The Environmental Science and Policy Lab

Guiding the pursuit of sustainable agriculture with data-driven and transdisciplinary approaches

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Editor, Earth's Future

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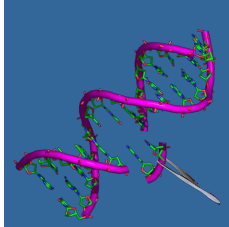
Appalachian Laboratory

http://research.al.umces.edu/xzhang/

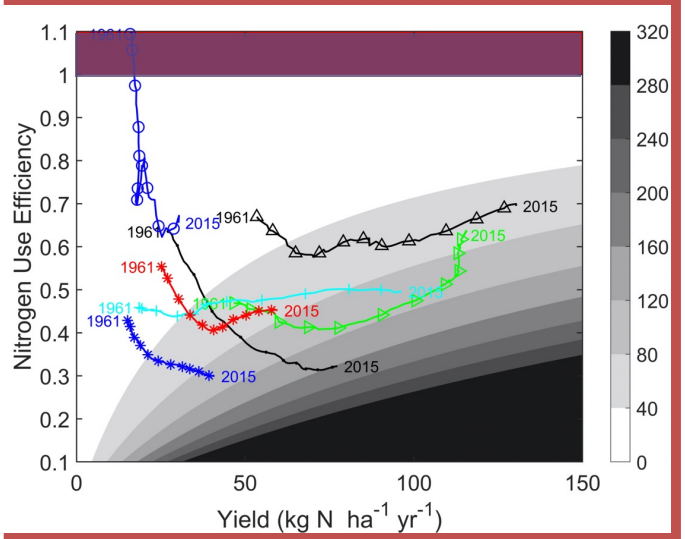
The need for a new paradigm?



- Couple socioeconomic and ecological processes
- Extend from production-focused to the agri-food-energy system
- Transdisciplinary & Transnational

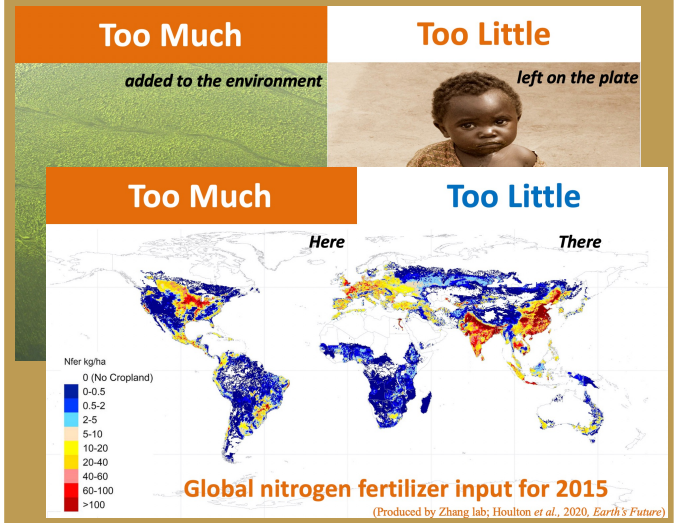
Converge socioeconomic and ecological processes

"High-tech, low-efficiency" paradox



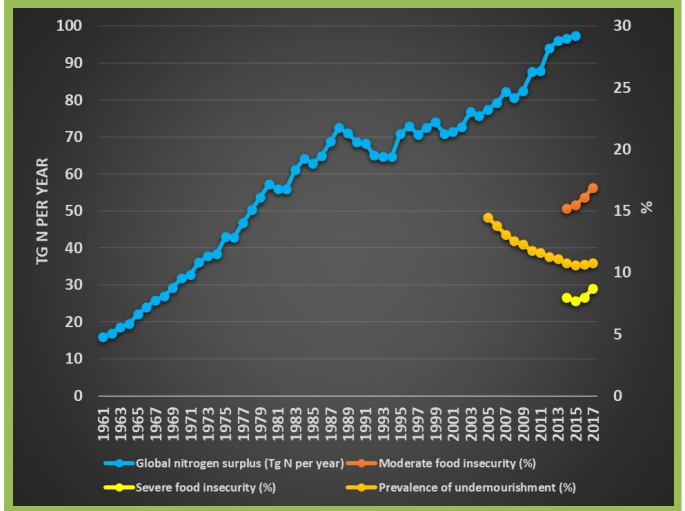
Extend from production-focused to agri-food system

"Too much, too little" paradox



Transdisciplinary & Transnational

"High productivity, low nutrition" paradox



Converge socioeconomic and ecological processes

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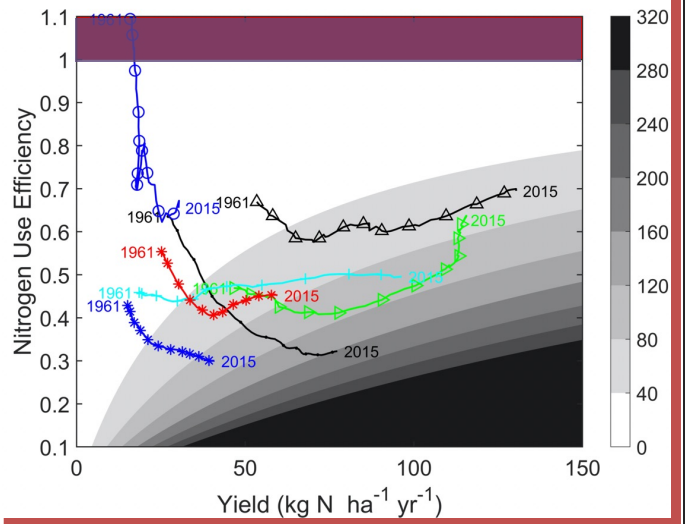

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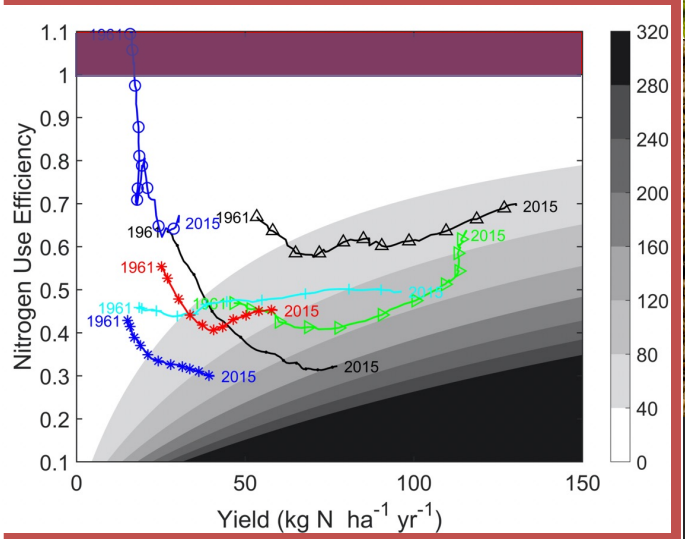
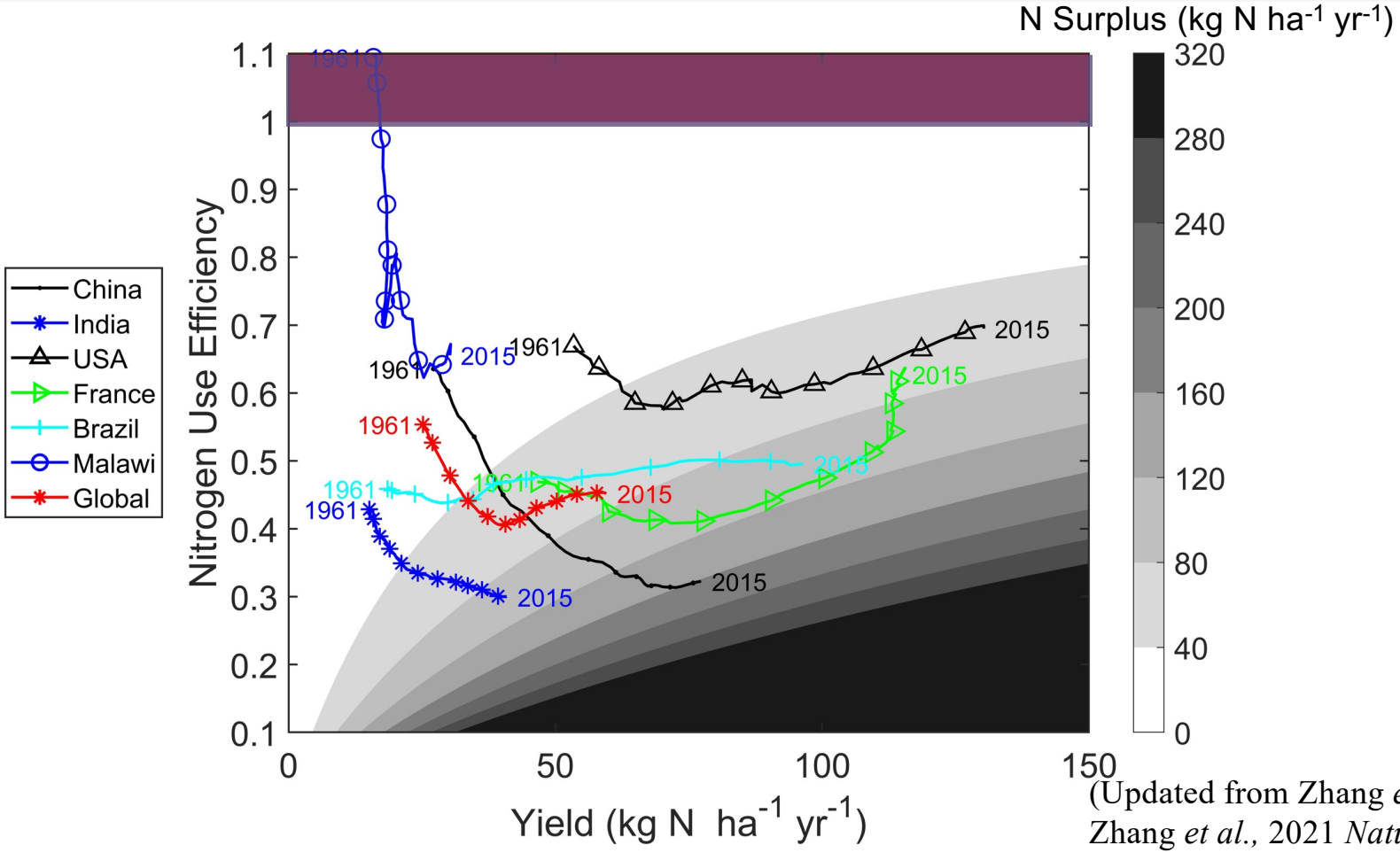


-Increasingly more available and affordable Technologies and Management Practices for Improving NUE (TMPs)

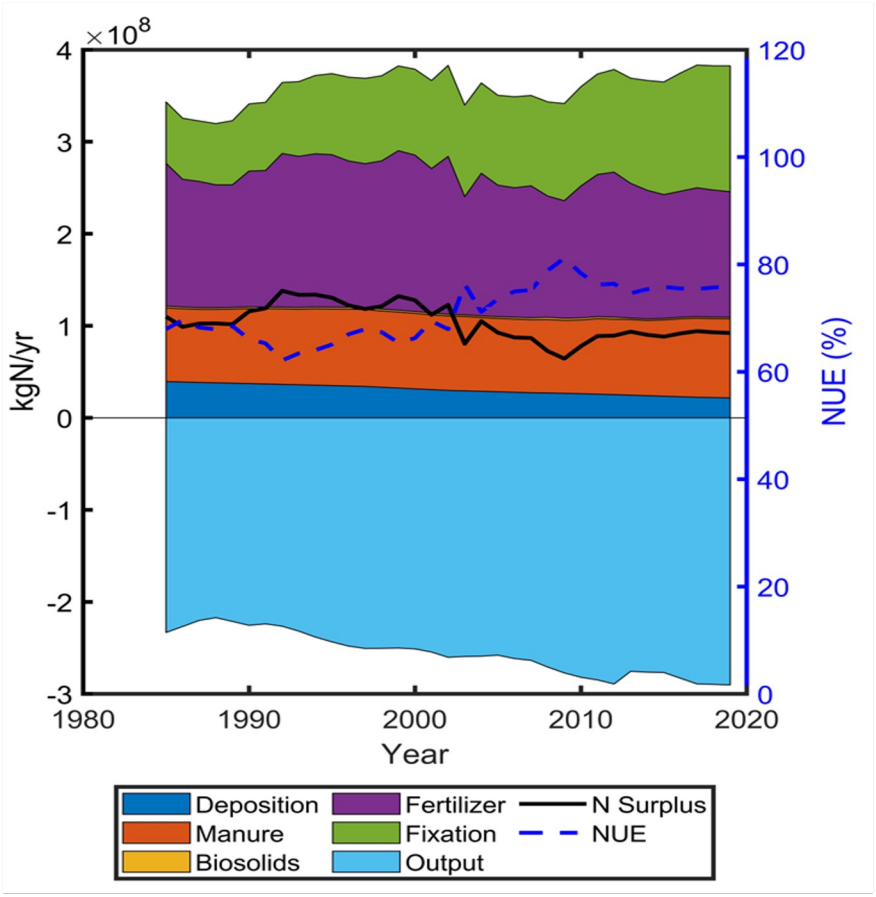
-Declining or stagnant NUE worldwide

NUE Trend for crop production



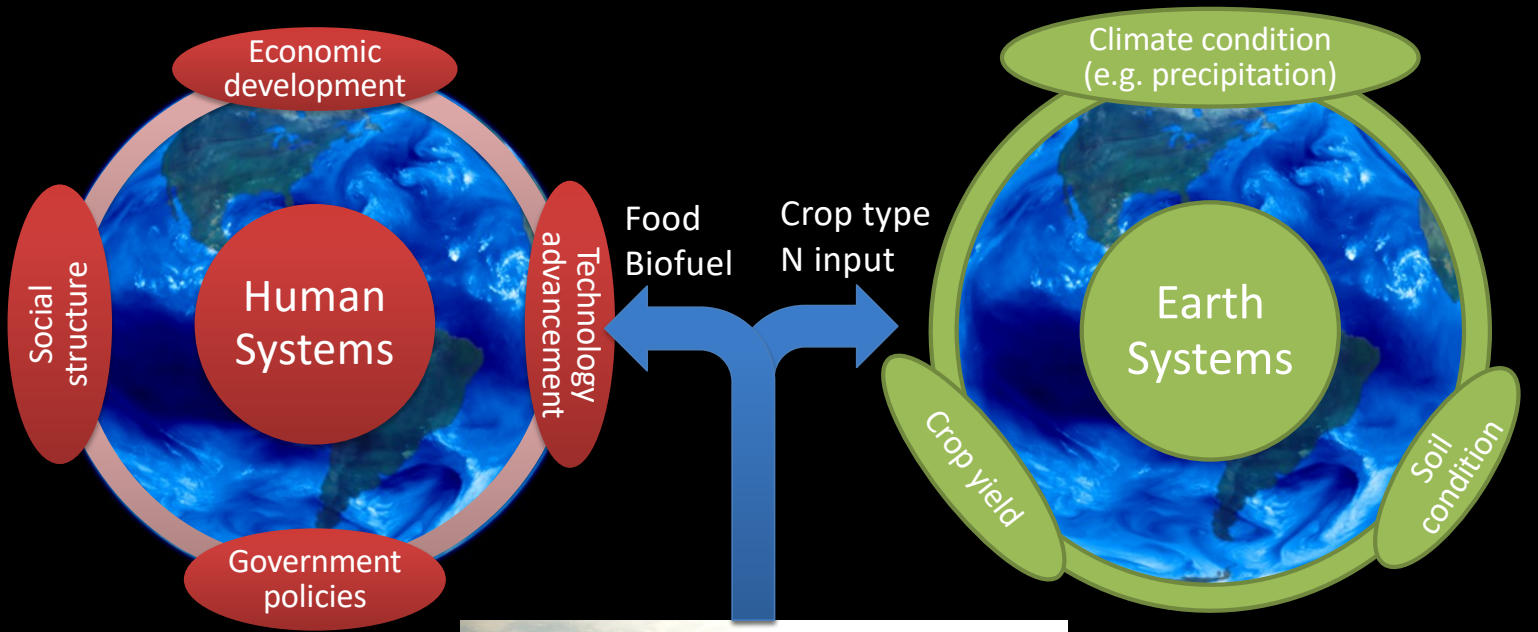
(Updated from Zhang *et al.*, 2015, *Nature*; Zhang *et al.*, 2021 *Nature Food*)

NUE Trend for crop production



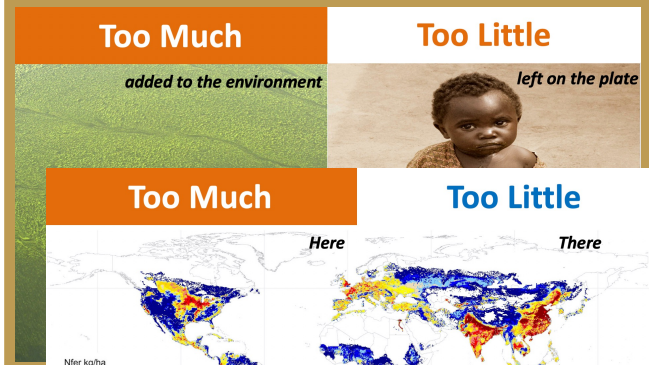
(Zou, 2023)

Converge socioeconomic and ecological processes



Extend from production-focused to agri-food system

"Too much, too little" paradox



Too Much

added to the environment

187

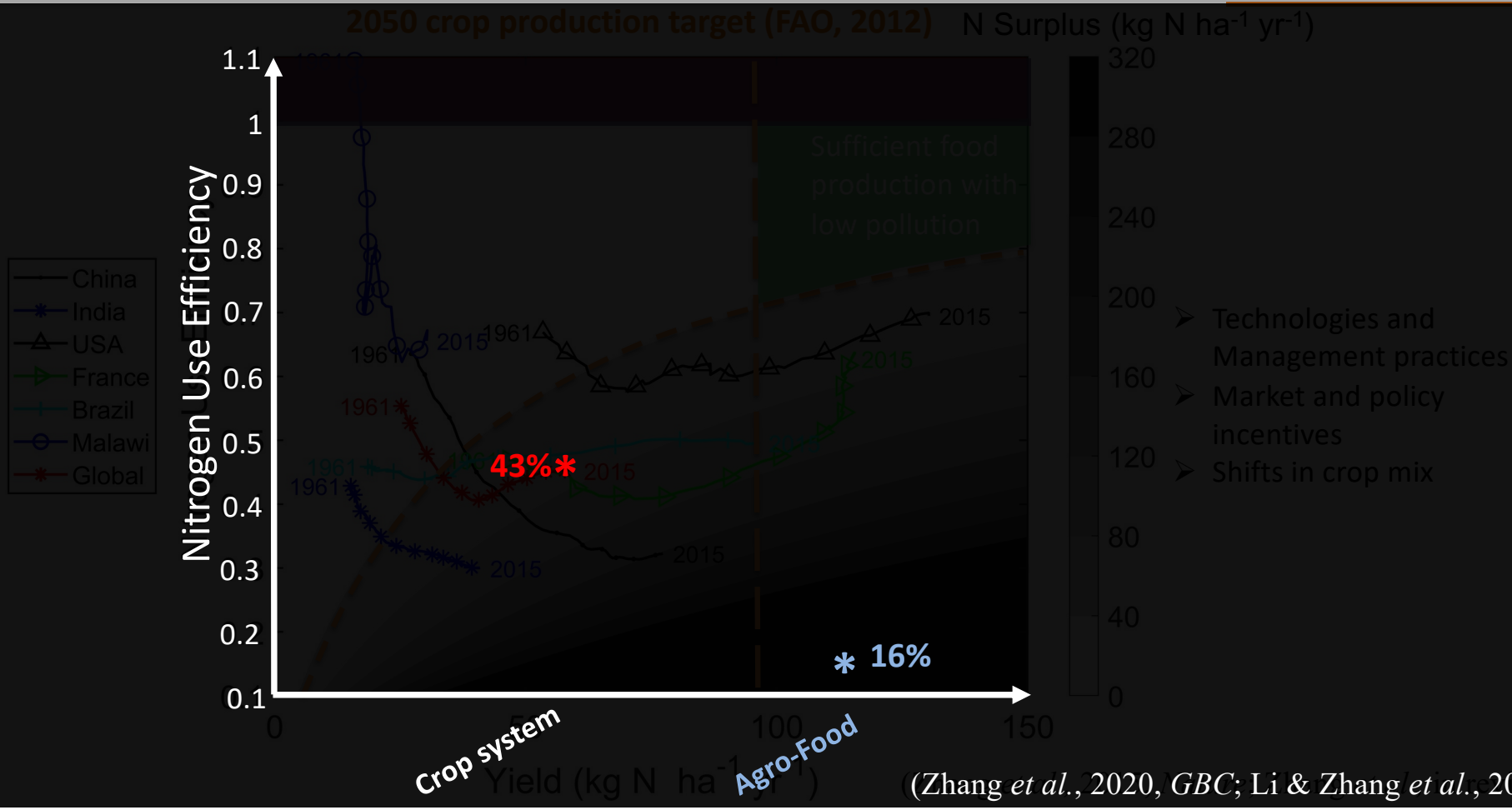
Too Little

left on the plate

30 Tg N yr^{-1}

~16%

NUE beyond crop production



(Zhang *et al.*, 2020, *GBC*; Li & Zhang *et al.*, 2022)

Extend from production-focused to agro-food system

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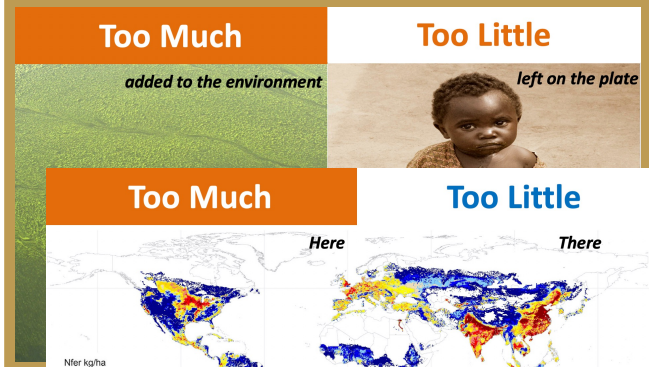
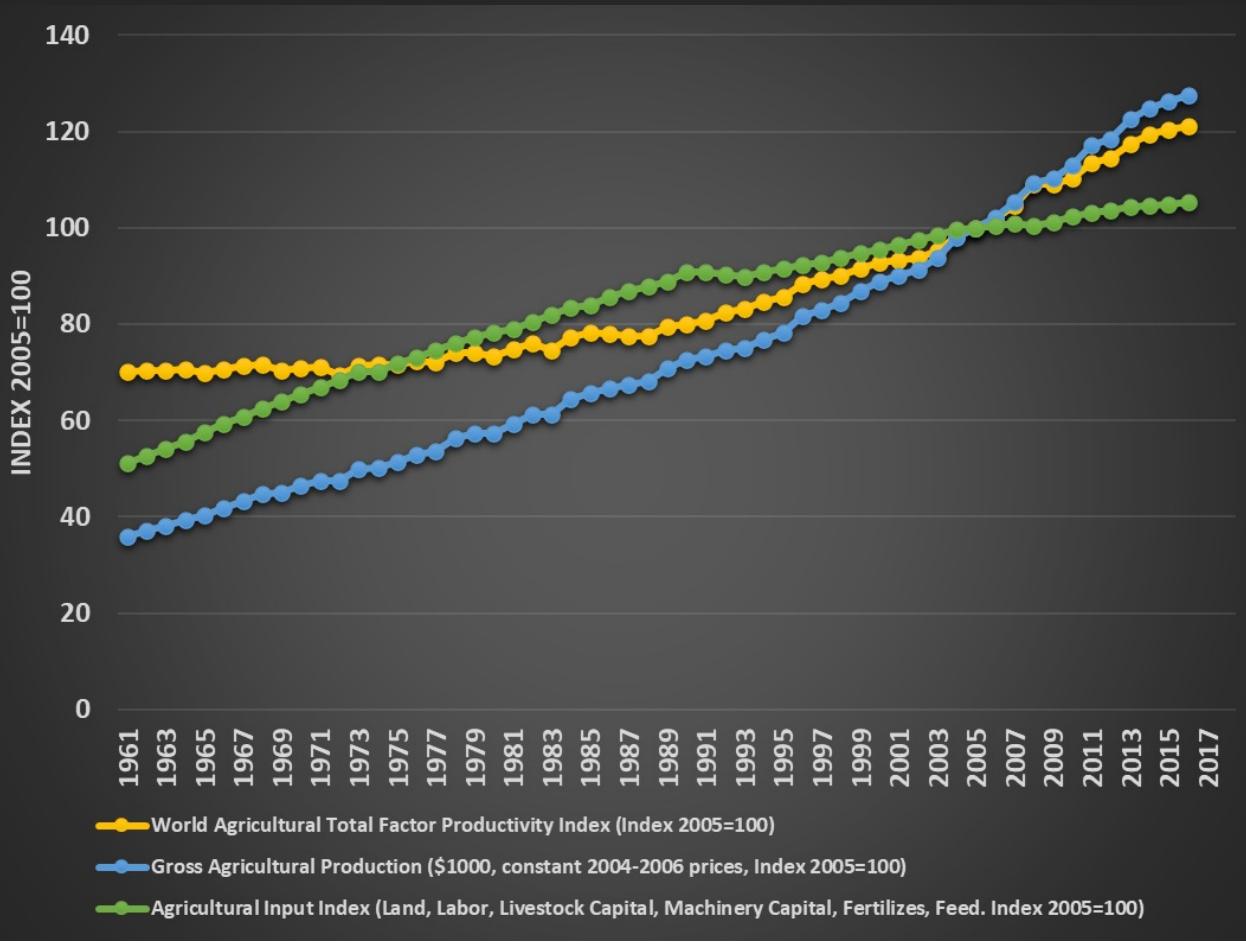
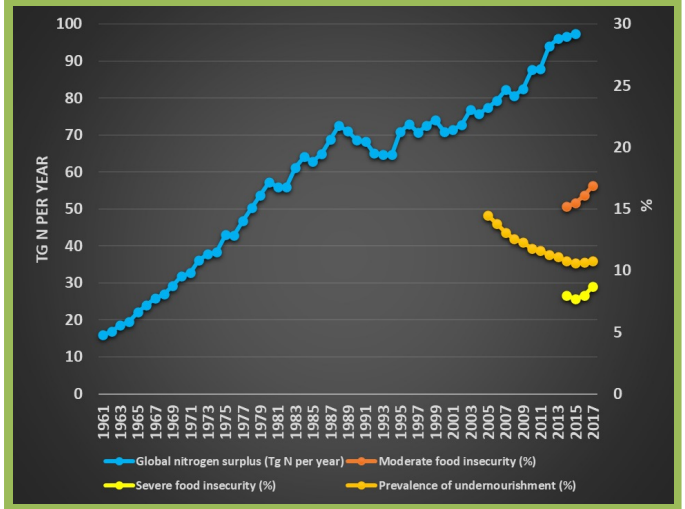


Increasing agricultural productivity

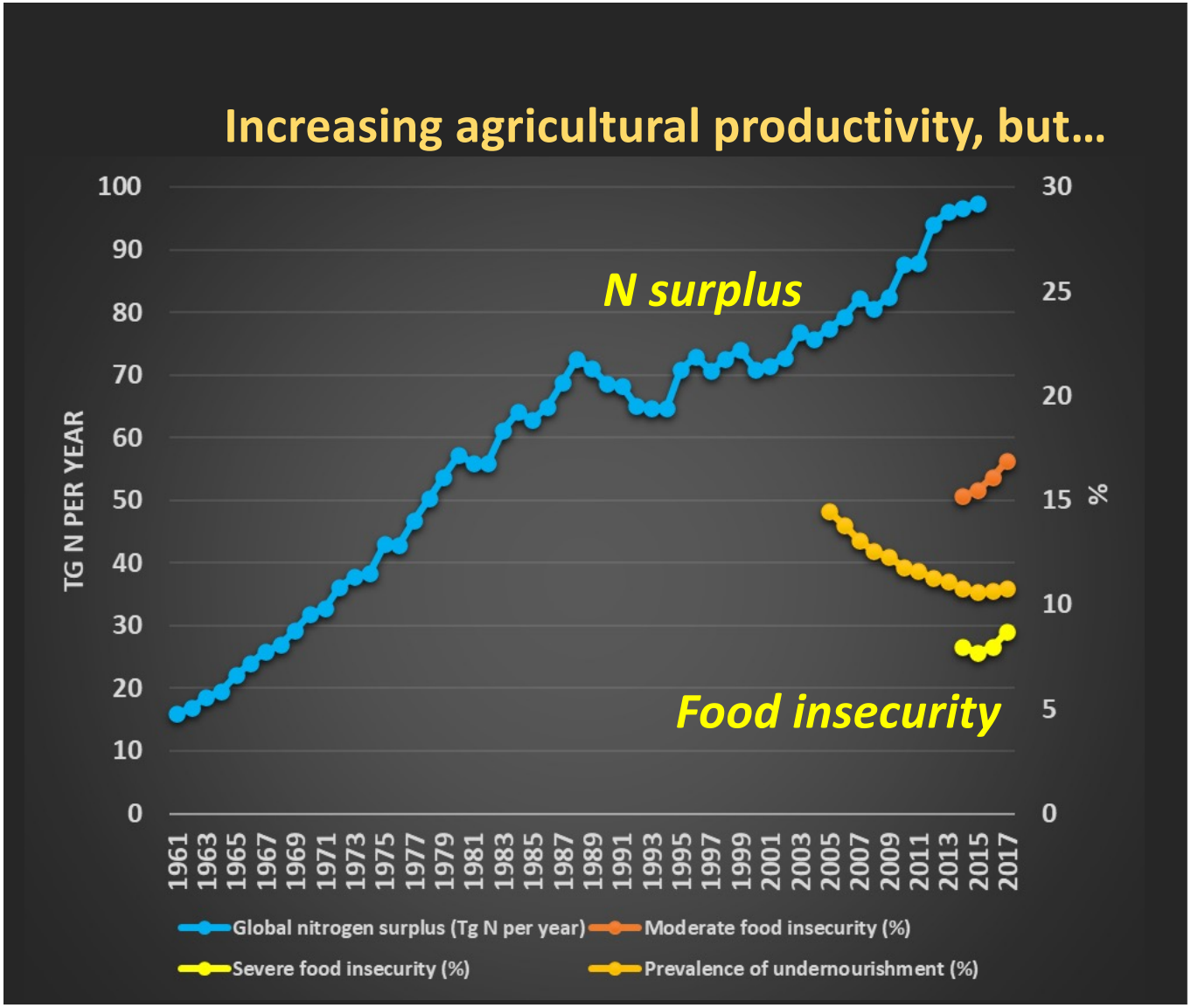


Transdisciplinary & Transnational

"High productivity, low nutrition" paradox



(Zou & Zhang *et al.*, report to FAO)



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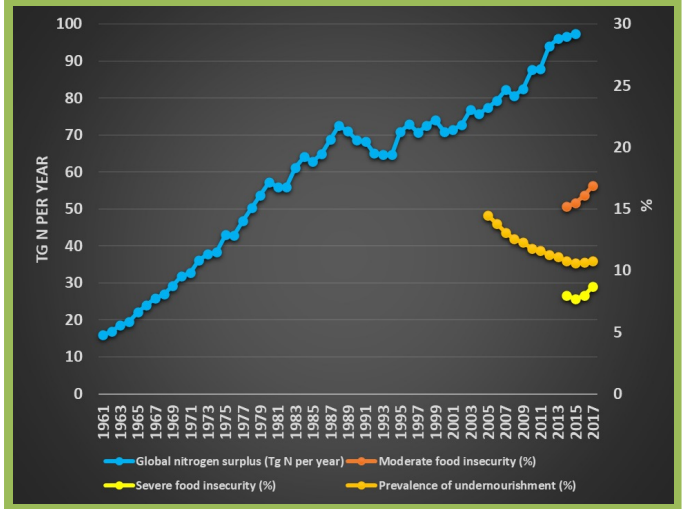

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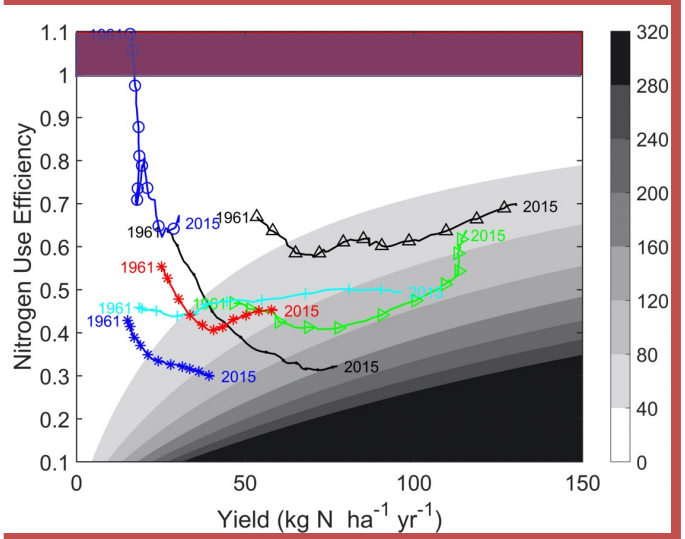

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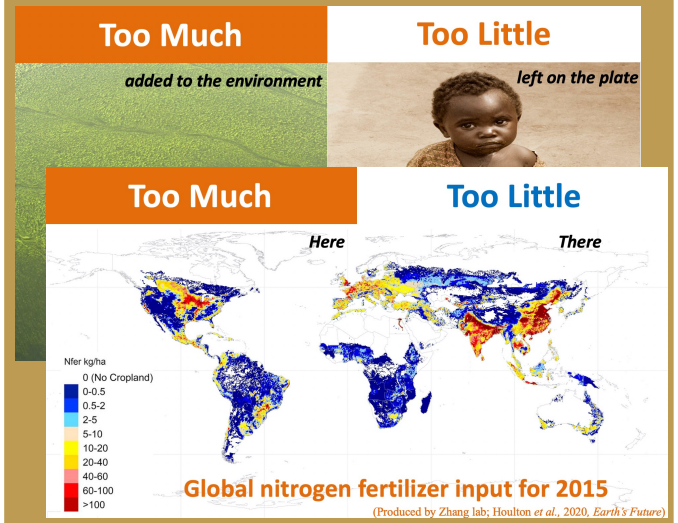

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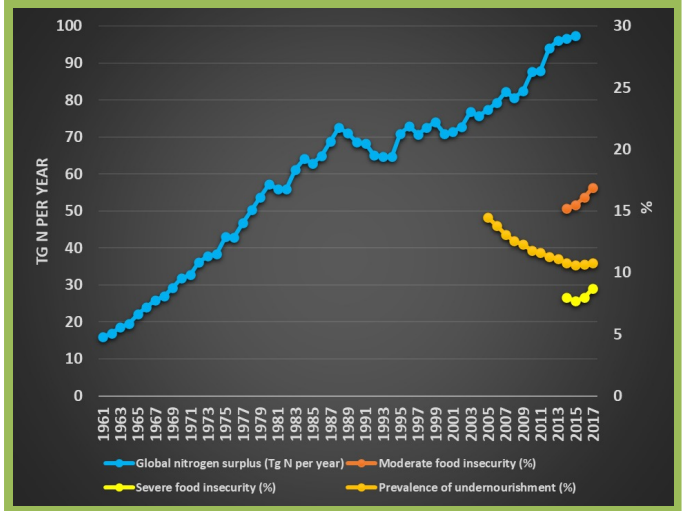
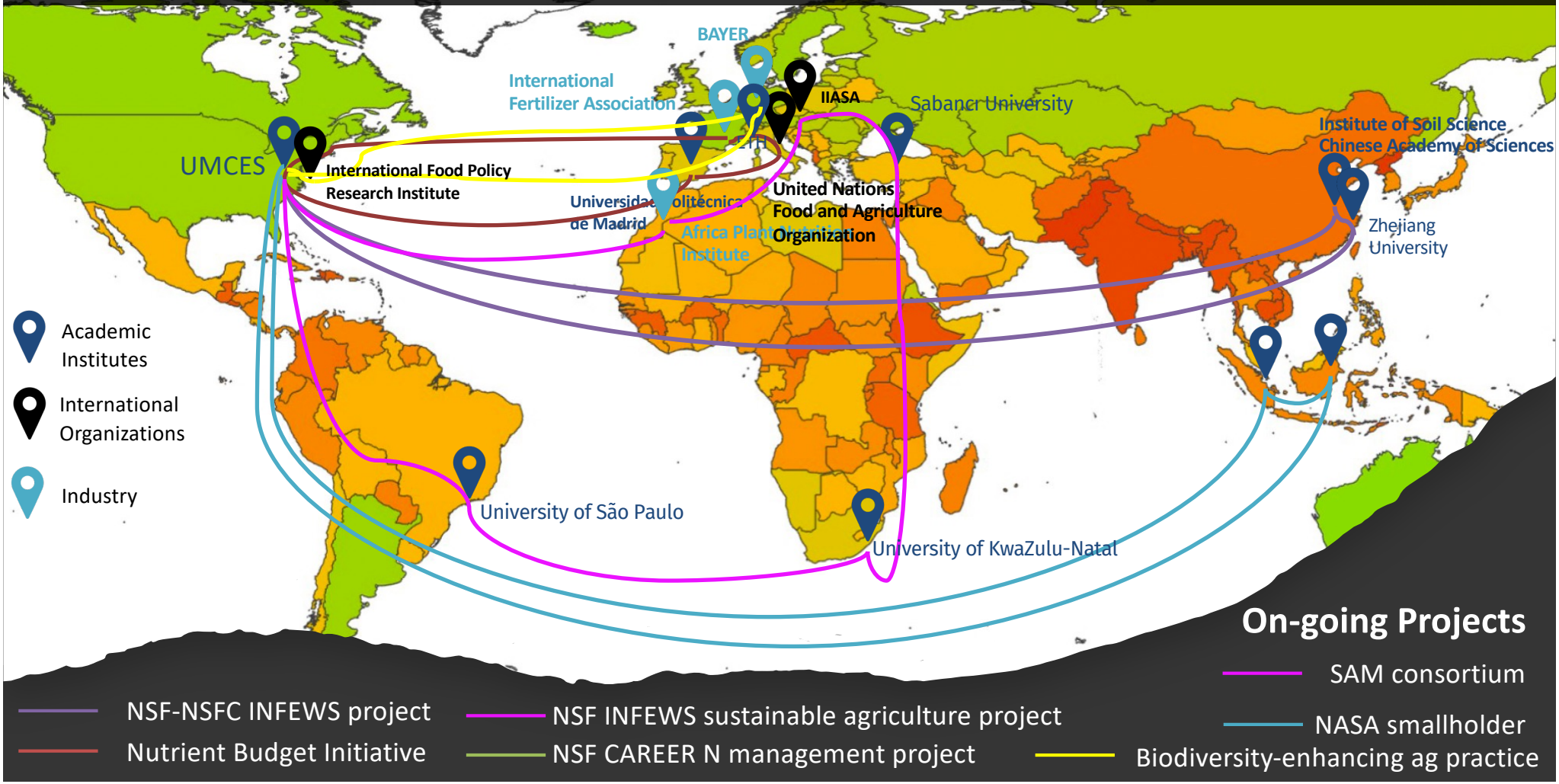


A Transdisciplinary and Transnational Network for Sustainable Innovation

http://research.al.umces.edu/xzhang/

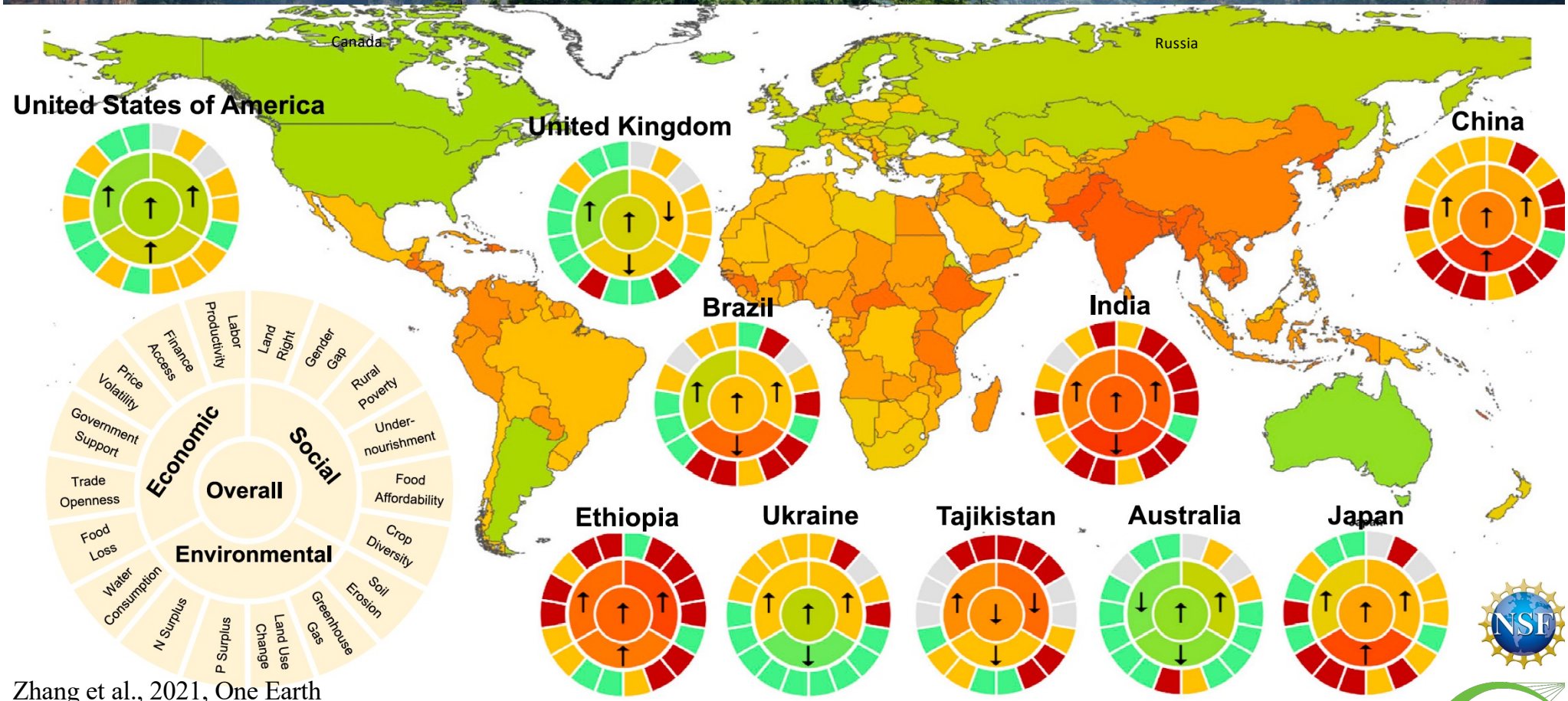


Converge socioeconomic and ecological processes	Extend from production-focused to agro-food system	Transdisciplinary & Transnational
"High-tech, low-efficiency" paradox	*"Too much, too little" paradox*	*"High productivity, low nutrition" paradox*

Sustainable Agriculture Matrix

- What is Sustainable Agriculture ?
- What are the drivers?
- How to improve it?

Sustainable Agriculture Matrix (SAM)
A report card for agriculture around the world



Zhang et al., 2021, One Earth
https://envrion-sci-and-policy-visualizations.shinyapps.io/samapp_v2/

NSF

SESYNC

Sustainable Agriculture Matrix (SAM)
Engaging Stakeholders in six countries and regions

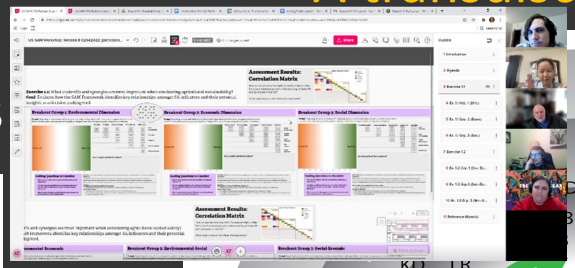
10 workshops

8 countries

150+ stakeholders

SAM Consortium

A transdisciplinary and transnational consortium



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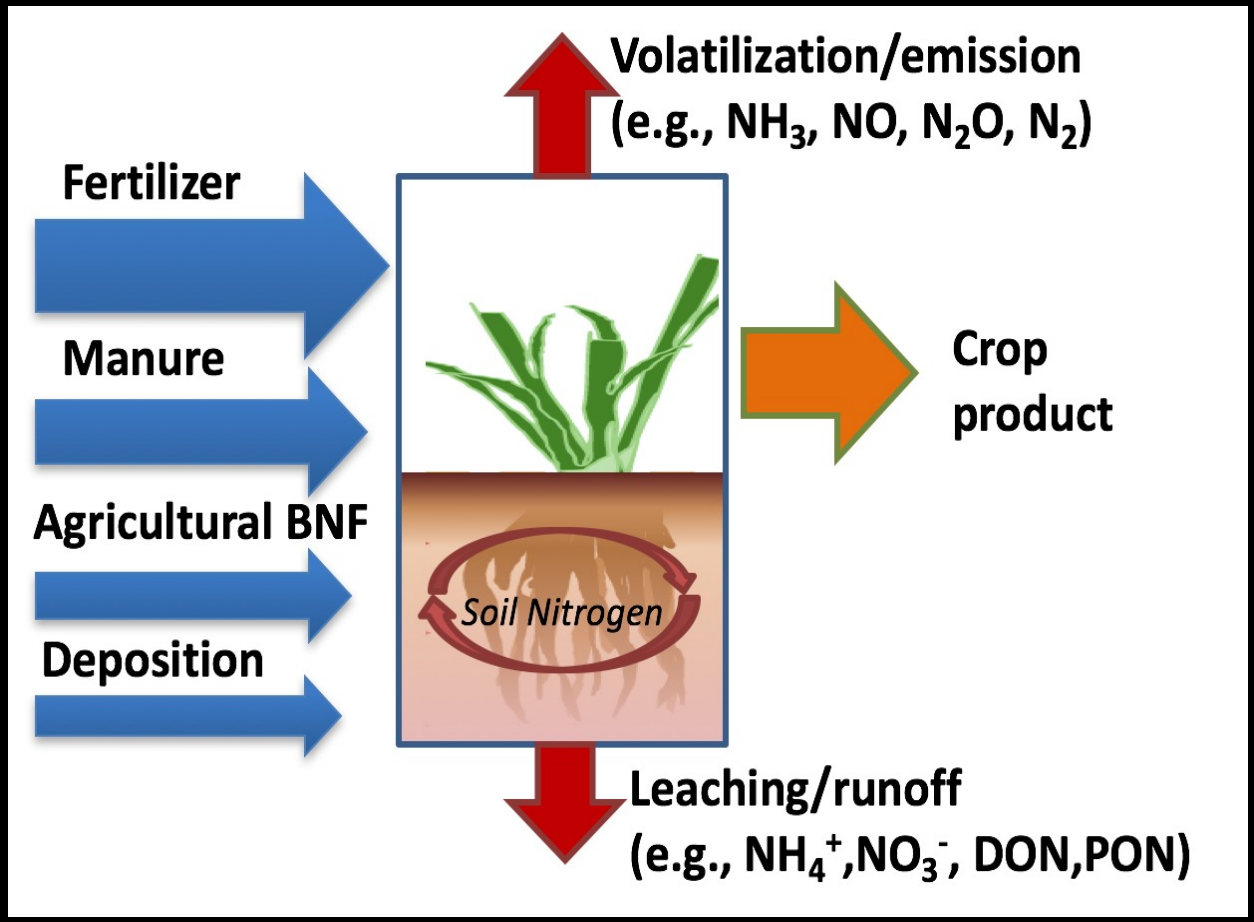
Converge socioeconomic and ecological processes	Extend from production-focused to agro-food system	Transdisciplinary & Transnational
"High-tech, low-efficiency" paradox	*"Too much, too little" paradox*	*"High productivity, low nutrition" paradox*

Nutrient Use Efficiency

- What is it?
- How it has been changing?
- What are the drivers?
- How to improve it?

Sustainable Nutrient Management

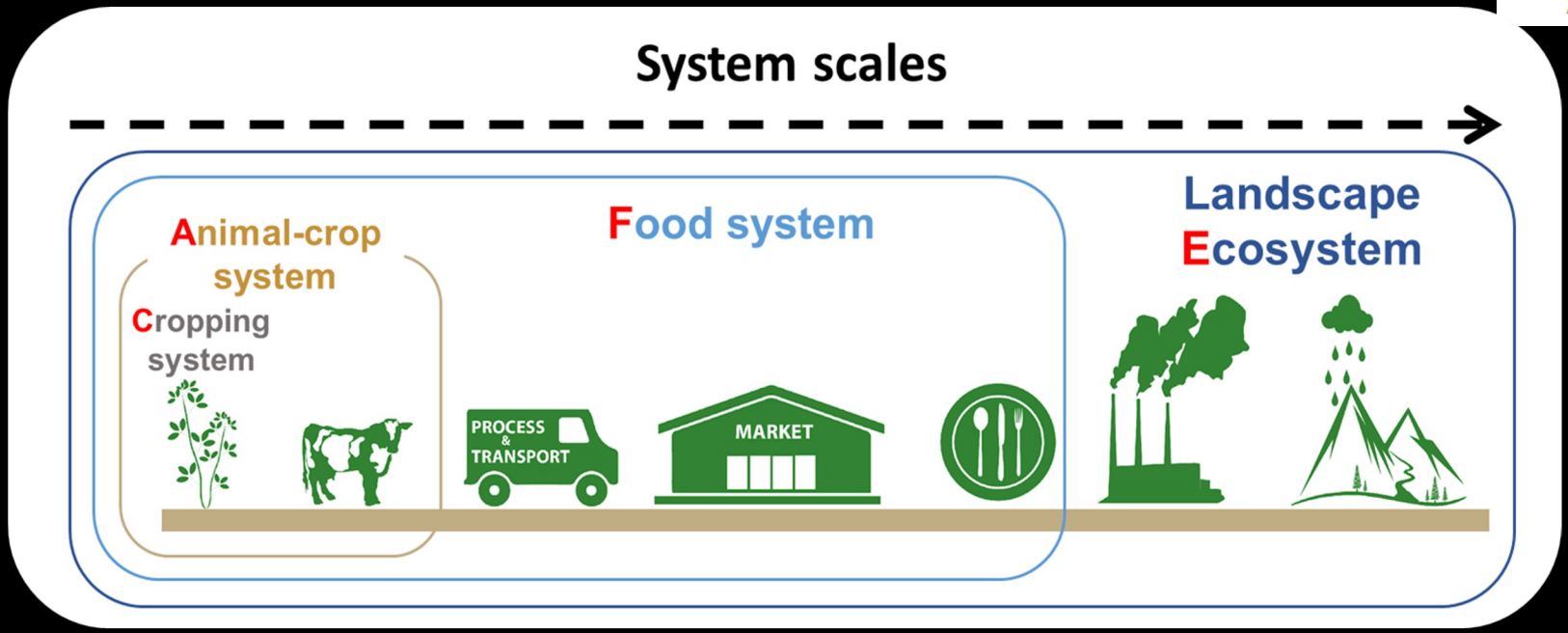


$$NUE = \frac{\text{Harvested Nitrogen}}{\text{Nitrogen input}}$$

N surplus = Nitrogen input - Harvested Nitrogen

(Zhang *et al.*, 2015, *Nature*)

Sustainable Nutrient Management



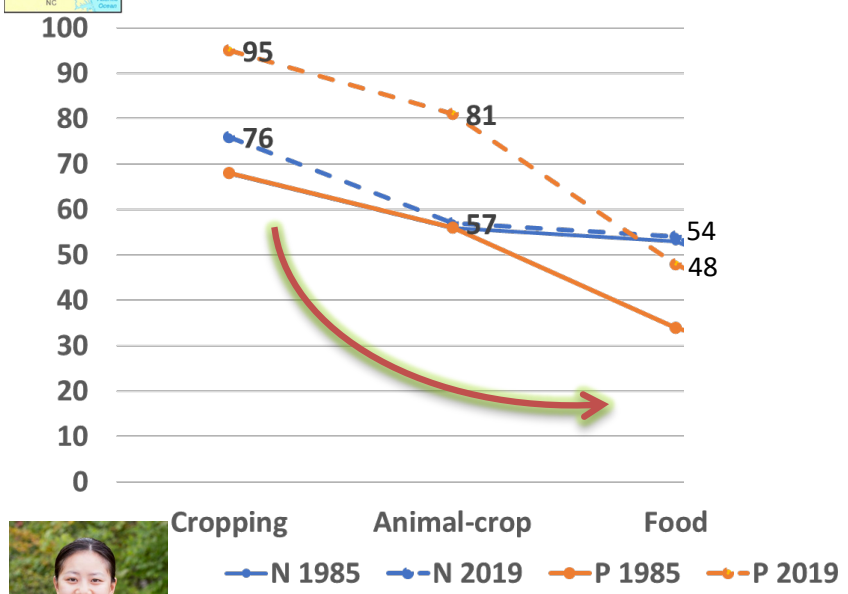
Crop production | *Animal production* | *Food processing and retail* | *Other nutrient-related human activities (e.g., urban agriculture, food trade, wastewater treatment…)*

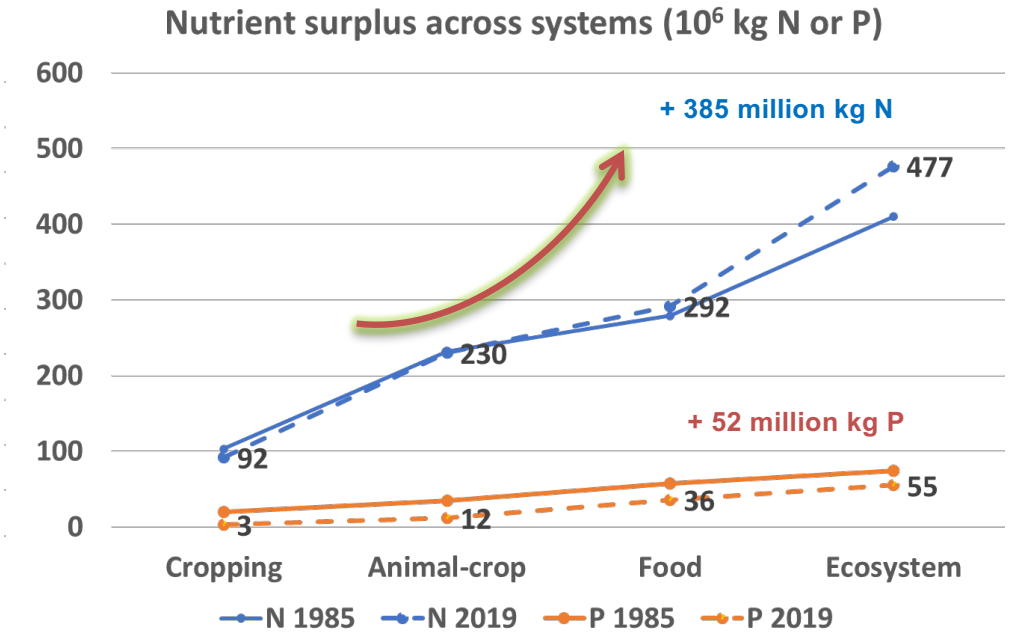
(Zhang *et al.*, 2020; *Global Biogeochemical Cycles*)

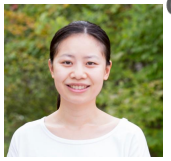
Sustainable Nutrient Management Across Spatial and System Scales

A CAFE Framework for unpacking nutrient management challenges

Co-development in Chesapeake Bay Watershed







Tan Zou, Assistant Research Scientist

Larger nutrient loss potential beyond crop farms

(Zou *et al.*, in preparation)

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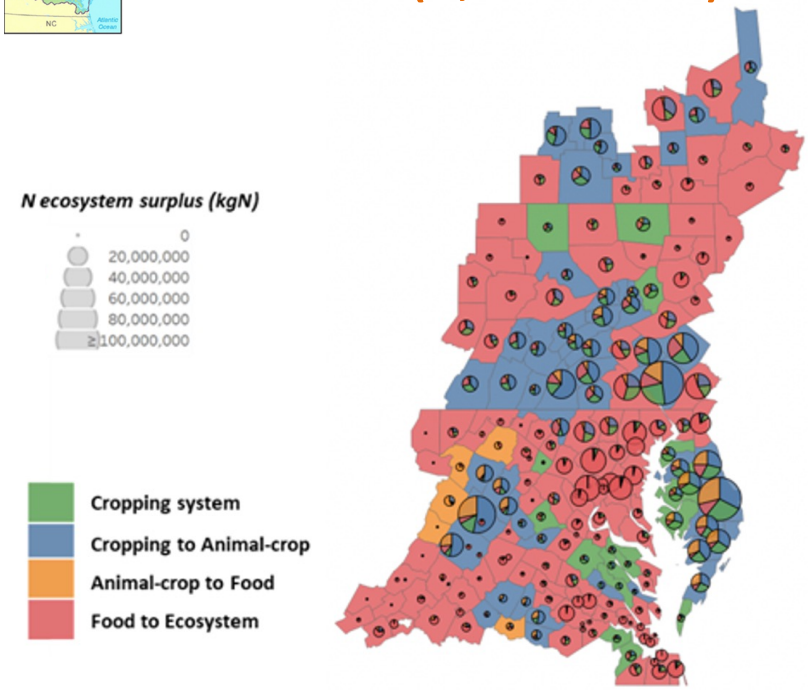
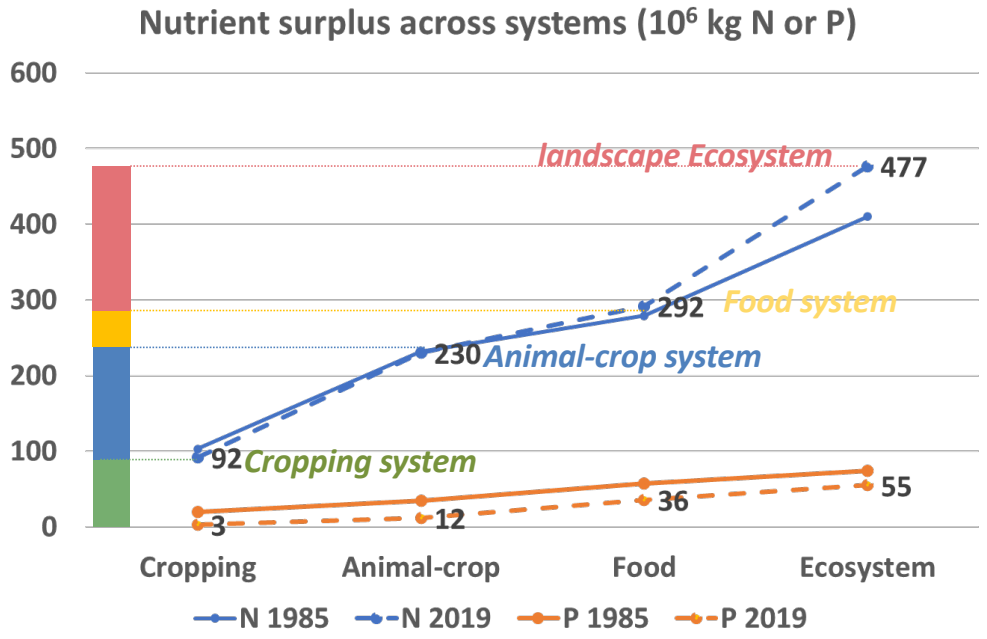
Co-development in Chesapeake Bay Watershed

Nutrient Management Priorities (N, 2015-2019)





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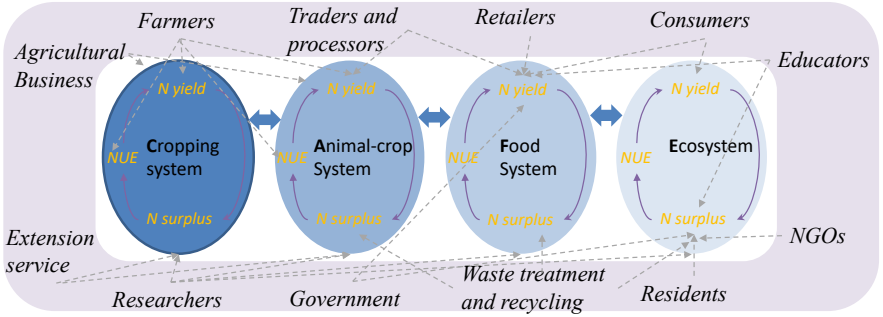
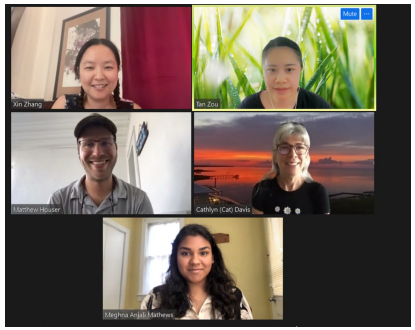


First-survey
~20 minutes' survey (include watching a 5-min video)

Second-survey
~10 minutes' survey
Sending out a few weeks after the first survey



Stakeholder Survey Team

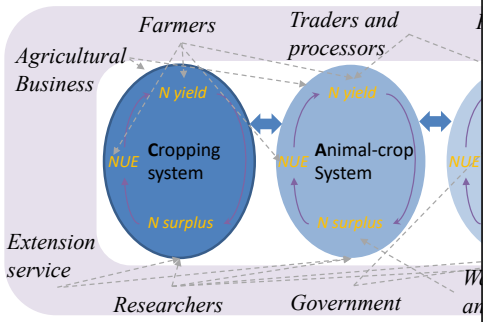
Survey goals:

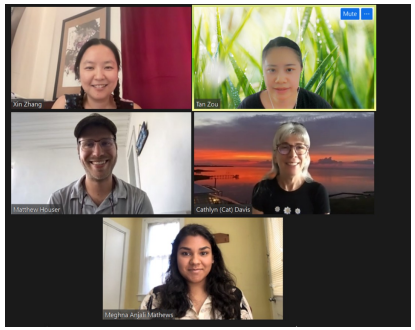
1. Participants' attitudes and their awareness towards nitrogen pollution and management in the Chesapeake Bay watershed.
2. Participants' feedback on the *CAFE* framework.
3. Whether the CAFE framework video influenced stakeholders' thinking on nitrogen pollution and management in any way

Sustainable Nutrient Management Across Spatial and System Scales

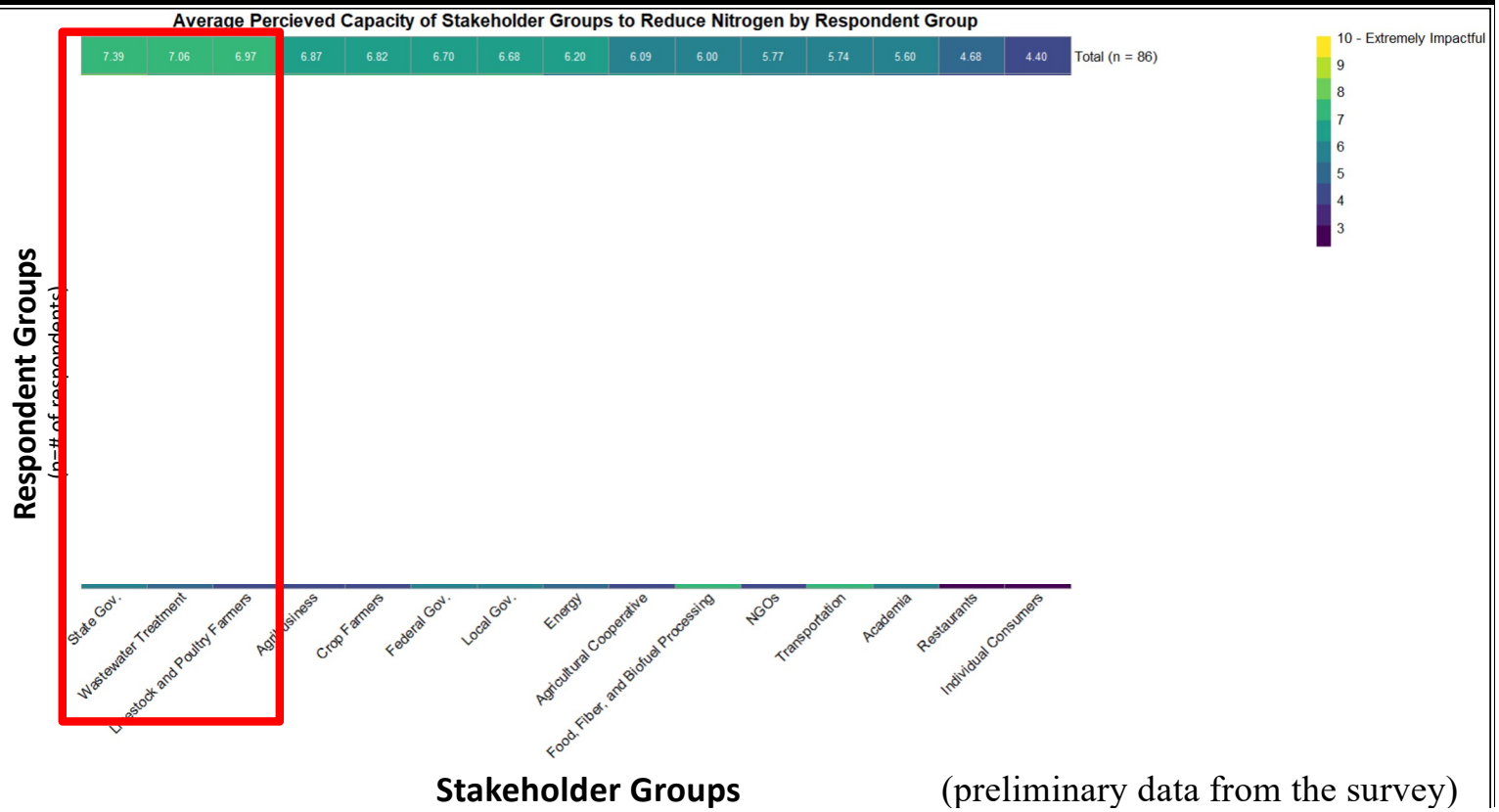
A CAFE Framework for unpacking nutrient management challenges

Co-development in Chesapeake Bay Watershed





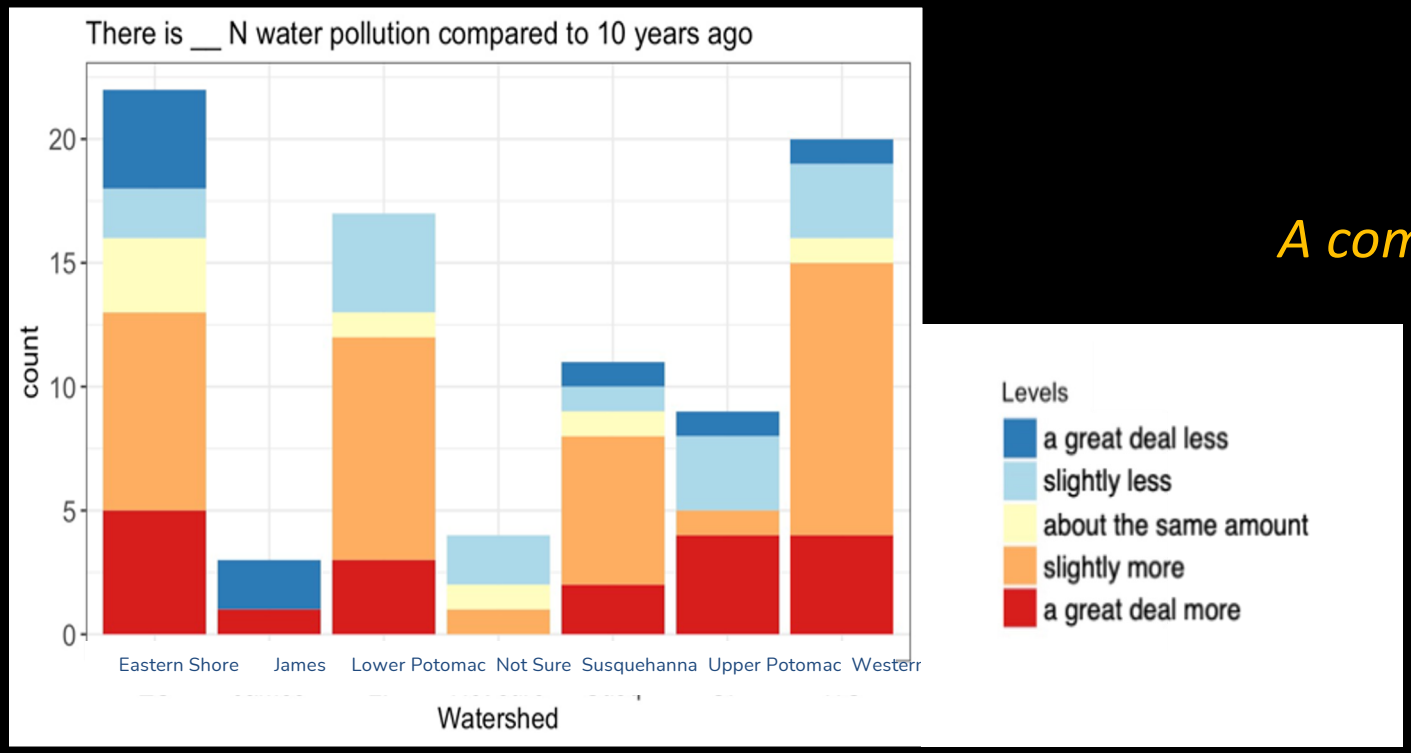
Stakeholder Survey



(preliminary data from the survey)

Sustainable Nutrient Management Across Spatial and System Scales

A CAFE Framework for unpacking nutrient management challenges

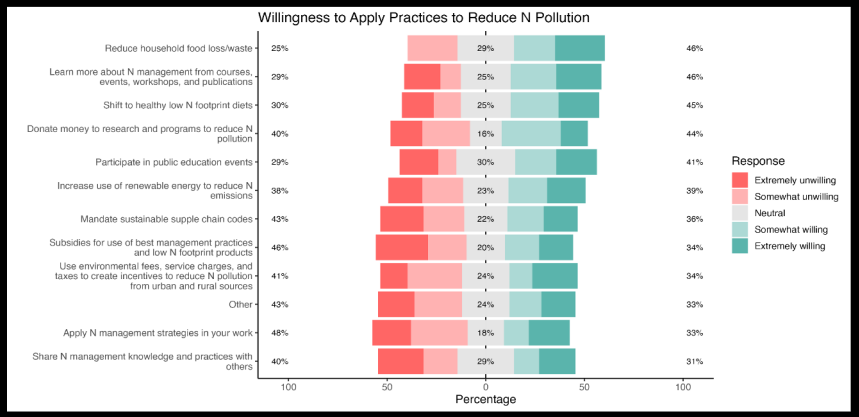


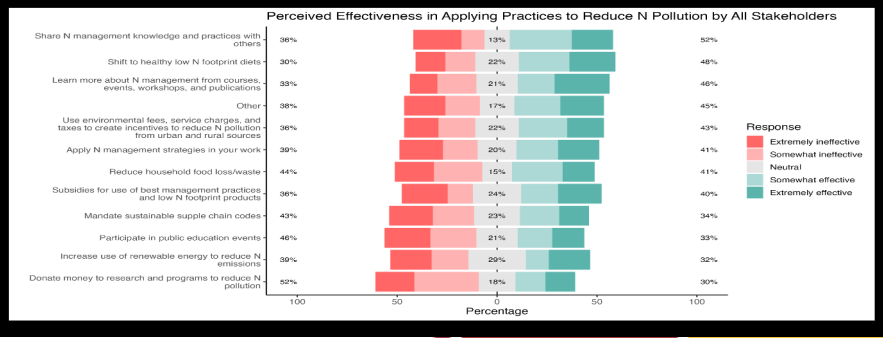
A communication gap?

Sustainable Nutrient Management Across Spatial and System Scales

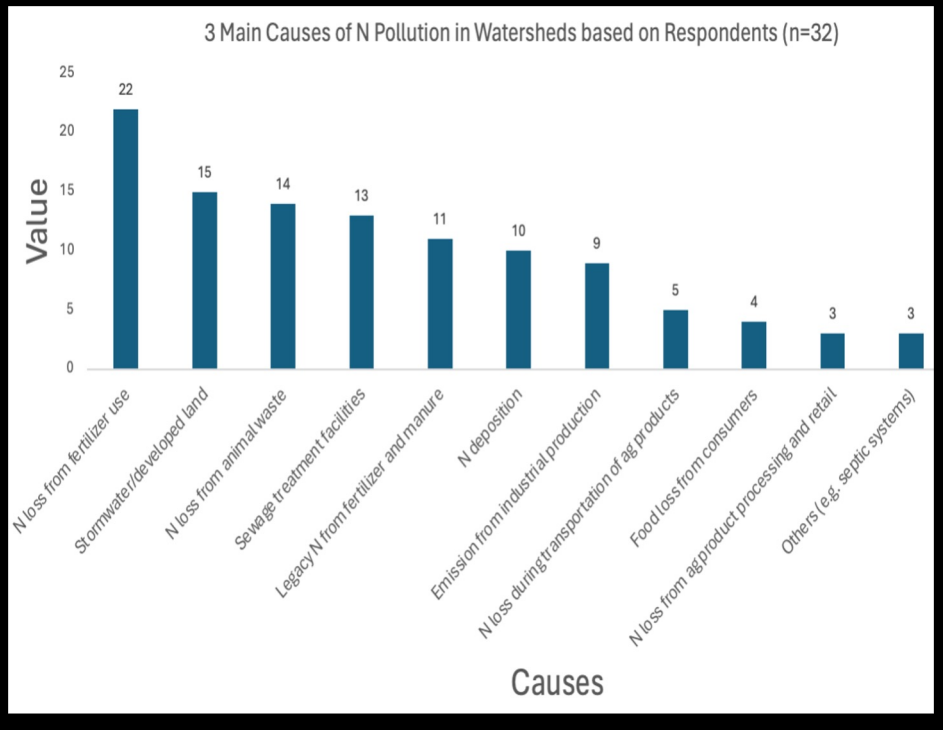
A CAFE Framework for unpacking nutrient management challenges

3. Different levels' willingness and beliefs about the practices' effectiveness among stakeholders.





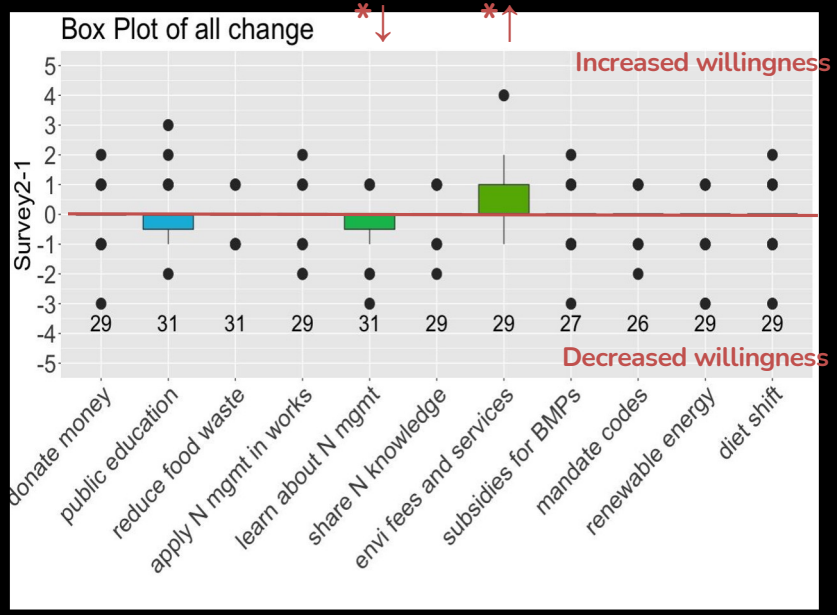
4. Main causes of N pollution include losses from food production to waste.



Sustainable Nutrient Management Across Spatial and System Scales

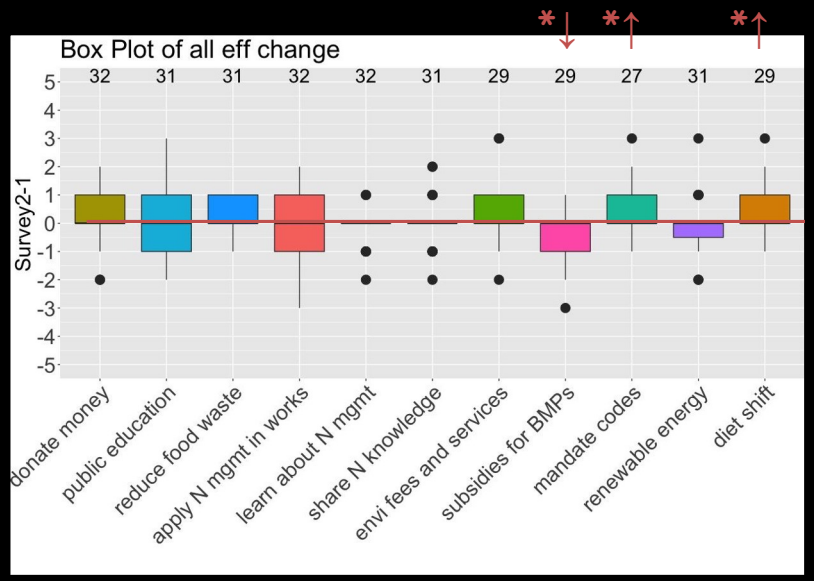
A CAFE Framework for unpacking nutrient management challenges

5. Stakeholders received N management knowledge from our 5-min video and pre-survey.



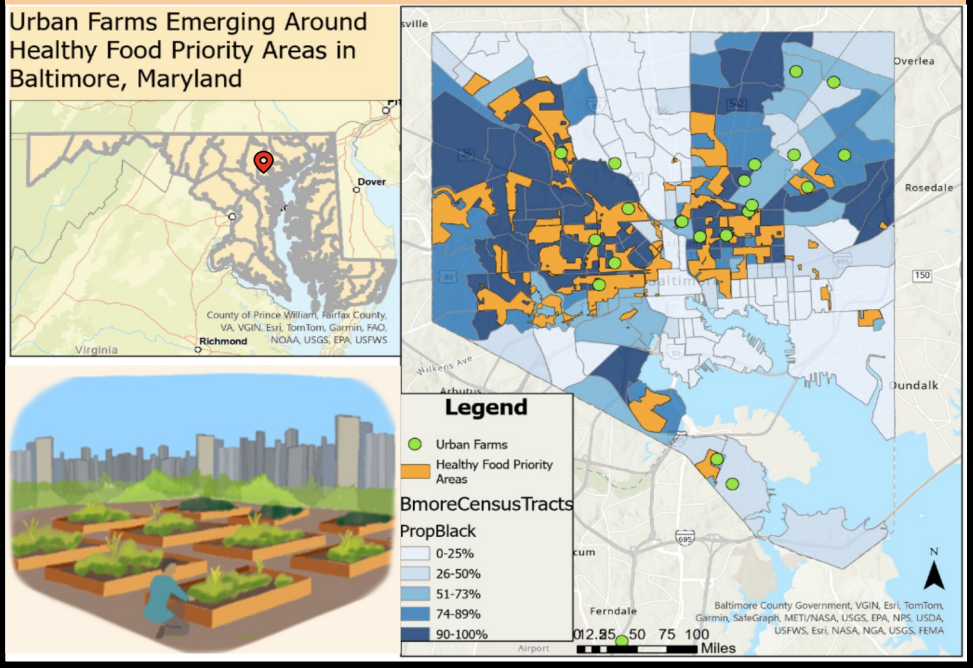
One-sample Wilcoxon signed rank test
*↓: significant decrease in post-survey (p value < 0.05)
*↑: significant increase in post-survey (p value < 0.05)

6. Stakeholders' beliefs about practice effectiveness changed in the post-survey.



Sustainable Nutrient Management Across Spatial and System Scales

Study Site



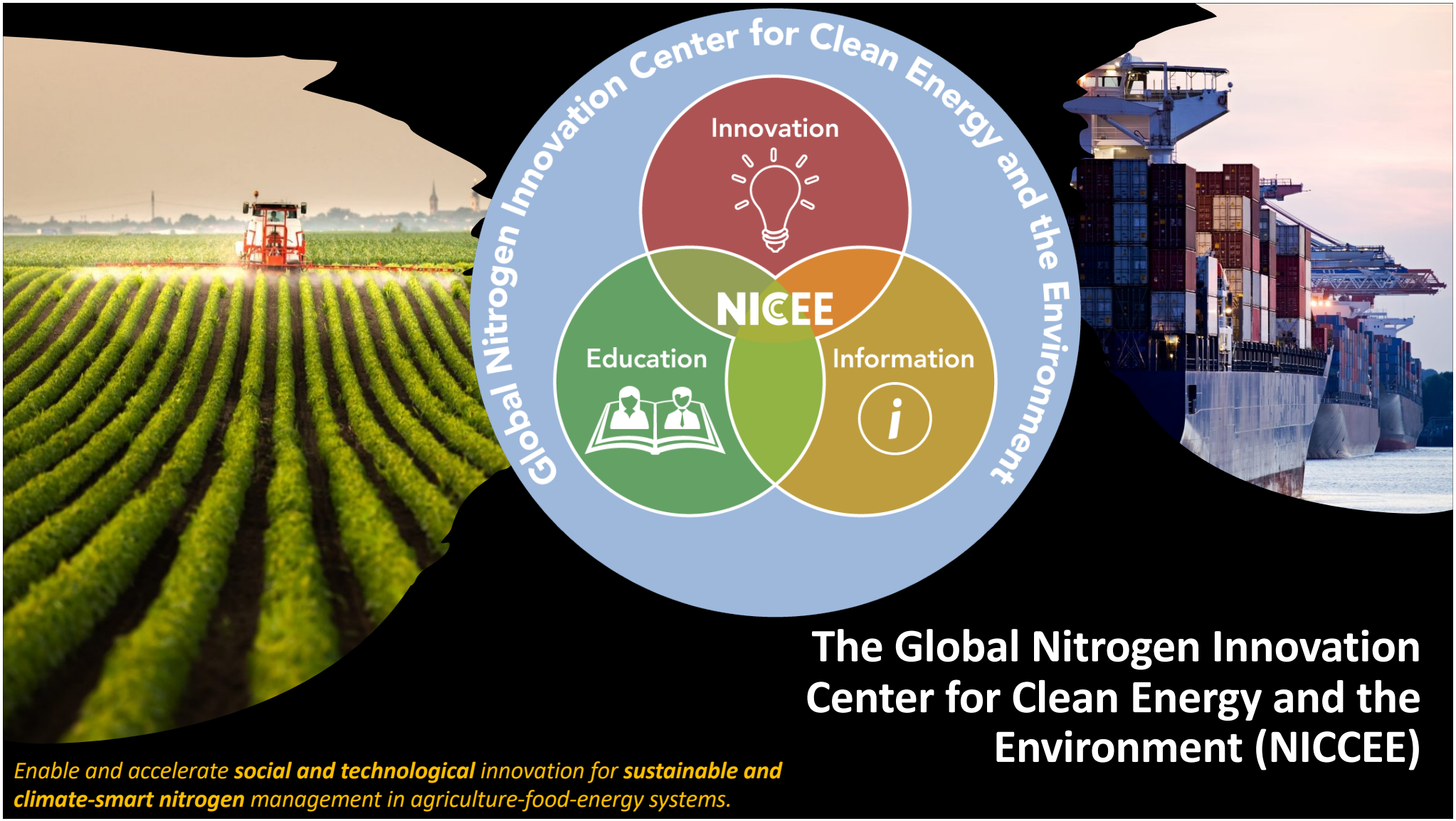
Methods

30-60 minute interviews with urban farmers and food insecure community members in Baltimore.
Asked urban farmers about farming practices, supply and distribution patterns, and accessibility of farm products
Queried food insecure community members about their fruit and vegetable consumption and associated challenges

Conclusion

Multifaceted approach that goes beyond emergency assistance and includes structural changes to improve food access, income security, and community resilience.
Implement community-based strategies to support local urban farms
Increasing the availability of food distribution services, along with expanding the operational hours throughout the week
Starting more urban agriculture initiatives to distribute to food banks and pantries would significantly increase household fruit and vegetable consumption

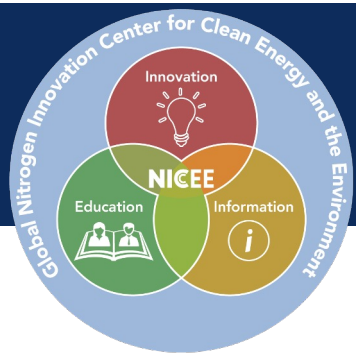
Meghna Mathews, Master Student

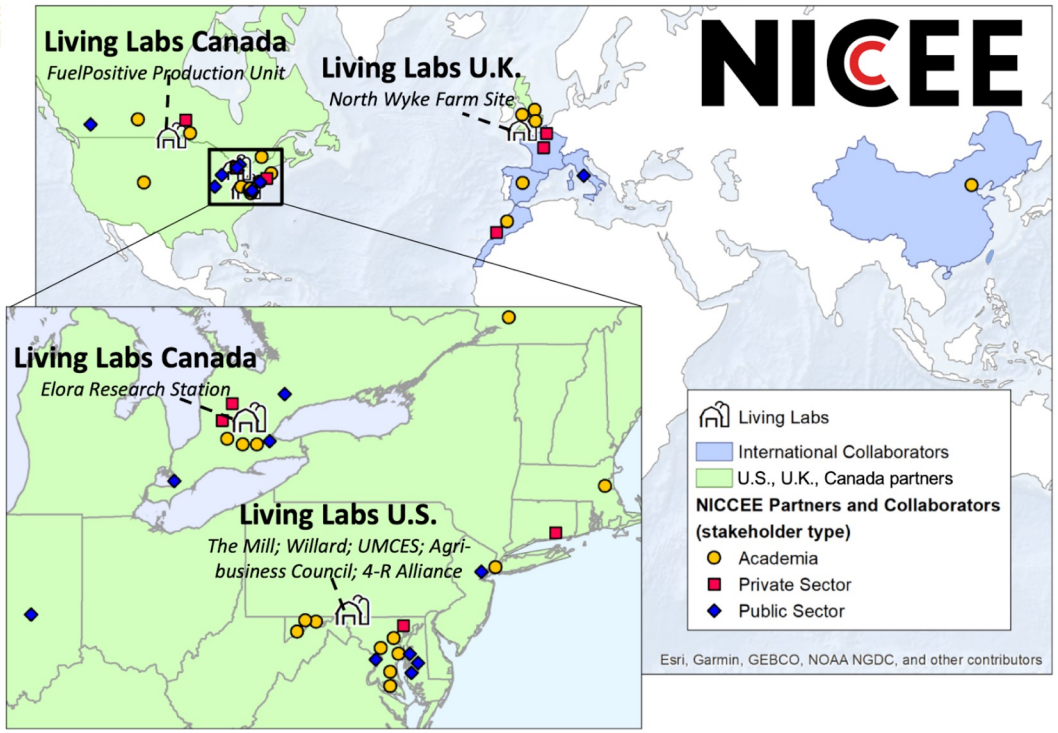


The Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE)

*Enable and accelerate **social and technological** innovation for **sustainable and climate-smart nitrogen** management in agriculture-food-energy systems.*

A transdisciplinary, transnational network

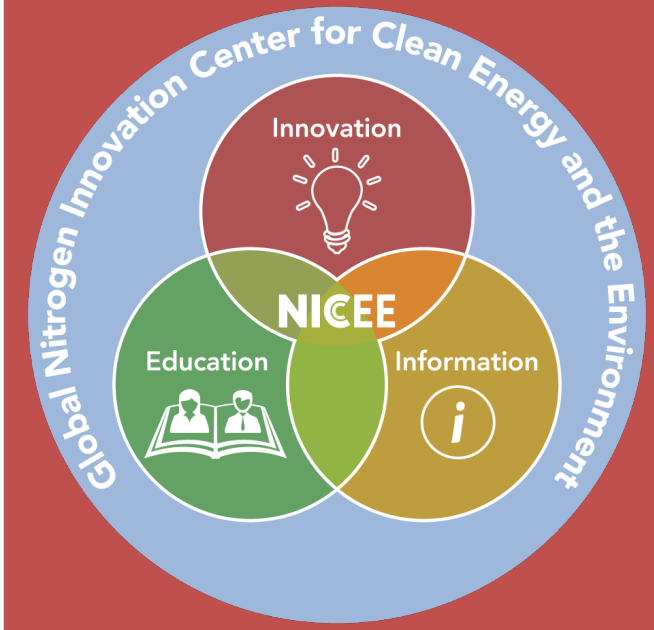




- 10 million $ from US, Canada, and UK
- 8 country partners
- Stakeholders from public and private sectors

Converge socioeconomic and ecological processes

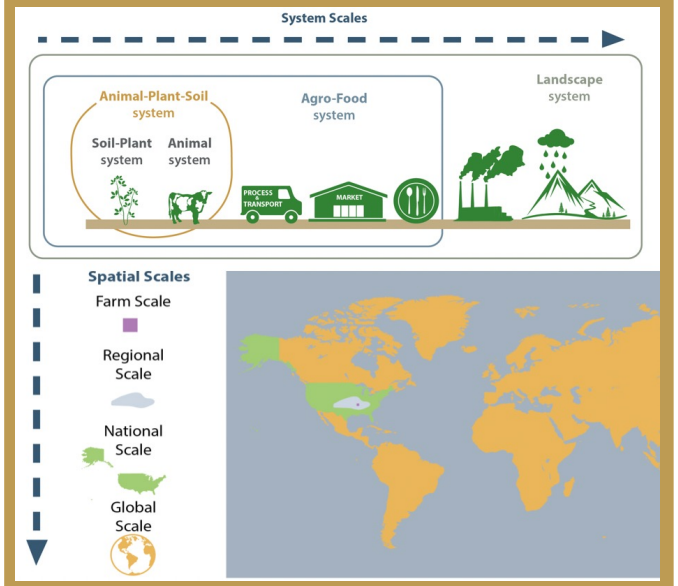
"High-tech, low-efficiency" paradox



Global Nitrogen Innovation Center

Extend from production-focused to agro-food system

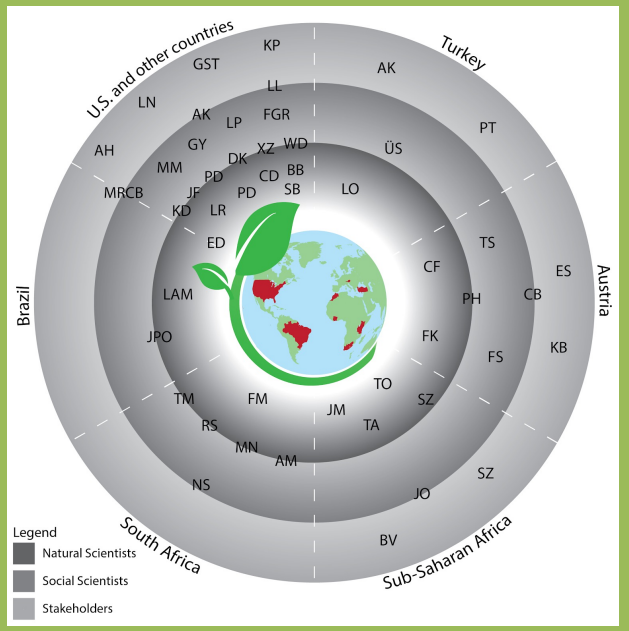
"Too much, too little" paradox



CAFE Framework

Transdisciplinary & Transnational

"High input, low nutrition" paradox



SAM Consortium

Acknowledgement

Major Collaborators at UMCES

Eric A. Davidson, Vyacheslav Lyubchich, Cathlyn D. Stylinski, William Dennison, Andrew Elmore, Mark Cochrane, Tan Zou, Srishti Vishwakarma, Guolin Yao, Jing Zhao, Mary Ollenburger, Matthew Lisk, Cassie Doty
Faculty advisory Committee: Keith Eshleman

Major Collaborators at Other Institutions

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