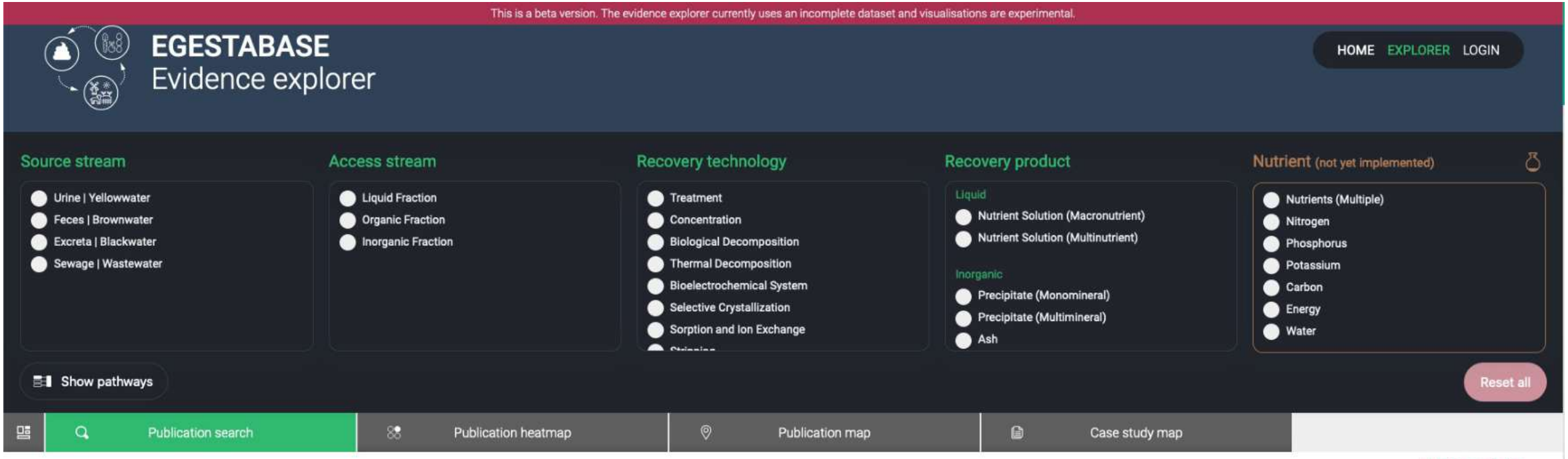
PATHWAYS



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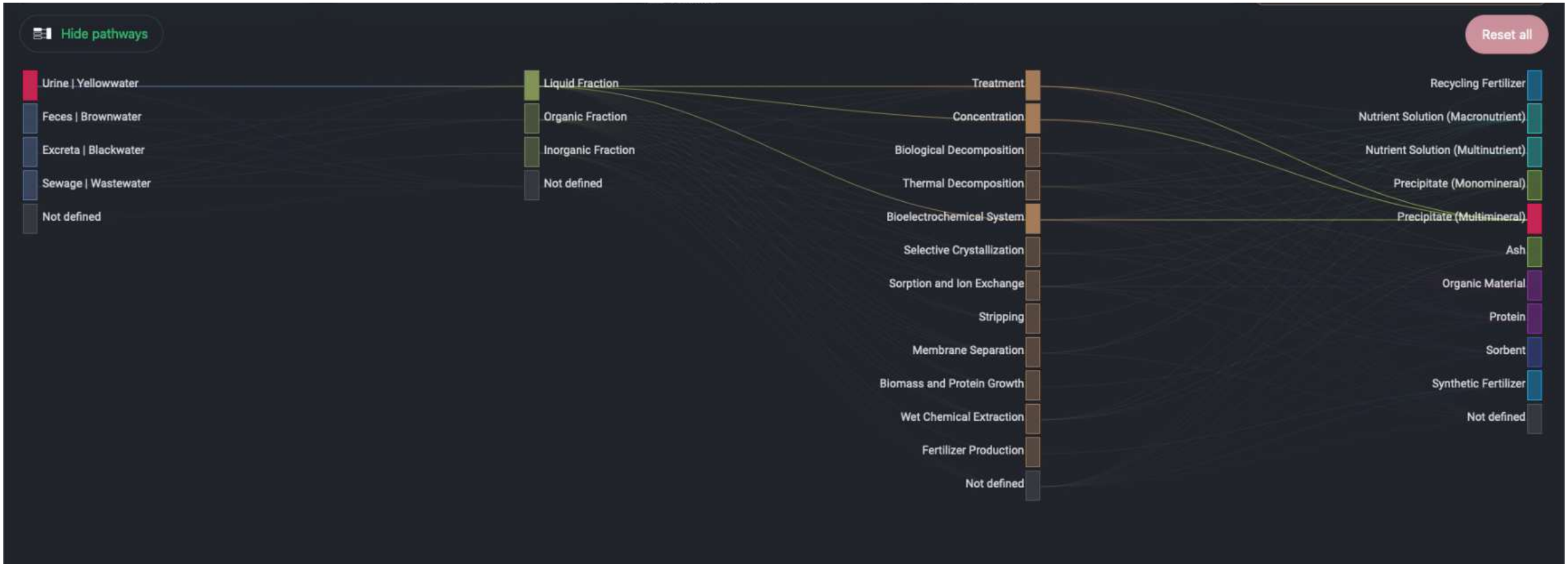
PATHWAYS



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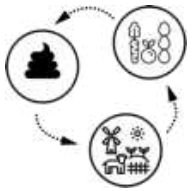
VIEWS



This is a beta version. The evidence explorer currently uses an incomplete dataset and visualisations are experimental.

Publication search | Publication heatmap | Publication map | Case study map

Help & search tips

Search

Abstract, DOI, Authors Go

Topic

- Agricultural Use
- Case Examples
- Concepts
- Recovery Products
- Recovery Technology
- Sustainability Assessment
- User Acceptance

Process (not yet implemented)

- Nitrification
- Granulation
- Heat Treatment
- Hydrolysis
- Heavy Metal Deposition
- Hydrothermal Carbonization (HTC)
- Hydrothermal Liquefaction (HTL)

2391 documents

Sort by year order desc

Vasiljev et al. (2022) | Drying fresh human urine in magnesium-doped alkaline substrates: Capture of free ammonia, inhibition of enzymatic urea hydrolysis & minimisation of chemical urea hydrolysis. *Chemical Engineering Journal* | Show details

Chia et al. (2021) | Sustainable membrane technology for resource recovery from wastewater: Forward osmosis and pressure retarded osmosis. *Journal of Water Process Engineering* | Show details

Lubensky (2021) | Pilot scale experiments for ammonium recovery from sludge liquor at a municipal waste water treatment plant. *Journal of Sustainable Development of Energy, Water and Environment Systems* | Show details

Carneiro et al. (2021) | Growth and bioactivity of two chlorophyte (Chlorella and Scenedesmus) strains co-cultured outdoors in two different thin-layer units using municipal wastewater as a nutrient source. *Algal Research* | Show details

Boniardi et al. (2021) | Assessment of a simple and replicable procedure for selective phosphorus recovery from sewage sludge ashes by wet chemical extraction and precipitation. *Chemosphere* | Show details

Naserian et al. (2021) | Qualitative investigation of sewage sludge composting: effect of aerobic/anaerobic pretreatments. *Arabian Journal of Geosciences* | Show details

Park et al. (2021) | Prediction of adequate pH and Mg2+ dosage using an empirical MgO solubility model for struvite crystallization. *Environmental Technology and Innovation* | Show details

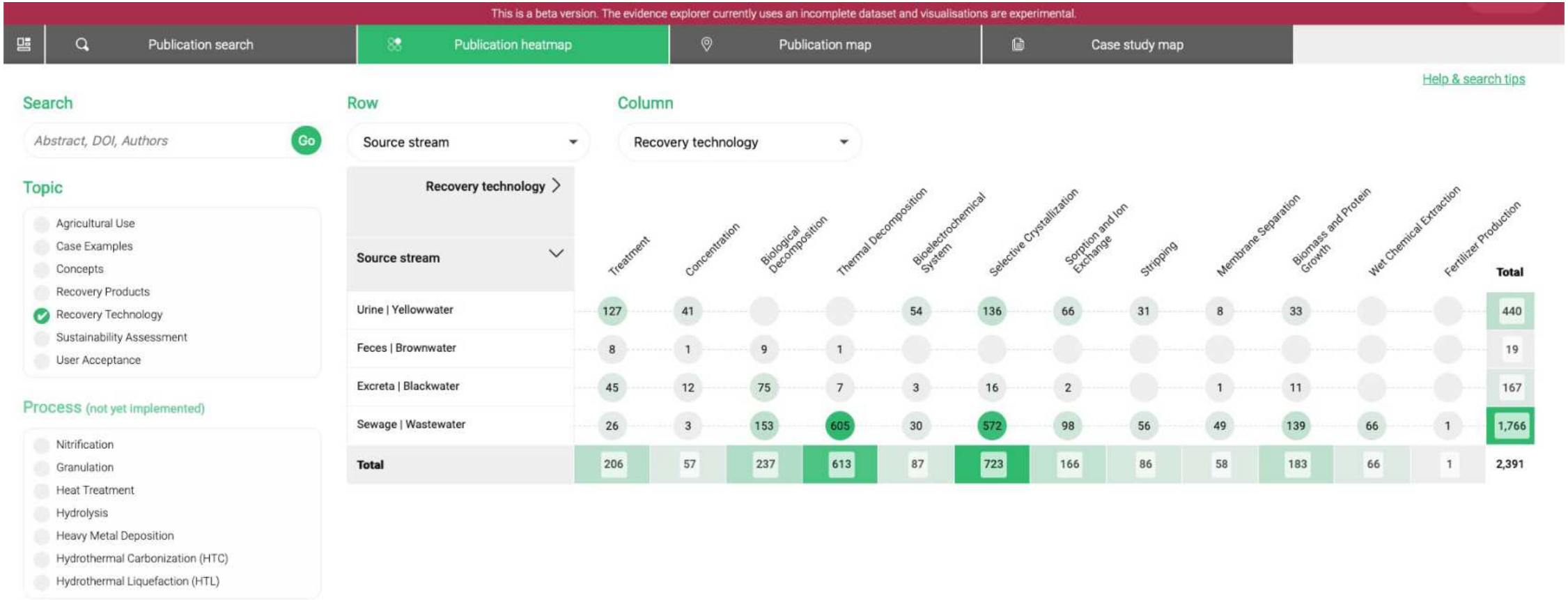
Huang et al. (2021) | Pushing the organic loading rate in electrochemically assisted anaerobic digestion of blackwater at ambient temperature: Insights into microbial community dynamics. *Science of the Total Environment* | Show details

Wen et al. (2021) | Contactless membrane distillation for effective ammonia recovery from waste sludge: A new configuration and mass transfer mechanism. *Journal of Membrane Science* | Show details

Liao et al. (2021) | Enhancing phosphorus recovery and dewaterability of waste activated sludge for combined effect of thermally activated peroxydisulfate and struvite precipitation. *Sustainability (Switzerland)* | Show details

Slides by Robin Harder

VIEWS



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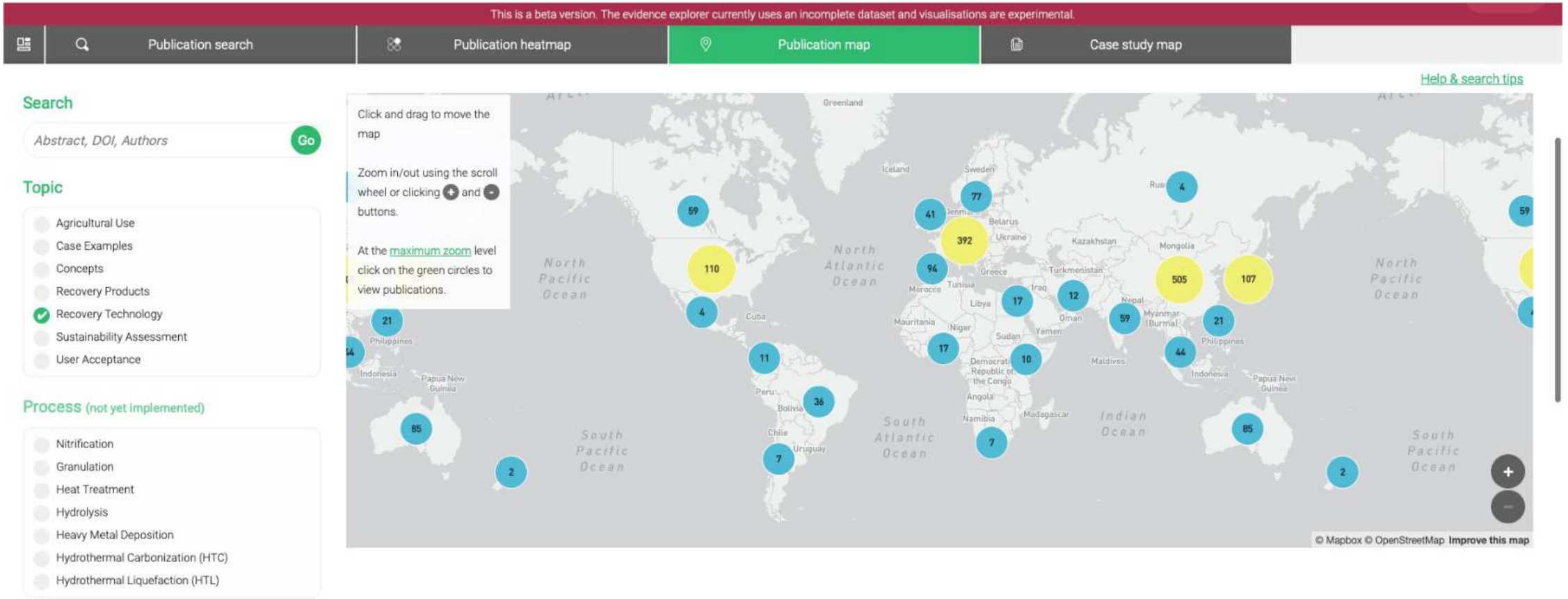
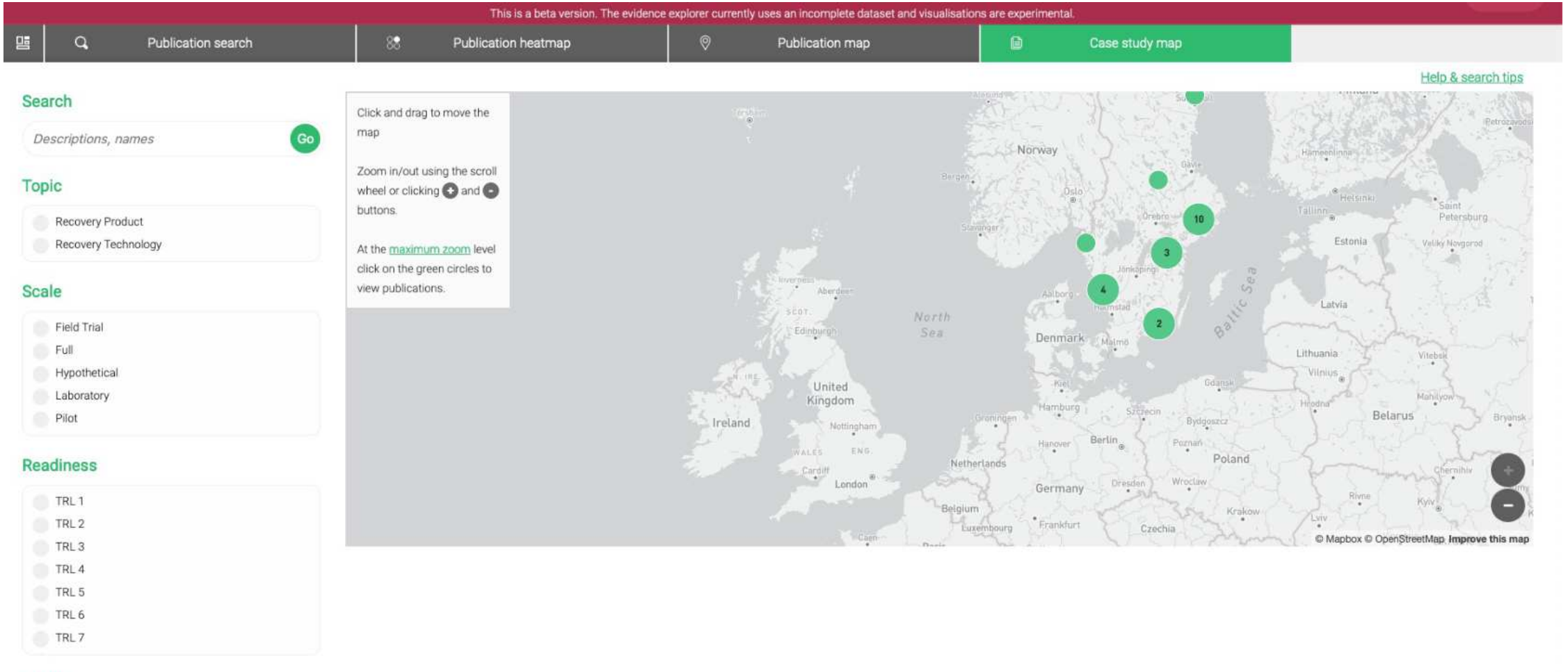
VIEWS



Slides by Robin Harder

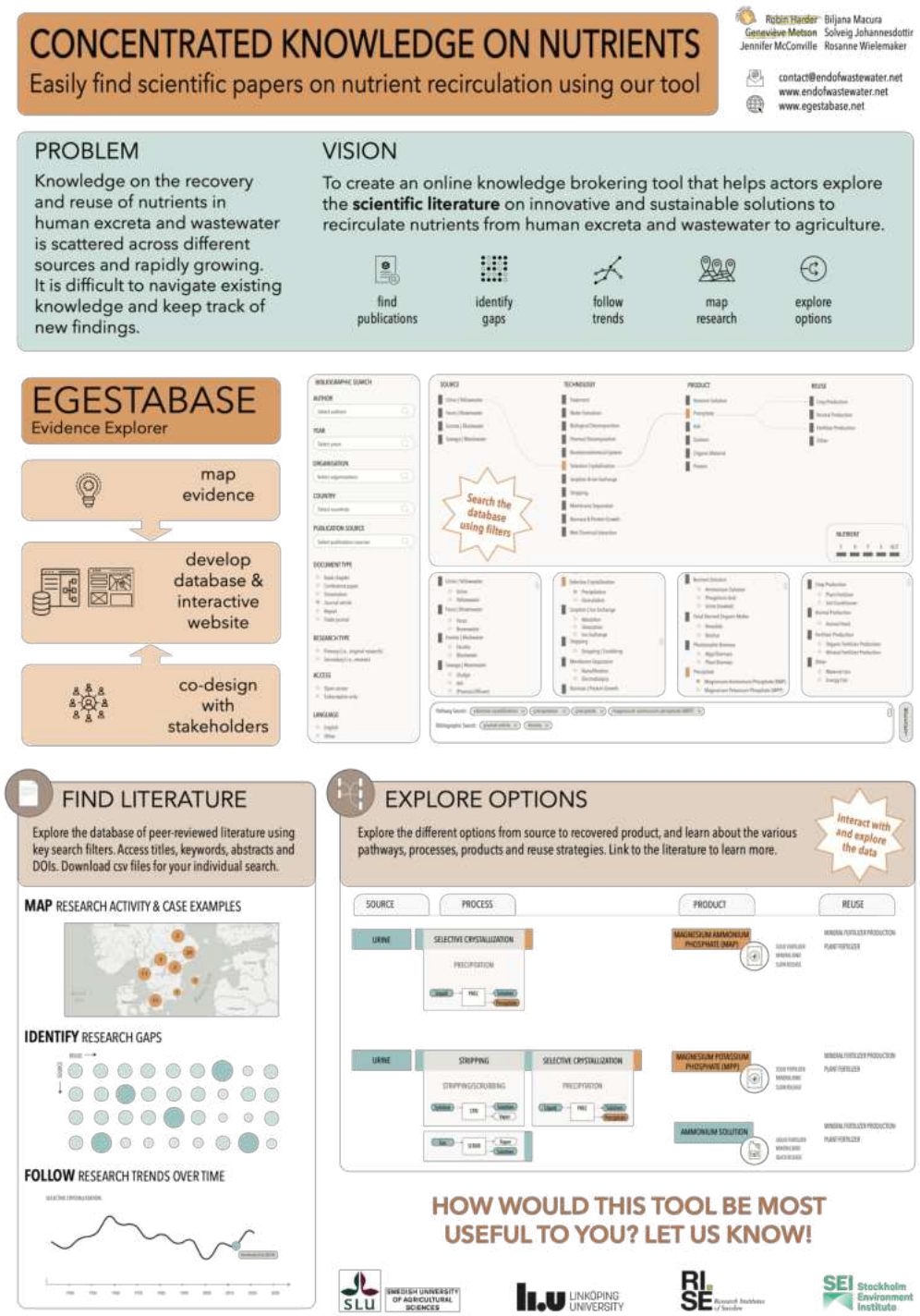
VIEWS



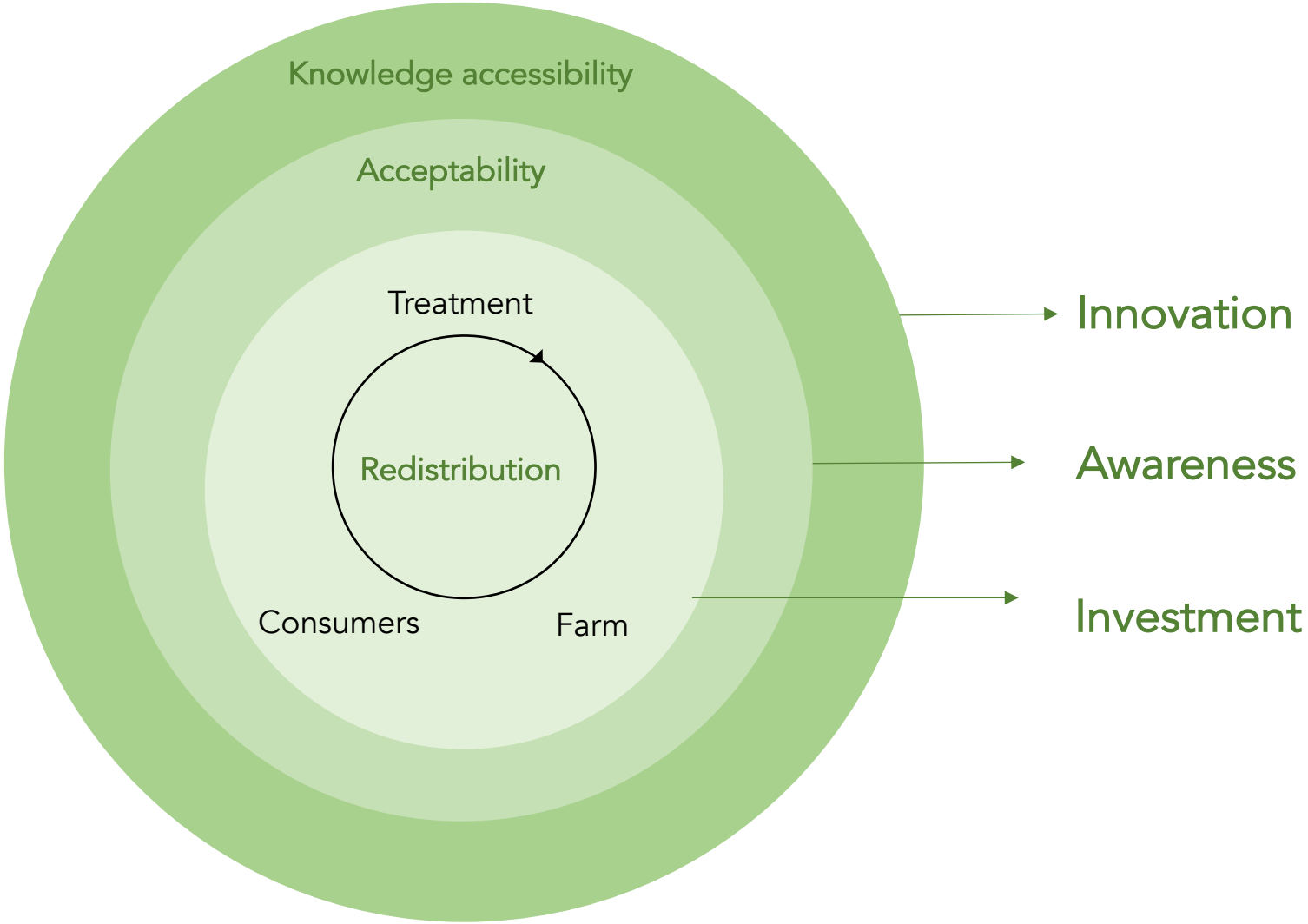
Slides by Robin Harder

New design and complete dataset coming

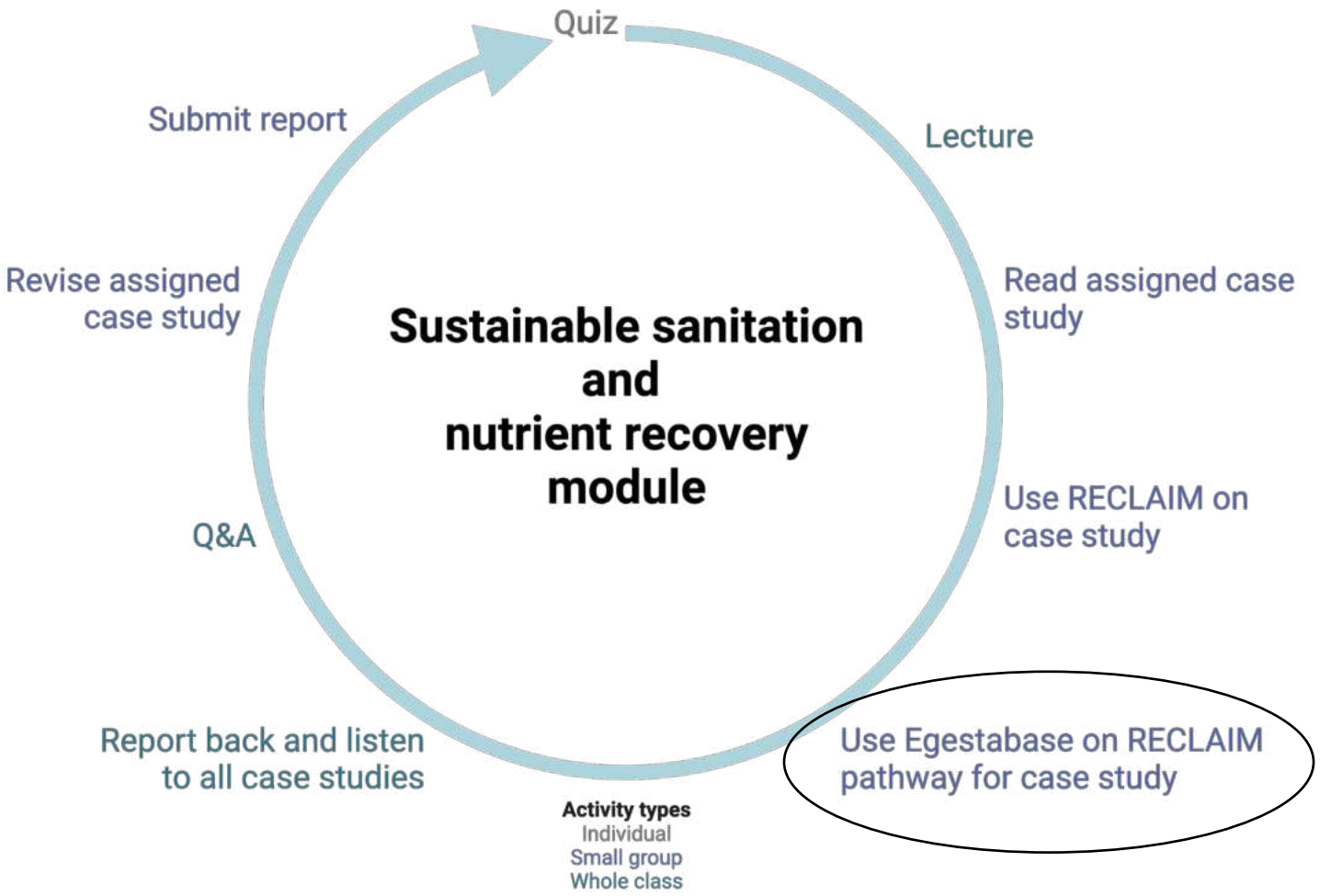
- How to keep it alive?
  Open-source vs Machine learning
- Still difficult to integrate practical examples
- Pedagogical component



Human excreta nutrients in sustainable food systems

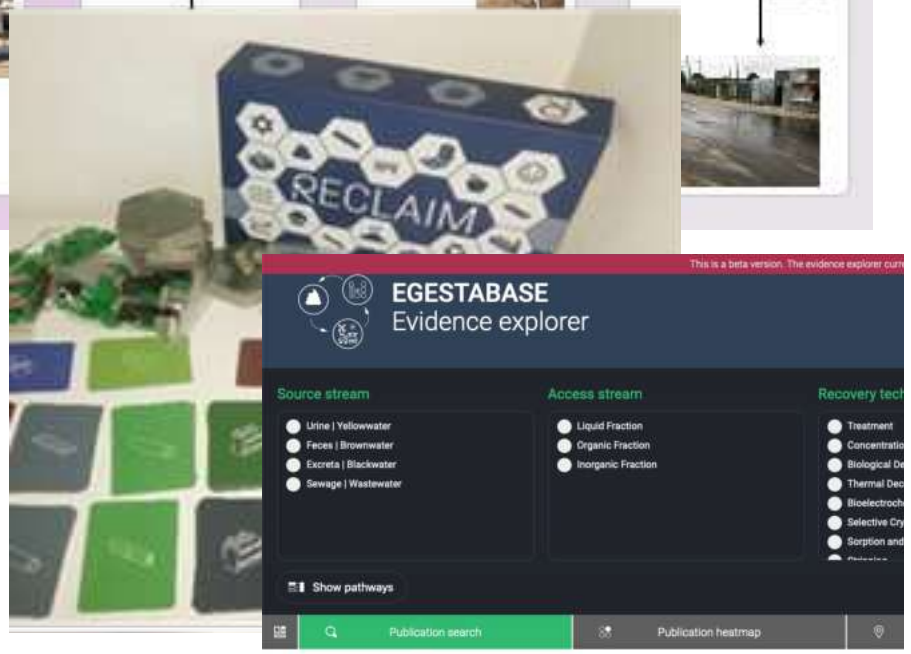


Facilitating student access to up-to-date research



Metson and McConville
(in prep) Frontiers in Education

No one right answer!

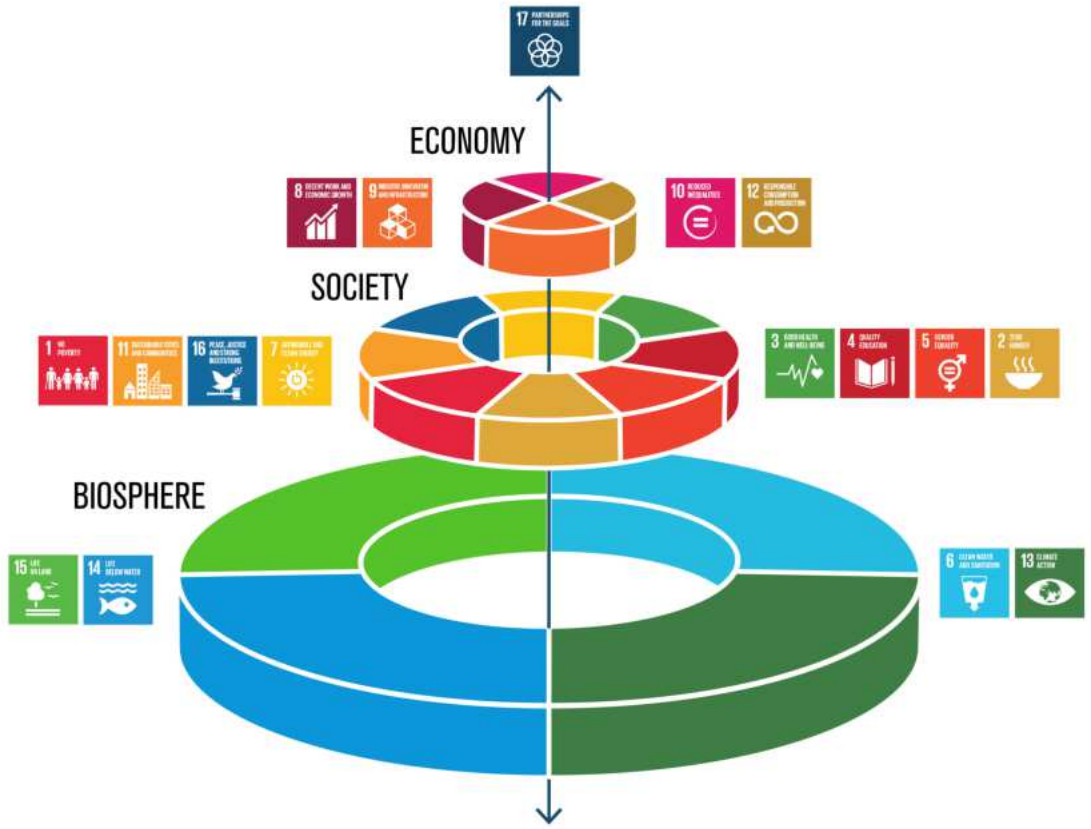


Sanitation system recommendation for Langrug, Franschhoek, South Africa

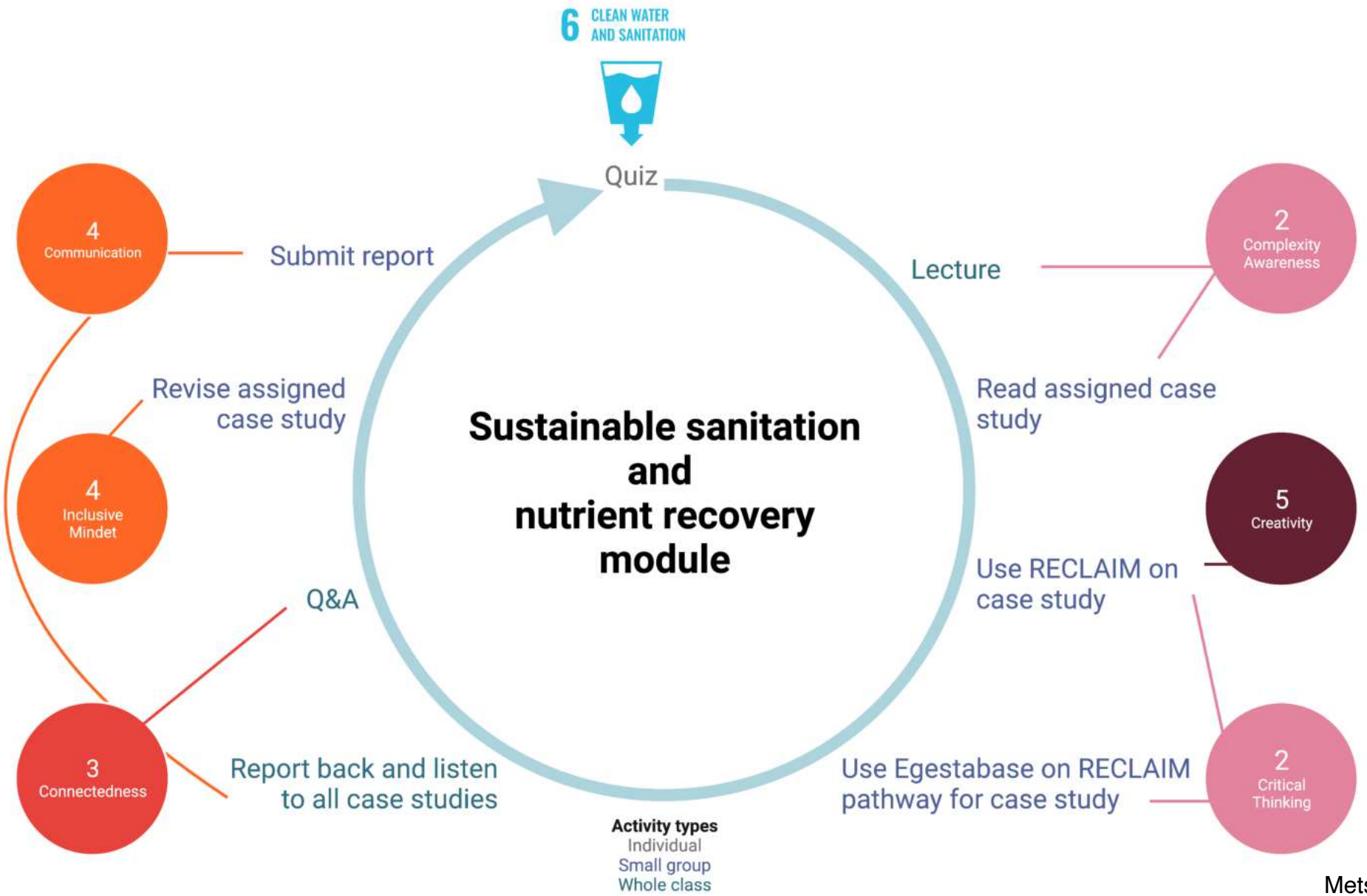
Table 1. Selected sanitation option round #1

	Housing	Treatment	Flows that leave treatment	Farm
Selection				
Why you selected it	As per the case description, there is no large-scale sewer system for household toilets and people may dispose of excreta in streets or ditches. As Szántó et al. (2012) state, decentralized technologies and an absence of sewerage are predominantly found in African slums (p. 617).	Co-composting of the remainders of the pit latrine seems like to economically most viable and feasible option, compared to other more complicated technologies.	By composting sludge/human excreta, soil conditioner remains that could be used as a fertilizer for certain kinds of agriculture.	Probably rather a fruit farm (the case description stated the importance of clean river water for wine fields/agriculture).
Potential challenge or barrier to implement this card	Financial feasibility Social: history of segregation White researchers "forcing" new technology upon local residents as form of colonization → acceptability Unplanned, growing settlements make it difficult to find the number of latrines to be installed As mentioned, a transdisciplinary project separating greywater and solid waste has failed, so establishing one location for disposing of everything might be more successful.	Financial feasibility Collection of excreta and transport to composting facility Maintenance of composting plant	Infrastructure to transfer composted sludge (fertilizer) to fields: A study by Akpo et al. (2019) found that the successful implementation of new sanitation depends greatly upon the succession of the different steps and services.	Marketing of South African wine (fertilized with human excreta → acceptance?) Management and acceptance from the farmers' side

Link access to information to SDGs



1	2	3	4	5
BEING – Relationship to Self	**THINKING** – Cognitive Skills	**RELATING** – Caring for Others and the World	**COLLABORATING** – Social Skills	**ACTING** – Driving Change
Inner compass	Critical thinking	Appreciation	Communication skills	Courage
Integrity and Authenticity	Complexity awareness	Connectedness	Co-creation skills	Creativity
Openness and Learning Mindset	Perspective skills	Humility	Inclusive mindset and intercultural competence	Optimism
Self-awareness	Sense-making	Empathy and Compassion	Trust	Perseverance
Presence	Long-term orientation and Visioning		Mobilization skills	



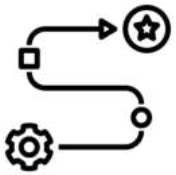
Metson and McConville et al.
(in prep) Frontiers in Education

Take home messages – Student engagement

One tool cannot be everything to everyone

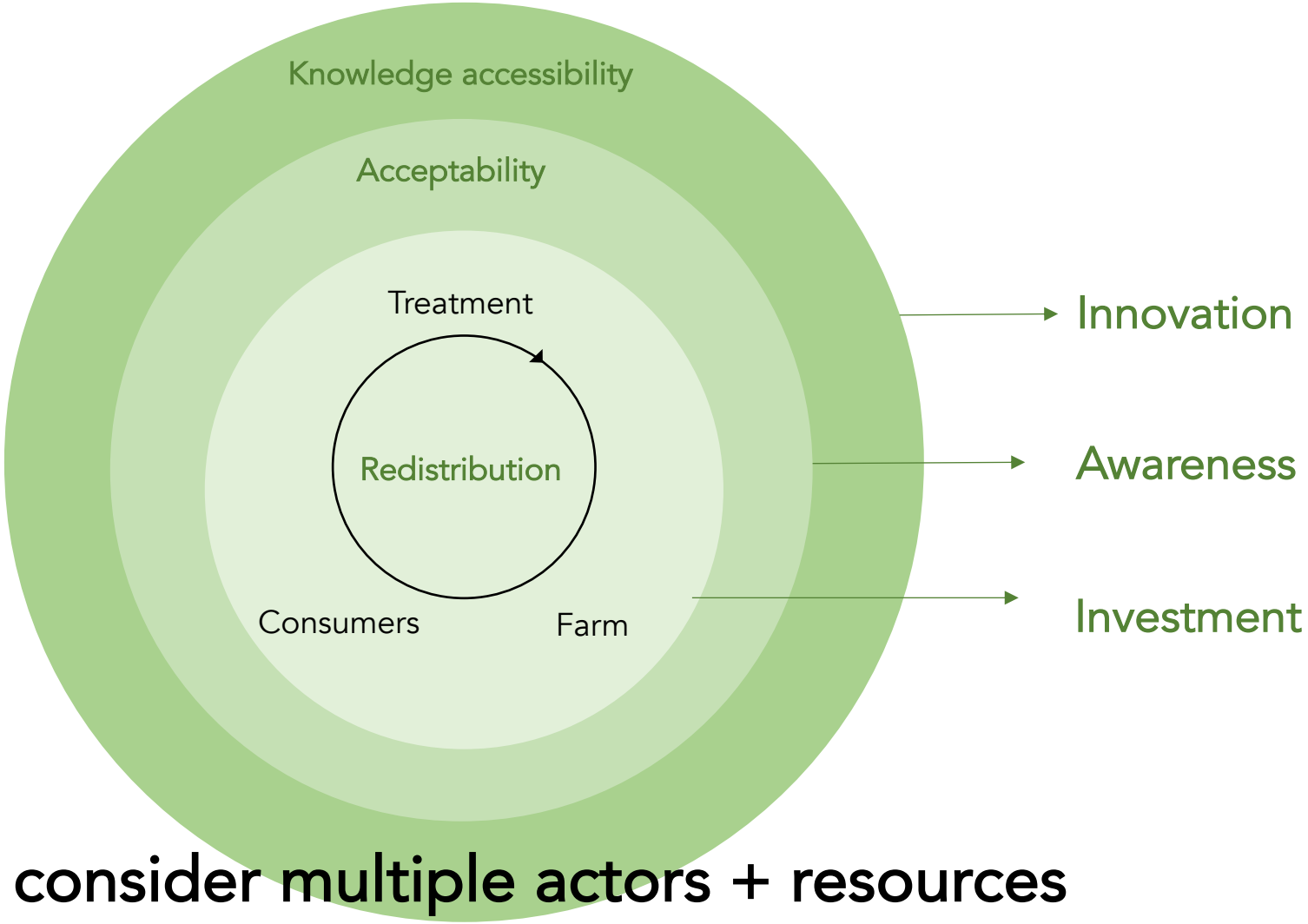
But designing for compatibility can help

Real case studies help go from idea to comprehension



May be one pathway towards acceptance (not only knowledge)

Human excreta nutrients in sustainable food systems



Must consider multiple actors + resources

Reading from the talk

Increasing effective nutrient reuse with biogas Sweden

- Metson, Feiz , Quttineh and Tonderski. 2020. Optimizing transport to maximize nutrient recycling and green energy recovery *Resources, Conservation & Recycling: X* 9–10 100049
- Metson, Sundblad , Feiz , Quttineh and Mohr. 2022. Swedish food system transformations: Rethinking biogas transport logistics to adapt to localized agriculture *Sustainable Production and Consumption* 29 370–86

Sustainable food systems in Sweden

- Karlsson, Röös, Sjunnestrand, Pira, Larsson, Andersen, Sørensen, J., Veistola, Rantakokko, Manninen, Brubæk. 2017 Future Nordic Diets: Exploring ways for sustainably feeding the nordics. Nordic Council of Ministers TemaNord 2017:566, Rosendahls, Denmark.
- Karlsson, Carlsson, Lindberg, Sjunnestrand, Röös. 2018. Designing a future food vision for the Nordics through a participatory modeling approach. Agronomy for Sustainable Development 38, 59.

Acceptance of recycled fertilizers

- Lundin, Metson, McConville, Westling. 2021. Recirkulering av näringsämnen mellan stad och land- vad vill gödselanvändaren ha? Aktivitetsrapport- tematisk workshop. IVL Svenska Miljöinstitutet rapportnummer B 2414
- McConville, Metson, Persson. Under review. Acceptance of human excreta-derived products in Swedish grocery stores. City and Environment Interactions

Increasing access to information

- https://www.endofwastewater.net/
- Macura, Thomas, Metson, McConville, Johannesdottir, Seddon, Harder. 2021. Technologies for recovery and reuse of plant nutrients from human excreta and domestic wastewater: a protocol for a systematic map and living evidence platform. Environmental Evidence 10(20)
- Metson and McConville (in prep). Beyond infrastructure: How the use of digital tools & serious games can improve sanitation education. To be submitted to Frontier in Education and/or as an open-access module for teachers

Thank you for your time

Please ask questions, it's the best part of a talk

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