Nutrient circular system construction coupling urban and rural systems: a perspective from food sourced Nutrient

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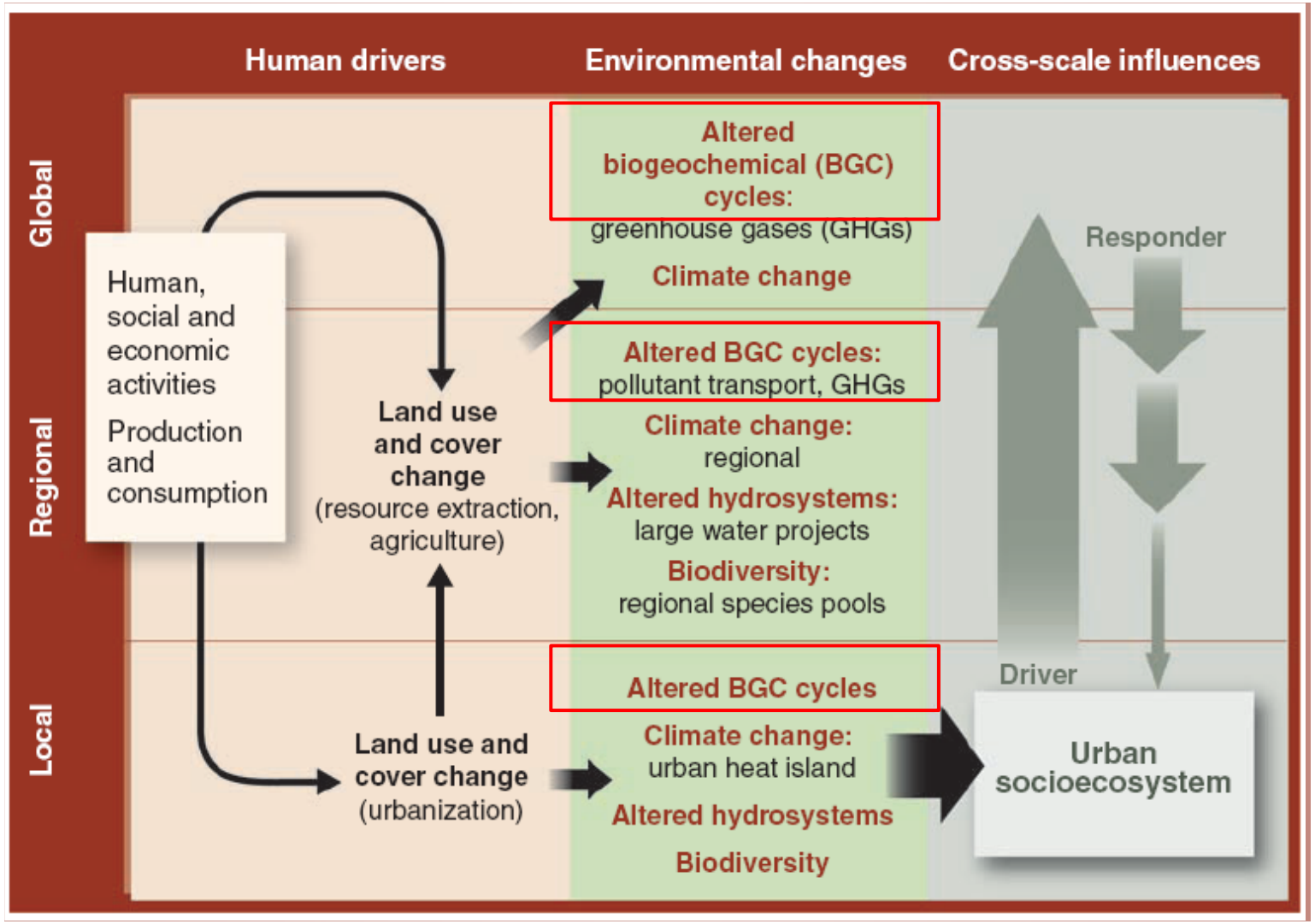
Problems

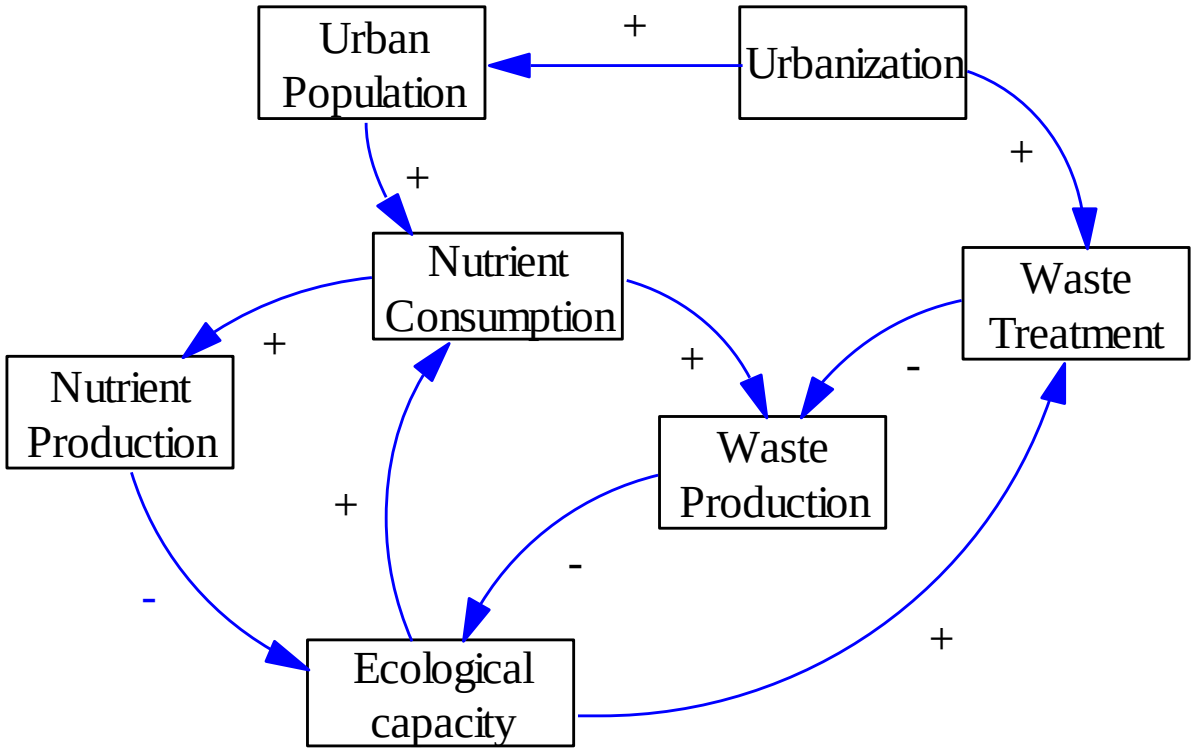
- **human activities are the major drivers of biogeochemical processes at different scales.**



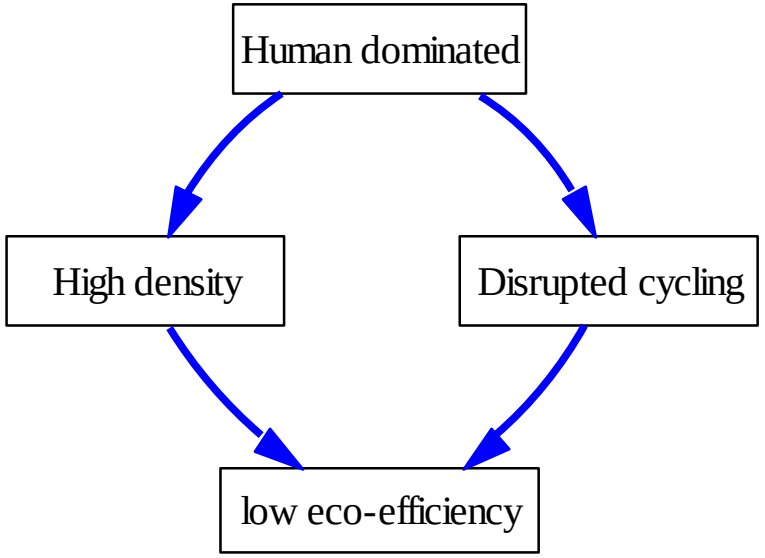
Grimm N et al. 2008. Science.

Problems

- **Nutrient urban metabolism through food consumption and waste management.**



Dynamic schematic diagram of nutrient cycling with urbanization
Note: + represents positive feedback, - represents negative feedback.

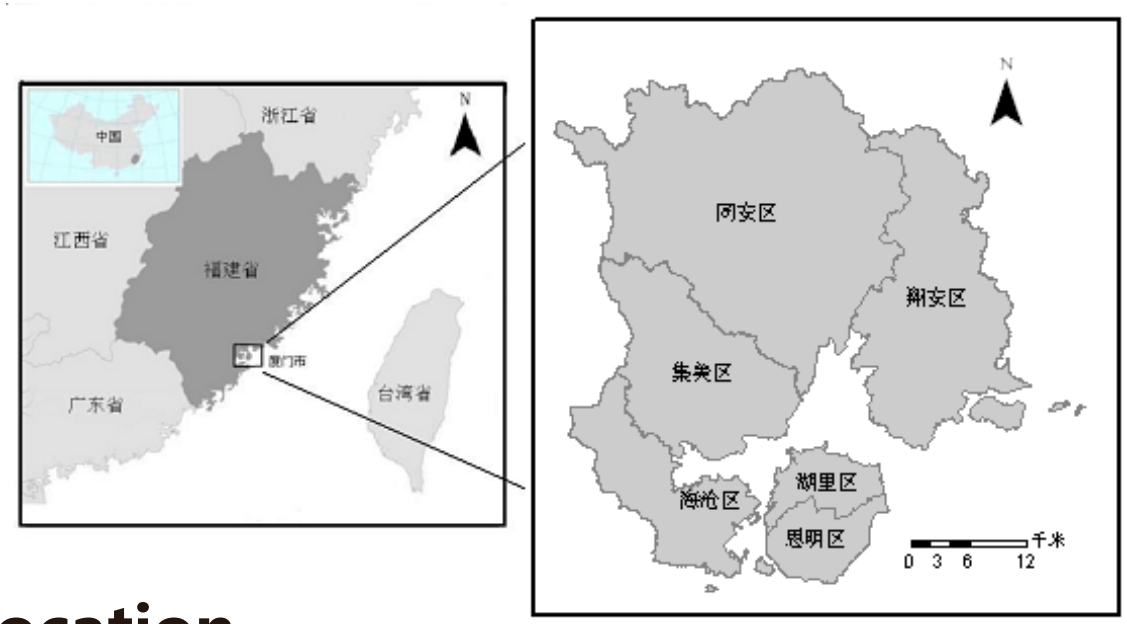


Characteristics of urban nutrient cycling

Lin T, Gibson V, et al. 2014. Environmetal Pollution.

Problems

Xiamen City



- **Six districts**

  Siming, Huli, Jimei, Haicang,Tongan, Xiangan

  Land area 1700.61km2

  Built area 397.84 km2

  Regular populstion 5 Million

- **Location**

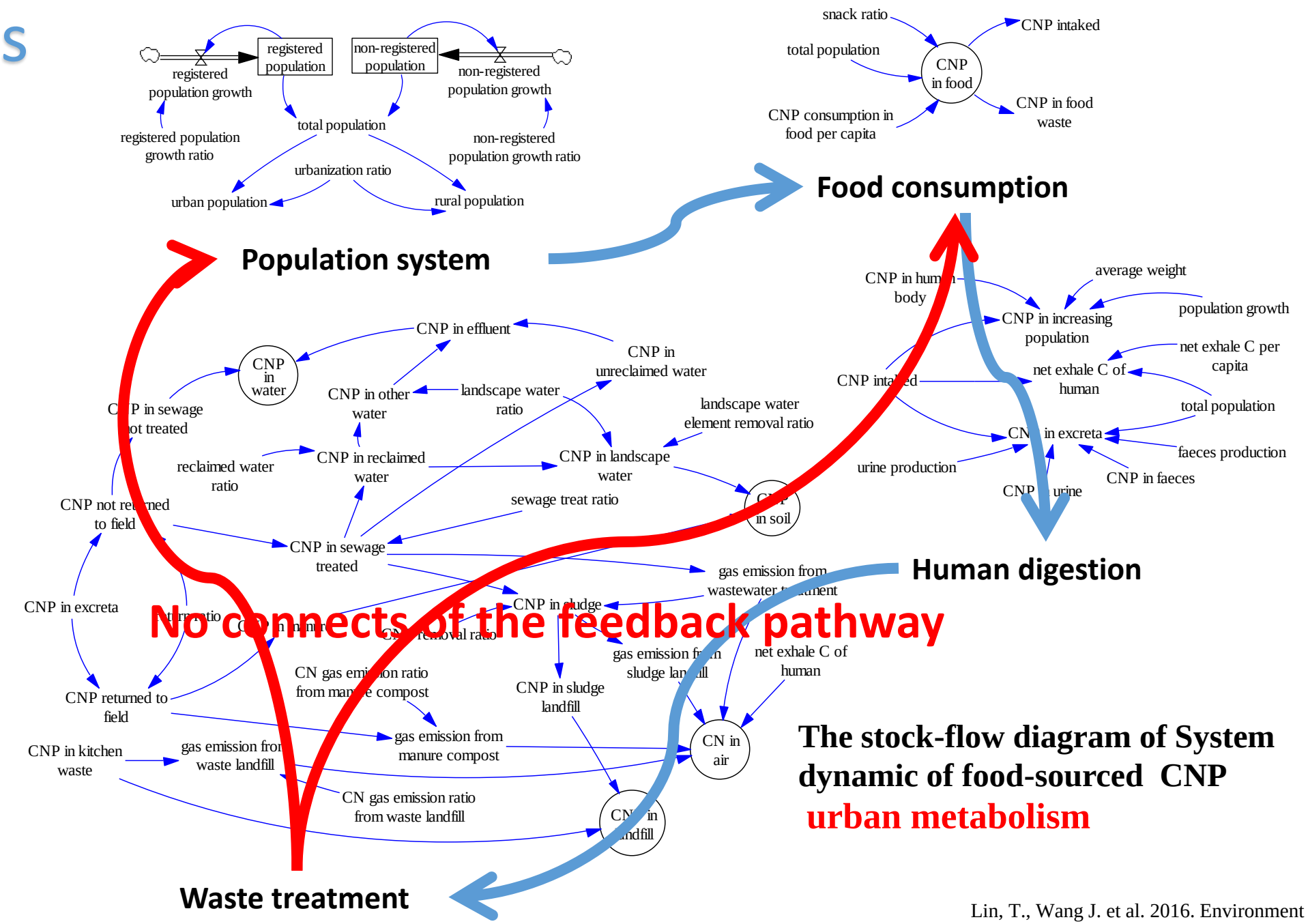
  117°52′53.8″~118°26′1.2″ E

  24°23′12.7″~24°54′29.3″ N

  Face to Taiwan Island

  Important central city, port and scenic tourist city in the southeast coast of China

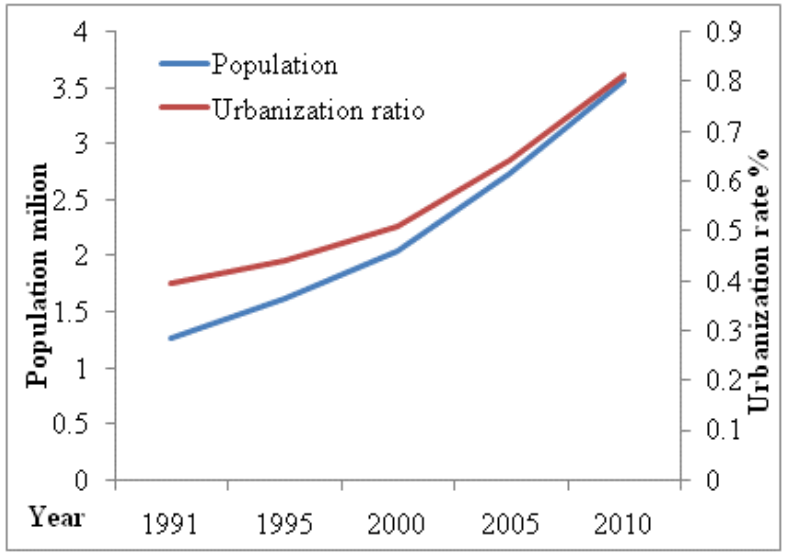
Problems

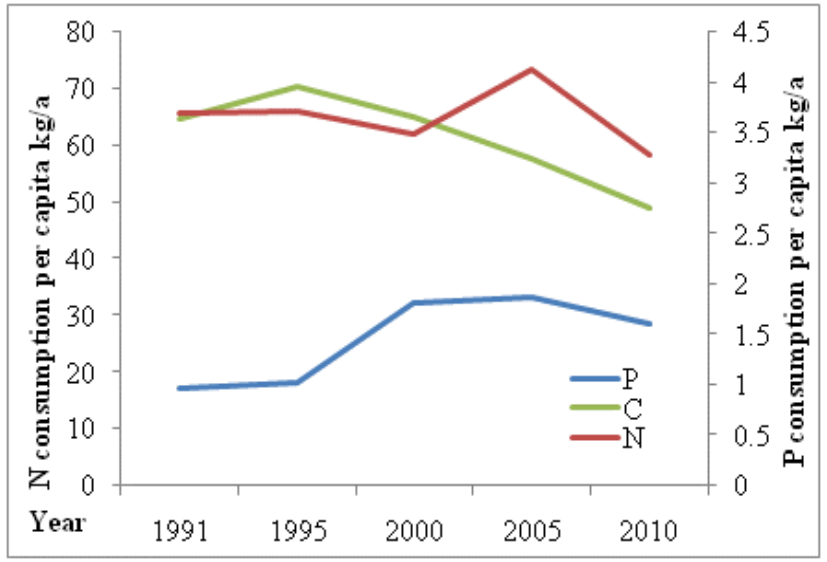


The stock-flow diagram of System dynamic of food-sourced CNP urban metabolism

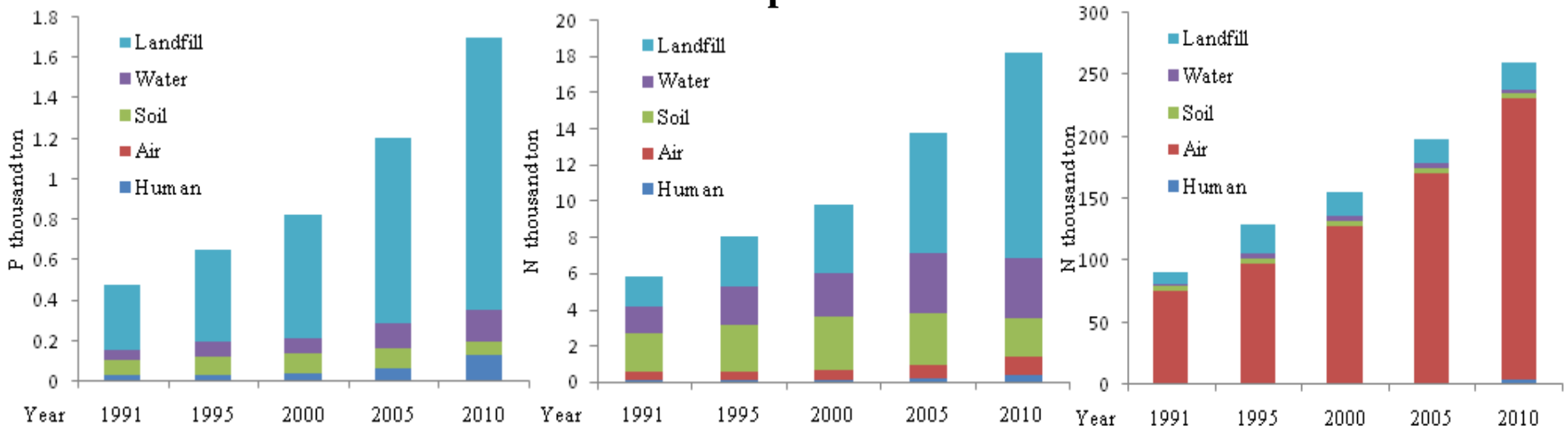
Lin, T., Wang J. et al. 2016. Environment International

Problems





Food sourced C N P consumption with urbanization in Xiamen



Fates of food sourced C N P with urbanization in Xiamen City, China

- Food-sourced CNP through urban systems presented distinguished differences
- Carbon mostly emitted into the air
- Nitrogen and phosphorus were largely discharged into landfill and water

Lin, T., Wang J. et al. 2016. Environment International

Problems

Sensitivities of the selected controllable variables to fate of food sourced CNP

EL [a] / CV [a]	Soil			Landfill			Air		Water		
	C	N	P	C	N	P	C	N	C	N	P
RERF [a]	19.81%	19.79%	19.75%	0.00%	0.00%	0.00%	0.00%	0.20%	16.98%	11.08%	7.03%
RWT [a]	0.09%	0.10%	0.15%	0.00%	11.23%	2.66%	0.01%	3.84%	89.44%	51.17%	25.03%
RRW [a]	0.09%	0.10%	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	1.92%	2.31%	2.58%
RSRF [a]	2.33%	2.31%	1.85%	0.13%	0.29%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
RMC [a]	0.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	78.72%	0.00%	0.00%
RMN [a]	0.00%	0.35%	0.00%	0.00%	11.23%	0.00%	0.00%	2.86%	0.00%	50.45%	0.00%
RMP [a]	0.00%	0.00%	0.22%	0.00%	0.00%	2.66%	0.00%	0.00%	0.00%	0.00%	24.78%

[a] EL and CV represent environmental loads and controllable variables respectively.

RERF, RWT, RRW, RSRF represent ratio of excreta returned to field, ratio of wastewater treatment, ratio of reclaimed water use, ratio of sludge returned to field respectively.

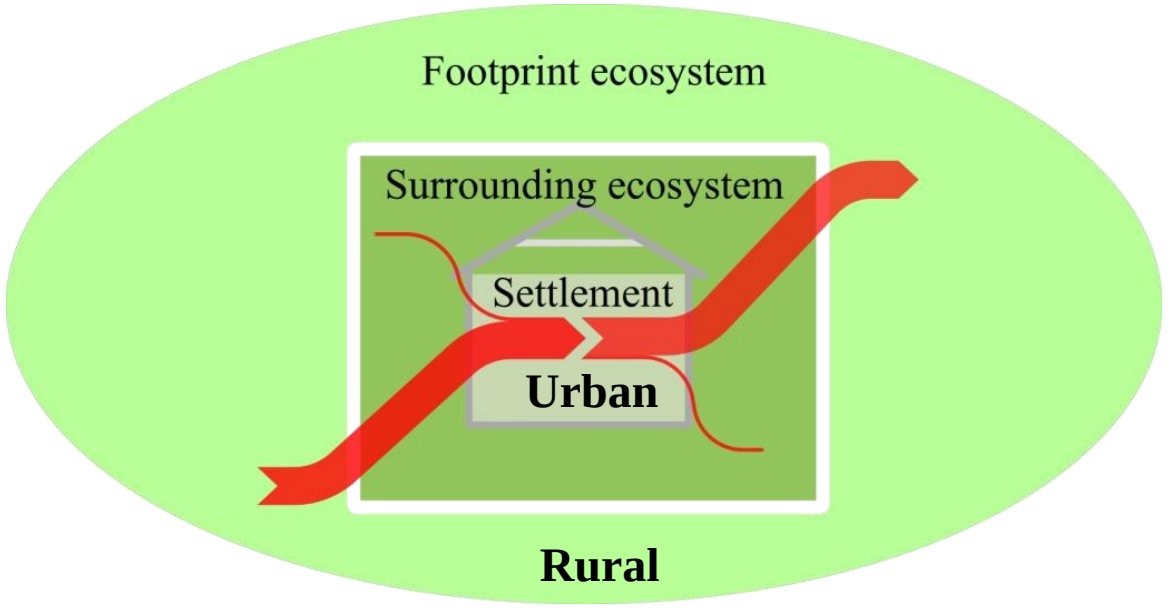
RMC, RMN, RMP represent CNP removal ratios of sewage plant.

- Enhanced the current waste treatment can only alter the emissions directions
- Different treatment have different capacities to adjust the food sourced CNP emissions
- **Any trade-offs, where mitigating one pathway will intensify the others.**
- **Urban system can not resolve the nutrient problem by itself!**

Lin, T., Wang J. et al. 2016. Environment International

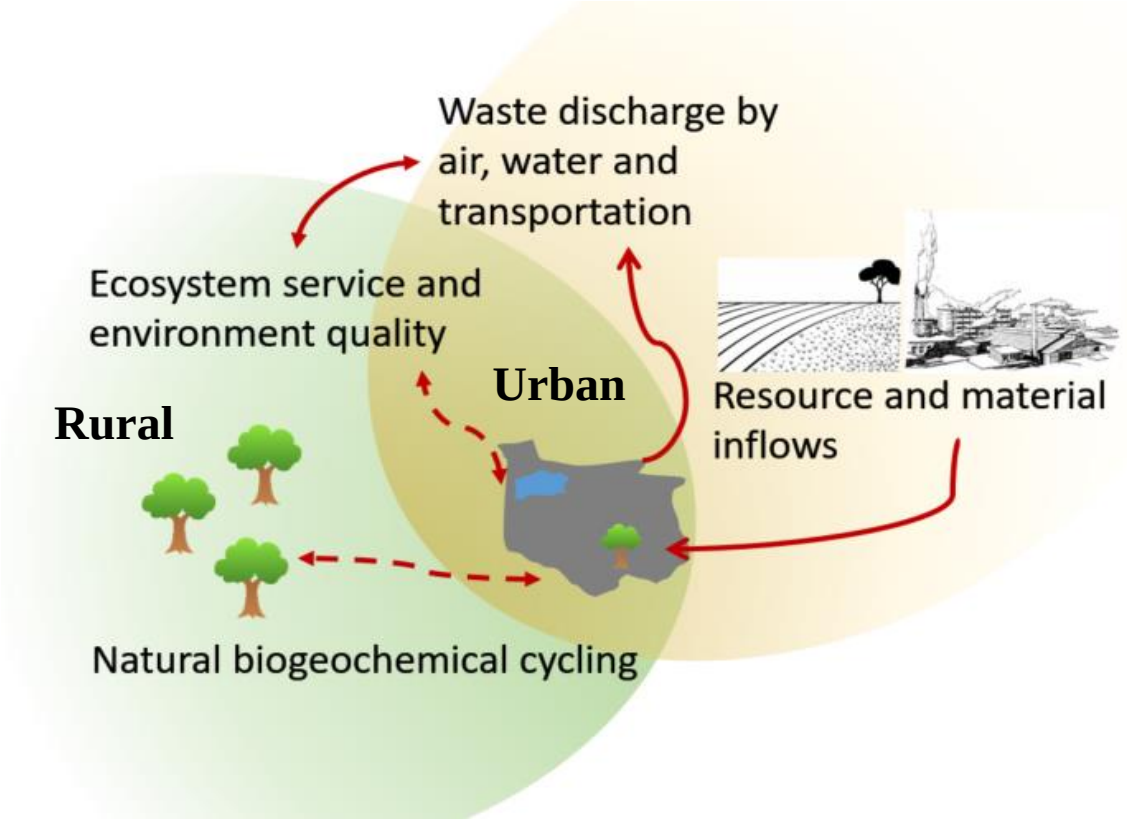
Solutions

Nutrient circular system by coupling urban and rural coupled system



Urban ecosystem boundary and material balance

Arrows represent the material fluxes.



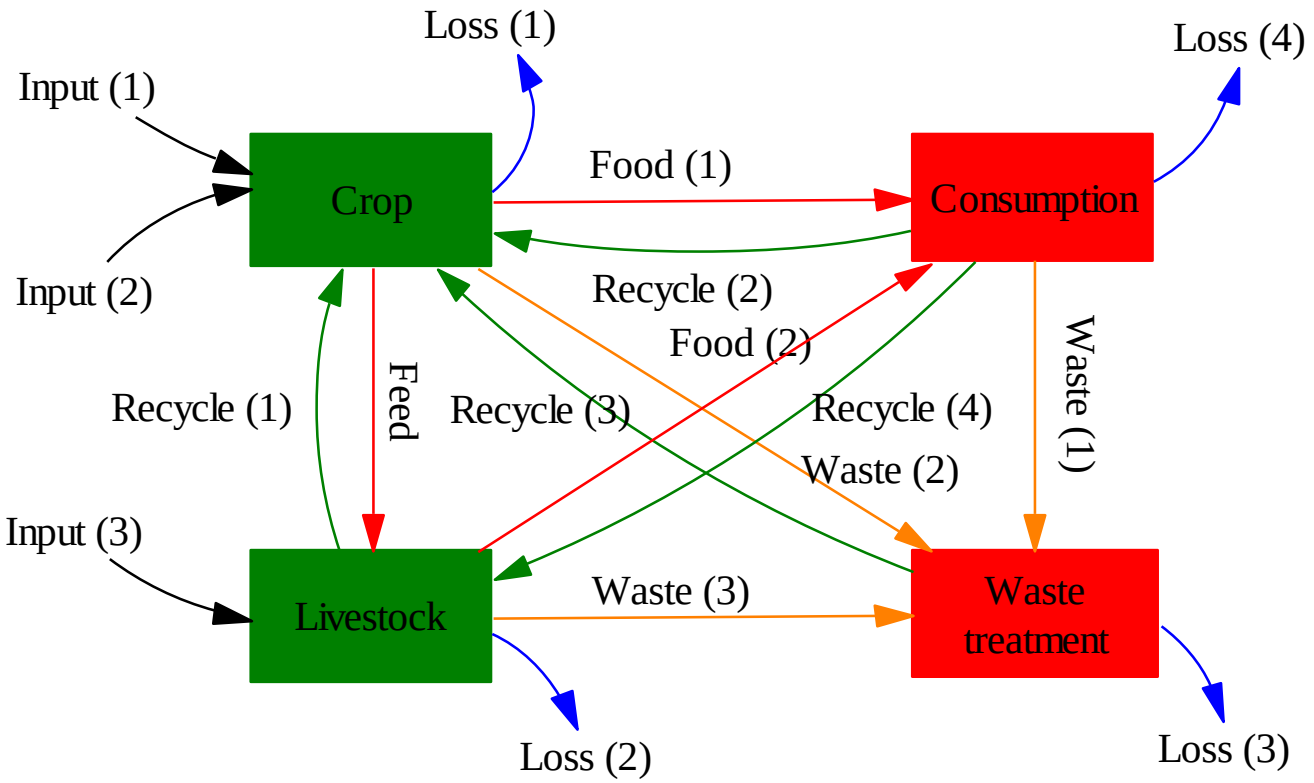
Flows of resources between urban and extra-urban areas

Lin T, Gibson V, et al. 2014. Environmetal Pollution.

Jones L, Reis S, et al. 2022. Nature-Based Solutions.

Solutions

Local scale
Technique & Design



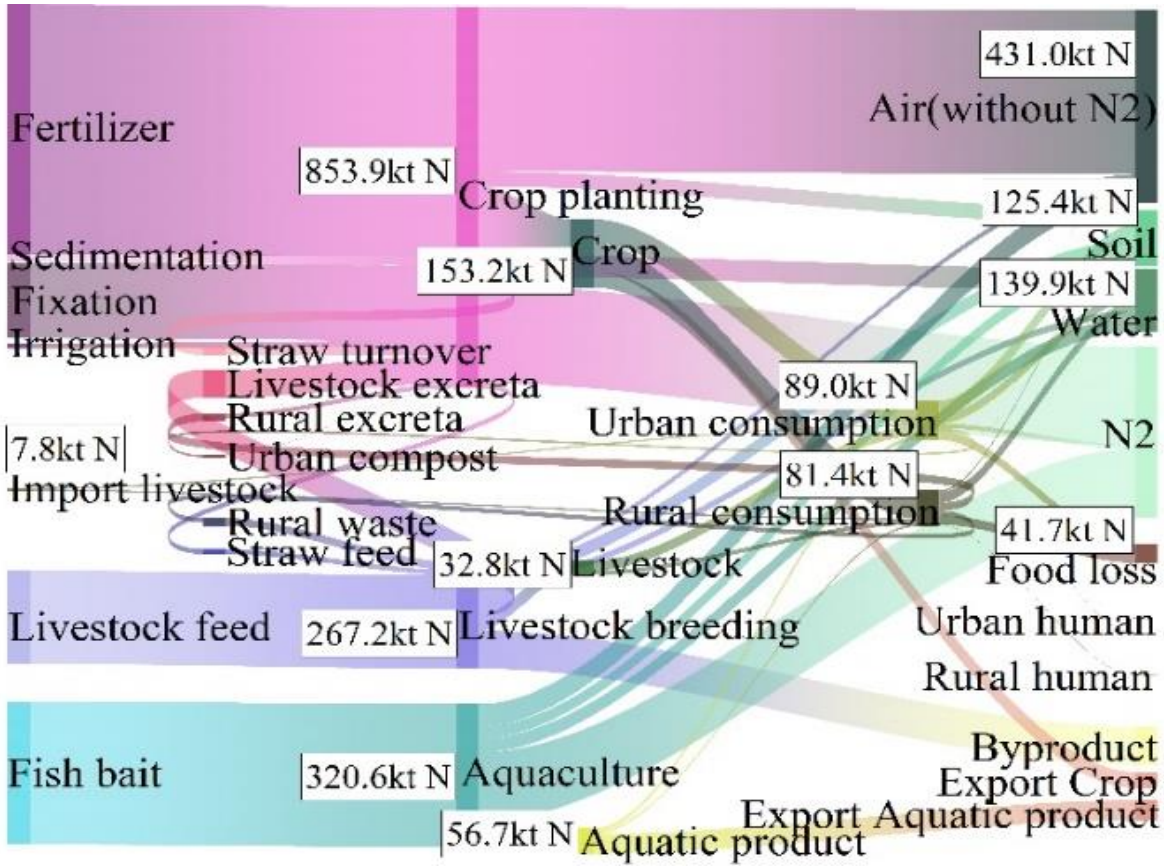
Sustainable food sourced nutrient cycling in a urban and rural coupled system at local scale

Note: Red and green boxes mean the processes of food consumption, waste treatment, livestock and crop production, which take place in **urban (red) and rural (green) areas** respectively. Input (1) is natural nutrient input such as N deposition; Input (2) is fertilizer application; Input (3) is extra feed input; Loss (1) is nutrient leaching and runoff; Loss (2) is nutrient loss from livestock's excreta; Loss (3) is reclaimed water discharge and landfill; Loss (4) is food waste discharged directly (not entering waste treatment); Food (1) is plant derived food such as wheat, vegetables; Food (2) is animal derived food such as egg, pork; Waste (1) includes food waste and human excreta; Waste (2) includes crop residues and runoff nutrients; Waste (3) includes animal excreta and carcasses; Recycle (1) is the recycled use of animal excreta as fertilizer; Recycle (2) is the recycled use of human excreta as fertilizer; Recycle (3) is the recycled use of food waste and sludge as fertilizer; Recycle (4) is the recycled use of food waste as feed.

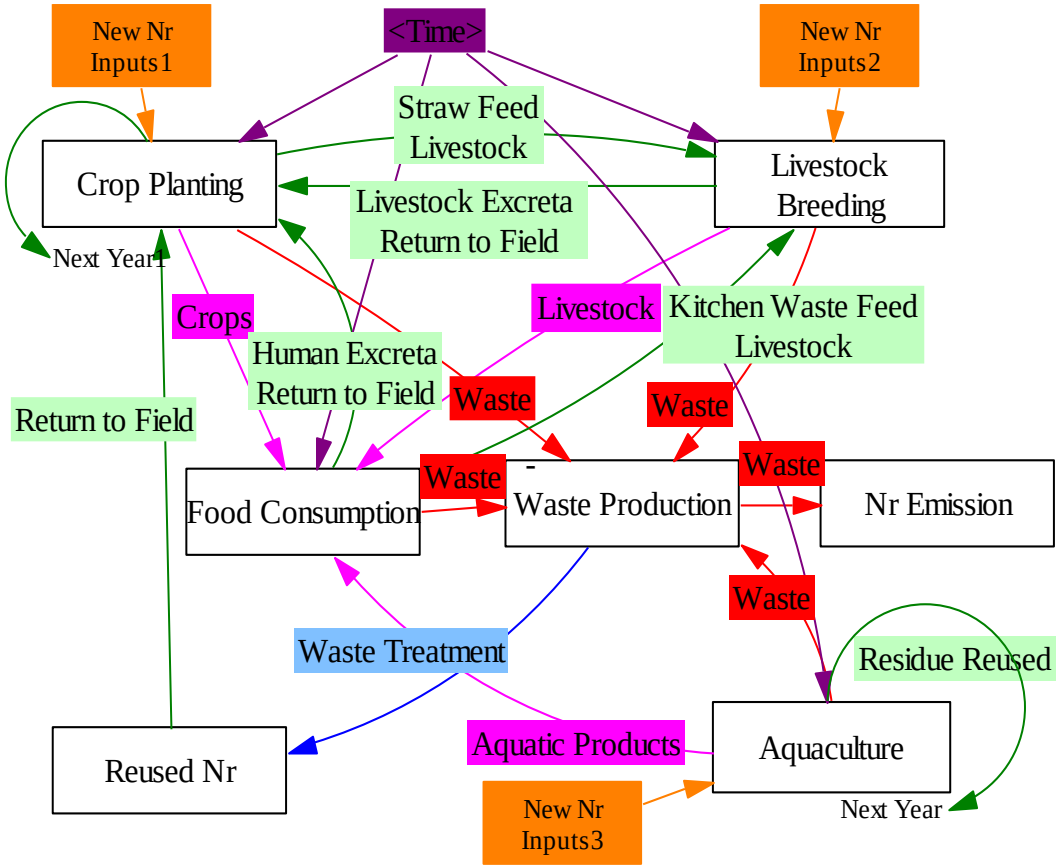
Lin T, Gibson V, et al. 2014. Environmetal Pollution.

Solutions

Regional scale
Industrial & Planning



Regional food system reactive nitrogen (Nr) flows of Fujian from 2000 to 2019.



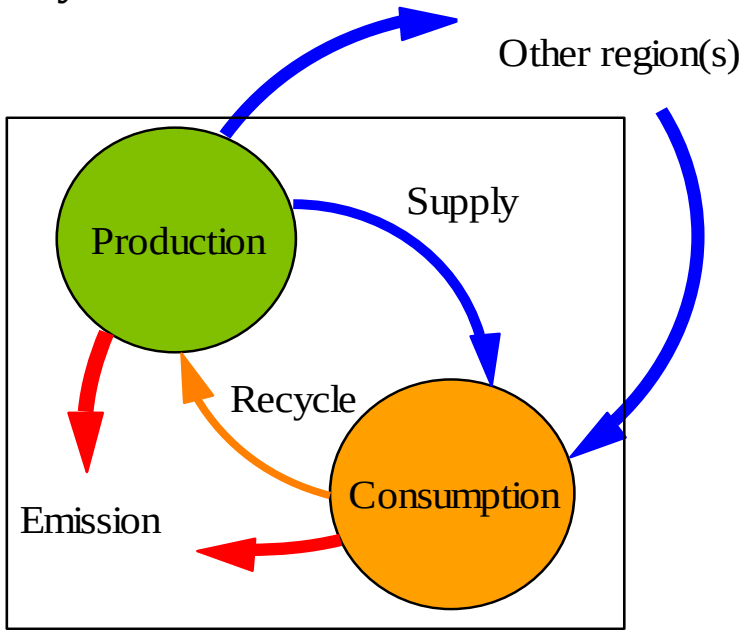
Causal loop diagram of Nr flow with recycling food system.

Sustainable food sourced nitrogen (Nr) cycling in a urban and rural coupled system in regional scale

Xing L, Lin T, et al. 2023. Resources, Conservation and Recycling

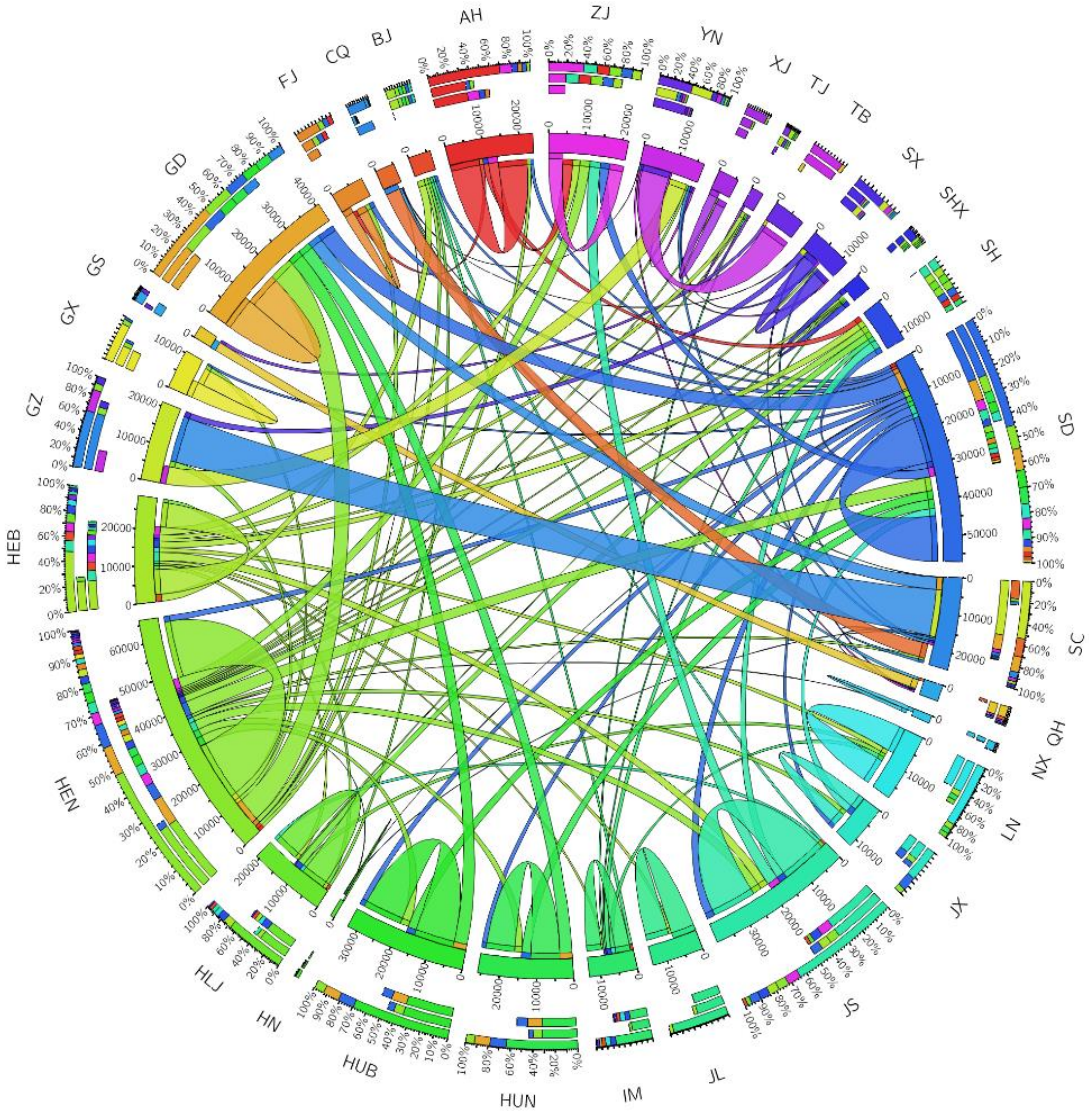
Solutions

Global scale
Trade & Policy



Conceptual diagram of food-sourced Nr footprint at a global scale

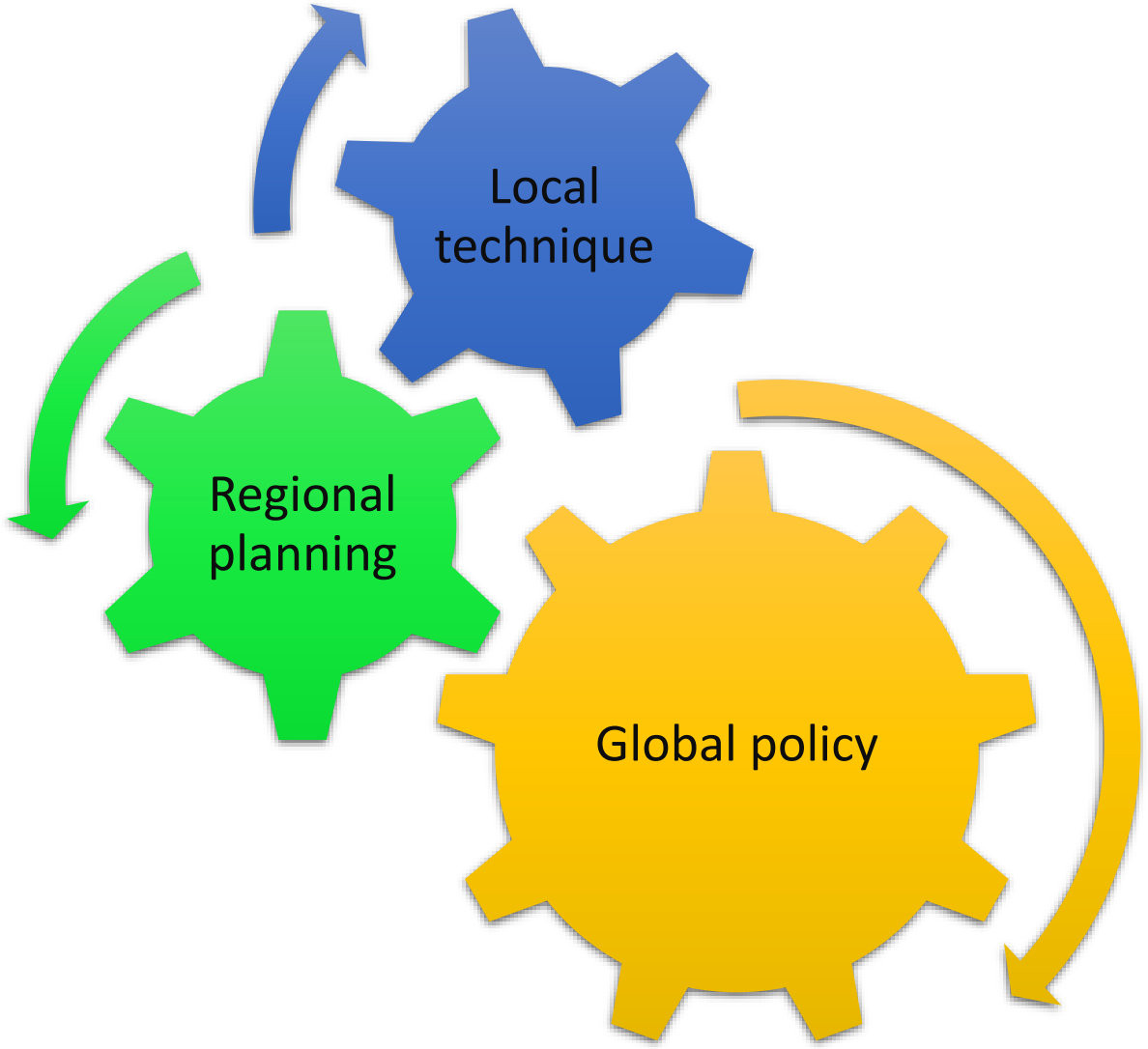
Nr flux within the box will be simulated by single regional production-consumption model and the Nr flux without the box will be simulated by using MRIO model



Food sourced Nr transferring among the 31 regions of Mainland China

Lin T, et al. 2023. unpublished results

Solutions



Sustainable nutrient circular system by coupling the urban and rural systems at different scales

Thanks

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