China-U.S. Scientific Engagement on Sustainability

Urbanization shifts food production and consumption

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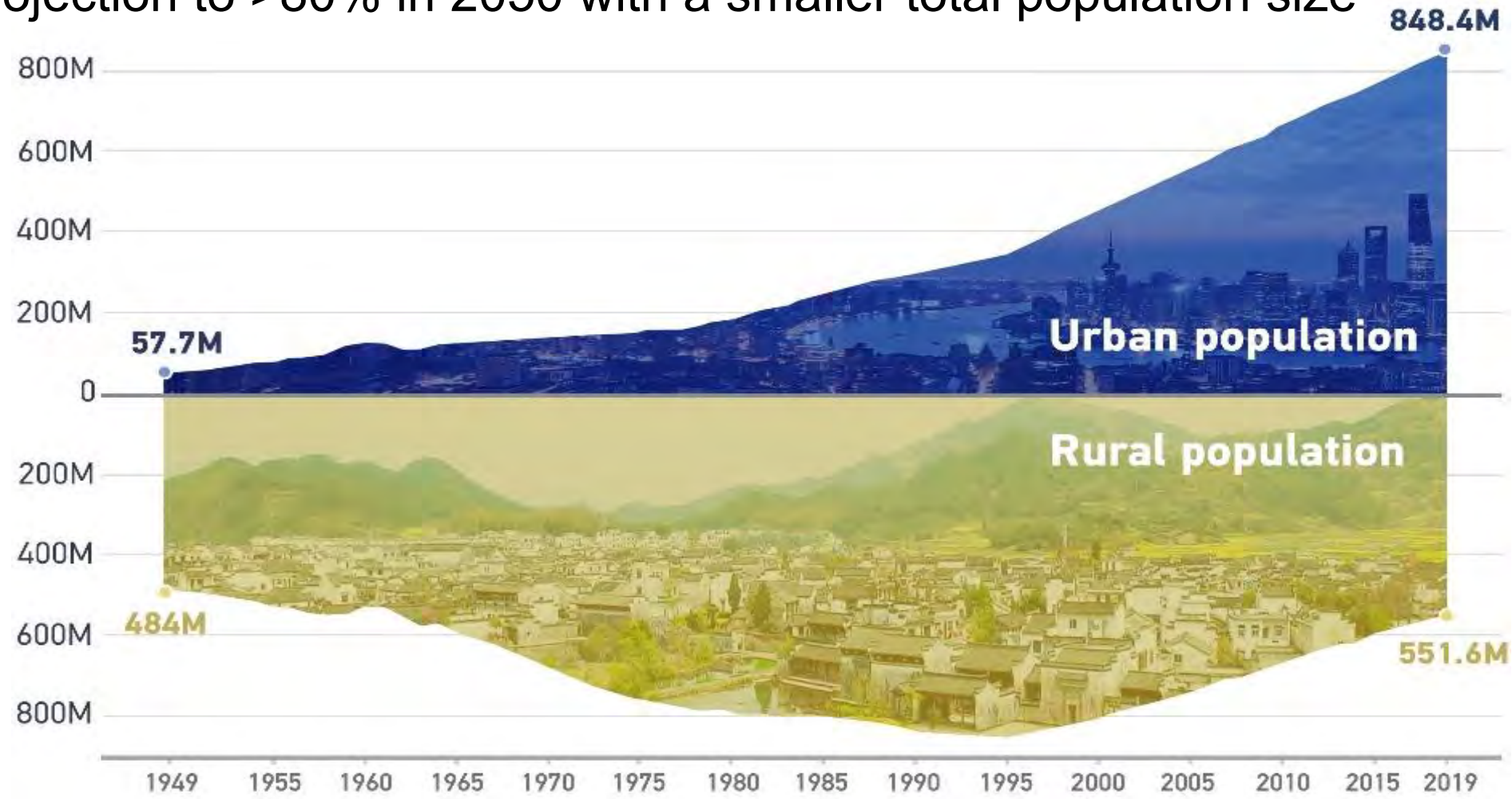
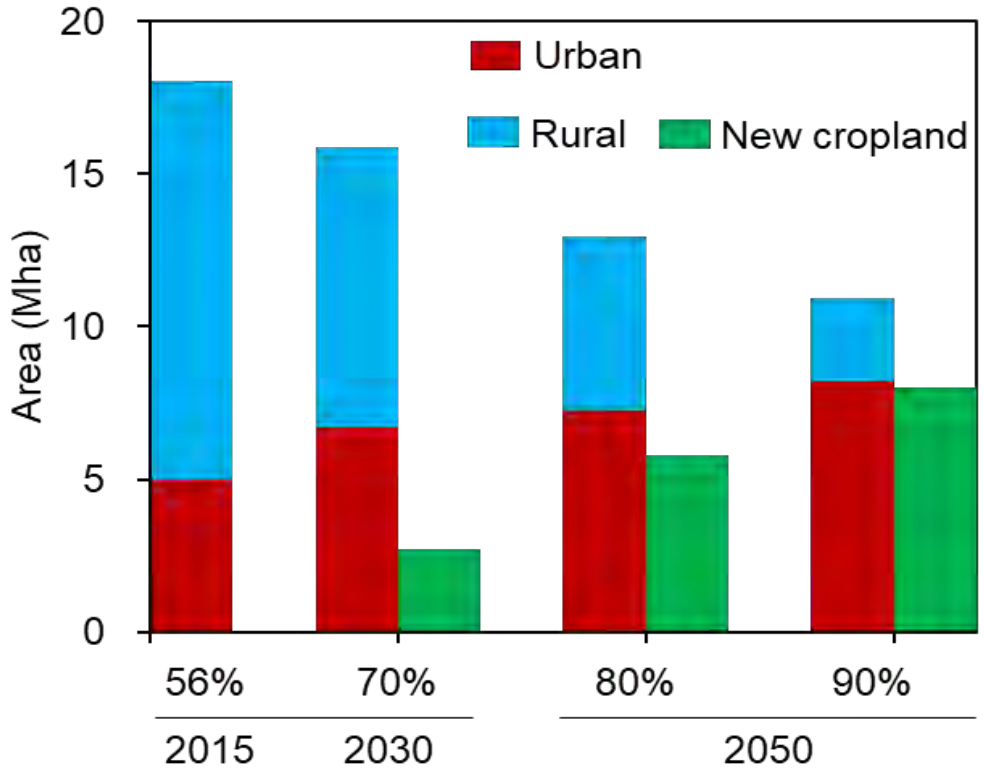
Urbanization in China

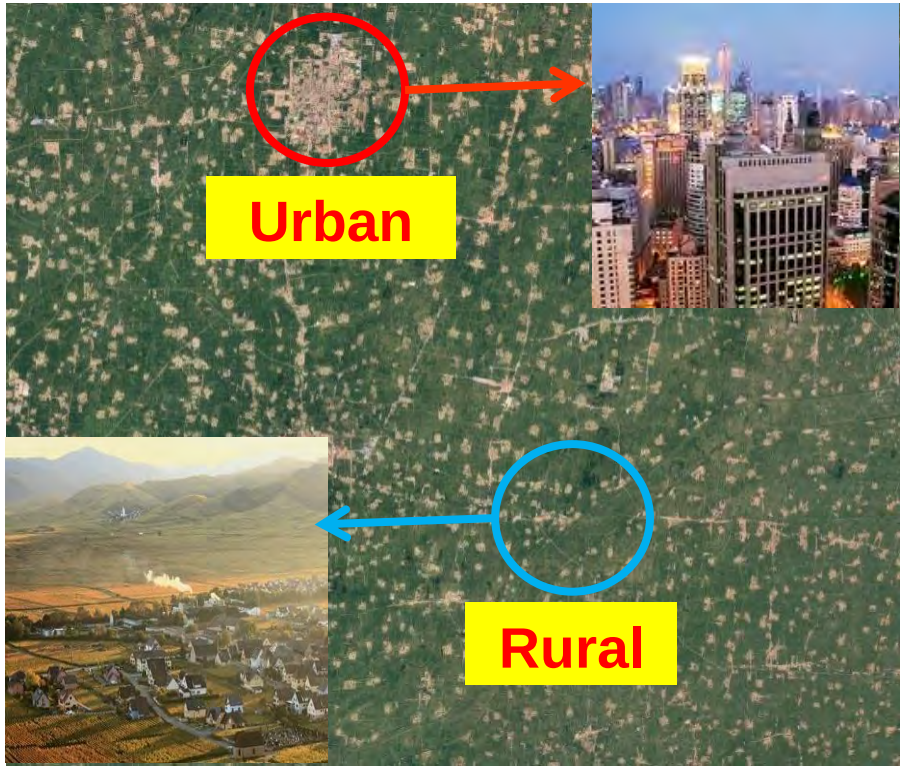
- **Urbanization** moved 14 million people from rural to urban during past decades, with projection to >80% in 2050 with a smaller total population size



Urbanization and land use

- Rural area takes more lands than urban due to its **lower population density**

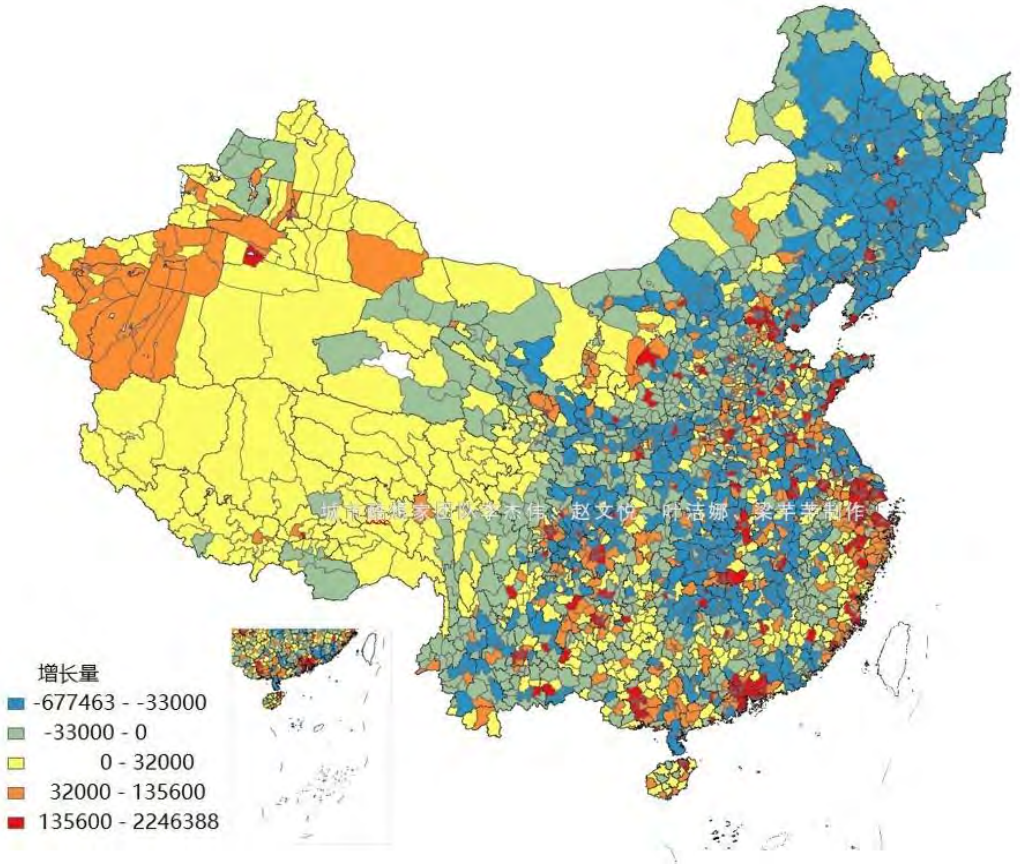


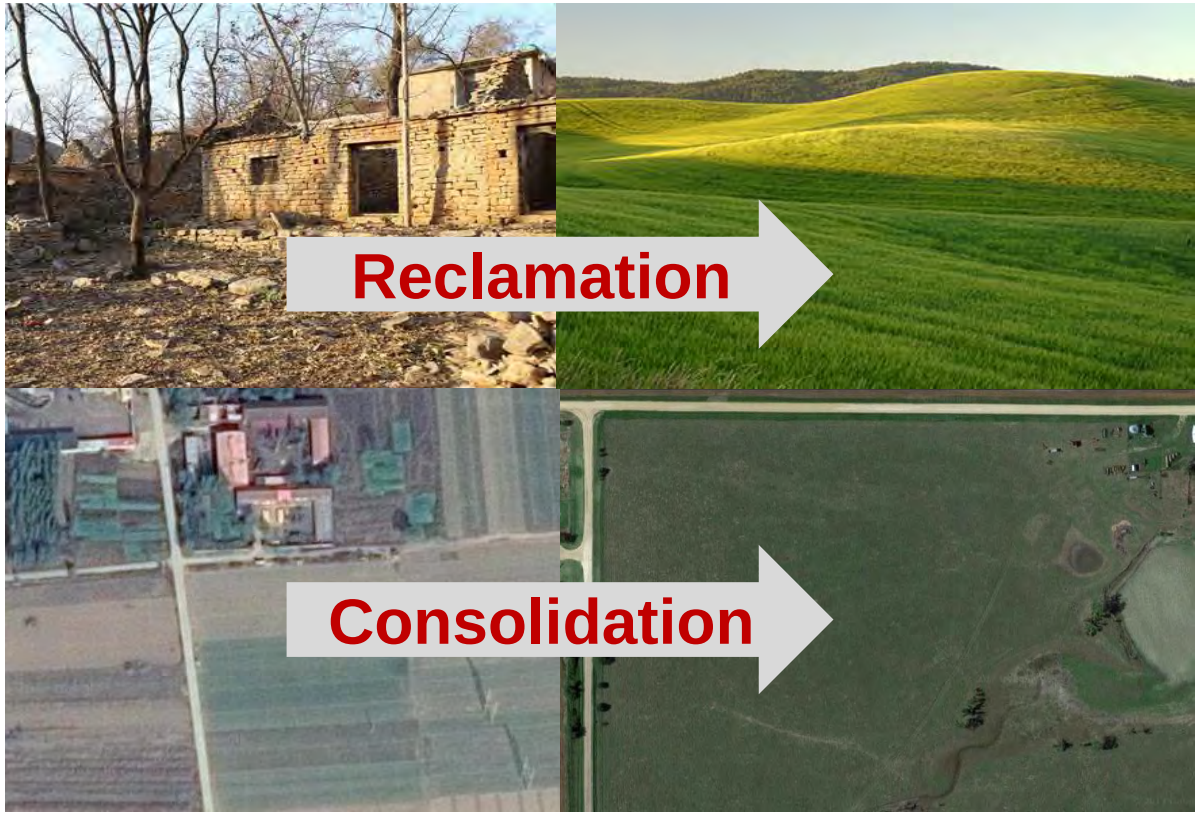


Gu et al., 2019, Nature

Population decline

- **Population declines** in half of counties during 2010-2020, land abandonment in rural and small cities is happening

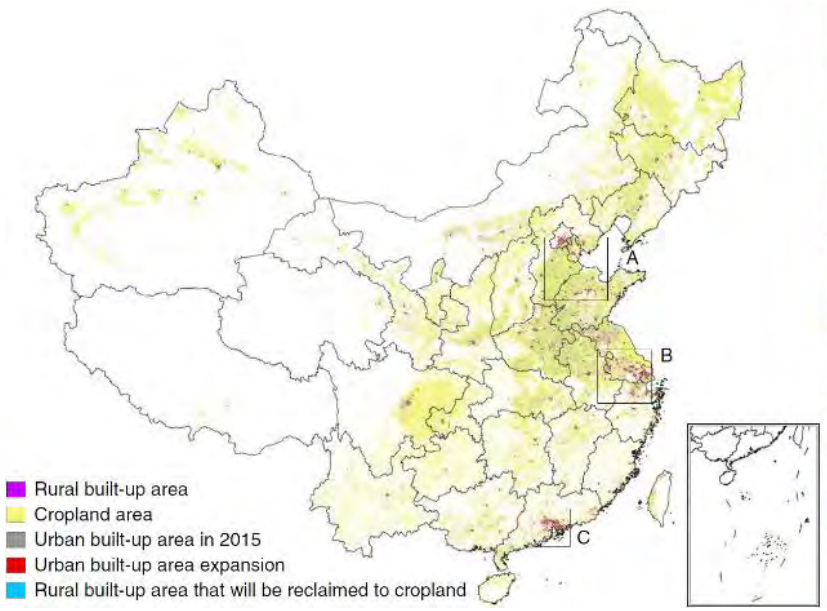


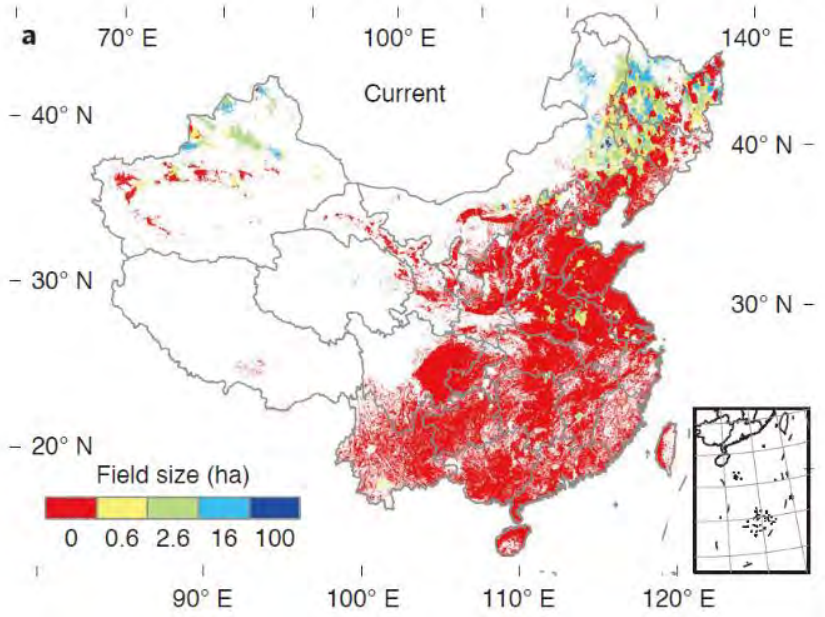


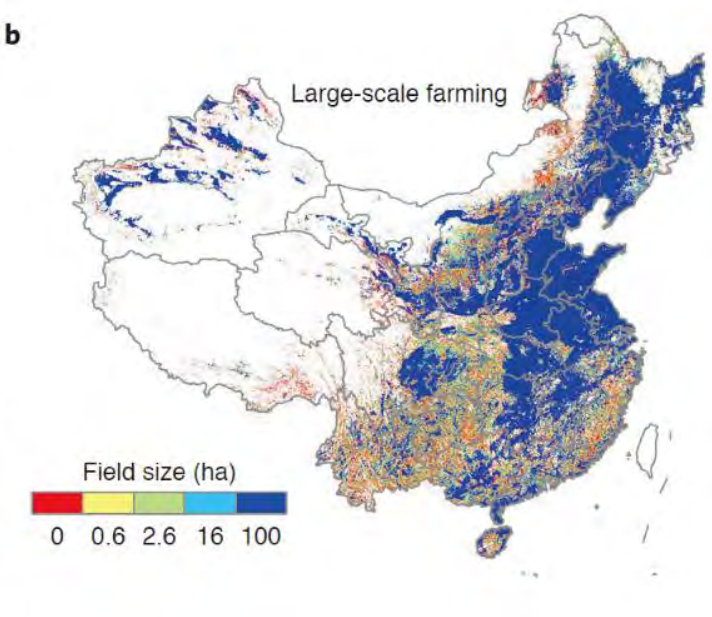
The Seventh National Population Census, 2020

Urbanization leads to large-scale farming

- **Urbanization** release 5-8 Mha rural land, reduce rural population and thus increase farm size, driving 90% of China's farmland to achieve >10 ha and increasing cropland NUE by 40%.





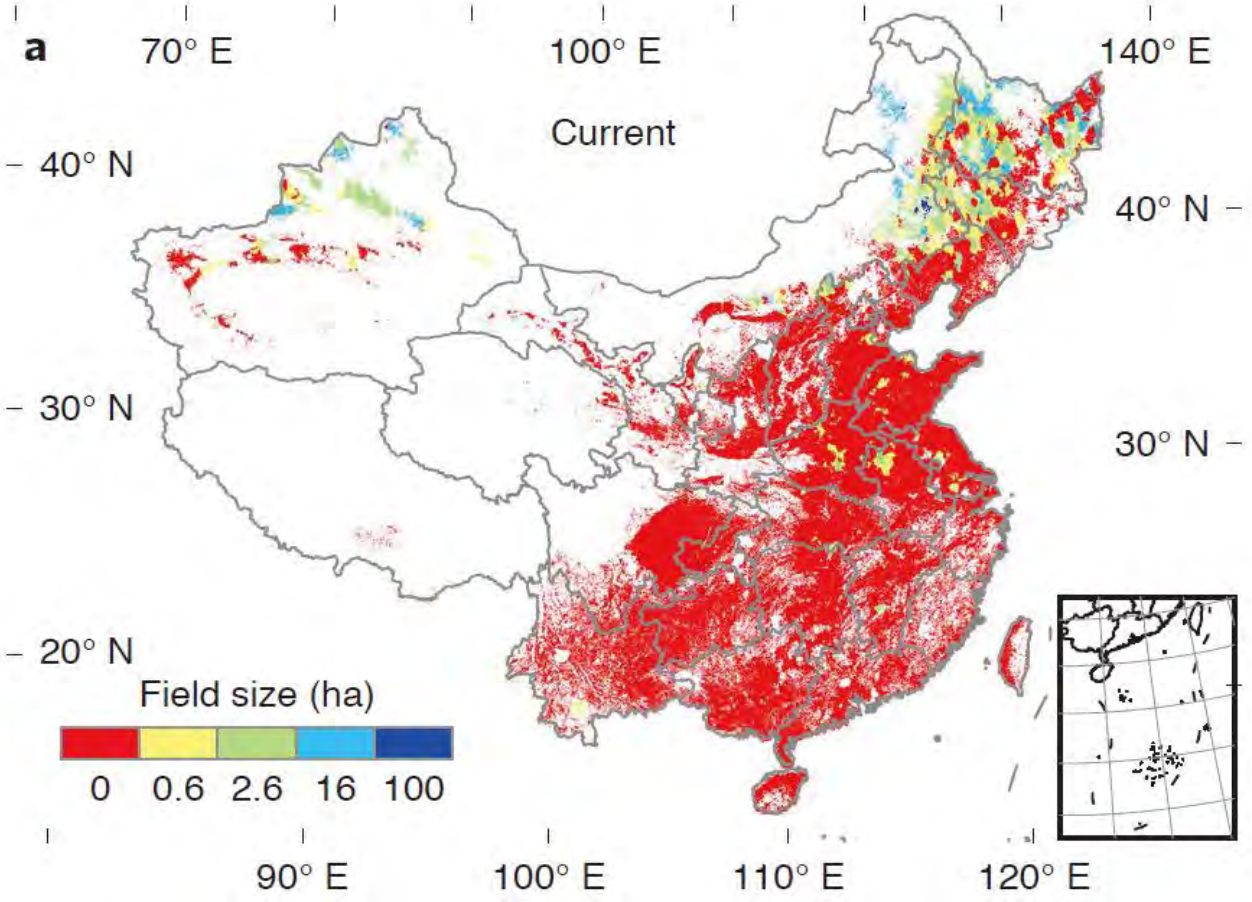


Urbanization **Large-scale farming**

Wang et al., 2021, Nature Food; Duan et al., 2021, Nature Food

Cropland ridges

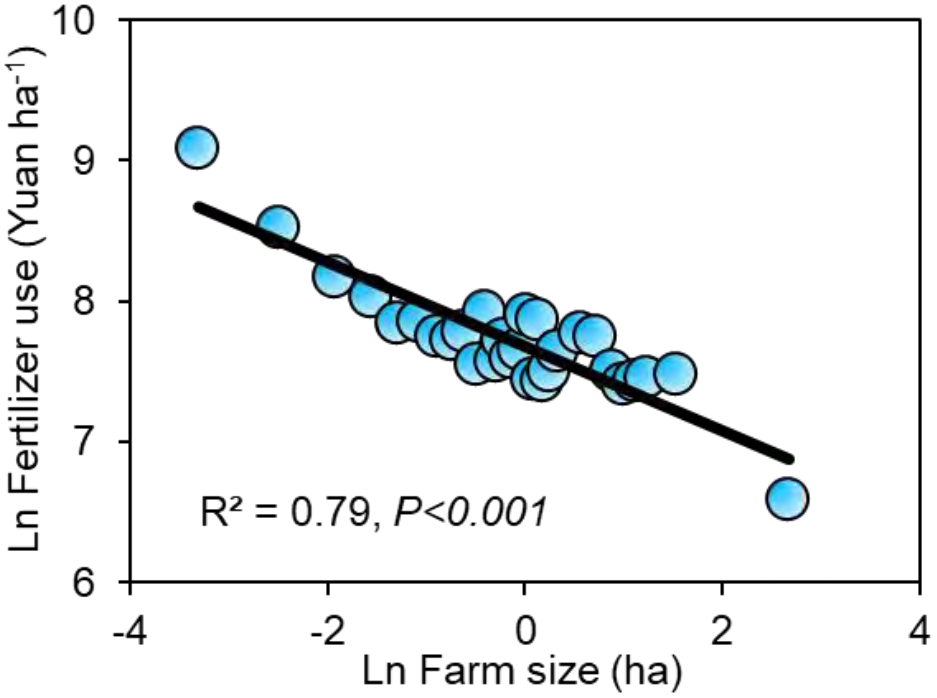
- **Cropland ridges** account for 14% of total cropland area in China, large-scale farming could save lands



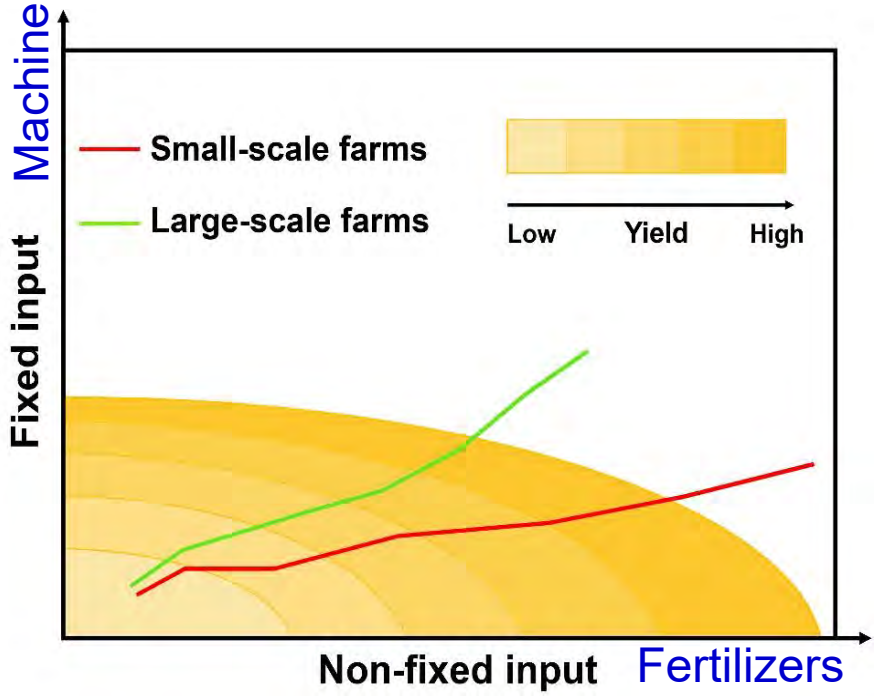
Duan et al, in preparation

Small farm size leads to over-fertilization

- Smallholder farmers prefer fertilizer as a **substitute** for machinery/knowledge inputs, leading to more fertilizer application at smaller scales



Reduce with farm size

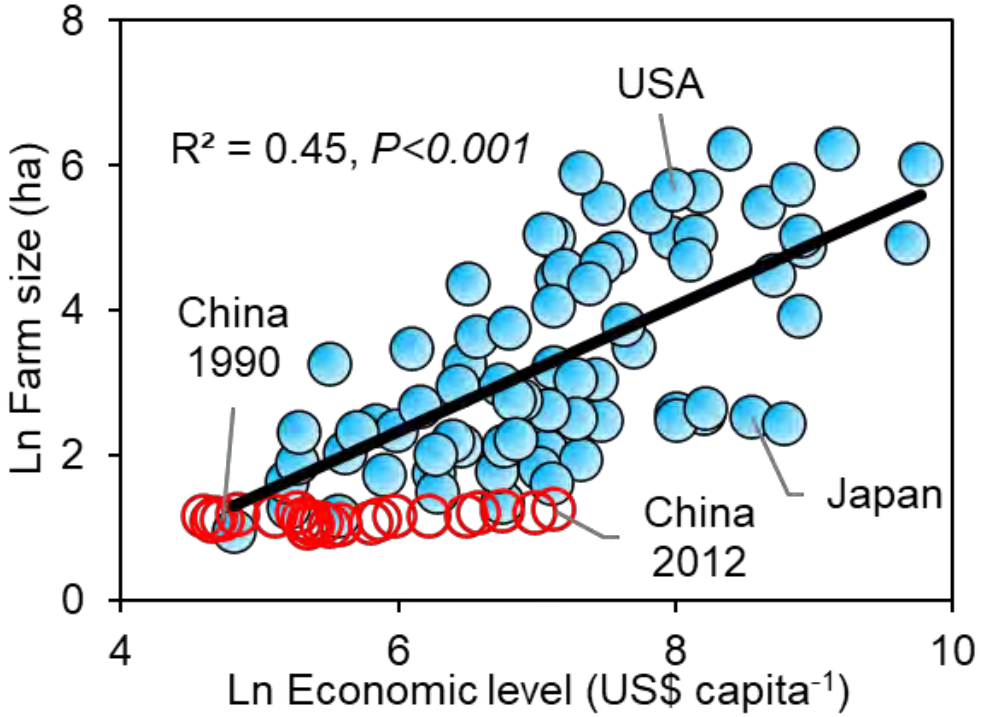


Substitute effect

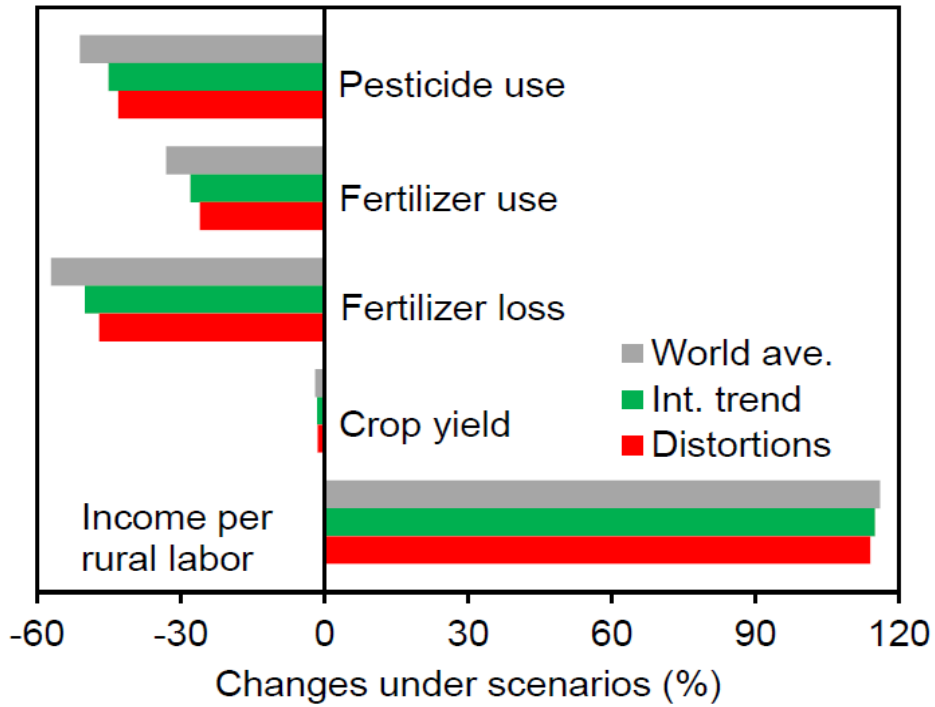
Wu et al., 2018, PNAS

Appropriate size will optimize fertilization

- Fertilizer use and loss will reduce 1/3 and 1/2, while income doubled under **3-5 ha** following global role with **machinery/knowledge use** increased by 60-90%



Appropriate size

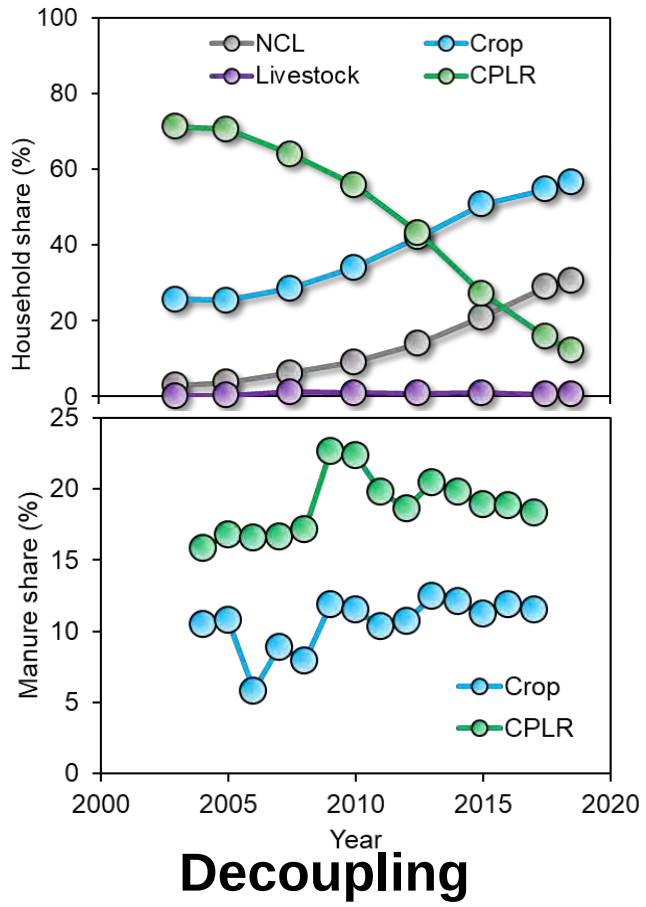


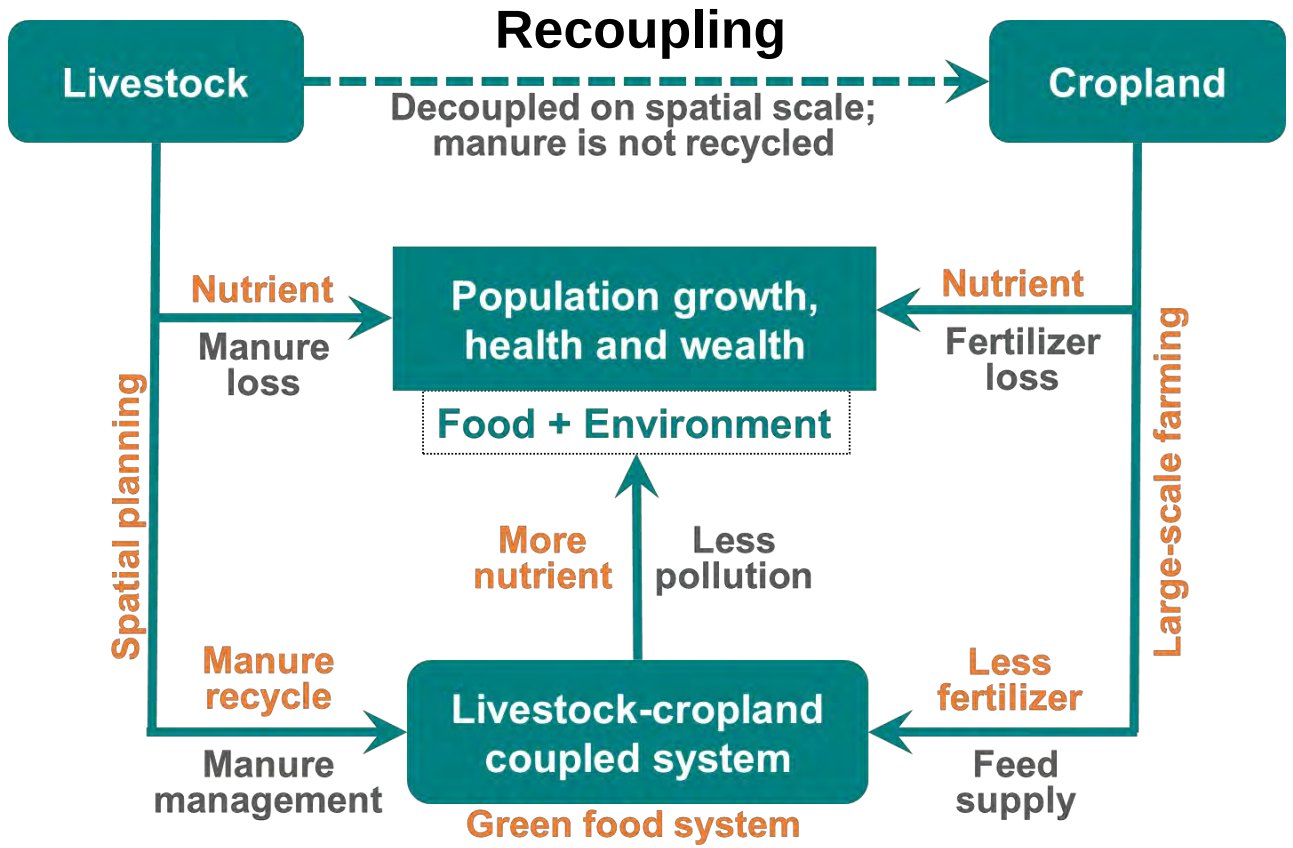
Reduction potential

Wu et al., 2018, PNAS; Wang et al., 2021, Environ Sci Technol

Recoupling livestock and crops to reuse manure

- **Small farm size** and **high non-agricultural income share** lead to decoupling, and appropriate farm size could promote recoupling to reduce manure loss

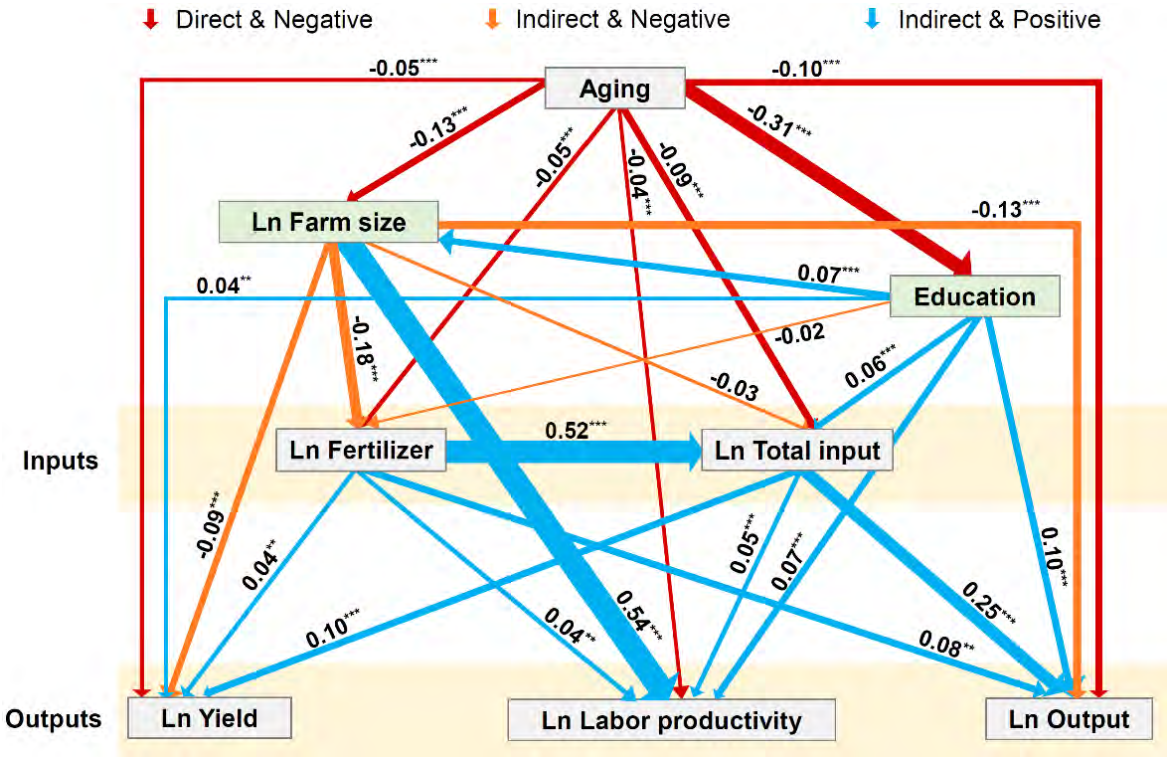




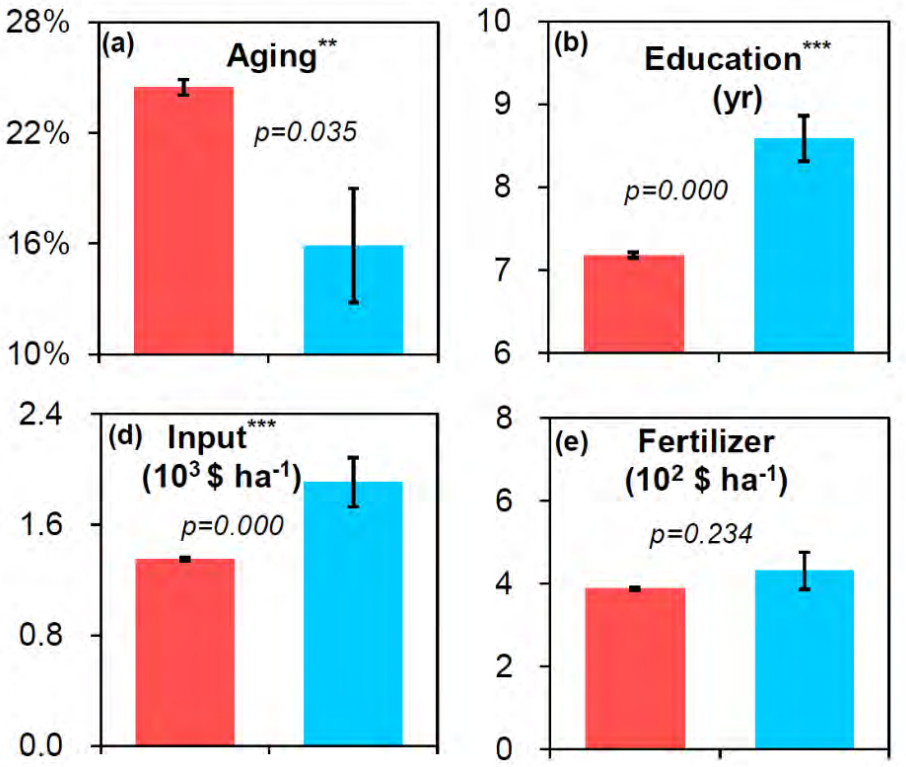
Jin et al., 2021, Nature Sustain; Gu, 2022, Nature Food

Urbanization and rural aging

- Expanding **new farming models** to address threats of sustainability by rural aging on cropland abandonment and low productivity



Impact pathway of ageing

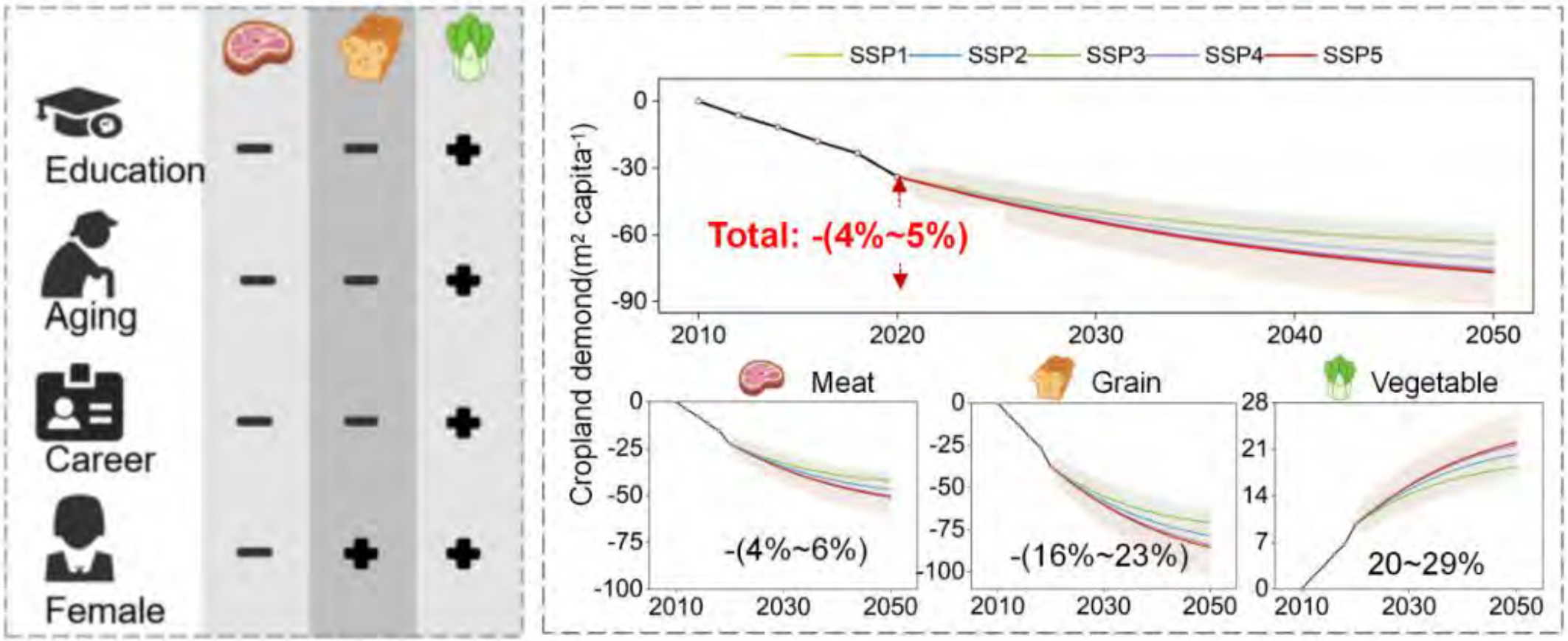


New farming models

Ren et al., 2023, Nature

Urbanization affects dietary structure

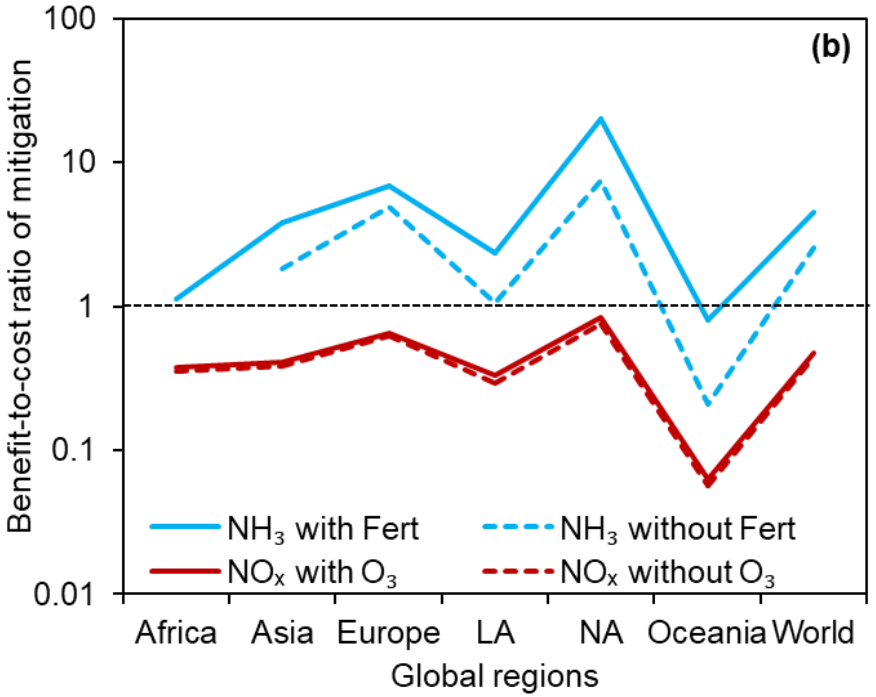
- **Urbanization** decrease food consumption through education and changes in society structures despite economic growth has an increase impact



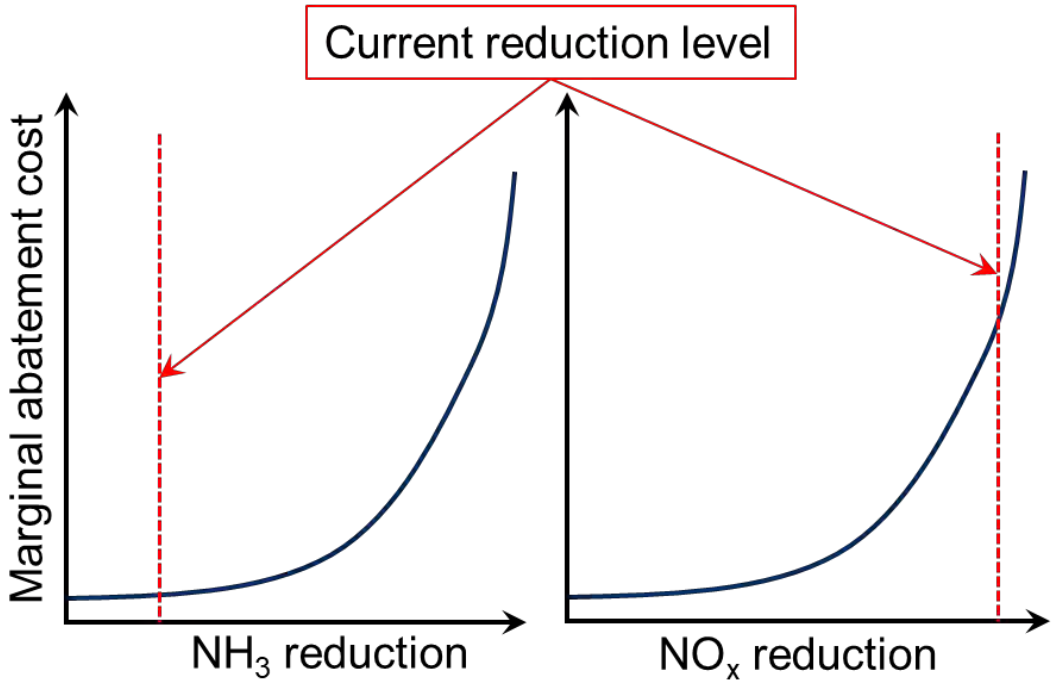
Deng et al., 2024, in review

Reducing NH_3 from food systems

- Nitrogen contributes **40%** of global $PM_{2.5}$ pollution with mitigation of **NH_3** from agricultural sources more cost-effective than that of **NO_x** from industrial sources.



Cost-benefit analysis

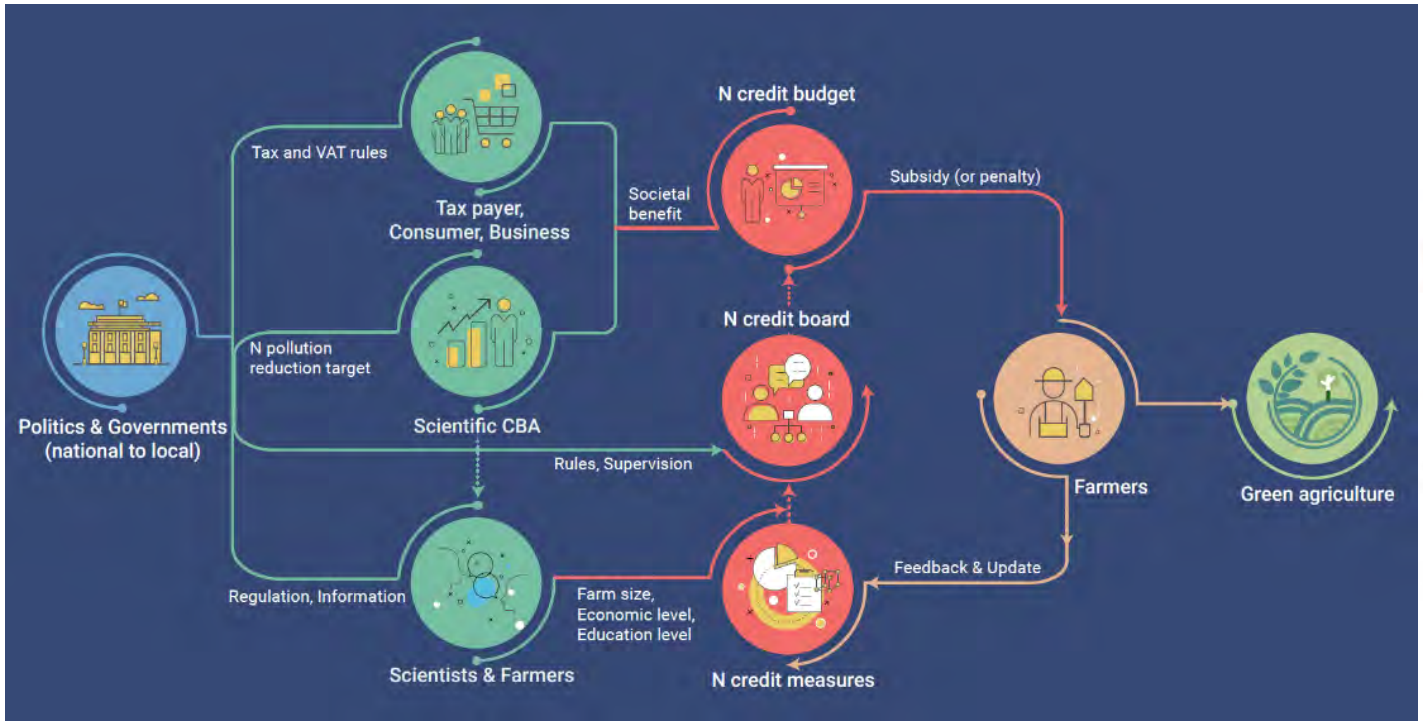


Mitigation NH_3 is still on the early stage

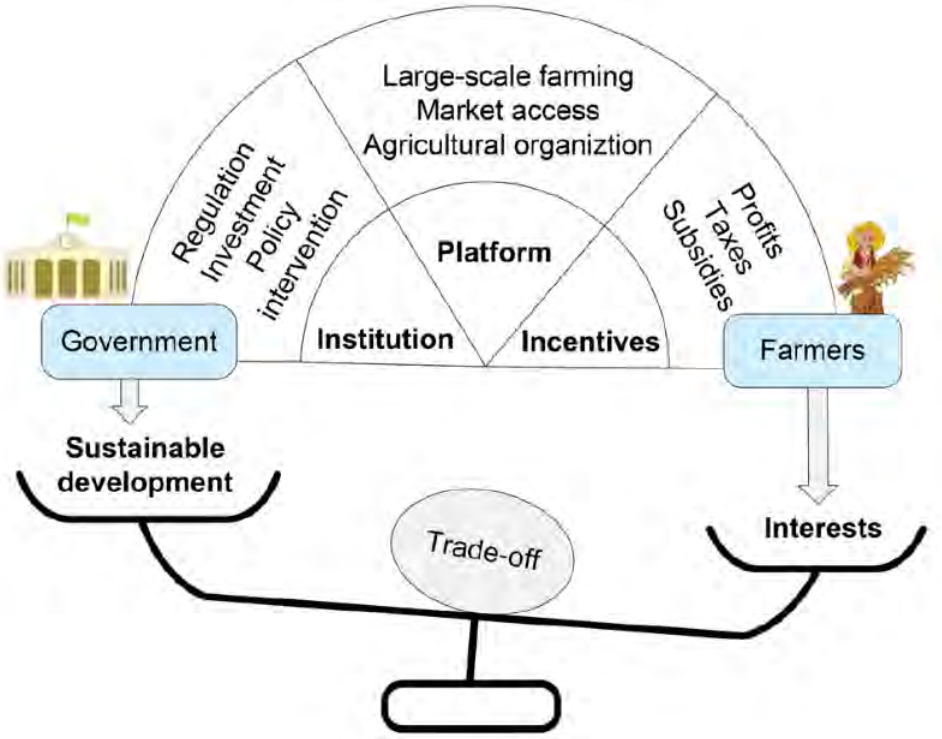
Zhang et al., 2020, Nature Commun; Gu et al., 2021, Science

Build NCS for sustainable agriculture

- **Nitrogen credit system (NCS)** resolve the **mismatch** between farmers paying abatement costs while the whole society gain the benefits



The NCS

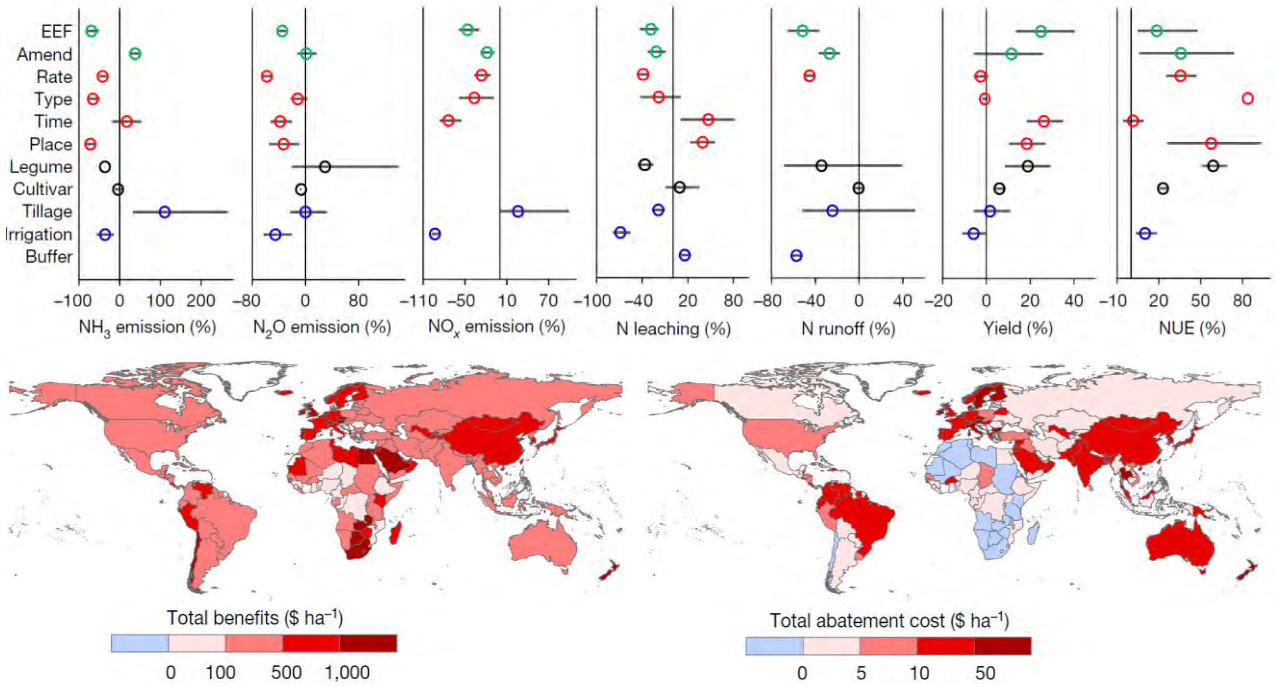


Mismatch

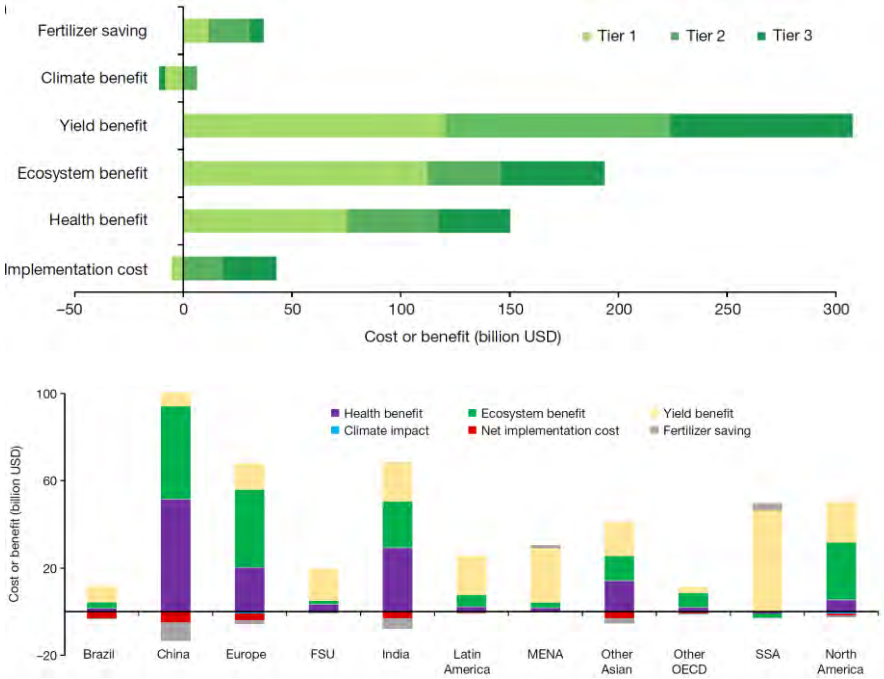
Gu et al., 2021, Innovation

Cost-effective mitigation of agricultural pollution

- Following the NCS, implementation of 11 global N abatement measures could **reduce 30-70% nitrogen pollution, with a benefit to cost ratio at 25**.



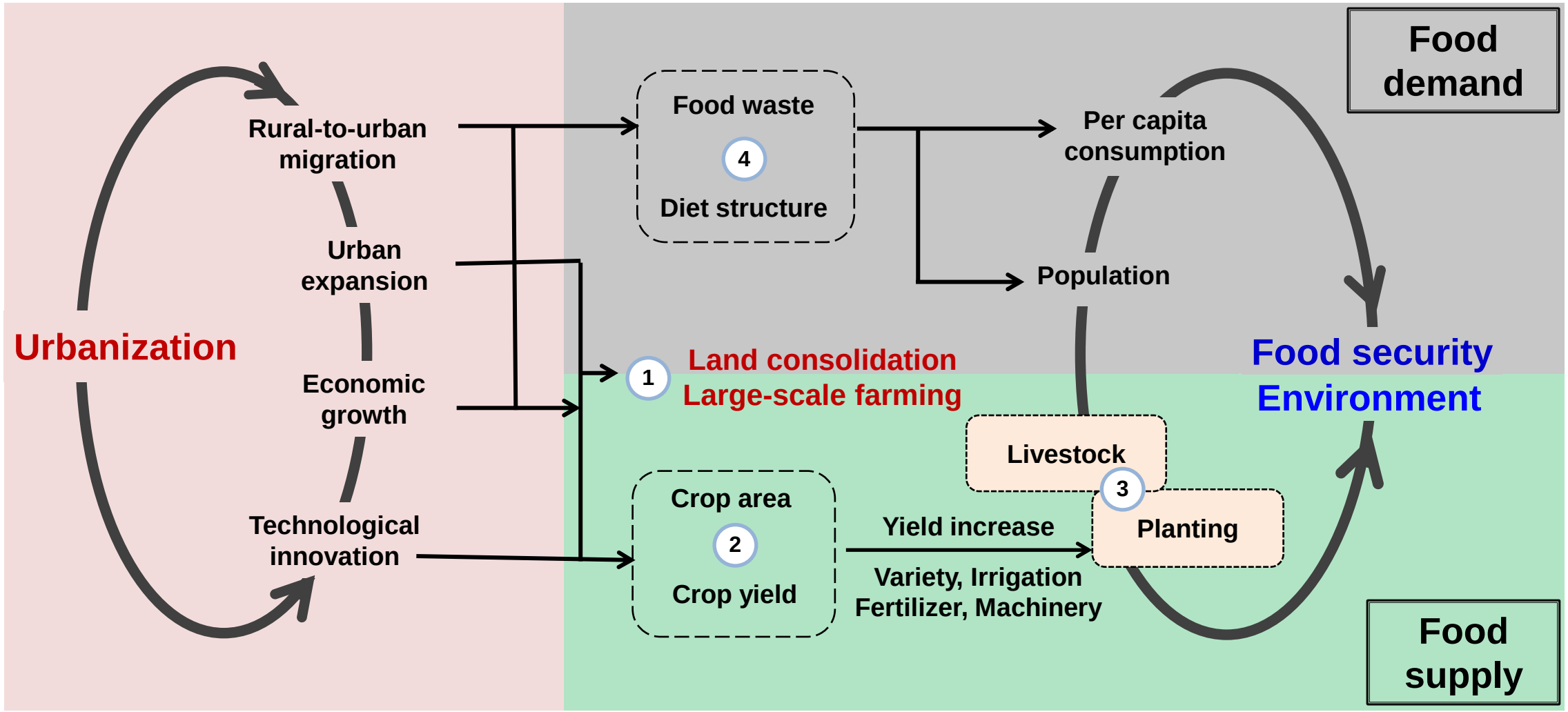
US$ 476 billion **US$ 19 billion**



Cost and benefit

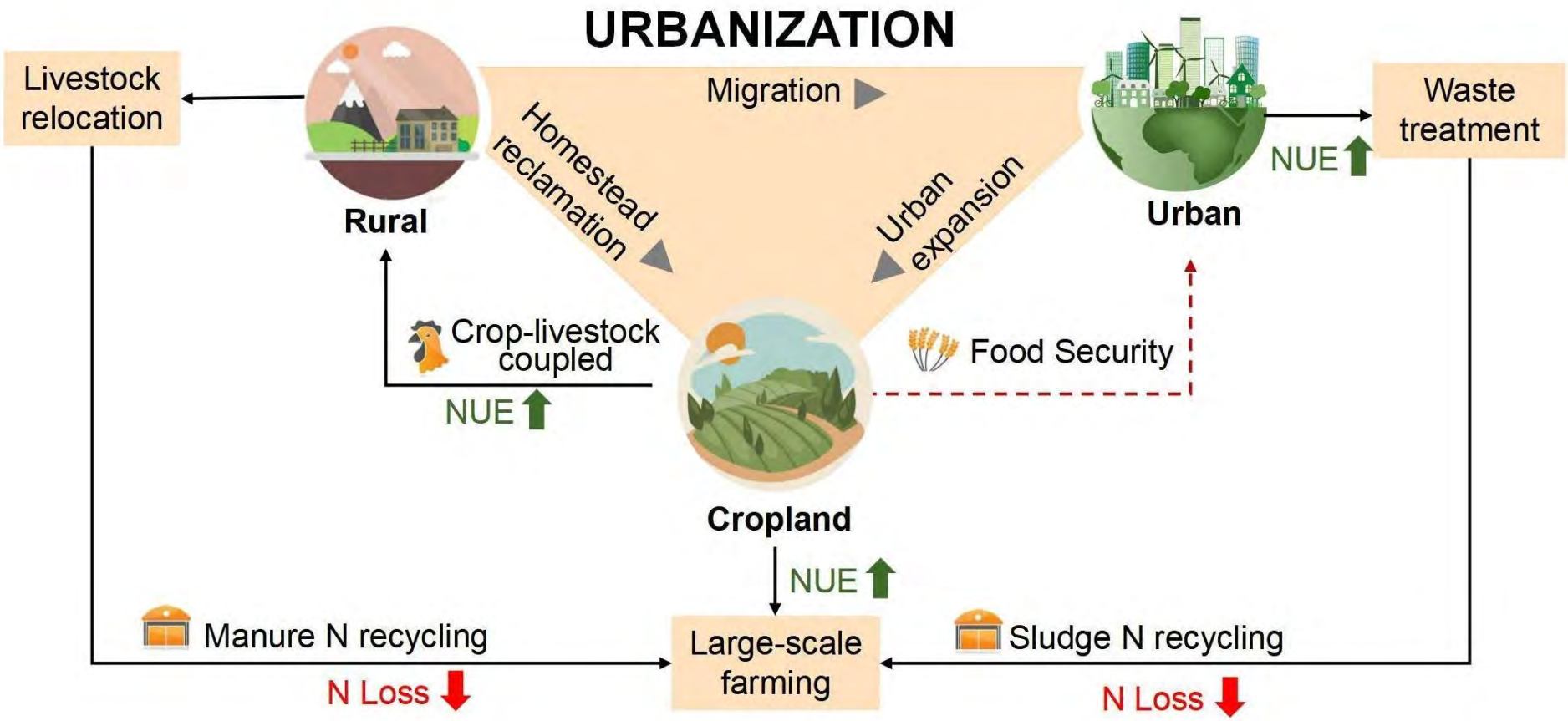
Gu et al., 2023, Nature

Full chain regulations



Urbanization and regional sustainability

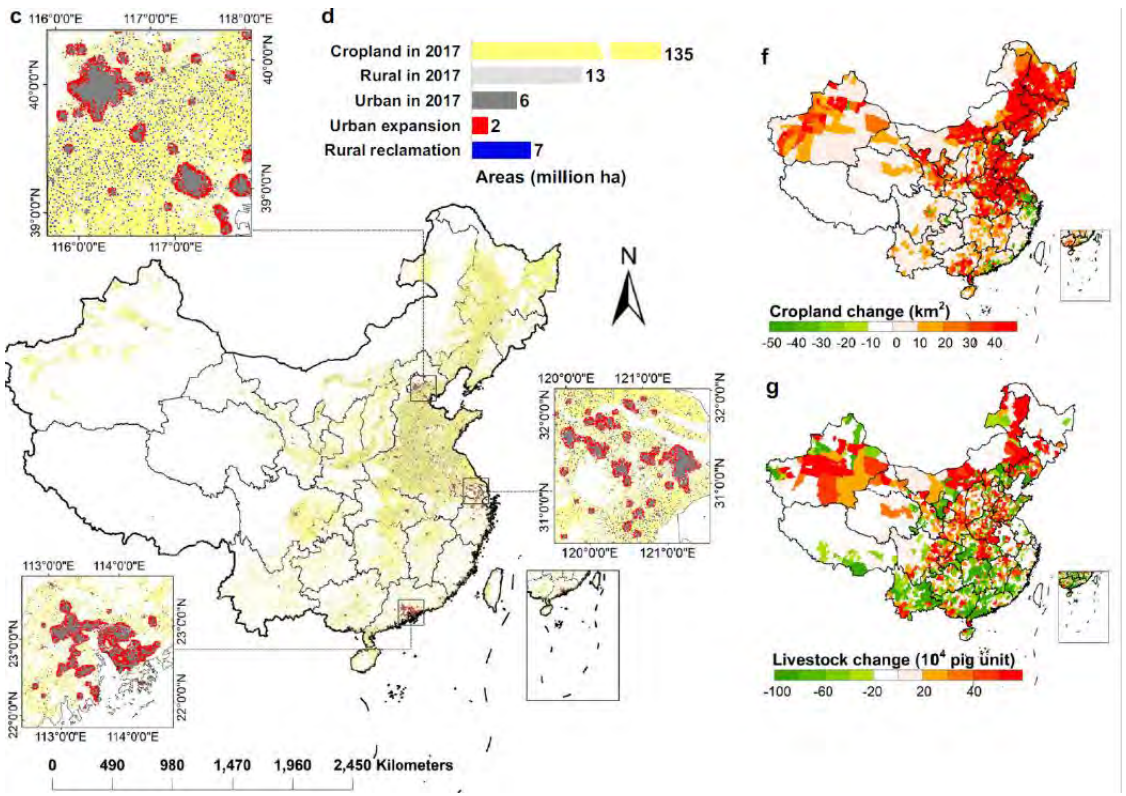
- **Urbanization** move people from rural to urban, leading to large-scale farming, coupling animal and lands, concentrated treatment of sewage



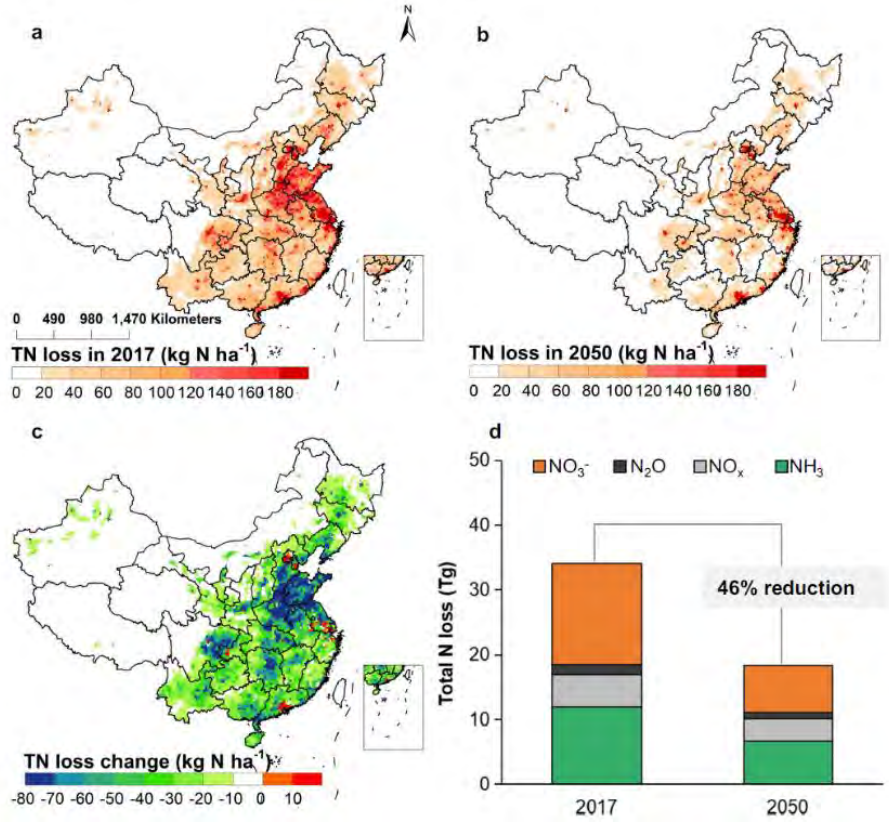
Deng et al., 2024, Nature Commun

Urbanization halves regional nitrogen waste

- **Urbanization** promotes resource use efficiency that could **halve nitrogen waste on regional scale**



Urbanization reshape

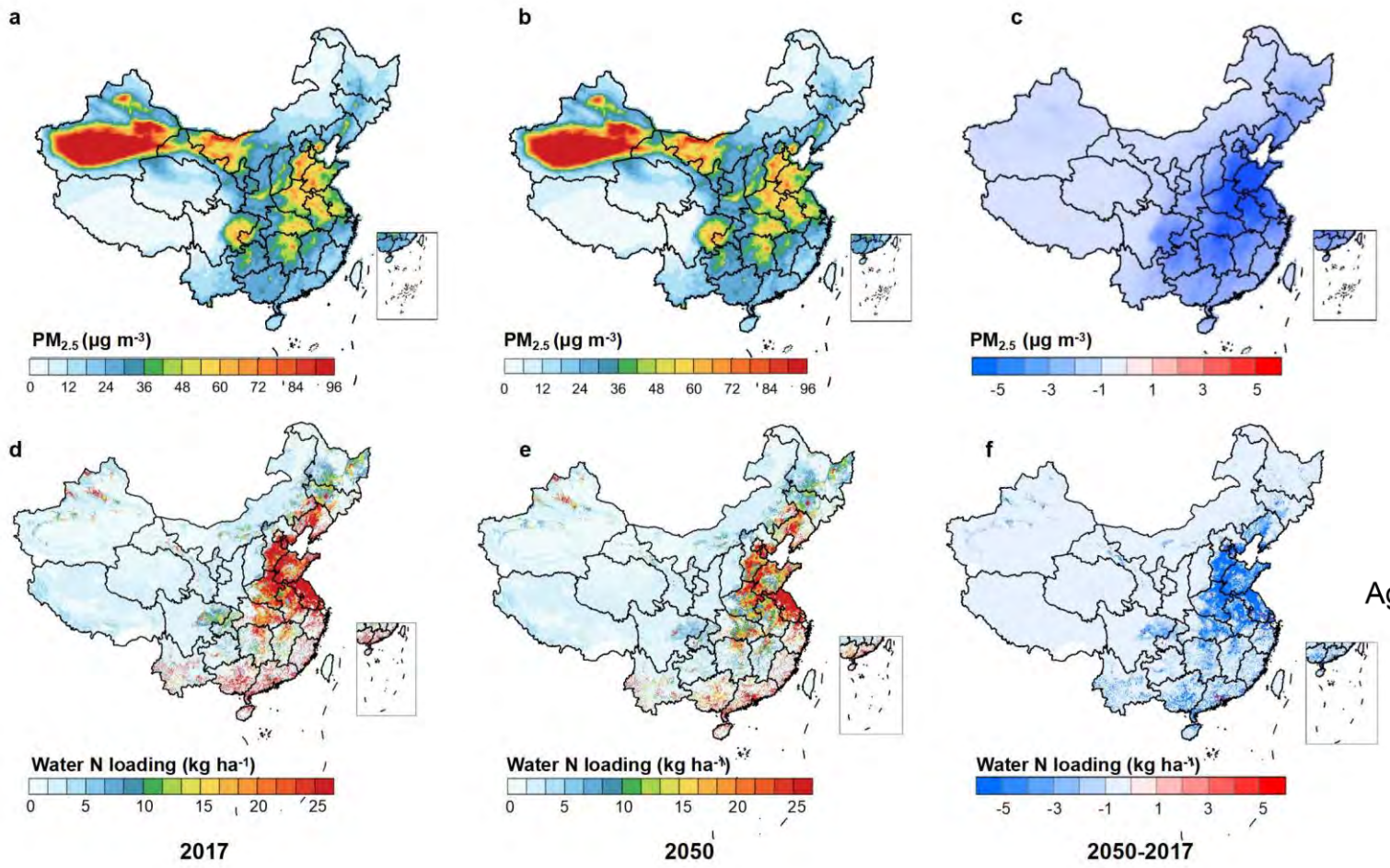


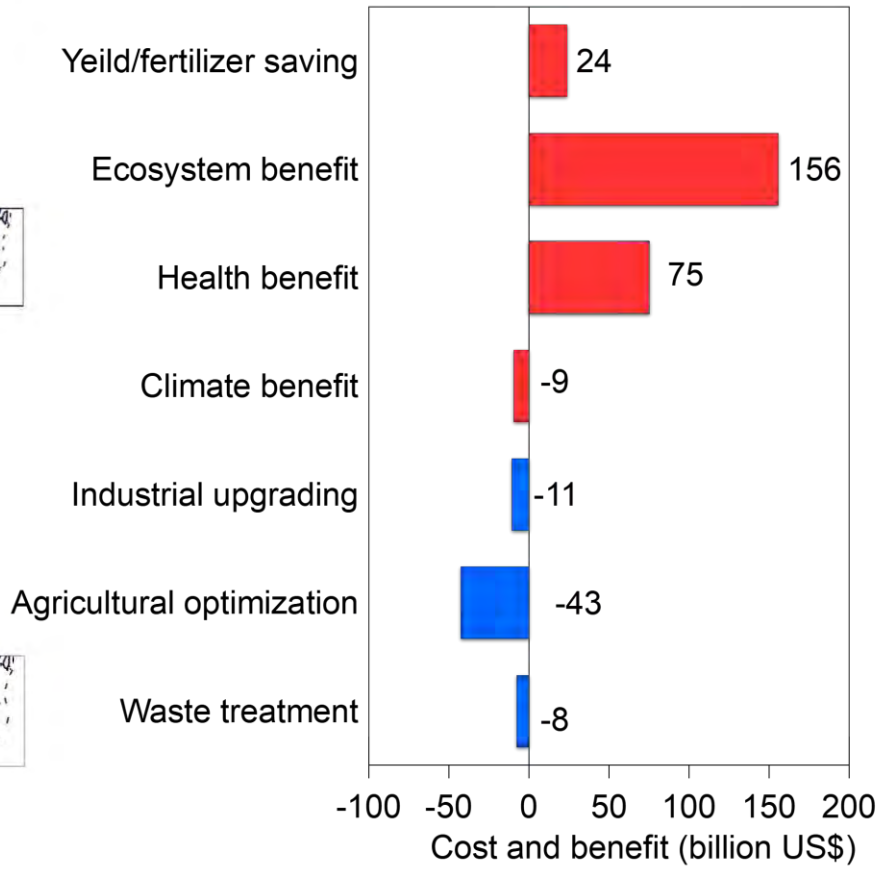
Halve N waste

Deng et al., 2024, Nature Commun

Regional environment improvement

- **Halve nitrogen waste** improve air and water quality cost-effectively





Deng et al., 2024, Nature Commun

Thank you！谢谢大家！