Current projects

Agriculture Green Development Programme

Poster overview May 2024

Wageningen University & Research

China Agricultural University

WAGENINGEN UNIVERSITY & RESEARCH

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CHINA AGRICULTURAL UNIVERSITY
1905

Contents

Graduates

Name (start year, PhD model)	*Project*
Theme Green animal production	
Tao Zhang (2019, 2+2)	Decreasing nutrient loss from crop-livestock systems by manure redistribution with minimum cost and improved management
Zhenyu Wang (2019, 2+2)	Improved utilization of organic wastes to develop new feed resources
Theme Green ecological environment	
Fanlei Meng (2019, 2+2)	Agricultural Green Development in China – Integrated Assessment of green food production, green products and a green environment
Zhibiao Wei (2019, 1+3)	Waste2C: From Waste to Crop – Quzhou as a Living Lab for Sustainable Agro-Food systems
Luncheng You (2019, 2+2)	Towards sustainable nitrogen and acidification management in the Quzhou and Zhaoyuan counties and the North China Plain
Theme Green plant production	
Jie Lu (2019, 1+3)	Increasing nutrient use efficiency in maize by merging functional structural root modelling and marker assisted breeding

Congratulations to all!

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Overview PhD projects – starting year 2019

Posters, May 2024

Theme: Green and nutritious food provision & governance

Name	*Model**	*Project*
1. Hongyi Cai	1+3	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
2. Taian Deng	2+2	Can Homestead Gardens Improve China rural Households' Vegetable Consumption? Evidence from Three Provinces in China
3. Jinghan Li	1+3	The social impact of Science and Technology Backyards (STBs) towards a rural revitalization in China
4. Zhiwei Yu	2+2	The social impact of Science and Technology Backyards (STBs) towards a rural revitalization in China

Theme: Green animal production

Name	*Model**	*Project*
5. Guichao Dai	2+2	Optimization and designing of integrated crop-livestock systems
6. Shiyi Zhang	1+3	Quantifying the effects of dietary fibres on protein digestibility in pigs
7. Hao Ye	1+3	Effects of protein kinetics in lactating sow diet on sow body condition losses, litter weight gain and nitrogen utilization
8. Hanlu Zhang	1+3	Optimizing the utilization of nonconventional feed ingredients in pigs by targeting hindgut fermentation of fiber and protein components for improved animal health and environment
9. Yaowen Zhang	2+2	Optimizing the utilization of nonconventional feed ingredients in pigs by targeting hindgut fermentation of fiber and protein components for improved animal health and environment

Theme: Green ecological environment

Name	*Model**	*Project*
10. Yu Gu	1+3	Assessment of the spatial distribution in phosphate balance and the required mitigation potentials
11. DongFang Zheng	2+2	Assessment of the spatial distribution in phosphate balance and the required mitigation potentials
12. Zhilong He	2+2	Mitigation of nitrogen losses and greenhouse gas emissions in a more circular cropping-poultry production system
13. Yanan Li	1+3	Agricultural Green Development in China – Integrated Assessment of green food production, green products and a green environment
14. Hongyu Mu	1+3	Agro-pollutants in the soil-water-air nexus: occurrence, transport, risk, and solutions-take pesticide as an example
15. Qi Zhang	1+3	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach

Theme: Green plant production

Name	*Model**	*Project*
16. Jiali Cheng	1+3	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
17. Zhengyuan Liang	1+3	Developing sustainable diversified crop production systems for the North China Plain
18. Mengshuai Liu	2+2	Crop rotations, intercropping, and negative plant-soil feedback in Quzhou and the North China Plain
19. Zhan Xu	1+3	The implications of positive deviant farms for crop production sustainability in the North China Plain
20. Lu Liu	2+2	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
21. Yujie Yang	2+2	Increasing nutrient use efficiency in maize by merging functional structural root modelling and marker assisted breeding

Model*: There are two different types of PhD candidates, hence 2 models.
2+2 model: Graduates at CAU; project starts and ends in China; stays for two consecutive years in Wageningen.
1+3 model: Graduates at WU; project starts in China; stays for three consecutive years in Wageningen.

Does following the national dietary guideline help improve the environmental sustainability? Evidence from China with a heterogeneity analysis

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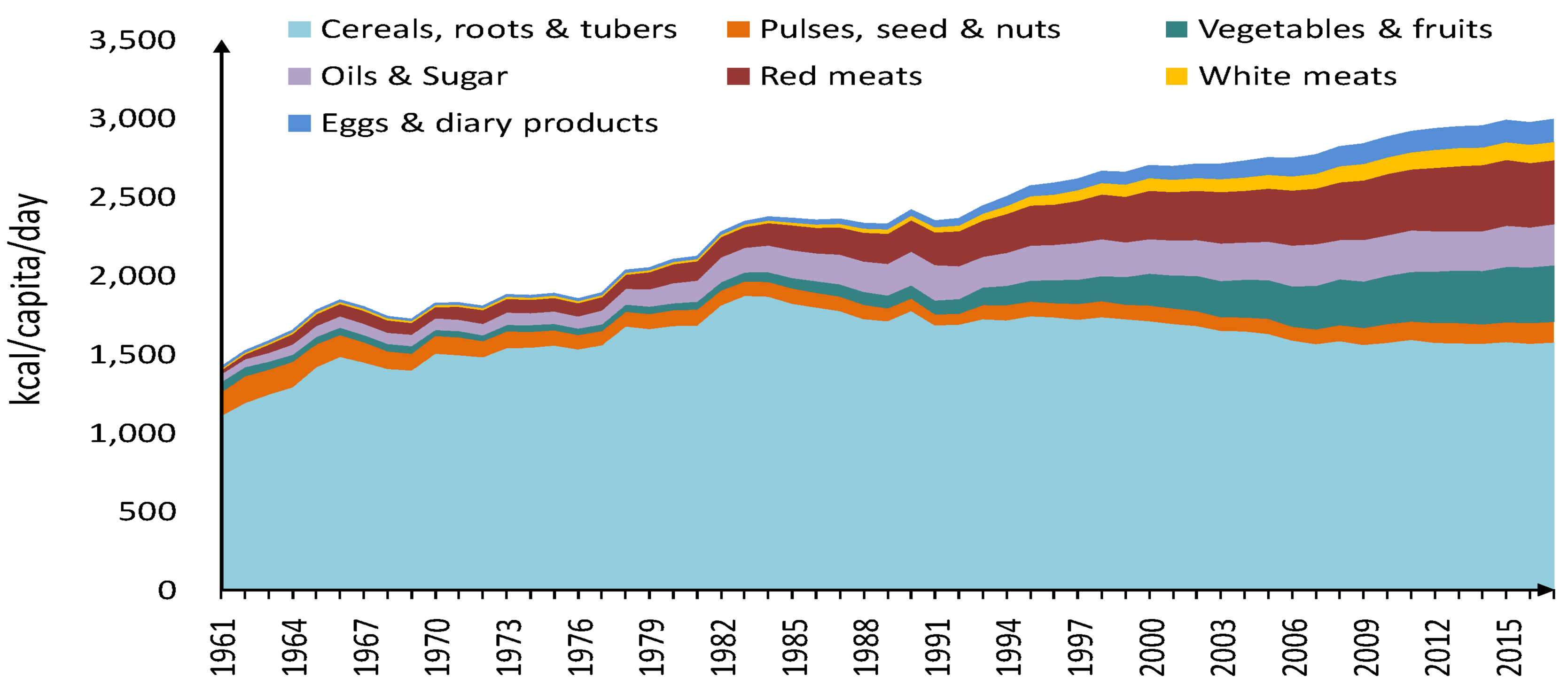
Background

1. Previous research has shown an inverse association between overall diet quality and diet-related environmental impacts.
2. Evidence of the association between the dietary quality and dietary environmental impacts is lacking for China, where dietary patterns are undergoing a rapid transition since the last decades.
3. The aim of this study was to analyze the association between diet quality and diet-related environmental impacts.



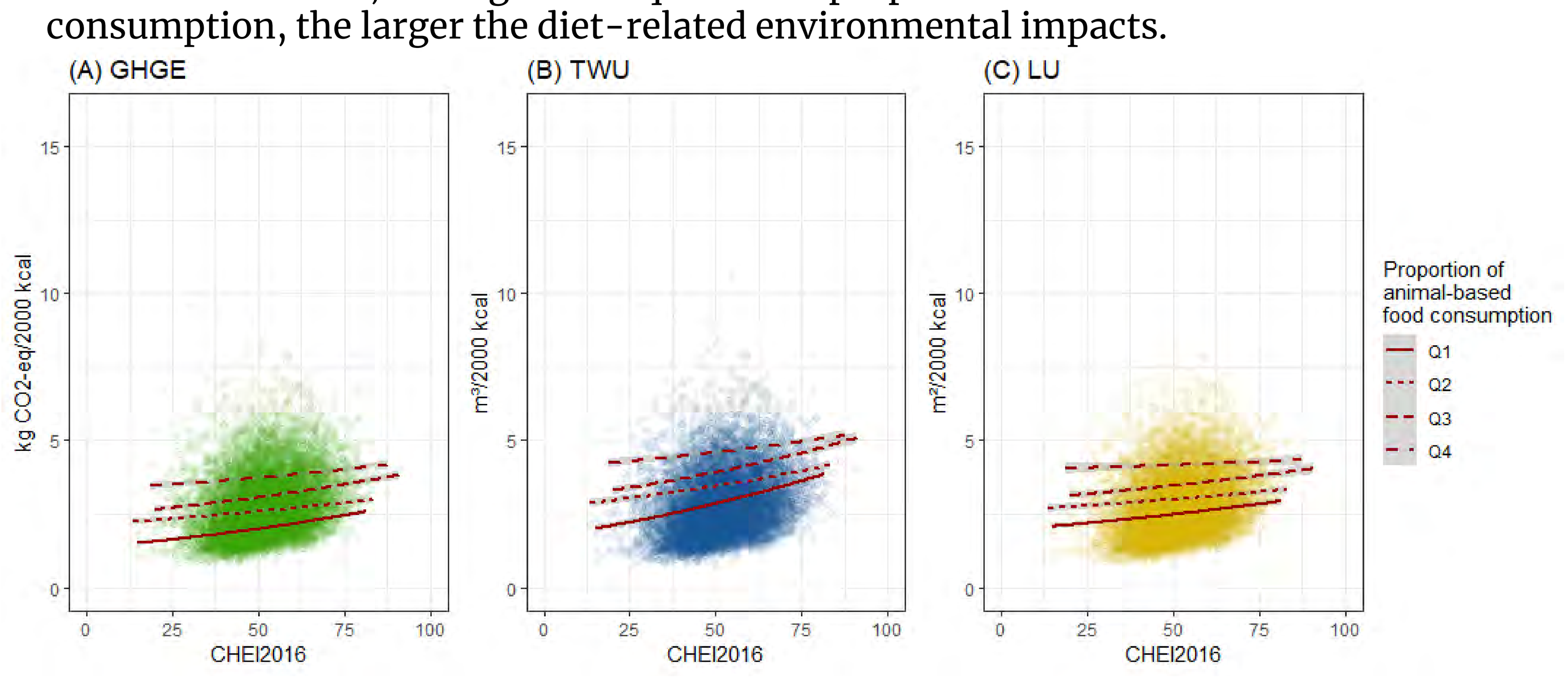
- *The daily per capita calorie intake increased from 1421 kcal in 1961 to 2950 kcal in 2017.*
- *Along with the growing economy, the dietary patterns of Chinese residents have shifted from plant-based to mixed diets that include a large proportion of animal-based foods.*

Methods

1. Data: the China Health Nutrition Survey 2011 (CHNS 2011). A multi-stage stratified random cluster sampling method was used in the CHNS to select survey households in 9 provinces and metropolitan areas.
2. Multiple linear regression: the association between the CHEI2016 and dietary environmental impacts.
3. Trend tests: examine differences in diet-related environmental impacts across CHEI2016 scores.
4. Multilevel regression models: with random intercepts and random slopes were used to explain the heterogeneity of the association by region and population subgroup characteristics.

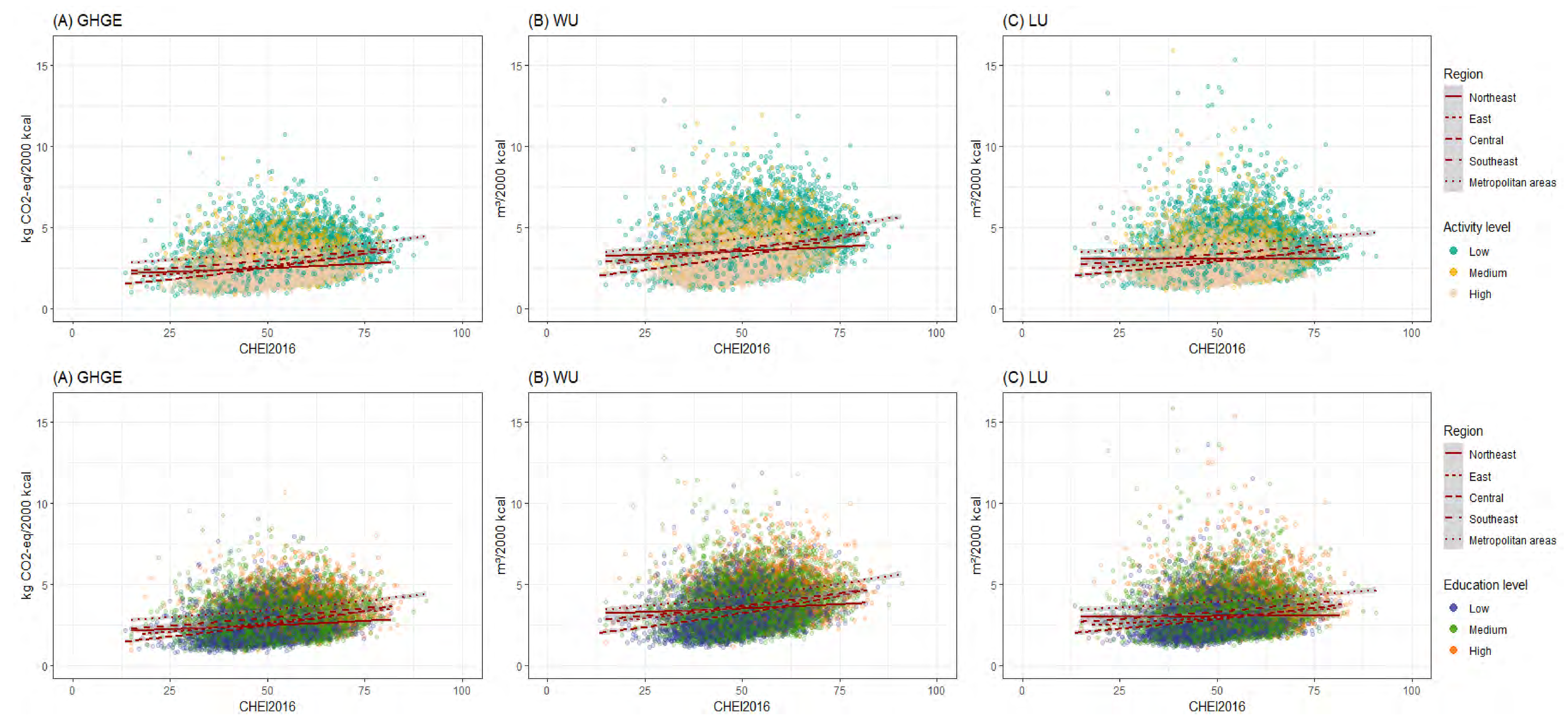
Results

- One standard deviation increased in CHEI2016 score (i.e., 10.5 points) was associated with increases of 10.6% GHGE, 10.4% TWU, and 7.5% LU, respectively.
- In each CHEI score, the higher the quartile of proportion of animal-based food consumption, the larger the diet-related environmental impacts.



- *Figure 1. The association between CHEI2016 and dietary environmental impacts of (A) GHGE, (B) TWU, and (C) LU across quartiles of proportion of animal-based food consumption for 10,324 participants derived from the Chinese Health Nutrition Survey 2011.*

- Education level and work-related physical activity level showed a positive association with dietary environmental impacts, and with higher education level and lower physical activity level, the dietary environmental impacts were higher.
- The proportion of animal-based food and dietary environmental impacts were higher for residents with high education level and low physical activity level than for those with low education level and high physical activity level in all five region.



- *Figure 3. The association between CHEI2016 and diet-related (A) GHGE, (B) TWU, and (C) LU in five different regions. Dots represent the individual observation, with different colors for the level of education and physical activity.*

Figure 2A: lowest quartile of the CHEI2016

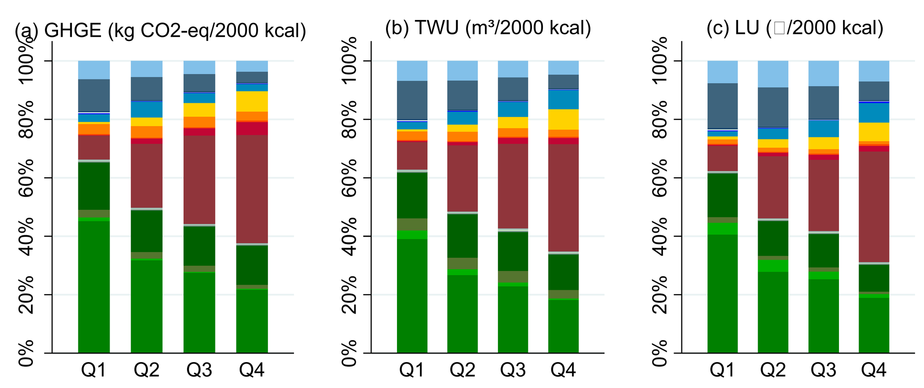
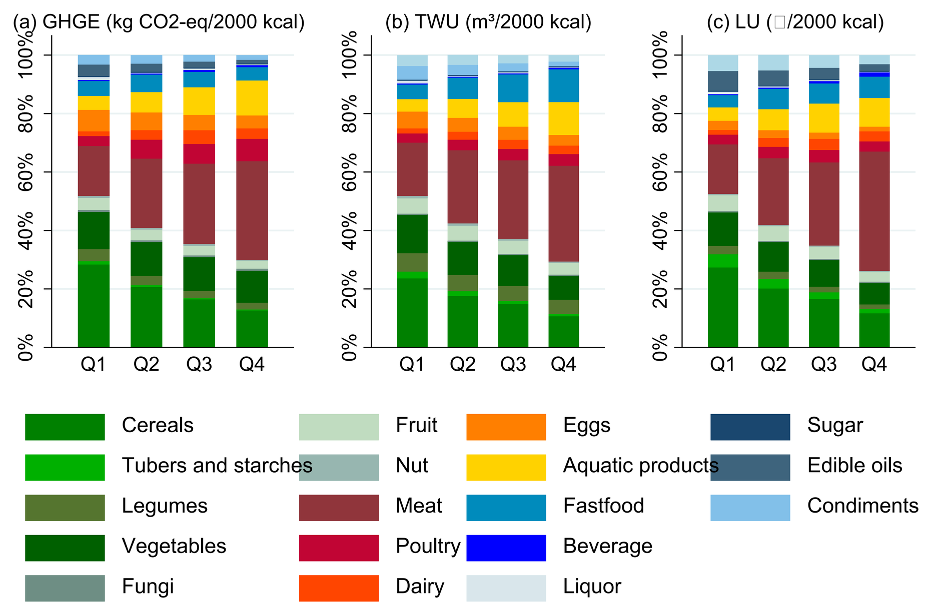


Figure 2B: Highest quartile of CHEI2016



- As shown in Figure 1, the diet-related environmental impacts vary largely at given scores for the total CHEI2016 score.
- The diet group with the highest environmental impacts consumed more vegetables, fruit, meat, poultry, fish and seafood, and dairy products per 2000 kcal compared to lowest environmental impacts diet group.
- Overall, a universal trend of a higher proportion of animal-based foods was found in higher diet-related environmental impacts diets within similar CHEI16 score.

Conclusions

1. Meat overconsumption is not as prevalent in LMICs, whereas consumption of dairy products falls significantly below the recommended level. Increasing the consumption of under-consumed foods, such as dairy products and fruit, partially offsets the environmental benefits of reduced meat consumption.
2. Differences in the diet-related environmental impacts could be explained by differences in the proportion of animal-based food consumption.
3. The Metropolitan areas have the highest dietary environmental impacts compared to the four regions. This is attributed to the proportion of highly-educated residents, a greater prevalence of animal-based foods in dietary patterns, and a larger population with low levels of physical activity.
4. It is advisable to integrate environmental sustainability into the Chinese dietary recommendations, considering the variations in economic and cultural factors across different regions.

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Cai H, Biesbroek S, Chang Z, et al. How do regional and demographic differences in diets affect the health and environmental impact in China?[J]. Food Policy, 2024, 124: 102607.

Cai H, Talsma E F, Chang Z, et al. Aligning health, environment, and cost aspects of diets: Identifying sustainable dietary patterns in China[J]. Environmental Impact Assessment Review, 2024, 106: 107531.

Cai H, Biesbroek S, Wen X, et al. Environmental footprints of Chinese foods and beverages: Literature-based construction of a LCA database[J]. Data in Brief, 2022, 42: 108244.

Chang Z, Cai H, Talsma E F, et al. Assessing the diet quality, environmental impact, and monetary costs of the dietary transition in China (1997–2011): Impact of urbanization[J]. Frontiers in Sustainable Food Systems, 2023, 7: 1111361.

Can Homestead Gardens Improve China rural Households' Vegetable Consumption? Evidence from Three Provinces in China

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Background

In recent decades, there has been a declining trend in vegetable consumption among rural residents in China (see Fig. 1). Each year, an increasing percentage of the population fails to meet the recommended intake of 300 grams of vegetables per adult per day, as suggested by both the Chinese dietary guidelines and the EAT-Lancet report.

Homestead garden is one approach to accomplish this. There are many success cases on homestead gardens for promoting vegetable consumption and nutrition outcomes in developing countries, such as Bangladesh, Cambodia, Nepal, and South. But evidence in China is still scarce. Hence, the effect of homestead garden on promoting households' vegetable consumption was investigated in this study.

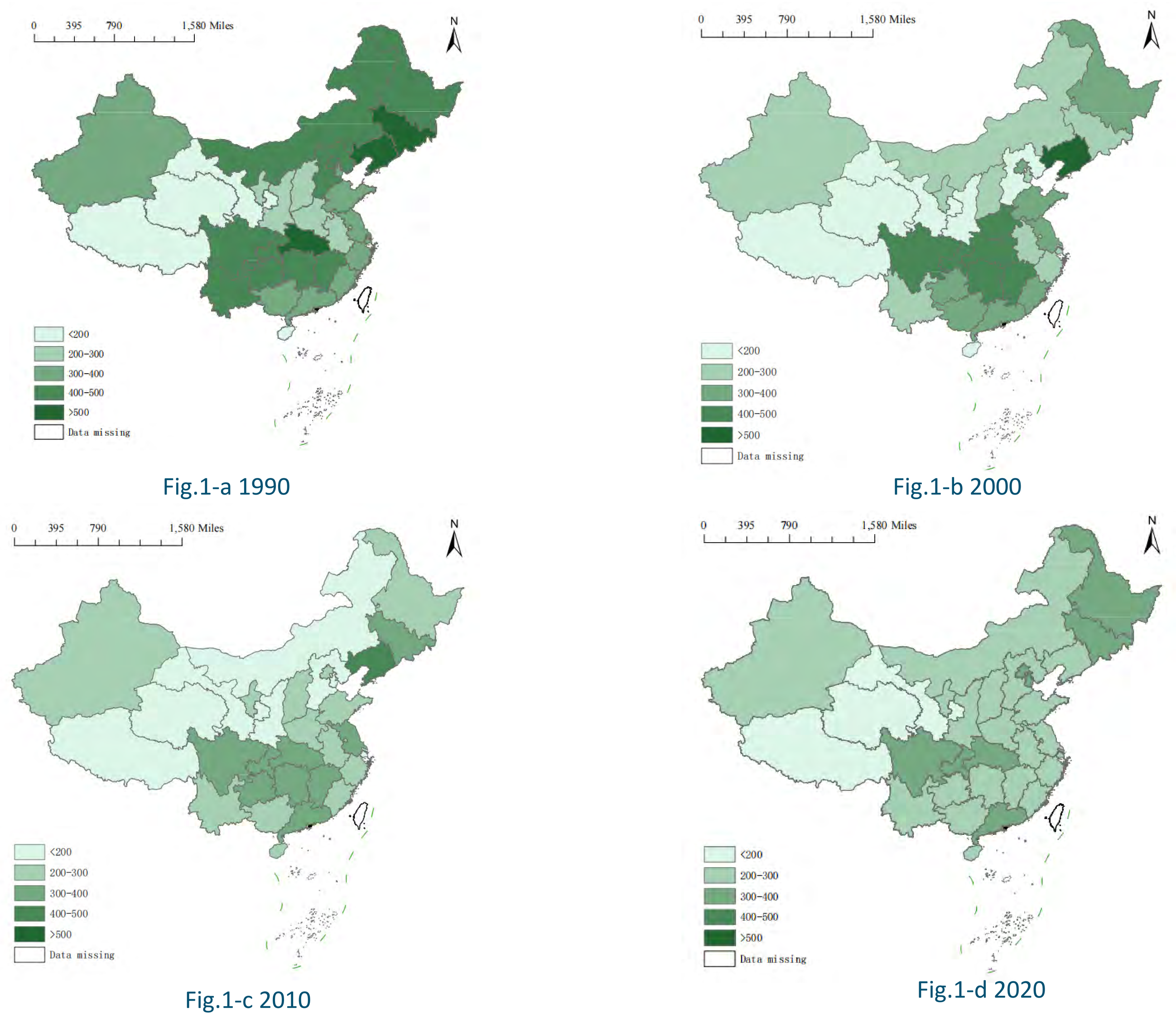

Fig.1 Evolution and Distribution of Vegetable Intake among Chinese Rural Populations
Source: National Bureau of Statistics of China (1990-2020)

Objectives

The goal of this study is to find out whether homestead gardening can affect households' vegetable consumption. Furthermore, we perform additional analyses to examine whether homestead gardening effects on vegetable consumption vary by income level, different species of vegetables, and between households with deficient and adequate vegetable consumption. The heterogeneity analysis may provide useful insights for future national nutrition health improvement initiatives and rural planning.

Data and Methods

Our primary data were collected by China Agricultural University, covering 82 villages in 46 townships in Henan, Shandong and Hebei provinces by using a multistage stratified random sampling approach. We quantified the individual's vegetable consumption by 24-hour dietary recall. Then, we reserved the individuals between the age of 18~65 because the minimum recommended of vegetable consumption (300g/per adult/person) in Chinese Dietary Guidelines is based on adult population. A total of 1073 valid observations were obtained by sorting and eliminating the missing values and outliers.

$$Vegintake_i = a_0 + a_1 \text{ HG}_i + a_2 \text{ X}_i + \varepsilon_i \quad (1)$$

Among them, $Vegintake_i$ is an average household vegetable consumption. HG $_i$ represented homestead gardens. The X $_i$ is a vector of control variables, including household income, demographic characteristics variables and regional levels of variables. ε_i is the error term.

Notably, the variable of HG is endogenous so that we use irrigation conditions and weather disasters as instrument variables by applying 2SLS.

Results

The results show that homestead garden has a positively causal impact on households' vegetable consumption, which is marginally significant. Homestead garden is now causally associated with 31.452g/person/day improvement in households' vegetable consumption. These results reveal potential bias of endogeneity when analyzing the impact of homestead garden on vegetable consumption using simple OLS.

Table 2. Impacts of homestead garden for vegetable consumption

Variables	(1) OLS	(2) OLS	(3) 2SLS
	vegetable consumption	vegetable consumption	vegetable consumption
Homestead garden	52.635***	51.063***	31.452***
	(9.325)	(10.365)	(5.216)
Control variables	No	Yes	Yes
N	1805	1805	1805
R^2	0.169	0.186	0.174

Note: Robust standard errors are presented in parentheses and are clustered at village level; ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively; Column (3) shows the result of second stage of 2SLS.

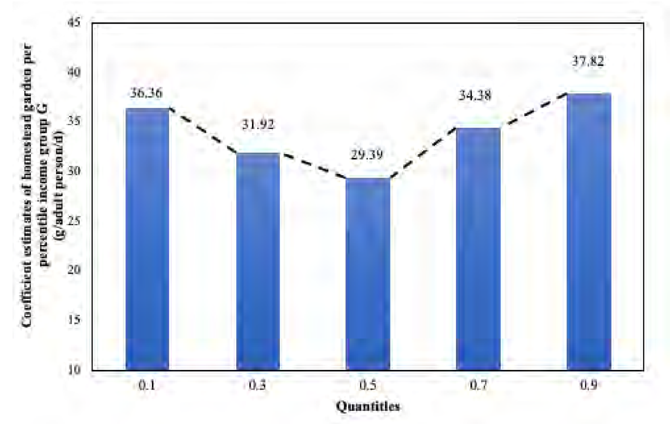

Fig.2 Distribution of vegetable intake of Chinese rural people

To explore the mechanisms of home gardens' impact on vegetable consumption, we investigate how these gardens affect the frequency and variety of vegetable intake in households. Additionally, we examine the heterogeneity of vegetable consumption across different income groups and consumption quantiles

Table 3. Testing the Mechanisms of Home Gardens on Vegetable Consumption

Variables	Mechanism Test 1	Mechanism Test 2	
	Intake Frequency	Dark Vegetables	Light Vegetables
Home Gardens (HG)	0.274***	31.262***	3.628
	-0.091	-9.374	-4.094
Control Variables	Yes	Yes	Yes
Observations	1073	1073	1073

Table 4.Impact of Home Gardens on Vegetable Intake among Rural Residents Based on Unconditional QTEs

	10th	30th	50th
Home Gardens (HG)	20.247***	32.155***	45.124***
(IV_1)	-7.924	-10.174	-13.814
Home Gardens (HG)	18.745***	29.017***	46.221***
(IV_2)	-7.647	-10.46	-14.538
	70th	90th	
Home Gardens (HG)	38.426***	29.848***	
(IV_1)	-12.501	-10.11	
Home Gardens (HG)	36.960***	27.033***	
(IV_2)	-13.166	-9.86	

The mechanism test results reveal that home gardens significantly increase the frequency of daily vegetable intake and the consumption of dark-colored vegetables in households (Table. 3). Quantile regression analysis shows that home gardens have a greater impact on vegetable consumption among groups with median levels of intake. After reaching a peak, the marginal effects begin to diminish (Table.4).

Robustness tests

We further use Propensity Score Matching (PSM) as a robustness check. ATT on homestead garden for vegetable consumption is set as follow.

$$ATT = E(Y_{iT} \mid D_i = 1) - E(Y_{iU} \mid D_i = 0) \quad (2)$$

Where Y_{iT} denotes household per capital vegetable consumption, T and U denote treatment group and control group. D_i denotes whether household has homestead garden.

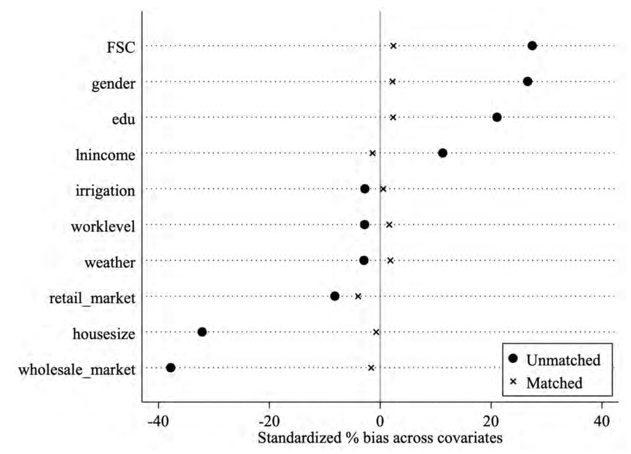

Fig.3 Normalized deviation for PSM (Kernel Matching)

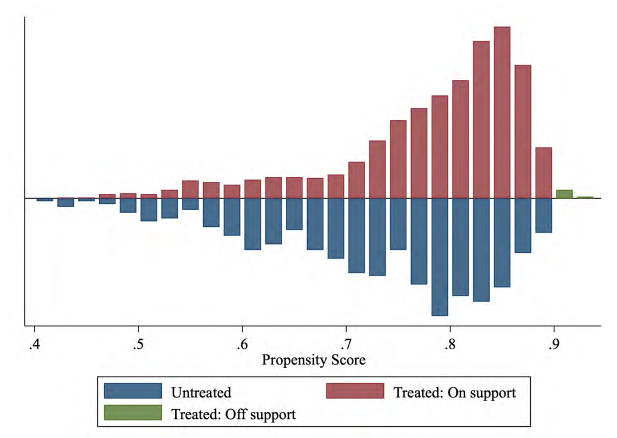

Fig.4 Common support area.

The results shows that the propensity score matched of rural households with homestead gardens consumed more than 31.37 to 35.12 per adult person per day than those who did not cultivate vegetable gardens. The results of the propensity score matching results suggest stability in the finding that homestead gardens significantly contribute to the level of vegetable consumption per capita in rural households.

Conclusions and Policy Implications

Our results indicate a positive causal link between homestead gardening and household vegetable consumption. Homestead gardening improve 31.5g/adult person/day in households' vegetable consumption as compared to those without homestead gardening. The mechanisms by which home gardens influence vegetable consumption include increasing the frequency of intake and the amount of dark-colored vegetables consumed, thereby improving overall vegetable consumption. Heterogeneity analysis indicates that home gardens have a greater impact on groups with median levels of vegetable consumption and more pronounced effects on groups at both ends of the income spectrum.

Our research findings have important policy implications. First, homestead gardening for producing vegetables in Chinese rural households should be taken into consideration in the future when the government designs the new countryside. Leaving a small plot to households may help rural households to produce and consume more vegetables. Second, actively encouraging the cultivation of home-grown vegetables in homestead gardening can provide an important contribution to the transformation to more balanced diets in rural China. Third, the effects of promoting homestead gardening on the when the efforts are focused in particular on the lowest income groups and groups with deficient vegetable consumption levels.

Acknowledgements

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Can a community-based intervention approach support scaling at regional level?

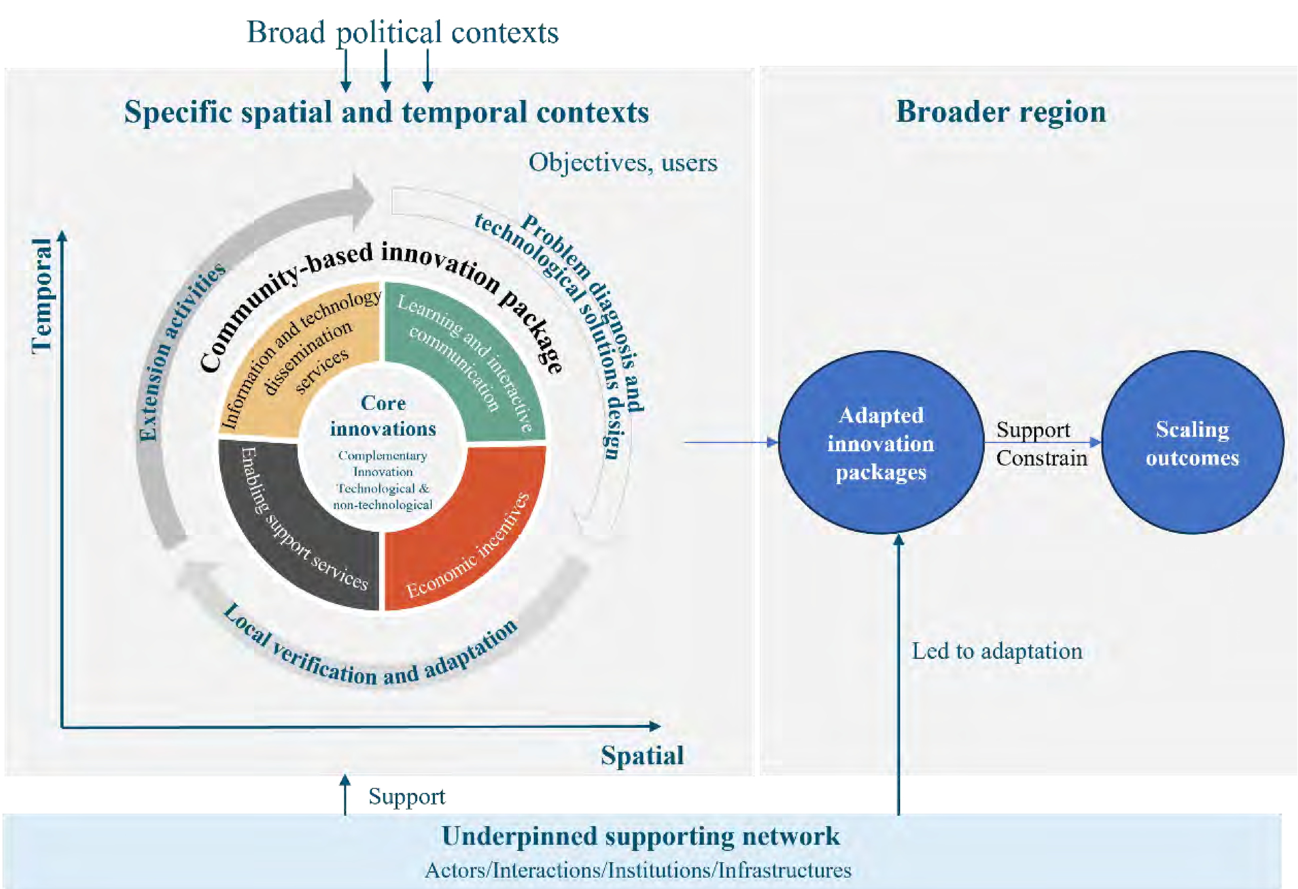
- A case study of Science and Technology Backyards in rural China

Jinghan Li, Nico Heerink, Cees Leeuwis, Weifeng Zhang

Background

- China is undergoing agriculture green development transformation, and the nitrogen (N) fertilizer overuse in wheat is the most severe obstacle for achieving it.
- Promoting site-specific N strategies is a possible way to solve the problems, which requires site-specific knowledge and tailored interventions.
- Science and Technology Backyards is community-based approach, and integrated multiple tools in the village to facilitate innovation.
- STB is localized for one village, and aimed to expanded its impacts from one village to a broad region.
- However, scaling is inherently site-specific, making it challenging to replicate STB's practices in their entirety or achieve the same outcomes even if replication is successful.
- This study aims to explore if and how the STB supports scaling core innovations from a specific community to a regional level, and the possible factors that contribute to or constrain the scaling outcomes.

Conceptual framework

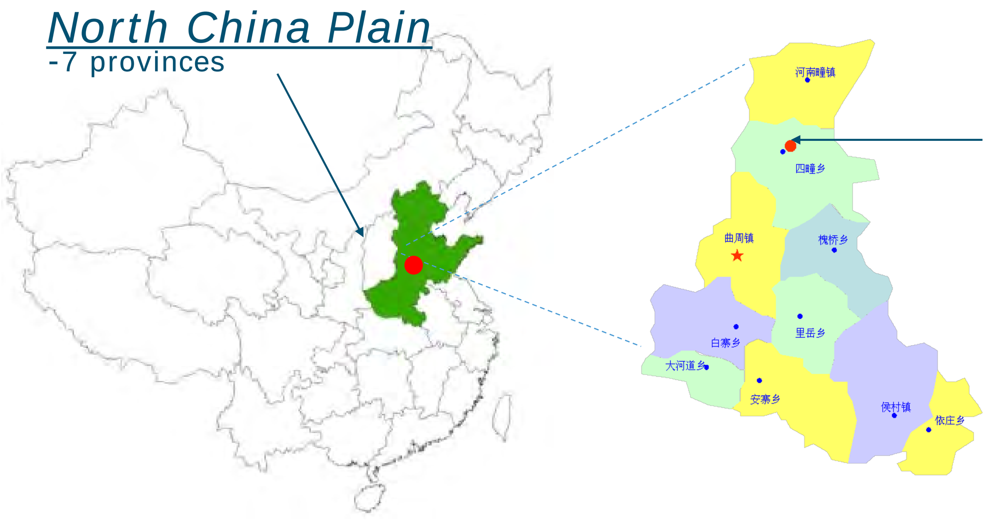


- Scaling can be conceptualized as a continual process of developing innovation packages tailored to specific social contexts, along with the establishment of a robust supporting network to underpin them.
- When scaling out from a community to a broader region, it is likely that adaptation will be made to the localized innovation packages, and this might influence scaling outcomes.

Methods

- Case study (North China Plain, Wangzhuang STB, optimized N efforts during 2016-2021)

North China Plain
-7 provinces



Wangzhuang (WZ) STB and WZ village

- established in February 2011 and continuously operated till now
- One of earliest established STB
- wheat-maize rotation cropping system
- WZ village: 835 farmers, 200 ha arable land area in total

- Combined first-hand and second-hand data
- Applied multiple qualitative analysis approach

(History events analysis, category analysis, comparison analysis, networking mapping)

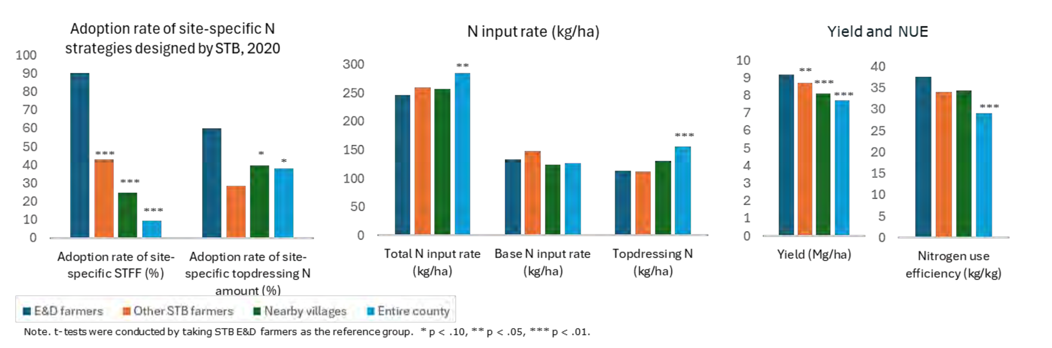
- Compared adoption rate in different groups to show difference in scaling outcomes

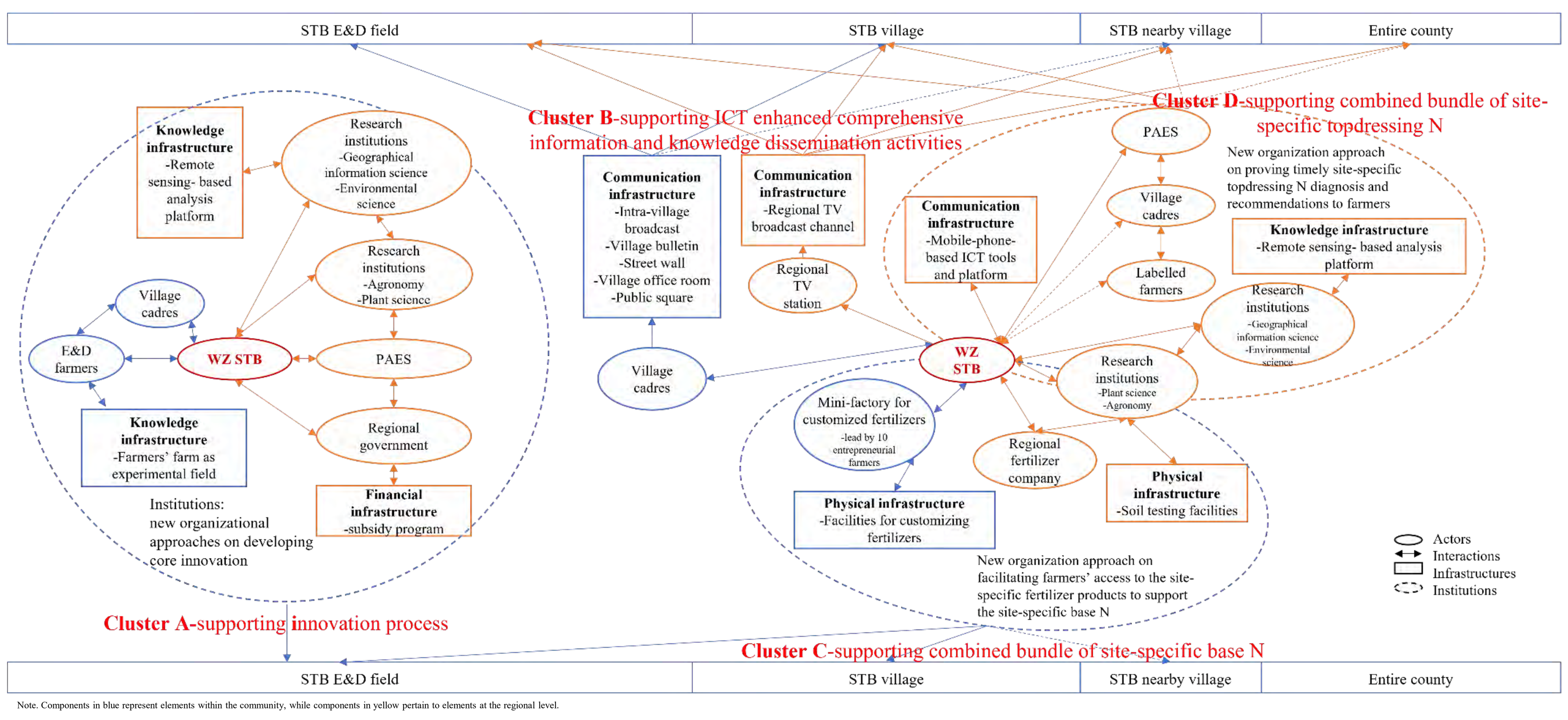
Results

- STB developed an integrated innovation packages to support the site-specific N strategies inside the STB community
- This innovation package is simplified when it scaling beyond the community level.
- As innovation packages have been simplified from STB experimental and demonstration (E&D) farmers to the entire county, the scaling outcomes have also weakened, evident in the decreasing trend of technology adoption rates for STB's optimized nitrogen strategies.
- Further analysis showed that STB community is supported by a well-developed network. In contrast, supporting networks beyond the STB communities weakened, hindering the scaling of innovation packages and ultimately resulting in inefficient scaling outcomes at the regional level.

No.	Elements within the innovation packages	STB village		Beyond STB village	
		E&D[1]	Other	Nearby	Entire county
Core technological innovation					
Site-specific wheat N fertilization recommendations, included 1) applying base N according to the site-specific soil-testing results and 2) topdressing N based on the site-specific wheat population diagnosis results					
Complementary innovations					
• *Problem diagnosis and strategy design process to support the implementation of the site-specific N practices*					
1	Field observation and communication with farmers	green	green	green *	
2	Literature learning	green			
3	Farmers survey or interview	green	green	green	green
4	Joint meeting with multi-stakeholders	green			
• *Local verification process to find out effective diagnosis tools*					
5	**Combined bundle** of on-farm experimentation (OFE)including:				
	-Participatory OFE	green			
	-Adoption subsidy	red			
• *Extension activities*					
6	In-time (online) lecture training	yellow	yellow	yellow	yellow
7	Offseason lecture training	yellow	yellow	yellow	yellow
8	Intensive lecture training through night school, farmer field school, and web-course	yellow	yellow	yellow	yellow
9	Long-lasting technology poster	yellow	yellow		
10	Timely reminder through intra-village broadcast system, and ICT tools	yellow	yellow	yellow	yellow
11	Regular on-site observation and persuasion	yellow	yellow		
12	Timely (online) consultancy service	yellow	yellow	yellow	yellow
13	Field demonstration session	yellow	yellow	yellow #	yellow #
14	**Combined bundle** of site-specific base N, including:				
	-Joint meeting with multi-stakeholders	green			
	-Interactive communication during the process	green	green	green	
	-A fertilizer custom mini-factory	blue	blue	blue	
	-Machine for customizing fertilizer	blue	blue	blue	
	-Soil-testing facilities and approaches	blue	blue	blue	
	-Site-specific customized soil testing and formula fertilizer	blue	blue	blue	
	-Free soil-testing services	orange	orange	orange	
	-Credit payment services	red	red	red	
15	**Combined bundle** of site-specific topdressing N, including				
	-Joint-meeting with multi-stakeholders	green			
	-Interactive communication during the process	green	green	green	green
	-Remote-sensing based wheat population diagnosis approach	blue	blue	blue ^	blue ^
	-Free wheat population diagnosis services	orange	orange	orange ^	orange ^
	-Plot GPS labelling services	orange	orange	orange ^	orange ^
	-Smart-phone based plot GPS labelling applications	blue	blue	blue ^	blue ^
	-ICT tools, including We-chat group, web-course, short text messages, live broadcast, TV channel broadcast.	blue	blue	blue ^	blue ^
	-Timely reminder through ICT tools	yellow	yellow	yellow ^	yellow ^
	-In-time online and offline lecture training	yellow	yellow	yellow ^	yellow ^

(blue) Technological elements
Non-technological elements
(green) Participatory learning and interactive communication
(yellow) Linear information and knowledge dissemination activities
(orange) Enabling support services
(red) Economic incentives





Conclusions

- STB **could support** the scaling of core innovation **inside the community** by developing complementary innovation packages, and these well-developed innovation packages were supported by an adapted internal networks and well-connected external networks, which finally led to effective scaling outcomes inside the STB community.
- However, the complementary innovation packages were simplified at regional level, which is associated with the weaken supporting network for non-STB villages. These **simplified innovation packages and weaken supporting networks** was further linked with the **ineffective scaling outcomes at regional level**.
- The absence of **effective interaction networks and robust intermediation actors** at non-STB communities, and **formal institutions at the regional level** further led to the weakened supporting networks at regional level.

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Comments and suggestions welcome! Contact: Jinghan.li@wur.nl

Enhancing straw-burning governance by multi-stakeholder collaboration: A case study from Northeast China

Zhiwei Yu, Fan Li*, Wei Si, Weifeng Zhang

Background

Straw burning, a widespread practice in developing countries, not only squanders valuable natural resources but also exacerbates air pollution. Existing studies have sufficiently demonstrated that the prevalence of straw burning in developing countries is due to the lack of effective enforcement of regulation. However, there exists a significant knowledge gap regarding viable management strategies to mitigate OSB and promote regulation enforcement in developing countries.

Objectives

This paper employs the straw-burning management reform (SBMR) in Heilongjiang Province, located in Northeast China, as a case study to explore viable management strategies for reducing straw burning. We utilized a mixed approach of qualitative and quantitative methods to scrutinize both the governance structure and effects of this reform.

Methods

(1) Qualitative analysis

There are three policy documents about the SBMR. We summarized the governance structure based on these three documents through the following steps: (1) Identifying the stakeholders mentioned in the documents. (2) Categorizing the identified stakeholders into the state, market, and community sectors. (3) Identifying the rules within the documents that either incentivize or penalize stakeholders. (4) Classifying these rules into hierarchy and market modes based on their nature.

(2) Quantitative analysis

We collected macro- and micro-level data to analyze temporal changes before and after the intervention of the SBMR. Regarding the macro levels, we collected satellite-based OSB spots in Heilongjiang from 2015 to 2019. The data for satellite-based OSB numbers is from NASA's website. Concerning the micro-level data, we conducted a two-wave household survey in Heilongjiang in July 2018 (before the SBMR) and July 2019 (after the SBMR). We inquired about farmers' straw utilization practices, their perceptions of the penalties associated with straw burning, and their perceptions of the availability of machinery for straw utilization.

Results

(1) The governance structure of the reform

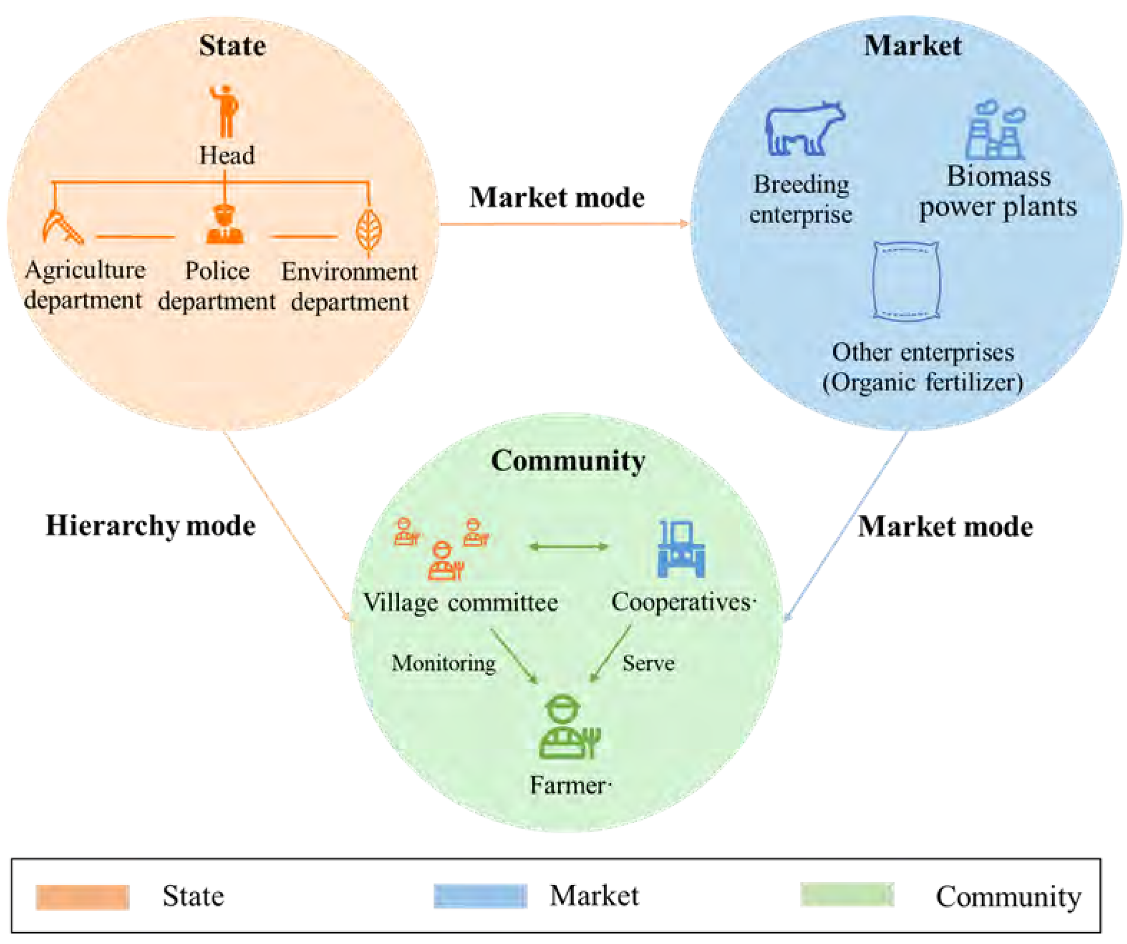

Figure 1. The governance structure of the SBMR

(2) The governance effect of the reform

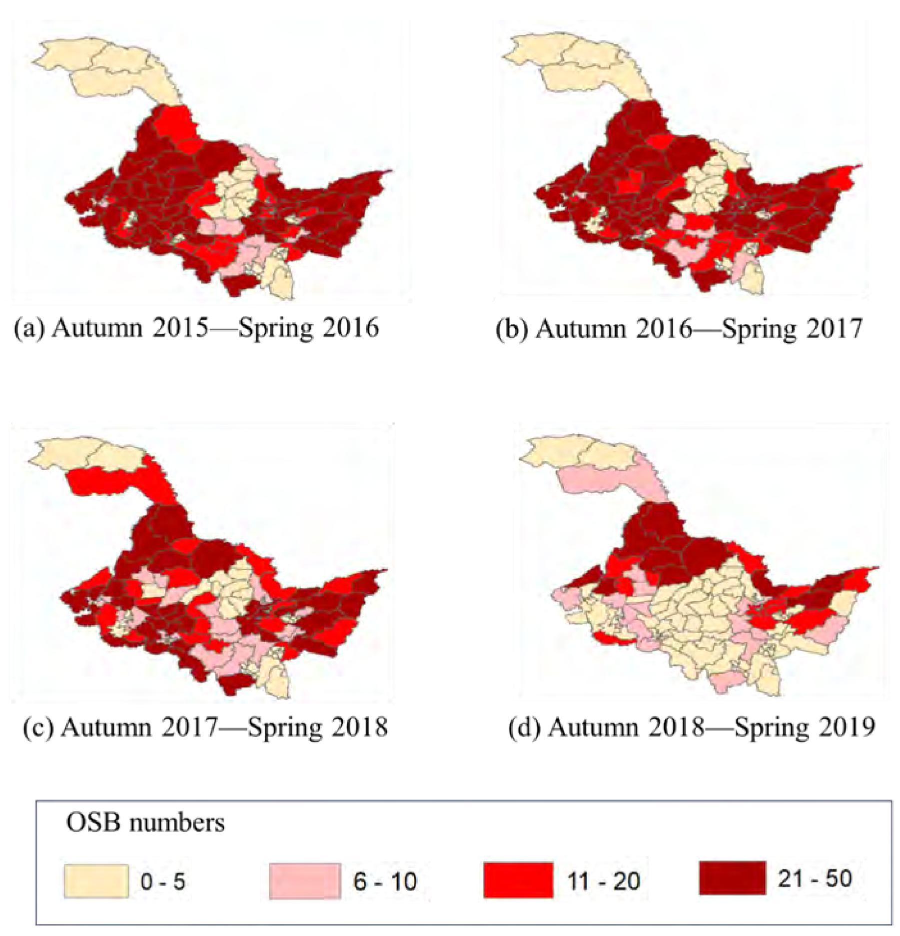

Figure 2. Spatial and temporal changes in straw-burning spots in Heilongjiang

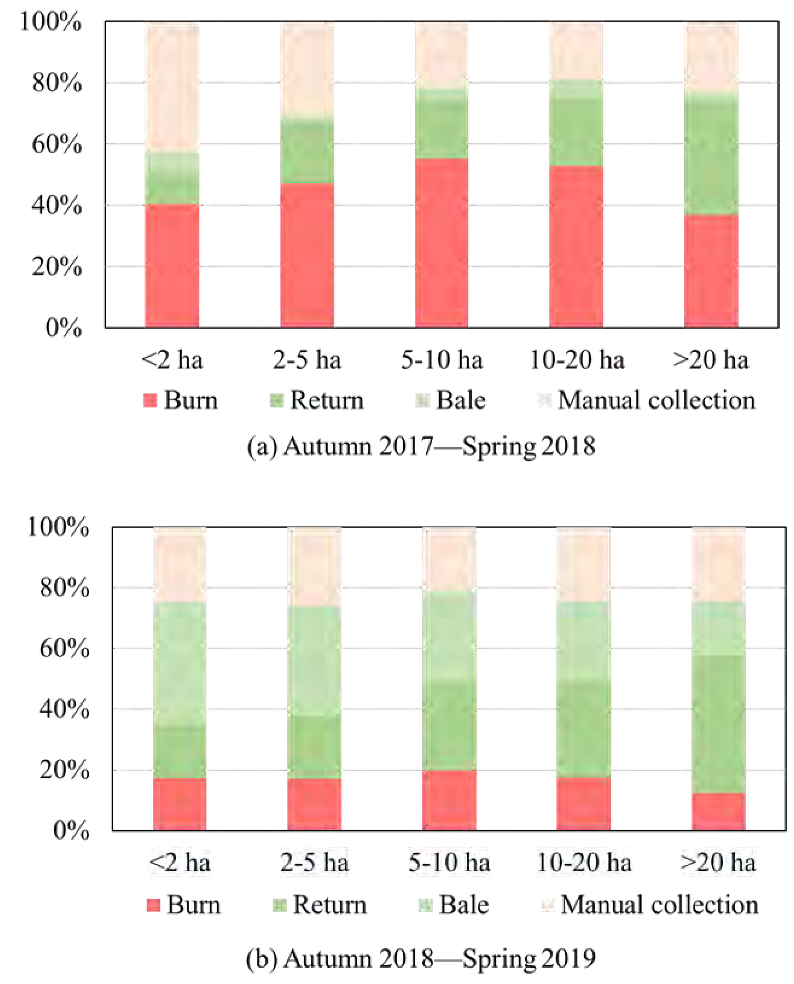

Figure 3. Temporal changes in farmers' strategies regarding straw disposal

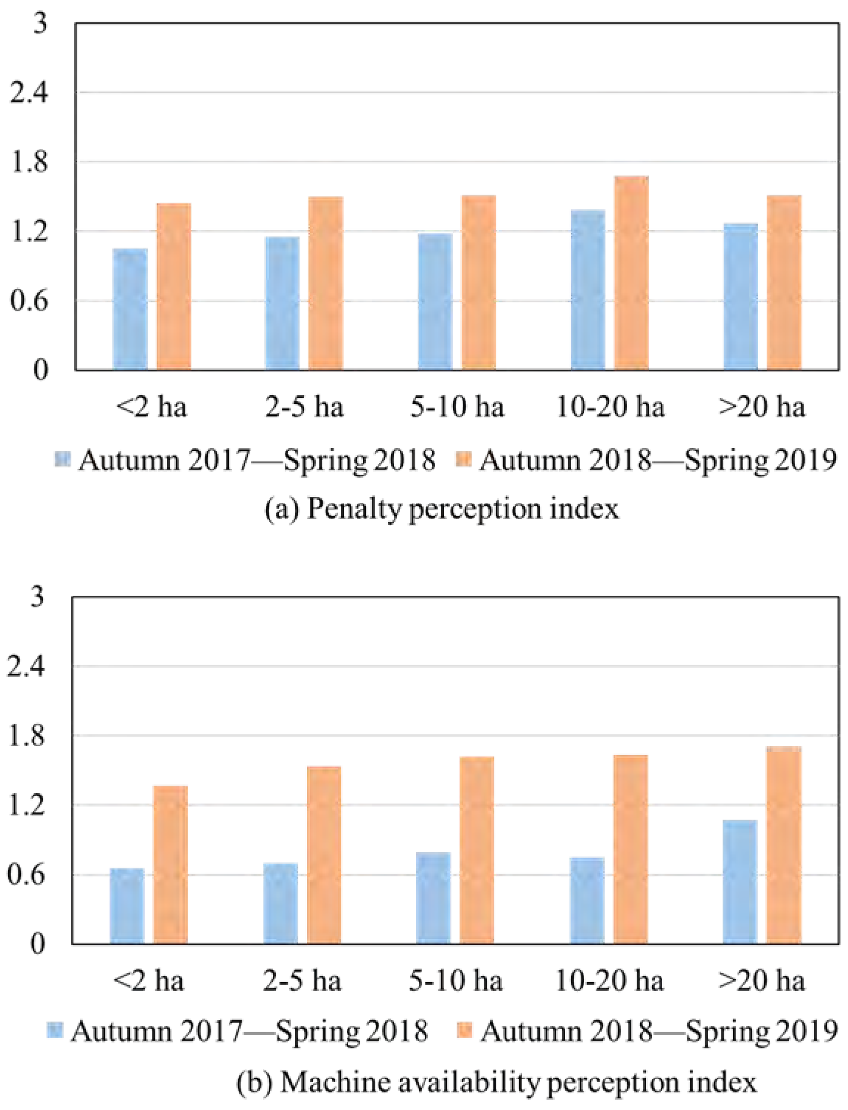

Figure 4. Temporal changes in the institutional environment

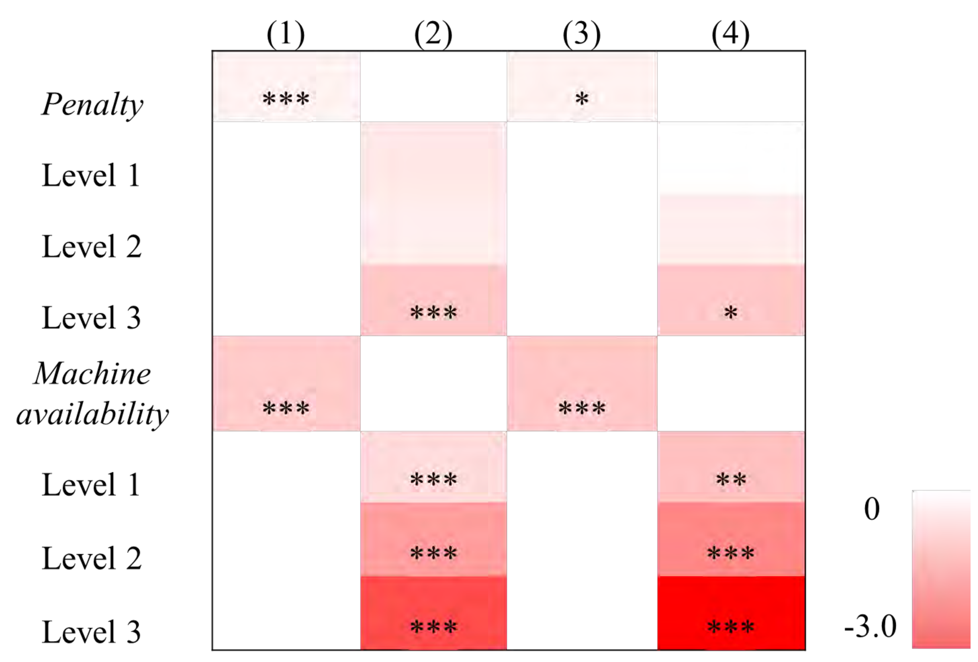

Figure 5. Estimated impact of institutional environmental on farmers' engagement in straw burning

Conclusions

Our findings reveal that the governance structure of the reform exhibits three distinct characteristics. First, the stakeholders involved in the reform extend beyond a single sector, encompassing participants from the state, the straw-utilization market, and the farmers' community. Second, these stakeholders' collaboration was facilitated by a hybrid governance mode that combined hierarchy and market modes. Third, the farmers' community, comprising village communities and cooperatives, acts as the intermediary linking farmers with both the state and the straw-utilization market. Regarding governance effects, the reform notably promoted a shift towards sustainable straw utilization practices among farmers. This shift was spurred by enhancements in the farmers' institutional environment created by the governance structure, manifesting in intensified penalties and increased access to straw-utilization machines.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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The sustainability of livestock system can be improved through livestock reallocation

Reporter ：Guichao Dai Supervisors : Yong Hou, Oene Oenema, Fusuo Zhang, Xueqin Zhu

Background

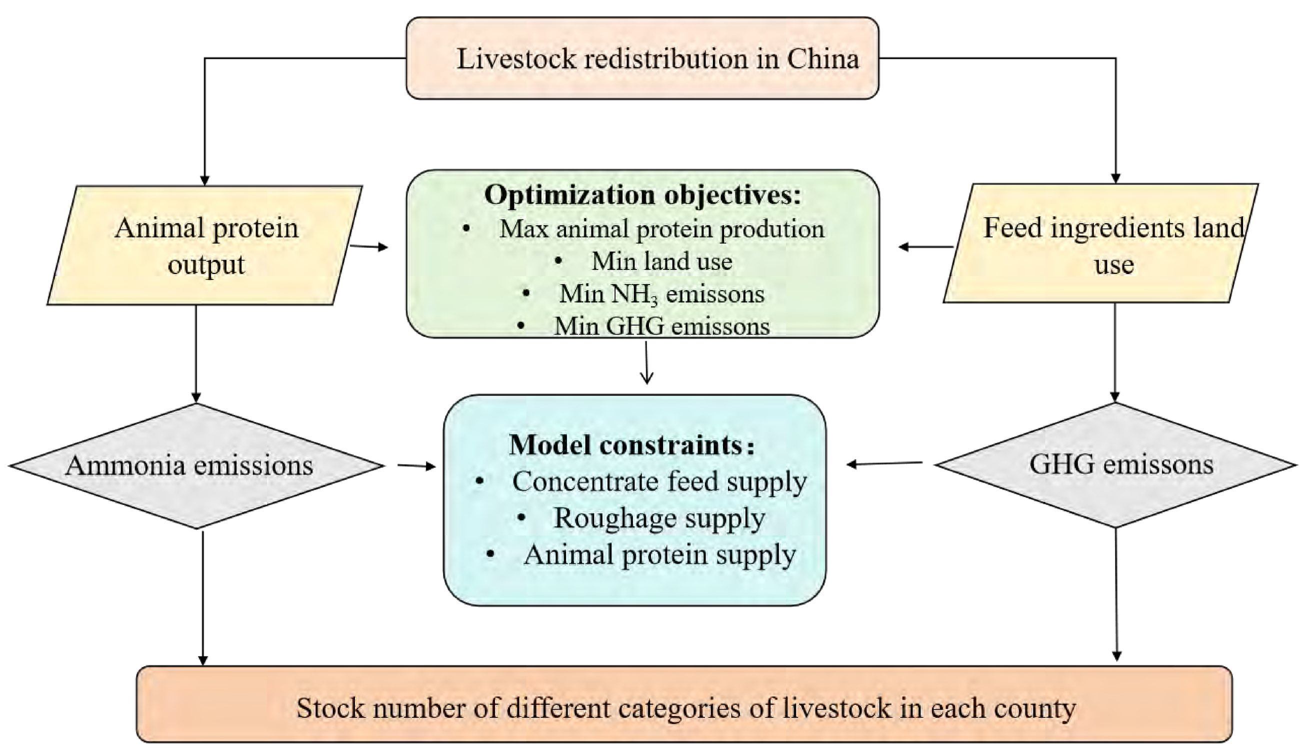
- Demand for animal products will increase further in China in the future.
- Animal production creates severe environmental stress.
- Mismatches between current crop nutrient requirements and livestock excretions
- There are differences in feed conversion rates, ammonia emission footprints, and GHG footprints between livestock categories.

Objectives

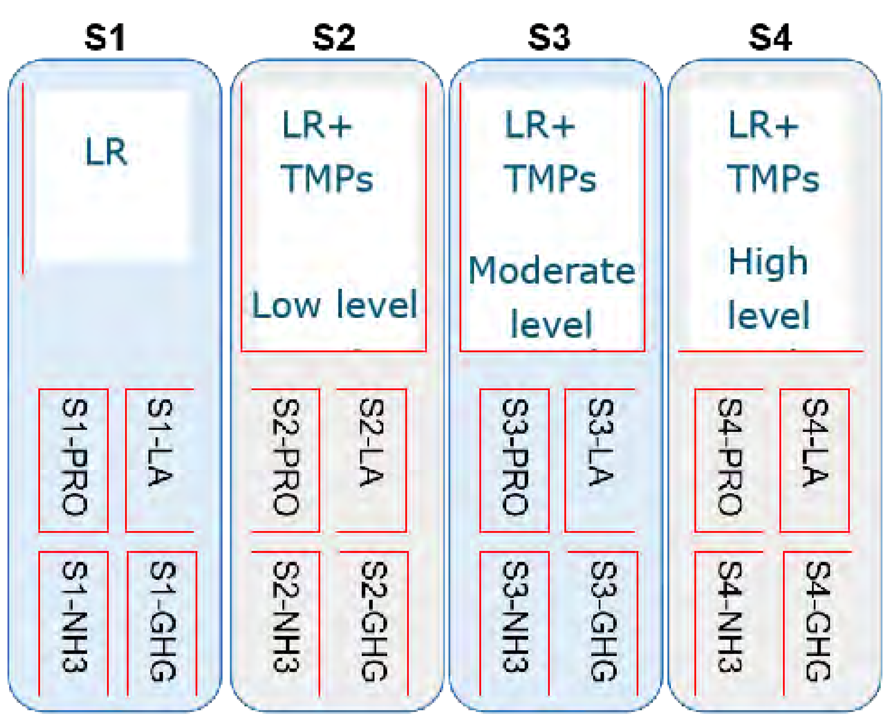
- Exploring the effects of livestock reallocation on animal protein output, feed crop land use area, ammonia emissions, and GHG emissions.
- Investigating synergies between livestock redistribution and technical management practices.
- Exploring the trade-offs between animal protein output and environmental emissions.

Methods

- Linear optimization model



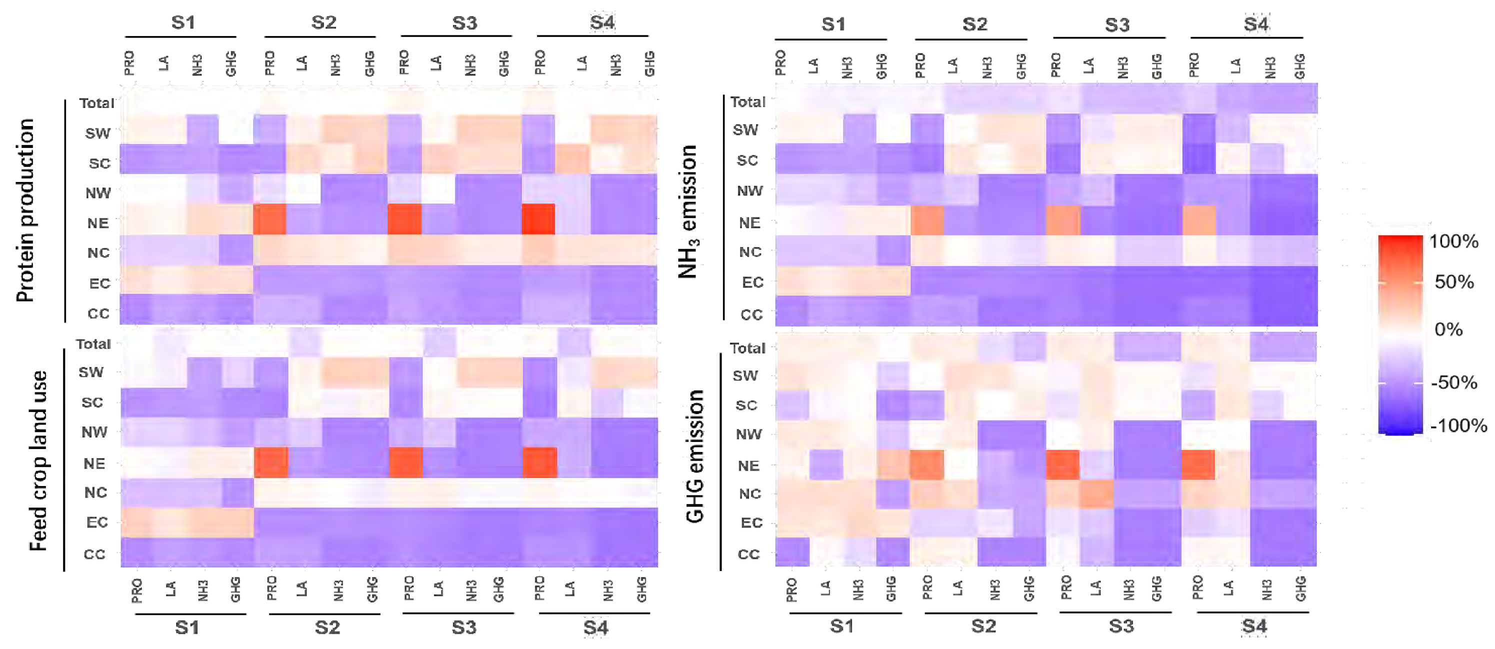
- Scenario analysis



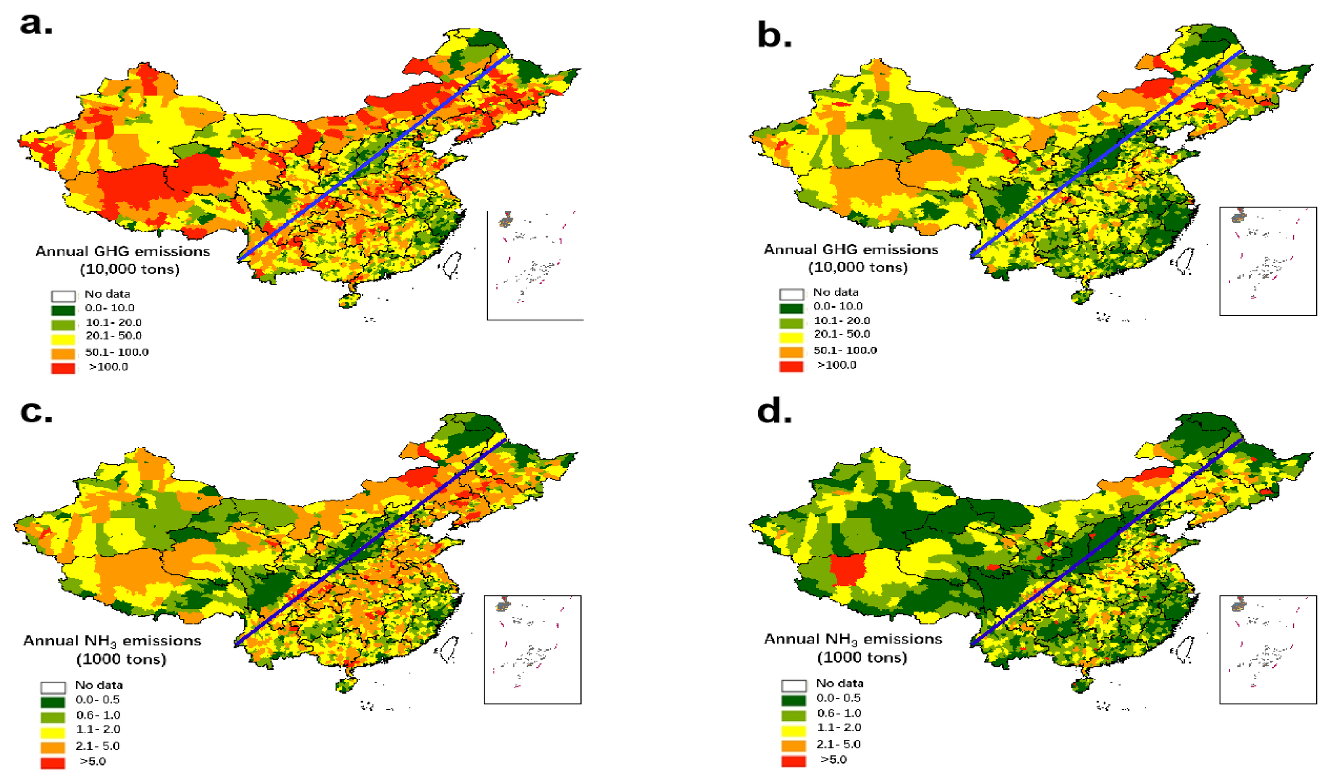
PRO- Max protein prodution LA- Min cropland use
NH3- Min NH_3 emissons GHG- Min GHG emissions

Results

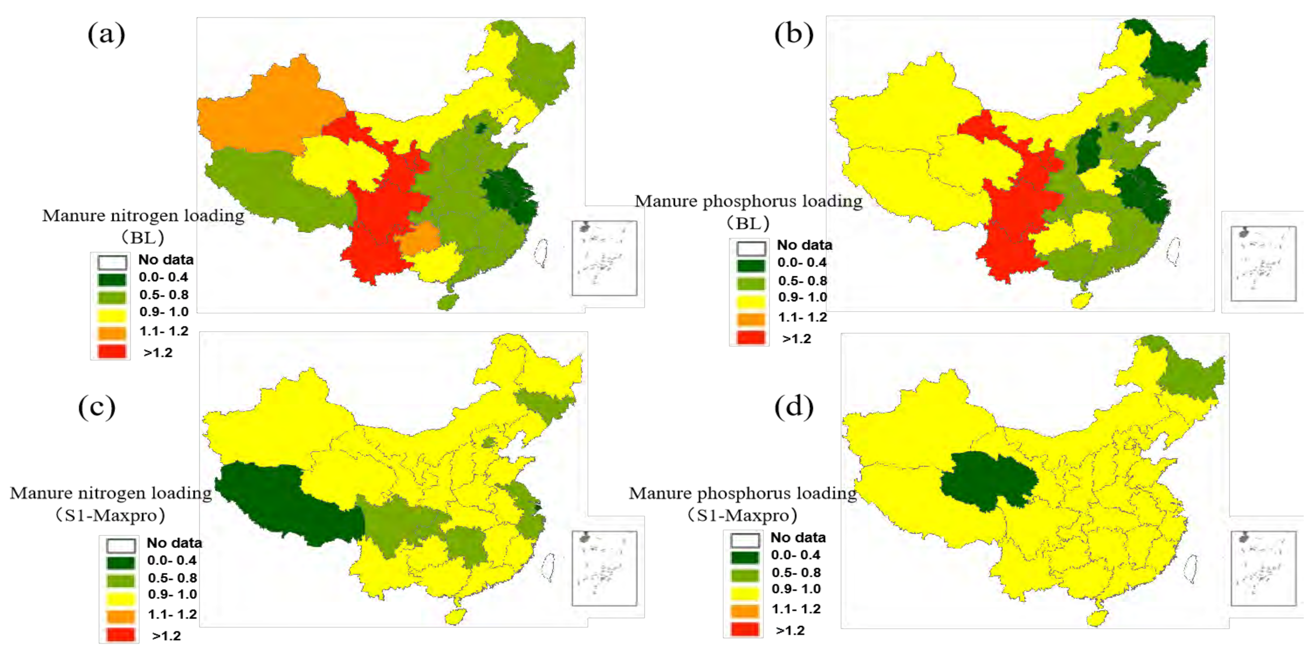
- Result 1：Impact on animal protein, feed land use, ammonia and GHG emissions



- Result 2：Impact on ammonia and GHG emission intensity



- Result 3：Impact on manure loading status



Conclusions

- Combining livestock reallocation and TMPs can increase animal protein output by 7%-25%, reduce land use for feed crops by 9%-24%, ammonia emissions by 6%-41%, and GHG emissions by 1%-38%.
- Livestock redistribution can reduce ammonia and GHG emission intensity and address the problem of manure surpluses in China.
- There are trade-offs between animal protein output and feed land use, ammonia and GHG emissions.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Quantifying protein digestion kinetics of feed ingredients using a modified in vitro incubation assay

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[2]State Key Laboratory of Animal Nutrition, College of Animal Science and Technology, China Agricultural University, Beijing, China

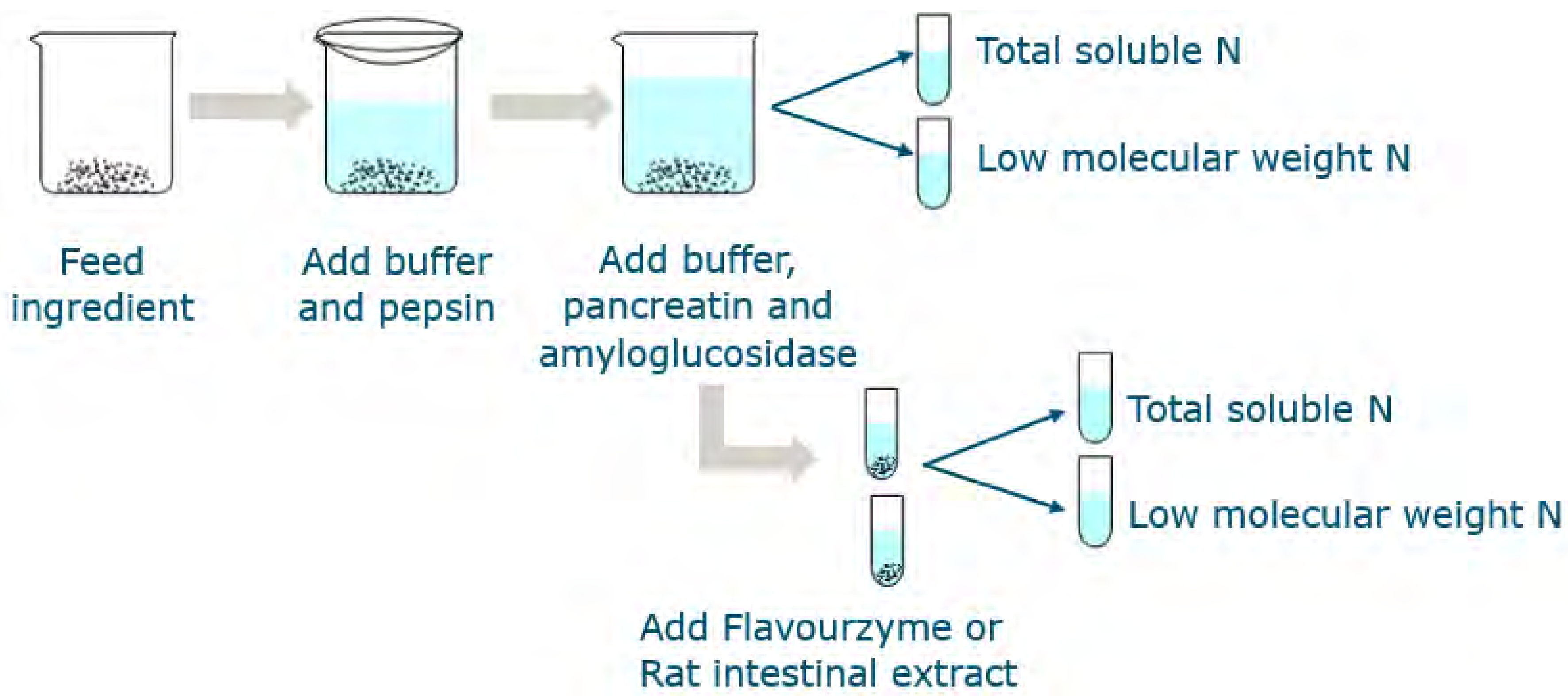
Background

Total tract and ileal digestibility values are commonly used to predict nutritional values of feed ingredients (CVB, 2021; MAFIC, 2020; NRC, 2012). For amino acids, standardized ileal digestibility values refer to the extent of digestion at the end of the small intestine and do not reflect the kinetics of absorption in the small intestine. The kinetics of absorption is related with hydrolysis and solubilization kinetics. In feed evaluation, measuring the kinetics of nutrient solubilization and break down is crucial for accurate predictions of nutrient absorption and the nutritional value of feed ingredients.

Objectives

The aim of the current study was to quantify the kinetics of N solubilization and low molecular weight N (LMWN) appearance for feed ingredients varying in protein concentration and digestibility, using a modified Boisen-based in vitro model.

Methods



The amount of N subjected to in vitro incubation was standardized (~0.48 g) among selected feed ingredients (rapeseed meal (RSM), fishmeal, barley and peas). In the beginning of stomach incubation with pepsin, pH was set at 4 and then adjusted to 2 after 90 min, followed by a further 90 min of incubation. Subsequently, pH was adjusted to 6.8, and after 15 min pancreatin and amyloglucosidase were added to simulate small intestinal digestion for 240 min. Total solubilized nitrogen (TSN) and low molecular weight nitrogen (LMWN) were measured at several time points (0, 10, 20, 30, 60, 90, 100, 180, 195, 215, 435 min) during incubation. Flavourzyme (FL) or intestinal acetone powders from rat (IAPR) were added for extra one hour incubation following small intestine incubation to simulate brush-border enzymes activity.

Results

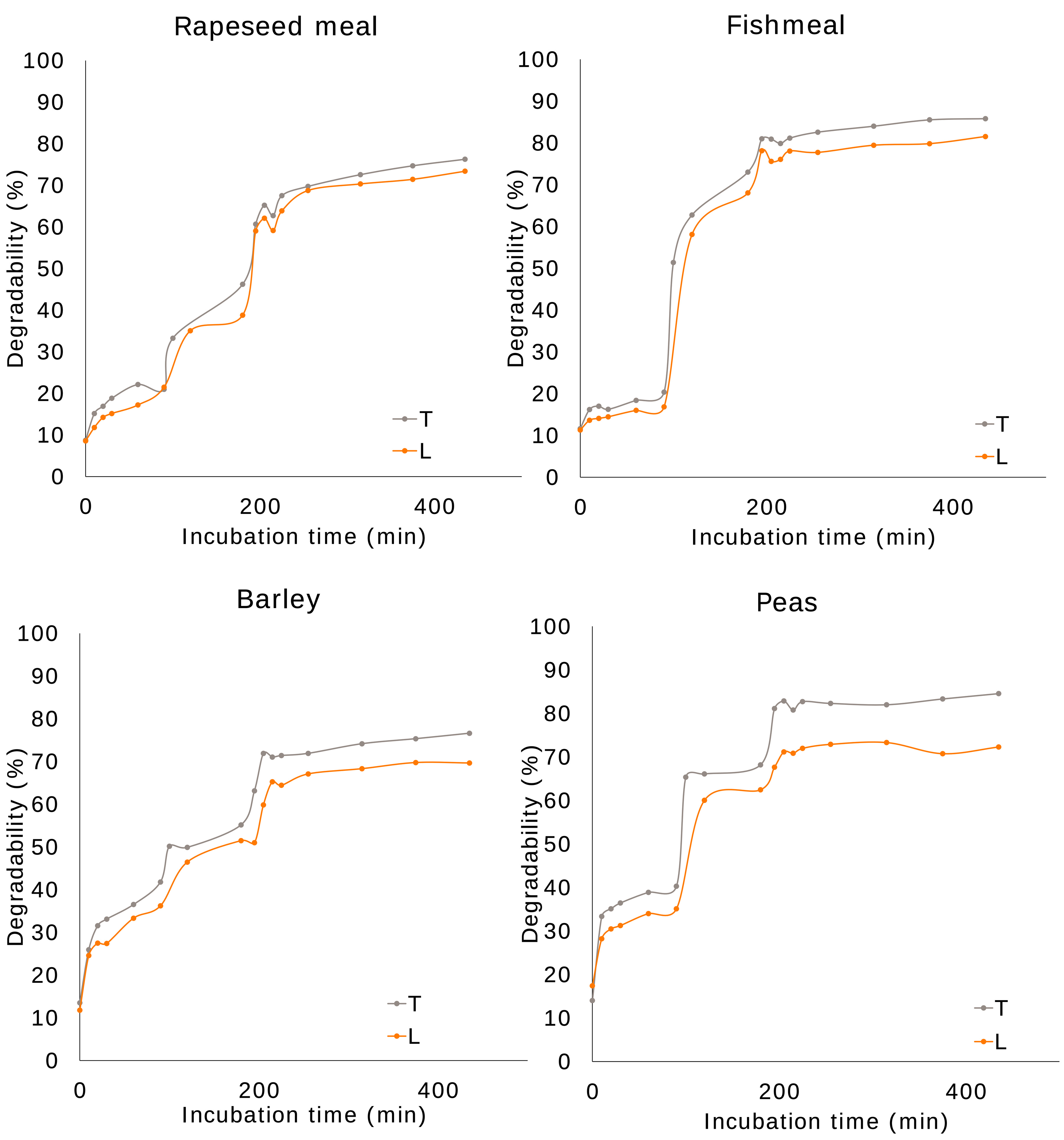


Figure The kinetics of N solubilization (T) and low molecular weight N appearance (L) for rapeseed meal, fishmeal, barley, and peas during a three-step enzymatic in vitro incubation conducted in replicate (n=2).

Conclusions

1. The majority N in the selected feed ingredients was solubilized and hydrolyzed during the stomach incubation.
2. The appearance of LMWN followed a similar pattern to N solubilization kinetics.
3. The higher amount of LMWN from fishmeal and peas appeared during the early stage of small intestine incubation, potentially leading to quicker absorption in the small intestine compared to RSM and barley.
4. Our modified in vitro assay allowed to quantify rate and extent of N solubilization and LMWN appearance of feed ingredients varying in protein content and digestibility, reflecting variation in protein characteristics.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Lactation body condition loss impaired conceptus development at day 8 post-ovulation in primiparous sows

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Background

Modern hybrid sows often mobilize body tissue to sustain high milk production for their large litters. This applies particularly to primiparous sows, since their voluntary feed intake is lower than multiparous sows. A high body condition loss during lactation can negatively affect milk production during the on-going lactation and sow subsequent reproductive performance

With modern sows developing into a leaner genotype that has less fat reserves, body protein mobilization has even more severe effects on reproductive performance than fat tissue loss. Hence, improving the availability of dietary amino acid for milk synthesis is critical to minimise sow body protein tissue mobilisation during lactation.

Objectives

In this study, we aimed to investigate effects of dietary amino acid availability on litter weight gain and body condition losses in primiparous sows, including body fat and protein tissue loss, and how the changes in body conditions affect conceptus survival and development and luteal functioning up to Day 8 post-ovulation.

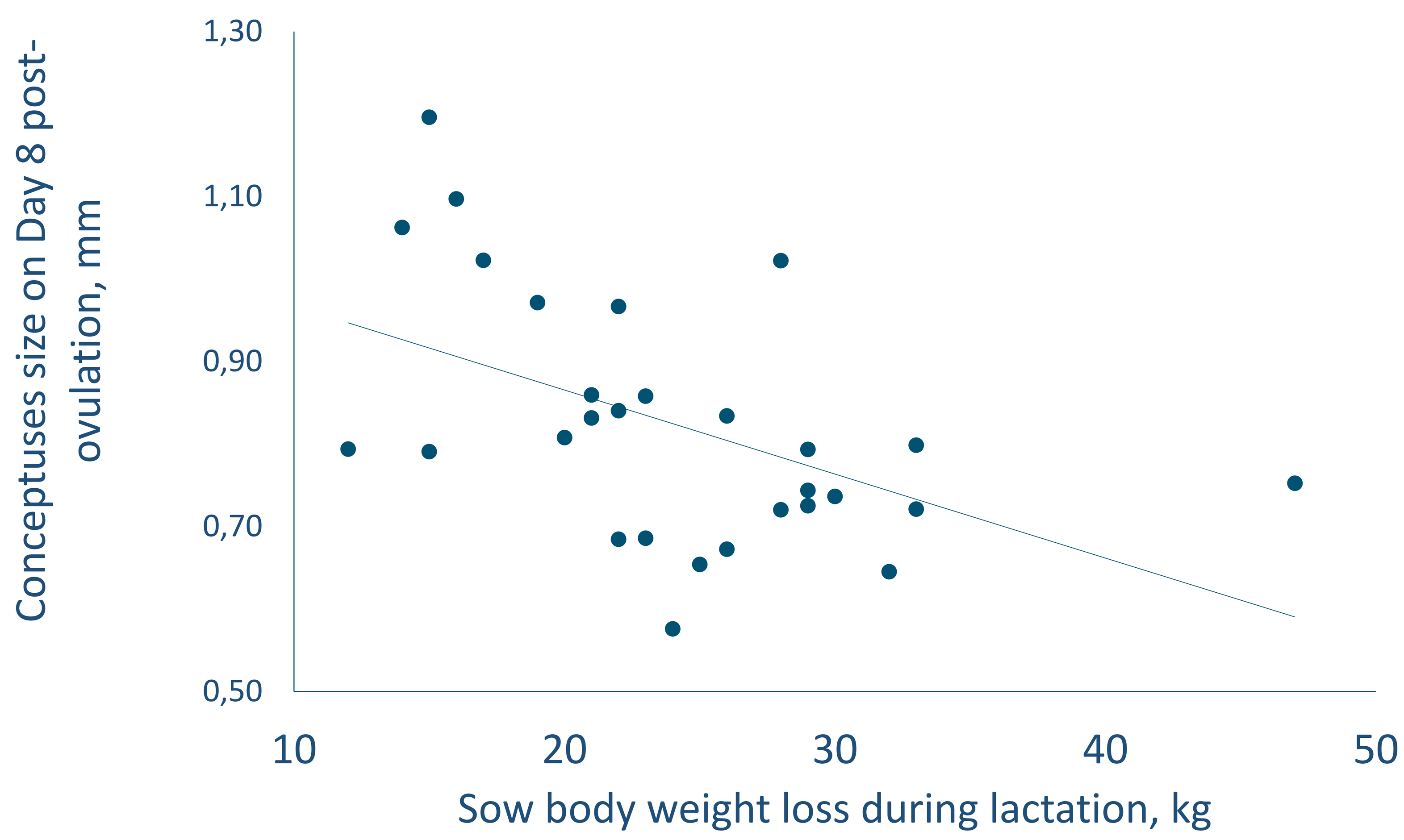
Methods

- A total of 35 primiparous sows of a Yorkshire × Landrace genetic line (Hypor Libra, Hendrix Genetics, Boxmeer, the Netherlands) were used in this study.
- sows were allocated to one of two lactation diets: low CP (140 g/kg) with a low percentage (8%) of slow protein in total protein (LL) or high CP (180 g/kg) with a high (16%) percentage of slow protein (HH).
- At farrowing and weaning (Day 21): sow body weight, backfat and loin muscle thicknesses at the last rib by ultrasound, and litter weight.
- Day 14 post-farrowing: Blood sampling before and after morning feeding for: plasma urea, creatinine, NEFA and IGF-1.
- After weaning: ultrasound was used to assess diameters of the five largest follicles on the ovaries (day 3) and at 12h intervals to assess ovulation time.
- Day 8 post-ovulation, 31 sows were euthanised. Number of corpora lutea on the ovary were counted (ovulation rate) and embryos were counted and evaluated.

Figure 1. Measurements of backfat and loin muscle thickness using ultrasound (Aquilla, Easote, Genova, Italy)(A). Ultrasound image of follicles post-weaning (B). The longest diameter and the diameter perpendicular to the longest diameter of the conceptus were measured using microscope (C).

Results

- A high dietary amino acid availability tended to increase litter weight gain during week 3 of lactation, but did not affect sow body condition loss or subsequent reproductive parameters.
- A high body weight loss during lactation led to a lower plasma IGF-1 concentration on Day 14 post-farrowing.
- The mean diameter of the five largest follicle on Day 3 post-weaning and conceptus on Day-8 post-ovulation was positively related to body weight on Day 1 and Day 21 post-farrowing.
- The mean diameter of the conceptus on Day 8 post-ovulation was negatively related to higher body weight loss ($\beta = -0.01$ mm · kg^{-1}, $P < 0.01$), higher estimated body protein loss ($\beta = -0.06$ mm · kg-1, $P = 0.02$), and higher estimated body fat loss ($\beta = -0.02$ mm · kg^{-1}, $P = 0.04$) during lactation



- Plasma progesterone concentration on Day-8 post-ovulation was negatively related to loin muscle loss (-0.67 mg/ml · mm^{-1}), backfat loss (-2.33 mg/ml · mm^{-1}), and estimated body fat loss (-1.32 mg/ml · mm^{-1}).

Conclusions

- Dietary CP concentration and protein digestion kinetics did not affect primiparous sows body weight loss during lactation.
- A higher body condition loss negatively affected sow plasma IGF-1 concentration during lactation.
- A higher body condition loss negatively affected conceptus size and plasma progesterone on Day 8 post-ovulation.
- A higher body condition loss relates to a lower plasma P4 at Day 8 post-ovulation.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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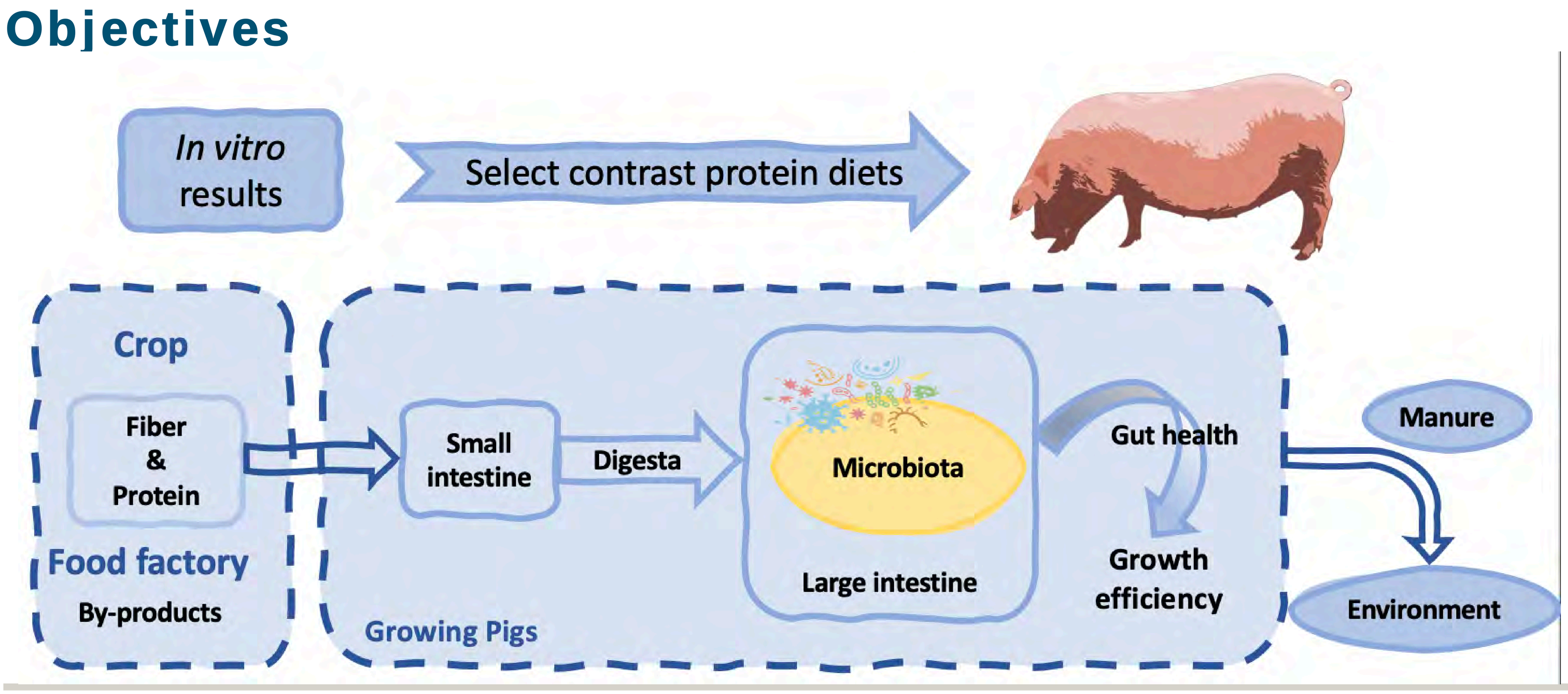
In vitro fermentation characteristics of different protein sources in the hindgut of growing pigs and human

PhD candidate: Hanlu Zhang
Supervisors: Junjun Wang, Defa Li, Wouter Hendriks, John Cone, Nikkie van der Wielen, Arie Kies

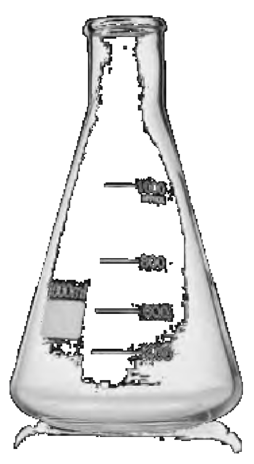
Background

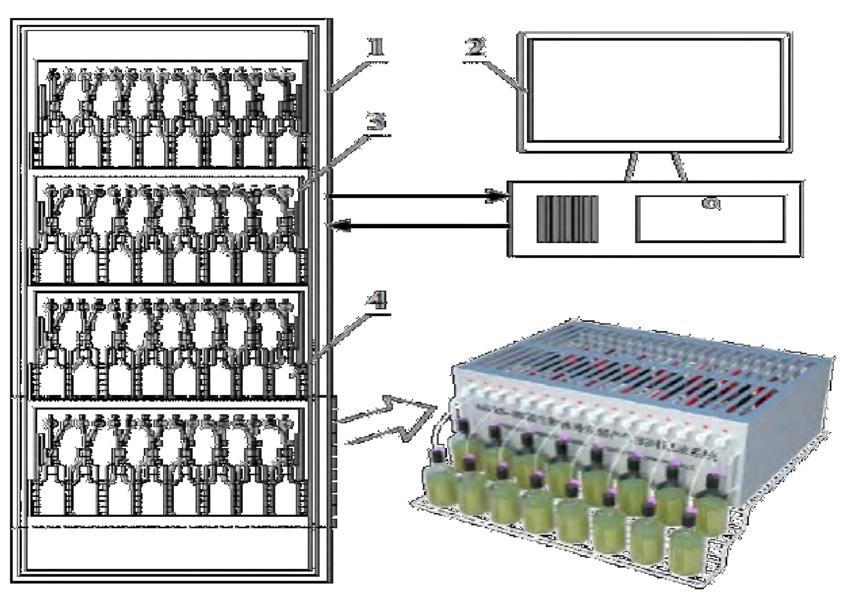
- Pig industry:
  - *Key consumer of natural protein sources; Competition of human food; High input pressure*
  - *N excretion causes environment pollution*
- Largely undeveloped unconventional feed
  - *Also causing pollution*
- *Hindgut fermentation of protein impair animal health*

Objectives



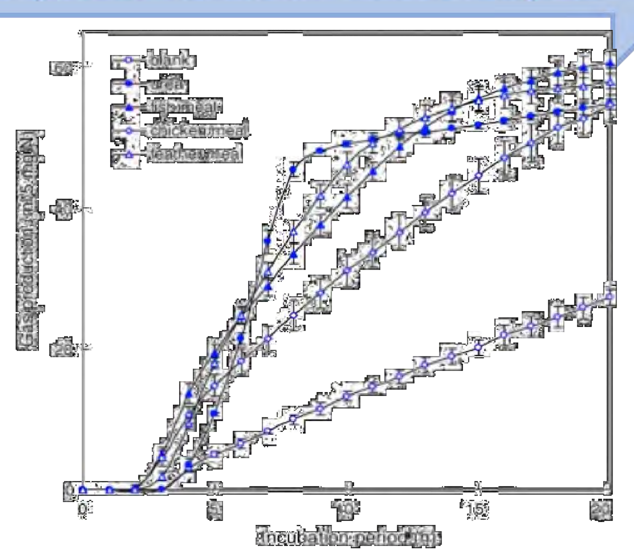
Methods





Pre-digested protein sources & Ileal digesta

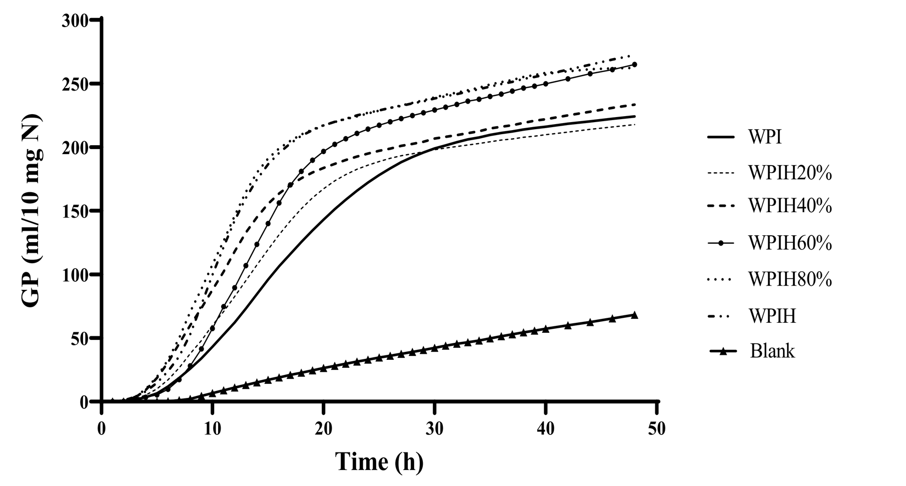
In vitro gas production technique

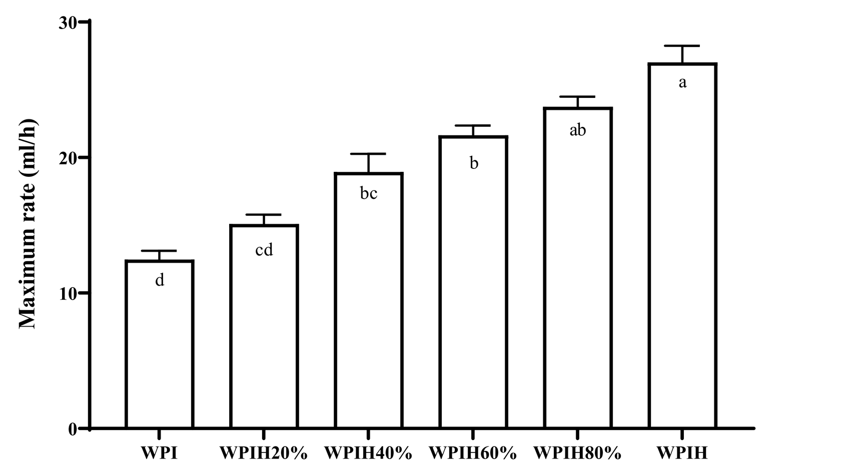


Gas production profile

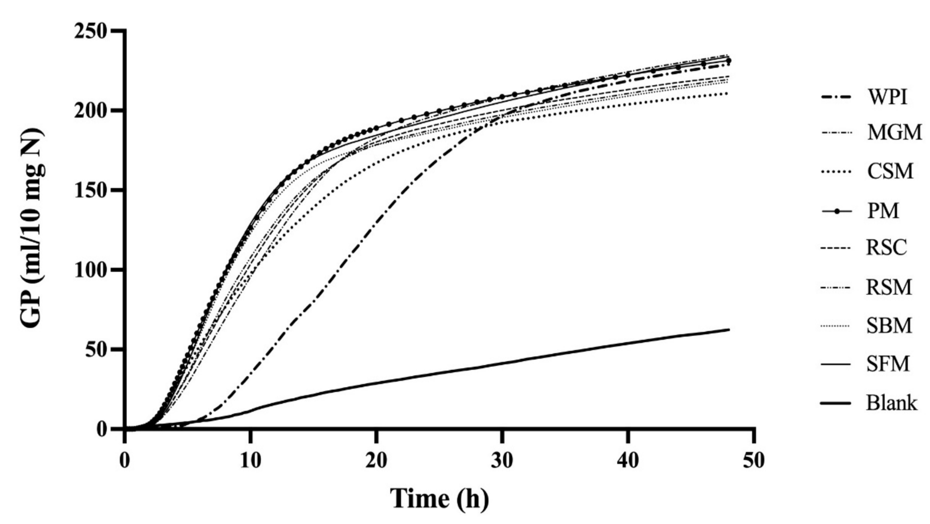
- ❑ *Gas production (GP) curves for 48 h*
- ❑ *Maximum gas production rate (R_{max})*
- ❑ *Cumulative GP before the microbial turnover phase (GP_s)*
- ❑ *Time of GP_s (T_{GPs})*
- ❑ *The slope of the linear microbial turnover*

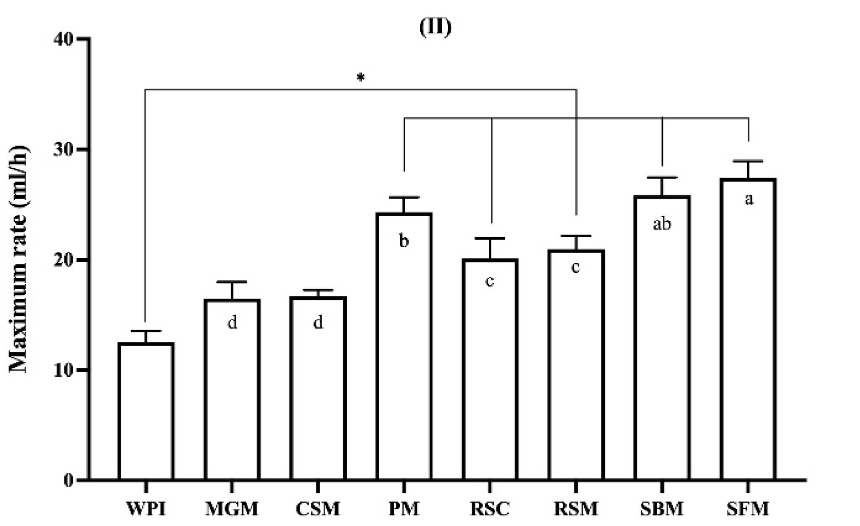
Results



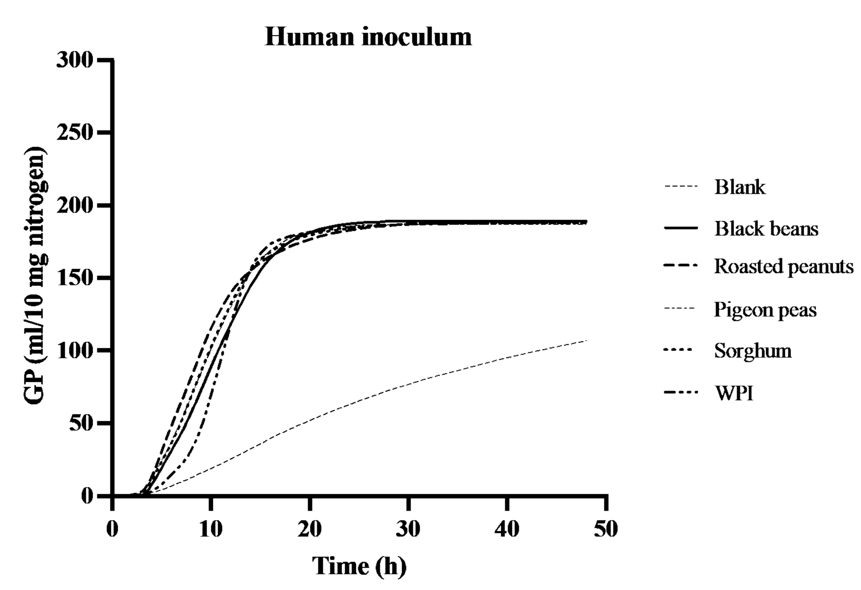


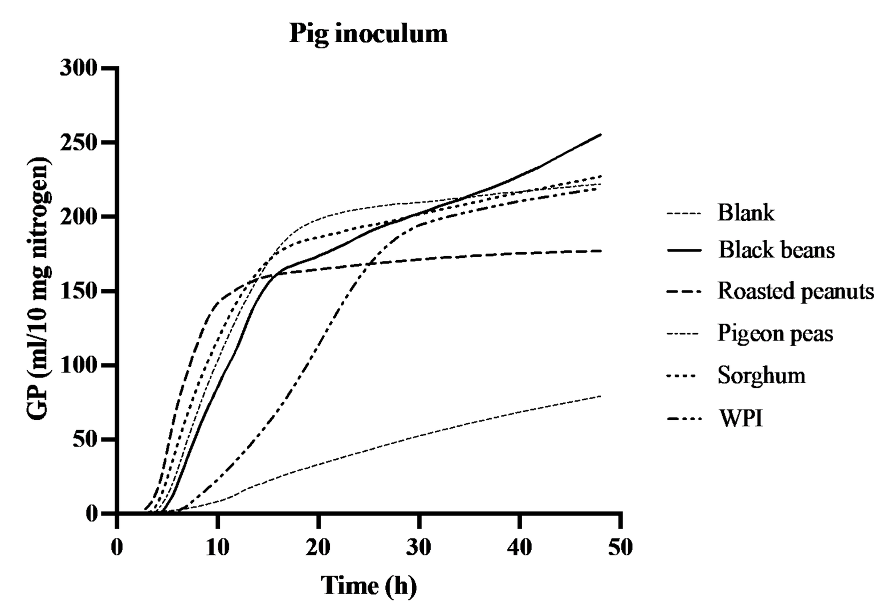
- R_{max} significantly increased while WPIH inclusion ratio increased





- Fermentation potential: ileal digesta > WPI
- Ileal digesta from different protein source has different fermentation rate





- GP reached plateau around 20h and the cumulative GP of all the substrates were around 200ml
- Samples showed higher variance with pig inoculum

Conclusions

1) Fermentation profile of different protein sources showed large variation
2) Maximum gas production rate is the most important and sensitive parameter
3) Ileal digesta with different R_{max} could be due to the different degree of hydrolysis
4) Human and porcine faecal microbiota ferment ileal-undigested proteins, peptides, and amino acids differently
5) For *in vitro* assessment of protein fermentation, the donor-species of the faecal inoculum should be selected carefully as different rank of fermentability was found based on GP_s and R_{max}

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Fermentation kinetics of resistant starch and its interaction with protein in large intestine of growing pigs

2+2 PhD candidate: Yaowen Zhang
Supervisors: Defa Li (CAU); Junjun Wang (CAU); Wouter Hendriks (WUR); John Cone (WUR); Nikkie van der Wielen (WUR)

Background

Animal feeding has been recognized as an essential tool for controlling gas emissions from manure in the livestock sector. That is because the undigested protein in the small intestine will go to the large intestine and be fermented by the bacteria in the large intestine. This process will produce some metabolites which will cause detrimental effects to gut health and gas emissions. Various nutritional strategies, as the inclusion of fiber sources in feeds, have been proposed to mitigate ammonia emission derived from manure in pig farms. Some studies have proved that combine protein diet with fermentable carbohydrates could improve gut health of pigs and reduce the nitrogen excretion and harmful gas emissions.

Objectives

Exploring the fermentation kinetics of different types of resistant starches by *in vitro* and *in vivo* methods, selecting appropriate resistant starch structure and dosage as the source of carbohydrate fermentation in the hindgut of growing pigs and fermenting with protein, changing the nutrient fermentation mode of pig hindgut and reducing the injury of pig intestines and environmental pollution problems caused by protein fermentation.

Methods

Ileum-cannulated growing pigs were used as animal model, by feeding four types of resistant starch to investigate their digestion, fermentation and structure changes in the whole intestine. All pigs were slaughtered to collect digesta samples in different intestine segments. Meanwhile, the *in vitro* digestion were conducted to compare the digestion characteristics with the small intestine digestion in pigs. The second animal experiment were conducted to investigate the pure fermentation of resistant starch substrates in the hindgut of growing pigs by infusing resistant starch to the ileum. The feces from normal and experimental pigs were collected to use as microbiota inoculum of the *in vitro* fermentation. After these experiments, the pivotal microorganisms that degraded the resistant starch substrates were found. Then the bacteria cultivation was conducted to research the resistant starch degradation mechanism. The optimal resistant starch substrates will be selected to ferment with protein and observe their fermentation interactions.

Figure 1. Ileum-caecum-cannulated pig model and gas production system

Results

By analyzing the changes of crystal and molecular structure of different types of resistant starch before and after in vitro digestion, insignificant results were observed, that means pure enzymatic hydrolysis cannot significantly influence the structure of different types of resistant starch. But resistant starch apparent structure endured more destruct during in vivo fermentation, suggesting small intestine bacteria involved in the resistant starch degradation. By comparing the resistant starch feeding and infusing experiments, we found *Lactobacillus* were the main bacteria which fermented original resistant starch and their fermentation could happen in both small or large intestine, according to the segments where resistant starch emerged.

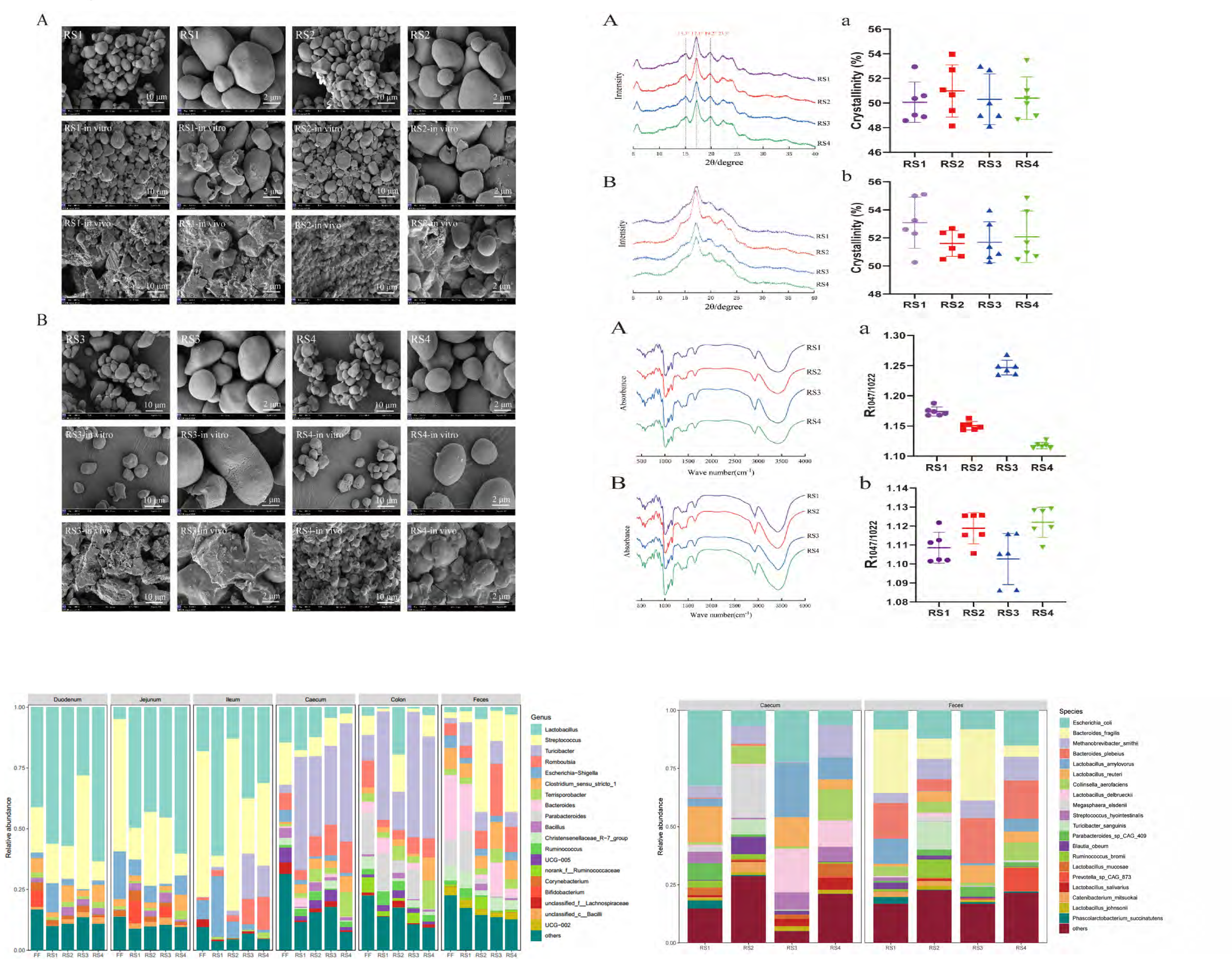

Figure 2. Resistant starch structural changes and their effects on microbiota composition of growing pigs

Conclusions

For now, we can conclude that:

- Different types of resistant starch have similar effects during digestion and fermentation
- Resistant starch structure is the main factor determined fermentation performance
- The fermentation ability of small intestine bacteria was underestimate
- The utilization of bacteria on resistant starch substrates are not intestine segments specific

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Combined field and model-based approaches for large scale sustainable phosphorous management

Yu Gu, Gerard H. Ros, Qichao Zhu, Jianbo Shen, Wim de Vries,

Background

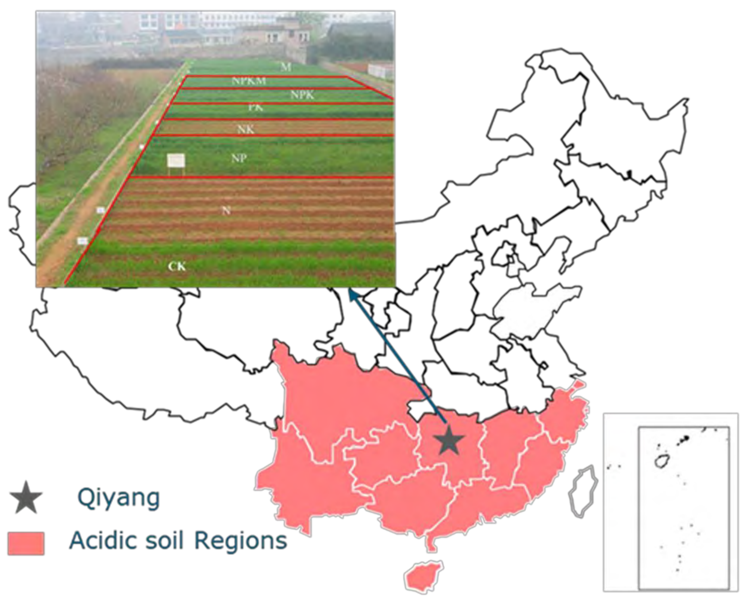
Overuse of P fertilizers causes resources waste and serious water pollution. Understanding the fate of bioavailable, reactive and stable P in soil is key to improve recommendations to optimize P fertilizer application for both agronomic and environmental objectives. A modelling approach which focuses on P transformations in soil is necessary to evaluate soil P fertility and guide P fertilization.

Objectives

- Evaluate the impacts of soil properties on the fate and crop availability of P in soil, using empirical data from literature for available P ($CaCl_2$ P), reactive P (Olsen P, Oxalate P) and stable P.
- Assess the impacts of fertilizer management on soil P dynamics and define a good indicator for P availability related to cop uptake and leaching, using data from a 29-year long-term field experiment
- Assess and map spatial variation in sustainable P fertilizer inputs on regional level for Qiyang county.

Study site

Data and insights are derived from Chinese fertilization long-term experiment in Qiyang county (1990-now), Hunan Province, China. The field is on a non-calcareous upland red soil, Ferralic Cambisol. There were 6 treatments, including CK, NP, NPK, NPKM, M, and 1.5NPKM where CK is control plot and M stands for manure (Fig 1). The rotation is winter wheat - summer maize.



Treatments	Total P input (kg P/ha/yr)
CK	0
NP	52
NPK	52
NPKM	215
1.5NPKM	320
M	227

Figure 1. The location and treatments information for Qiyang long-term experiment

First Results

- The size of the reactive and available P pools increased with long-term surplus P (R^2 of 0.81-0.84; see Fig 2) where the rate of change increases in the order total P < Oxalate P < Olsen P < $CaCl_2$ P
- Added P was partly lost by leaching when reactive P pools became saturated, nearby a P surplus of 3200 kg P/ha (see Fig 2a)
- Where reactive P pools were saturated, available P ($CaCl_2$ P) increased continually with increasing P surplus (see Fig 2c)

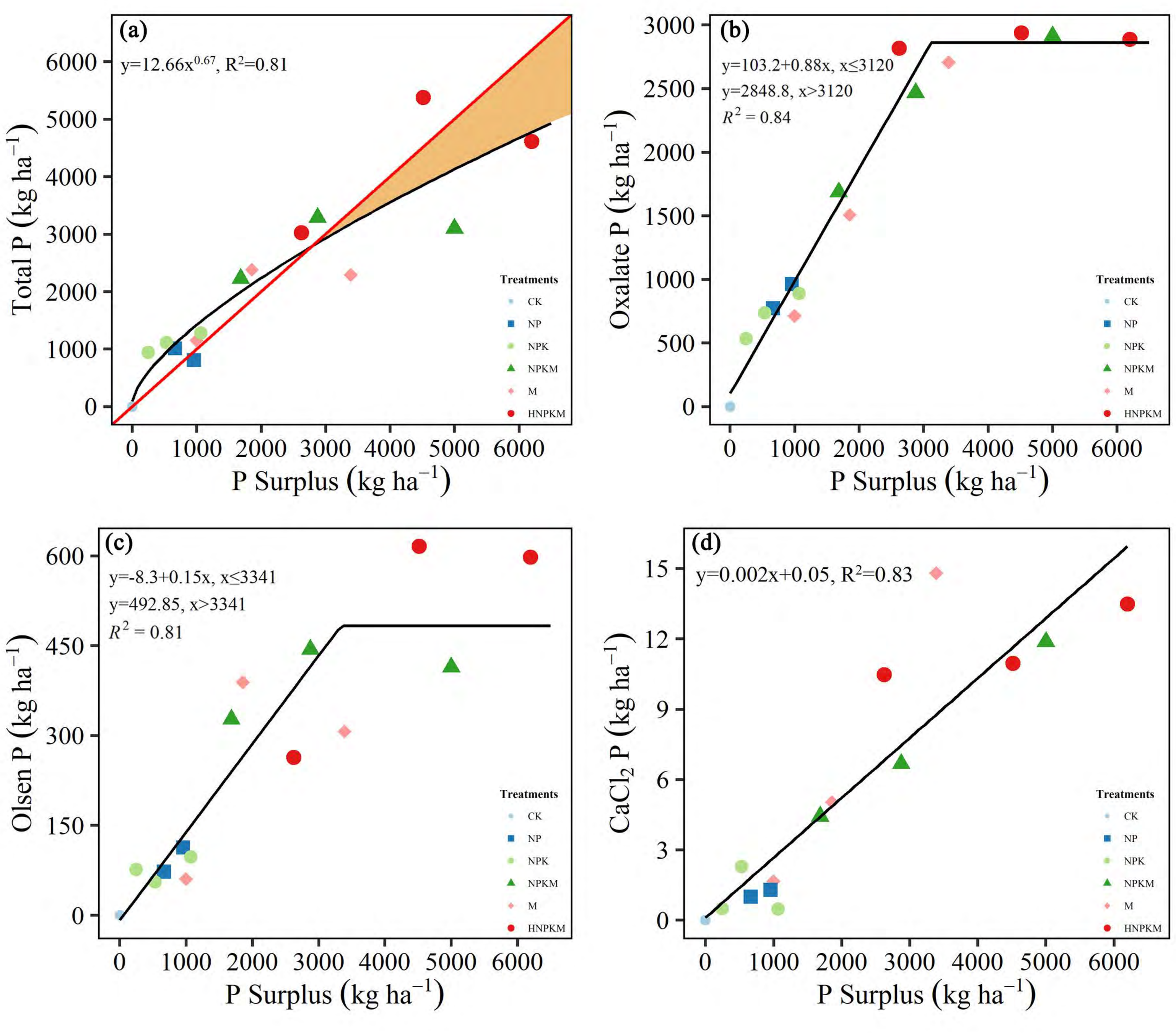


Figure 2. The relationship between changes in soil P pools and soil P surplus

- The soil P status was highly correlated to crop yield, especially for PSI (Fig 3a) and Olsen P (Fig 3b)
- Critical threshold values for PSI are more uncertain than for Olsen P (Fig 3)

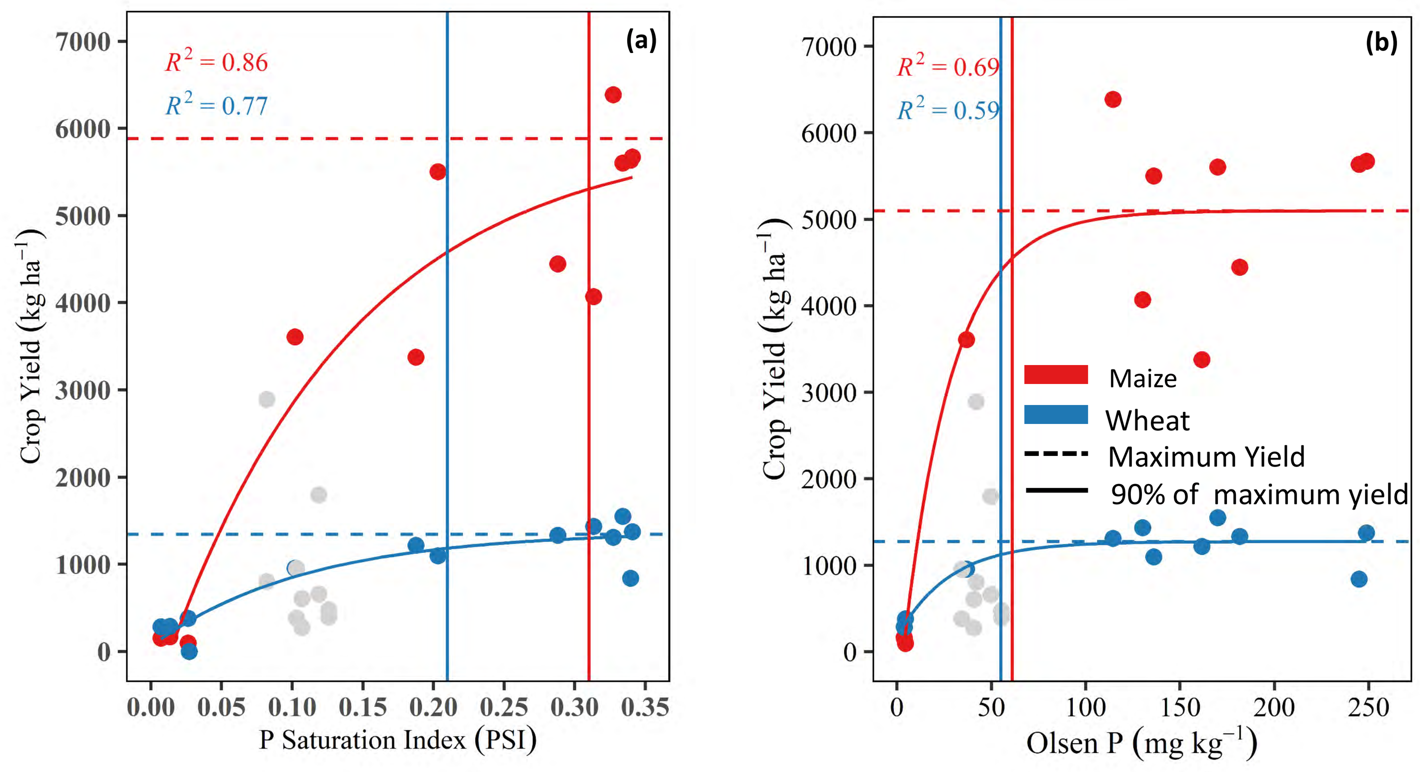


Figure 3. The relationship between crop yield and soil P indicators (Data points in grey were skipped from regression lines because of severe crop yield reduction due to acidification)

- Concentrations of $CaCl_2$ P were strongly enhanced above a PSI near 0.14 and Olsen P near 47 mg/kg (Fig 4)
- The relationship with PSI was stronger than for Olsen P (R^2 of 0.91 vs 0.81), and so were the $CaCl_2$P change points (Fig 4)

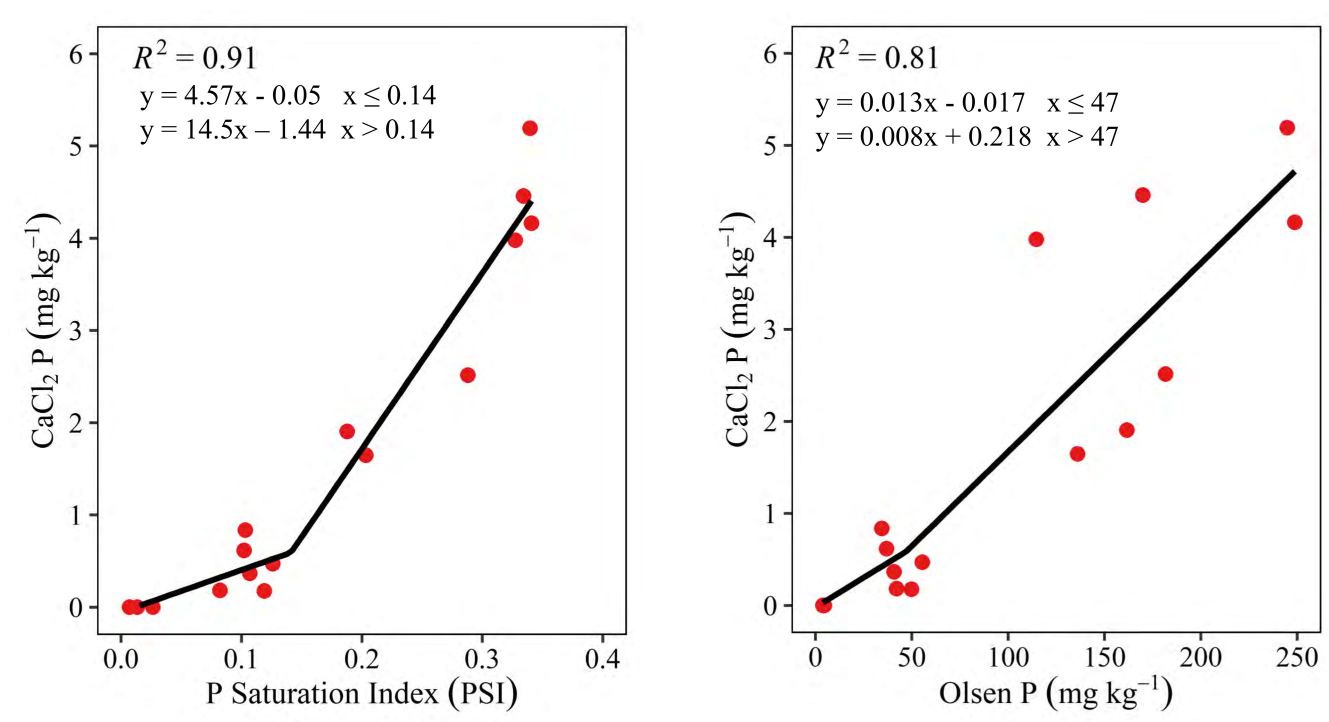


Figure 4. The relationship between $CaCl_2$ P concentration and soil P indicators

Main conclusions

Under long-term soil P accumulation, 1) reactive P pools became saturated and further added P was increasingly lost by leaching beyond this point and 2) critical values for leaching risk were lower than target values for crop yields.

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Phosphorus adsorption-desorption characteristics of major soils in China in relation to soil properties

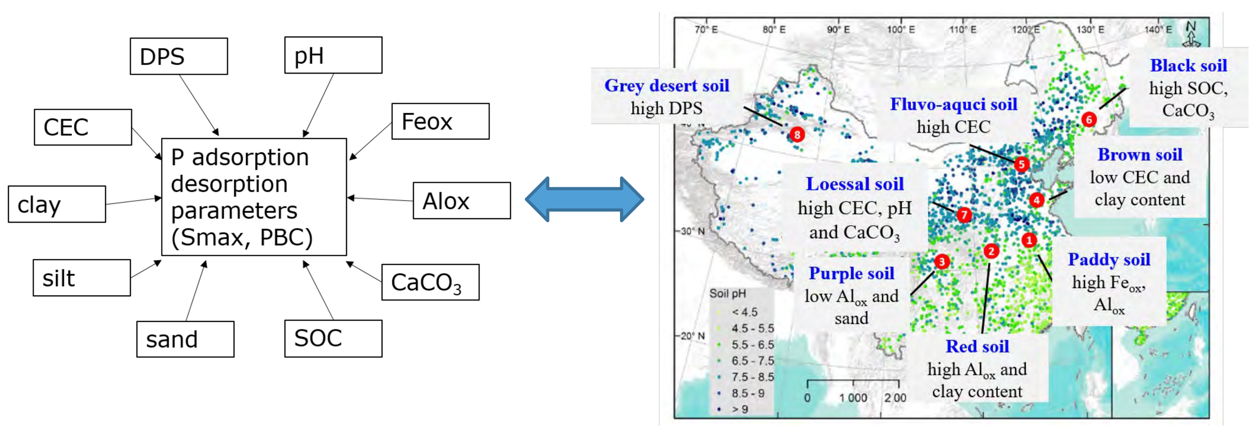
Dongfang Zheng, Gerard Ros, Jianbo Shen, Wim de Vries

Background

In the past decades, crop production in China has strongly improved due to greater N and P input. While P input increased from 88 to 123 kg P_2O_5 ha^{-1} yr^{-1} between 2004 and 2014, the P-use efficiency (PUE) dropped from 68 to 20%, resulting in high P accumulation in soil. This is only beneficial at low P status. At high P status the excess P input leads to environmental pollution and waste of P resources. It is crucial to optimize P management through better understanding of the match between soil P supply and P demand by crops, P soil transformations and rhizosphere processes based on field and lab experiments.

Objectives

The objectives of this study were (1) to assess P adsorption and desorption processes using Langmuir isotherm models for soils in China covering a large range of soil properties and (2) how the adsorption and desorption (using Q_{max}, K_L and P desorption constant) vary with the soil properties controlling these properties.



Methods

The P adsorption parameters according to Langmuir isotherm :

$Q = Q_{max} \times K_L \times C/(1+ C \times K_L)$

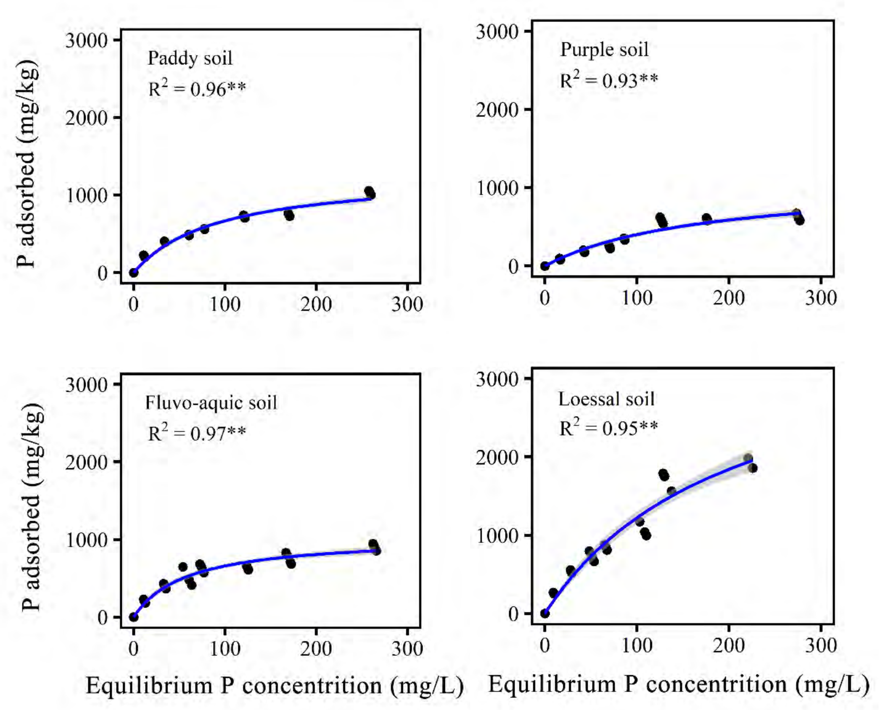
where S is the adsorbed amount of P (mg P kg^{-1}), Q_{max} is the P adsorption maximum (mg P kg^{-1}), C is P concentration in solution after a 24h equilibration period (mg P L^{-1}) and KL is the Langmuir constant related to the binding energy of P (L mg^{-1} P).

P desorption was fitted based on a linear P desorption model :

$Y = \beta X + \alpha$

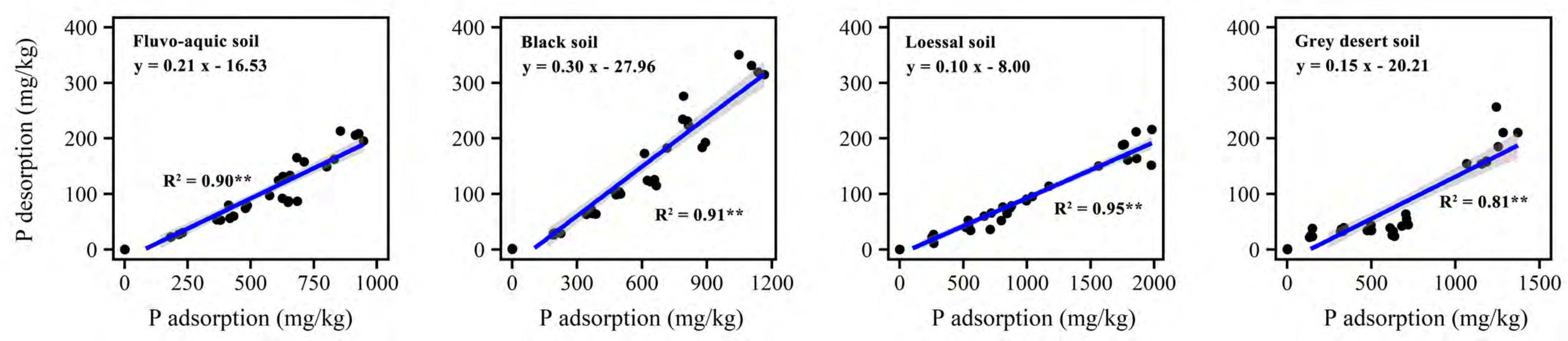
Where Y and X are the amounts of desorbed P and adsorbed P (mg kg^{-1}); β and α are the desorption constants where β reflects the amount of desorbed P per unit P adsorbed.

Results

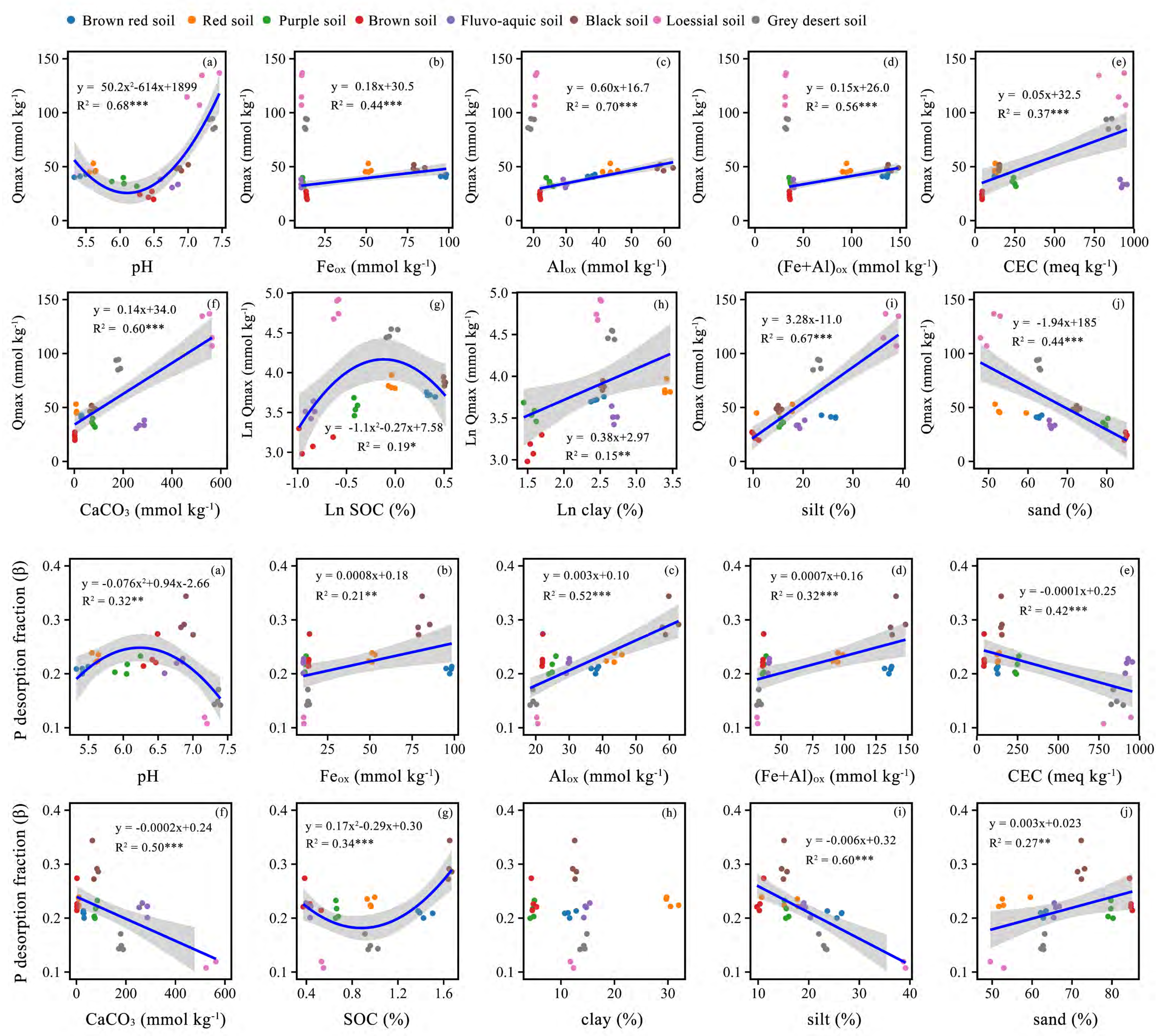


Location	Soil type	Qmax (mg P kg^{-1})	K_L (L mg^{-1})
Anhui	Paddy soil	1282	0.011
Hubei	Red soil	1469	0.0076
Chongqing	Purple soil	1102	0.0058
Shandong	Brown soil	718	0.005
Beijing	Fluvo-aquic soil	1052	0.176
Jilin	Black soil	1513	0.0088
Shaanxi	Loessal soil	3821	0.0048
Xinjiang	Gray desert soil	2783	0.0036

- The Langmuir equation accurately described P adsorption.
- P adsorption increased at higher dissolved P level but saturation was not yet found.
- Large variations in P adsorption (up to a factor 5) were found in different soil types.



There was a strong positive correlation between soil adsorbed and desorbed P (P < 0.01). The amount of P desorbed from the P pre-adsorbed soil was much less than the amount of P adsorbed (a ratio of 20%-25%), close to PUE, suggesting a low release of P.



- Provides P adsorption sites leading to an increase in Q_{max}: Fe_{ox}, Al_{ox}, $CaCO_3$, clay and silt; Less P adsorption sites leading to an decrease in Q_{max}: sand; Soil pH and SOC have a dual effect on the Q_{max}, both inhibiting and promoting.
- The impact of soil properties on desorption constant were opposite to the impact of those soil properties on adsorption except for Al_{ox} and Fe_{ox}

Conclusions

the P adsorption maximum (Q_{max}) generally increased with increasing contents of oxalate extractable iron (Fe_{ox}) and aluminium (Al_{ox}) (in non-calcareous soils), cation exchange capacity (CEC), $CaCO_3$, clay and silt. The desorption constant (β) decreased with an increase CEC, $CaCO_3$, and silt, being opposite to the impact of those soil properties on adsorption. Furthermore, the desorption constant first increased and then decreased with the increasing pH, while the opposite occurred for SOC.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Benefits and trade-offs of measures reducing ammonia emissions in poultry-crop systems: a systems analysis

Zhilong He, Ying Zhang, Xuejun Liu, Wim de Vries, Gerard H. Ros, Oene Oenema, Wen Xu, Yong Hou, Hongliang Wang, Fusuo Zhang

Background

Poultry production significantly contributes to anthropogenic ammonia (NH_3) emissions affecting terrestrial biodiversity. Various NH_3 cleaner production technologies have been proposed along the three stages of the poultry manure management chain, i.e., housing, manure storage and treatment and field application, to reduce those pollutant emissions. However, the effects of these stage-specific technologies on NH_3 emissions and the accompanying impacts on NO emissions, N leaching (including N runoff) and non-CO_2 greenhouse gas (GHG) emissions (i.e. N_2O and CH_4) in typical poultry systems have yet to be fully quantified.

Objectives

The aim of this study was to identify effective actions that provide strategic opportunities to reduce NH_3 volatilization, NO emissions, N leaching and non-CO_2 GHG emissions from typical poultry production systems.

Methods

A holistic technical-driven framework was developed and applied to seven typical poultry systems in China. We first assessed the baseline using material (C and N) flow methods and 970 emission observations. We further identified 33 stage-specific NH_3 mitigation strategies for poultry production by synthesizing 1554 observations worldwide. Mitigation strategies were selected based on the variations in poultry enclosure and manure states.

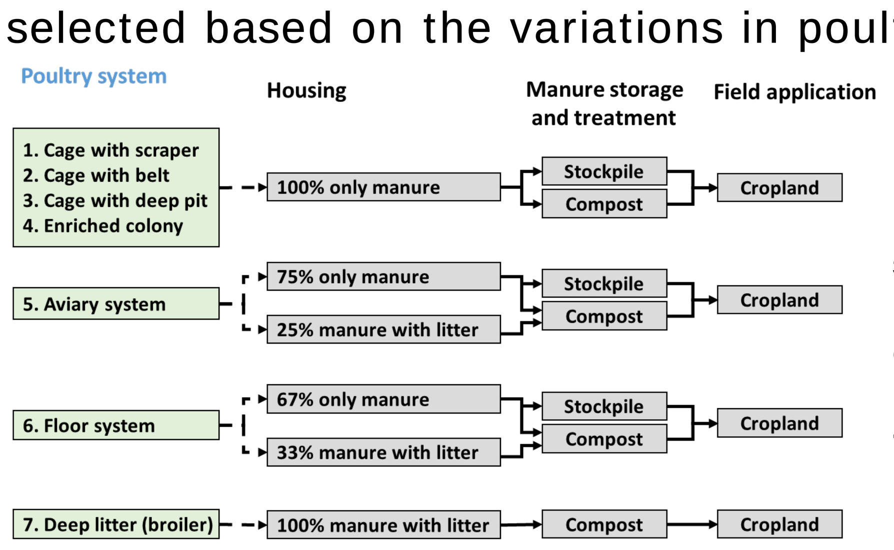

Fig. 1. Representation of the baseline of seven poultry manure management systems, including six laying hen systems (1-6) and one broiler system (7), considering three major stages (housing, manure storage and treatment, and field application) in the manure management chain.

Results

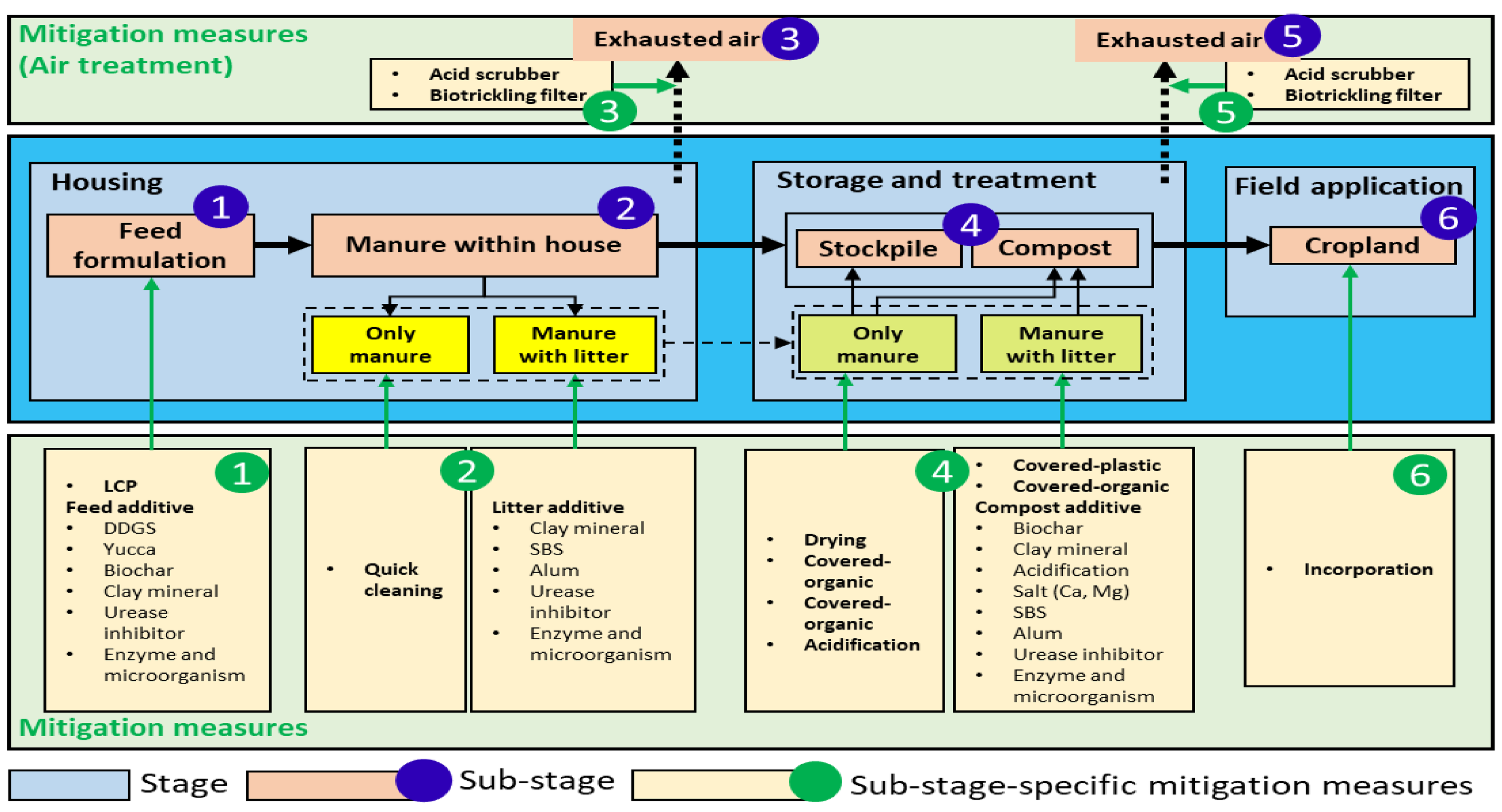

Fig. 2. Representation of the included NH_3 mitigation measures for each sub-stage along the manure management chain.

Mitigation measures description

Numerous mitigation measures can be employed along the whole poultry manure management chain (i.e. housing, manure storage and treatment, and field application) (Fig. 2). System-and stage-specific mitigation measures exist objectively, and thus, designing a distinguished combination of mitigation measures to adapt various poultry systems is needed and vital to managing manure precisely. The potential measures are summarized and further grouped into several subsets matched with the sub-stages along the manure management chain. Six sub-stages, including (1) feed formulation, (2) manure management within the house, (3) exhausted air treatment in the housing stage, (4) manure storage and treatment, (5) exhausted air treatment in the manure storage and treatment stage, and (6) final field application, were designed in this study.

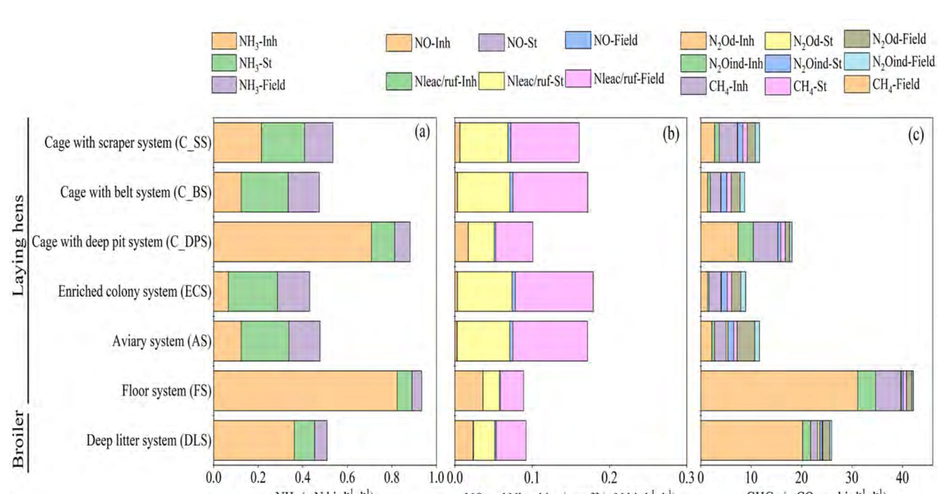

Fig. 3. NH_3 emissions (a), N leaching and NO (b) and non-CO_2 GHG (N_2O and CH_4) emissions (C) of baselines for cage with scraper (C_SS), cage with belt (C_BS), cage with deep pit (C_DPS), enriched colony system (ECS), aviary system (ECS), floor system (FS), and deep litter system (DLS) as defined in Figure1. Inh, in house; St, storage and treatment; Field, field application; Nleac/ruf, N leaching and runoff; N_2Od, direct N_2O emission; N_2Oind, indirect N_2O emission.

Nogen losses and greenhouse gas emissions in the baseline situation

As shown in Fig. 3. FS has the greatest NH_3 emissions (0.93 g NH_3 bird^{-1} d^{-1}), followed by C_DPS (0.88). There are comparable values among C_SS (0.51), C_BS (0.47), ECS (0.43), AS (0.48) and DLS (0.51). The housing stage is the main contributor to NH_3 emissions in C_SS, C_DPS, FS and DPL, accounting for 40%, 80%, 88%, and 71%, respectively; while, for C_BS, ECS and AS, NH_3 emissions from manure storage and treatment stages dominate the total losses, accounting for 45%, 51% and 45%, respectively. The field application stage also is an important NH_3 source for C_SS, C_BS, ECS and AS, accounting for 24%, 29%, 34% and 29%, respectively. The numbers of NO plus N leaching（g N bird^{-1} d^{-1}）are comparable for C_SS, C_BS, ECS and AS, ranging from 0.16 to 0.18, followed by C_DPS (0.10), DLS (0.09) and FS (0.09). The amount of GHG emissions（g CO_2-eq bird^{-1} d^{-1}）decrease in the following order: FS（42)>DLS(26)>C_DPS(18)>C_SS(12)>AS(12)>ECS(9)> C_BS (9), showing the similar patterns of total NH3 emissions.

Effects of combined mitigation measures on nitrogen losses and greenhouse gas emissions

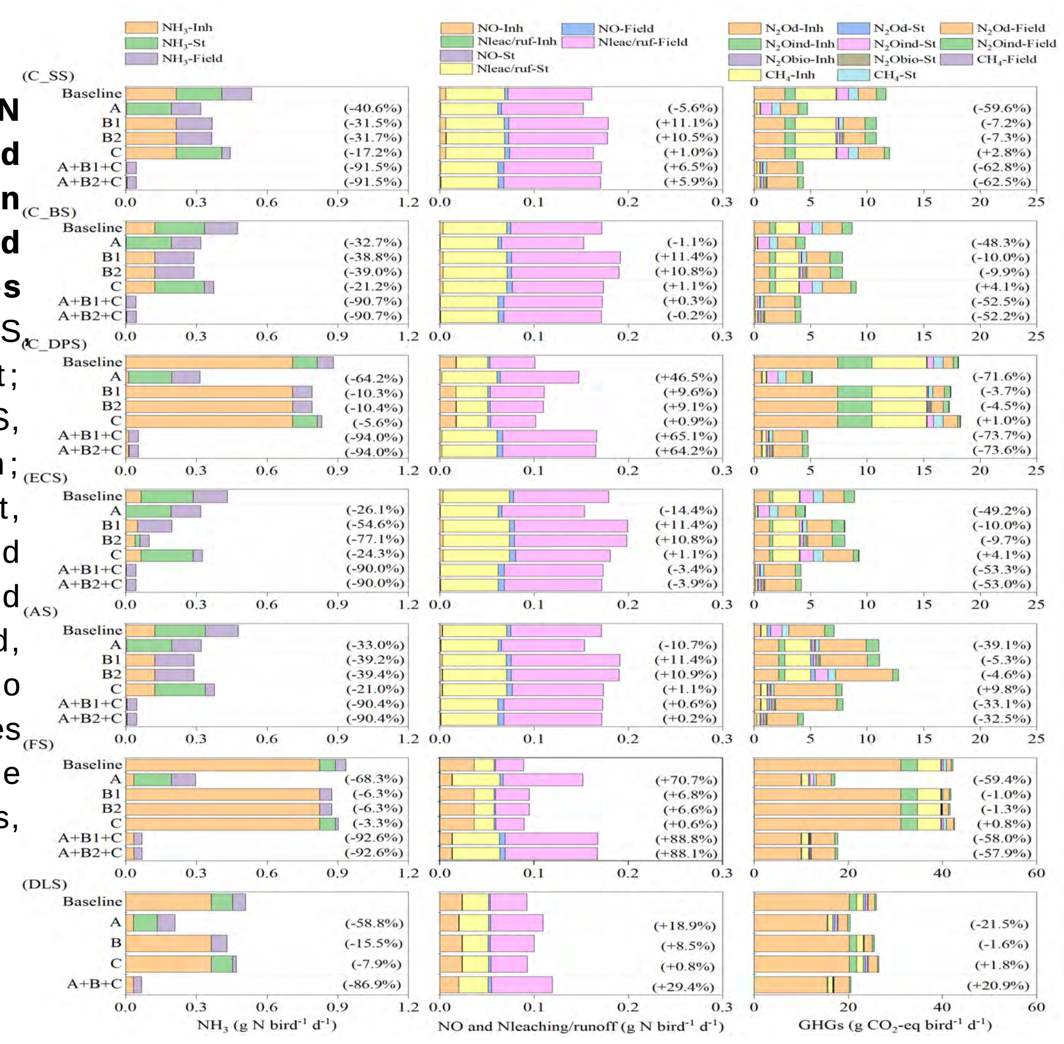

Fig. 4. NH_3 emissions, NO plus N leaching and non-CO_2 GHG (N_2O and CH_4) emissions across the seven poultry-crop systems of baselines and scenarios. The numbers in parentheses indicate the mitigation efficiency. C_SS, cage with scraper; C_BS, cage with belt; C_DPS, cage with deep pit system; ECS, enriched colony system; FS, floor system; DLS, deep litter system. Inh, in-house; St, storage and treatment; Field, field application; Nleac/ruf, N leaching and runoff; N_2Od, direct N_2O emission; N_2Oind, indirect N_2O emission. A, B and C refer to the optimal mitigation measures combination for housing, manure storage treatment and field application stages, respectively.

Conclusions

The results exhibited considerable variations among poultry systems, for NH_3, NO plus N leaching and non-CO_2 GHG. The contributions of the three stages to the whole system emissions varied with the types of emissions and the poultry systems. Implementing mitigation measures for NH_3 can lead to the simultaneous reduction of -3%-95% of NH_3, -3%-11% of N leaching and -61%-81% of non-CO_2 GHG.

Evaluating the responses of different pollutants to NH_3 abatement technologies in poultry systems can aid in the identification of targeted manure management interventions in the different stages of those systems, as well as benchmarking and monitoring poultry production practices.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Multi-pollutant assessment of water quality and food production for agricultural green development in China

Yanan Li, Carolien Kroeze , Maryna Strokal, Wen Xu , Fusuo Zhang , Lin Ma

Background

❖ Waters often contain multiple pollutants

❖ Pollutants can come to waters from common sources

❖ Urbanization and agriculture are important common sources of water pollution

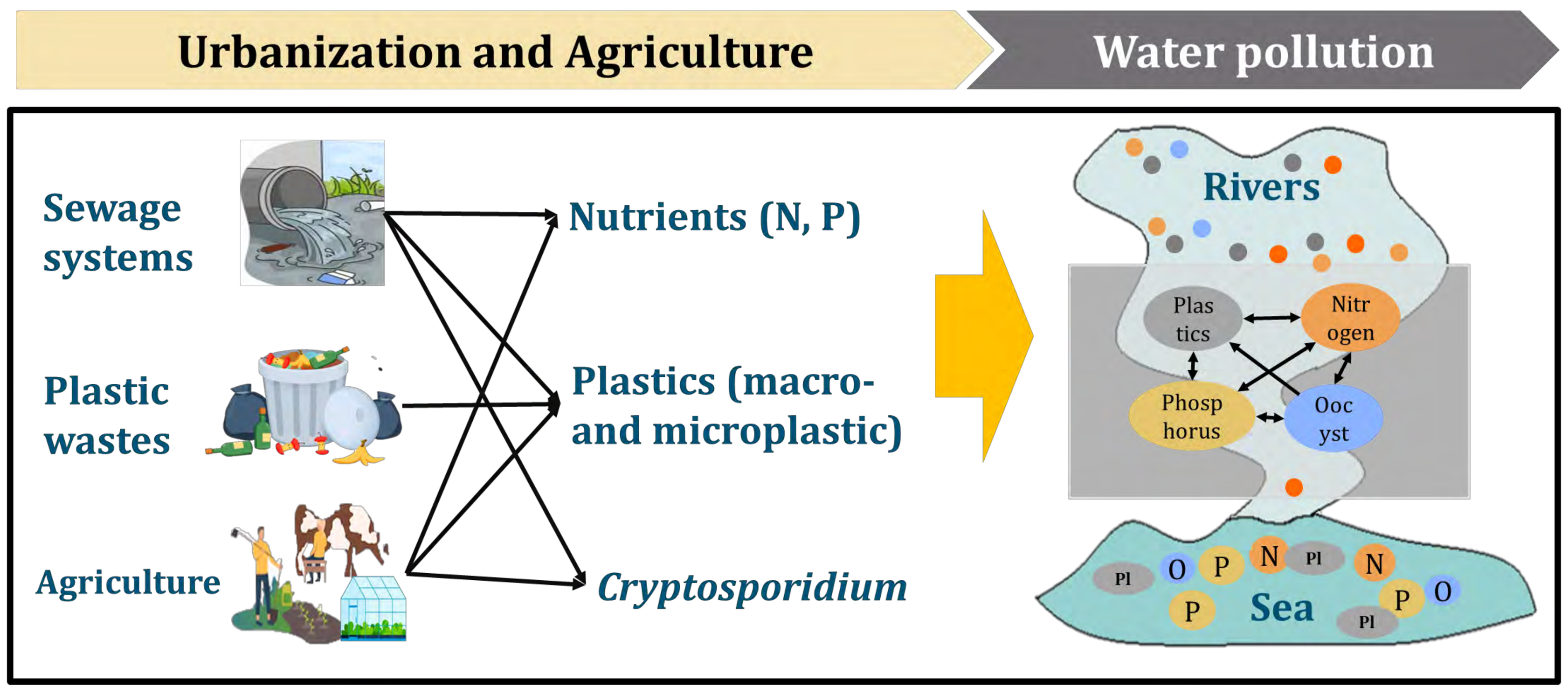


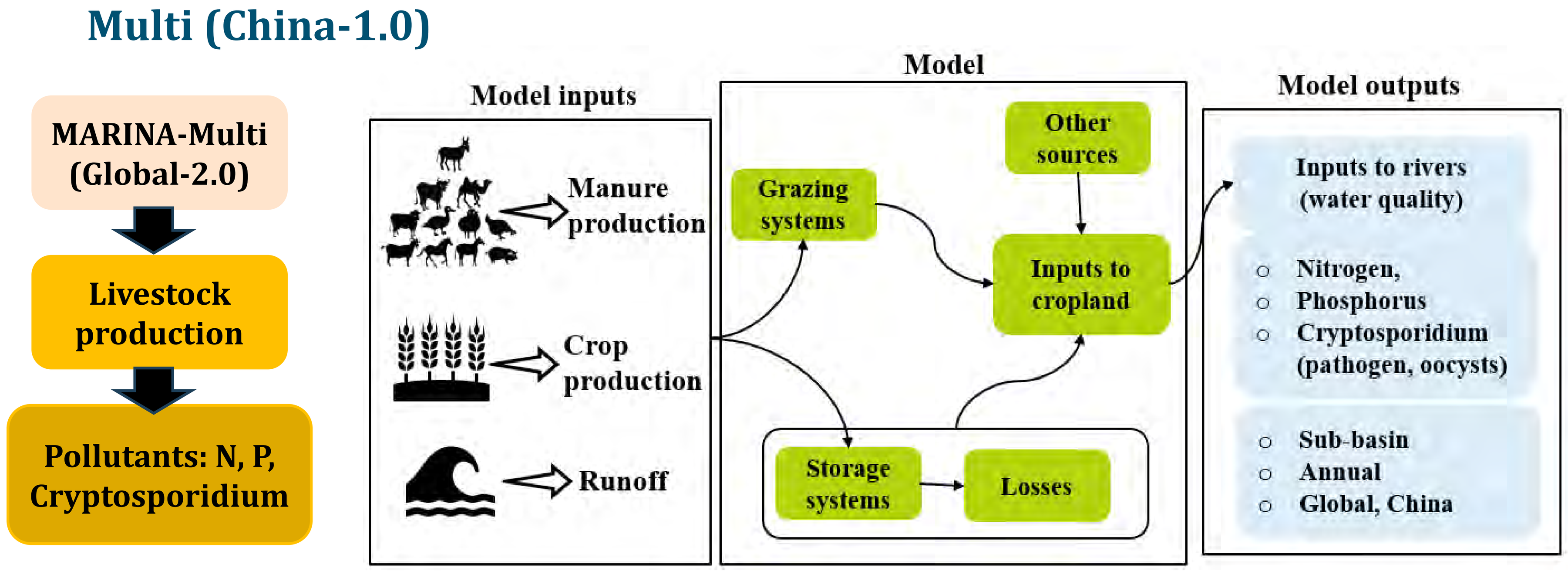
Fig. 1 Multiple pollutants in rivers from urbanization and agriculture

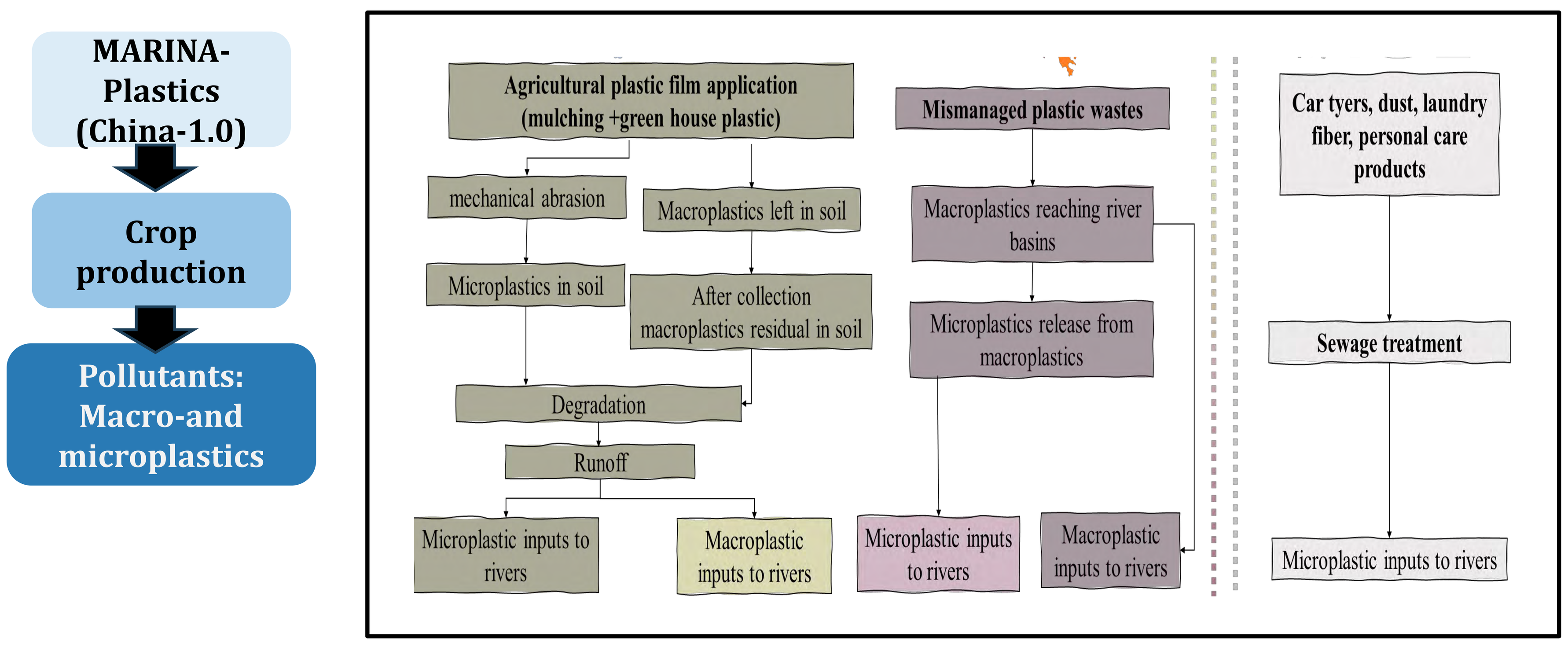
Objectives

Assess river pollution hotspots associated with multiple pollutants and their causes worldwide and in China

Methods

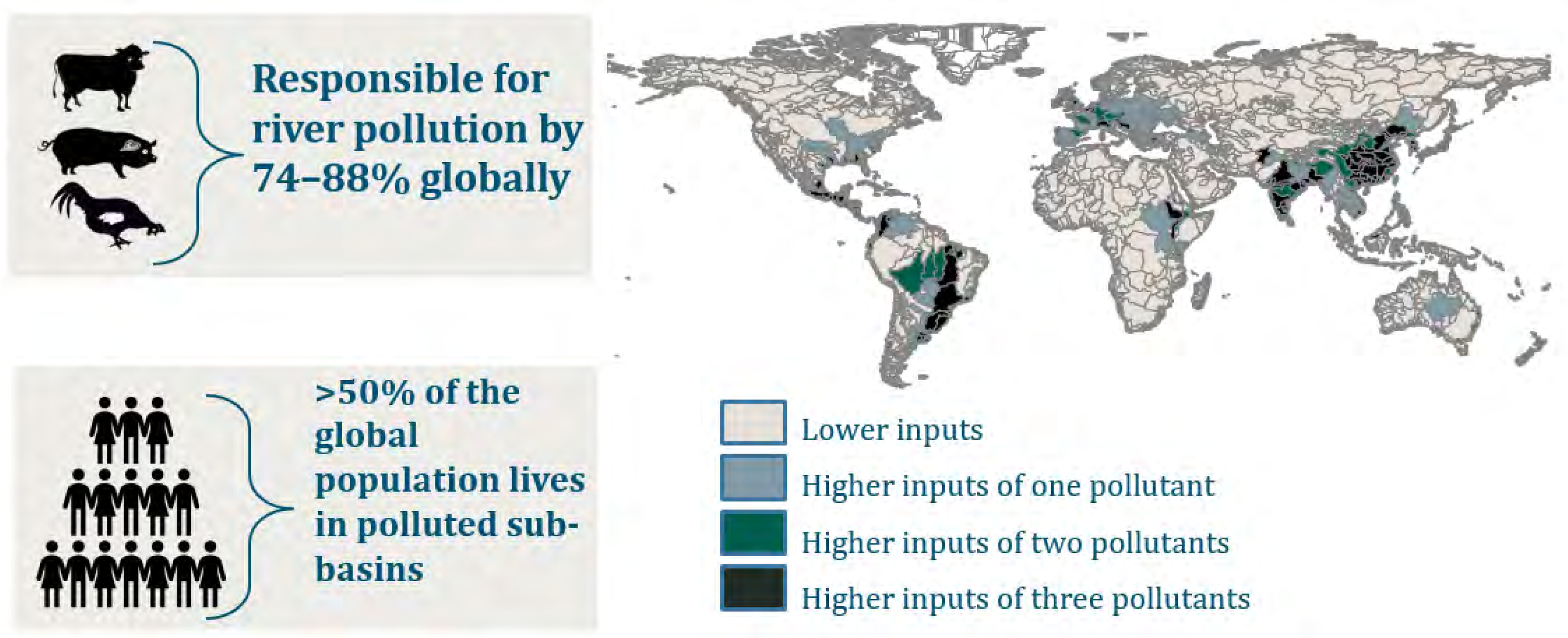
- **Model development : MARINA-Multi (Global-2.0)& MARINA-Multi (China-1.0)**



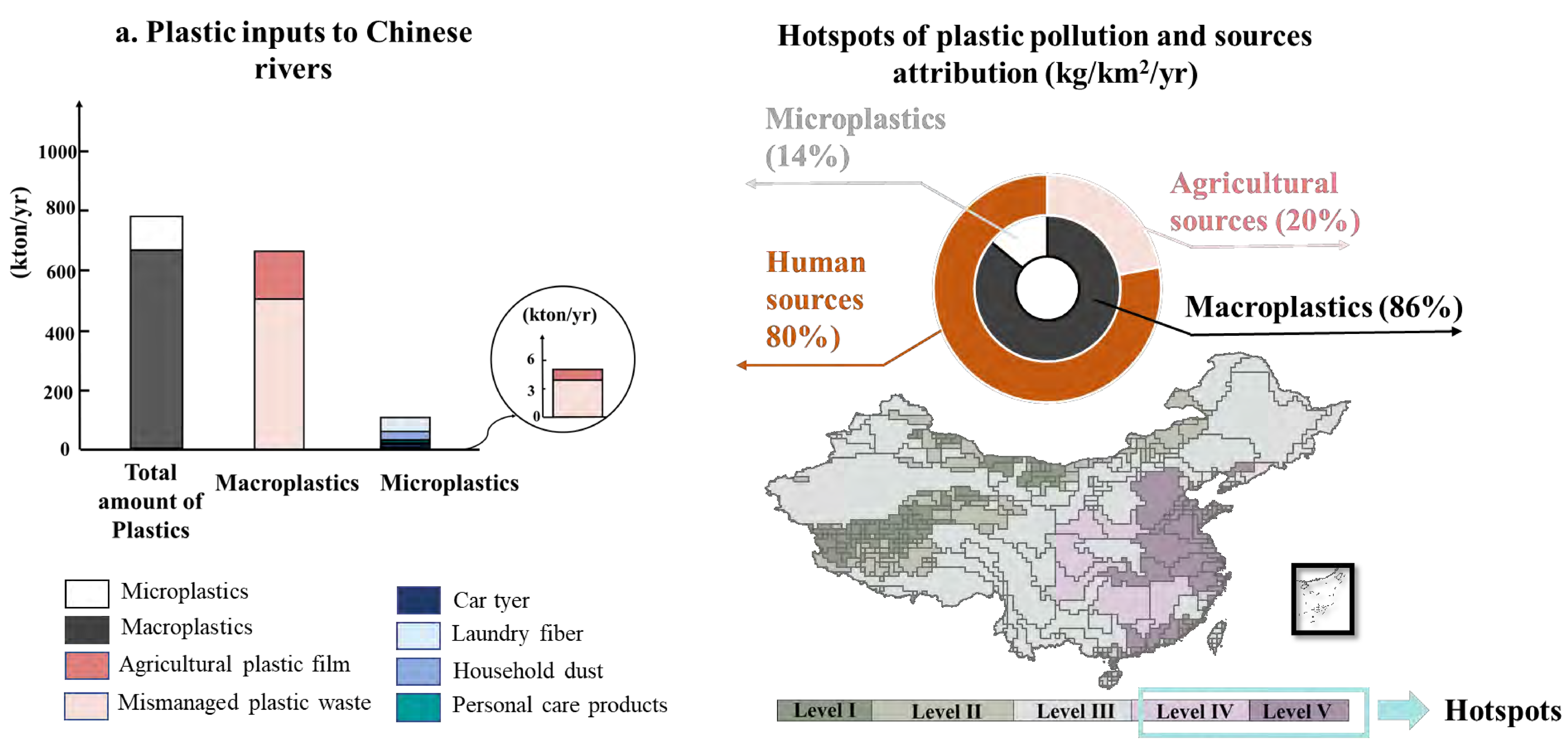


Results

❖One-fourth of global sub-basin areas contribute by 71–95% to river pollution (Li et al., 2022)



❖71% of the total plastics in rivers is from about one-fifth of the basin area (Li et al., 2023)



Conclusion

❖ Livestock production is the common source of nutrients and *Cryptosporidium*

❖Mismanaged soild waste is the dominate source of plastic pollution in China

❖Sewage systems contribute to the majority microplastics entering rivers

❖Multiple pollutant assessment is important for future water pollution management

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Exposure risk of particulate and gaseous pesticides to rural residents

Hongyu Mu, Xiaomei Yang, Kai Wang, Rima Osman, Xuejun Liu, Coen Ritsema, Violette Geissen

Background

Rural residents are exposed to both particulate and gaseous pesticides in the indoor-outdoor nexus in their daily routine. However, previous personal exposure assessment mostly focuses on single aspects of the exposure, such as indoor or gaseous exposure, leading to severe cognition bias to evaluate the exposure risks

Objective

- To investigate pesticide levels in particulate and gas phases in the indoor-outdoor nexus under rural settings
- To obtain the individualized pesticide exposure profiles of farmers and bystanders
- To assess the probabilistic health risks of pesticides for the local populations

Materials and methods

- Environmental monitoring:

Particulate pesticides: resideuntal dust collected at indoor and outdoor locations

Gaseous pesticides: stationary silicone wristabnds at indoor and outdoor spaces

- Personal exposure measurements:

Silicone wristbands for farmers and bystanders

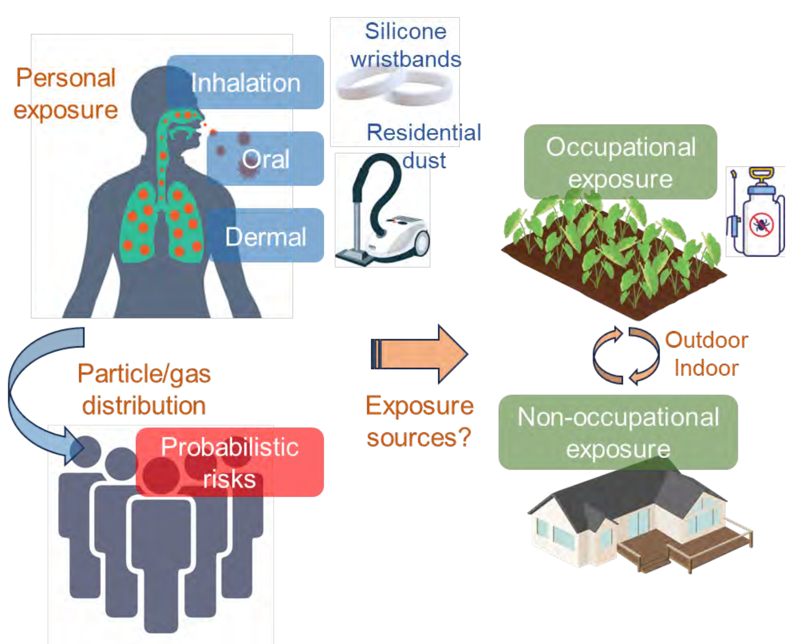

Figure 1 Structural framework of this study.

Results

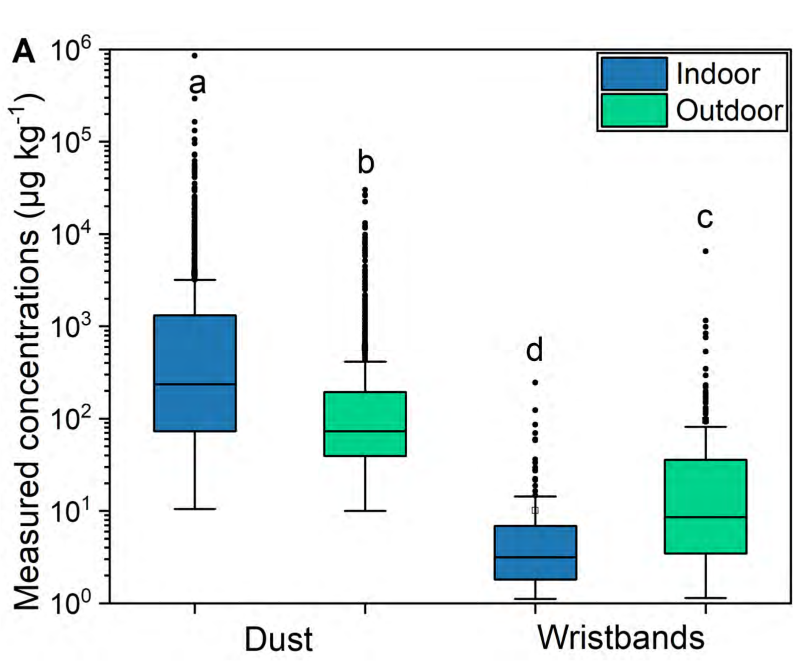

Figure 2. Measured pesticide concentrations in dust and wristbands at indoor and outdoor locations.

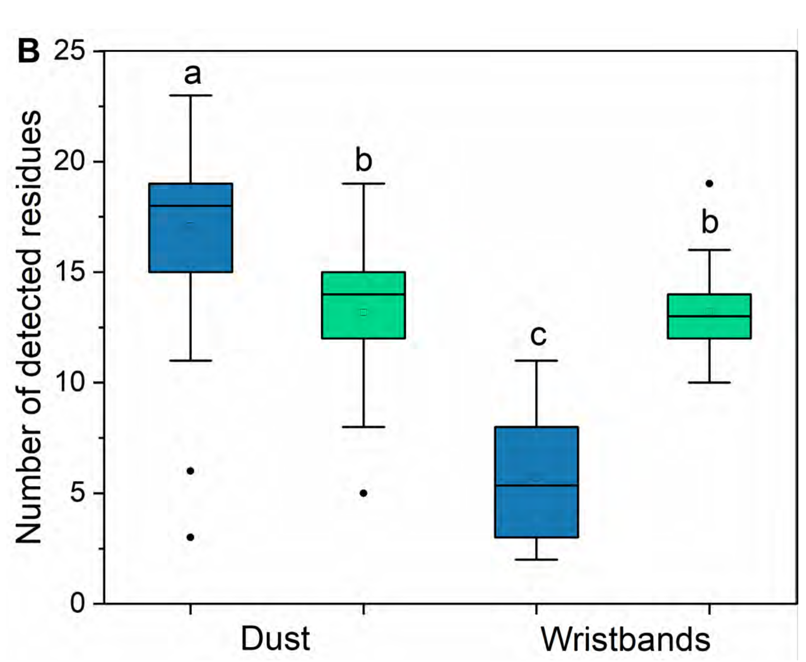

Figure 3. Number of detected pesticides in dust and wristbands at indoor and outdoor locations .

Highly differed accumulation characteristics were found among particulate and gaseous pesticides in the indoor-outdoor nexus with much higher detection rates and concentrations showing in particulate pesticides.

- Particulate pesticides showed higher detection rates and concentrations than gaseous pesticides in the indoor environment.
- By contrast to the particulate pesticides, gaseous pesticides exhibited higher levels at outdoor locations.

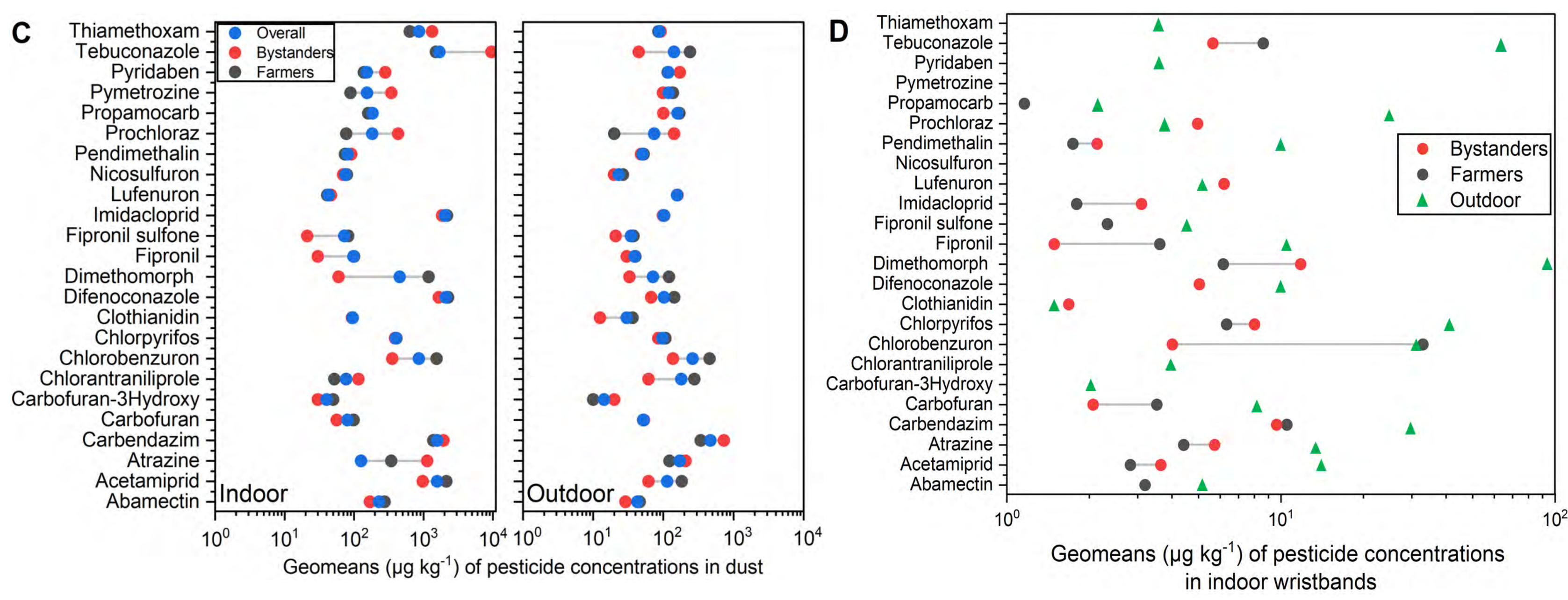

Figure 2. Geomeans of pesticides (μg kg⁻¹) in the indoor and outdoor environments.

Farmers had higher exposure levels than bystanders with the exposure dosages of pesticides positively correlated with the usage frequencies.

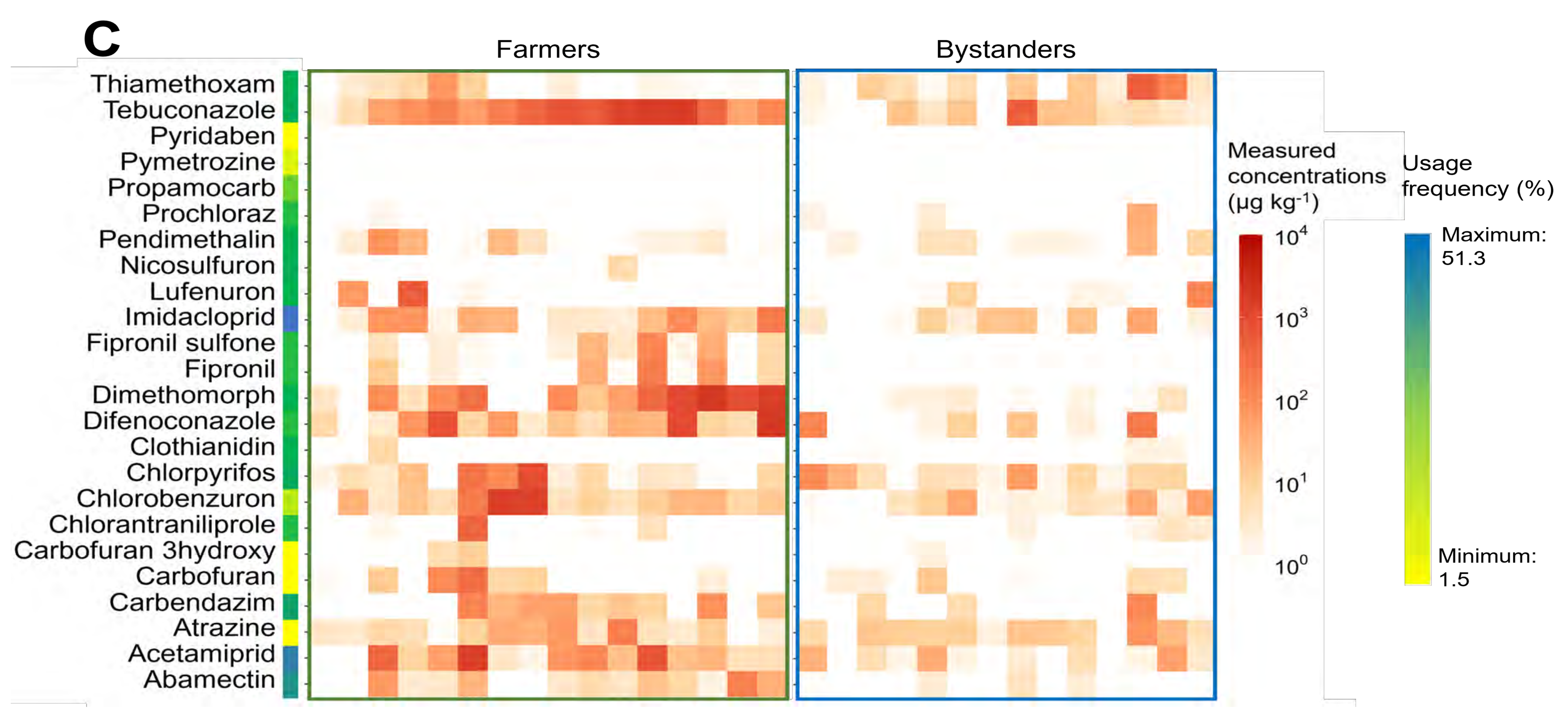

Figure 3. Personal pesticide exposure profiles of farmers and bystanders.

- Unexpectedly, most of pesticide exposures originated from non-occupational sources, rather than the occupational source.
- Approximately 7% and 3% of farmers and bystanders in the study region might suffered chronic health risks under the non- and occupational exposures of pesticides

Conclusions

- Particulate pesticides had higher accumulation levels in the indoor environment, while the gaseous pesticides tend to accumulated in the fields.
- Most of pesticide exposures originated from non-occupational sources
- The non- and occupational exposure have brought chronic health risks to rural residents in Quzhou county

Acknowledgements

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Modelling assessment of glyphosate and AMPA in surface water

Qi Zhang, Yanan Li, Carolien Kroeze, Wen Xu, Lingtong Gai, Miltiadis Vitsas, Lin Ma, Fusuo Zhang, Maryna Strokal

Background

- Glyphosate has been one of the most widely used herbicides in food production worldwide since the 1970s.
- AMPA is the main metabolite of glyphosate biodegradation, which is more persistent in the environment than glyphosate.
- Glyphosate and AMPA pollution generated debates due to their potential negative effects on the environment and society.

Objectives

- A better understanding of the interrelations between glyphosate and AMPA affect river pollution.
- The spatial explicitly of river pollution with glyphosate and AMPA.
- Quantitative information about the contribution of crops to river pollution with glyphosate and AMPA.

Methods

Newly developed MARINA-Pesticides model

- **Time step: 2020**
- **Glyphosate and its by-product into rivers at the sub-basin scale**

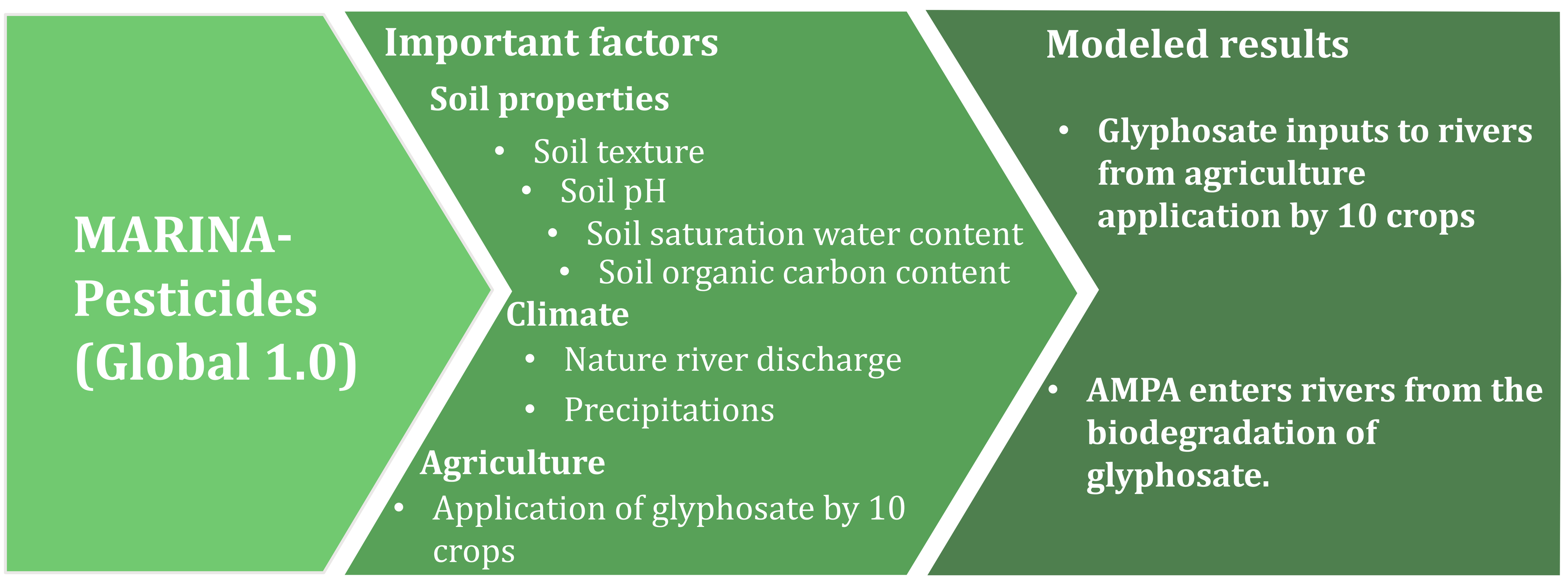

Fig.1. The conceptual framework of the MARINA-Pesticides model (Zhang et al., under review).

✓ The MARINA-Pesticides model was developed to estimate annual inputs of glyphosate and AMPA to rivers, considering 10 crops in over 10,000 sub-basins worldwide for the year 2020.

✓ The chemical, physical, and biological processes of glyphosate and AMPA transport in the soil and from land to rivers.

Results

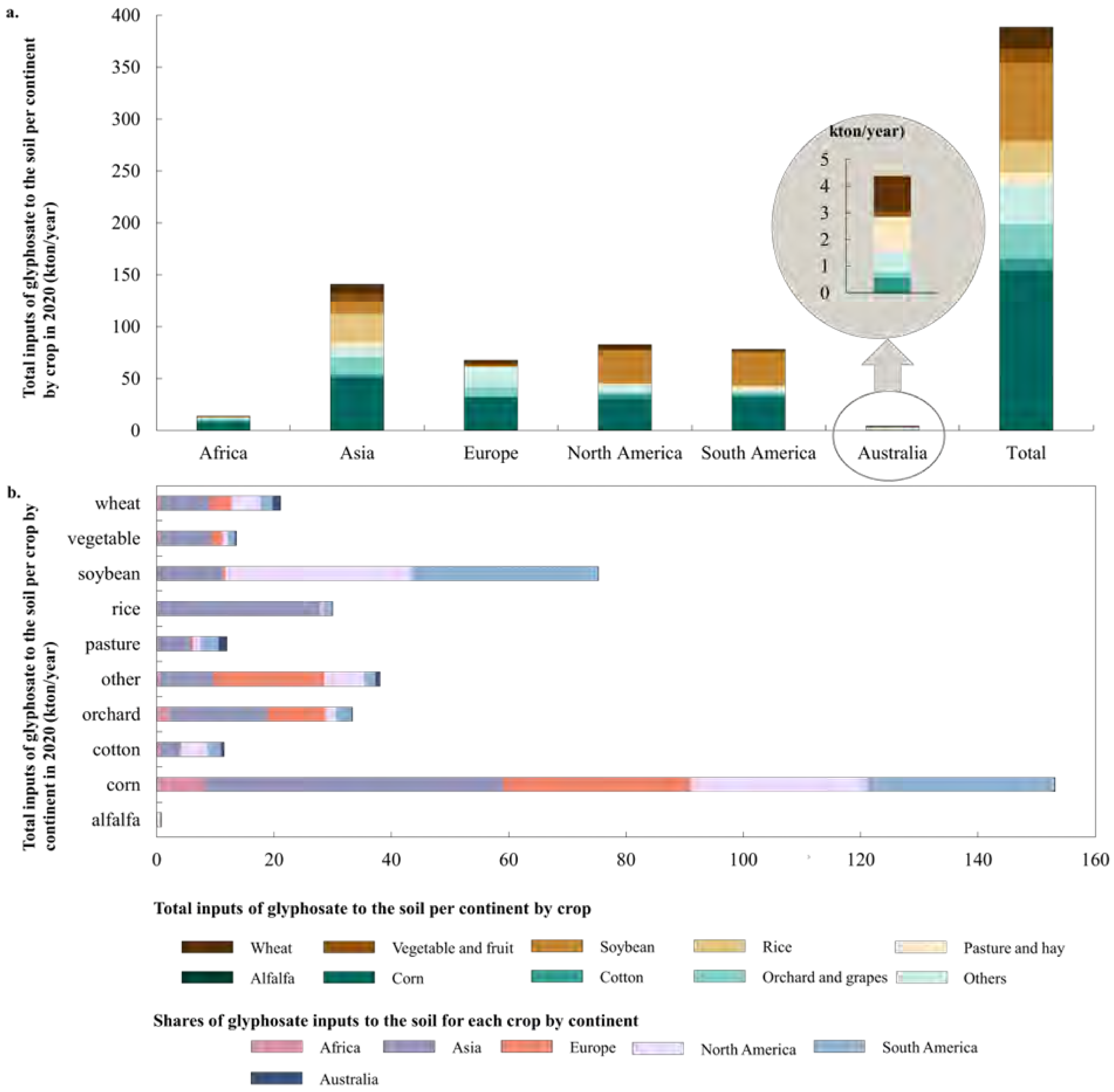

Fig.2. Annual flows of glyphosate in the soil from cropping systems in 2020, globally (kton/year) (Zhang et al., under review).

Conclusions

✓ 880 tons of glyphosate and 4,090 tons of AMPA were estimated input to rivers in the year 2020.

✓ Half of the global glyphosate in rivers was contributed by Asian sub-basins.

✓ Approximately two-thirds of the AMPA in rivers globally were in South American sub-basins.

✓ Corn and soybean were main contributors to river pollution with glyphosate and AMPA in the year 2020.

✓ Differences in pesticide use and soil characteristics (e.g., soil and surface runoff) have led to differences in strategies to reduce river pollution across sub-basins.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Integrating stakeholders' preferences into model-based redesign of agricultural landscapes to enhance ecosystem services

PhD candidate: Jiali Cheng (1+3), Farming System Ecology Group & Crop Analysis Group
WUR supervisors: dr. Wopke van der Werf, dr. Jeroen Groot, dr. Andries Richter
CAU supervisors: dr. Wenfeng Cong, dr. Chaochun Zhang

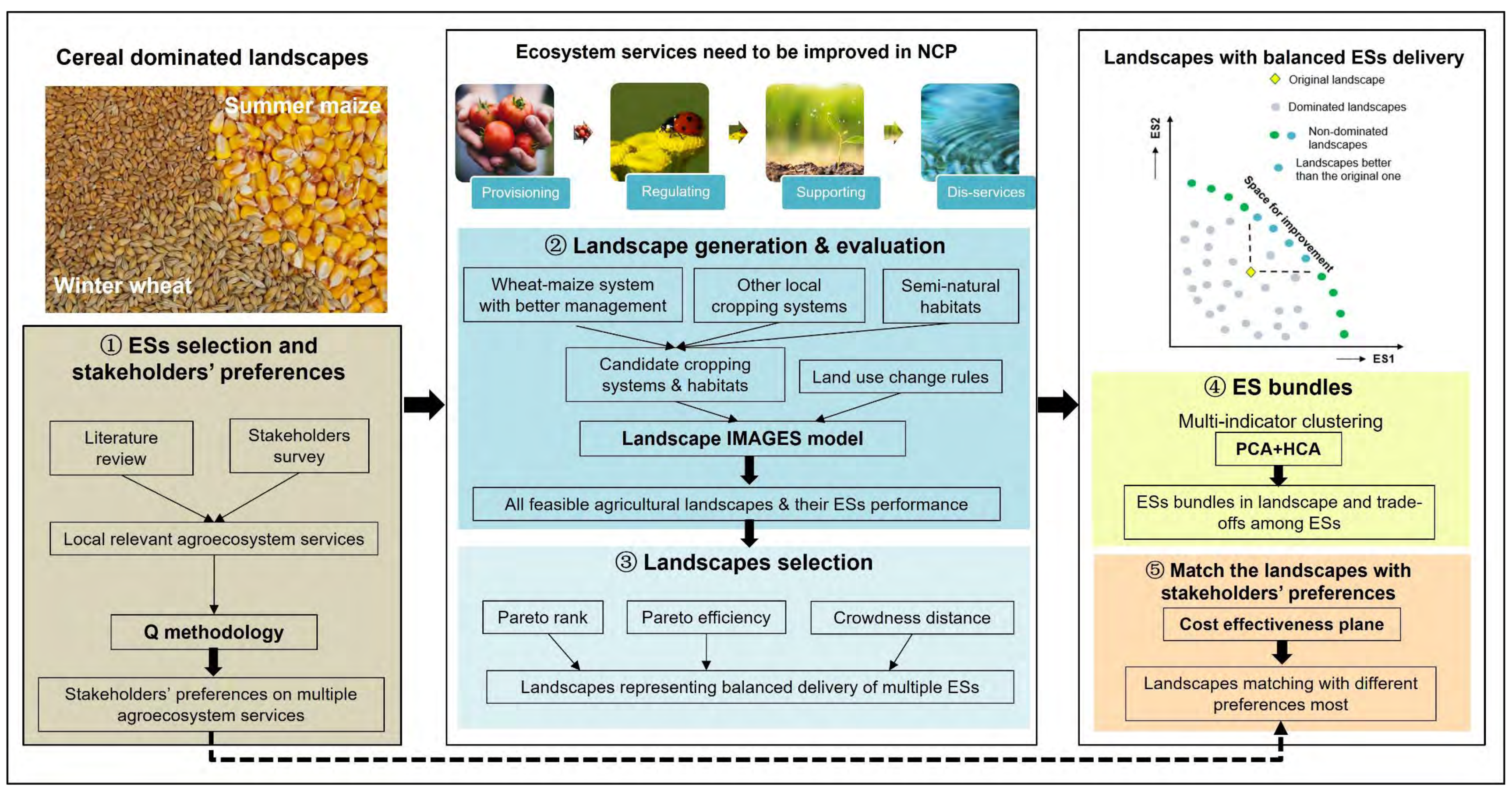
Background

- Multifunctional landscapes aim to provide various ecosystem services (ESs), but dominance by a few cereal species has led to declined ESs.
- Redesigning intensified landscapes is crucial for sustainability, addressing a wide spectrum of ESs.
- Diversified landscapes are believed to reduce dis-services by promoting regulating and supporting services, but trade-offs and stakeholder preferences complicate planning.
- The North China Plain faces issues like groundwater decline and loss of biodiversity due to intensive cropping.
- Efforts to systematically design landscapes are limited, especially in regions like the North China Plain.
- The potential of crop diversification to meet stakeholders' preferences remains largely unknown.

Objectives

- The main objective of this study is to present a model-based methodological framework for redesigning multifunctional agricultural landscapes to tackle the local issues of ESs supply with consideration of stakeholders' preferences.
- Redesign the agricultural landscapes with improved field-scale crop management and more landscape-scale crop diversification that address compromises across a wide spectrum of ESs indicators.
- Characterize the bundles of ESs delivered by selected compromise landscapes to understand their potential contribution to multifunctionality.
- Investigate how these compromise landscapes meet the different preferences from different stakeholders.

Methods



(Proxy) Indicators: Objectives

Provisioning services:
- **Maximum** Provisioning of profit: Gross revenues (CNY/ha/year)
- **Maximum** Provisioning of food: Dietary energy (Gcal/ha/year)

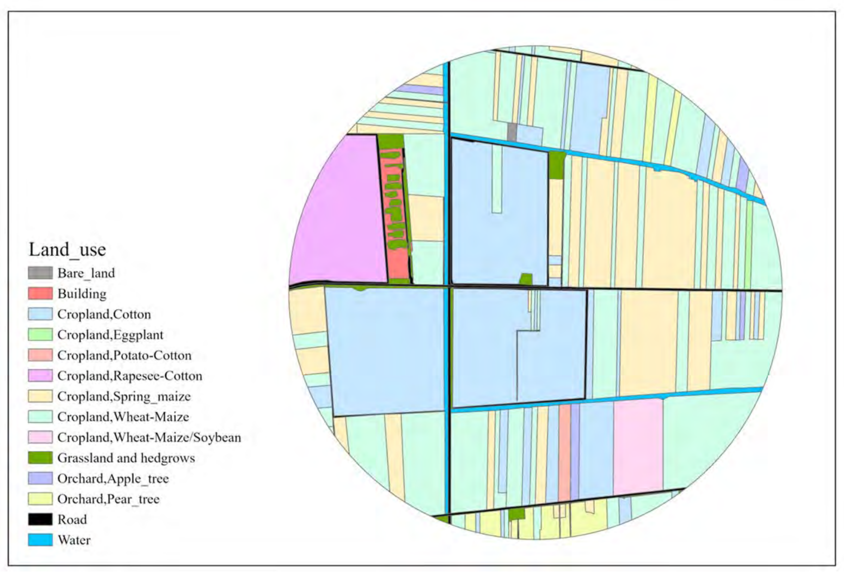
Supporting and regulating services:
- **Minimum** Groundwater sufficiency: irrigation water use amount (mm/year)
- **Maximum** Biodiversity potential: connectivity of potential habitats in the landscape
- **Maximum** Land-use diversity: Satoyama index

Dis-services:
- **Minimum** Health risk: TFI (treatment frequency index of pesticide)

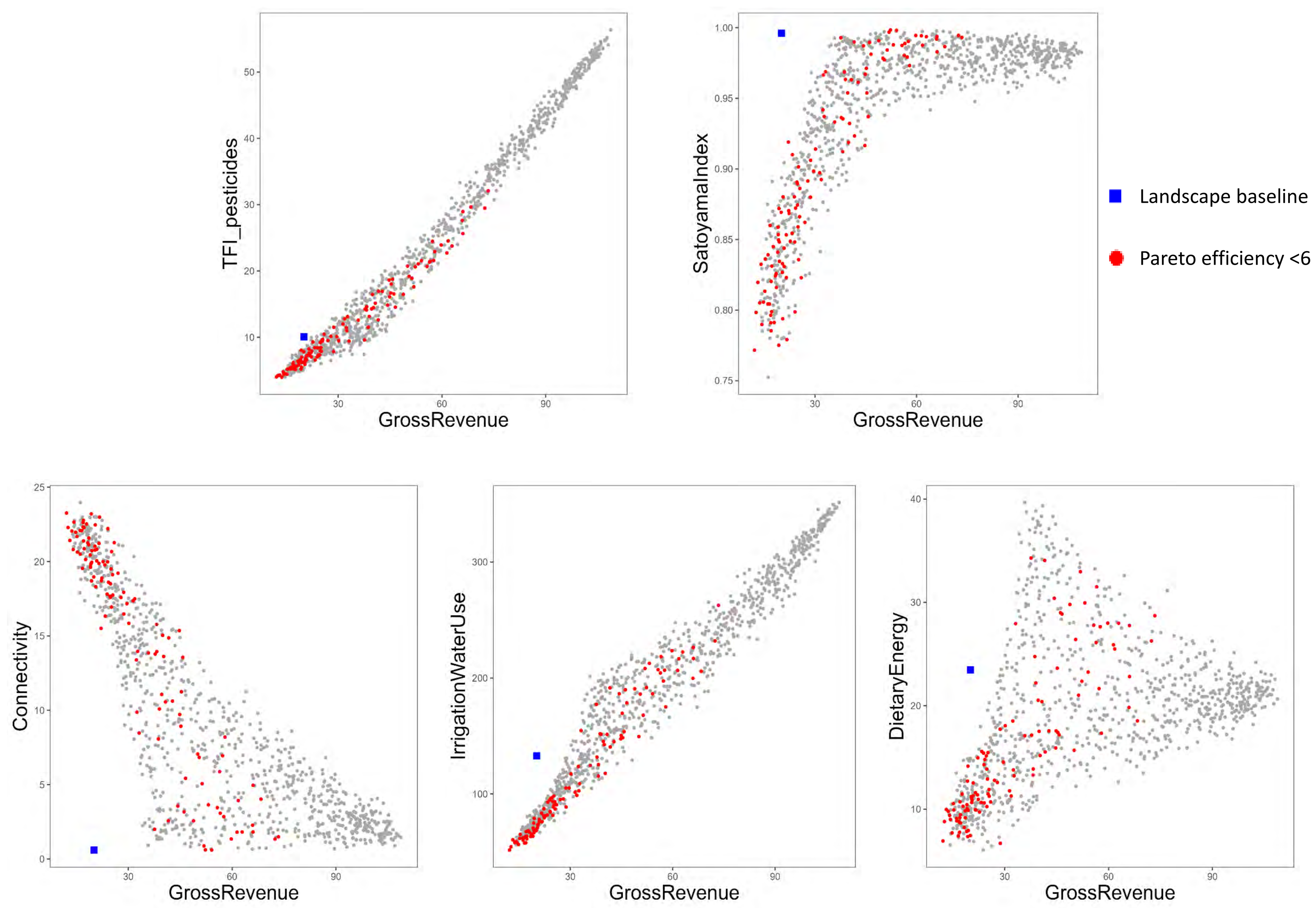
Candidate cropping systems and natural habitats

- Single cropping (6): Spring maize; Cotton; Stevia; Chili; Spring millet; Spring peanut;
- Double cropping/Relay-intercropping (4):
- Winter wheat-Summer maize; Garlic-Maize; Wheat-Millet; Cotton/Mungbean;
- Triple cropping (1): Cabbage-Chili-Spinach
- Semi-natural habitats (1): Wildflower combinations*

Preliminary results



Case study landscape
- A landscape near a typical cereal-based village in Quzhou County, North China Plain.
- Mostly wheat-maize cropping system and cotton system, with little semi-natural habitats area.



Indicator biplot matrix for the entire set of Pareto-optimal landscapes

Conclusions

- Gross revenue is negatively associated with groundwater sufficiency, landscape connectivity, and TFI.
- There are strong trade-offs between gross revenue and other environment quality (proxy) indicators.
- Increasing the gross revenue will also increase the landscape diversity while the diversity is quite low, but will be stable at some point.
- More landscape explicit indicators are still needed.
- The model framework needs to be applied in different landscapes with different composition and configurations and social context.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Model-aided spatial-temporal exploration of sustainable and diversified crop sequence plans for arable farms

Zhengyuan Liang
WUR supervisor: Dr. Jeroen Groot, Dr. Wopke van der Werf
CAU supervisor: Dr. Wenfeng Cong, Prof. Chaochun Zhang, Prof. Fusuo Zhang

Background

- Diversifying crop sequences shows promise to improve farming sustainability in the economic and environmental terms but requires planning.
- Crop sequence generator models can create promising solutions but merely at the plot scale, without considering farm-specific configuration, resource availability and stakeholder demands.

Diversified crop rotation

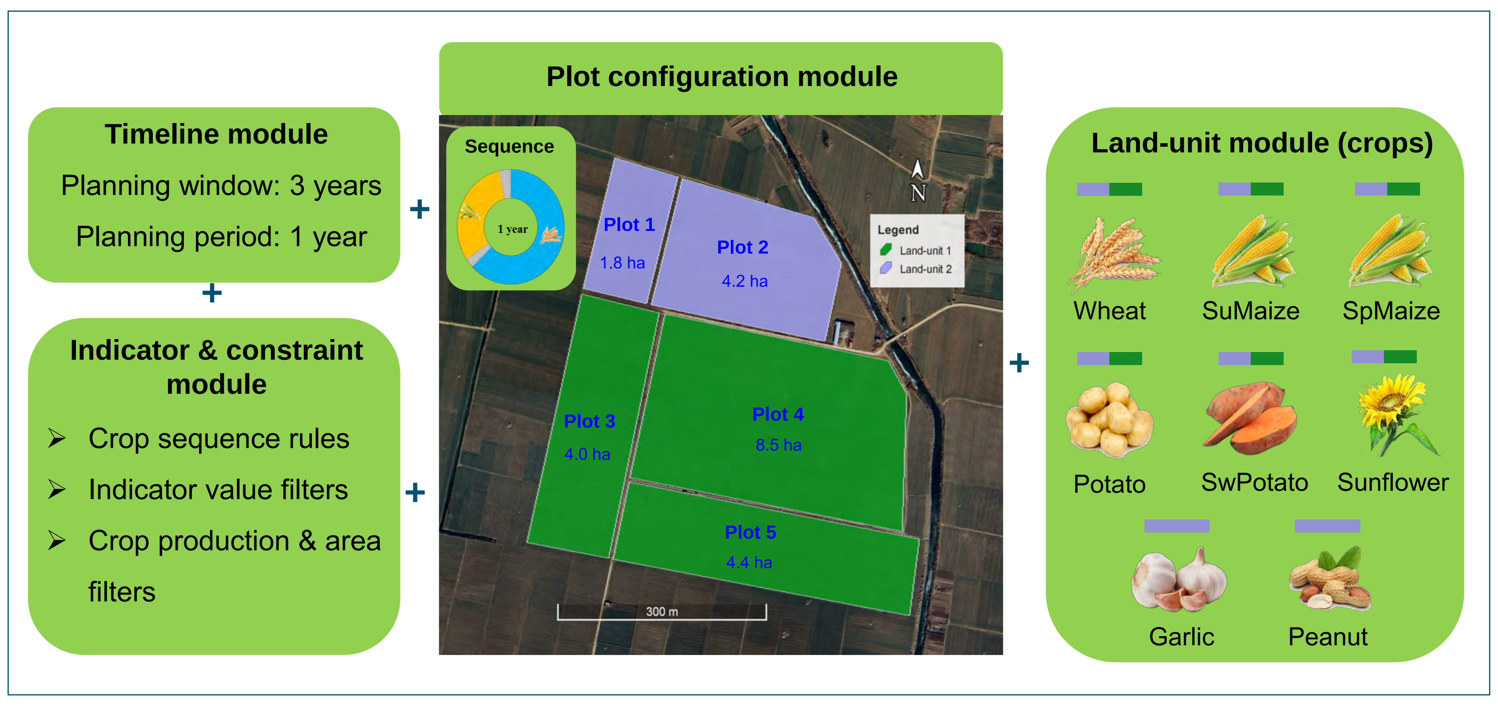
Objectives

- To develop a model tool to systematically generate and assess all feasible whole-farm crop sequence plans aligned with farm-specific situations, and to explore the sustainable and diversified farm cropping plans for a cereal-dominated case farm using this model.

Methods

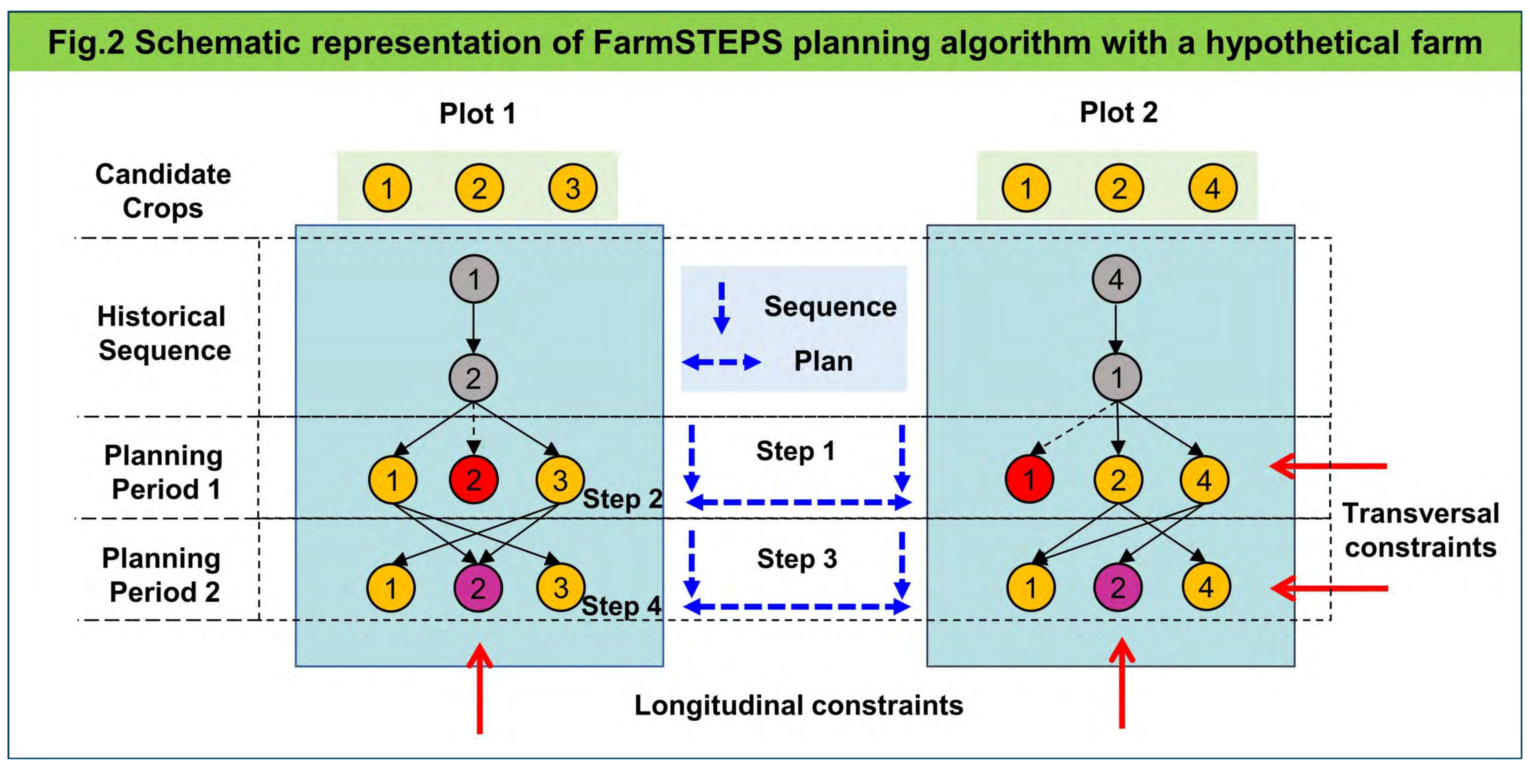
- The FarmSTEPS model was devised and applied in a wheat-maize farm in the North China Plain to increase farm gross margin and reduce environmental costs, i.e., groundwater depletion, pesticide use, aquatic eutrophication, and greenhouse gas emission.
- The application started with farm characterization by loading farm plot map, entering crop input-output inventory, describing the historical and baseline crop sequences, and defining agronomic and farm constraints.

Fig.1 Characterization of the case farm for the FarmSTEPS model



- Then, the model algorithm generated farm crop sequence plans from the first planning period, and repeated the process for next periods until the end of the planning window, subject to predefined constraints.

Fig.2 Schematic representation of FarmSTEPS planning algorithm with a hypothetical farm



Results

- The model created 213,679 feasible farm cropping plans for the future three years and 128 of them were Pareto-optimal.
- Relative to the wheat-maize baseline, optimal plans increased gross margin by 3-50% while mitigating environmental costs by 10-56%, albeit with trade-offs between economic and environmental objectives.

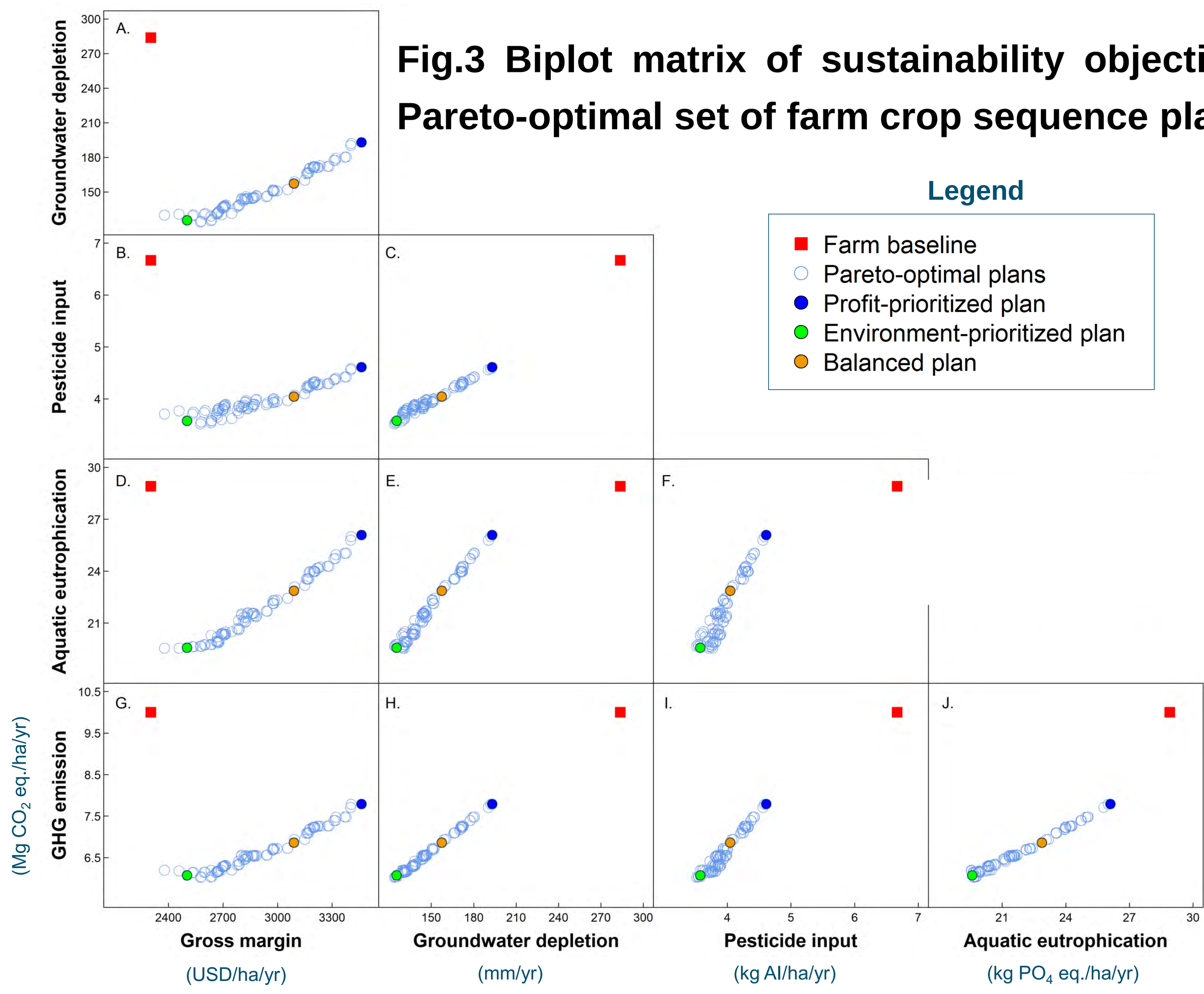
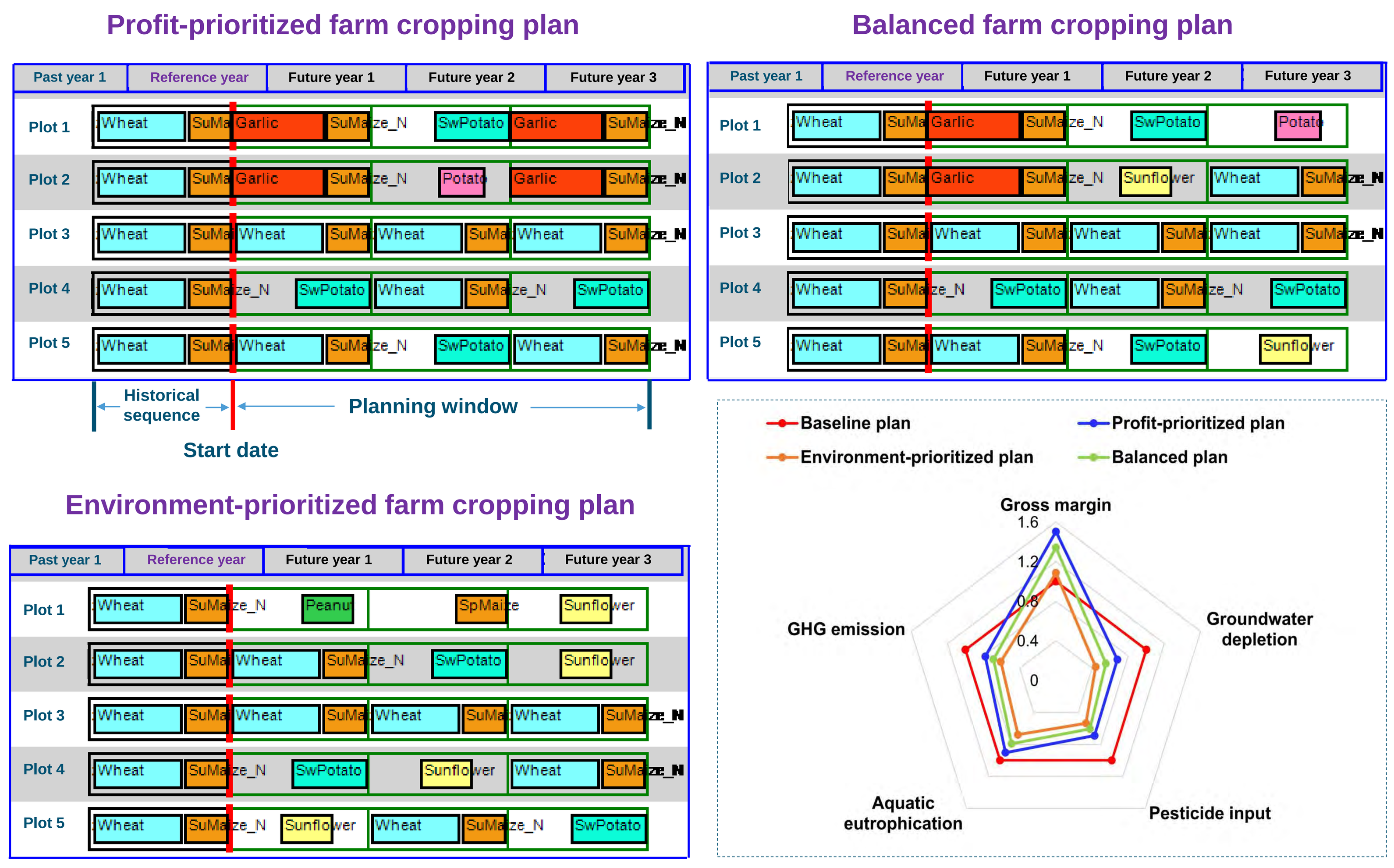


Fig.3 Biplot matrix of sustainability objectives for Pareto-optimal set of farm crop sequence plans

- The improved economic and environmental sustainability of optimal farm cropping plans was attributed to inclusion of garlic, tubers and oil crops, particularly sweet potato and sunflower.

Fig. 4 Examples of sustainable and diversified farm crop sequence plans



Caption: Each of three example farm plans displays crop sequences across five plots of the case farm. The top row denotes the calendar year. Three one-year-long planning periods (shown as red boxes) constitute the entire planning window. The boxes with crop names represents the growing season of the corresponding crops.

Conclusions

- The FarmSTEPS model is an efficient tool to systematically explore diversified and sustainable crop sequence plans tailored to farm-specific conditions and to inform stakeholders on synergies and trade-offs among sustainability objectives.

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We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Unveiling the prevalence of soil-borne fungal pathogens in the North China Plain: a global analysis approach

Mengshuai Liu, Liesje Mommer, Jasper van Ruijven, Wopke van der Werf, Zhan Xu, Fusuo Zhang, Chunxu Song, Jose G. Maciá-Vicente

Background

Soil-borne fungal plant pathogens lead to worldwide economic yield losses to more than 20%. However, despite the agricultural importance of the North China Plain (NCP), little is known about the occurrence and severity of soil-borne fungal pathogens that could potentially affect the yields of three main crops in this area: wheat, maize and soybean. Moreover, to what extent distributions of these soil-borne fungal pathogen species are driven by climatic factors, spatial correlations and host availability is unclear.

Objectives

In this study, we aim to (1) identify the major soil-borne fungal pathogens that could potentially affect maize, wheat and soybean in the NCP; (2) evaluate the prevalence of these pathogens in the NCP as compared to their distribution at increasingly larger scales (i.e. within China and globally); and (3) identify the main predictors influencing the distribution of these pathogens, with a particular emphasis on the availability of the specific host crop species (evaluated through regional crop area density).

Methods

(1) Selection of focal pathogens: they have been reported in the literature as causal agents of disease in at least one of these crop species; they are soil-borne (i.e. transmitted via soil); the diseases that they cause have been reported to cause agricultural yield losses in the NCP.
(2) Retrieval of pathogen distribution, climatic, spatial and host data.
(3) Analysis of pathogen distributions: the proportion of studies per country/province where the target pathogen was detected.
(4) Linear models were fitted to estimate the effects of climatic, the selected spatial, host availability and covariates variable on pathogen prevalence data (Fig. 1).

Fig. 1 Conceptual model of this study. The global distribution of soil-borne fungal pathogens that represent potential threats for main crop production in NCP and the factors driving their global distributions are assessed to provide roadmaps for potential improvements.

Results

We identified 25 soil-borne fungal pathogen species that could potentially affect the productivity of the main crops produced in NCP. Respect to the global and China scales, we identified 13 pathogen species to be disproportionately overrepresented in the NCP (Fig. 2).

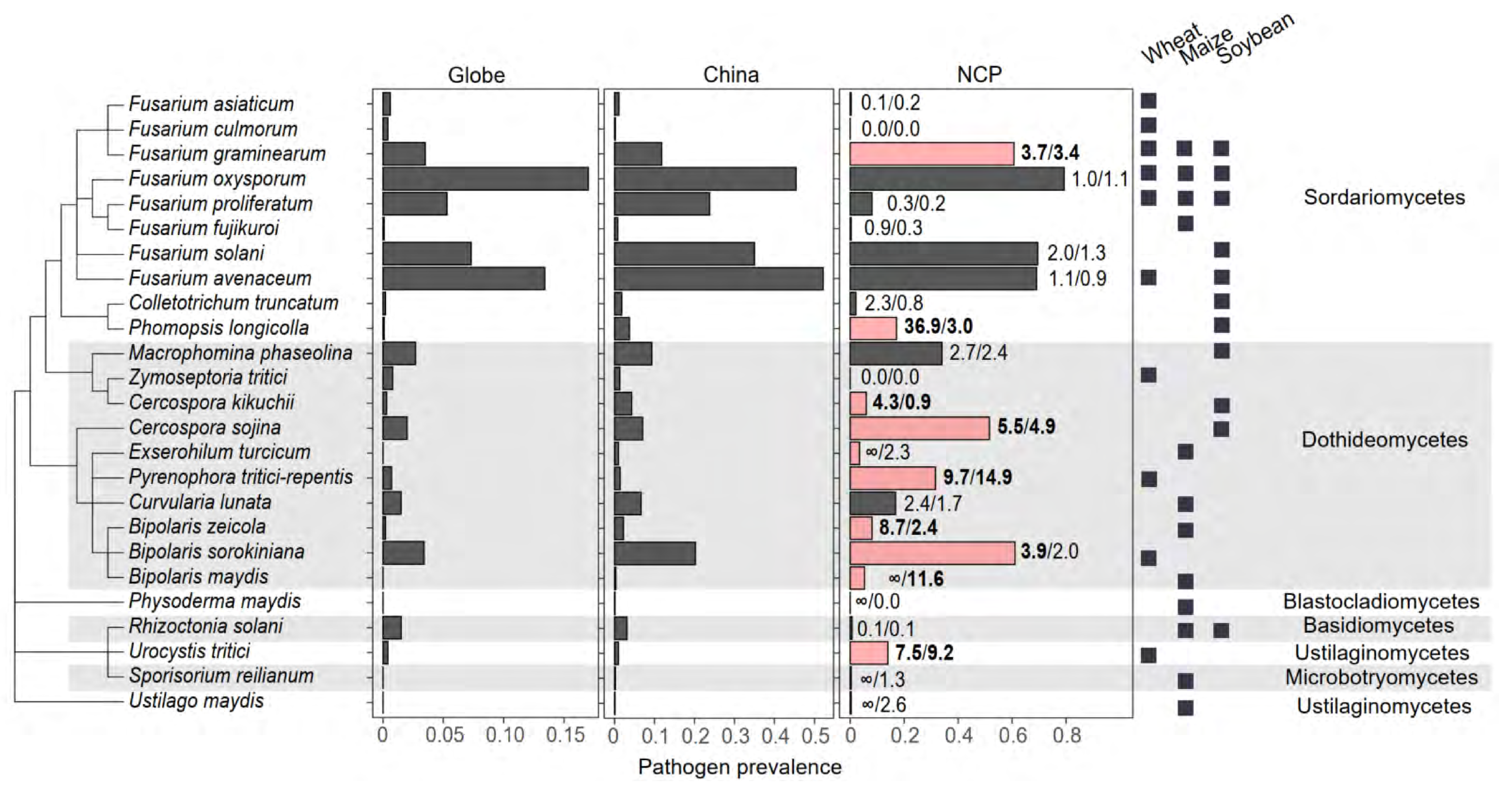

Fig. 2 Prevalence profile of the 25 selected soil-borne fungal pathogens at the three scales considered (Global, China, and NCP). The red bars highlight the pathogens identified as being overrepresented in the NCP as compared to the globe and China scales.

Two specialist pathogens - *Urocystis tritici* and *Sporisorium reilianum* (both biotrophic Basidiomycota) were positively related to regional crop area density of their respective host crops (Fig. 3).

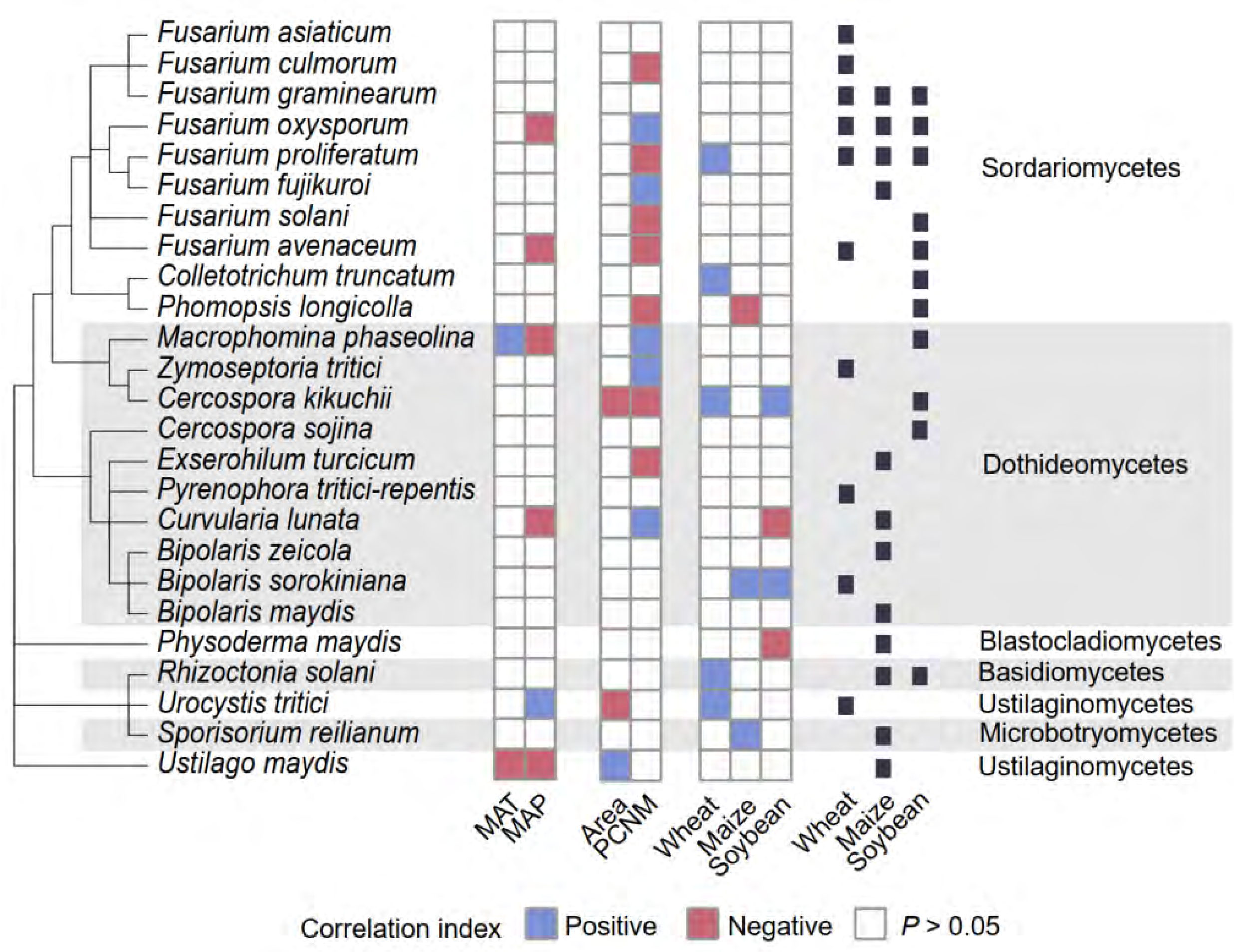

Fig. 3 Relationship between ecological drivers and the prevalence of selected soil-borne fungal pathogen species.

Conclusions

Our study provides valuable insights for implementing approaches to enhance crop sustainability in the NCP. By establishing an inventory of pathogen prevalence in the region, our research serves as a foundation for developing sustainable agricultural systems that are more resilient against soil-borne fungal diseases in the future.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Diversity and sustainability of crops and cropping systems in a cereal-dominated area, the North China Plain

Zhan Xu
WUR supervisor: Dr. Wopke van der Werf, Dr. Jeroen Groot
CAU supervisor: Prof. Chaochun Zhang, Prof. Wenfeng Cong

Background

- The specialization and intensification of food production have resulted in reduced crop diversity, shorter crop rotation, and more uniform agricultural landscapes, all of which contribute to various sustainability challenges.
- The North China Plain is one of the most important granaries of China and the crop production has been intensified and simplified, by shifting from three crops in two years to two crops per year.
- Researchers have suggested that diversifying crop production systems and increasing agricultural land-use diversity could be core areas of action to enhance crop production sustainability in the North China Plain.

Objectives

- To access the current state of diversification and its potential in the North China Plain in practical applications;
- To explore the relationship between diversity and crop production sustainability.

Methods

We developed a hierachical stratified random sampling scheme to collect data to ensure survey representativenes. We collected information on farming households and agricultural practices on all plots greater than 0.5 mu (1/30th ha) on a farm.

Each species was classified into a livelihood functional group, which was defined as a set of species with similar impacts on the livelihood of local people (Table 1).

Table 1. The description of crop functional groups based on their impact on local livelihood

Crop functional group	Description
Food crops	Crops are providing dietary energy, including cereals and sweet potato in Quzhou.
Feed crops	Crops are used to feed domesticated livestock, such as pigs and chickens.
Fiber crops	Crops are characterized by a high concentration of cellulose, which gives it strength. Fiber crops are used to make cloth, paper, or rope.
Condiments	Crops produce edible materials used in small amounts to flavor food.
Grain legumes	Crops used for the seeds of plants from the Fabaceae family, usually consumed to fulfill protein requirements.
Oil crops	Producing seeds with high fat amount are used to produce vegetable oils.
Vegetables	Vegetables can be eaten raw or cooked and play an important role in nutrient and vitamin supply.
Fruit	Crops that are sweet or sour seed-bearing and can be eaten raw.
Medicinal plants	Plant that possesses therapeutic properties or exerts a beneficial pharmacological effect on the human or animal body.

We calculated overall benefit and trade-offs of sustainability for cropping systems.

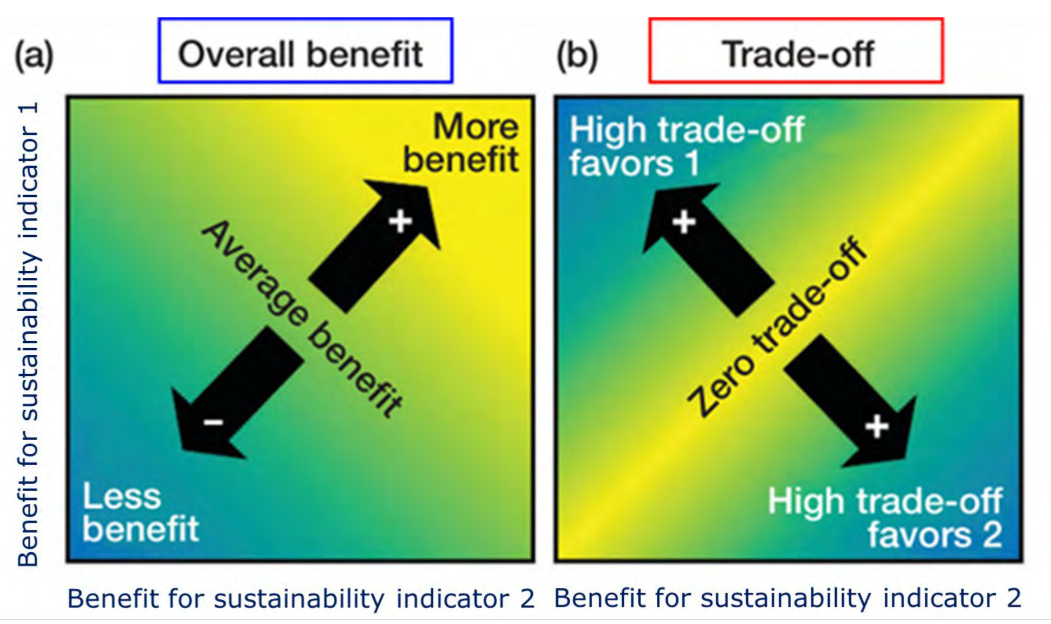

Fig.1 "Illustration and example of overall benefit and trade-off between two sustainability indicators. (a) Overall benefit is calculated as the mean of individual benefits and increases from low benefit in the lower left to greater benefit in the upper right. (b) Trade-off is calculated as the root mean squared error of the individual benefits and increases with distance from the 1:1 line, where benefit in 1 equals benefit in 2." From: Bradford and D'Amato (2012).

Results

- Among the 505 farm surveyed, 28 crop species and sixty-one cropping systems were recorded. Maize and wheat emerged as the predominant crops, and cotton was the third most common crop.
- The sustainability performances exhibited variability across crop functional groups, with variations observed with each functional group. No functioanl groups showed high benefits across all three sustainability dimensions, including environmental benefit, social benefit and economic benefit.
- Sixty-one cropping systems were divided into five clusters, considering their sustianability performances.

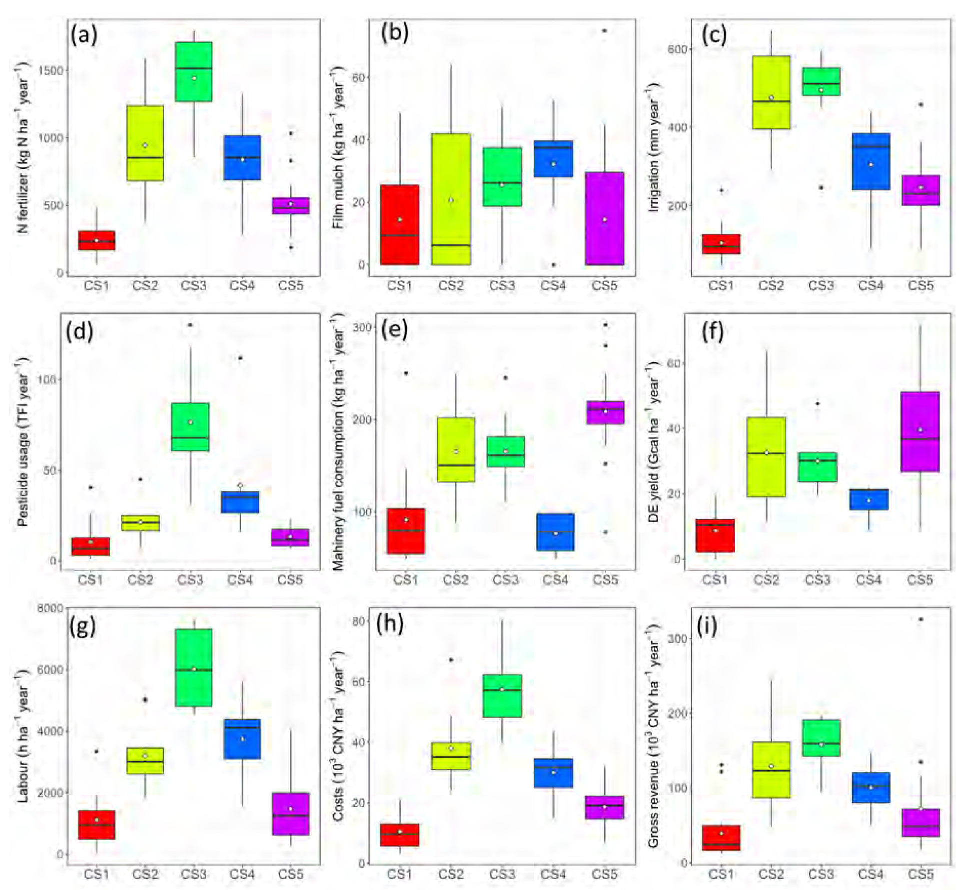

Fig. 2 Sustainability indicators of clusters (CS1-CS5) of cropping systems. The white rhombus indicates the average value of a cluster and the black horizontal line indicates the median value of a cluster. The whisker indicates the minimum value and the maximum value of a cluster.

- Compared to cropping systems consisting of a single functional group, those with a greater diversity of functional groups generally exhibited either higher overall benefit or lower tarde-off, but could not achieving both simultaneously.

Table 2. Average number of functional groupsm benefits and trade-offs for cropping system types

Cropping system type	Average number of functional groups	Benefit				Trade-off
		Environment	Social	Economic	Overall	
CS1	1.24	0.86	0.49	0.49	0.61	0.22
CS2	1.44	0.56	0.51	0.47	0.51	0.08
CS3	1.00	0.40	0.32	0.38	0.37	0.10
CS4	1.00	0.65	0.38	0.47	0.50	0.14
CS5	2.00	0.69	0.70	0.49	0.63	0.15

Conclusions

- The landscape was used to cultivate 28 different crop species across nine functional groups, each contributing to the local livelihoods in distinct ways. However, at the farm scale crop diversity was low, with an average of 2.6 crop species and 2.5 functioanl groups per farm.
- Sustainability of cropping systems was not just related to species diversity per se but rather to diversity in functional groups. However, the relationship between overall benefit or trade-off and functional group diversity was not linear.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Improving Zinc flows in the food chain of China for human and environmental health

Lu Liu（2+2）
Supervised by: TjeerdJan Stomph, Wopke van der Werf, Wenfeng Cong, Fusuo Zhang

Background

Zinc (Zn) is an extremely important nutrient for human health and is involved in the life activities of more than 300 enzymes in the body. The potential problems caused by insufficient dietary Zn intake threaten the health of the Chinese population. At the same time, as a kind of heavy metal element, more evidences have shown that Zn is one of the most important polluting elements in farmland soil. There is still a lack of systematic and comprehensive evaluation of Zn nutrition from a food chain perspective and effect on both nutrition supply and environmental health.

Objectives

Using data from statistical yearbook and literatures, this study aims to quantify the Zn flows and their changes from 1990 to 2030 in China with NUFER (NUtrient flows in Food chains, Environment and Resources use) model, evaluate supply and demand balance of Zn in food and explore the potential of relevant policies on the change of Zn flow and impact on the soil and environment.

Methods

Definition of system
The food chain system is divided into four subsystems, including crop production subsystem, animal production subsystem, food processing subsystem and household consumption subsystem, which is also defined as the food nutrient pyramid.

The research objects includes 17 main crops, 11 main livestock and poultry, and the household consumption subsystem was divided into urban households and rural households.

Data source
The data for this study mainly came from various government statistical databases and scientific literatures, including three time scales, including 1990, 2010 and 2030. The planting area and yield of various crops in 1990 and 2010 were mainly obtained from China Statistical Yearbook and China Rural Statistical Yearbook, and the production of livestock and poultry breeding was obtained from China Animal Husbandry Yearbook. Crop production and livestock breeding data for 2030 are derived from projections in the literatures.

Calculation Module
The calculation in this study is based on the nutrient flow model of the food chain system. Input-output balance was made in each subsystem.

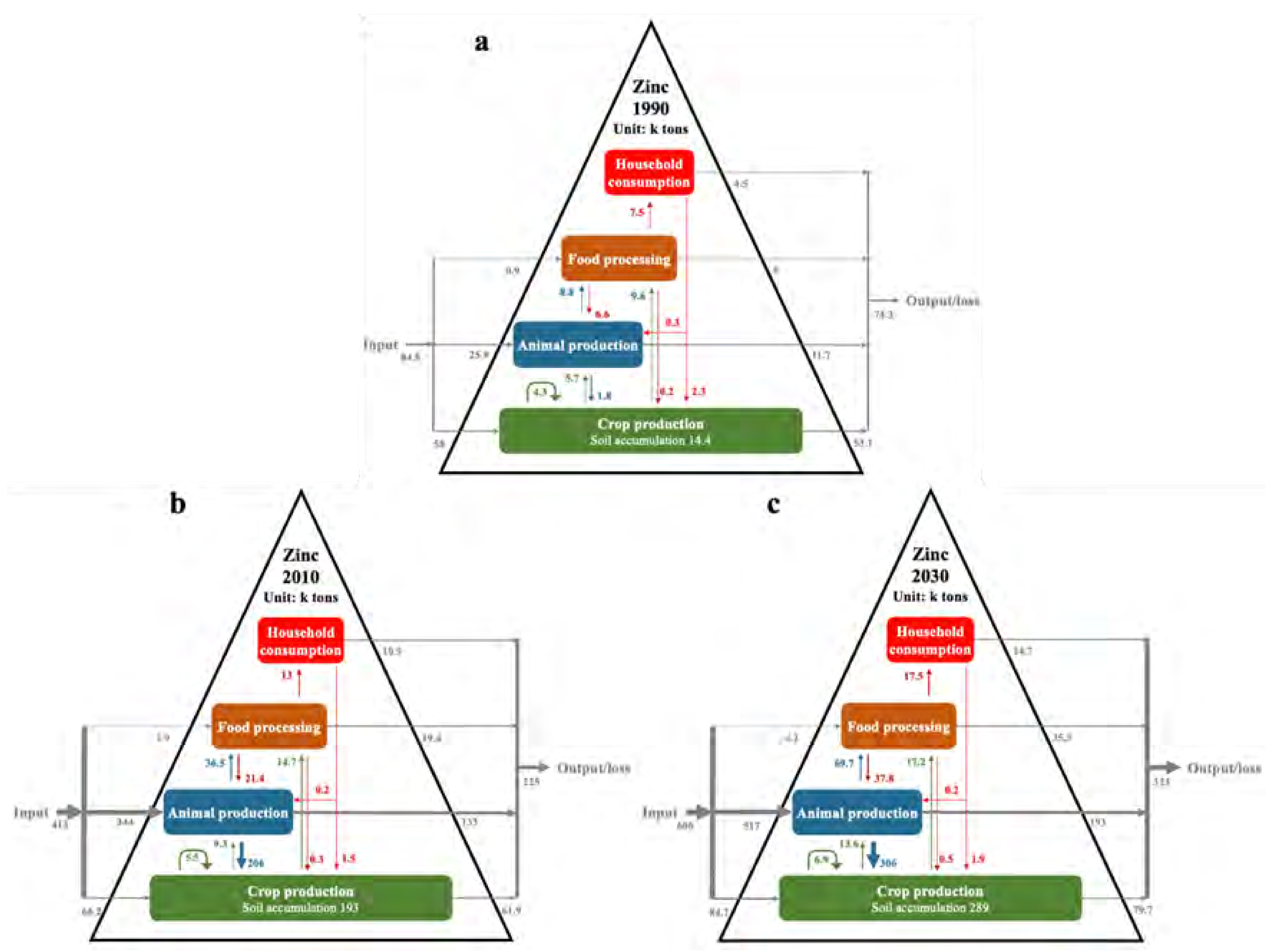
Results

In 1990, 84.8k tons of exogenous Zn was imported into the food chain, including 48.2k tons of dry and wet deposition, (Figure 1a). Output and loss amounted to 74.3k tons of Zn, of which 46.9k tons were leached into the environment from soil, 0.4k tons were absorbed and stored by the human body.

In 2010, 413k tons of exogenous Zn was imported into the food chain, including 336k tons of waste feed and feed additives (Figure 1b). The output and loss amounted to 225k tons of Zn, of which 53.6k tons were leached into the environment from.

It is estimated that in 2030, the import of exogenous Zn into the food chain will reach 606k tons, including 504k tons of waste feed and feed additives (Figure 1c). Output and loss amounted to 323k tons of Zn, of which 193k tons were not returned to the field in the manure and urine of livestock and poultry but flowed out of the food chain.

Figure 1. The Zn flows in the food chain in China in 1990 (a), 2010 (b) and 2030 (c) as a pyramid



Conclusions

The main flow of Zn has changed from the natural process dominated by atmosphere deposition and soil leaching in the 1990s to the man-made process dominated by feed addition and manure discharge in livestock and poultry farming in 2010, and the nutrient flow of Zn into the environment through livestock and poultry manure will further develop in 2030. In order to improving the Zn flow efficiency and reducing the environment pollution, it is necessary to formulate corresponding policies and standards to restrict the use of Zn feed additives and the detection and discharge of livestock and poultry feces.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Evaluating genotype-environment-management interactions for maize cultivars to tap biological potential yield in different zones of China

Author: Yujie Yang
Supervisors： CAU: Qingchun Pan, Lixing Yuan; WUR: Jochem Evers, Tjeerd Jan Stomph

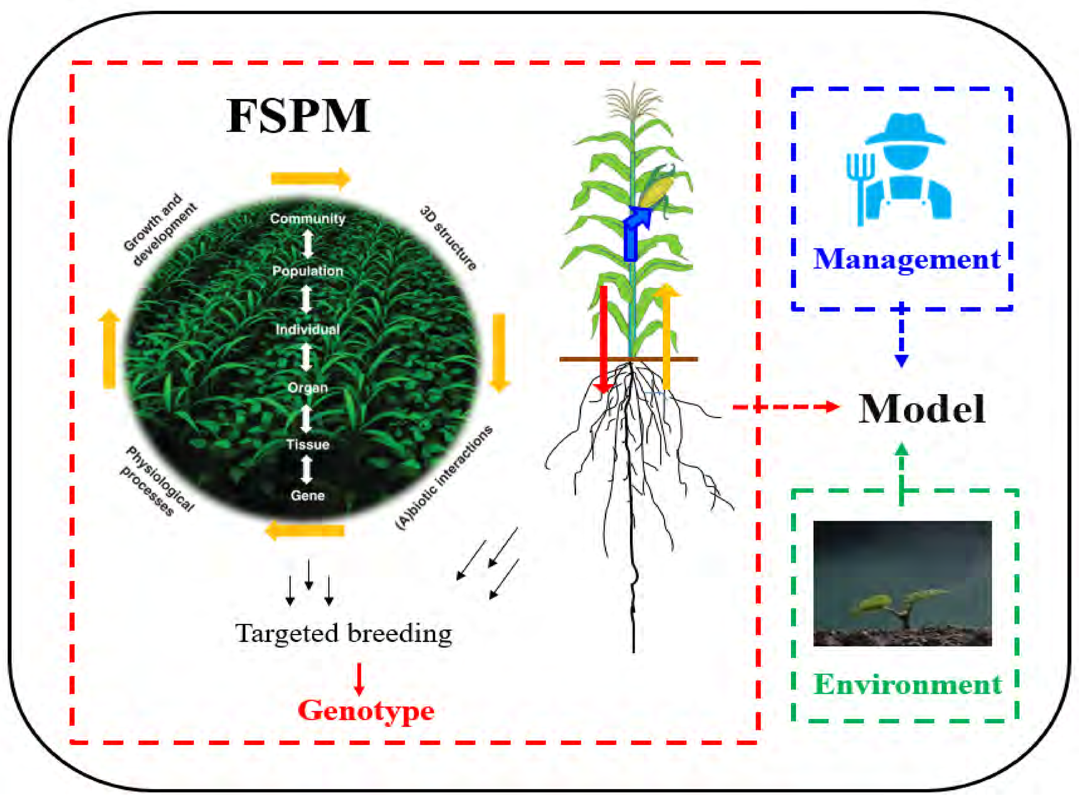
Background

In China:

➢**Genotype**
2000-2019, 1362 maize varieties were authorized.

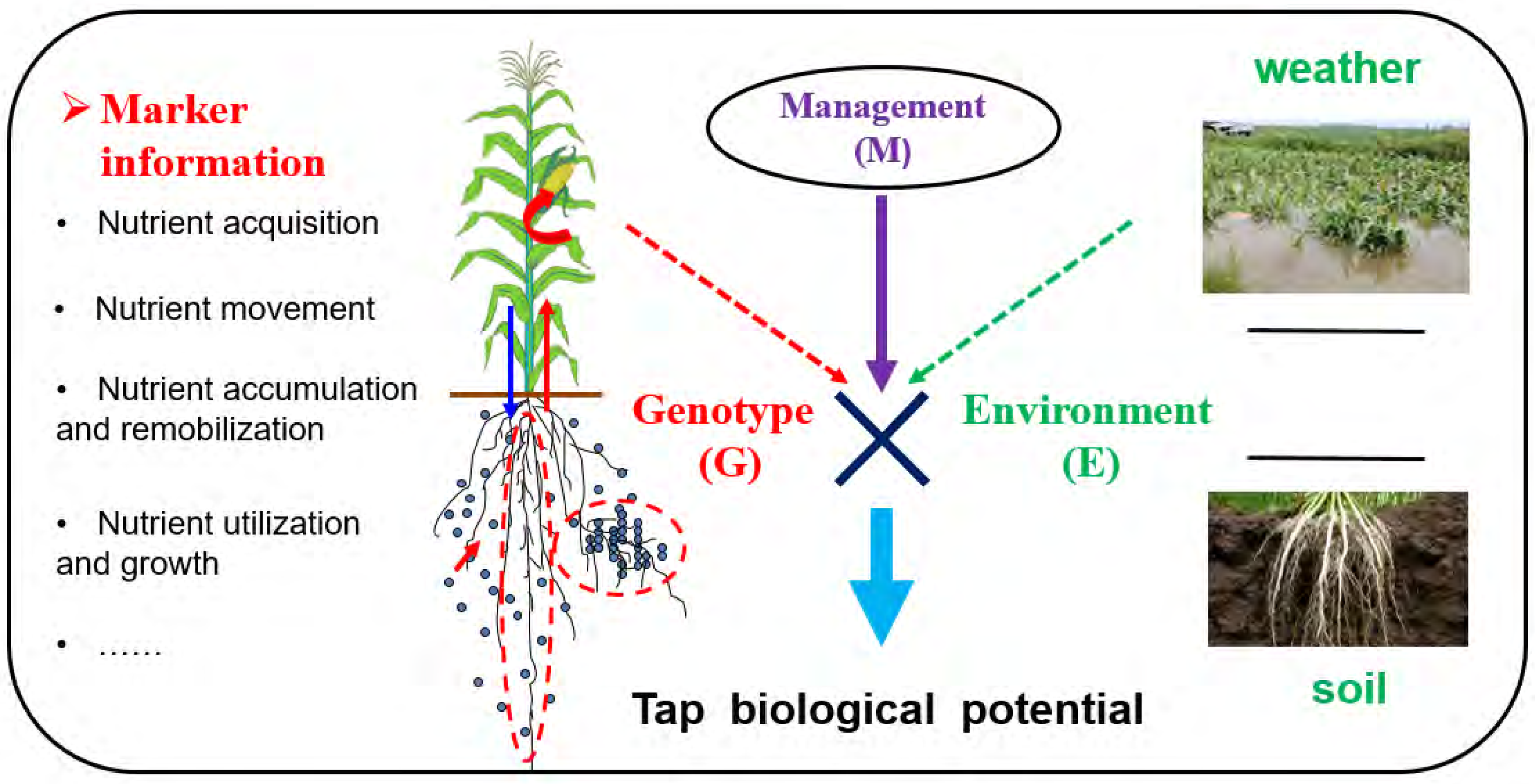
➢**Environment**
- Longitude and latitude
- Precipitation
- Photoperiod
- Temperature
- ……

➢**Management**
- Fertilizers
- Pesticide
- Planting patterns
- ……



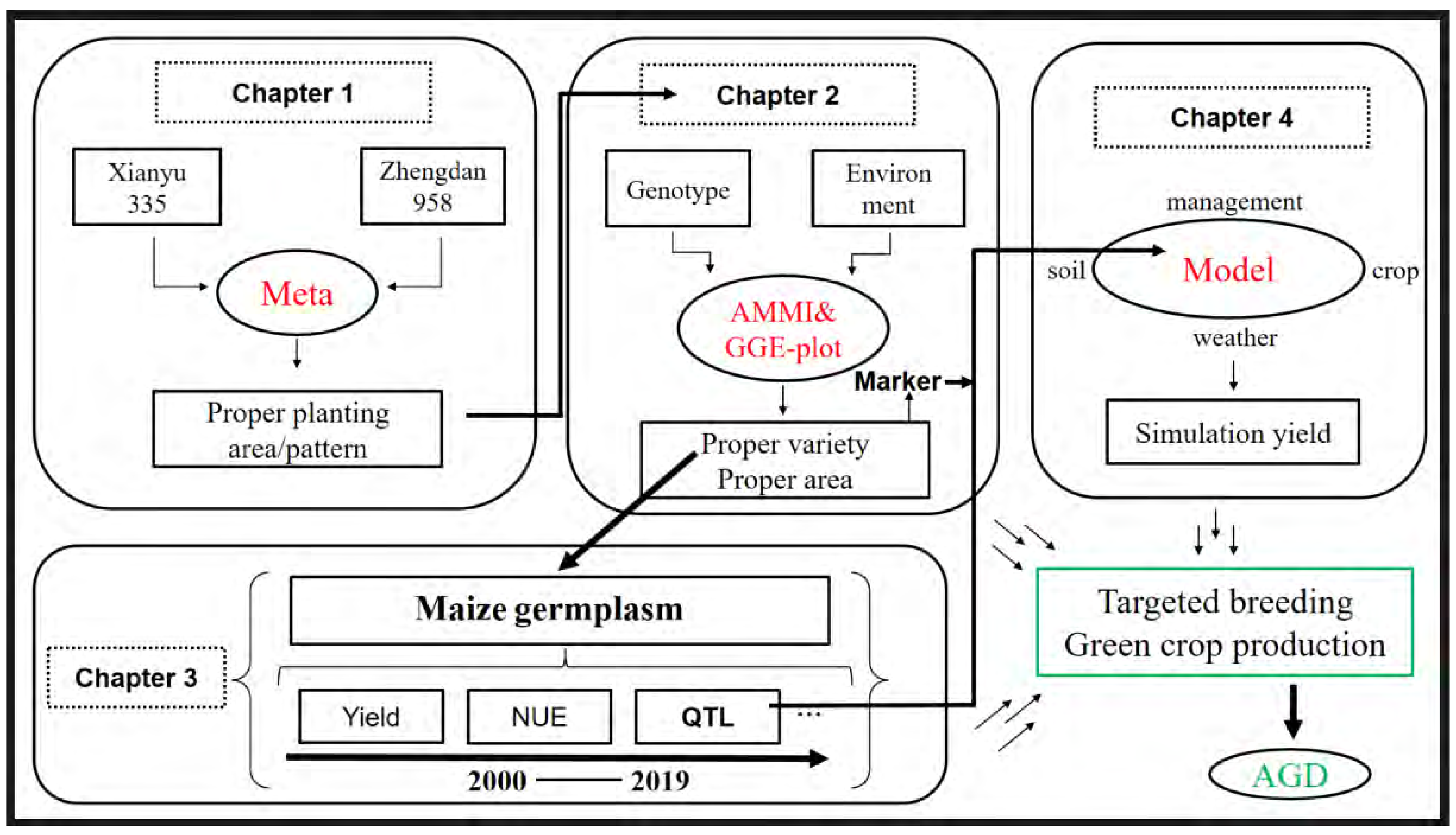
Research question: How to use GEM models to predict the potential yield of different maize varieties in different regions of China?

Objective



- High yield
- High efficient utilization of resource
- Low environmental cost

Method-roadmap



Results

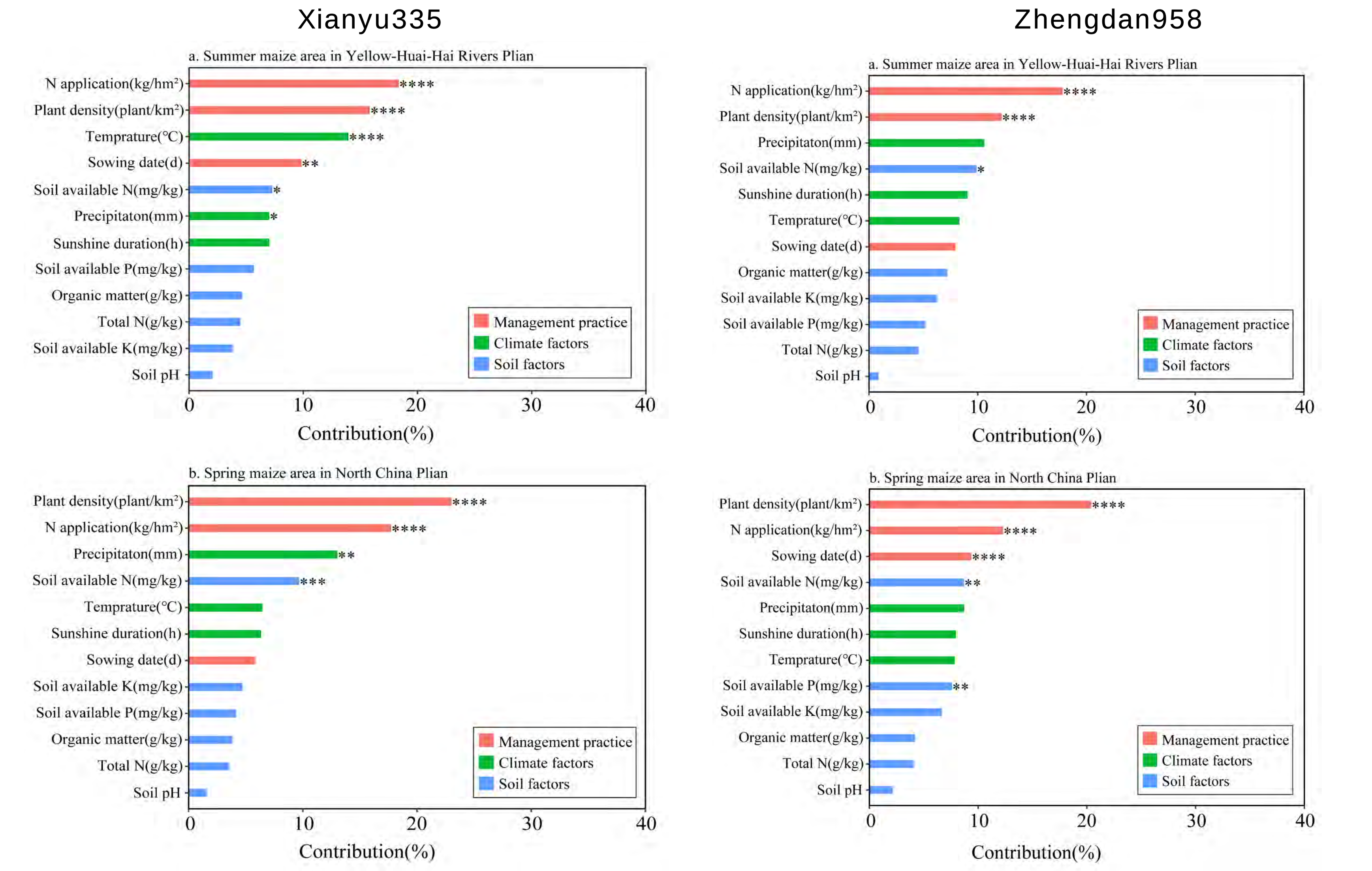


Figure 1. The contribution rate of different factors to the yield of Zhengdan958 in different regions of China. The importance values are derived from a random forest analysis. **** p < 0.0001, *** p < 0.001, ** p < 0.01 and * p< 0.05. (a: Summer maize area in Yellow-Huai-hai Rivers Plain and b: Spring maize area in North China Plain).

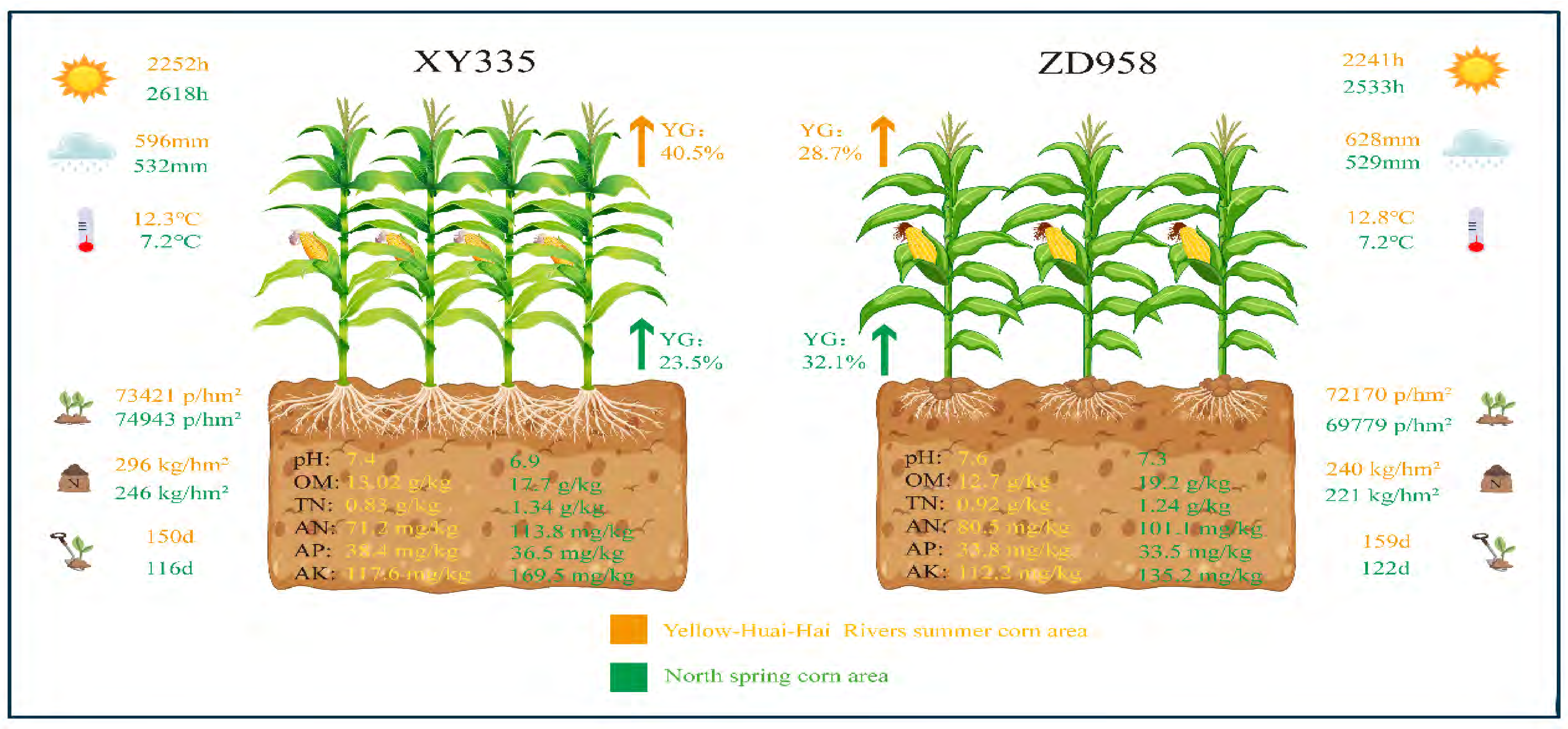


Figure 2. The corresponding optimal management practices (plant density, N application and sowing date), suitable weather condition (sunshine duration, precipitation and temperature) and proper soil environment (soil pH, soil organic matter, soil total N, soil available N, soil available P, soil available K) of two maize cultivars in the two major corn producing areas.

Conclusions

➢ 1) These results suggest that Xianyu335 is more sensitive to density and fertilization than Zhengdan958. Additionally, Xianyu335 shows a higher sensitivity to temperature and rainfall, while the yield of Zhengdan958 is more stable in the face of changes in weather conditions. However, Zhengdan958 is more suitable for soil environments with higher levels of available potassium and phosphorus.

➢ 2) XY335 had higher potential yield than ZD958 in different areas under high N condition. XY335 has greater production potential in the Huang-Huai-hai region. While ZD958 has greater production potential in the North spring corn area.

References & Acknowledgements

- [1] Wang EL, Brown HE, Rebetzke GL et al. Improving process-based crop models to better capture genotype×environment×management interactions. Journal of Experimental Botany, 2019, 70: 2389-2401.
- [2] Chen XP, Cui ZL, Vitousek PM, et al. Integrated soil-crop system management for food security. Proceedings of the National Academy of Sciences, 2011, 108: 6399-6404.
- [3] Rakshit A, Singh HB, Sen A. Nutrient use efficiency: from basics to advances. Springer Publishing Company, 2015, ISBN 978-81-322-2168-5.

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Overview PhD projects – starting year 2020

Posters, May 2024

Theme: Green and nutritious food provision & governance

Name	*Model**	*Project*
1. Yujun Wei	1+3	Evaluating and innovating Green Food system using smart sustainability assessment and novel circular biotechnology
2. Yi Zhang	2+2	Evaluating and innovating Green Food system using smart sustainability assessment and novel circular biotechnology
3. Chenqiang Qin	2+2	Exploring green transformation of plant extract industry: a case study on CCGB
4. Ruijin Luo	2+2	Green Food Impulse: Multi-model Decision Support for Market Driven Circular Green Food Supply Chain Networks in China
5. Junhan Zhang	1+3	Green Food Impulse: Multi-model Decision Support for Market Driven Circular Green Food Supply Chain Networks in China
6. Zhiyao Chang	2+2	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
7. Xiaoxia Guo	2+2	Upscaling China's Science and Technology Backyards (STB) through modified technologies and policies

Theme: Green animal production

Name	*Model**	*Project*
8. Rui Shi	1+3	Developing sustainable breeding strategies for dairy cattle in China with emphasis on improved resilience
9. Yujuan He	2+2	Diversifying forage production systems: increasing productivity and resource use efficiency
10. Hao Liu	1+3	Diversifying forage production systems: increasing productivity and resource use efficiency
11. Dongdong Lu	2+2	Effects of alternative dietary fibre sources and dietary protein levels in lactating sow diets on reproductive performance and litter characteristics
12. Weitong Long	1+3	Optimization and designing of integrated crop-livestock systems
13. Zhenpeng Hu	1+3	The pig toilet as solution for animal welfare and environmental-friendly pig production
14. Fei Xie	2+2	The pig toilet as solution for animal welfare and environmental-friendly pig production

Theme: Green ecological environment

Name	*Model**	*Project*
15. Juhui Chen	2+2	Labelling for sustainable development: perspective from both production and marketing
16. Haorang Li	1+3	Labelling for sustainable development: perspective from both production and marketing
17. Sijie Feng	2+2	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach
18. Donghao Xu	1+3	Towards sustainable nitrogen and acidification management in the Quzhou and Zhaoyuan counties and the North China Plain

Theme: Green plant production

Name	*Model**	*Project*
19. Zhaoqi Bin	1+3	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
20. Ruotong Zhao	2+2	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
21. Bowen Ma	2+2	Developing sustainable diversified crop production systems for the North China Plain
22. Laiquan Luo	1+3	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
23. Yuxiang Wang	2+2	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
24. Jiyu Jia	2+2	Linking aggregated soil attributes to ecosystem functions: mechanistic understanding of soil management – ecosystem function relationships and analyses of possible trade-offs
25. Yizan Li	1+3	Linking aggregated soil attributes to ecosystem functions: mechanistic understanding of soil management – ecosystem function relationships and analyses of possible trade-offs
26. Yanjie Chen	2+2	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
27. Bo Wang	2+2	Towards more sustainable groundwater use for food security in Quzhou
28. Yalin Liu	2+2	Waste2C: From Waste to Crop – Quzhou as a Living Lab for Sustainable Agro-Food systems

Model*: There are two different types of PhD candidates, hence 2 models.
2+2 model: Graduates at CAU; project starts and ends in China; stays for two consecutive years in Wageningen.
1+3 model: Graduates at WU; project starts in China; stays for three consecutive years in Wageningen.

The complexities of decision-making in food waste valorization: A critical review

Yujun Wei, Marta Rodriguez-Illera, Xuezhen Guo, Martijntje Vollebregt, Xuexian Li, Huub Rijnaarts, Wei-Shan Chen

Background

Food waste hierarchy is a widely used framework to guide the decision-making in food waste valorization (FWV). However, an increasing number of studies demonstrated that the hierarchy cannot reflect the rank of sustainability performance. Besides food waste hierarchy, a wide range of studies has been conducted to support and enhance decision-making in FWV, leading to diverse decision-support approaches for FWV (DSA-FWV). However, most studies tend to take an individual perspective via case studies, upon which they are prone to address only part of the overall decision-making puzzle. The diverse system boundaries and diverse DSA-FWV result in several issues in advancing this research area. It is also difficult for decision-makers to position their work into the whole FWV system.

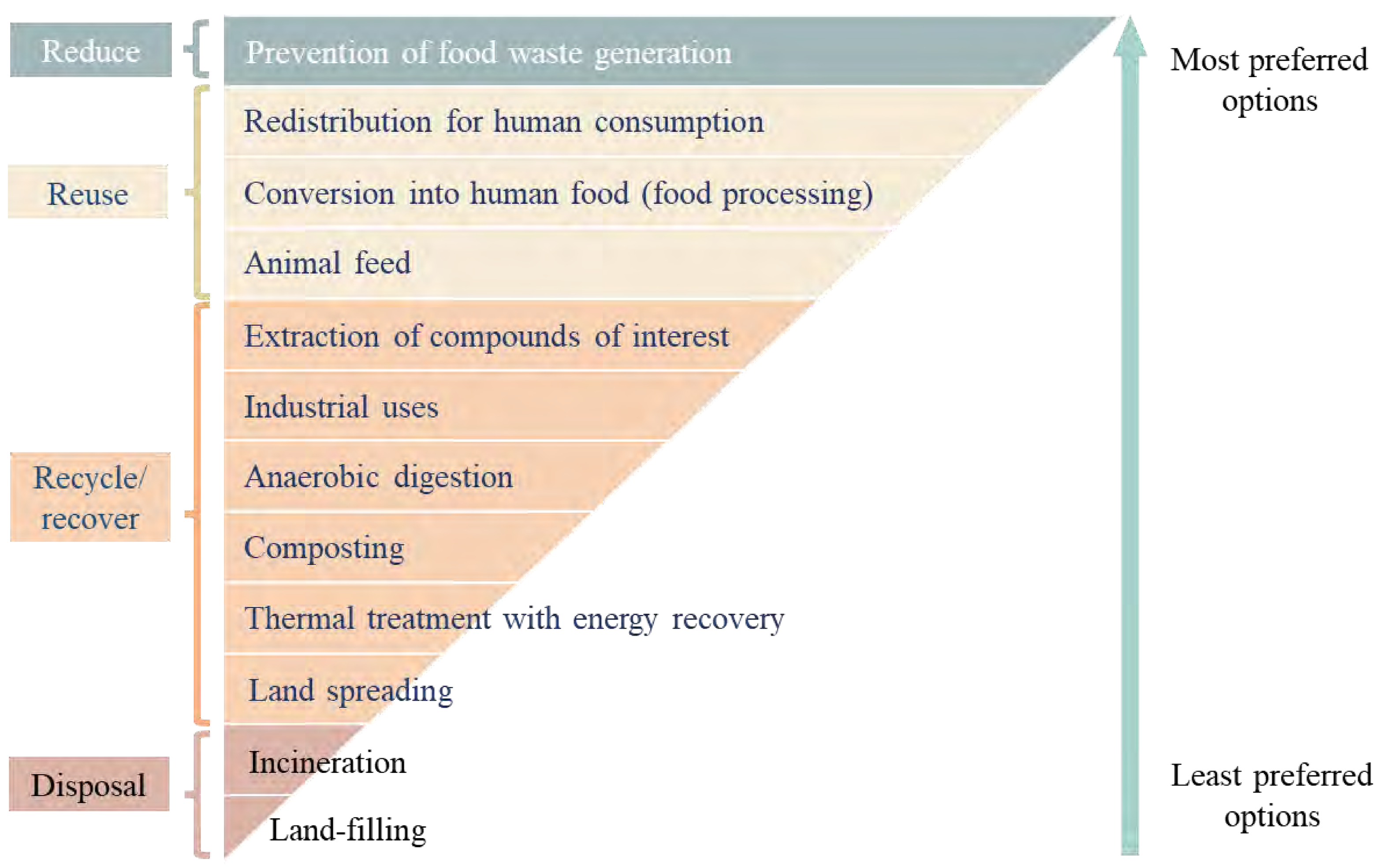

Fig 1. Waste hierarchy for surplus food and food waste (Food waste hierarchy), adapted from Garcia-Garcia et al. (2017).

Objectives

This research will try to achieve the following research objectives:

(1) What decisions are relevant in the context of FWV decision-making, and how do they connect?

(2) What decision-support approaches and indicators have been employed to facilitate decision-making in FWV?

(3) To identify an overall decision layout for FWV decision-making, which can help untangle the complexity of FWV decision-making

Methods

A systematic literature review is conducted to achieve the research objectives (Fig. 2). The literature search was performed via the Web of Science.

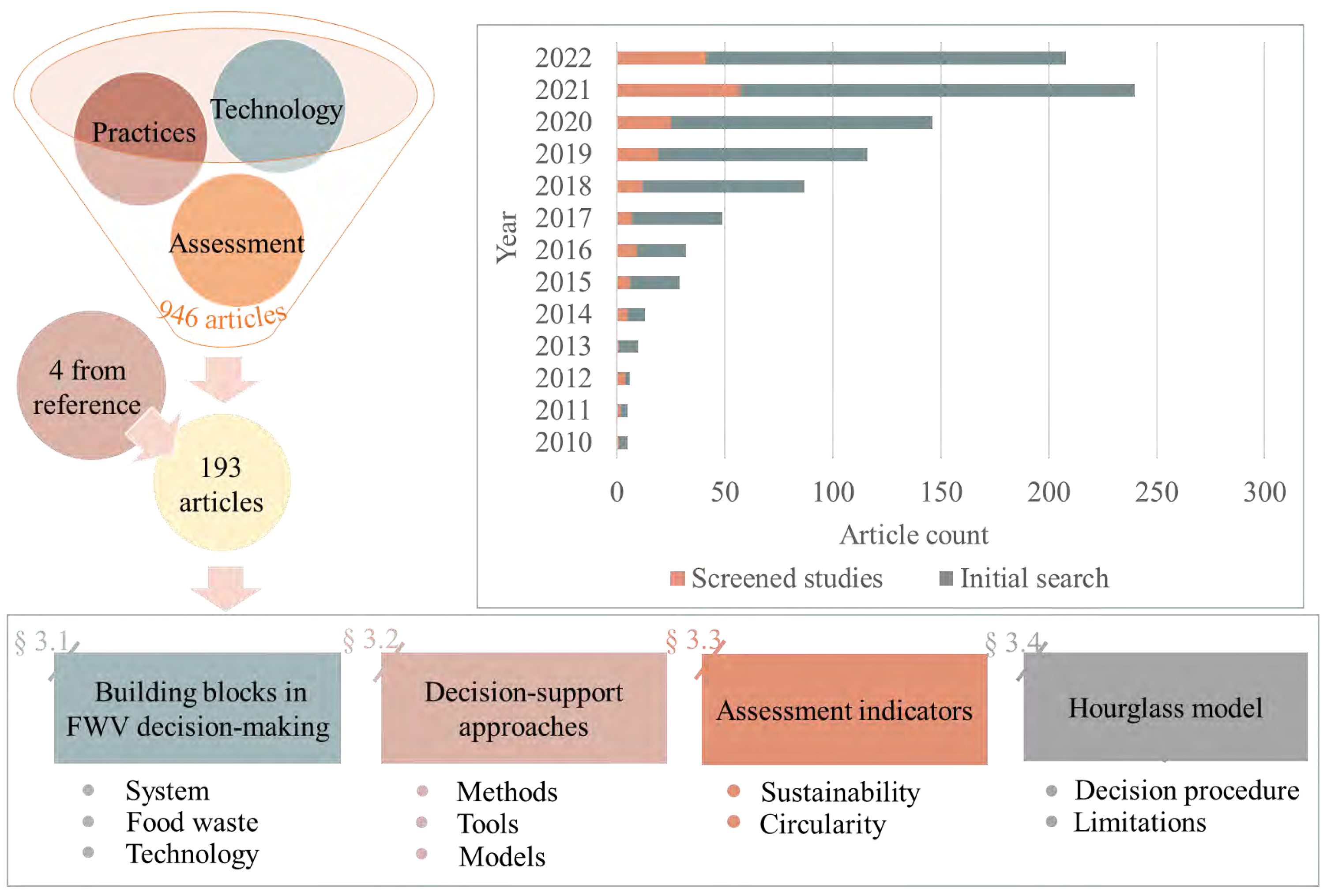

Fig 2. Overall methodological approach of this study.

Results & conclusions

Decision-making elements and their classification:

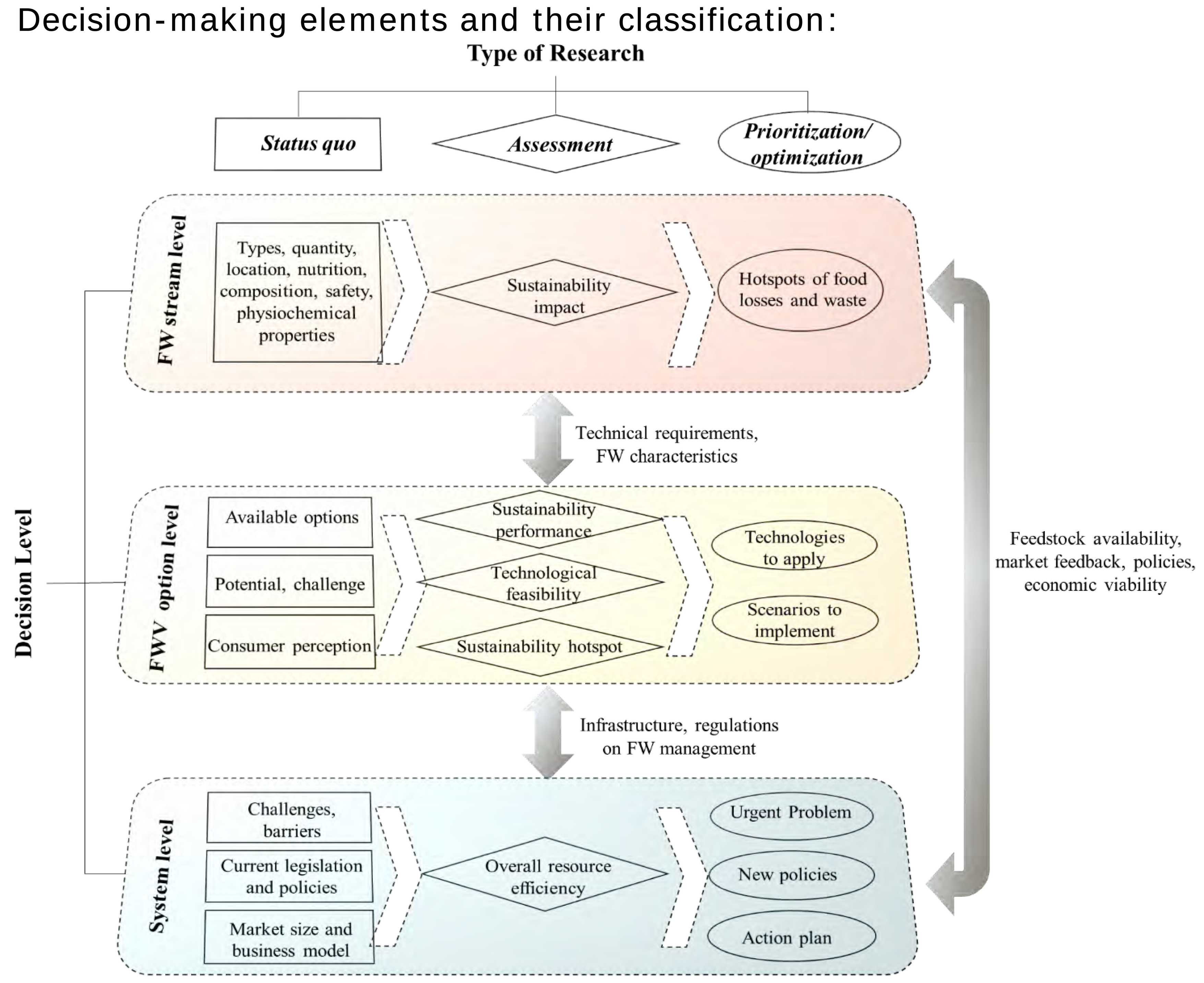

Figure 3. Classification matrix of decision-making elements in food waste valorization decision-making. The three different colored boxes indicate the three decision levels, which are determined by the research scope of the literature (Table S1). The three shaped inner boxes indicate the three types of research at each decision level, which is determined by the commonalities of research objectives. The interplays between the different decision levels are indicated by gray double-headed arrows located between the decision-level boxes.

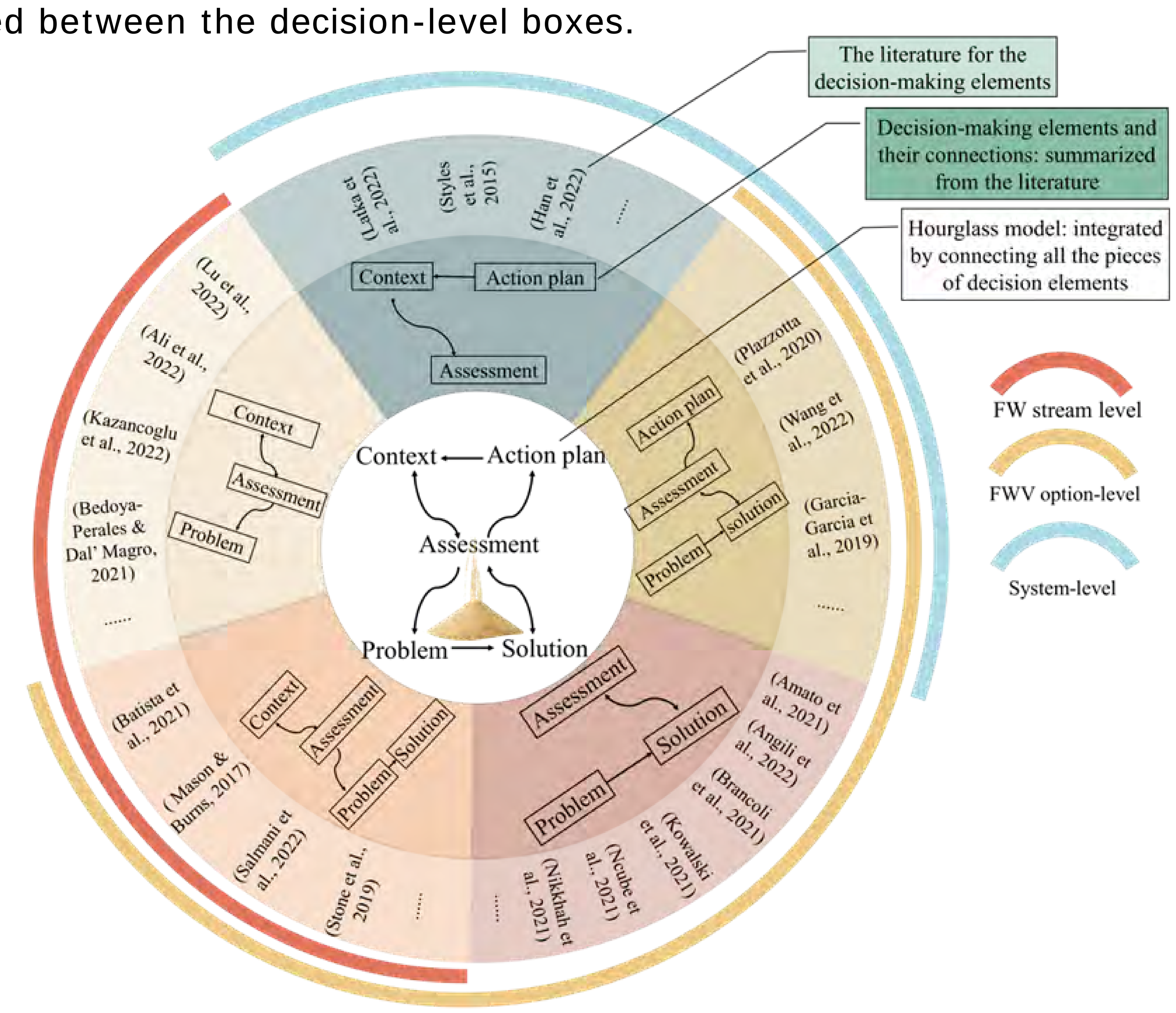

Figure 4. The formation of the hourglass model.

The hourglass model (in the center) demonstrates the decision-making layout for the practice of Food Waste Valorization. The outer circle lists the literature from which the decision-making elements were derived, and the middle circle shows the connections between these decision-making elements. The arcs indicate the relationship between the decision-making elements and the three decision levels.

Acknowledgments

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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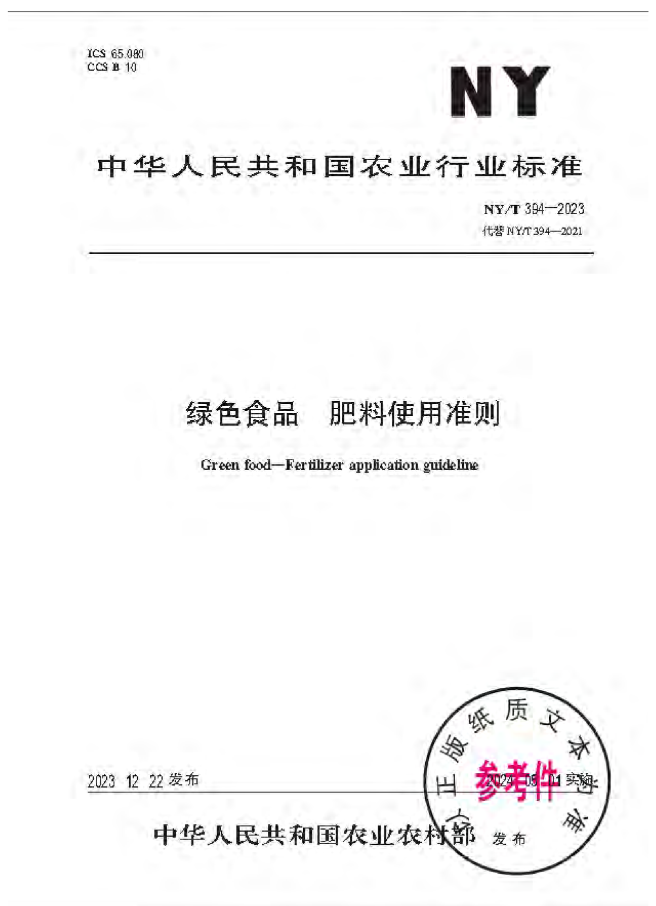
Traditional agriculture to Green Food standards: transition pathway analysis

Yi Zhang
Supervisors: Xuexian Li, Wei-Shan Chen

Background



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中华人民共和国农业行业标准

NY/T 394—2023
代替 NY/T 394—2021

绿色食品　肥料使用准则

Green food—Fertilizer application guideline

2023 12 22 发布

中华人民共和国农业农村部 发布

Fig 1. NY/T 394-2023 Green food-fertilizer application guideline Cover

	Fertilizer type
Fertilizers permitted	
	Farmyard manure
	Organic fertilizer
	Microbial fertilizer
	Inorganic fertilizer
	Organic inorganic compound fertilizer
Fertilizers prohibited	
	Uncomposted manure
	City waste & Sludge
	Fertilizers with unclear ingredients or containing ingredients with potential safety hazards
	Fertilizers with added rare earth elements
	Fertilizers prohibited by national laws and regulations

Table 1. According to NY/T 394-2023 Green food-fertilizer application guideline, list of permitted and prohibited fertilizers for green food cultivation

Due to modern agricultural fertilization methods and agricultural product supply chains, there is currently a large amount of nutrient migration in China's farmland, which is a one-way line from the soil of a farmland to the dining table in urban population gathering areas. Eventually they become a form of municipal waste and food scraps that are no longer recyclable and are often disposed of in landfills or incinerated.

As a special sustainable eco-label agricultural product production method in China, green food is between traditional agricultural production methods and organic food production methods. Green food allows farmers to use less chemical fertilizers from fossil sources and encourages farmers to use sustainable farmyard manure and organic fertilizers (see Table 1).

Objectives

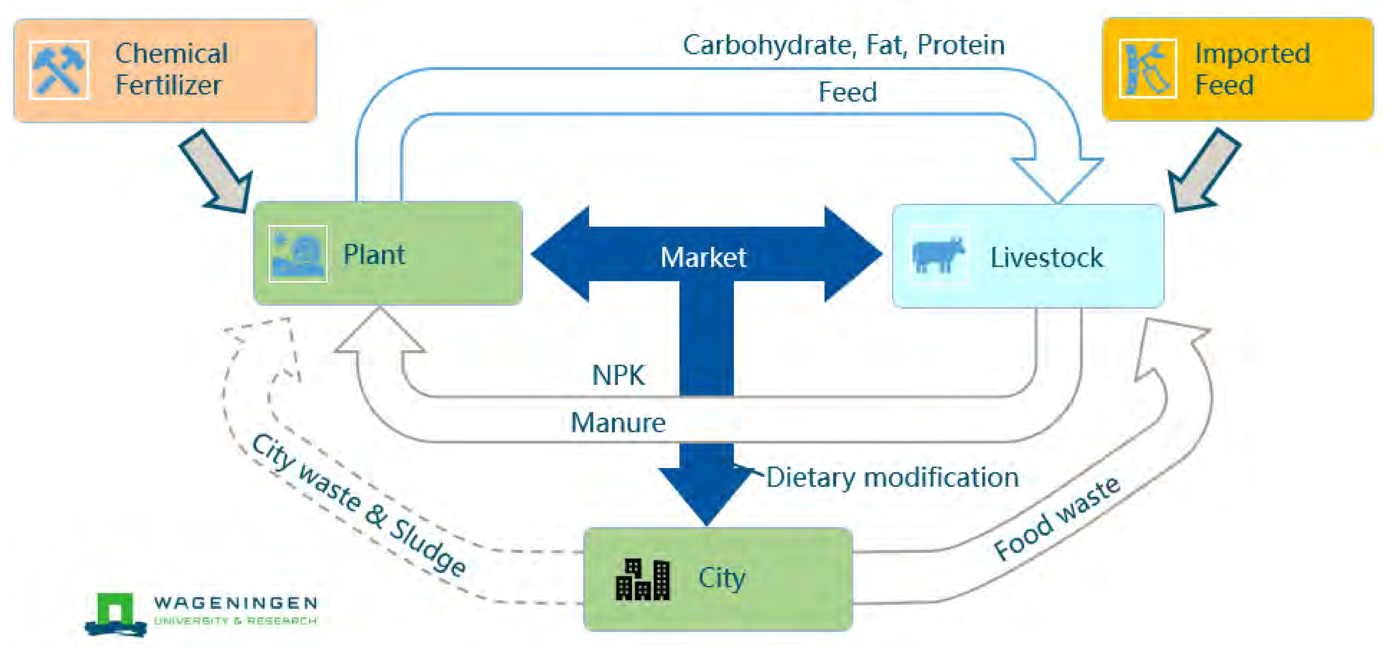

Fig 2. Sustainable nutrient recycling framework for Green food

Our current research aims to establish a sustainable nutrient cycle(Fig 2.) in agriculture that gradually replaces the use of chemical fertilizers from fossil sources. The purpose is to reduce nutrient migration and try to propose that municipal waste and sludge can be regarded as an important source of sustainable nutrients after harmless treatment.

Methods

Nutrient content of manure of main livestock and poultry (g/kg)

Category	Manure(dried)		
	N	P	K
Pigs	5.47	2.45	2.94
Cattles	3.83	0.95	2.31
Sheep and Goats	10.14	2.16	5.32
Poultry Birds	10.32	4.13	7.17

Daily produced of livestock and poultry manure nutrients(kg/d)

Category	Manure	Urine
Pigs	2	3.3
Cattles	18	4.67
Sheep and Goats	2	0.5
Poultry Birds	0.15	-

Nutrient loss in livestock and poultry manure composting(%)

Nutrient	Aerobic composting	Biogas
N	30.7	9.0
P_2O_5	11.2	4.2
K_2O	18.7	4.3

We updated and recalculated the data of organic manure, the main source of nutrients for green food cultivation in the previous year's study. We also tried to collect and calculate the nutrient content of China's municipal waste and sludge from China's Bureau of Statistics, Water Resources Department and the papers of other related researchers.

Although these nutrients are not allowed to be used as fertilizers in the soil by national regulations and standards, we believe that with the efforts of other researchers and the completion of the harmless treatment of city waste, sludge, and food waste, they can be reintroduced as another important source of nutrients into farmland soils. Avoiding the unidirectional migration of nutrients forces the country to mine more ores to produce chemical fertilizers to make up for the annual shortfall in farm nutrients.

Results

Crops	Average amount of N from organic fertilizer used(kg per mu)	Average amount of N from chemical fertilizer used(kg per mu)	Average amount of organic fertilizer used(kg per ha)	The scale of traditional farming(ha)	The total amount of N needed of traditional farming(ton)
Grain					
-Maize	14.48	8.64	346.82	41,292,000	14,320,994.67
-Rice	11.02	9.34	305.35	30,341,784	9,264,787.89
-Wheat	10.75	2.38	196.95	23,518,500	4,631,968.57
Vegetables					
-Leafy vegetables	20.72	9.69	456.22	20,514,067	9,358,876.36
-Melons	23.27	13.82	556.34	2,197,139	1,222,345.33
-Nightshade	23.67	11.77	531.57	1,902,138	1,011,119.50
-Beans, Peas	22.48	4.59	406.09	11,292,495	4,585,741.06
Fruits					
-Apple	21.01	11.90	493.70	1,911,848	943,869.80
-Orange	17.87	11.12	434.80	393,598	171,135.43
Cash crops					
-Tea	10.90	12.24	347.15	3,365,697	1,168,384.89
Total	176.17	95.49	4,074.97	136,729,266	46,679,223.50

(a)

Crops	Total P2O5(kg per mu)	Total P2O5(kg per ha)	The scale of traditional farming(ha)	The total amount of P2O5 needed of traditional farming(ton)
Grain				
-Maize	6.31	94.65	41,292,000	3,908,287.80
-Rice	5.89	88.35	30,341,784	2,680,696.62
-Wheat	6.48	97.2	23,518,500	2,285,998.20
Vegetables				
-Leafy Vegetables	12.68	190.2	20,514,067	3,901,775.54
-Melons	9.71	145.65	2,197,139	320,013.30
-Nightshade	11.26	168.9	1,902,138	321,271.11
-Beans, Peas	5.4	81	11,292,495	914,692.10
Fruits				
-Apple	14.09	211.35	1,911,848	404,069.07
-Orange	19.72	295.8	393,598	116,426.29
Cash crops				
-Tea	6.49	97.35	3,365,697	327,650.60
Total	98.03	1470.45	136,729,266	15,180,880.62

(b)

Crops	Total K2O(kg per mu)	Total K2O(kg per ha)	The scale of traditional farming(ha)	The total amount of K2O needed of traditional farming(ton)
Grain				
-Maize	5.68	85.2	41,292,000	3,518,078.40
-Rice	6.75	101.25	30,341,784	3,072,105.63
-Wheat	7.13	106.95	23,518,500	2,515,303.58
Vegetables				
-Leafy Vegetables	12.48	187.2	20,514,067	3,840,233.34
-Melons	10.12	151.8	2,197,139	333,525.70
-Nightshade	12.62	189.3	1,902,138	360,074.72
-Beans, Peas	4.88	73.2	11,292,495	826,610.63
Fruits				
-Apple	18.33	274.95	1,911,848	525,662.61
-Orange	17.78	266.7	393,598	104,972.59
Cash crops				
-Tea	6.54	98.1	3,365,697	330,174.88
Total	102.31	1534.65	136,729,266	15,426,742.07

(c)

Crops	Total N (kg per ha)	Total P2O5 (kg per ha)	Total K2O (kg per ha)	NPK Ratio	GF Land use (ha)(2023)	Traditional farming land use(ha)	GF vs traditional land use ratio
Grain					4,000,446.67	95,152,284	4.20%
-Maize	346.82	94.65	85.2	0.66:0.18:0.16		41,292,000	
-Rice	305.35	88.35	101.25	0.58:0.17:0.19		30,341,784	
-Wheat	196.95	97.2	106.95	0.37:0.18:0.20		23,518,500	
Vegetables					836,440	35,905,839	2.33%
-Leafy Vegetables	456.22	190.2	187.2	0.87:0.36:0.36		20,514,067	
-Melons	556.34	145.65	151.8	1.06:0.28:0.29		2,197,139	
-Nightshade	531.57	168.9	189.3	1.01:0.32:0.36		1,902,138	
-Beans, Peas	406.09	81	73.2	0.77:0.15:0.14		11,292,495	
Fruits					1,020,433	12,807,993	7.97%
-Apple	493.7	211.35	274.95	0.94:0.40:0.52		1,911,848	
-Orange	434.8	295.8	266.7	0.83:0.56:0.51		393,598	
Cash crops					415,727	3,365,697	12.35%
-Tea	347.15	97.35	98.1	0.66:0.18:0.19		3,365,697	
Total					2,272,600	178,306,248	

(d)

Table 2(a, b, c, d). 2(a, b, c) The average annual N, P, and K amounts required by major green food crop varieties, (d) Nutrients required for main green food crop varieties, planting area comparison with traditional agriculture

Based on the production data of green food enterprises, we calculated the average annual fertilizer use of various crops by green food farmers in China. We also compare it with the area of traditional agriculture in China to get the upper limit of the total nutrient demand assuming that all agriculture in China is converted to the Green food agriculture mode.
We further calculated the upper limit of China's current total organic fertilizer production to obtain the upper limit of nutrient supply for China's green food planting and fertilization mode, i.e., the upper limit of green food expansion scale.

2022		
Category	Value	Unit
Pigs	699947.9	1000 Head
Cattles	102160	1000 Head
Sheep & Goats	326272	1000 Head
Poultry birds	67.7	10M Head

Table 3. Total numbers of poultry and livestock in China in 2022

Compost(dried)(%)	Organic Carbon	N	P	K
Horses	28.26	1.16	0.35	1.23
Sheep & Goats	21.68	1.38	0.32	1.42
Mules	5.07	0.59	0.3	0.37
Asses	11.9	1.39	0.37	2.16
Cattles	26.79	1.41	0.36	1.97
Pigs	17.45	0.96	0.47	0.95
Rabbit	36.2	2.11	0.74	1.61
Poultry birds	44.11	2.17	0.7	1.95

Table 4. Nutrient content of livestock and poultry manure(composted)(g/kg)

Total manure weight	N	P	K
1,790,987,767	2,096,252.1	655,078.8	2,227,268

Table 5. Nutrient contentof composted livestock and poultry manure in 2022(ton)

Domestic Organic Residue(DOR)			
(all on a wet weight basis)	N (kg/ton)	P (kg/ton)	C (kg/ton)
Kitchen and Yard Residue (KYR)	6.7	1.2	145
Sewage Sludge	20.8	408(carbon P)	

Table 6. Domestic Organic Residue average nutrition content (Bernstad and la Cour Jansen, 2012; Bernal et al., 1998)

		Unit
Total output	39040	1000 ton
Moisture content	80	%
Total N content	5580	1000 ton
Total P content	4196	1000 ton

Table 7. Nutrient content of sludge in China in 2019 (Xin, 2024)

Through calculation, we obtained the total amount of NPK nutrients required per hectare of the main green food crops every year. The total amount of nutrients required to transform the country's traditional agriculture into a green food growing model was also calculated (see Table 2).
We have updated the calculation of last year's research data, using the updated 2022 China's poultry and livestock inventory data (from the Ministry of Agriculture and Rural Affairs of China) and calculated the corresponding poultry and livestock manure production and nutrient content. At the same time, the work in (Xin, 2024) was referred to obtain the nutrient content of China's sludge in 2019, of which the total nitrogen content was 5580 kilotons and the total phosphorus content was 4196 kilotons.

Conclusions

- The sources of animal manure used in this research are mainly large-scale farmed animals (pigs, cattle, sheep and goats, poultry) in China, and all small-scale animal subdivisions were not selected.
- Assuming that all the calculated livestock manure and sludge nutrients can be reinvested back into agricultural soils, sustainable organic fertilizers could supply 16.4-32.8% of the nation's nutrient needs from a nitrogen perspective, and 31.9-63.9% of the nation's nutrients from a phosphorus perspective. (Calculated based on the use of chemical fertilizers from 0 to 50% of the total nutrient requirements).
- When calculating the nutrient content of city waste, sludge, and food waste, we find that it is much higher compared to livestock manure, which is usually incinerated and landfilled after simple treatment. If they can be effectively treated in an environmentally sound manner and logistically reintroduced back into the farmland, the nutrient migration effect can be mitigated at the same time as the pressure on city waste is resolved.
- Our subsequent plan is to establish a pool of sustainable organic fertilizers in China by classifying the types of fertilizers defined in the current Green food standard with harmless treated city waste, sludge, and food waste in the definition of sustainable fertilizers. By matching the proportion of NPK content of different types of sustainable organic fertilizers with the proportion of nutrient requirements of green food crops. Fertilizer application measures were further optimized to reduce the use of chemical fertilizers.

Acknowledgements

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A comparison between centrifugation and filtration process to obtain oleosome and protein mixtures from rapeseeds

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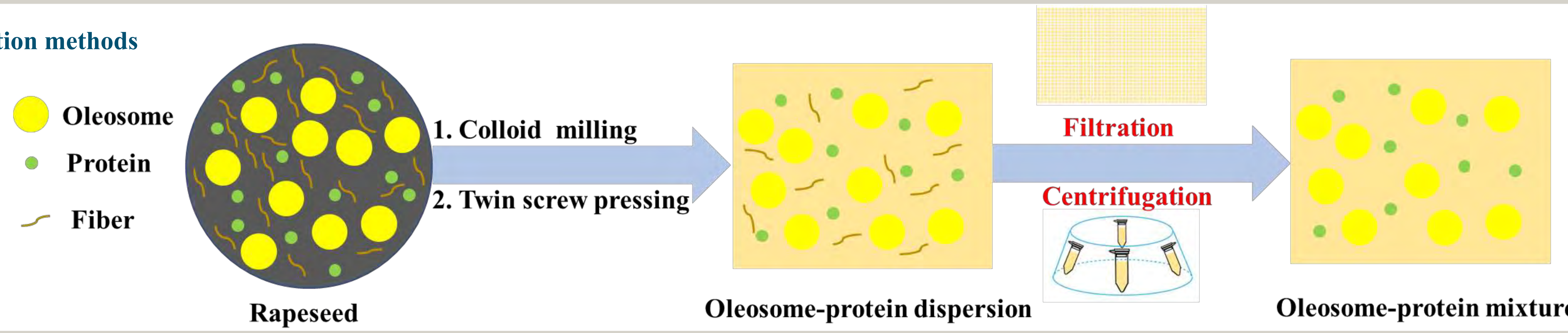
2. Wageningen University and Research, Food Process Engineering, POB 17, NL-6700 AA Wageningen, Netherlands
3. Wageningen University and Research, Biobased Chemistry and Technology, POB 17, NL-6700 AA Wageningen, Netherlands.

Background and objective

Oleosome and protein mixture can be aqueously extracted together from rapeseed by colloid mill and twin-screw press. The oleosome-protein mixture can be extracted by centrifugation and filtration. The stability of the oleosome-protein mixture is important for its food application, which might be different between these two methods. The objective in this study is to compare the yield and purity of the extracted oleosome and protein in the oleosome-protein mixture from rapeseed by these two methods, as well as the physical properties of the extracts.

Extraction methods

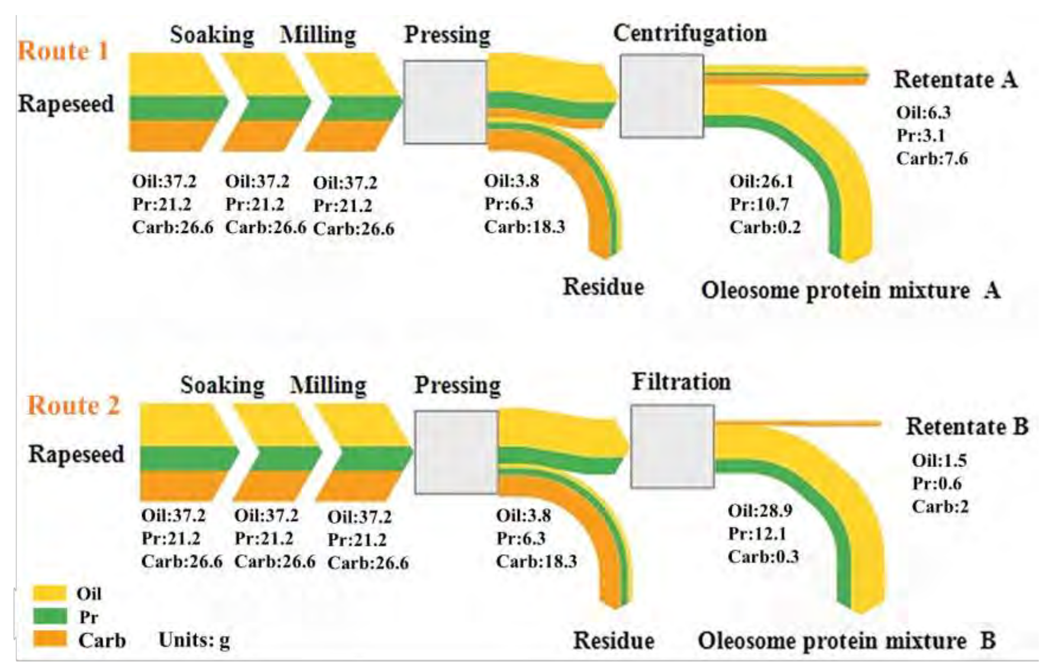


Result-Extraction

Yield and purity

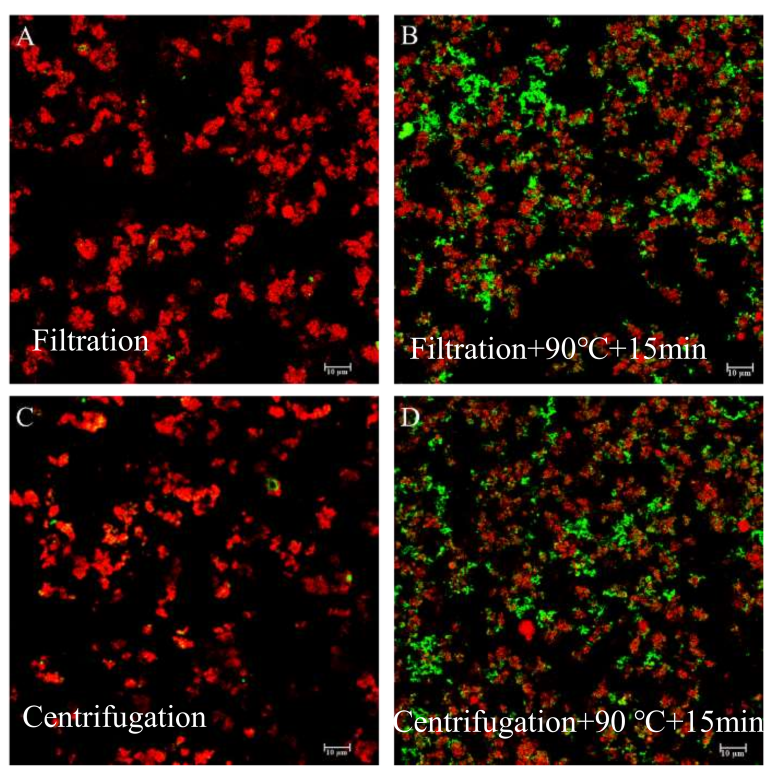
Yield and purity	Oil		Protein	
	Filtration	Centrifugation	Filtration	Centrifugation
Yield (wt/wt%)	76.99 ± 0.16	70.44 ± 0.63	57.04 ± 0.20	50.24 ± 2.35
OPM composition (wet basis: wt/wt%)	6.66 ± 0.01	6.22 ± 0.06	2.81 ± 0.01	2.52 ± 0.02
OPM composition (dry basis: wt/wt%)	58.81 ± 0.17	58.33 ± 0.12	24.67 ± 0.03	23.81 ± 0.21

Mass balance

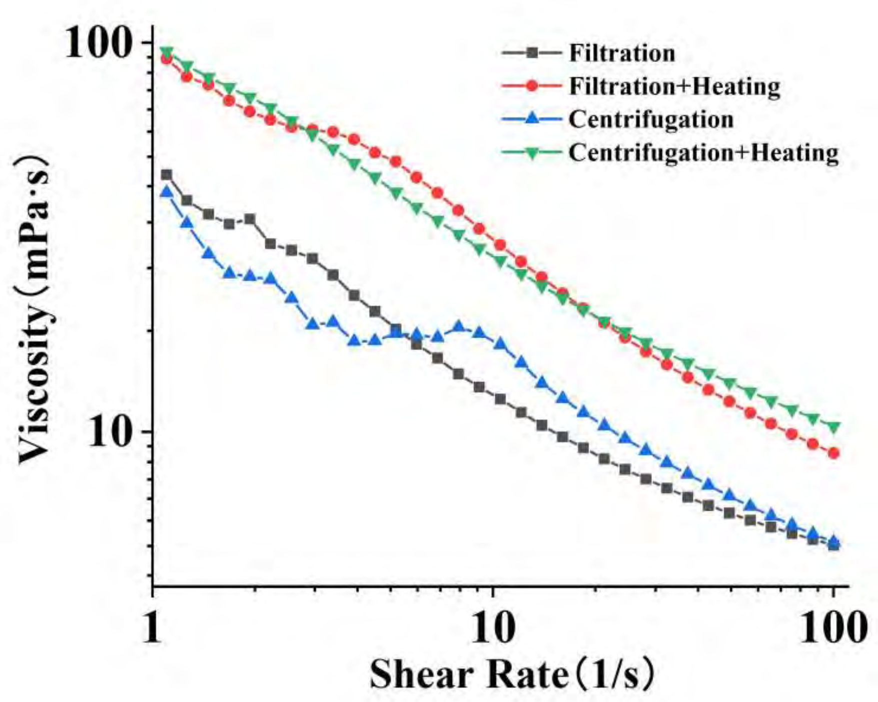


Viscosity and stability against creaming after heating

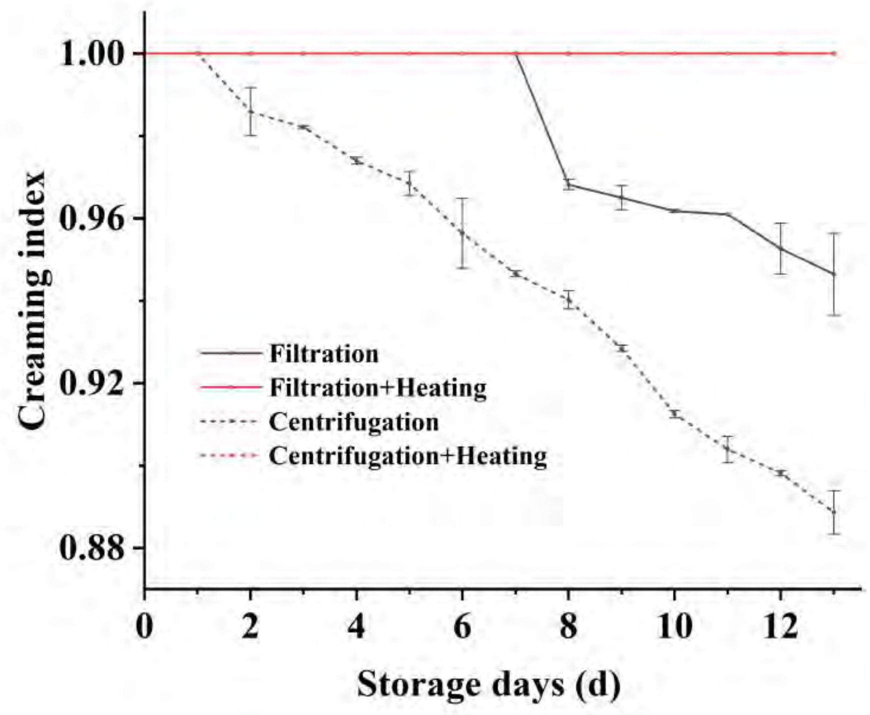
CLSM (red for oil; green for protein)

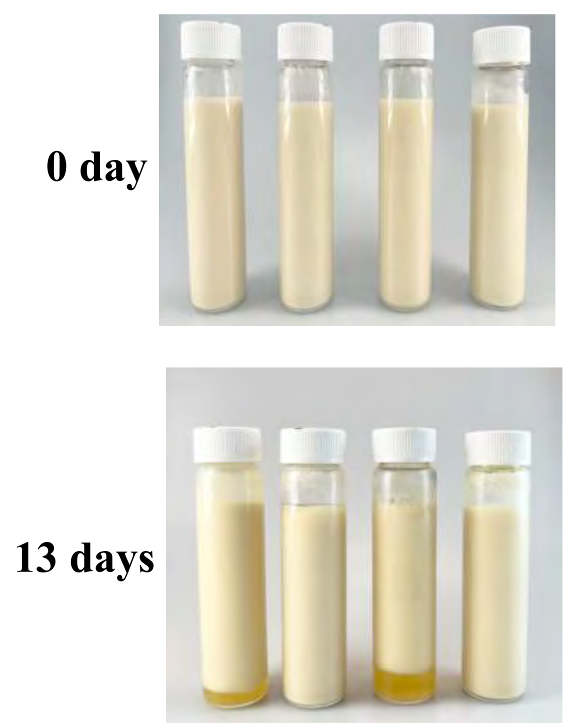


Viscosity



Storage stability

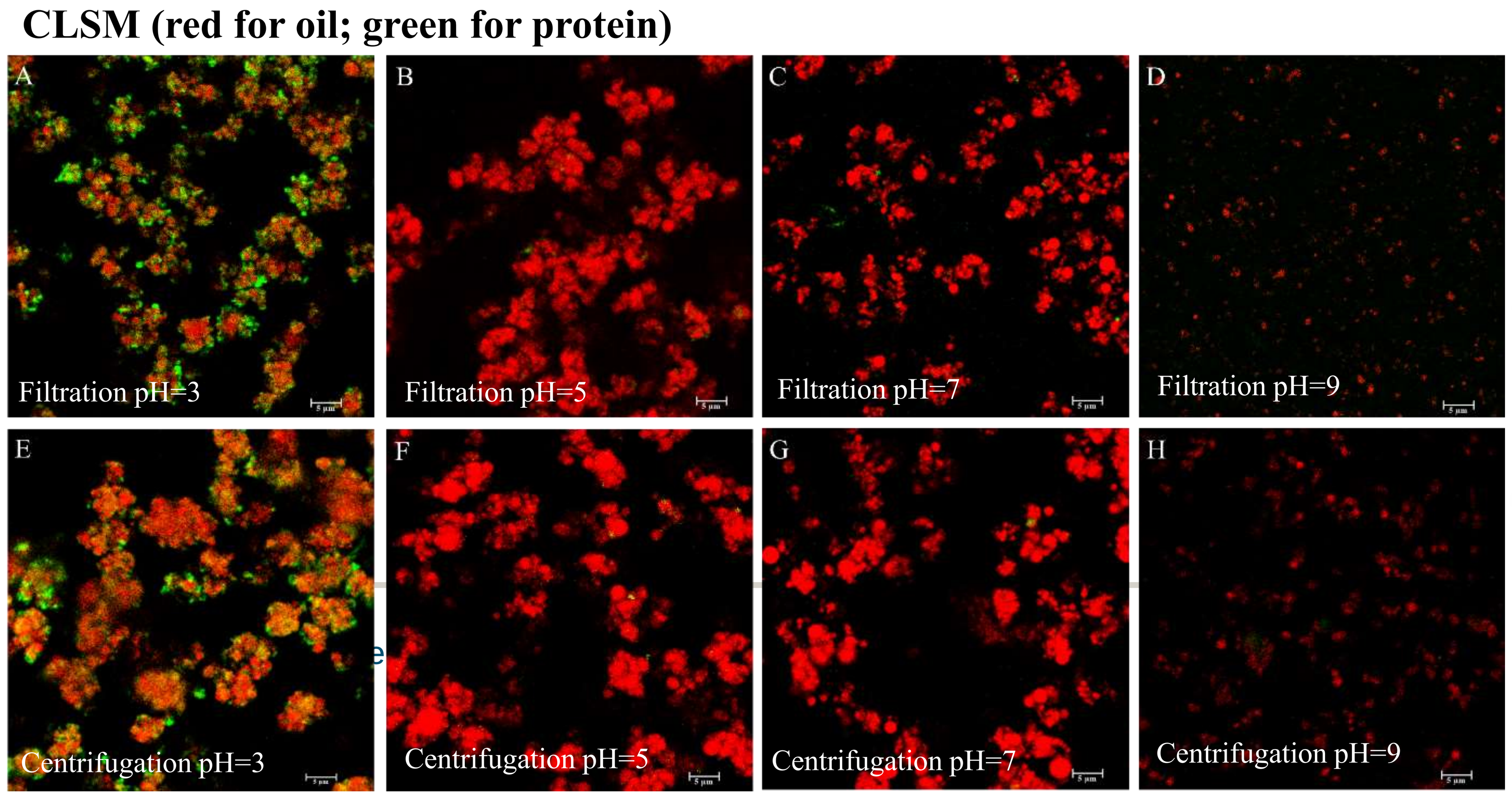




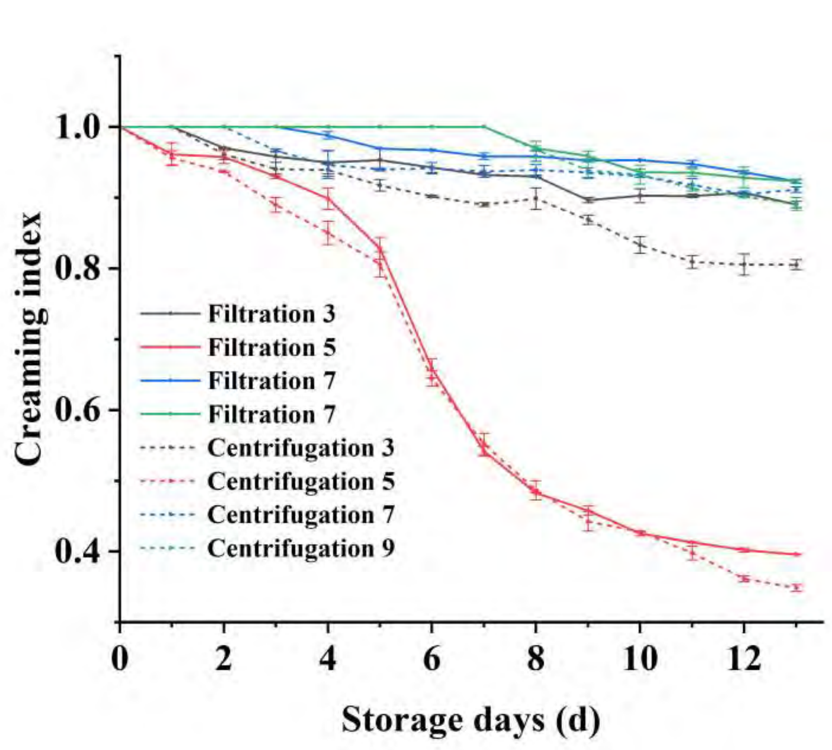
From left to right: Filtration; Filtration+heating; Centrifugation; centrifugation+ heating

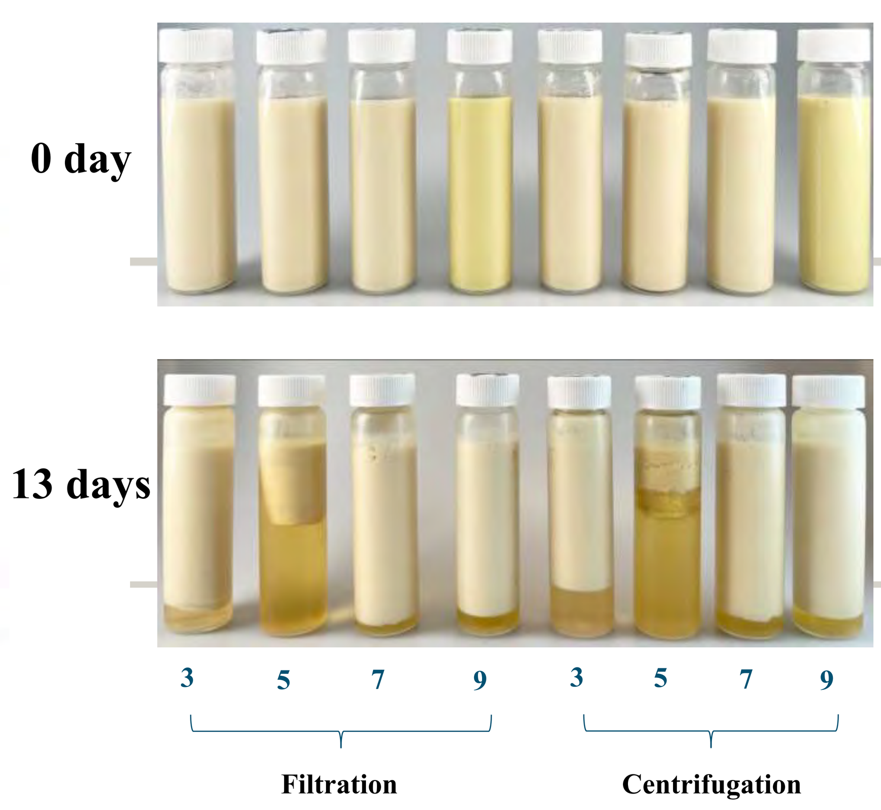
Partcile size and stability against creaming under different pHs

CLSM (red for oil; green for protein)



Storage stability





Conclusion: Filtration resulted to smaller particle sizes of oleosome/protein aggregates which lead to more stable emulsion systems. Heating enhanced the storage stability.

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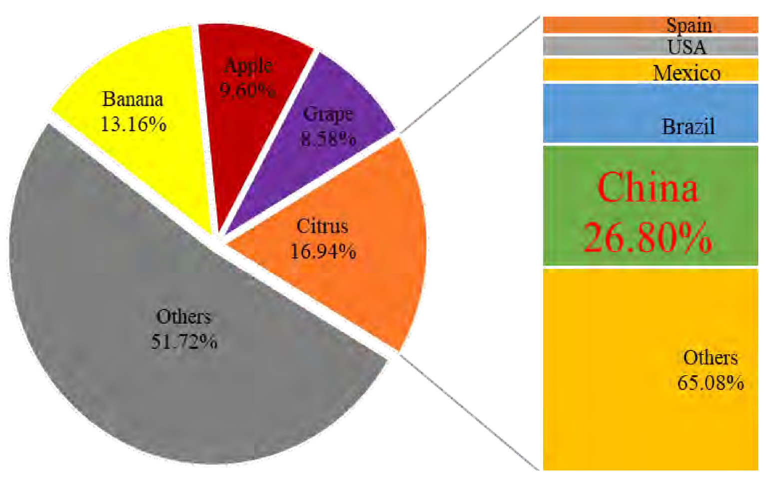
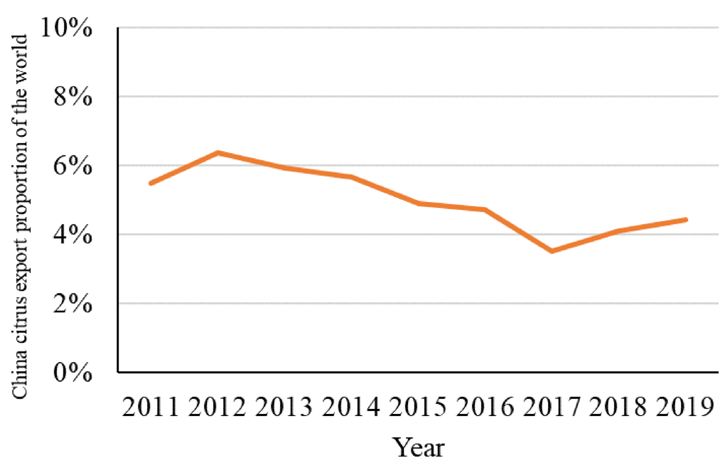
Optimizing the Economic and Environmental Performance of the Gannan Navel Orange Supply Chain (GNSC)

Ruijin Luo*, Junhan Zhang
Supervisors: Xuexian Li, Ting Meng, G.D.H. (Frits) Claassen, Sander de Leeuw

Background



Citrus - Most popular fruit
China – Largest production



Export – Low & fluctuated

Input – High
Efficiency – Low
Activeness – Moderate

Objectives

1. Framing a food supply chain assessment method from economic and environmental perspectives via life cycle thinking and multi-criteria decision making analysis.
2. Determining the economic and environmental performance of navel orange supply chains in southern Jiangxi as an umbrella case study.
3. Exploring agriculture green development (AGD) options for China's green navel orange industry to redesign and transform the existing structure towards a circular and market driven one.

Methods

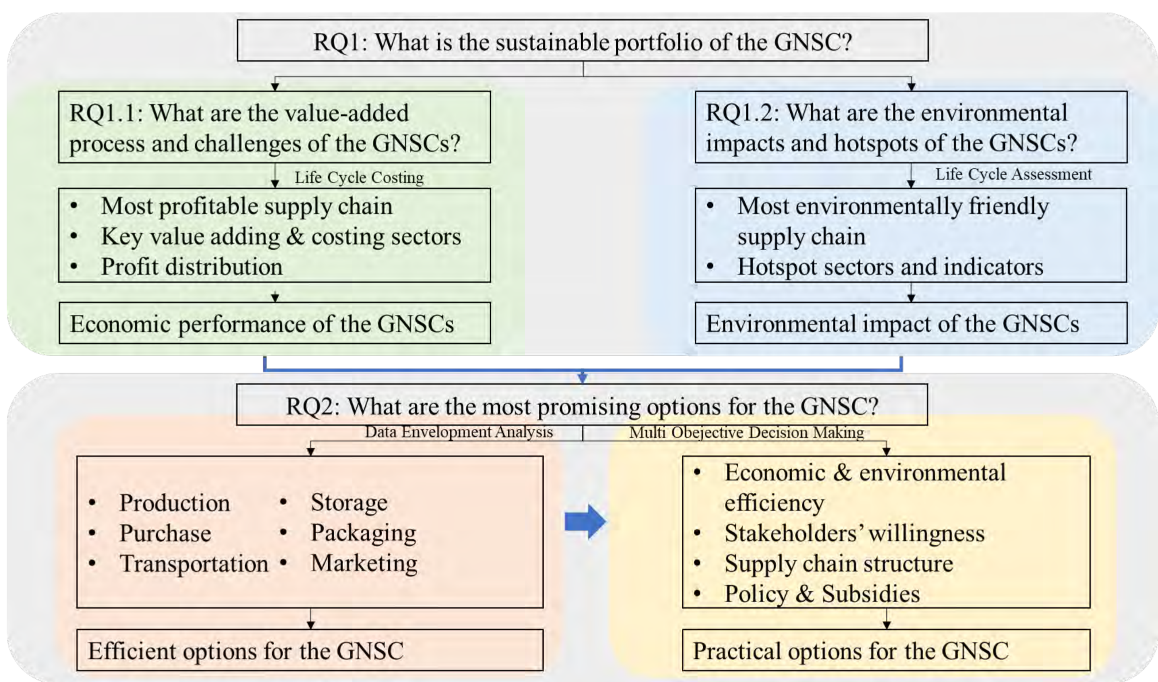


Fig.1 Technical routes

1. Life Cycle Assessment (LCA)

Life cycle assessment (LCA) is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service. For instance, in the case of a manufactured product, environmental impacts are assessed from raw material extraction and processing (cradle), through the product's manufacture, distribution and use, to the recycling or final disposal of the materials composing it (grave).[1] [2] The aim is to document and improve the overall environmental profile of the product.[2]

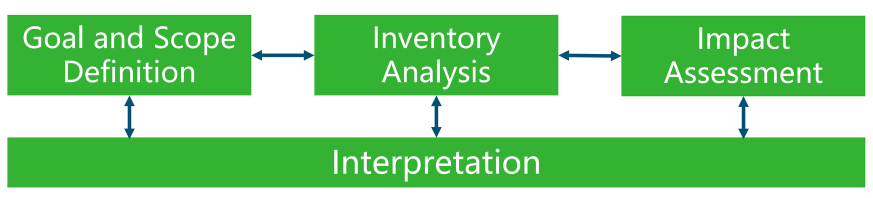


Fig.2 Illustration of the general phases of a life cycle assessment, as described by ISO 14040

2. Data Envelopment Analysis (DEA)

Data envelopment analysis is a process of defining valid measures of performance comparison among peer Decision Making Units (DMUs), using them to determine the relative positions of the peer DMUs and, ultimately, establishing a standard of excellence to explore improvement options to achieve the excellence[3]. Dimensions typically measured are quality, time and cost.

3. Multiple Objective Decision Analysis (MODA)

Multiple objective decision analysis, also known as multi-objective optimization is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making and choosing the best solution[4]. MODA has been an active area of research since the 1970s. MCDA is divided into multiple approaches in order to evaluate several alternatives or design an alternative (solution) by solving a mathematical model.

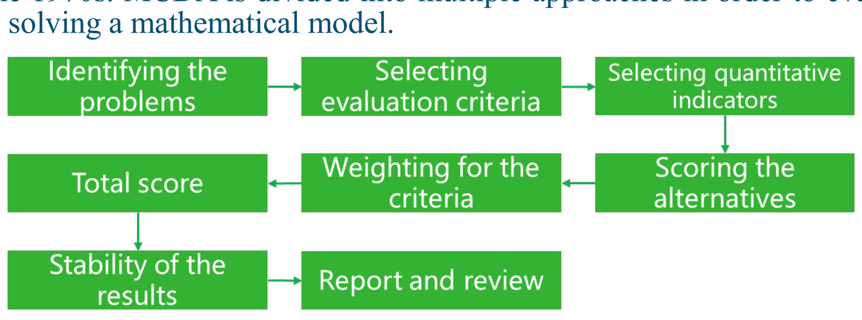


Fig.3 Multi Objective Decision Analysis Procedure

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An Umbrella Case – Southern Jiangxi Navel Orange

- Most famous and valuable citrus
- Since: 1970s
- Brand value: 67.8 billion CNY (2020)
- Harvested area: 1.1×10^5 ha
- Output: 1.4×10^6 t

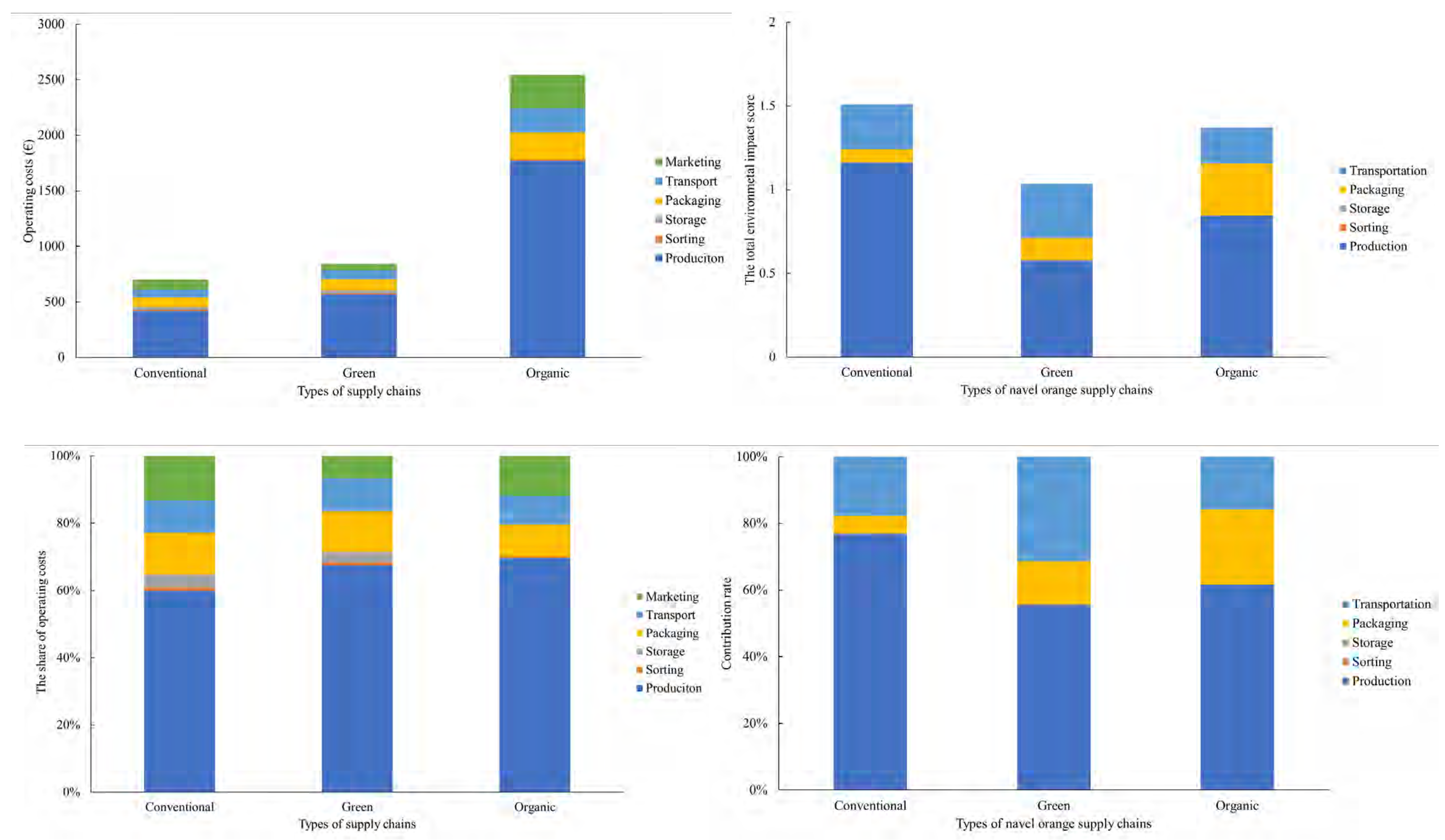

Fig.3 The economic and environmental performance of navel orange supply chains in southern Jiangxi and their contribution rates.

- Green labeled GNSC is economically and environmentally less costing than its organic counterpart.
- Production, packaging and transportation are the most economically and environmentally costing sectors.
- Fossil fuel potential, terrestrial ecotoxicity potential and agricultural land occupation potential are identified as more critical indicators to GNSCs.
- Green labeled GNSC is less profitable than its organic and conventional counterparts.

References

[1] Ilgin, Mehmet Ali; Surendra M. Gupta (2010). "Environmentally Conscious Manufacturing and Product Recovery (ECMPRO): A Review of the State of the Art". Journal of Environmental Management. 91 (3): 563–591.

[2] EPA NRMRL Staff (6 March 2012). "Life Cycle Assessment (LCA)". EPA.gov. Washington, DC. EPA National Risk Management Research Laboratory (NRMRL). Archived from the original on 6 March 2012. Retrieved 8 December 2019.

[3] Zhu J (2009). Quantitative models for performance evaluation and benchmarking: data envelopment analysis with spreadsheets[M]. New York: Springer.

[4] Claassen, G.D.H., Hendriks, Th.H.B., Hendrix, E.M.T., (2007). "Decision Science, Theory and applications"[M]. The Netherlands: Wageningen Academic Publishers.

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Network Design for Perishable Fresh Food Supply Chains

Case Study: A Chinese Orange Supply Chain

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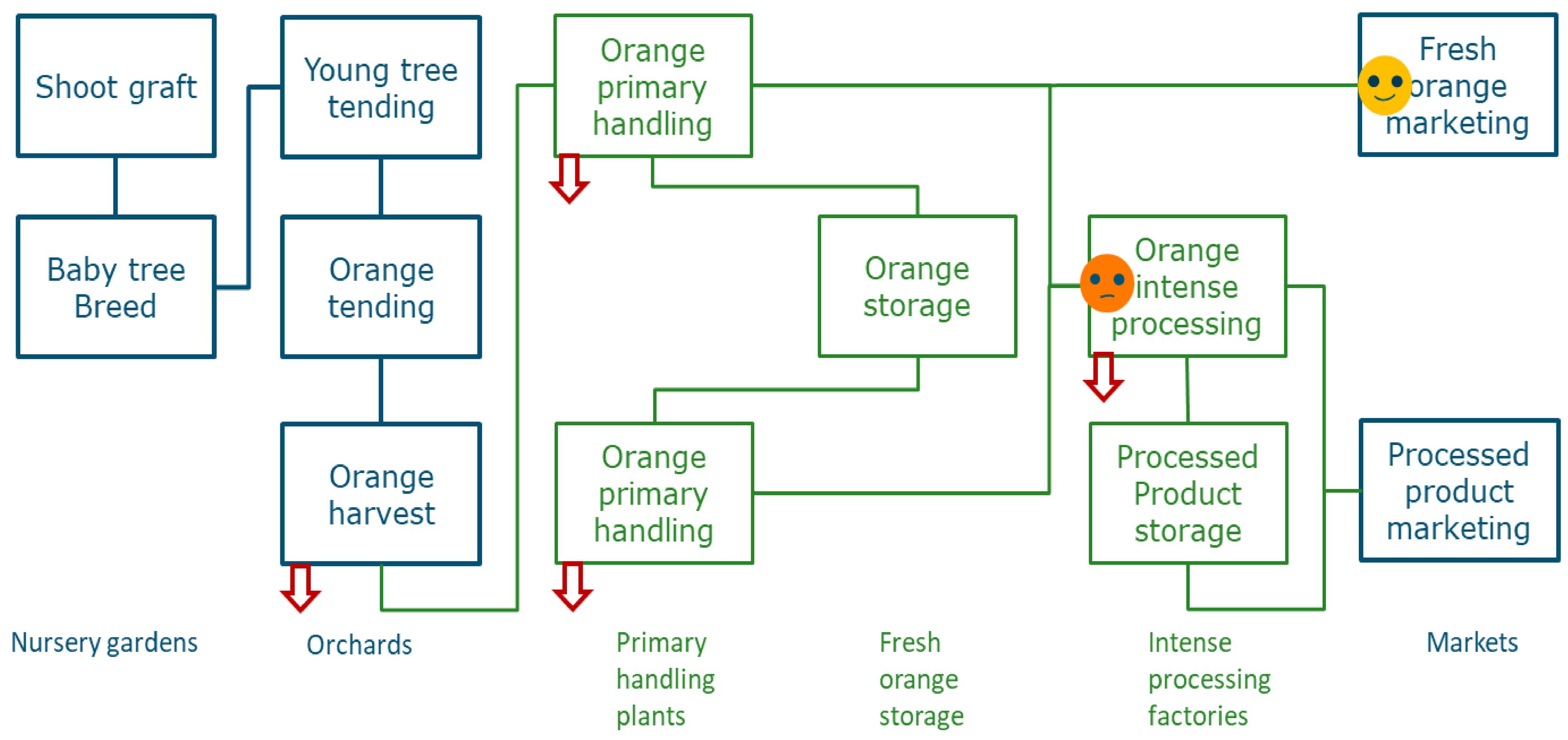
Supervisors from WUR(ORL group): Prof.dr. Sander de Leeuw, Dr.ir. Frits Claassen, Dr. Peter Kirst
Supervisors from CAU: Prof.dr. Xuexian Li, Dr. Ting Meng

1. Introduction

Fresh food supply chain (FSC) research is gaining increasing interest. **Perishability** of products poses recurring challenges along **fresh FSCs.** One major concern refers to the post-harvest **food loss and waste** (around 1/3 of produced foods).

Site-visits in a developing country like China show that the processes among fresh FSCs are more complicated than currently modeled. For instance, **Quality deterioration** has a major impact on final consumption e.g., whereas best products fulfilling some specific requirements are ideally consumed as fresh food, other products are often more suitable for processed food products. This holds especially for improving profit as well as food safety.

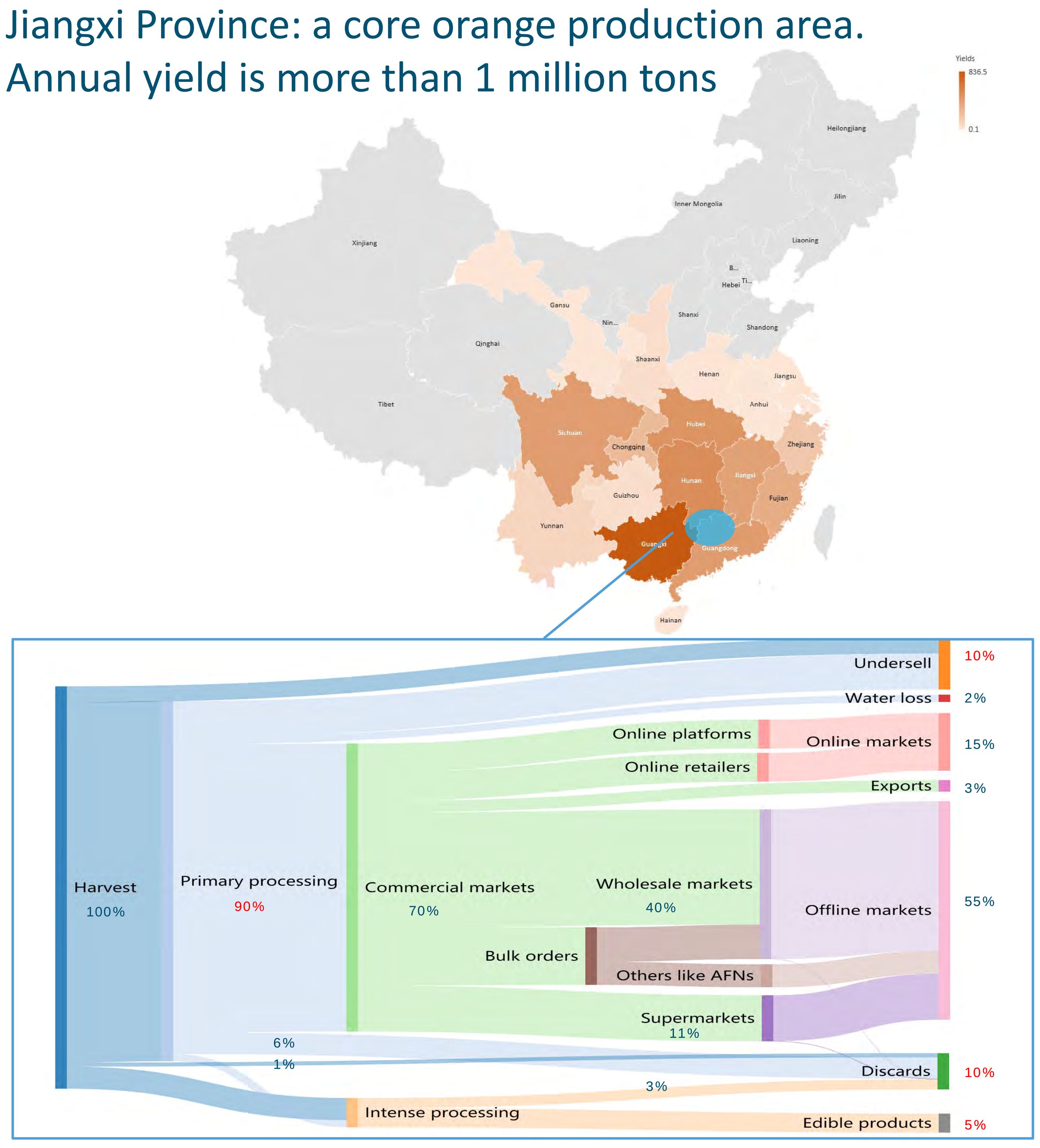
Food intensive processing is often used for fruits that are edible but not of the highest quality. In developing countries, this industry is still not fully developed yet.



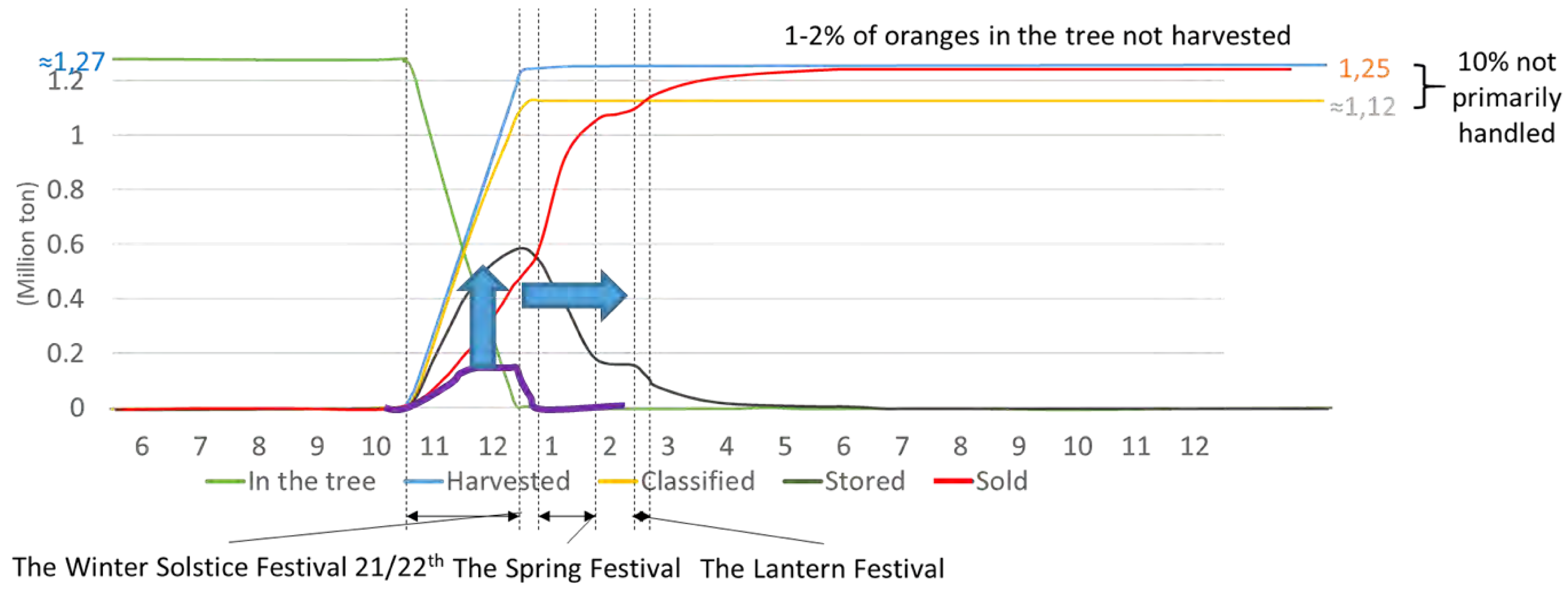
In many developing countries, fresh FSCs are combined with a segment towards food manufacturing industry. Figure shows an example of an integrated naval orange FSC in China.

2. Case background

Jiangxi Province: a core orange production area.
Annual yield is more than 1 million tons



The harvest season is only 2 months. Stakeholders in the chain have to primarily handle (sort, wash, classify, store) and manufacture all the oranges within these 2 months.
The selling season starts together with the harvest season and lasts for around 6 months. There are three selling peaks: the harvest season, the month before the Chinese new year holiday, the week before the Lantern Festival.



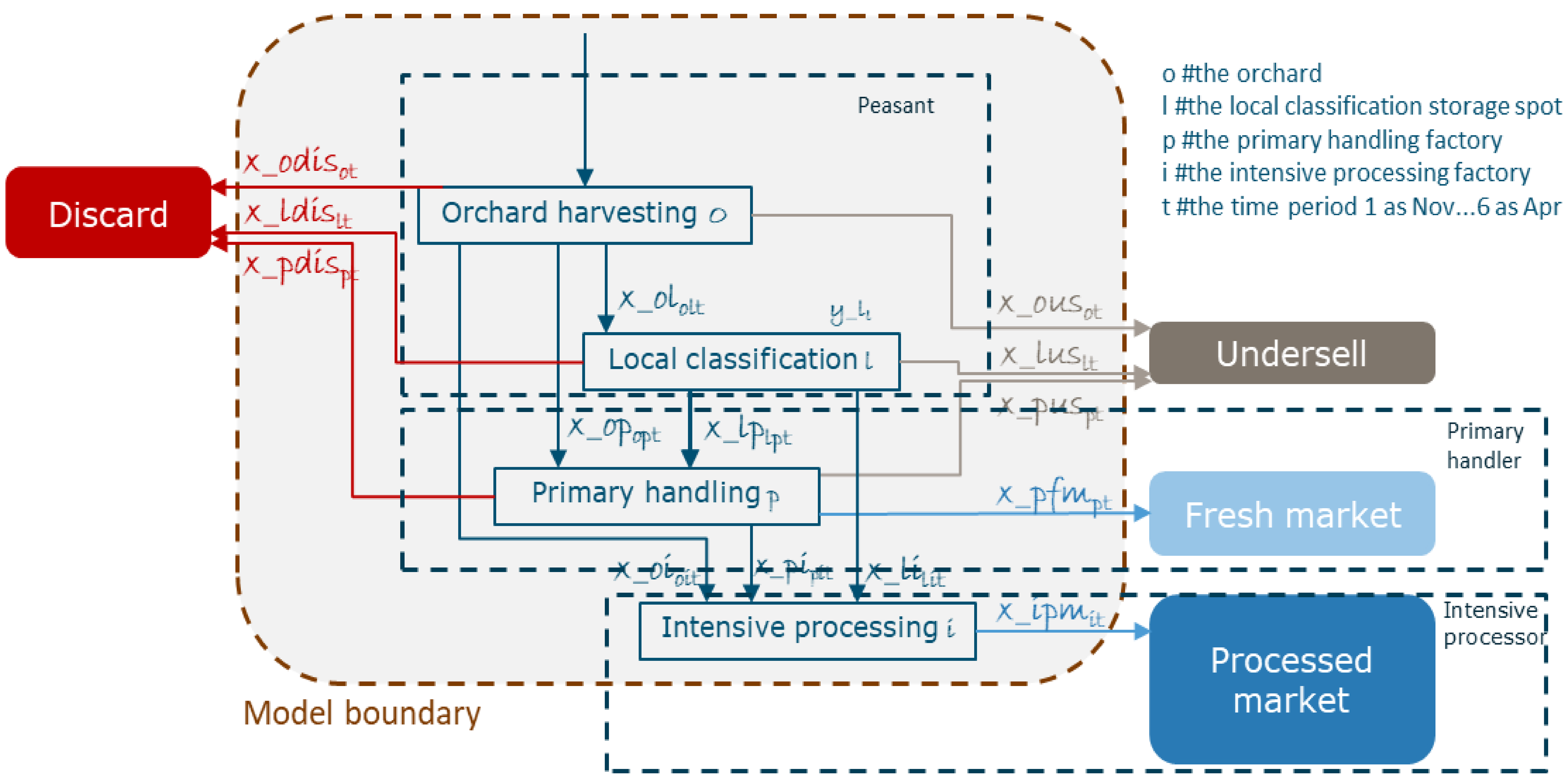
Intensive processing of orange is an option to relieve the unbalance between demand and supply during the harvest season, because processed foods typically have a longer shelf life.

- Encourage the enterprises to invest on intensive processing, increasing its capacity.
- Develop low-cost storage of fresh products to extend the manufacturing period.

3. The research

Our work is about fresh FSC network design concerning quality deterioration during storage, integrated with chain segment towards food intensive processing. We also consider decentralization at the primary processing step.

- Add local primary handling facilities
→Classify the oranges earlier (less FLWs, less transportation amounts, less mechanical physical harms to products)
- Mimic quality degradation during storage
→Illustrate the impacts and importance of intensive processing of low-quality products in fresh FSCs.
- Limit the FLW amount
→ Push the flows towards intensive processing, discover the benefits of food manufacture for perishable products.



We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043)

Developing the Sustainable Alternative Diets with Respecting Regional Food Culture in China

Zhiyao Chang, Elise F. Talsma, Hongyi Cai, Shenggen Fan, Yuanying Ni, Xin Wen, Pieter van 't Veer, and Sander Biesbroek

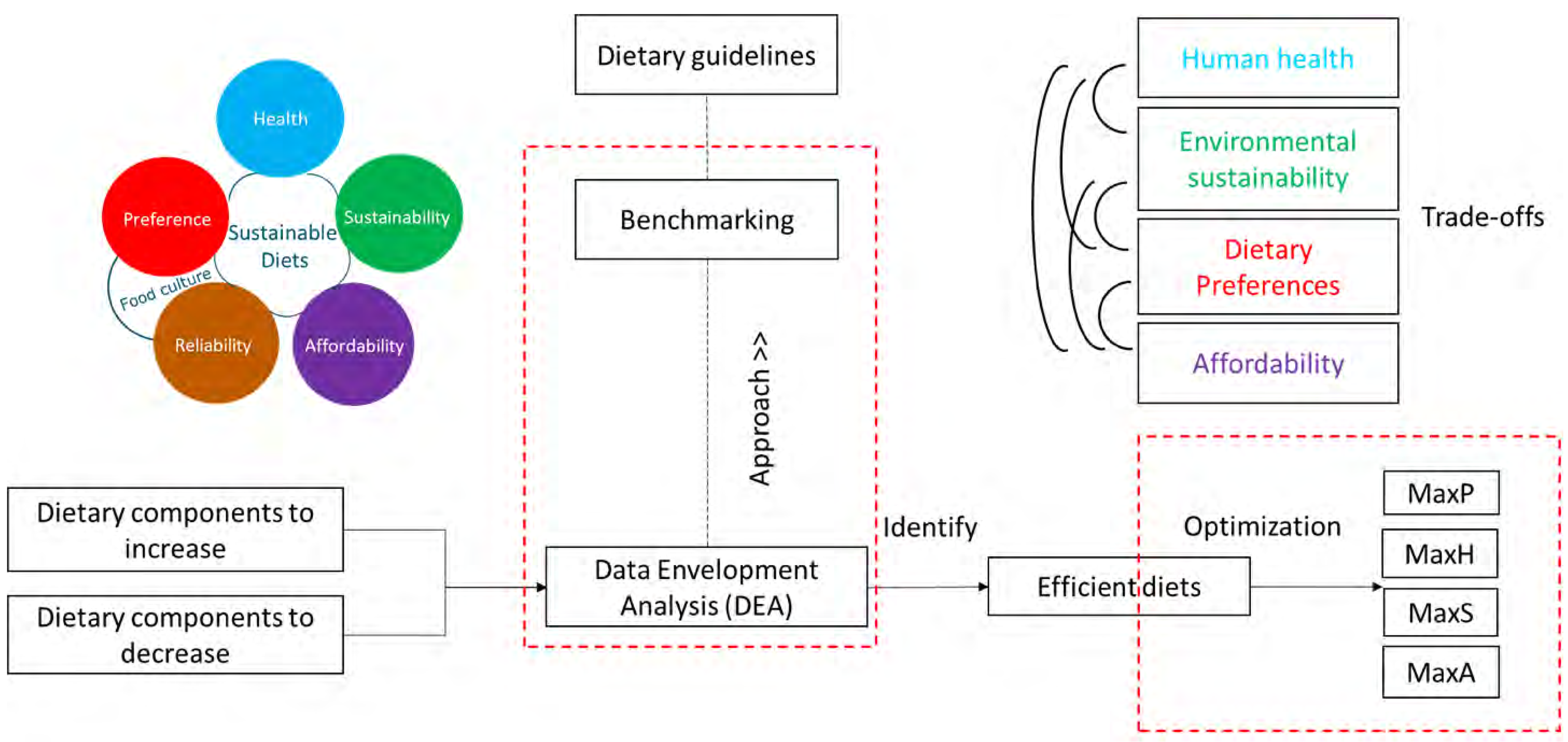
Background

Diet shifting towards a more sustainable pattern is urgently needed for China. Diet modelling can integrate multiple dimensions of sustainability to identify improved diets. This study aimed to define Chinese diets that are nutritious, affordable and have lower environmental footprints, while accounting for diet preference by a benchmarking approach.

Objectives

- To identify benchmarked diets among Chinese regions for adults using the DEA method.
- To achieve alternative diets that improve each/all sustainability dimension(s) regarding nutrient quality, environmental footprints, affordability, and diet preferences.
- To investigate trade-offs between every two of the four sustainability dimensions when optimizing the alternative diets.

Framework



Methods

1) Study population and dietary data

15,725 participants (10,324 adults) till 2011
12 provinces or municipalities till 2011
289 communities in 2011
24-h dietary recall (Dietary data)

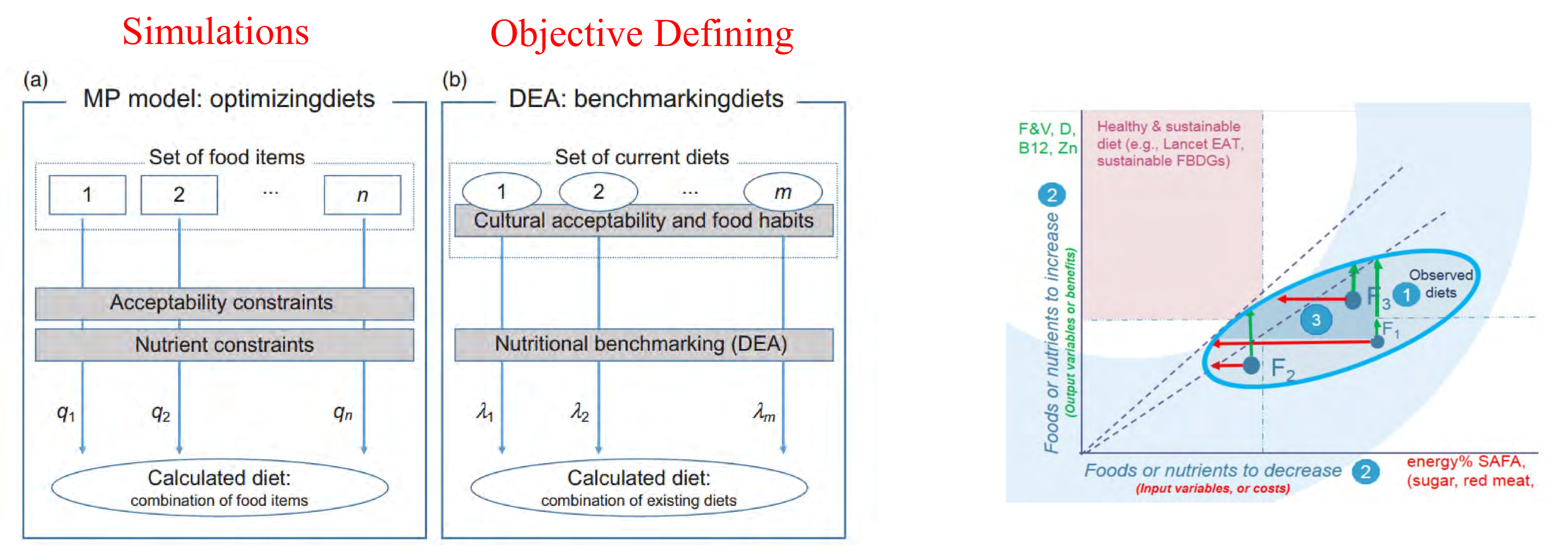
- Northeast region
- Metropolitan cities
- East region
- Central region
- Southwest region

2) Sustainability indicators

- Nutrition quality: Nutrient-rich Diet Index (NRD15.3)
- Environmental footprints based on Chinese Food Life Cycle Assessment Database (CFLCAD):
  GHG emissions
  Total water use
  Land use
- Affordability: Diet cost
- Preference: Diet similarity index (DSI)

3) Diet optimization: DEA model

Data envelopment analysis (DEA) was applied to benchmark diets for increasing the adherence to food-based dietary guidelines and alternative diets were optimized as linear combinations of benchmarked diets that complied with different sustainability goals: maximized nutrient quality (Nutrient Rich Diet score, NRD15.3), minimized greenhouse gas emissions, GHGE (the other environmental footprints: Total water use (TWU) and Land use (LU) were calculated meantime but not optimized), minimized diet cost, maximized diet preference (i.e. minimized absolute deviation from observed diets), and an integrated scenario. Trade-off analyses were also conducted between sustainability indicators.



Results

Improved diets were obtained as linear combinations from 13% to 22% of all diets that served as a benchmark for males and females from the five regions. When nutrient quality, environmental sustainability, and affordability were optimized separately in each sex and region subgroup, the NRD15.3 was 22% to 35% higher, GHGE was 17% to 38% lower, TWU was 14% to 35% lower, LU was 21% to 33% lower, and diet costs was 23% to 32% lower. When diet preference was optimized, around 90% of food consumption remained similar as observed diets compared to less than 80% in the other scenarios. When the four objectives were considered simultaneously, all indicators improved, albeit less than in the separate scenarios. The improvement of sustainability indicators was larger when the benchmarking was done for sex only and not for individual regions. In trade-off models, increasing the nutrient quality was always accompanied by decreases in environmental sustainability and affordability.

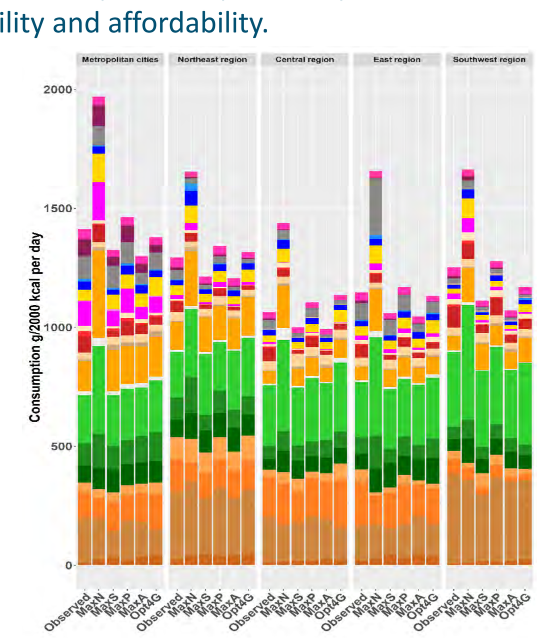


Figure 1. Food group consumption in observed and modelled diets (women).

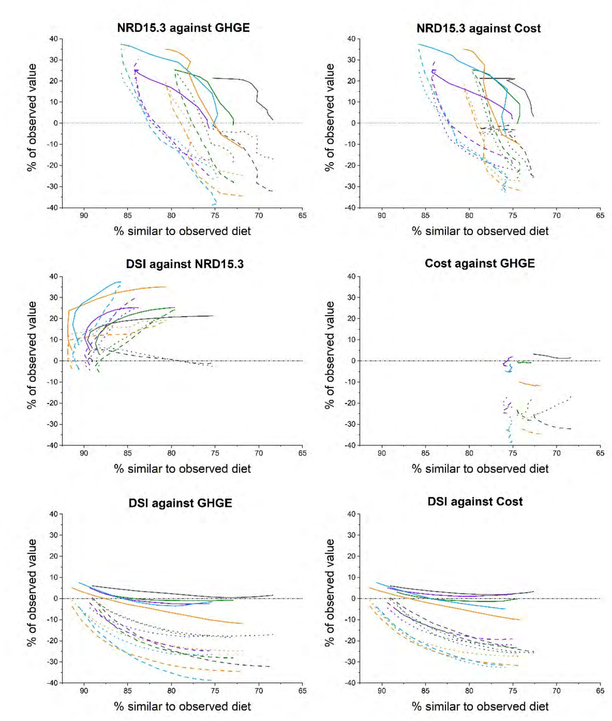


Figure 2. Trade-offs analysis for men among five regions. Metropolitan cities: ——, NRD15.3; - - -, GHGE, ⋯⋯, Cost; East region: ——, NRD15.3; - - -, GHGE, ⋯⋯, Cost; Central region: ——, NRD15.3; - - -, GHGE, ⋯⋯, Cost; Northeast region: ——, NRD15.3; - - -, GHGE, ⋯⋯, Cost; Southwest region: ——, NRD15.3; - - -, GHGE, ⋯⋯, Cost.

Discussion and conclusion

Realistic and more sustainable diets considering multiple indicators are possible for Chinese consumers, the trade-off effects might be further magnified when attempting to simultaneously pursue multiple sustainability goals. To attain ultimate sustainable diets, a necessary stepwise process is needed through the efforts of generations.

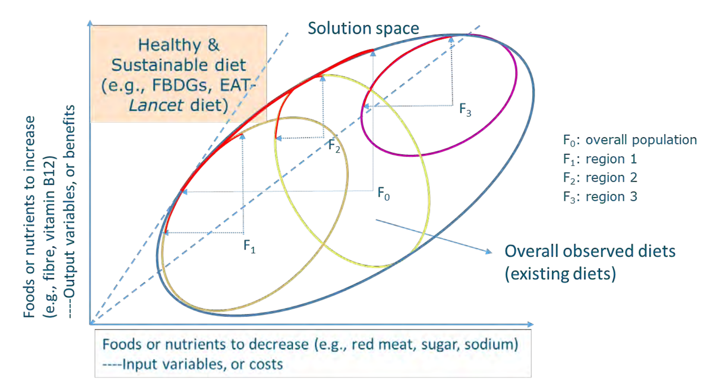


Figure The conceptual diagram of identified DEA-efficient diets (peers) under the individual regions versus overall population circumstance. Red lines are the DEA-efficiency frontiers for each scenario

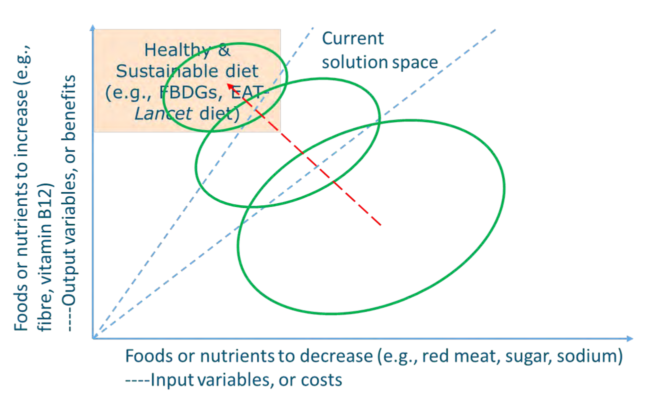


Figure Achieving fully sustainable diets is a necessary stepwise process through the efforts of generations

Acknowledgements

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Optimization and realization of green planting technology for wheat and maize based on multi-objective coordination: A case study in the North China Plain

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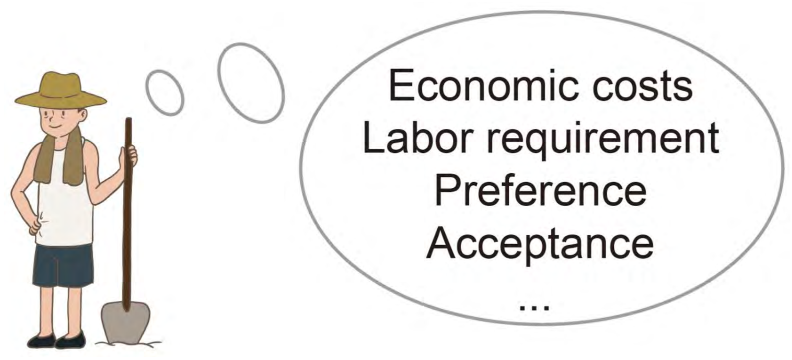
Background

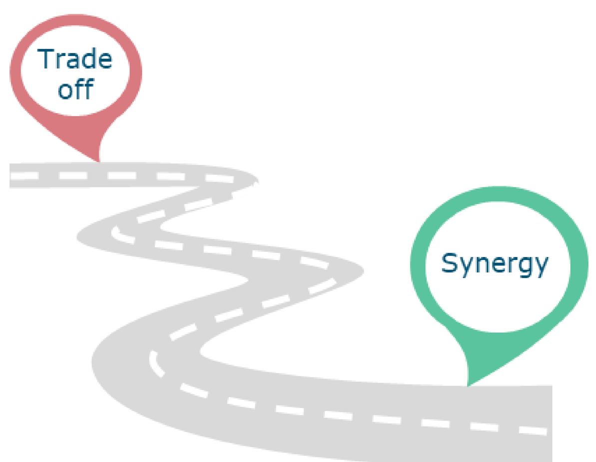
- Environmental issues such as high greenhouse gas (GHG) emissions, water depletion and pollution, soil degradation, and biodiversity loss are prevalent in smallholder farming systems due to sub-optimal management.

- Most of field experimentations lack a systematic methodology for recommending localized practice bundles best suited to farmer conditions.



Objectives

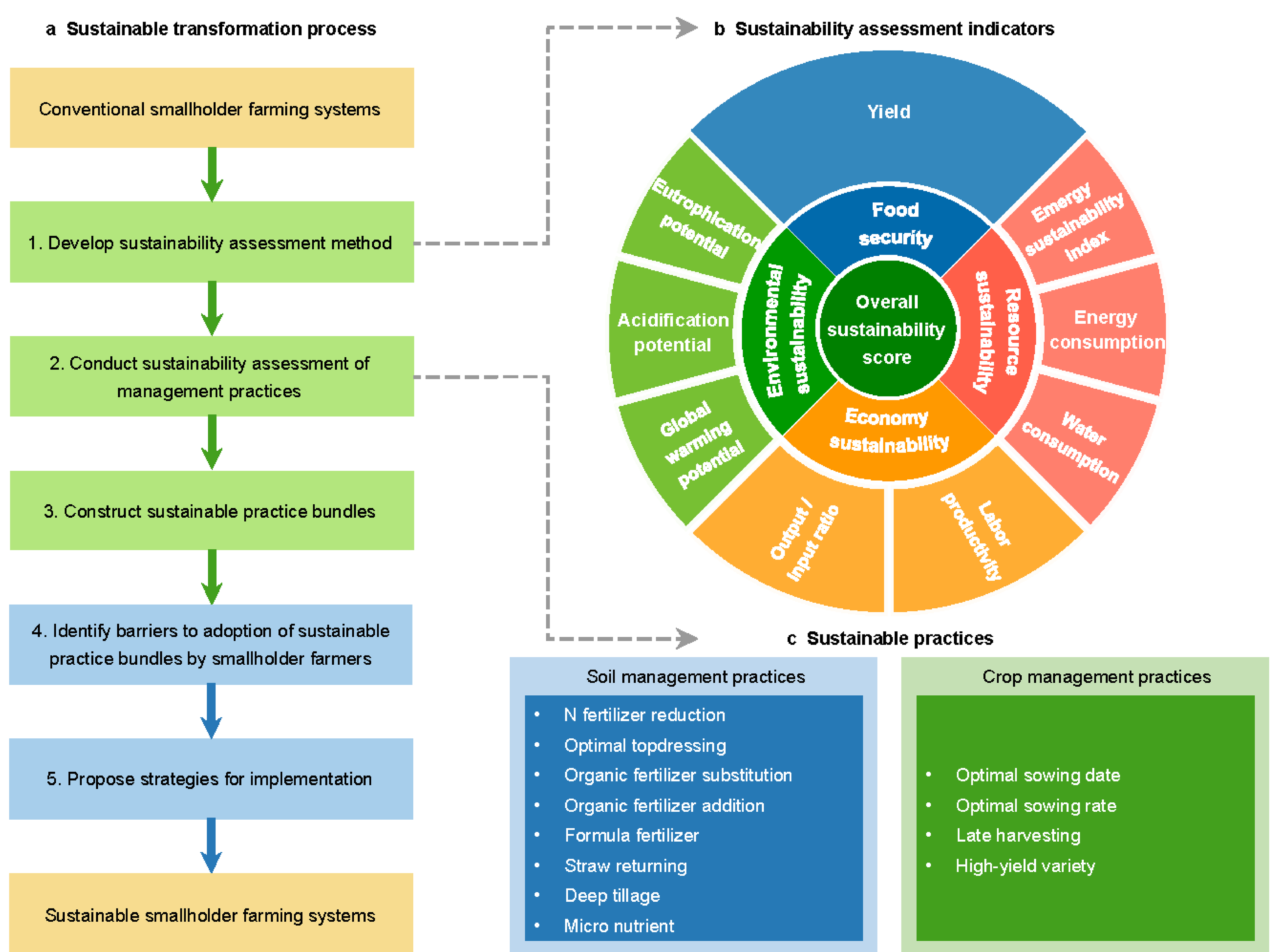
- Design a framework for integrating technical innovations and practical applications in order to explore sustainable transformation pathways tailored to smallholder agriculture.



Methods

- We design a framework for integrating technical innovations and practical applications in order to explore sustainable transformation pathways tailored to smallholder agriculture.

- This involves developing a sustainability assessment method for smallholder farming systems to identify sustainable practice bundles, as well as practical pathways for implementing them on the ground based on smallholder farmers' preferences.

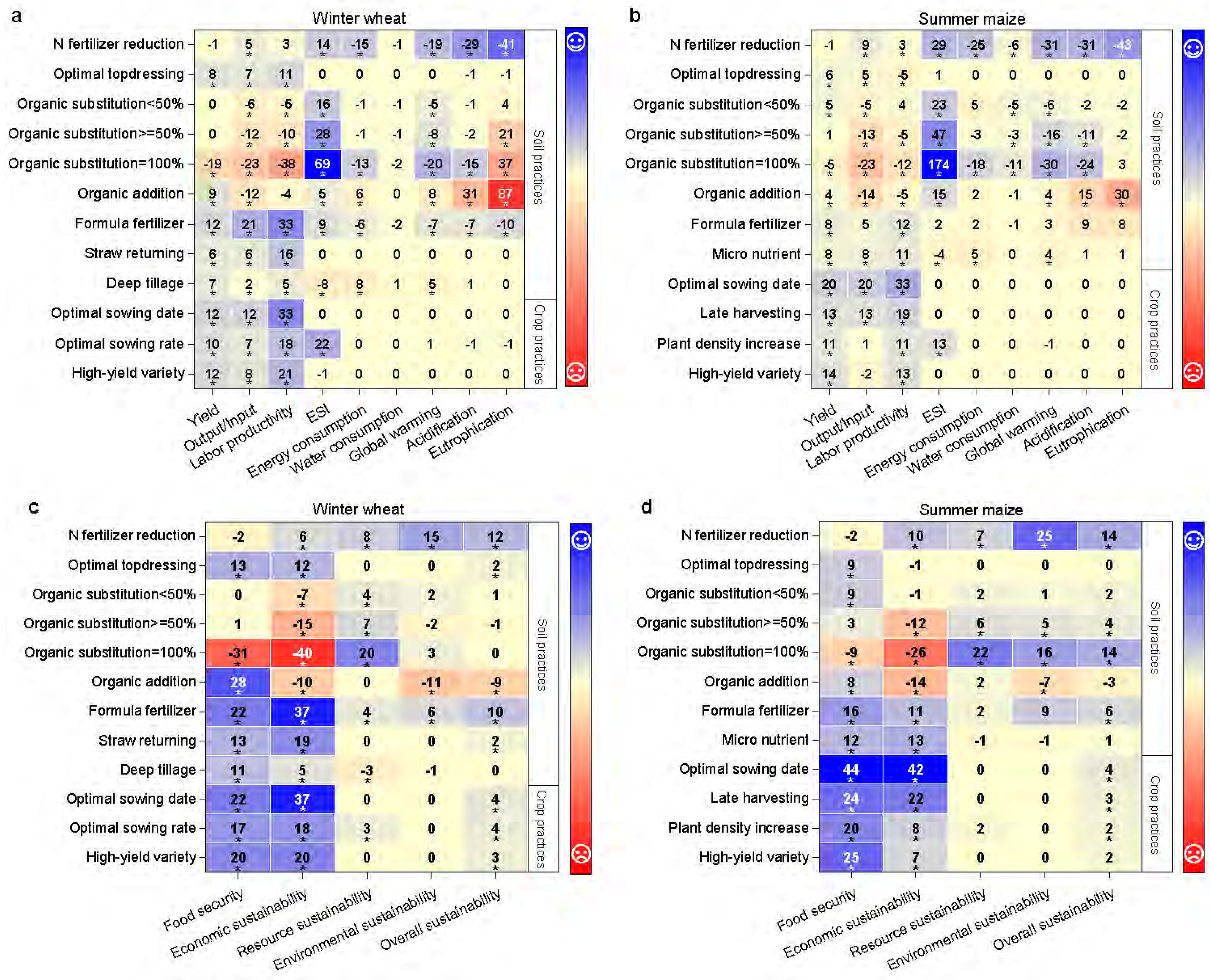


Acknowledgements

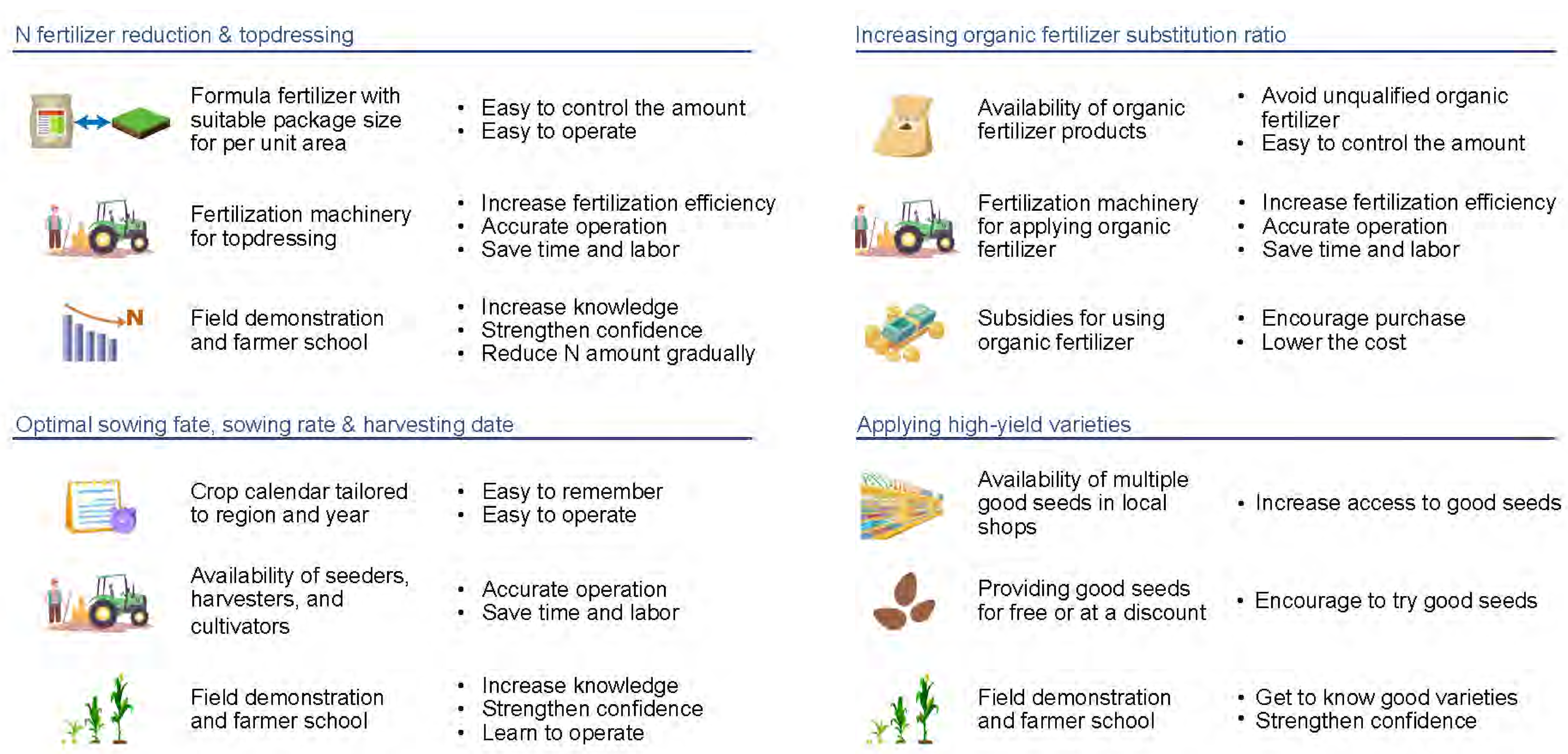
We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

Results

- Nitrogen reduction has the greatest positive effects on the overall sustainability (12–14%).
- Formula fertilizer can also increase the overall sustainability by 6–10%.
- Optimal crop practices can enhance the overall sustainability by 2–5%.



- Achieving this goal requires the integrated strategies from multiple efforts to change the smallholder farmers' inner thoughts and provide them with material and financial assistance.



Conclusions

- Optimal management practices in winter wheat-summer maize cropping systems can increase yield and labor productivity by 10–20% and 11–33%, respectively, without compromising resource and environmental sustainability.

- The large-scale application of these optimal management practices faces practical barriers associated with economic costs, labor requirements, and farmer's preferences and acceptance.

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Balancing farm profit and greenhouse gas emissions along the dairy production chain via breeding

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Background

- Dairy farming is responsible for approximately 20% of the greenhouse gas (GHG) emissions caused by all global livestock
- Selective breeding can help in GHG mitigation
- For breeding a parameter is needed that penalizes increase of GHG
- The penalty should cover all GHG produced along the dairy chain
- GHG breeding might be in conflict with economic profit

Objectives

- Define a GHG penalty for the breeding goal traits, to quantify the GHG-impact in breeding programs
- Design optimal breeding programs for selecting against GHG and economic profit

Methods

- Data: from a typical commercial Holstein dairy farm in Beijing, China

Table 1. Characteristics of the study farm in Beijing, China.

Item	Unit	Value
Number of cows	head	1,523
Number of youngstock	head	1,429
Milk yield	kg/cow/year	11,533
Protein content of milk	%	3.3
Fat content of milk	%	4.5
Age at first calving	month	26
Replacement rate	% per year	33.5

- Economic consequences assessed by bio-economic model
- GHG emissions: life-cycle assessment (LCA)
  - ✓ Emission sources: fertilizer manufacturing, field operations, processing and transportation of crops and concentrates, enteric fermentation from animals, manure management, and the production and combustion of energy
  - ✓ GHGs: CO_2, CH_4, and N_2O
- Breeding program on the following traits
  - ✓ Production: milk yield (MY), protein yield (PY), and fat yield (FY)
  - ✓ Reproduction: calving interval (CI)
  - ✓ Longevity: productive life (PL)
  - ✓ Health: clinical mastitis (MAS)

Results

- Intensity value = extra GHG (in CO2 -eq) from 1-unit increase of a trait

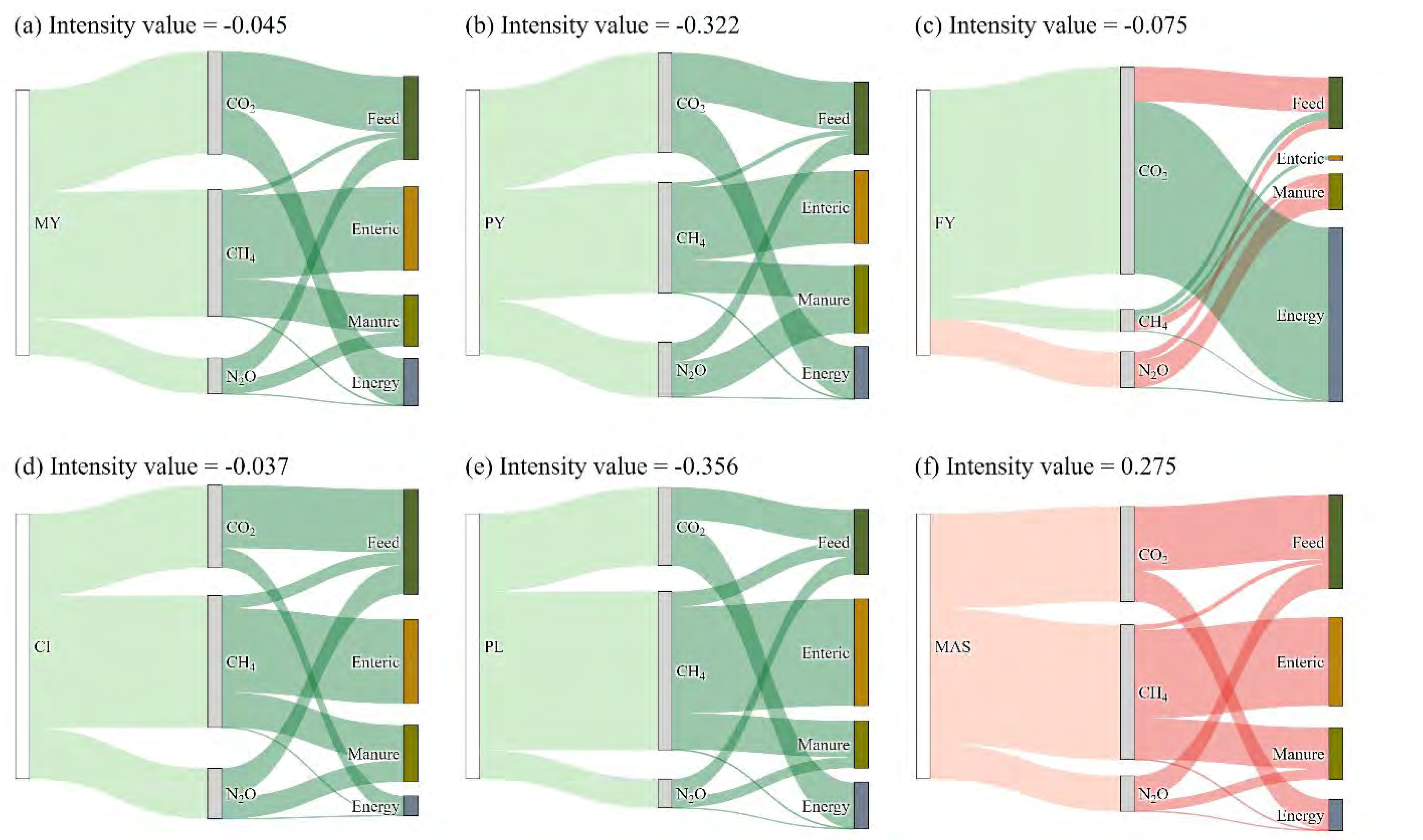

Fig 1. contribution of GHG-sources (Feed, Enteric, Manure, Energy) to intensity value of a trait

- The breeding programs are balanced for GHG-reduction and economic profit, without negative consequences for other breeding goal traits
- Breeding animals with optimal indices could reduce GHG emissions by 6 to 10 CO_2-eq per ton of fat-protein-corrected milk, while increasing profitability by 822 to 1,355 Chinese Yuan per cow unit

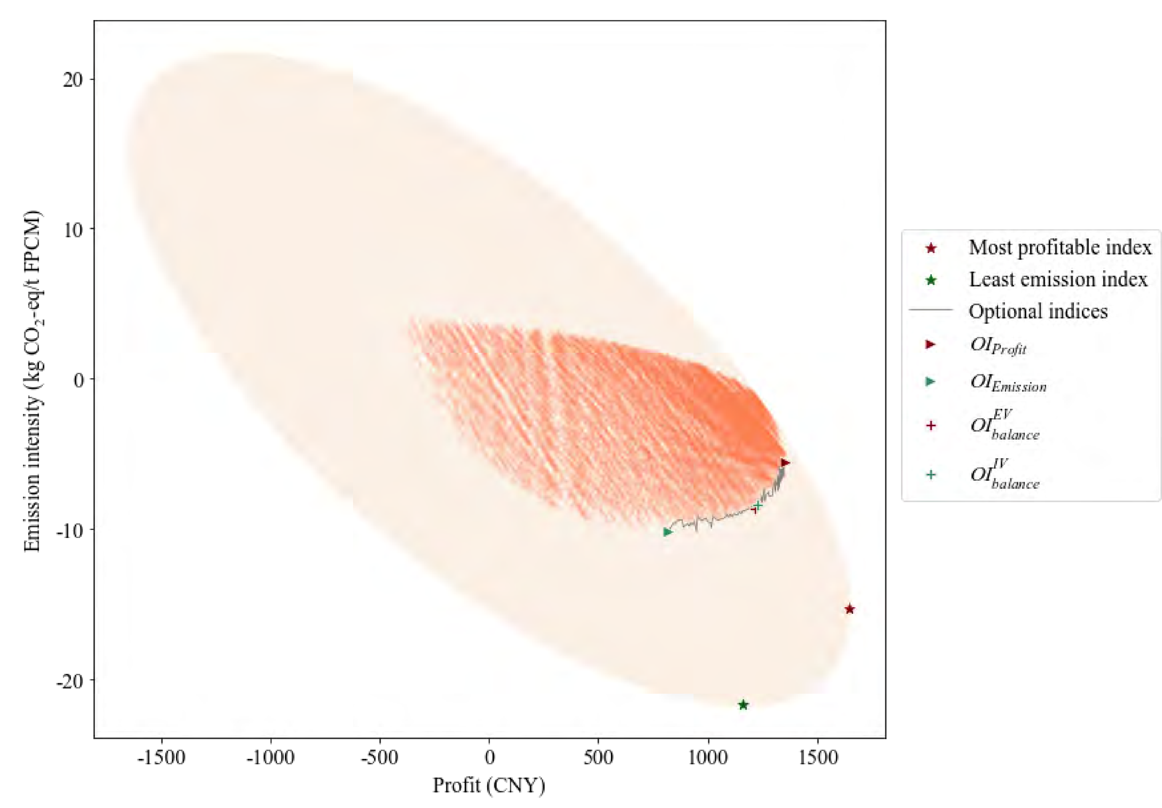

Fig 2. Economic (x-axis) and environmental (y-axis) consequences of different breeding programs

Conclusions

- The constructed Intensity Value is a GHG-penalty for a breeding trait and is based on GHG from on the entire dairy chain
- Intensity values can be used in breeding programs to reduce GHG production and to balance with breeding for economic profit

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Plant species identity drives soil legacies by affecting root morphology of maize but effects depend on phosphorus supply

PhD Student: **Yujuan He** Supervisors: **Jingying Jing ,Yingjun Zhang, Paul C. Struik**

Background

Various plant species trigger the multiplication of different microorganisms as they grow (Bardgett and Van Der Putten 2014; Philippot et al. 2013). When these plants eventually disappear, their microbial legacies remain in the soil and subsequently affect the following plant growth in the same soil (Teste et al. 2017; Van der Putten et al. 2013). However, the optimal grass: legume ratio in ley pastures that could benefit the subsequent crop and the mechanisms of their biotic legacy effects on the subsequent crop are unknown.

Hypotheses

In this study, we hypothesized that:

(1)The identities of various plant species have varying impacts on the composition of soil fungal and bacterial communities.

(2) Legume and grass forages can enhance or reduce maize growth due to accumulation of beneficial microorganisms and pathogenic bacteria, respectively.

(3) Phosphorus fertilizer enhances the legacy effect.

Methods

An experiment with two factors was set up in a greenhouse at China Agricultural University in a randomized block design, with nine soil legacy inocula (based on monocultures of *Medicago sativa*, *Onobrygis viciifolia*, *Dactylus glomerata*, *Festuca arundinacea*, and mixtures of two legumes (L) and two grasses (G) in L:G ratios of 3:7, 4:6, 5:5, 6:4 and 7:3) and with three P addition levels: 0, 20, 50 mg kg^{-1} soil (P0, P1 and P2). Each pot contained two maize plants and 1.5 kg soil (10% inoculum soil, 90% sterilized soil).

Results

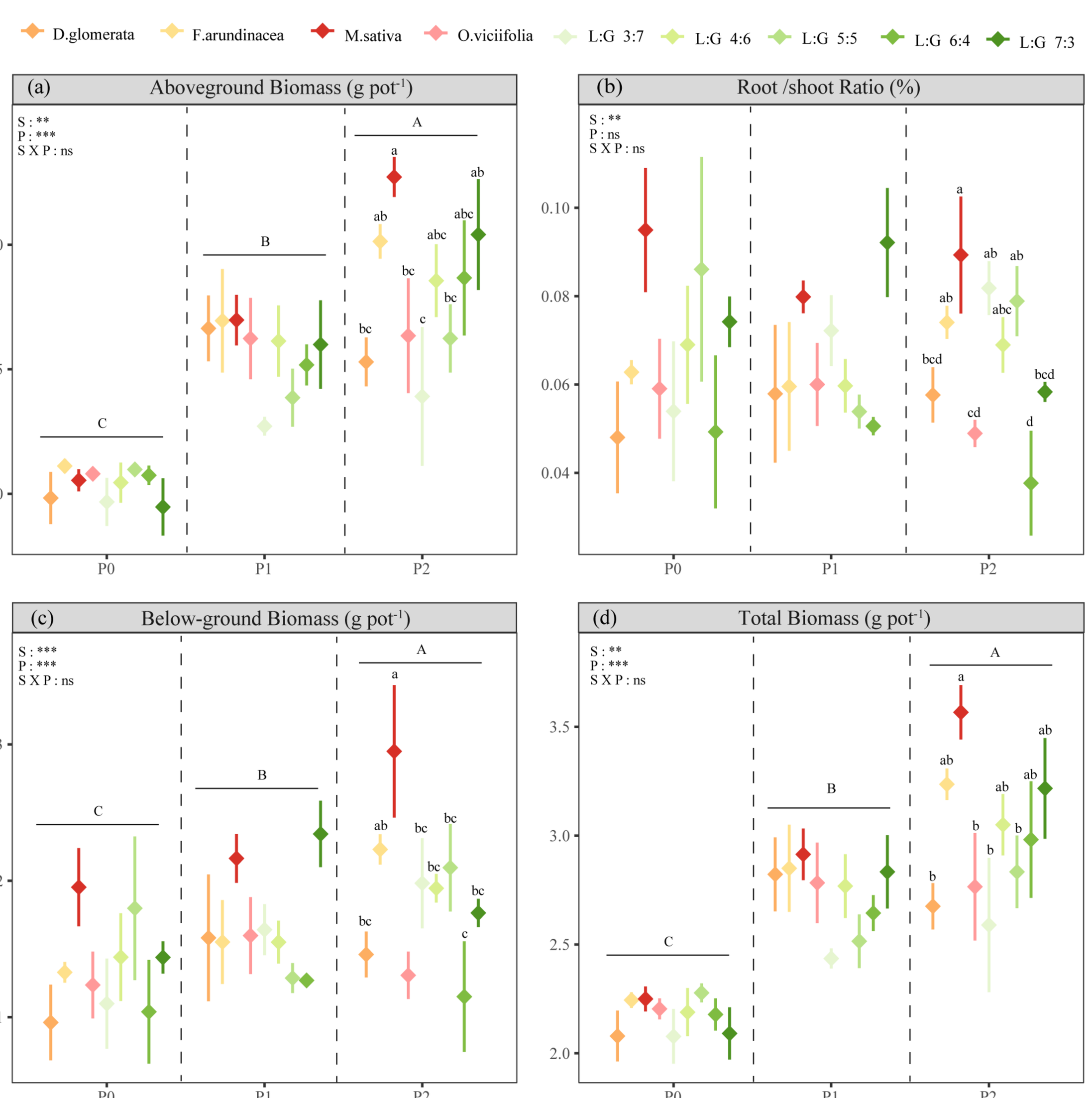

Fig. 1 The aboveground biomass (a), below-ground biomass (b), root/shoot ratio (c) and total biomass (d) under different soil legacies and P levels of maize. The aboveground, belowground and total biomass increased with increasing P level.

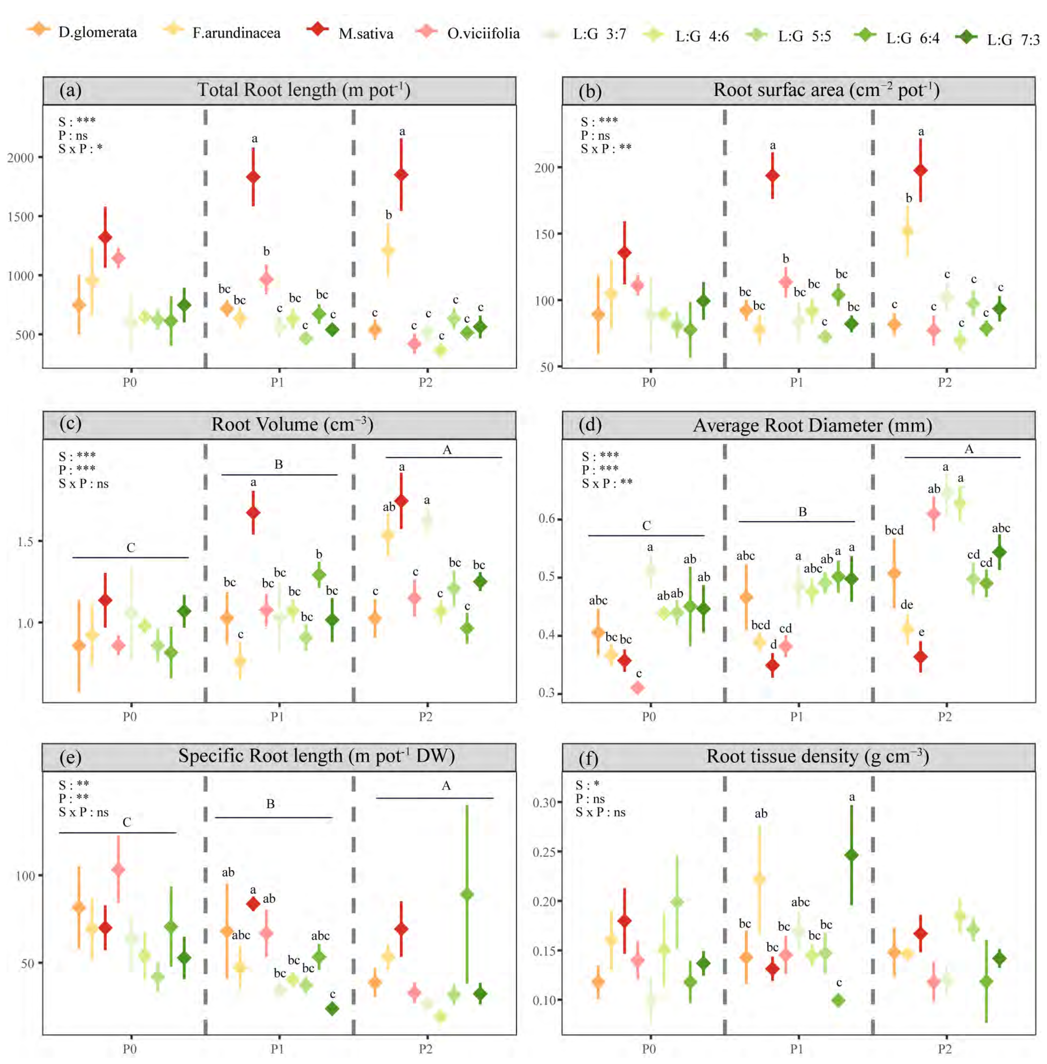

Fig. 2 The effect of different soil biotic legacies and P levels on root traits of maize. Root volume and average root diameter were increased with increasing P level. Specifically, the effects of soil biotic legacies on specific root length and root tissue density were only found in the intermediate P level.

Fig. 3 Linear discriminant analysis effect size (LEfSe) of soil bacterial (a) and fungal (b) communities. Enriching beneficial bacteria by previous legume monoculture to promote maize growth. Accumulation of pathogenic fungi by previous grass monoculture to inhibit maize growth.

Conclusions

We explored soil biotic legacies conditioned by different species in monocultures and mixtures to affect the growth at early growing stage of maize under different phosphorus fertilizer levels. Our results demonstrated that the species-specific effects influenced the direction in which the bacterial and fungi legacies developed and impacted the growth of the subsequent crop which depend on P fertilizer input. These effects were partly brought about by effects on root traits, especially at high phosphorus levels.

Bardgett RD, Van Der Putten WH (2014) Belowground biodiversity and ecosystem functioning. Nature 515: 505-511.

Philippot L, Raaijmakers JM, Lemanceau P, Van Der Putten WH (2013) Going back to the roots: the microbial ecology of the rhizosphere. Nature reviews microbiology 11: 789-799.

Teste FP, Kardol P, Turner BL, Wardle DA, Zemunik G, Renton M, Laliberté E (2017) Plant-soil feedback and the maintenance of diversity in Mediterranean-climate shrublands. Science 355: 173-176.

Van der Putten WH, Bardgett RD, Bever JD, Bezemer TM, Casper BB, Fukami T, Kardol P, Klironomos JN, Kulmatiski A, Schweitzer JA (2013) Plant–soil feedbacks: the past, the present and future challenges. Journal of Ecology 101: 265-276.

Acknowledgements

We gratefully acknowlege the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University.

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Forage quality in cereal-legume intercropping: meta-analysis and field experiment

Hao Liu
Supervisors: Yingjun Zhang, Jingying Jing, Paul C. Struik, Tjeerd-Jan Stomph

Background

Cereal-legume intercropping has been found to significantly increase yield, resource use efficiency, and a range of other agriculture ecosystem services. In forage production, mixtures may more effectively balance the fiber and crude protein concentration of the forage in view of nutrient requirements of ruminants than sole crops, principles underlying optimization of mixture design are unknown.

Objectives

The aim of this study is to determine the forage quality and quantity effects of legume-cereal intercropping and the key factors influencing these.

Methods

We report a meta-analysis aiming to determine the forage quality and quantity effects of legume-cereal intercropping and the key factors influencing these. For comparison of the yield of mixtures and sole crops, the net effect will be used. The advantage of intercropping over monocropping in terms of percentages of CP, ADF, NDF and non-CP non-NDF were measured by the log of the net effect ratio (Log-NER). The net effect ratios (NERs) in this analysis are defined as the ratios between the concentration of CP, ADF, NDF and non-CP non-NDF in the intercrops and that in the sole crop.

$$NER_{CP\%} = \frac{\frac{CPY1 + CPY2}{Y1 + Y2}}{\frac{ECPY1 + ECPY2}{EYI + EY2}} = \frac{NER_{cpy}}{NER_{dmy}}$$

Where NER is the net effect ratio, CPY1 and CPY2 are respectively the observed CP yield of Species 1 and Species 2 in the intercropping situation, ECPY1 and ECPY2 are the expected CP yields of the two species, which were calculated based on the CP yield of each sole crop and its land share.

Results

The average Log-NER values for %CP (0.009±0.008), %NDF (0.002±0.007), ADF% (-0.005±0.006) and %non-CP non-NDF (0.002±0.005) were all not significantly different from zero (Fig. 1). But the change in %CP showed a much wider distribution than the change in %NDF and %ADF.

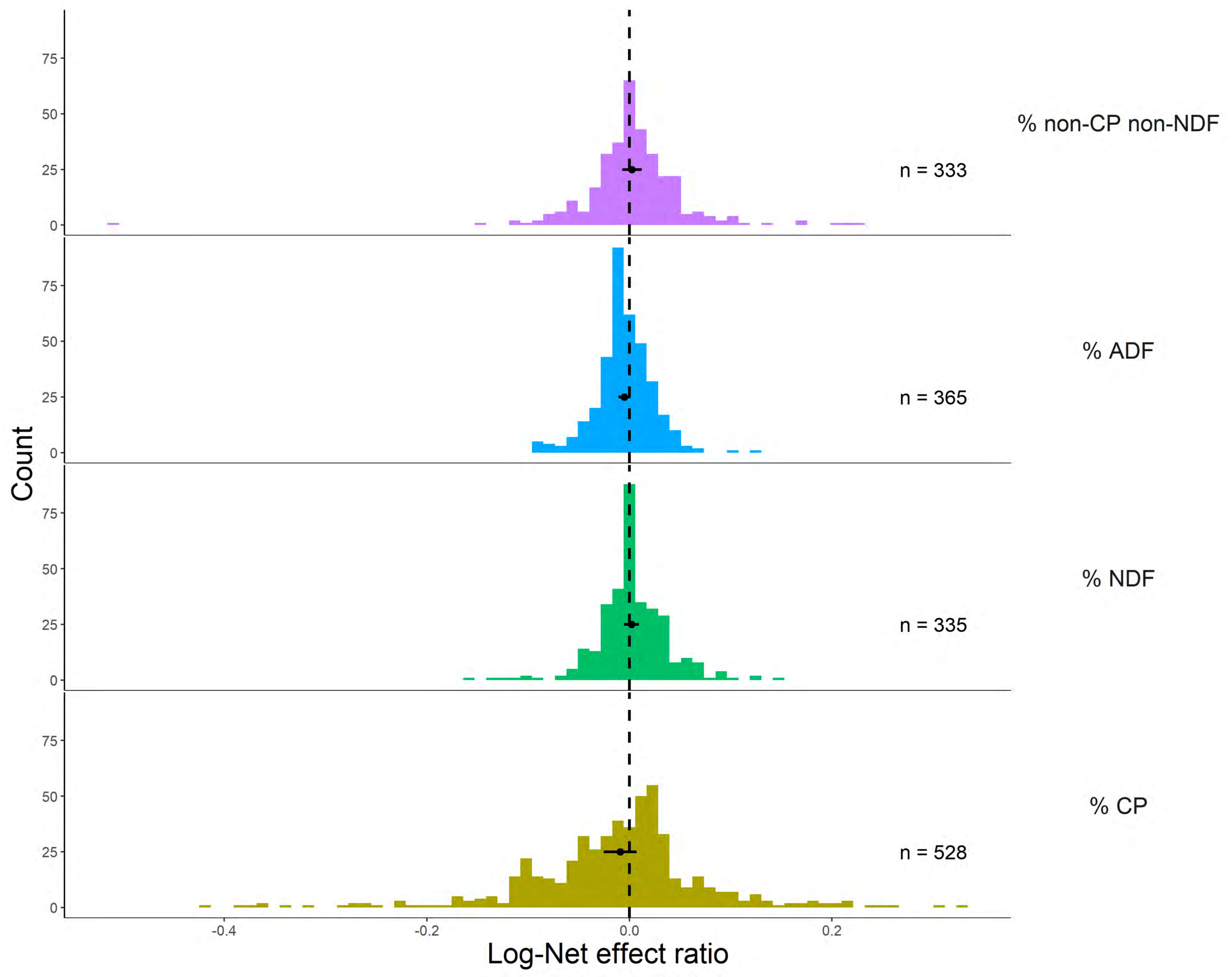

Fig. 1. The log net effect ratios (Log-NER) of cereal-legume intercropping calculated for the %non-CP non-NDF, %ADF, %NDF and %CP of intercrops. The dots represent the mean value. The horizontal bars reflect 95% confidence intervals. The dashed vertical line represents zero Log-NER.

Conclusions

In this meta-analysis, we quantitatively evaluated the productivity and quality of cereal-legume intercrops. We found that intercropping can significantly increase the DM, CP, NDF, ADF and non-CP non-NDF yields of cereal/legume intercrops grown for fodder, without compromising the overall quality.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Maternal fiber-rich diet promotes early-life intestinal development in offspring through milk-derived extracellular vesicles

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Background

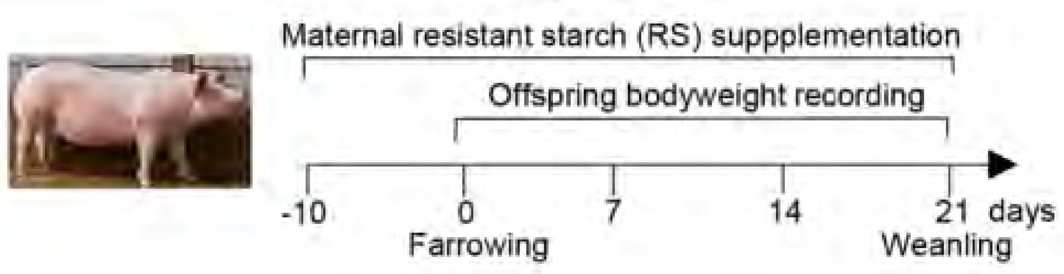
The biological information in milk-derived extracellular vesicles (mEVs) is mainly determined by the mother, but the role of mEVs in the connection between maternal diet and offspring is still unknown.

Resistant starch (RS) has been proposed as a promising dietary fiber source in human and animal food. Maternal RS intake could not only benefit the body condition of mothers, but also reduce the risk of allergic disease, and improve the insulin sensitivity and glucose balance of infants Moreover, maternal dietary RS intake promotes the expression of mucous membrane-binding protein and improves the intestinal health of infants. However, the mechanism by which maternal RS promotes intestinal health in offspring is still inconclusive, and the underlying mechanism, whether breast mEVs plays a role here, needs to be further explored.

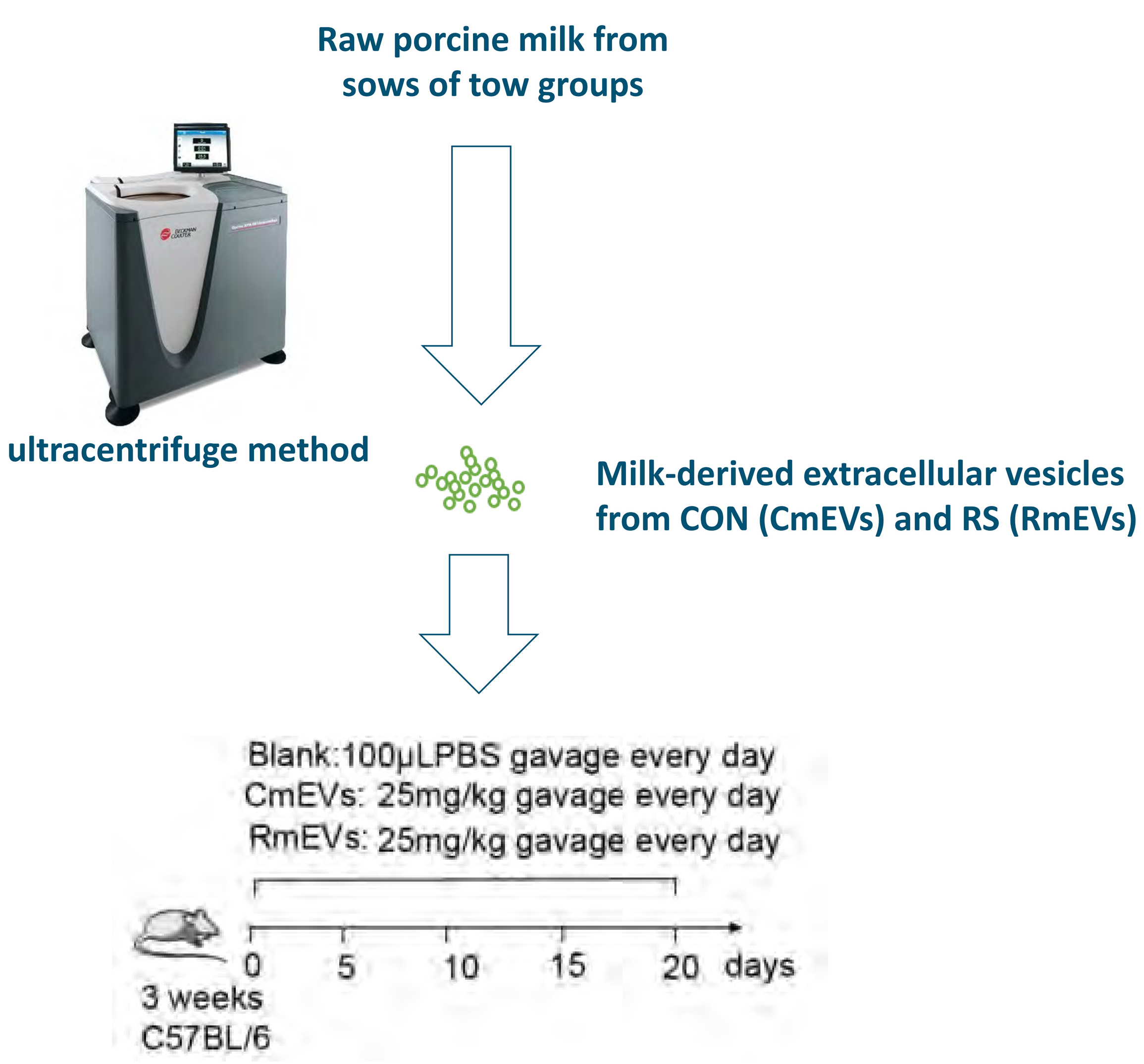
Objectives

This study, therefore, aims to investigate how maternal dietary RS supplements affect the intestinal development of offspring through mEVs. The effects of maternal RSrich mEVs on the proliferation and renewal of offspring intestinal development were studied both in vivo and in vitro. This study, therefore, aims to investigate how maternal dietary RS supplements affect the intestinal development of offspring through mEVs. The effects of maternal RS rich mEVs on the proliferation and renewal of offspring intestinal development were studied both in vivo and in vitro.

Methods



Exp. 1: a total of 40 sows were allocated into two groups based on their body weight and parity. During the whole experimental period (from 104 days of gestation until weaning), the control (n = 20) was fed with a basal diet (CON) and the treatment (n = 20) was fed a diet with 2% wheat bran replaced by RS fiber (RS)



Exp. 2: a total of 21 3-weeks-old female mice were allocated into three groups based on their body weight. Mice from different groups were administrated with saline, CmEVs, RmEVs every day, respectively. The experiment lasted for 20 days.

Results

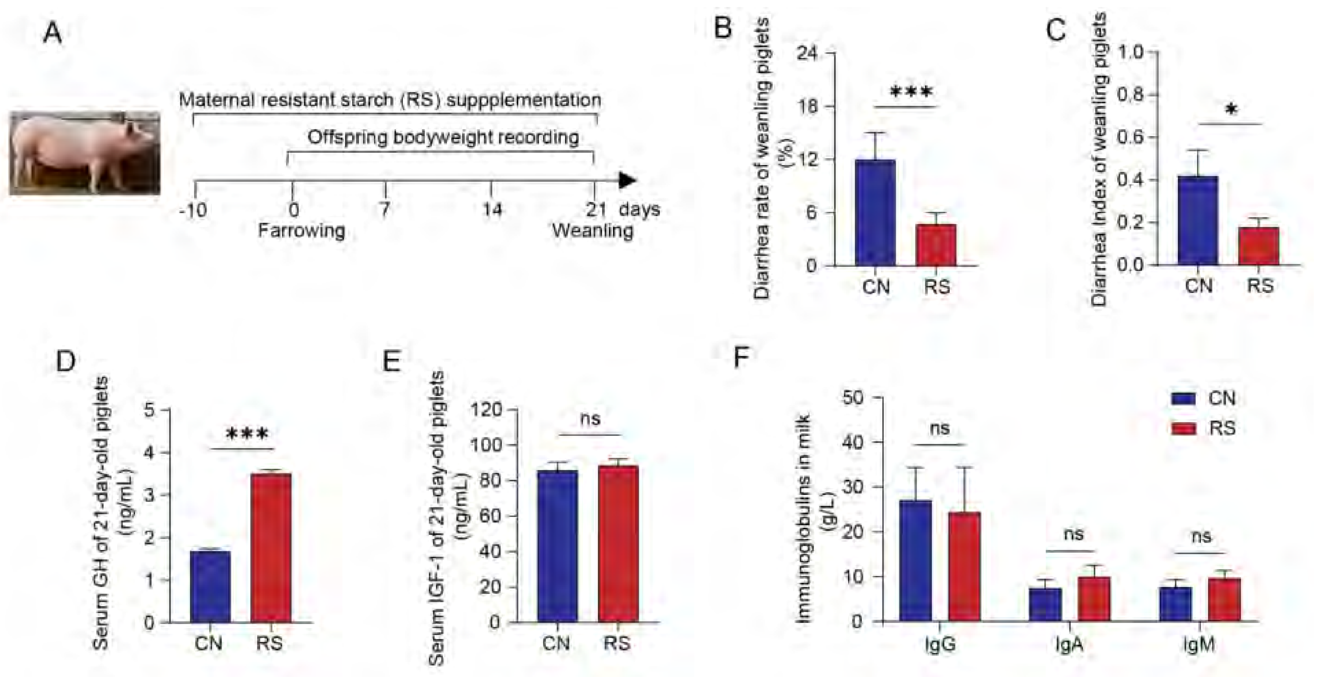


Fig. 1 Maternal RS supplementation enhances growth performance and reduces diarrhea in weanling piglets (n = 20). (A) Animal design and maternal RS diet treatment. (B) Diarrhea rate of piglets during weaning. (C) Diarrhea index of piglets during weaning. (D) Serum growth hormone (GH) level in piglets at 21 d of age. (E) Serum insulin-like growth factor 1 (IGF-1) level in piglets at 21 d of age. (F) Immunoglobulins G, A, and M in sow milk on day 21 of lactation.

As shown in Fig.1, maternal dietary RS supplementation decreased the diarrhea rate and diarrhea index of weanling piglets (Fig. 1B and C). The serum level of growth hormone (GH) was profoundly increased in piglets of RS (Fig. 1D), but not in insulin-like growth factor 1 (IGF-1) (Fig. 1E)

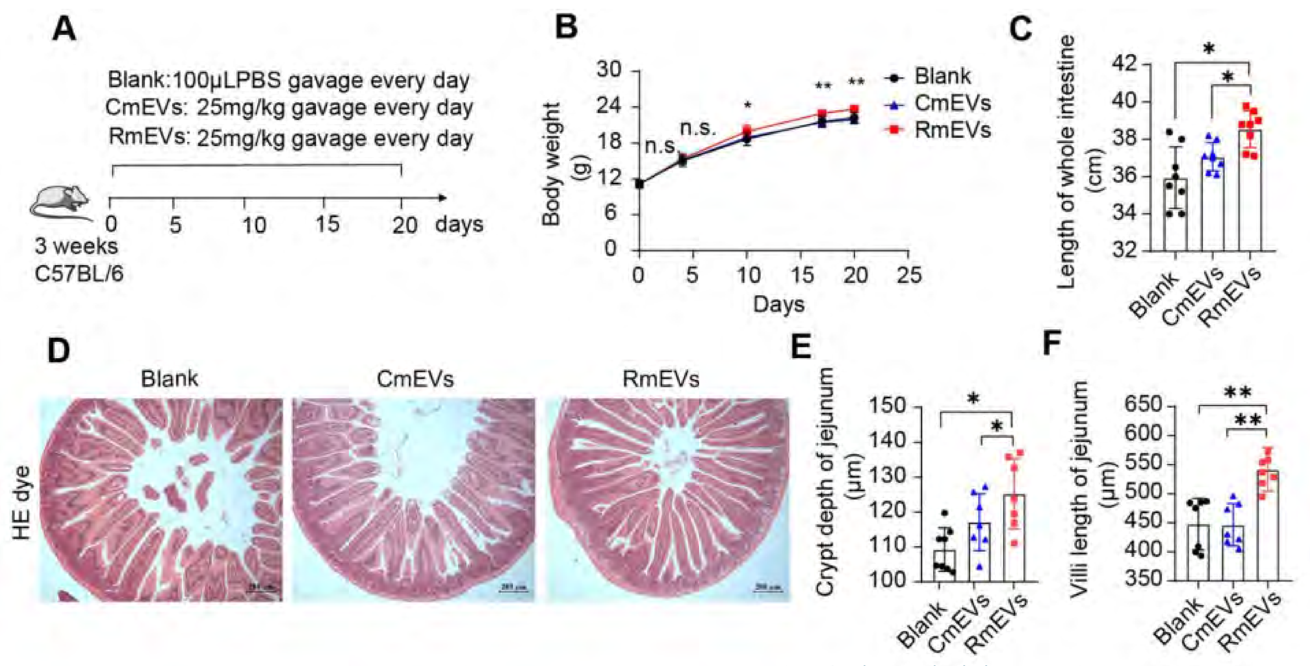


Fig. 2 RmEVs improve intestinal development in vivo during early life (n = 7). (A) Animal designs and mEVs administration schedule in young C57BL/6 mice. (B) The body weight of mice. (C) The length of the whole intestine of mice. (D) The images of HE dye in the jejunum, scale bar: 200 μm. (E) The crypt depth of jejunum. (F) The villi length of jejunum.

As shown in Fig.2, RmEVs significantly increased body weight gain from day 5 of the experiment. The body weight of mice from RmEVs was higher than that from the CmEVs and PBS at the end of the trial (Fig. 2B). Besides, RmEVs could promote intestinal development, as evidenced by the longer total intestinal length, improved intestinal morphology, and increased jejunal crypt depth and villus length in the RmEVs group (Fig. 2C-F).

Conclusions

The present study demonstrated that maternal RS consumption promotes the growth and intestinal health of offspring during early life. The mEVs is an important effector in maternal RS supplement influence the intestinal development of offspring.

Publications

Lu, D., Liu, Y., Kang, L., Zhang, X., Hu, J., Ye, H., Huang, B., Wu, Y., Zhao, J., Dai, Z., Wang, J., & Han, D. (2024). Maternal fiber-rich diet promotes early-life intestinal development in offspring through milk-derived extracellular vesicles carrying miR-146a-5p. J Nanobiotechnology, 22(1), 65.

Acknowledgements

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The asymmetric impacts of feeding China's monogastric livestock with food waste on food security and environment sustainability

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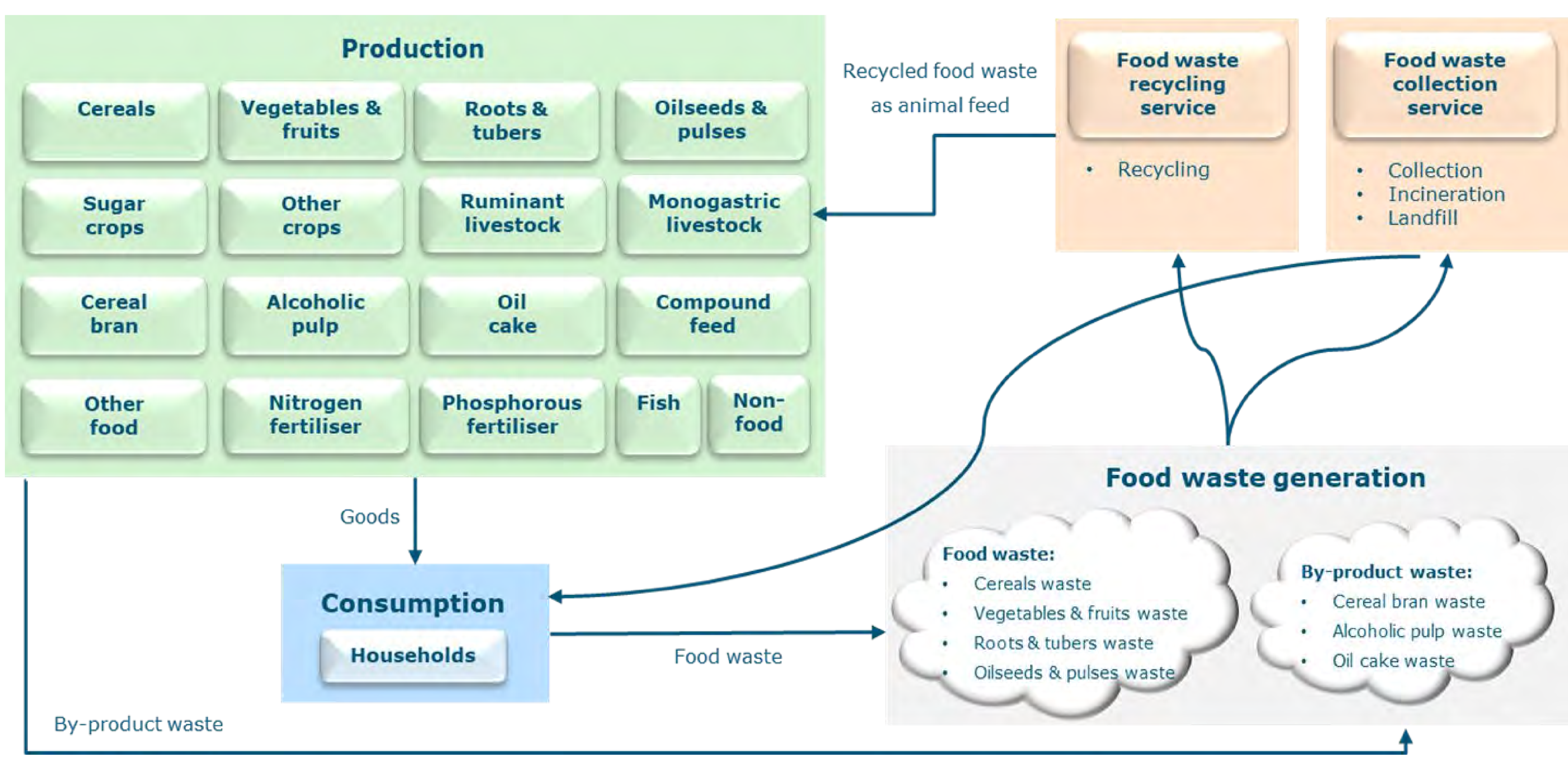
Background

Around 1.3 billion tonnes of food waste are produced in the world, which are mainly disposed in landfills and incinerators, and are a significant source of greenhouse gas (GHG) emissions. Feeding animals with food waste offers a pathway to mitigate land-related pressures, alleviate the food-feed competition, and diminish the emissions arising from improper food waste disposal. However, feeding animals with food waste may lower feed costs and boost farm profits, which may drive livestock production expansion and lead to increased emissions, a phenomenon known as the "rebound effect", which remains unexplored.

Objective

The objective of this study is to analyse the possible environmental and economic consequences of upcycling food waste in China's monogastric livestock production in a global context.

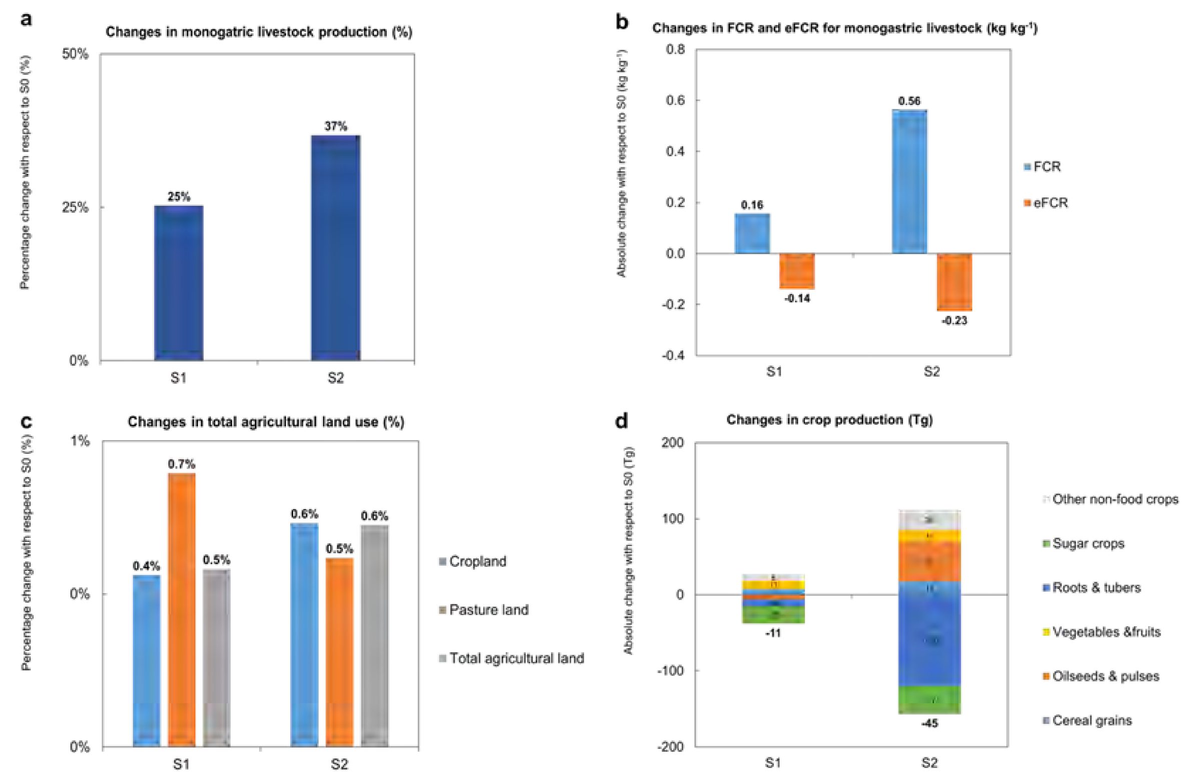
Framework & Methods



- **Model type:** Static applied general equilibrium (AGE) model of the global economy
- **Data source:** Global Trade Analysis Project (GTAP) model version 10
- **Scope:** 65 sectors, 141 regions (Base year: 2014)

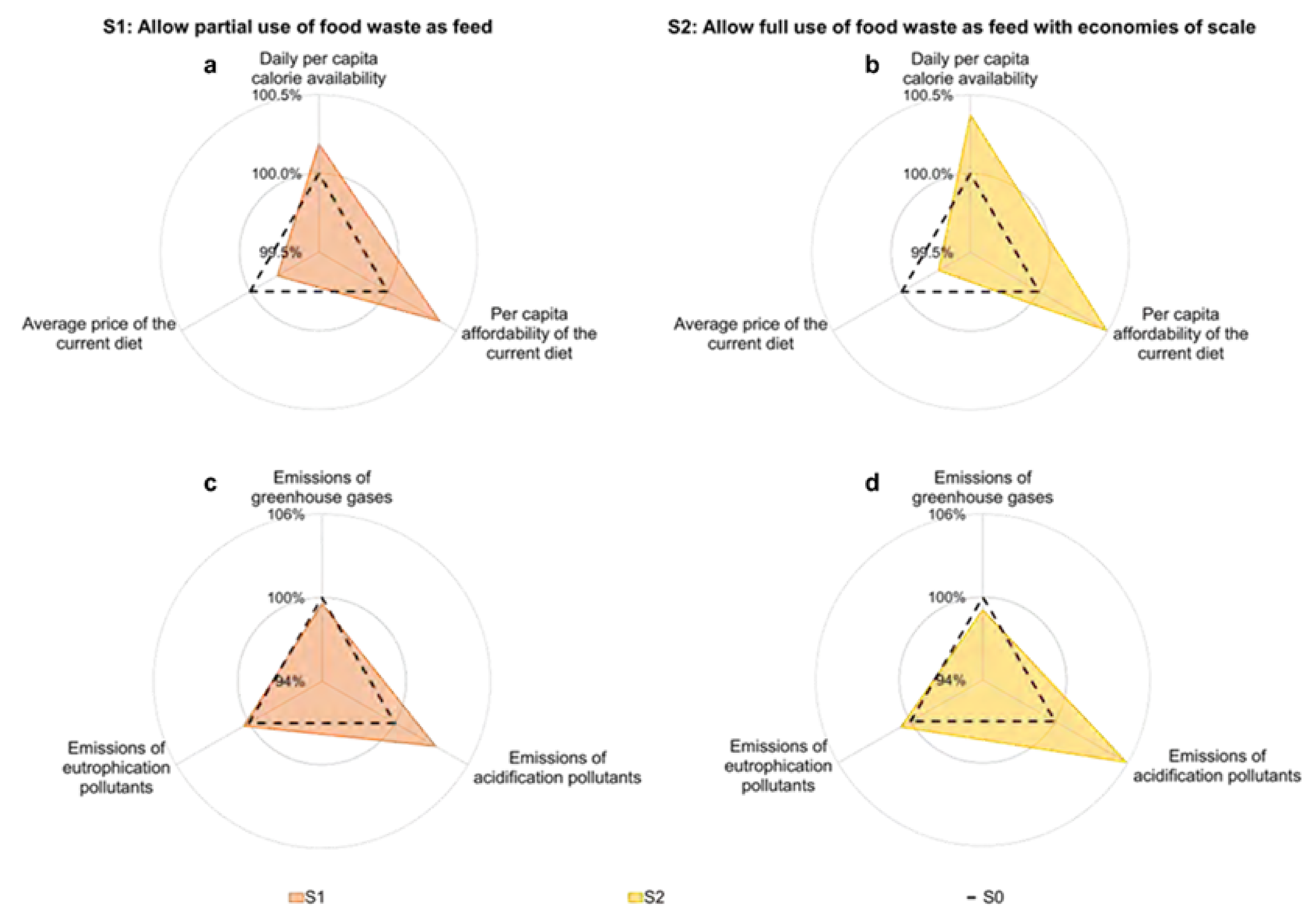
Results

➢Impacts on livestock production and food supply.



- Upcycling 54-100% of food waste as feed increased and monogastric livestock production (25-37%) with negative indirect effects such as increased total agricultural land use (0.5-0.6%).

➢Impacts on food security and environment sustainability.



- Upcycling 54-100% of food waste as feed decreased economy-wide GHG emissions (0.5-0.9%), but increased economy-wide emissions of acidification (3-6%) and eutrophication (0.5-0.8%) pollutants in China.
- While feeding food waste strategies enhanced food availability (6-12 kcal capita^{-1} day^{-1}) and affordability (0.38-0.49%) in China, it slightly reduced food availability (0.5-1.0 kcal capita^{-1} day^{-1}) and increased affordability (0.18-0.22%) in its trading partners.

Scenarios

- S0: Baseline (39% of food waste and 51% of By-products are used as feed for China's monogastric livestock production)
- S1: Allowing partial use of food waste as feed (54% of food waste and 100% of by-products are used as feed for China's monogastric livestock production)
- S2: Allowing full use of food waste as feed with economies of scale (100% of food waste and 100% of by-products are used as feed for China's monogastric livestock production)

Conclusions

- Our results highlight the asymmetric impacts of feeding China's monogastric livestock with food waste on food security and environment sustainability, urging complementary measures and policies to mitigate negative spillovers when promoting more circular food systems.
- Our analysis holds significant policy implications not only for China, a key global market for food and feed, but also serves as a blueprint for other populous emerging economies.

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Training pigs to excrete in a toilet area by manual rewarding; preliminary study.

Hu Zhenpeng
Supervised by: Peter Groot Koerkamp, Andre Aarnink, Marc Bracke, Wang Chaoyuan, Li Baoming

Background

In intensive as well as in extensive pig farming, the environmental and welfare problems related to elimination behaviour are becoming increasingly unneglectable. A small designated area in pig pen for excretion, namely a pig toilet, can be a solution.
Pigs are clean animals, and it is the pig's natural behavior to separate lying and dunging area. Also, pigs are clever and can be trained in different behavioral tasks quickly. From the basic characteristics of pig behavior, it is expected that pigs can be trained to use a toilet via operant conditioning, e.g., by providing a reward for correct excretion behaviour.
Few studies have focused on steering pig excretion behavior. In the current study, we are trying to train pigs to use a pig toilet by providing a reward when they excrete in the toilet.

Objectives

- Can we train pigs to excrete in designated area with manual rewarding?
- Characterize the learning process of pig toilet training.
- After being trained, to what extent pigs would change their excretion area to other locations?

Methods

Fattening pigs in 2 pens (3.2*2.7m, 4 pigs/pen) were rewarded with apple pieces via a steel pipe when they excreted in the toilet. In phase 1, there were six 15-min training sessions per day with 1 hour interval, 5 training days/week, for a period of 16 days. In phase 2, the toilet location was switched to the lying area of the pigs for 2 weeks. In phase 3, the toilet location alternated between two areas (the corner trained in phase 1, and the corner near the feed trough) for 13 days. Excretion location and rewarding events were recorded during training.
Data were gathered during live observation during training sessions, and video analysis were done via Boris.

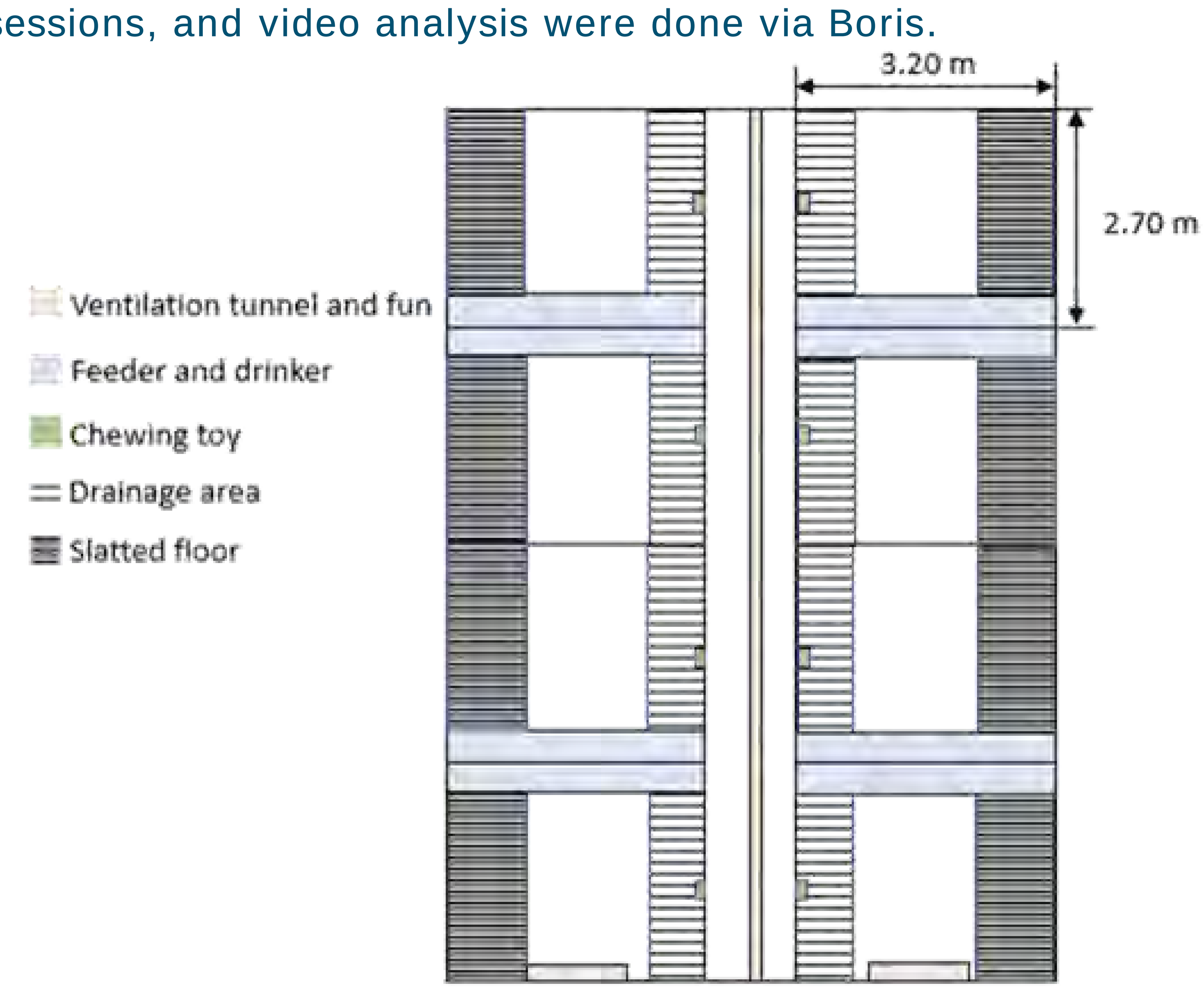


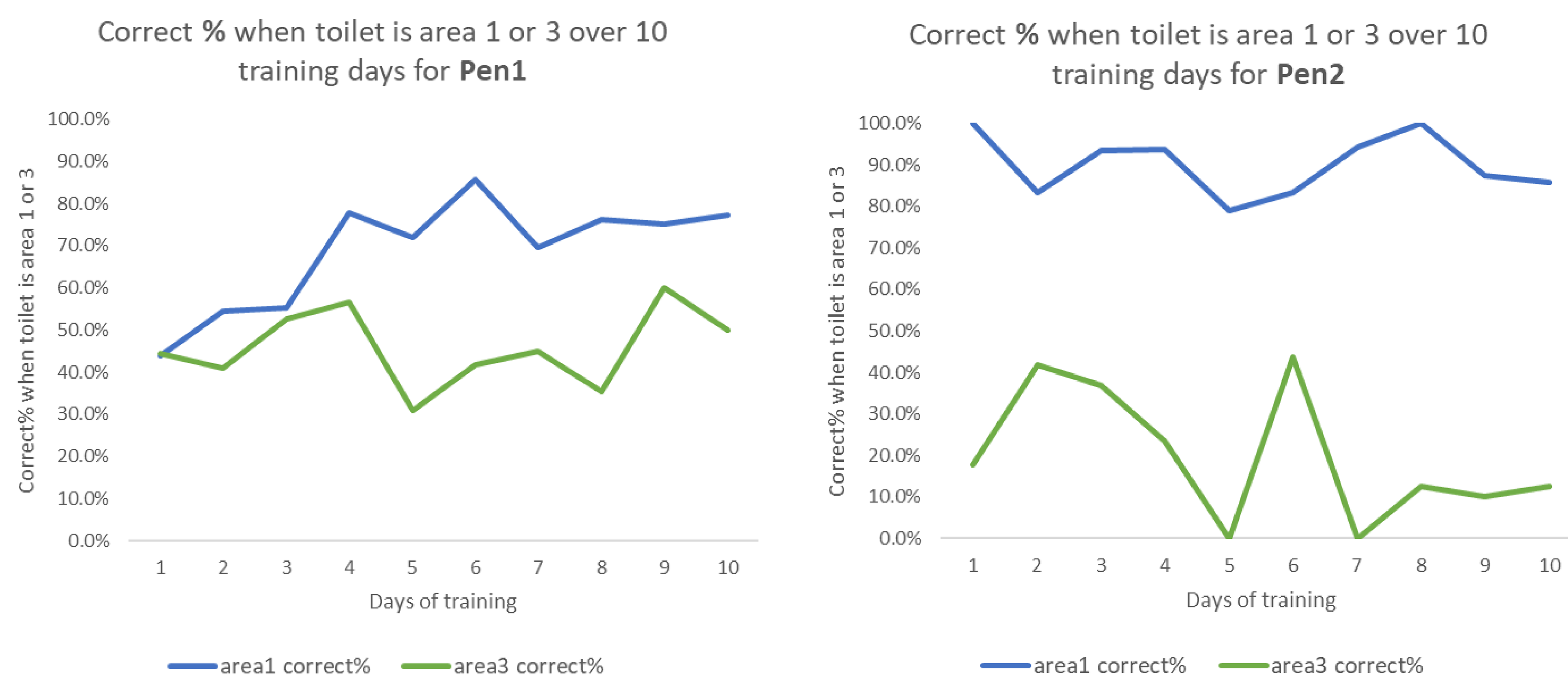
Figure 1, Lay out of the pig house and experimental pen

Figure 2, Manual rewarding for pig excreted in the toilet area

Results

A total of 1196 defaecations and 1175 urinations were recorded. In phase 1, 70.1% and 96.8% of excretions was in the toilet area for pen 1 and 2, respectively.
For pen 1, excretion in the toilet significantly decreased as the toilet area got more crowded over training days.

In phase 2, almost no excretion (5.1%) occurred in the toilet.
In phase 3, pigs kept using the location previously trained in phase 1 for elimination, while there was no significant increase in excretion in the designated toilet area near the feed trough.



Conclusions

Pigs would use a small, designated area for excretion and get a reward, however, increased activity may reduce the number of excretions in the designated area. The toilet area should be placed in a preferred place for pigs, away from other functional areas.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043)

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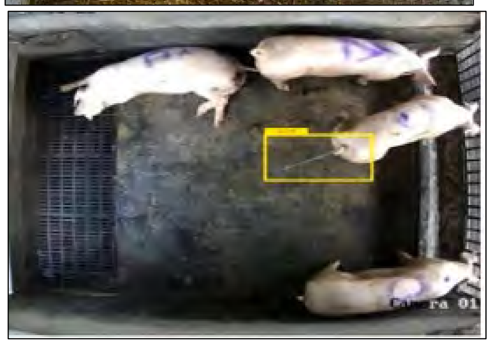
Using thermal and RGB images to recognize defecation and urination event in pig toilet

Fei Xie
Supervisors: Chaoyuan Wang, André Aarnink, Marc Bracke, Peter Groot Koerkamp, Baoming Li

Background



Current automatic training toilet only has urination behaviour rewarding system

Current vision technique is difficult to identify boar urination behaviour

Automatic training pig toilet with recognition of urination and defecation behaviour based on thermal images

Objectives

- Recognition of pig urination and defecation behaviour based on thermal images and deep learning
- Comparison of recognition accuracy in different camera viewpoints

Methods

Acquire thermal image data of pig excretion and non-excretion behaviour:

- 75 pigs in all, 8-9 pigs per pen (35kg)
- Thermal camera: Testo 862
- Rear and side angle

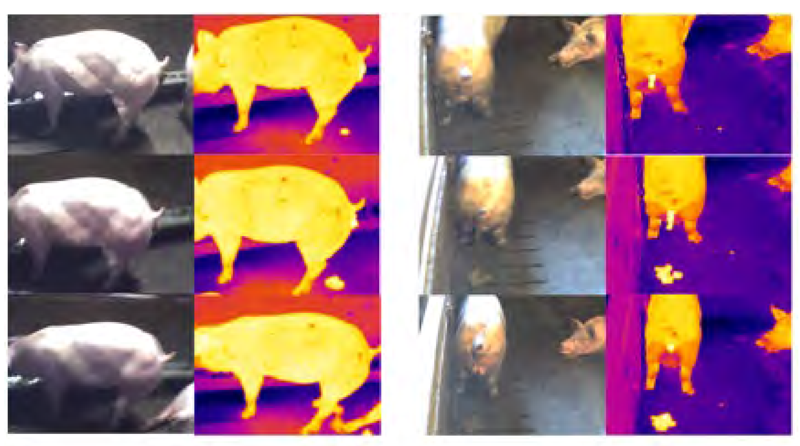
Results

1. Pig urination / defecation events in thermal and RGB images

- The pig excretion events in thermal images and RGB images are shown in figure 2 and 3.
- The urination posture of female pigs is different from male pigs.
- The defecation posture of pigs in both genders is same.

(a) (b) (c) (d)

Figure 2. Pig urination events in thermal and RGB images: (a) the rear view of female pigs; (b) the rear angle of male pigs; (c) the side angle of female pigs; (d) the side angle of male pigs.



(a) (b)

Figure 3. Pig defecation events in thermal and RGB images: (a) the side angle; (b) the rear angle.

2. Data training

- The data were divided into a train, validation and test set as 8:1:1.
- 3 models were applied in this experiment: EfficientnetB0, resnet50 and vgg19.

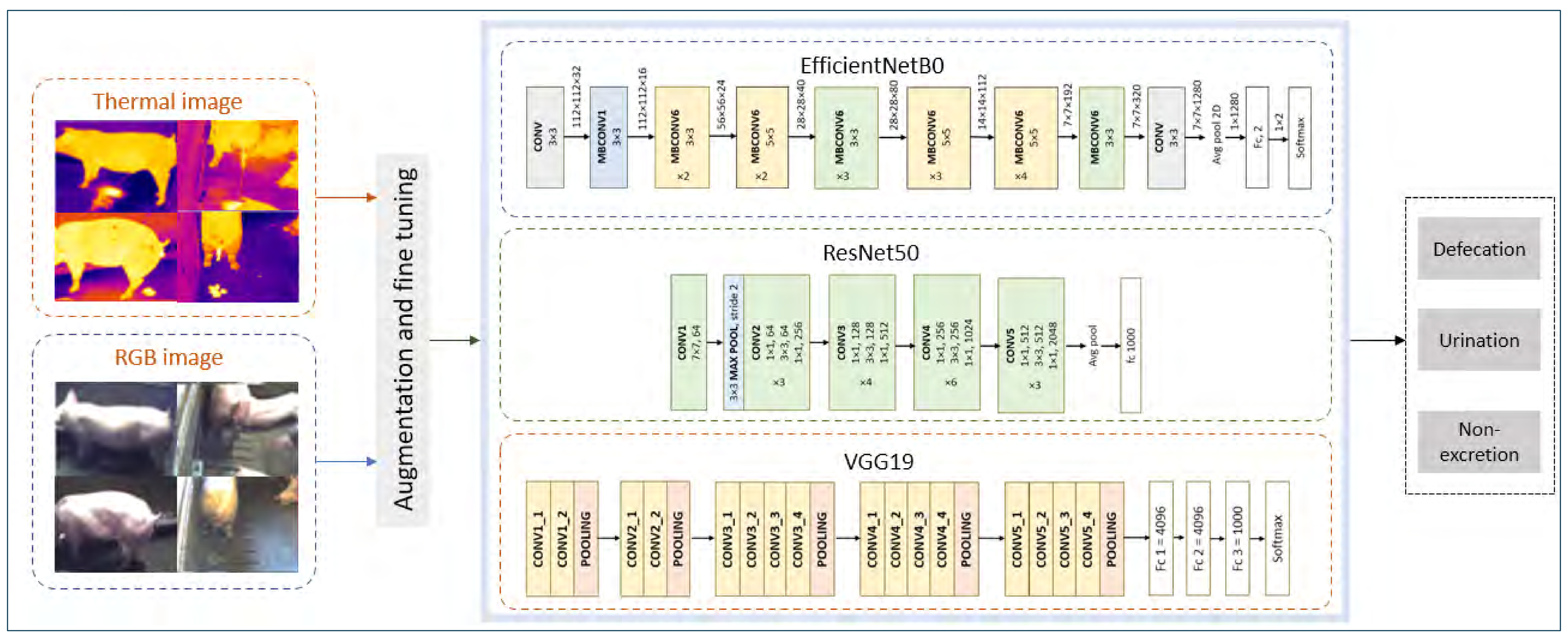


Figure 4. Flow chart of data training

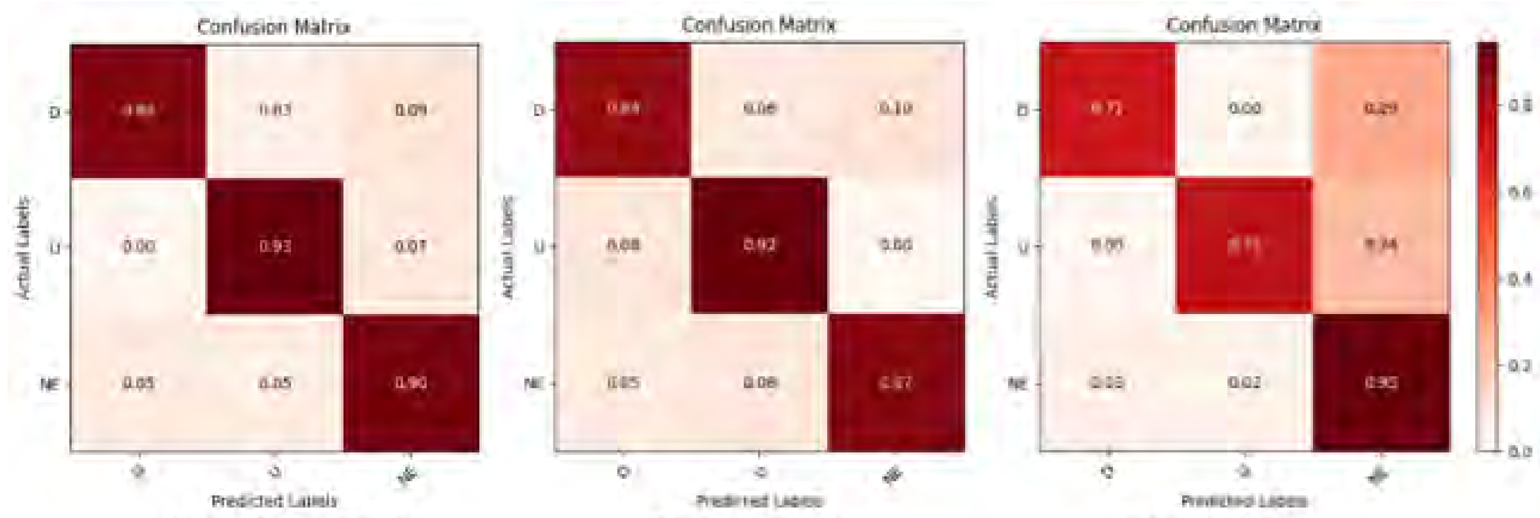
3. The performance of three deep learning model

The accuracy of EfficientB0, ResNet50 and VGG19 model to classify excretion events are 79.1%, 76.4% and 74.0% for RGB images and 90.3%, 87.6% and 81.8% for thermal images, respectively.

Table 2. Comparative results of precision, recall, and F1-score for RGB and thermal images

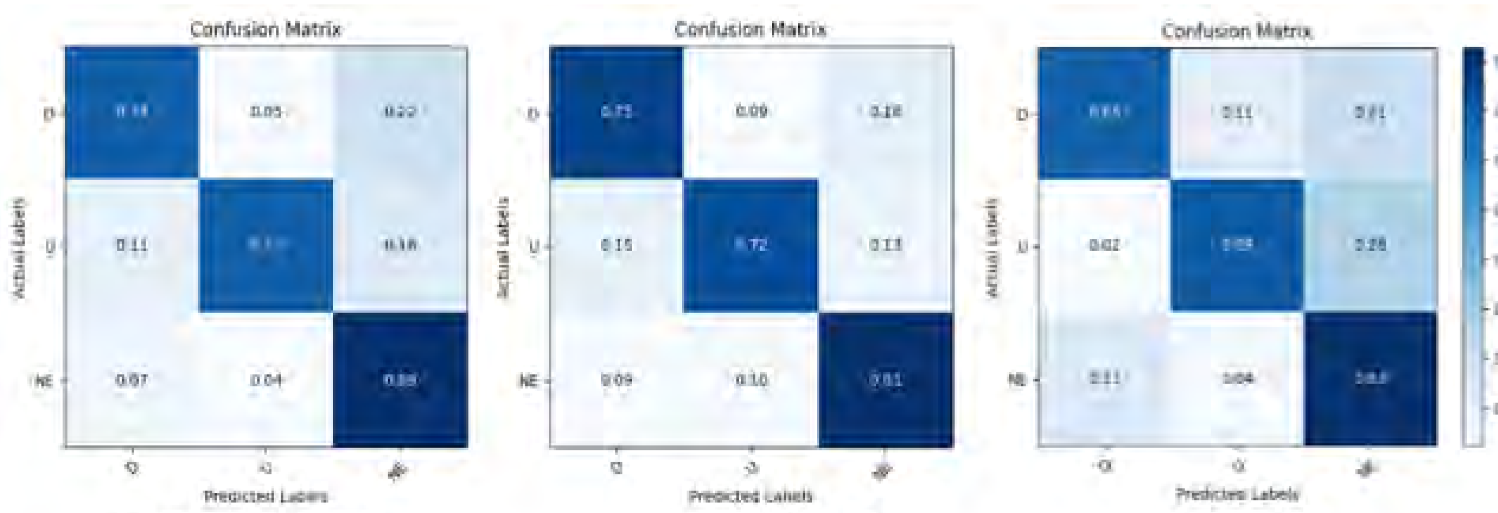
		RGB images			Thermal images		
		Precision (%)	Recall (%)	F1-score (%)	Precision (%)	Recall (%)	F1-score (%)
EfficientNetB0	D	78.63	73.60	76.03	93.22	88.00	90.53
	U	88.57	73.23	80.17	91.47	92.91	92.19
	NE	73.89	88.67	80.61	87.10	90.00	88.52
ResNet50	D	74.02	75.20	74.60	85.37	84.00	84.68
	U	77.97	72.44	75.10	85.40	92.13	88.64
	NE	77.07	80.67	78.83	91.55	86.67	89.04
VGG19	D	78.70	68.00	72.96	95.70	71.20	81.65
	U	81.48	69.29	74.89	97.00	76.38	85.46
	NE	66.84	82.78	73.96	68.42	95.33	79.67

4. Comparison between RGB and thermal images.



(a) EfficientNetB0 (b) ResNet50 (c) VGG19

Figure 5. The confusion matrix of three deep learning models for thermal images: D: defecation; U: urination; NE: non-excretion event.



(a) EfficientNetB0 (b) ResNet50 (c) VGG19

Figure 6. The confusion matrix of three deep learning models for RGB images: D: is defecation; U: urination event; NE: non-excretion event.

Conclusions

- ❑ Compare to VGG19 and Resnet50, EfficientNetB0 has higher accuracy.
- ❑ The accuracy of using thermal images as dataset is higher than using RGB images as dataset

Acknowledgements

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Savior or Driver? Retailer recommendation and pesticide overuse

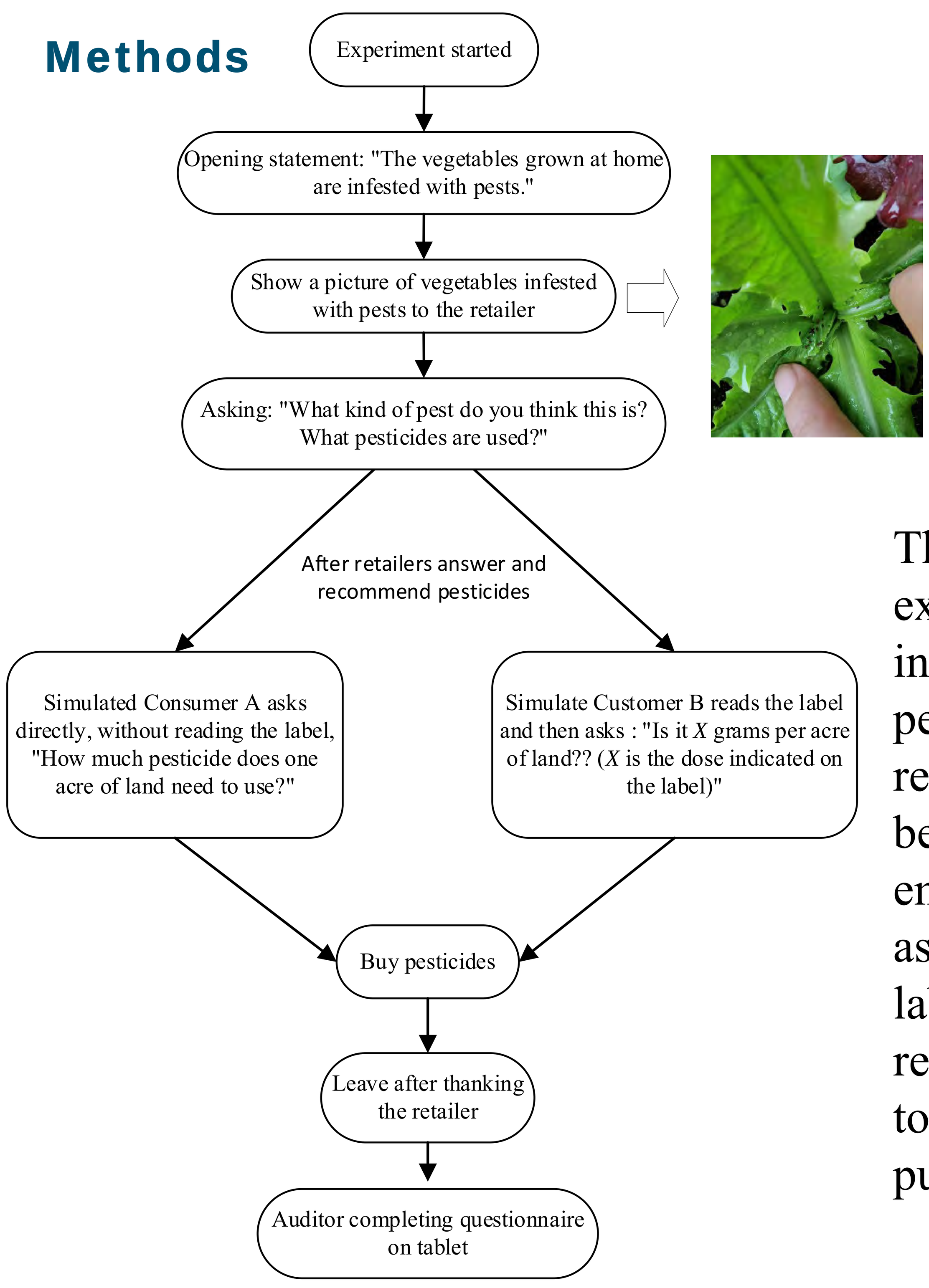
Juhui Chen

Supervisors: Junfei Bai, Hans van Trijp, Xi Lu

Background

The excessive use of pesticides is a crucial concern in both China and worldwide in the context of sustainable agricultural practices. Given that farmers as the primary users, considerable attention has been directed toward researching strategies to regulate their pesticide usage. However, the pesticide retailers, a key player on the supply side, has received limited attention due to challenges in observing their actual sales practices. this study employs an audit experiment, offering a methodologically robust approach for an accurate depiction of Chinese pesticide retailers' sales and recommendation behaviors. Furthermore, this study offers a potentially more feasible and effective solution, which is to optimize pesticide package size to mitigate retailers' recommended dosages, thereby addressing the issue of pesticide overuse at its origin.

Methods



This study employs the audit experiment method to investigate Chinese retailers' pesticide sales and recommendation strategies. A between-subject design was employed, randomly assigning customers as either label-reading or non-label-reading, who were then sent to a pesticide retail store for purchasing.

Fig. 1. The experiment protocol

All simulated customers adhered to a standardized script during the pesticide purchase process. Specifically, simulated customers first presented a photograph of affected vegetables to communicate the severity of the pest infestation with retailers and ask retailers' diagnostic about it. Subsequently, simulated customers sought information from the retailer regarding pesticide dosage, exhibiting distinct behaviors based on customer type. In the control group, customer, not reading the pesticide label, directly inquired about the dosage of pesticide required per acre of land. In the treatment group, customer first read the label's specified dosage per acre and then queried whether employing the labeled dosage (X grams per acre) was sufficient. Aside from this minimal difference, all other conditions were identical in both groups.

Objectives

- Empirically evaluate whether pesticide retailers over-recommend the dosage of pesticides.
- If there is over-recommendation, try to find ways to reduce pesticide use from the supply side (retailer side).

Results

By comparing the pesticide recommendation strategies employed by retailers facing these two types of customers, it was possible to identify whether over-recommendation occurs. Fig.2 shows results. Retailers facing with label-reading customers perform well in terms of both the percentage of over-recommending retailers and the overall degree of over-recommendation, displaying a lower proportion and a reduced extent of over-recommendation. Noteworthy is the substantial average degree of over-recommendation, surpassing the maximum label dosage by several multiples. These outcomes provide empirical support for the existence of over-recommendation behavior among retailers, revealing a substantial potential to reduce pesticide use through interventions targeting retailers.

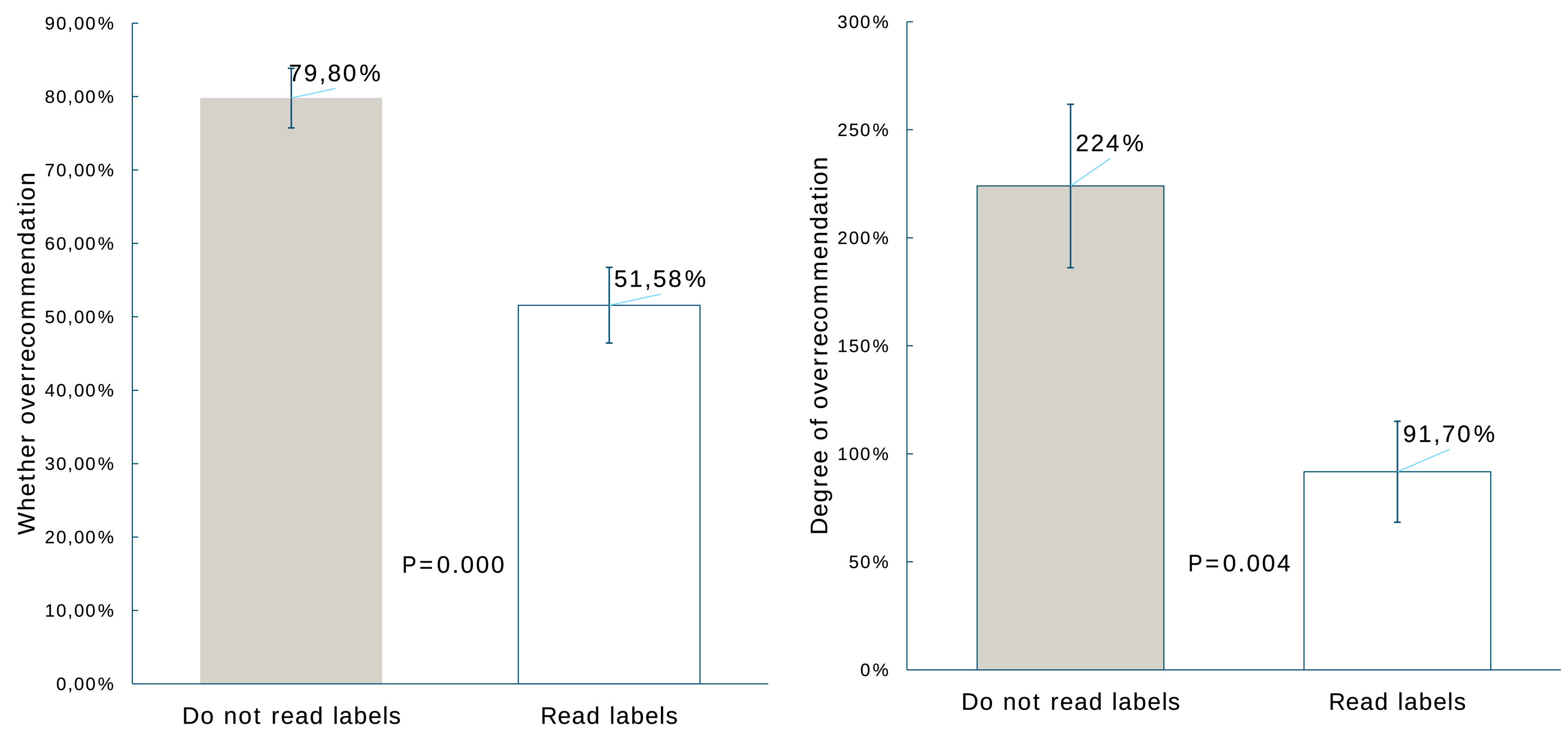


Fig.2. The treatment effect

The regression analysis examining the impact of pesticide product packaging size on the degree of retailer over-recommendation reveals a U-shaped relationship. Retailers tend to recommend more pesticides when the packaging size is either small or large. Further examination indicates that as the net weight approaches the label dosage, the degree of over-recommendation decreases (Results are not presented).

Conclusions

This study employs the audit experiment method to examine whether retailers engage in excessive pesticide dosage recommendation, shedding light on the unexplored territory of retailer recommendation behavior. Furthermore, the study proposes strategies for reducing recommended pesticide dosages by focusing on the optimal packaging size of pesticides. These findings are significant as they contribute valuable insights into addressing the issue of pesticide overuse at its source.

Acknowledgements

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Understanding consumer attitude toward the name framings of cultured meat: Evidence from China

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Introduction

The development of new protein alternatives could potentially provide a solution to some of the limitations inherent in conventional livestock farming. One of the available substitutes, cultured "meat"[1](CM[2]), is expected to satisfy consumer demand for meat products, given its projected benefits to animals and the environment. CM has proliferated since its proof-of-concept in 2013 (Post, 2014). The world's first restaurant to serve cultured chicken "meat" opened in Singapore in December 2021 (The Spoon, 2021). The Chinese *The Ministry of Agriculture and Rural affair of China* (2022) has also highlighted the need to accelerate CM technology in the next five years. These developments suggest that CM may appear in the Chinese and global markets in the future.

The naming of novel foods can be regarded as a type of information framing. Compared to descriptive information, the term used to describe CM constitutes the most immediate input on which consumers can base their impressions. Various names that have been assigned to CM include "lab meat", "clean meat", "synthetic meat" ,"in-vitro meat", and "cell-based meat" . The preferred name of CM may be specific to particular countries or regions.

Although previous research has identified differences in the extent to which consumers accept the names used to describe CM, the mental mechanisms underlying this phenomenon have yet to be fully explored. To the best of our knowledge, this study is the first to contribute to the existing body of knowledge by distinguishing and testing a number of complementary processing pathways through mediation analysis in order to examine the mechanism(s) underlying the name-framing effect.

Theoretical hypothesis and empirical model

- Our study developed a comprehensive framework that integrated pathways relevant to explaining framing effects: cognitive processing, affective processing, perceived naturalness, and affect heuristics processing.
- Based on our assumptions, we proposed that perceived benefits and risks (as cognitive factors), perceived disgust (as an affective factor), and perceived naturalness could mediate the effects of name-framing on consumer attitudes.

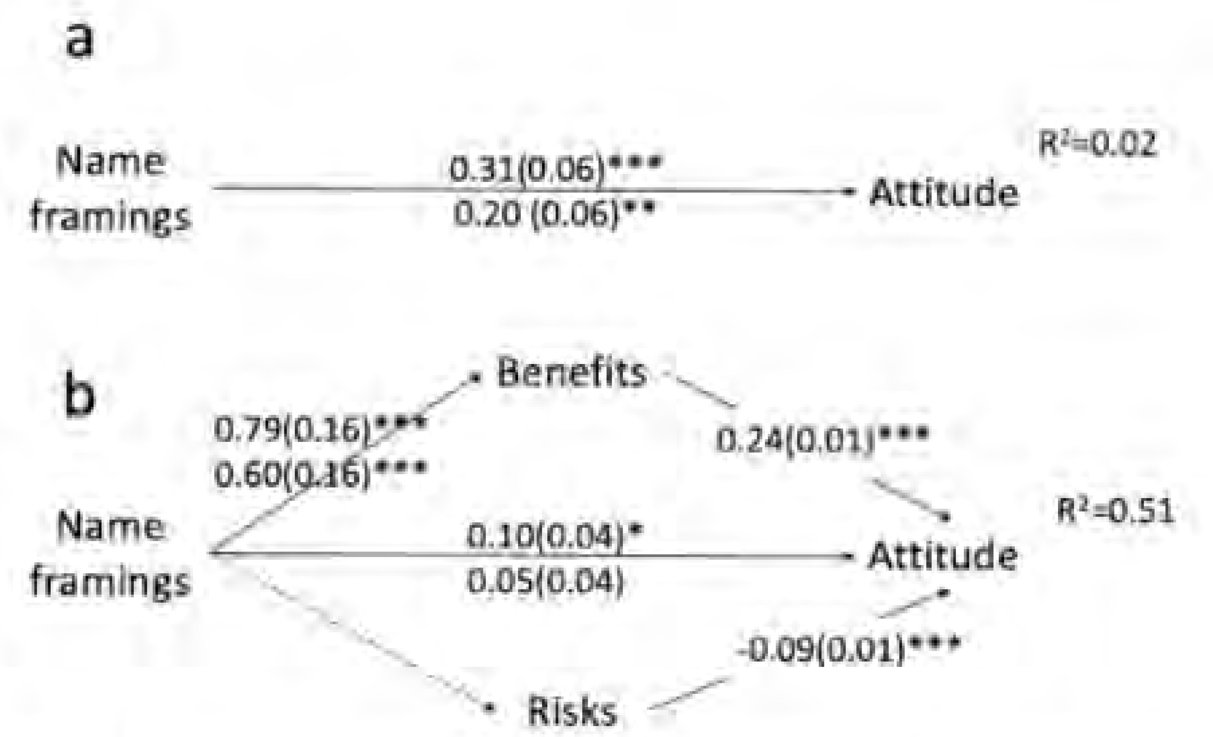


Fig. 1. Results of the mediation analysis of Hypotheses 1, 2a, and 2b. Note: Upper coefficients represent the comparison of the "cultured meat" and the "artificial meat" treatment; bottom coefficients represent the comparison of the "cell-based meat" and the "artificial meat" treatment. Non-significant paths are depicted as dotted lines. All coefficients presented are non-standardized. ***p < 0.001; **p < 0.01; *p < 0.05.

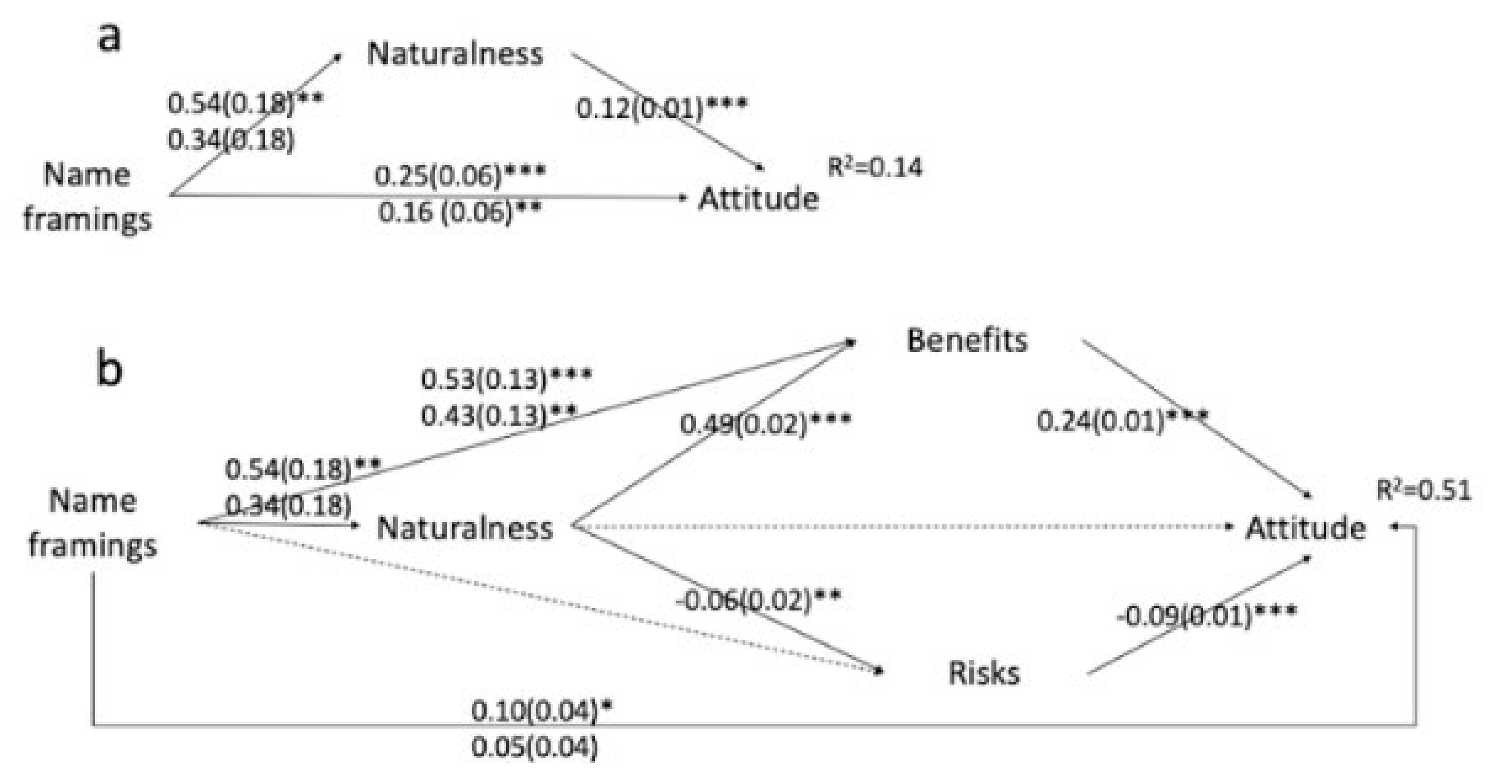


Fig. 2. Results of the mediation analysis of Hypotheses 2a and 2b.

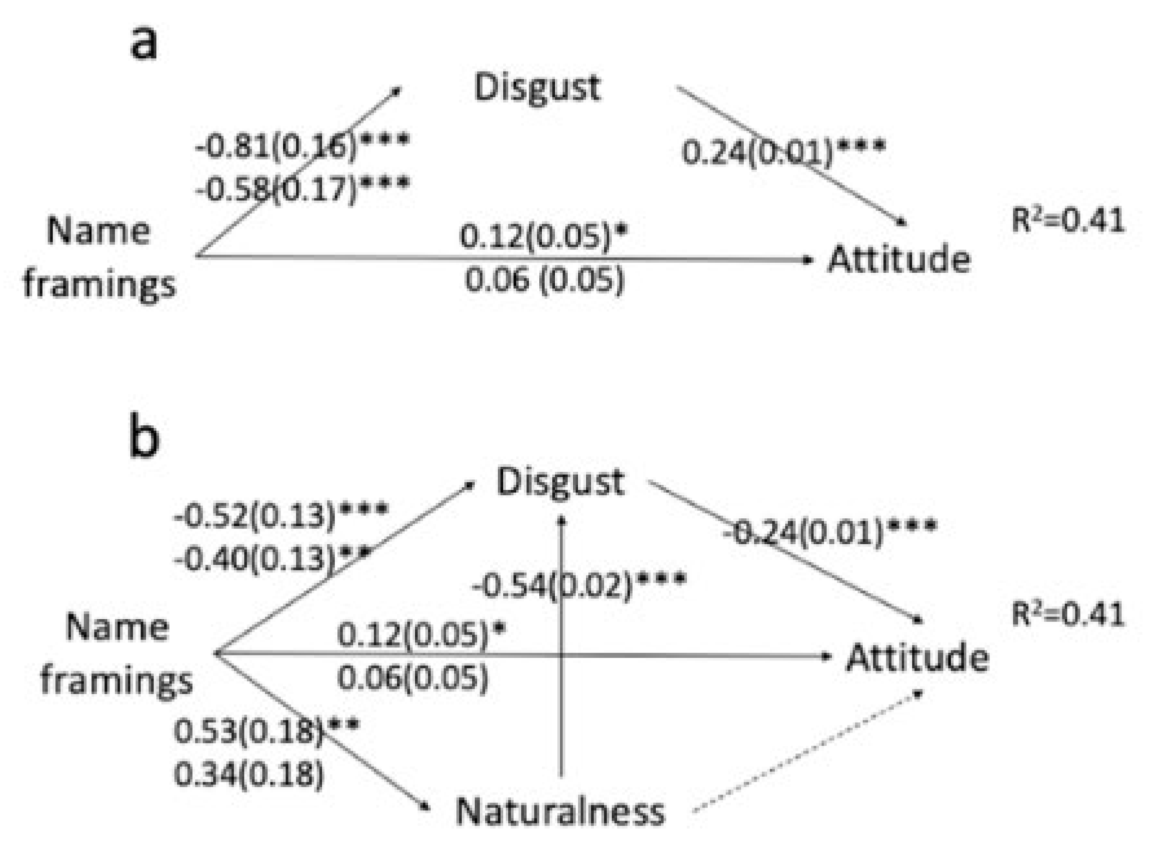


Fig. 3. Results of the mediation analysis of Hypotheses 4a and 4b.

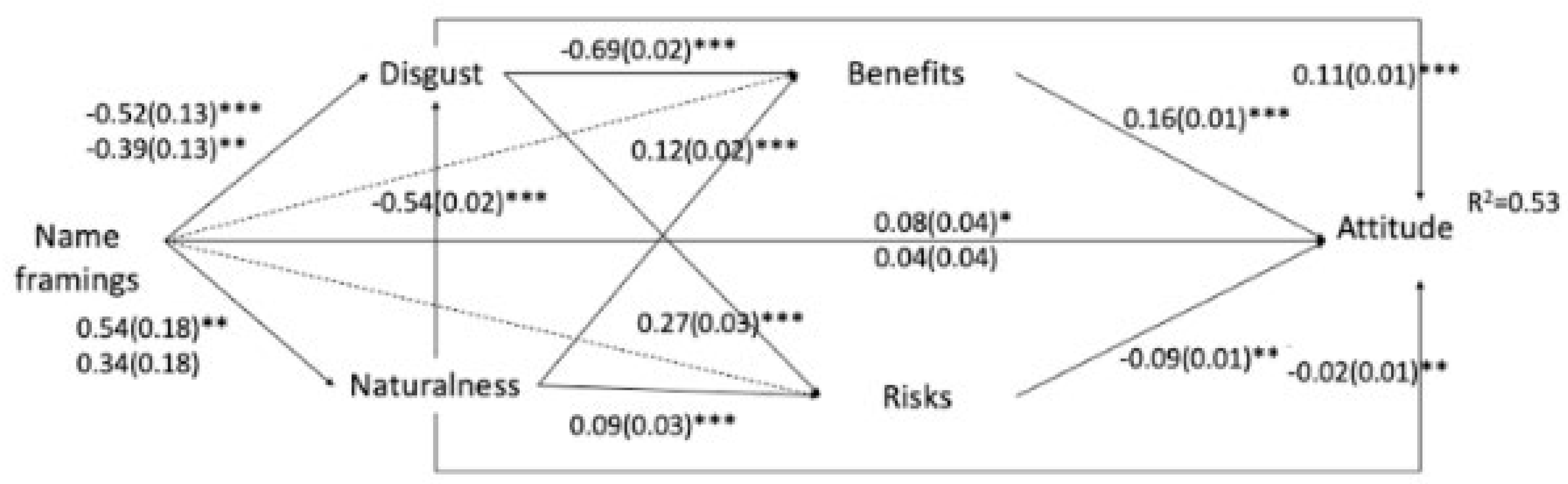


Fig. 4. Results of the mediation analysis of Hypotheses 5a, 5b, 5c, and 5d.

Conclusion and implications

- Our results confirm that disgust and naturalness are vital mediators of the effect of naming on consumer attitudes. When communicating with public audiences, stakeholders should aim to use names for CM that approach conventional meat without focusing on the human intervention. This approach could help to reduce unpleasant associated feelings (e.g., perceived disgust, unnaturalness, and low benefits).

- Name framings of CM affect consumers' perception of benefits more than risks. The provision of relevant beneficial information associated with the name of a CM product could therefore help engender positive consumer attitudes

[1] The word meat is put in inverted commas because cultured "meat" is an imitation meat product. Whether it could be labeled as meat is still under discussion in regulation and scientific perspectives.
[2] To avoid confusion, we use the abbreviation CM throughout the manuscript to refer to the cultured "meat" product in general. We use the terms "cultured meat", "cell-based meat" and "artificial meat", when referring to the three experimental naming conditions. To clarify, we regard cultured meat, cell-based meat, and artificial meat as imitation meat alternatives.

Contact: Email: Haoran.li@wur.nl, more information about this paper could be find at https://doi.org/10.1016/j.appet.2024.107240

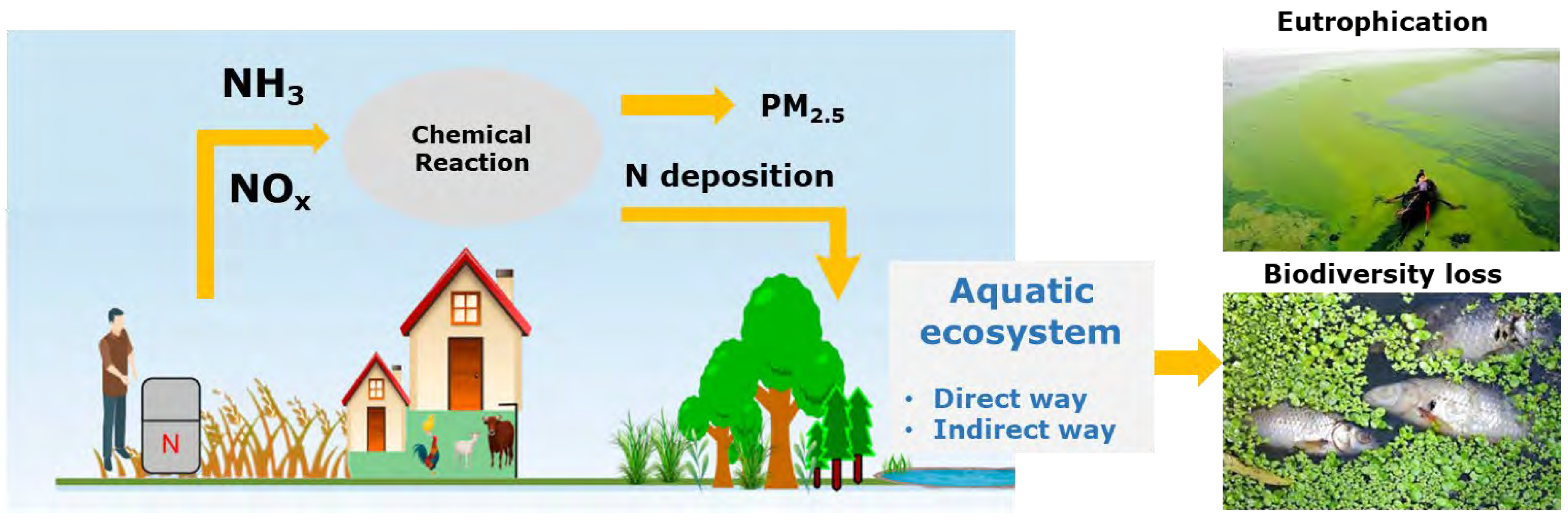
Quantifying synergies between water pollution strategies and nitrogen deposition in China

PhD candidate: Sijie Feng

Supervision team: Wen Xu, Mengru Wang, Maryna Strokal, Carolien Kroeze, Fusuo Zhang

Background

- Human activities leads to excessive atmospheric nitrogen (N) deposition on land and rivers (**direct N deposition**). Part of the deposited N on land is transported to rivers (**indirect N deposition**), contributing to water pollution by N.

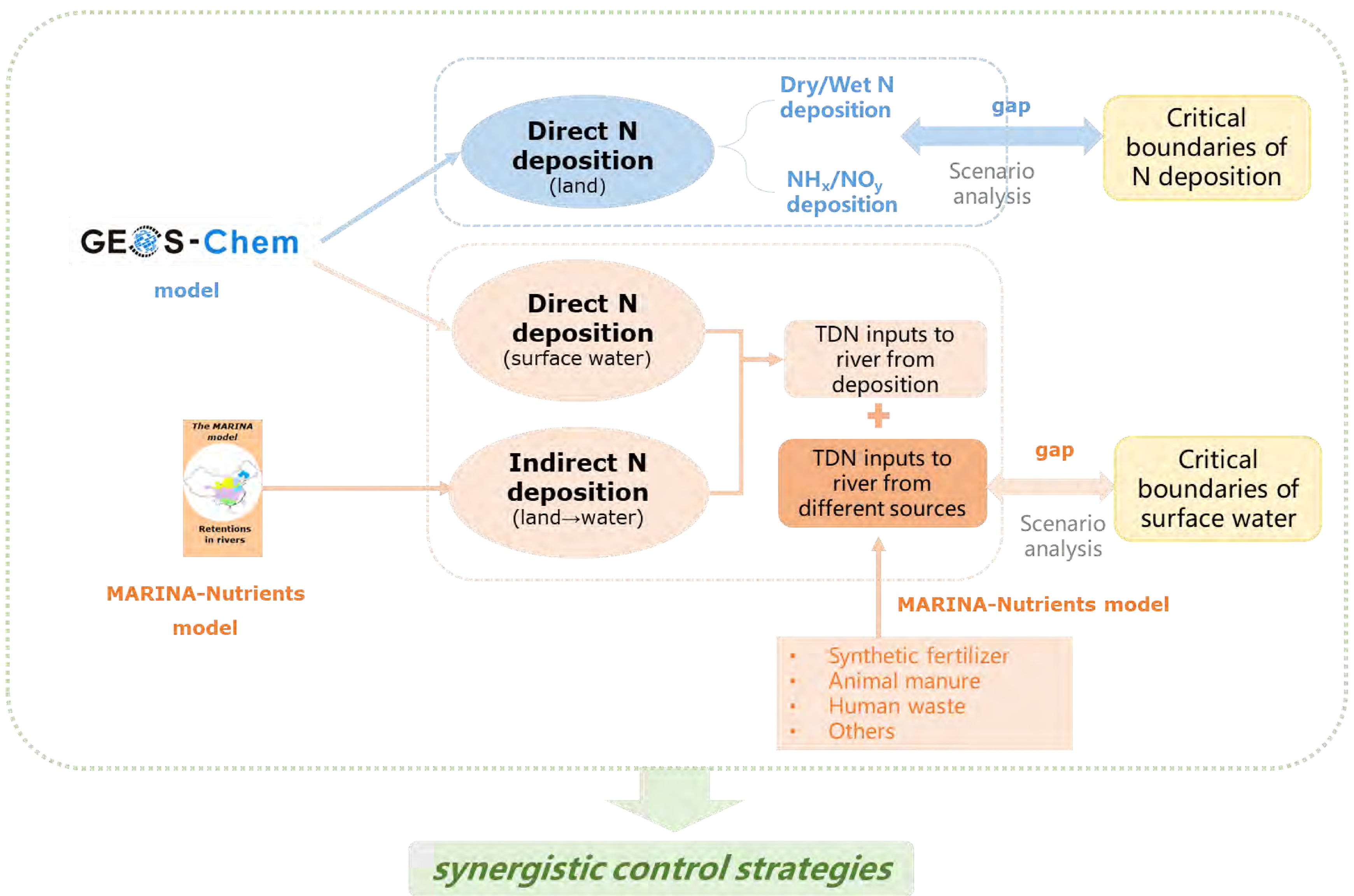


- N pollution in water poses significant environmental challenges in China, prompting the exploration of various control strategies. However, the intricate positive **(synergies)** and negative **(trade-offs)** interactions between water pollution controls and their impacts on N deposition remain unclear.

Objectives

Elucidates the synergistic impact of water pollution control strategies in mitigating N deposition, exploring the imperative for additional measures in future nitrogen deposition control.

Methods



Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

Results

- Compared to 2012, the BASE scenario projects persistent N deposition and water pollution exceedances.
- The other scenarios decrease in exceedance of regional critical boundaries by 56% to 63% to N deposition and 56% to 70% to TDN inputs to rivers.
- The AG+SE+SFC scenario emerges as the optimal solution for concurrently mitigating N deposition and water pollution, yet N deposition still contributes significantly (36%) to surface water TDN inputs.

Scenarios	*2012 (kton N year⁻¹)*	*2050 BASE*	*AG*	*AG+SE*	*AG+SE+SFC*
Total N deposition on land	13682	(-8%)	(-24%)	(-24%)	(-27%)
TDN inputs to river	21385	(-1%)	(-39%)	(-44%)	(-50%)
Total exceedance of critical N load to N deposition	3155	(-24%)	(-56%)	(-56%)	(-63%)
Total exceedance of critical N load to surface water	14497	(-2%)	(-56%)	(-63%)	(-70%)

≤30% 30%~50% ≥50%

Figure. 1 Total nitrogen (N) deposition, total dissolved N (TDN) inputs to rivers, total exceedance of critical N load to N deposition, and total exceedance of critical N load to surface water summed over the 33 Chinese river sub-basins for 2012, and the % reductions in these relative to 2012 for the four 2050 scenarios. The different colors give a broad indication of the magnitude of the % reductions. The 2050 scenarios include a baseline that follows SSP5-RCP8.5 (BASE) and scenarios that cumulatively target agricultural nutrient use efficiency (AG), sewage treatment (AG+SE) and sustainable food consumption (AG+SE+SFC).

Outlook

Future water pollution and N deposition controls:

- Based on the AG+SE+SFC scenario, further control of N deposition is needed. For example, promotion of further reductions in NO_x emissions alongside all the measures targeting NH_3 assumed in this work.
- Development of measures synergetic also with impact on climate change.

References

(1) Feng, S. J, 2024. China Agricultural University.
(2) Wang, M. R. et al. 2020. Earth's Future.
(3) Wang, M. R. et al, 2022. Nature Communications

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Optimal fertilizer, manure and liming strategies to reduce soil acidification and nutrient losses

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[2] College of Resources and Environmental Sciences; National Academy of Agriculture Green Development, China Agricultural University, 100193 Beijing, China

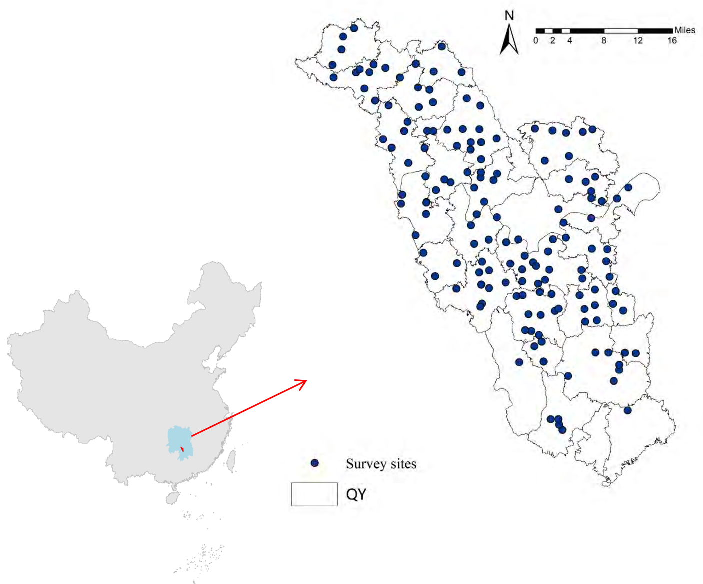
Background

- Excessive nitrogen (N) and phosphorus (P) fertilizer use accelerates N and P losses, causing acidification in soils (by N) and eutrophication in water systems, which affect food production and agricultural sustainability[1, 2].
- Enhancing animal manure recycling to replace mineral fertilizers mitigates soil acidification and reduces N losses[3], but it may also cause undesirable P accumulation. Current optimal manure recycling strategies mainly focus on minimizing acidification and N losses, neglecting possible undesirable P accumulation[4].

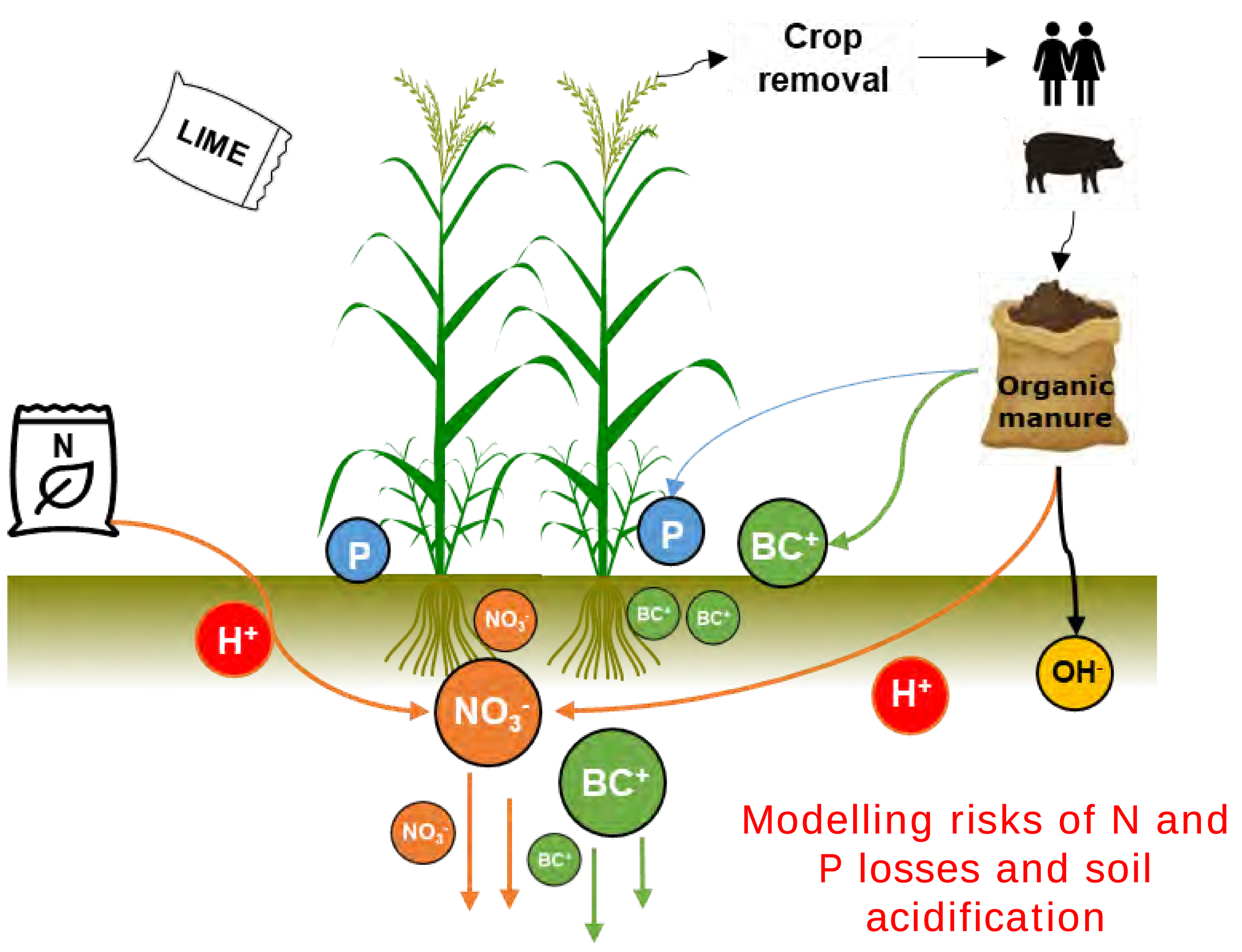
Objectives

This study aims to explore optimal strategies to simultaneously reduce soil acidification and both N and P surpluses at a county scale in China.

Methods



- **Systematic farmer surveys** and **soil sampling** (2.7×2.7 km^2) were done at Qiyang County in China, assessing inputs and outputs of major nutrients including N, P, and the base cations (calcium, magnesium, potassium and sodium) to assess soil acidification rates with the model VSD+.
- **The optimal combination of fertilizer, manure and lime application rates** was identified by adapting the manure recycling rate such that N and P inputs satisfy crop demand, while N and P surpluses and soil acidification risks are reduced (**BNPR scenario**).



Results

- **The VSD+ model well simulated historic soil pH changes** (1985-2019) in non-calcareous sites (n=69) under farmers conventional practices (indicated as BAU scenario) (Figure 1).
- **BNPR scenario would increase soil pH from 4.8 to 5.4 until 2050**, preventing negative effects of acidification on crop yields.

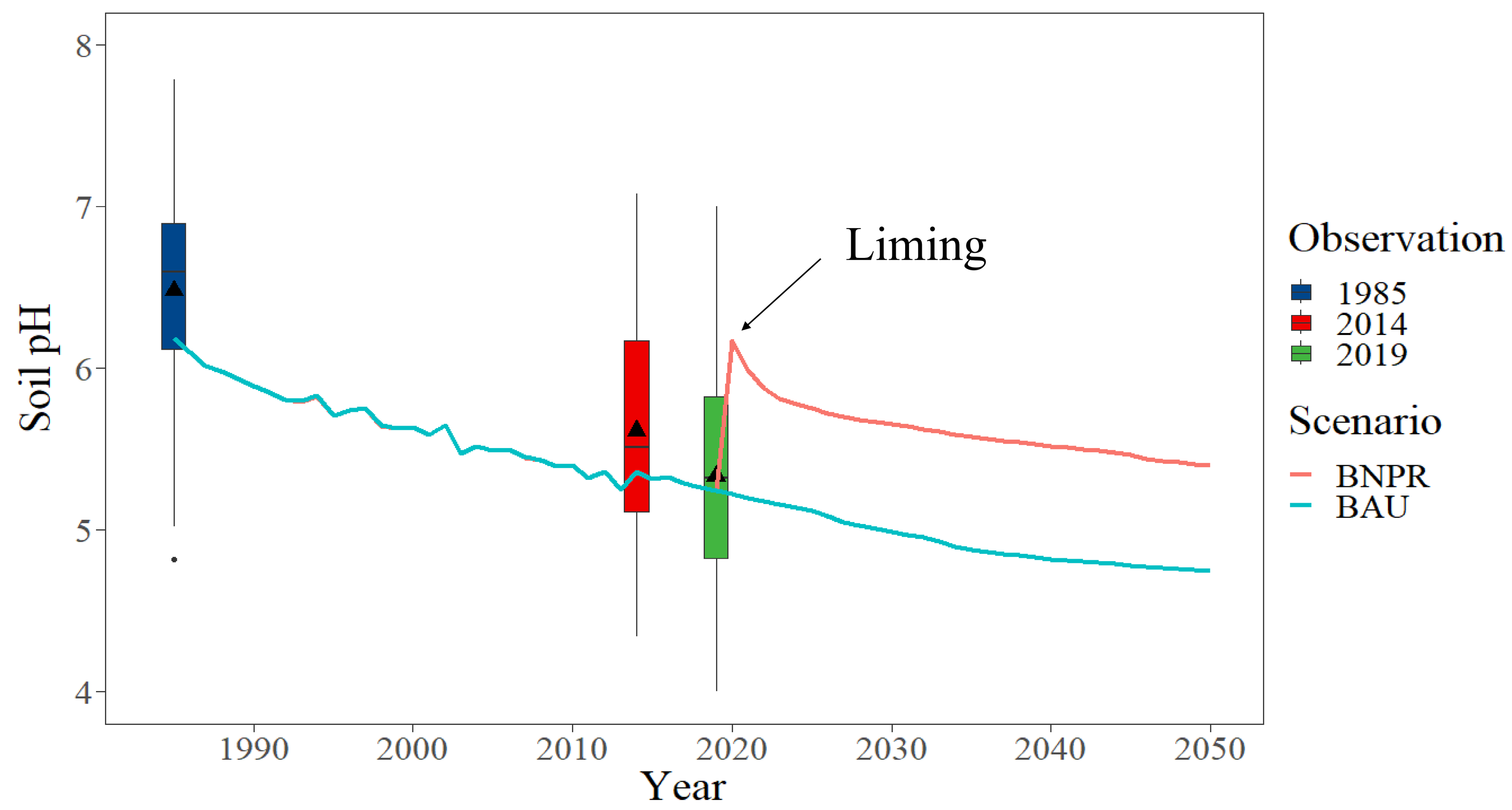


Fig. 1 Mean of simulated soil pH (1985-2050) of different scenarios (BNPR and BAU) compared to the observations in 69 non-calcareous sites (1985-2019). The average liming rate is 600 kg $CaCO_3$ ha^{-1}.

- Implementation of scenario BNPR at a county scale showed:

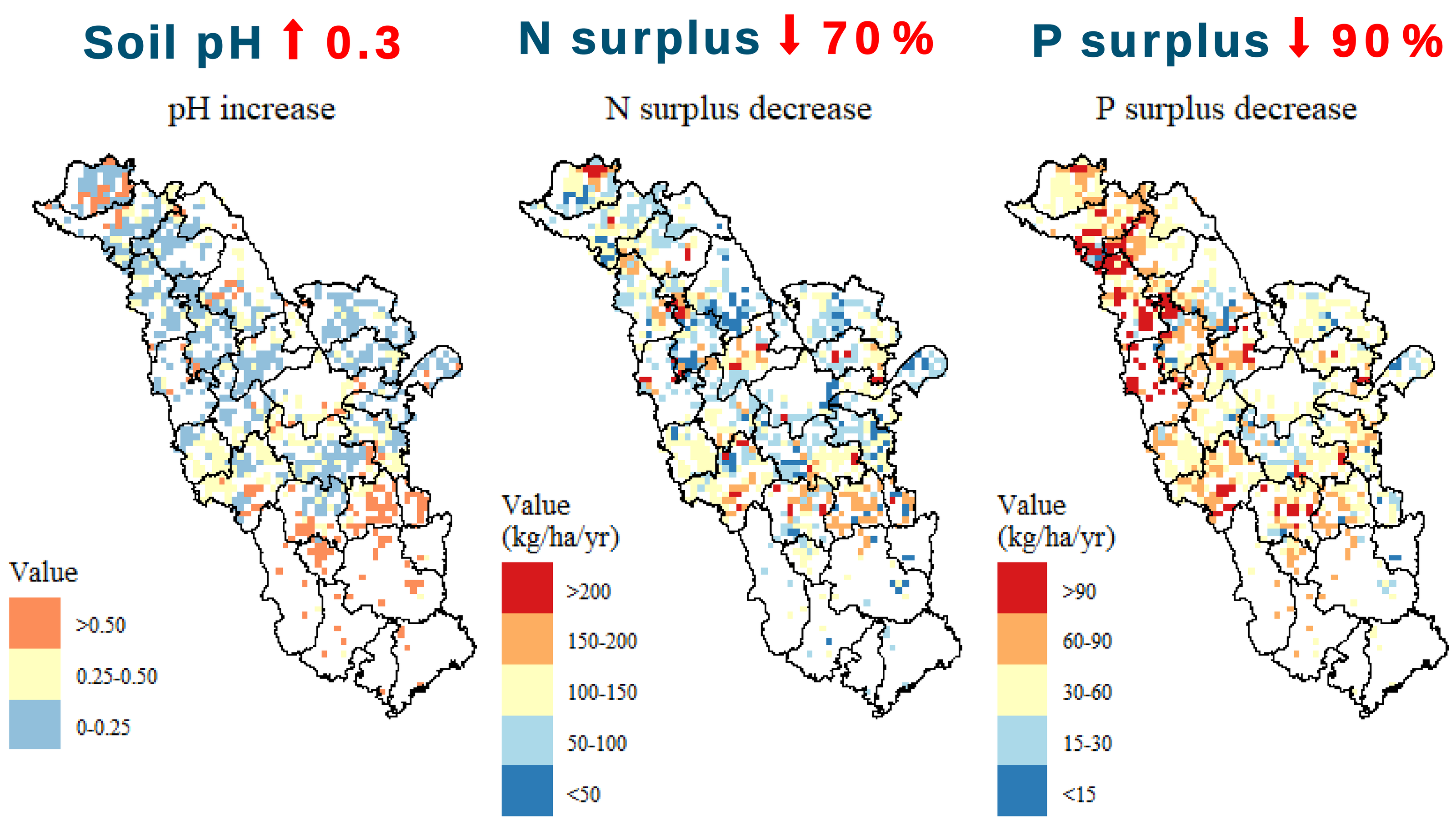


Fig. 2 Maps of mean (2020-2050) changes in soil pH, N and P surplus for scenario BNPR compared to farmers' conventional strategies. N or P surplus indicates total N or P input minus crop uptake.

Conclusions

The VSD+ model can be used to derive optimal application rates of fertilizer, manure and lime at regional level, offering a sustainable approach for managing nutrients and soil acidity in **promoting soil health and environmental quality.**

References

(1) Zhu, Q. C. et al. 2020. *Environ. Pollut.*
(2) Zhang W. et al. (2019). J. Environ. Qual., 48: 1167-1175
(3) Zhang X. et al. (2020). Glob Change Biol., 26: 888– 900.
(4) Cai Z. et al. (2021). SCI TOT ENV., 754: 142189.

Acknowledgements

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Crop effects on soil functions and soil multifunctionality

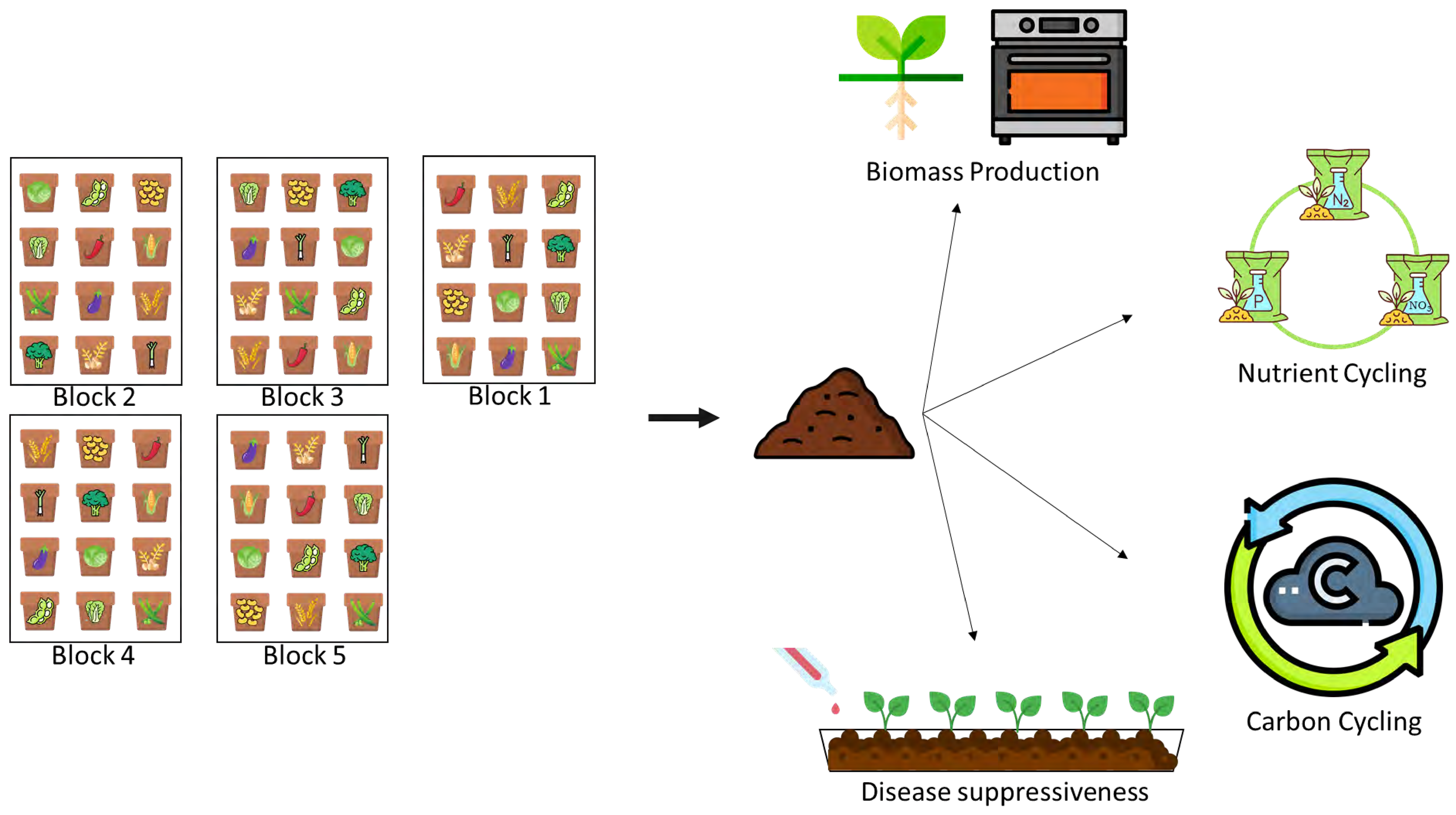
Zhaoqi Bin, Wim van der Putten, Guangzhou Wang, Junling Zhang, G.F.(Ciska) Veen

Background

Soil plays a vital role in agriculture by serving as a medium for crop growth and driving critical ecosystem functions, including carbon and nutrient cycling, water purification and regulation, and supporting soil biodiversity. Current agricultural practices prioritize maximizing yields, often at the expense of other ecosystem functions provided by soil. Plants can alter soil properties and functions by the uptake of water and minerals, returning organic materials, interacting with pathogens and mutualists, and providing habitats for other soil biota. However, the impact of different crop species on soil's capacity to provide multiple functions and multifunctionality remains poorly understood.

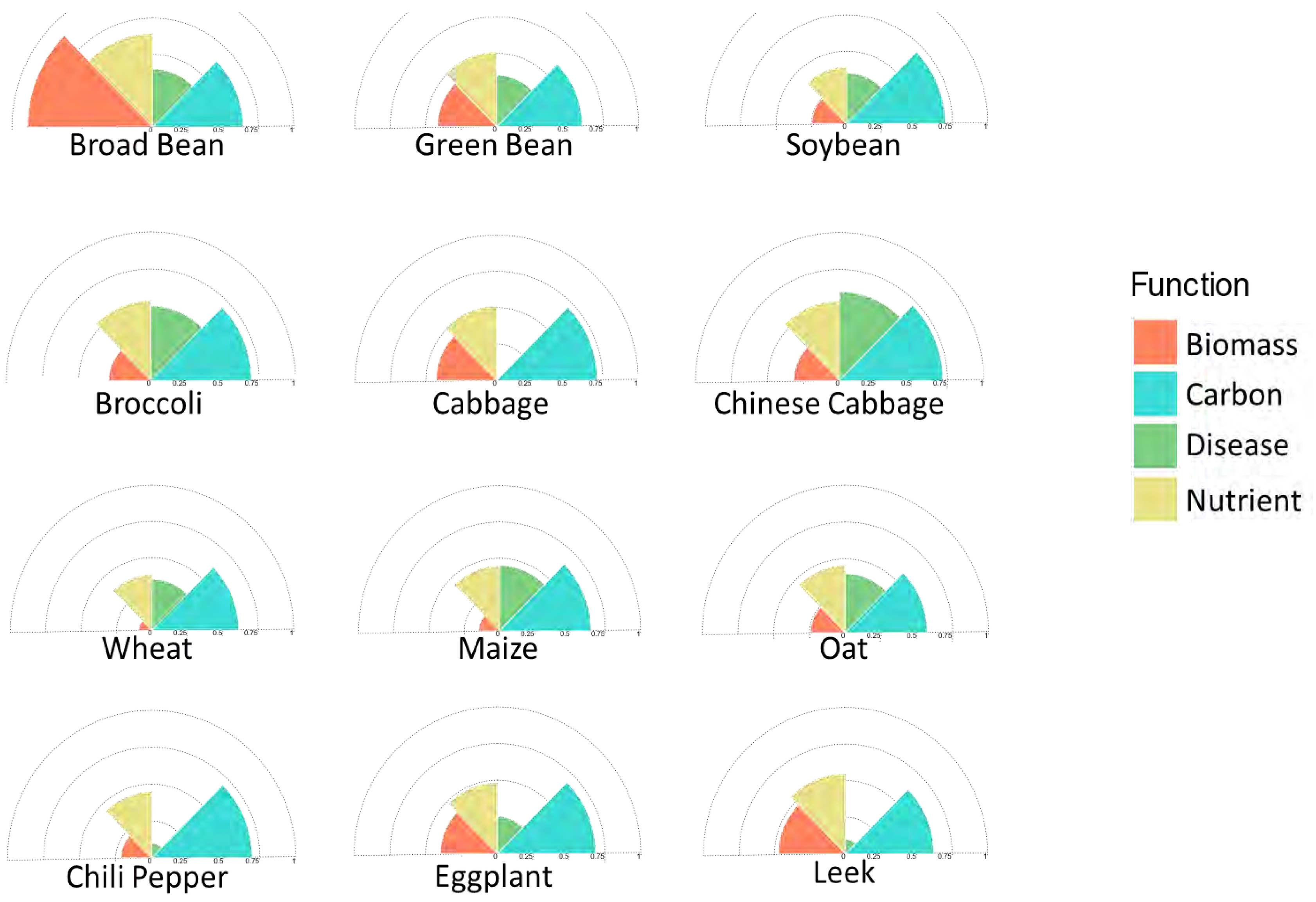
Objectives and methods

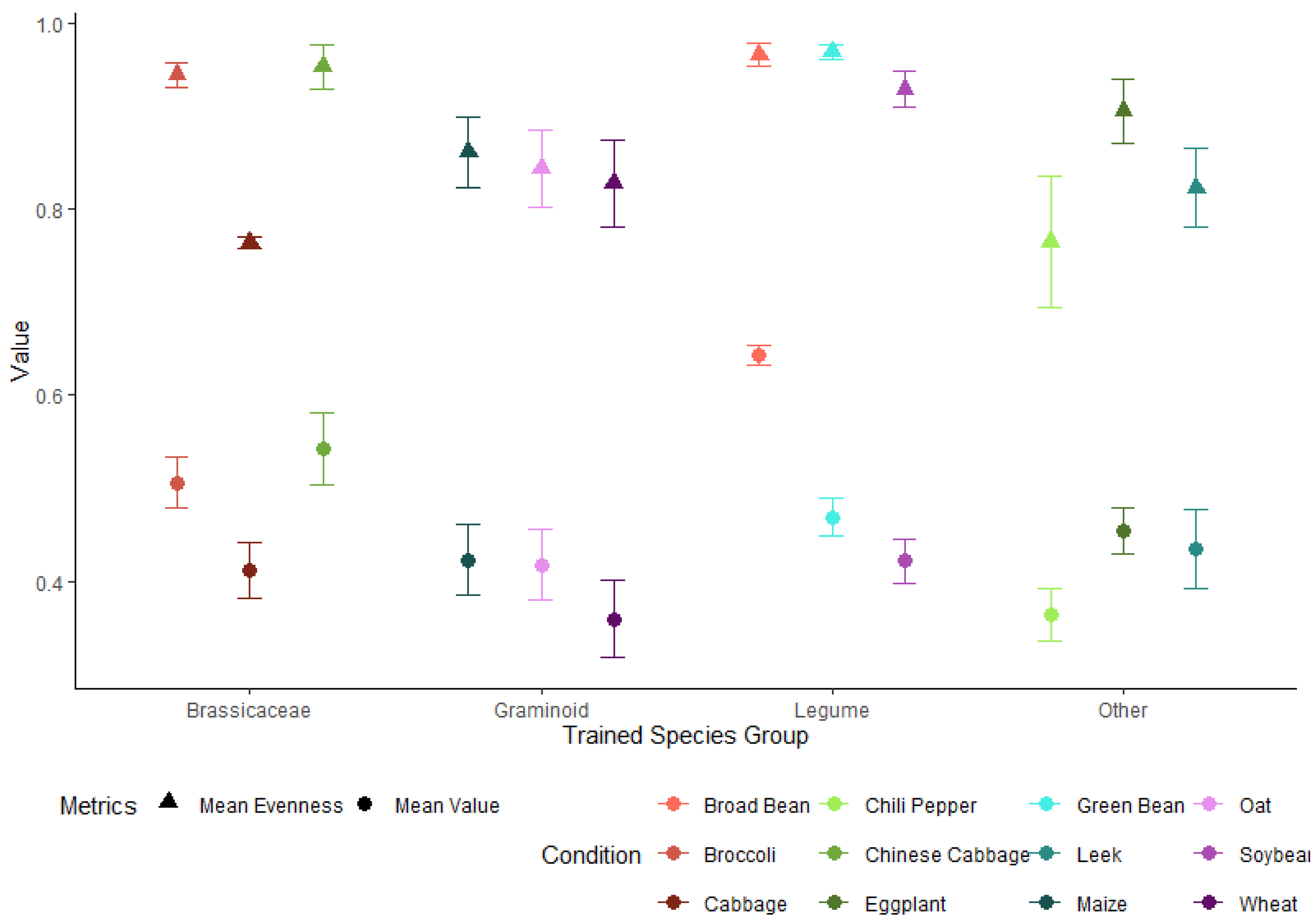
We grew twelve common crop species, organized into four groups (the legumes: broad bean, green bean, soybean; the crucifers: broccoli, Chinese cabbage, cabbage; the cereals: wheat, maize, oat; and the vegetable mix, here after named 'vegmix': eggplant, chili pepper, leek) and determine their impacts on individual soil functions-namely, plant biomass production, nutrient cycling, carbon storage, and disease suppressiveness. We also analyze multifunctionality and the balance in performance across these functions, referred to here as "evenness," under controlled conditions.

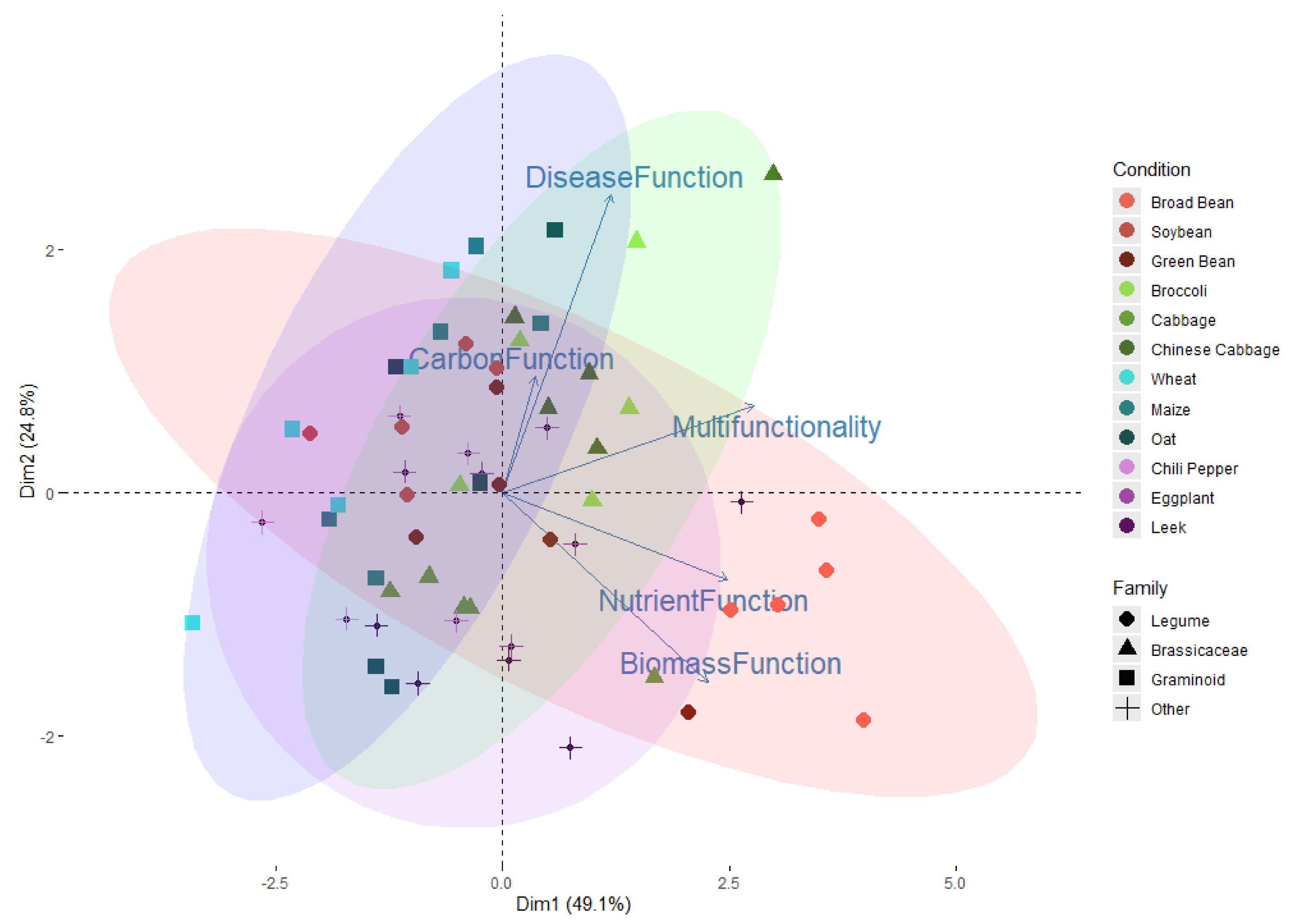


Results

Significant differences were found in individual soil functions, multifunctionality, and evenness of multiple functions among species and crop groups. Broad bean soils showed the highest levels of biomass production, nutrient cycling, and overall multifunctionality, whereas wheat soils had the lowest. Chinese cabbage soils were most effective in disease suppressiveness and carbon storage, whereas cabbage and oat soils exhibited the least effectiveness in these functions, respectively. Green bean soils displayed the most even distribution of functions, in contrast to cabbage soils. Chinese cabbage were the highest in disease suppressiveness and carbon storage, cabbage were the lowest in disease suppressiveness, oat were the lowest in carbon storage.







There was a positive correlation between the evenness of multiple functions and soil multifunctionality. Principal Component Analysis (PCA) revealed that the nutrient cycling and biomass production functions were correlated and that they operated in a direction orthogonal to the disease suppression and carbon cycling functions. Our findings suggest that crop species affect soil functions and multifunctionality in a species-specific way. This offers practical recommendations or guidelines for farmers and agricultural practitioners for crop selection based on the different functional performances of species-conditioned soil. This is crucial in identifying optimal, diversified cropping systems for field application.

Acknowledgements

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Mycorrhiza-mediated recruitment of complete denitrifying *Pseudomonas* reduces N_2O emissions from soil

PhD Students: **Ruotong Zhao**   Supervisors: **Junling Zhang; Wim H. van der Putten; Ciska Veen; Guangzhou Wang**

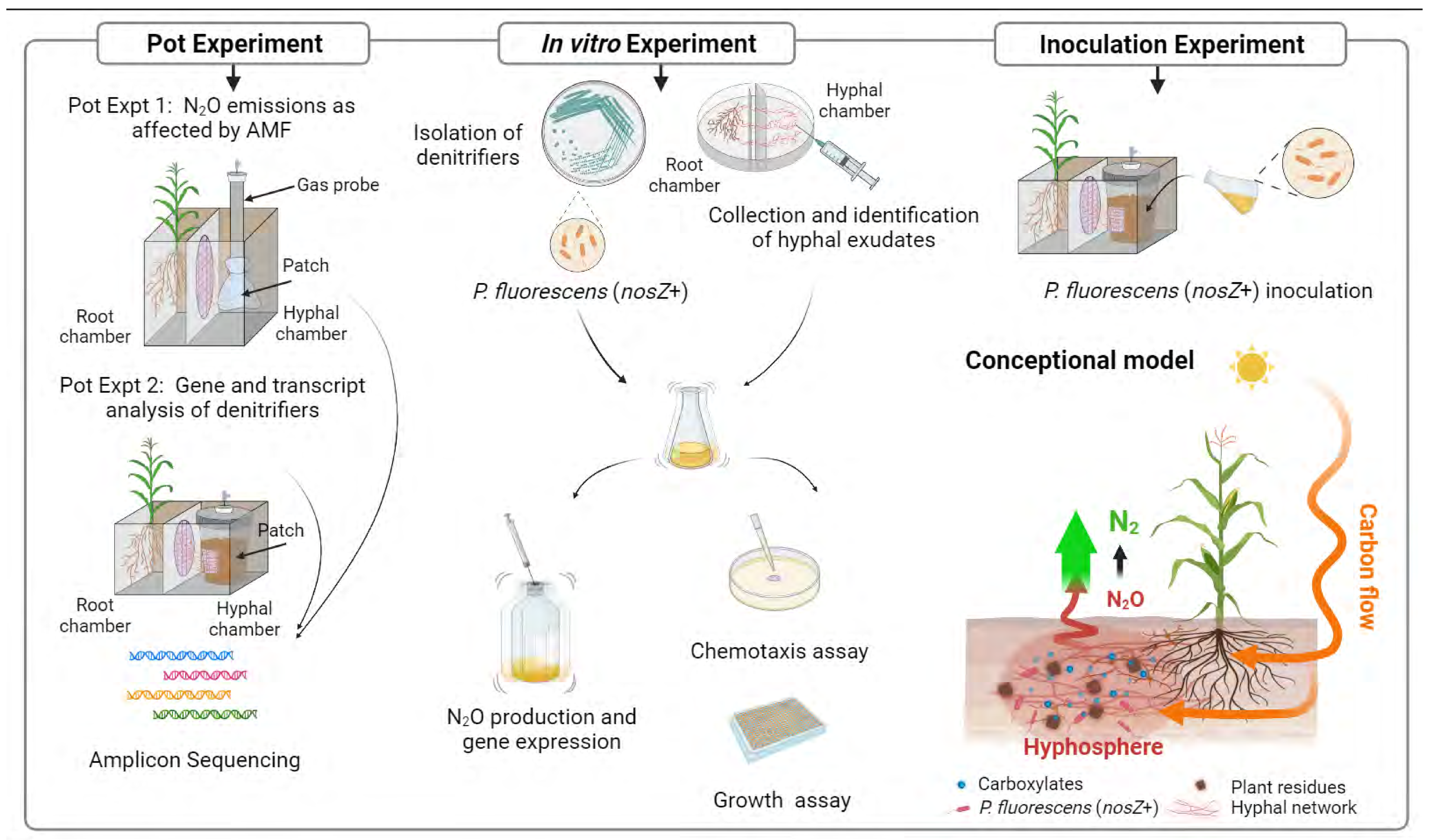
Background

Arbuscular mycorrhizal fungi (AMF) are key soil organisms and their extensive hyphae create a unique hyphosphere associated with microbes actively involved in N cycling. However the underlying mechanisms how AMF and hyphae-associated microbes may cooperate to influence N_2O emissions from 'hot spot' residue patches remains unclear. Here we explored the key microbes in the hyphosphere involved in N_2O production and consumption using amplicon and shotgun metagenomic sequencing. Chemotaxis, growth and N_2O emissions of isolated N_2O-reducing bacteria in response to hyphal exudates were tested using *in vitro* cultures and inoculation experiments.

Objectives

Previous studies have shown that AMF indirectly affect denitrifying microorganisms by promoting water absorption or promoting soil aggregation. However, direct evidence in support of AMF interacting with the hyphosphere microbiome, especially complete denitrifiers, remains ambiguous. Given that AMF receive 4-20% of total photosynthetic C from plants and that hyphae form a network redistributing C into unexplored nonrhizosphere zones, this knowledge gap has important implications for the potential exploitation of the soil microbiome in terms of the development of suitable management practices to increase nutrient use efficiency while mitigating N_2O emission. This is especially important in sustainable agriculture because current intensive agricultural practices result in a substantial decline in AMF diversity and abundance and hence hamper their potential to mitigate N_2O emission.

Methods



Flow chart of the experiments. The study comprised several experiments: two pot experiments, *in vitro* experiments and an inoculation experiment. The two pot experiments (pot expts 1 and 2) tested whether the proliferation of AMF into microsites of residues may reduce N_2O emissions and disassemble the regulation pathway. We isolated denitrifiers and identified the key components of hyphal exudates. We then examined the chemotaxis, growth, N_2O emission and denitrifying gene expression of *P. fluorescens* in response to AMF exudates and key compounds under *in vitro* culture conditions; finally, the inoculation experiment validated the effects of AMF or citrate exuded by AMF on N_2O emissions and *nosZ* gene expression of *P. fluorescens* in pot culture. A conceptual model is used to illustrate the pathways by which AMF interact with *P. fluorescens* to mitigate N_2O production.

Results

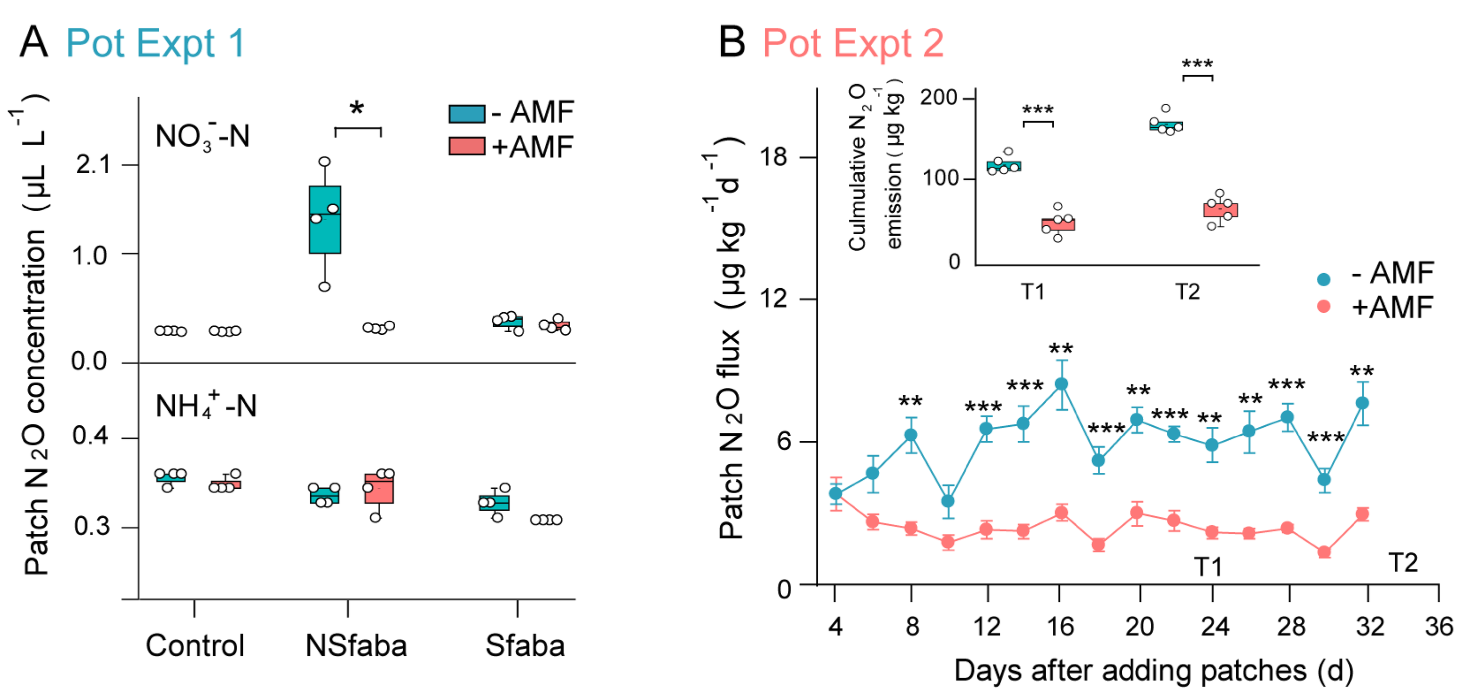


Figure 1. N_2O emissions from patches in the absence (–AMF) or presence (+AMF) of AMF. A, pot expt 1. B, pot expt 2. T1 and T2, first (day 24) and second (day 34) harvests, respectively; asterisks, significant differences between –AMF and +AMF treatments within each gas-sampling time or each harvest according to two-tailed unpaired t test (*, P < 0.05; **P < 0.01; ***, P < 0.001). The box plots show the 25–75th percentiles (box), the median and the mean (the band and the dot inside the box), and the minimum to maximum values excluding outliers (whiskers).

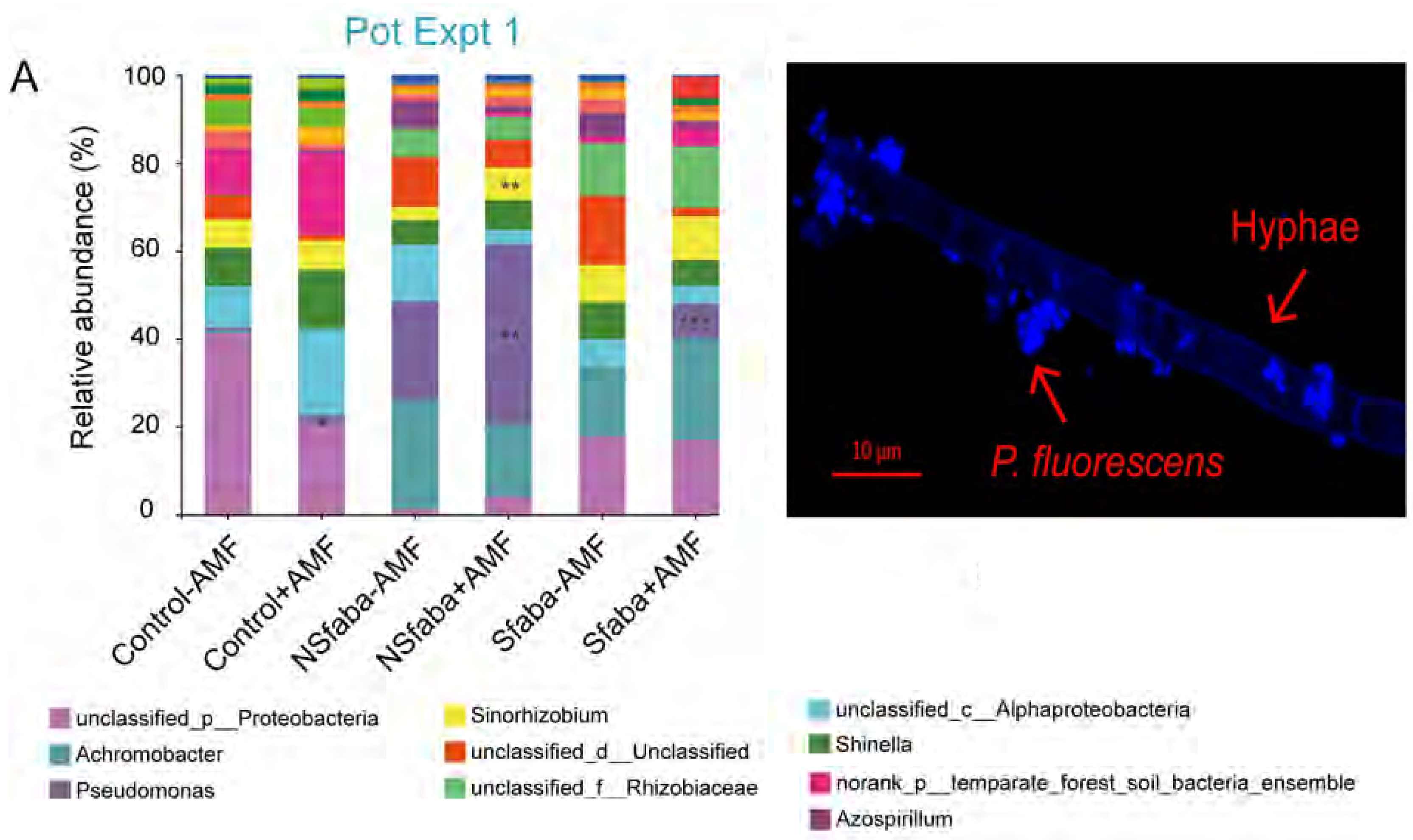
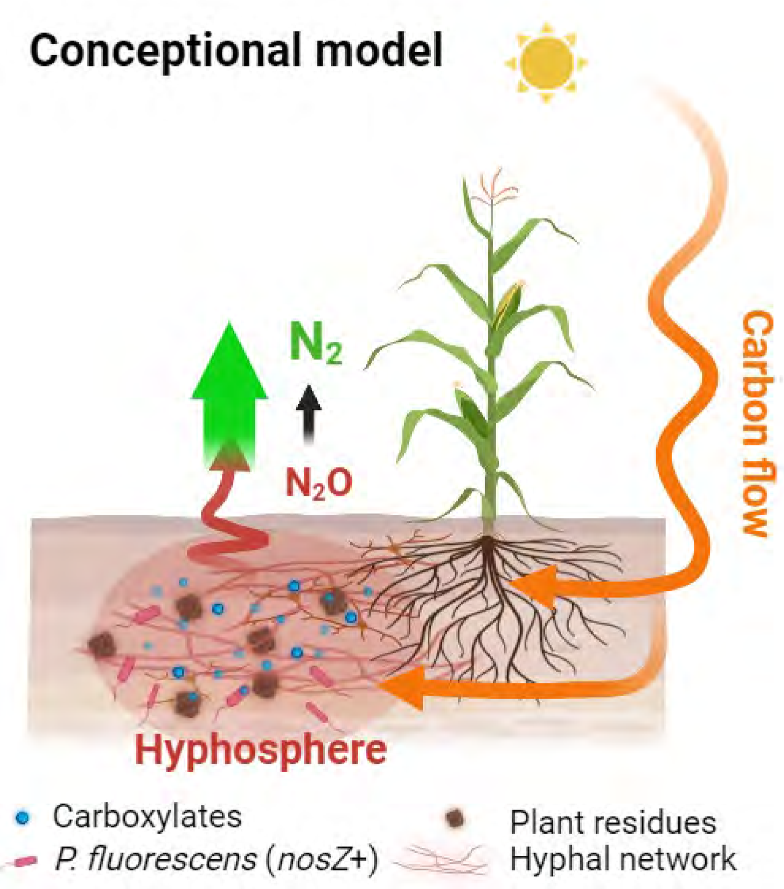


Figure 2. Structure of clade I *nosZ* community in three different patches in pot expt 1 (A) and AMF hyphae with attached *P. fluorescens* stained with 4′,6-diamidino-2-phenylindole (DAPI); scale bar, 10 μm **(B).**

Conclusions



Our study provides novel insights into the importance of AMF in mediating nitrogen transformation processes conducted mainly by denitrifiers that lead to cascading effects on soil N_2O emission. We demonstrate that AMF enriched the N_2O-reducing *Pseudomonas* in the hyphosphere, which was responsible for the decline in N_2O emissions in the residue patches. These insights provide a novel mechanistic understanding of the intriguing interactions between AMF and microbial guilds in the hyphosphere, and collectively indicate how these trophic microbial interactions substantially affect the denitrification process at microsites.

Acknowledgements

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Developing diversified cropping systems for enhancing integrated sustainability on the North China Plain

PhD student: Bowen Ma
Chinese supervisors: Dr. Wenfeng Cong, Dr. Chaochun Zhang, Prof. Fusuo Zhang
Dutch supervisors: Dr. Jeroen Groot, Dr. Wopke van der Werf

Background

- Transforming traditional high-input and high-output agriculture into green agriculture in China urgently requires the introduction of new sustainable diversified cropping systems.
- Crop diversification through intercrops, long-term rotation and cover crops provides options to enhance integrated sustainability.

Objectives

- To evaluate the agronomic, economic, environmental performance of different rotation systems with wheat and maize, peanut or soybean, with or without maize intercropping with legumes under different N managements.
- To design and verify new diversified crop rotation systems with enhanced integrated sustainability in the North China Plain(NCP).

Research framework

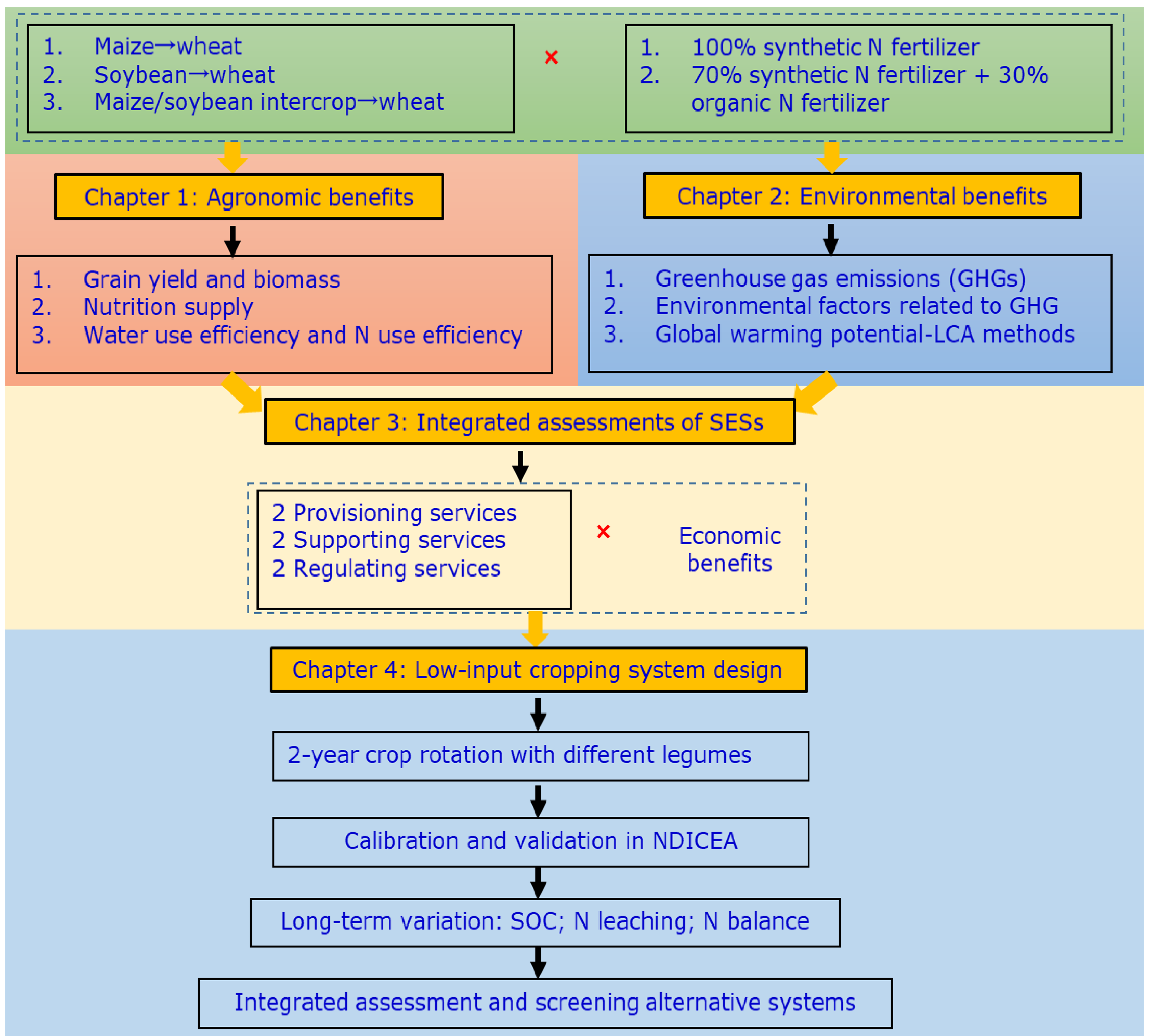

Figure 1. Framework of the project.

Methods

- The field experiment will be established in June 2021 at Quzhou Experimental Station (36.87ᴼN, 115.02ᴼE), China Agricultural University, Hebei province. The main cropping system is a rotation of winter wheat and summer maize which accounts for >80% of agricultural fields in this region.
- A completely randomized design will be employed with three treatment (Table 1) and three replicates.

Table 1. The treatments of experiment.

Treatments	Cropping systems (1-year rotation)	Fertilizer managements
T1	Summer maize → Winter wheat	FM1: Optimized chemical N fertilizer application (Opt. N) (maize: 185 kg N ha^{-1}; wheat: 175 kg N ha^{-1})
		FM2: The total nitrogen input was the same as that of FM1; 30% of chemical N fertilizer will be replaced by organic N fertilizer
T2	Summer soybean → Winter wheat	FM1: Optimized chemical N fertilizer application (soybean: 45 kg N ha^{-1}; wheat: 175 kg N ha^{-1})
		FM2: The total nitrogen input was the same as that of FM1; 30% of chemical N fertilizer will be replaced by organic N fertilizer
T3	Summer maize-soybean intercropping → Winter wheat	FM1: Optimized chemical N fertilizer application (intercropping: maize 111 kg N ha^{-1}; soybean 18 kg N ha^{-1}) (wheat: 175 kg N ha^{-1})
		FM2: The total nitrogen input was the same as that of FM1; 30% of chemical N fertilizer will be replaced by organic N fertilizer

Results

- Compared with expected cumulative N_2O emission of intercrop, observed grain yield of intercrop significantly decreased by 18%.

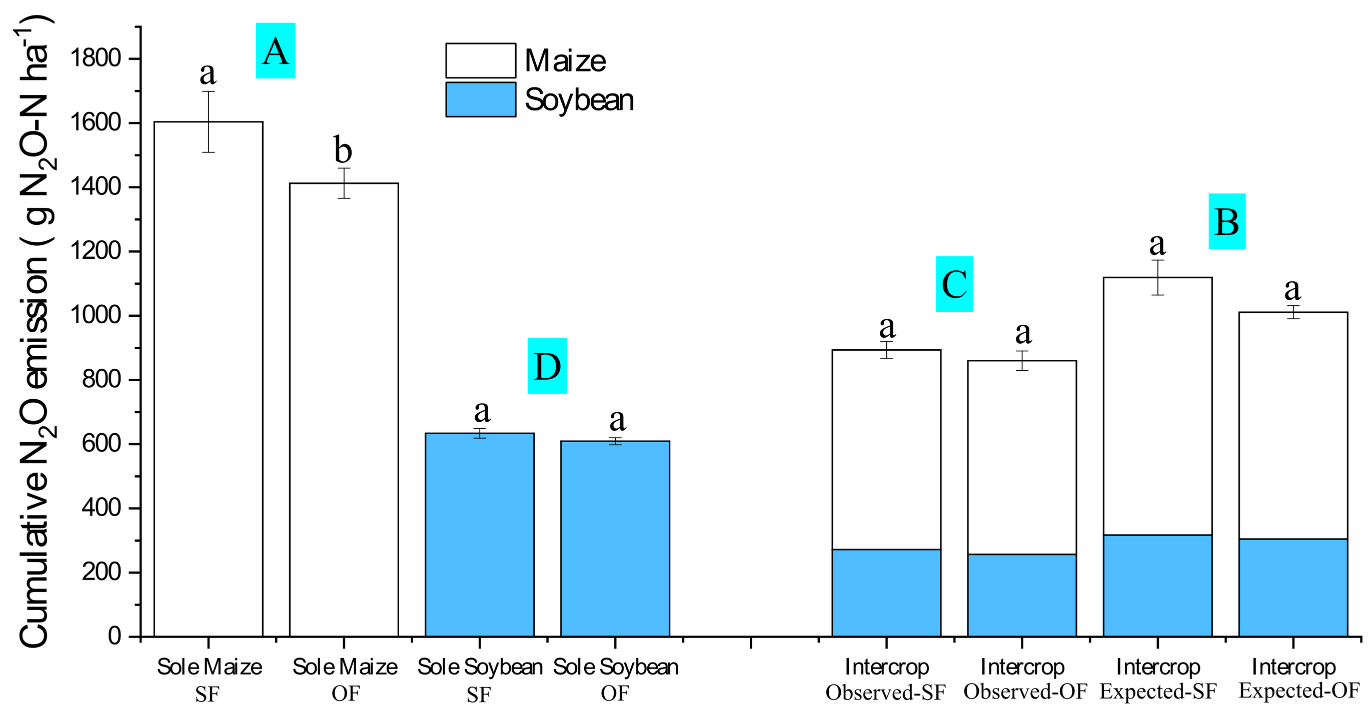

Figure 2. Cumulative N_2O emission of maize, soybean and intercrop under two fertilizer treatment (SF: synthetic fertilizer; OF: 70% Synthetic N fertilizer + 30% Organic N fertilizer). Expected value is calculated as the weighted mean value in the sole crops, with weighing according to the relative density (intercrop/sole crop) of each species in the intercrop.

- The N_2O emissions were significantly positively correlated with soil temperature and soil mineral N concentration but were significantly negatively correlated with soil pH.

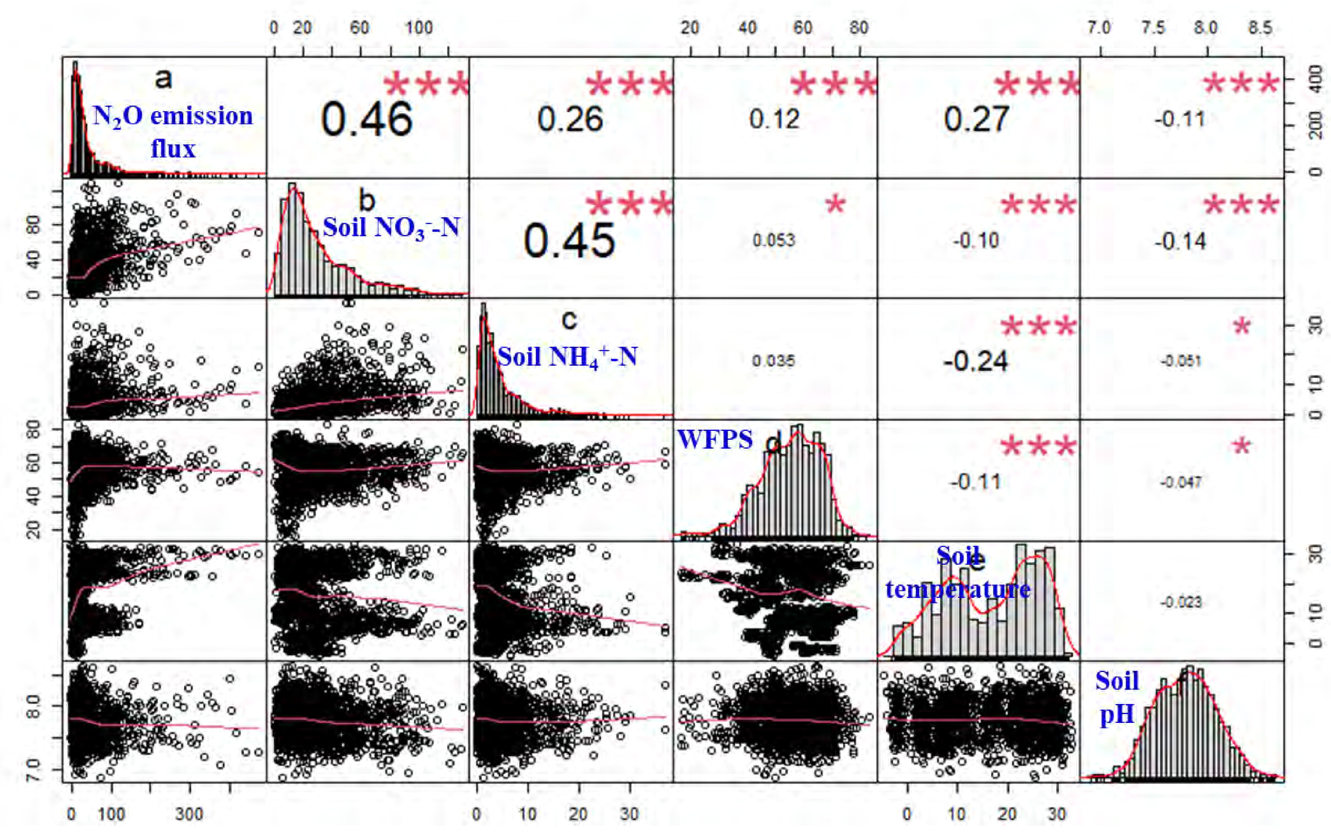

Figure 3. Correlation matrix of associations between N_2O emissions and environmental factors in different cropping systems..

Conclusions

- Introducing maize-soybean intercropping in the cropping systems has the potential to decrease GHG emissions, and this study will prove the suitability of maize-soybean intercropping as a system for low C agriculture in the NCP.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043).

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A hybrid design for a safe, versatile soft robotic gripper for agri-food

Supervisors: WUR: EJ van Henten, GW Kootstra
CAU: Lujia Han, Kailiang Zhang
PhD candidate: Laiquan Luo

Background

The delicate, high-value agri-food relies heavily on the human labor, which is very costly and time-consuming, Indicatively, in Dutch greenhouse horticulture, an average of 29% of the total costs goes to human labor, which amounts to €300.000 per company per year. However, the current mass-automation or specialized robotic gripper does not hold because of the large variability and rigid robotic grippers have a high risk of damaging delicate agricultural produce.

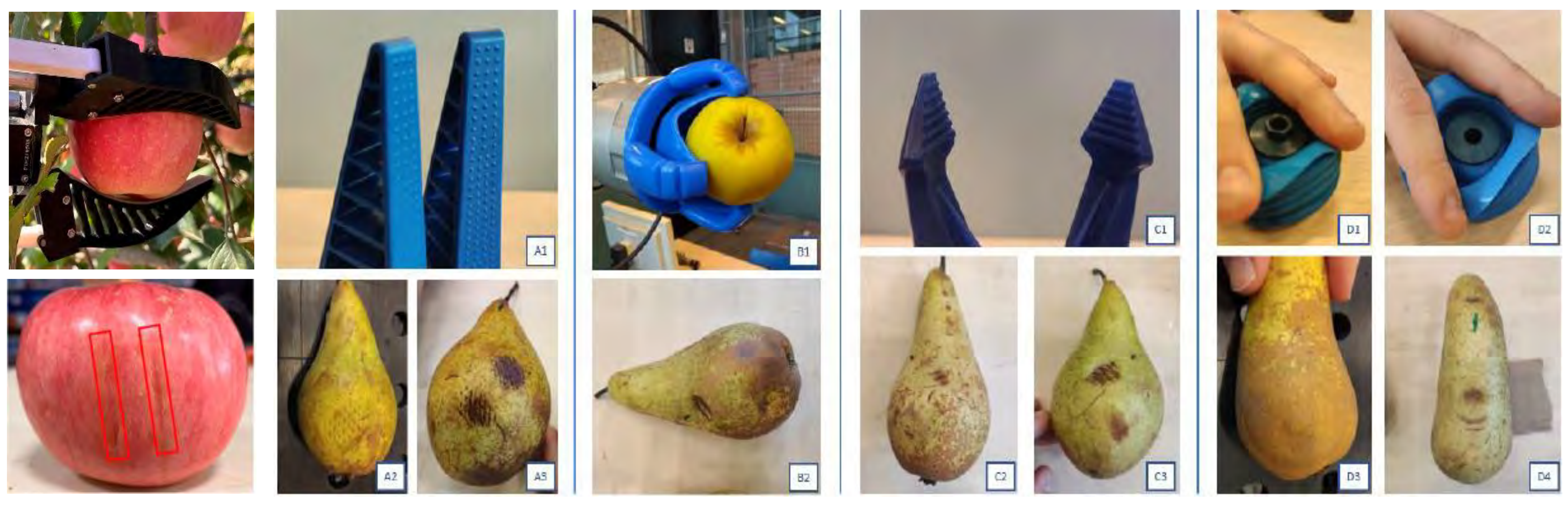

Fig. 1 Examples of grasping damage to the fruit cause by grippers.

Objectives

Soft robotics is a promising solution for agri-food grasping, as it intrinsically has high adaptability feature highly required in grasping of agri-food with vast variability of appearance, geometrical and mechanical properties. The stiffness variability also enables a single versatile robotic system to deal with the safety issue in delicate agri-food grasping. In this context, soft robotics is a suitable alternative approach for rigid robotic approach. So, the main objective in this project is to design and fabricate a safe, versatile soft gripper to address the existing challenges for agri-food grasping.

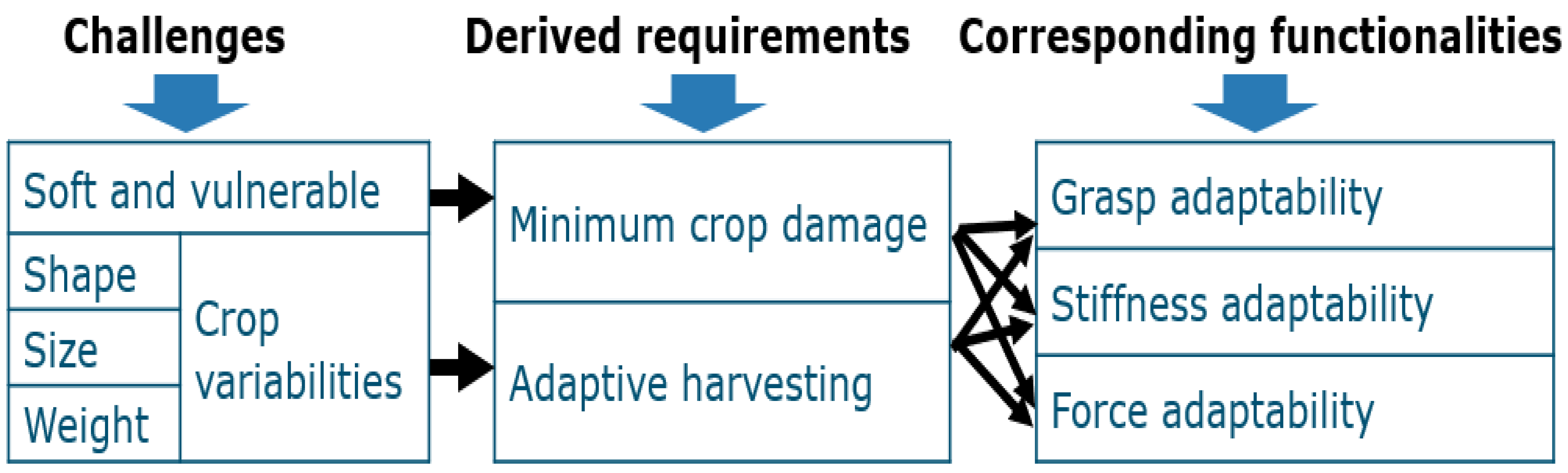

Fig. 2 The challenges, requirements and functionalities for the safe and versatile soft robotic gripper.

Methods

Meta-analysis and hybrid design were used for the gripper design. By listing the pros and cons of all the existing soft robotic gripper mechanisms, it can give us a guideline for selecting the suitable candidate mechanisms for hybrid design. Here in Figure 3 examples of soft robotic gripper mechanisms are categorized into three categories which are grasping by actuation, grasping by stiffness and grasping by adhesion. It also gives a qualitative overview of the suitability of the three different gripper technologies for different object shapes. To enhance their advantages and complement their disadvantages, one mechanism from each category has been selected for the gripper hybrid design. And choose the suitable design based on the task.

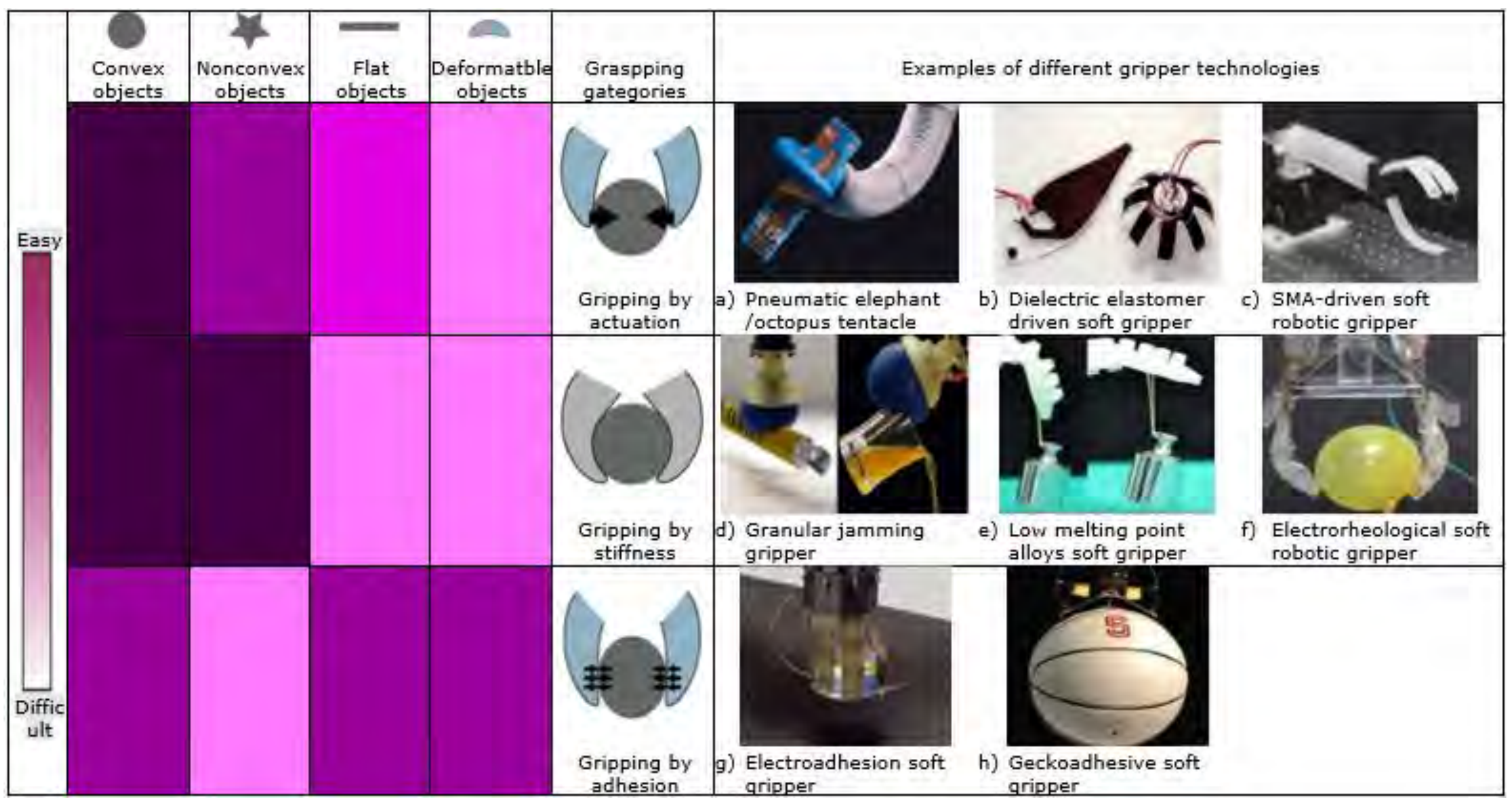

Fig. 3 Examples of soft gripper mechanisms and a qualitative overview of the suitability of different gripper technologies for object shapes.

Results

A hybrid design solution has been proposed through meta-analysis. Tendon driven from grasping by actuation, granular jamming from grasping by stiffness have been chosen, their functionalities and strength are shown in Tab. 1. The schematic view of the hybrid design gripper finger is shown in Fig. 4

Mechanisms	Functionalities	Shape deformability	Size range	Multiple direction approach	Surface condition adaptability
Tendon driven	• Global grasping adaptability • Grasping force	Low	**High**	**High**	**High**
Granular jamming	• Local grasping adaptability • Adaptable stiffness	**High**	**High**	Low	**High**

Tab. 1 The complementary functionalities of candidate mechanisms.

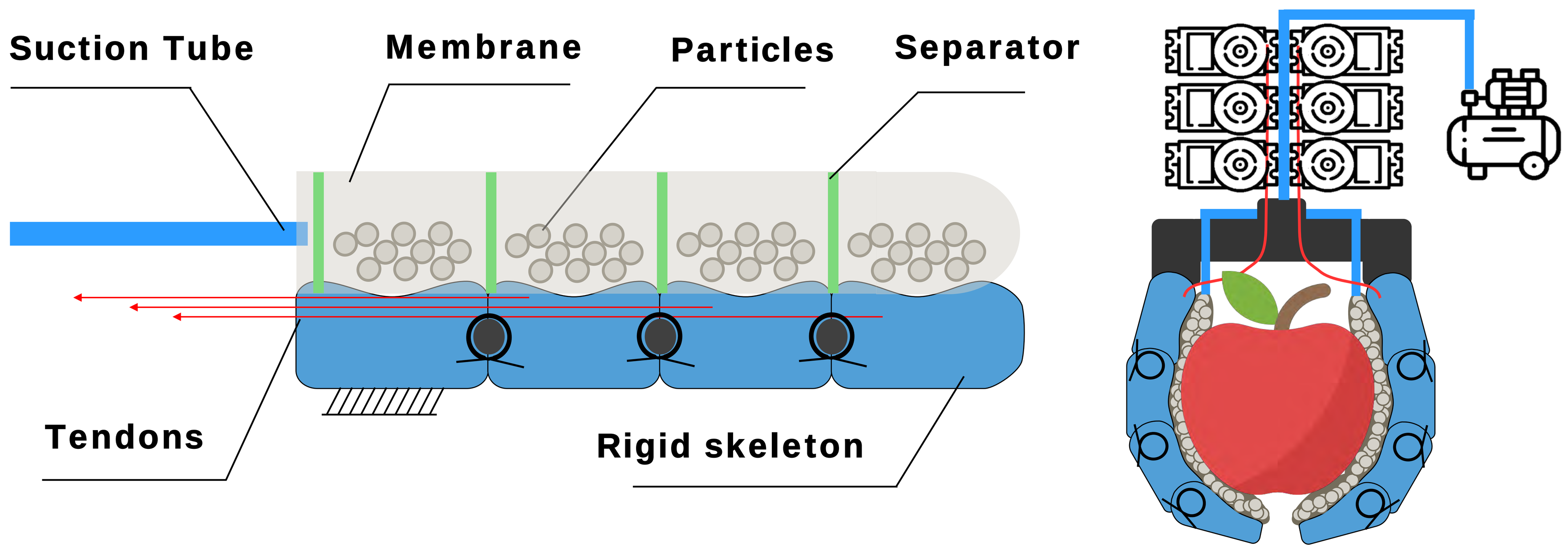

Fig. 4 The schematic view of the finger and gripper design.

Conclusions

A conclusion can be made that the tendon-driven and granular jamming are selected as candidate mechanisms for our safe and versatile agri-food grasping task. As they have complementary functionalities to enhance grasping adaptability. which will improve the performance of adaptive grasping and robust holding for the agri-food with vast variability.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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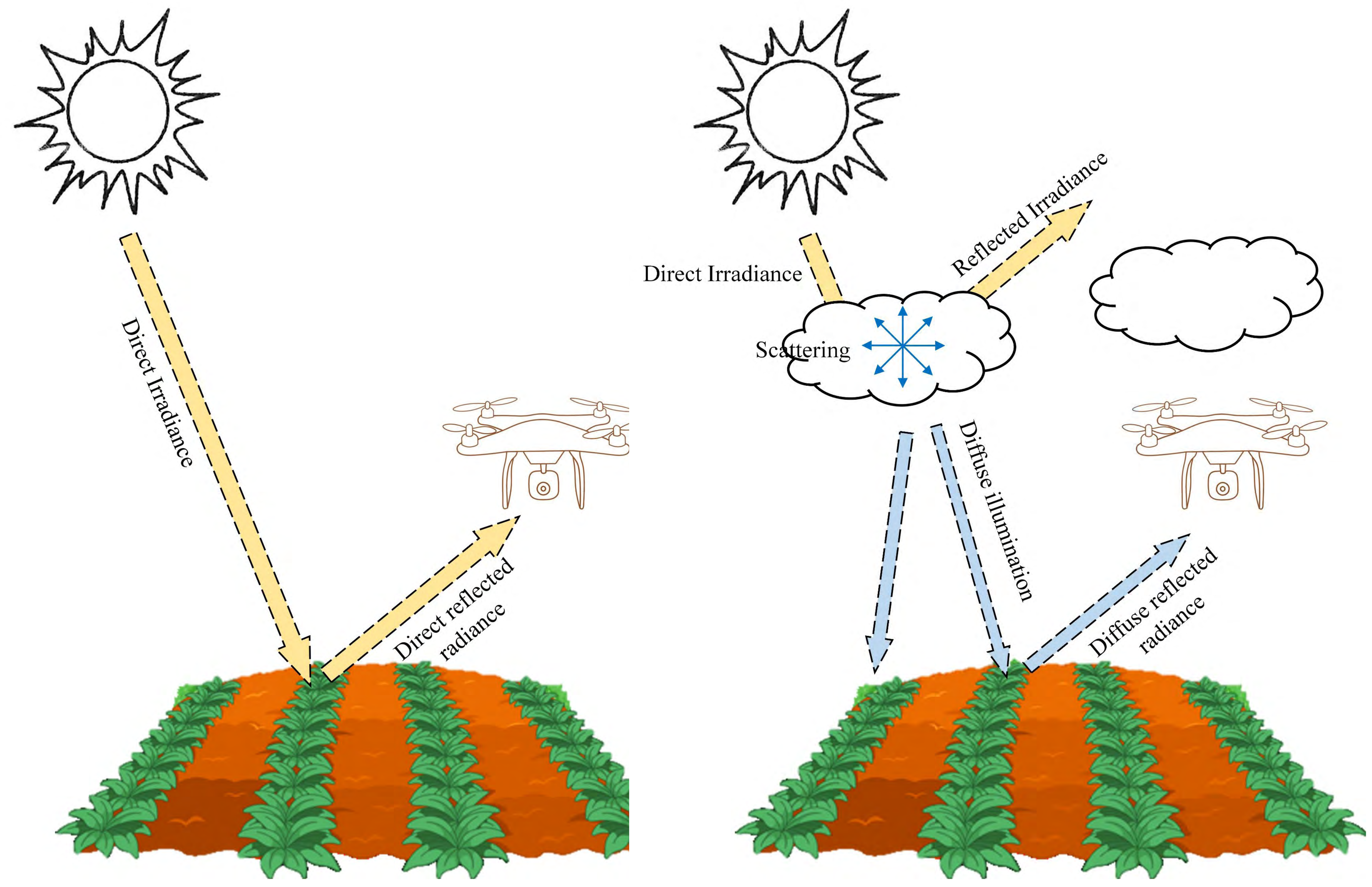
An Improved Radiometric Block Adjustment Method of UAV Multispectral Imagery for Precision Agriculture under Variable Illumination Conditions

2+2 PhD Candidate: Yuxiang Wang
Supervisors: Zengling Yang, Haris Ahmad Khan, Gert Kootstra

Background



- Unmanned aerial vehicles (UAVs) are widely used in field monitoring
- Variable illumination affect the UAV-based crop monitoring

Objectives

a) The objective of this work is to develop an image-based radiometric calibration method for UAV multispectral images

Methods

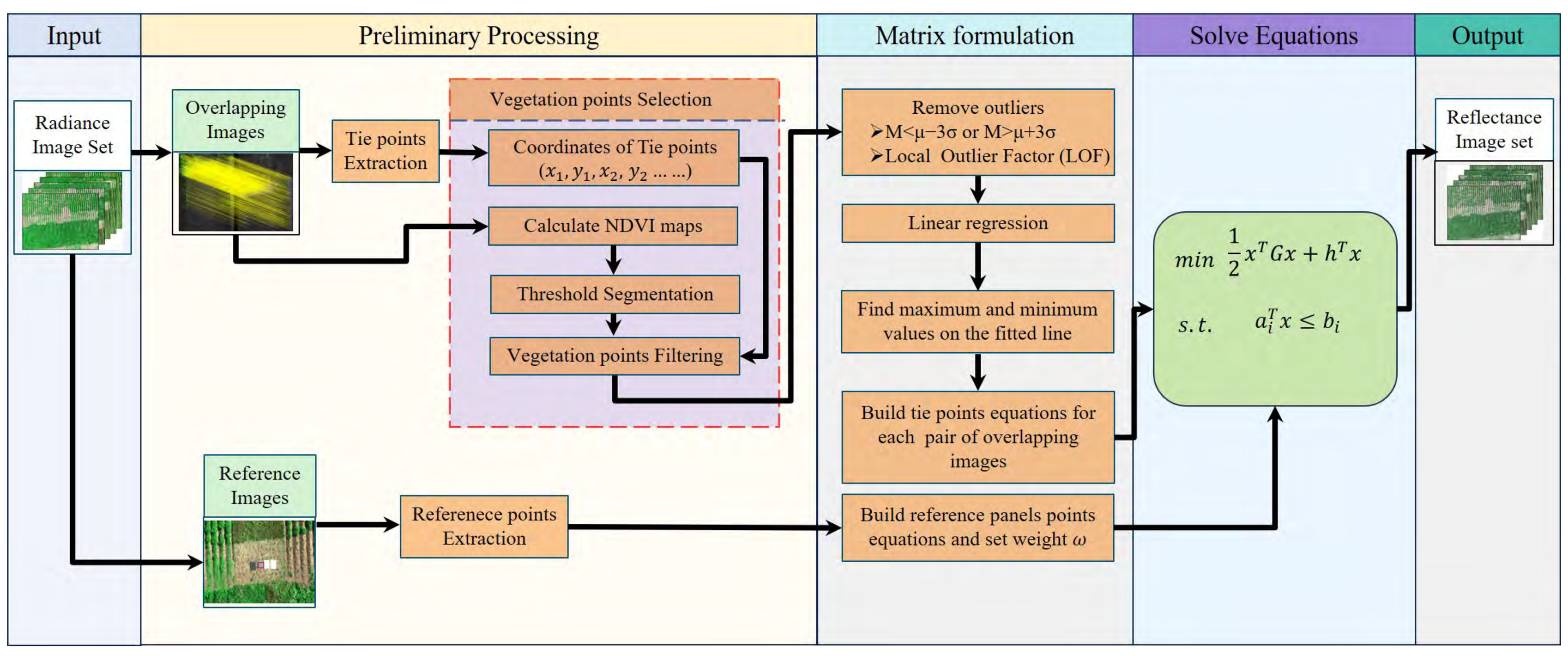


Figure 1. Workflow for the optimized radiometric block adjustment method.

- Reference points:

$$M_1 = \begin{Bmatrix} a_\lambda^1 \times L^1(\lambda, x, y) + b_\lambda^1 = \rho^1(\lambda, x, y) \\ a_\lambda^2 \times L^2(\lambda, x, y) + b_\lambda^2 = \rho^2(\lambda, x, y) \\ \vdots \\ a_\lambda^n \times L^n(\lambda, x, y) + b_\lambda^n = \rho^n(\lambda, x, y) \end{Bmatrix}$$

$$\mathbf{X} = \left[a_\lambda^1, b_\lambda^1, a_\lambda^2, b_\lambda^2 \cdots, a_\lambda^s, b_\lambda^s\right]^T$$

The matrix form of M_1 and M_2 can be formulated as:

- Tie points:

$$M_2 = \begin{Bmatrix} a_\lambda^{j_1} \times L^{j_1}\left(\lambda, x_{j_1}^1, y_{j_1}^1\right) + b_\lambda^{j_1} - a_\lambda^{k_1} \times L^{k_1}\left(\lambda, x_{k_1}^1, y_{k_1}^1\right) - b_\lambda^{k_1} \\ a_\lambda^{j_2} \times L^{j_2}\left(\lambda, x_{j_2}^2, y_{j_2}^2\right) + b_\lambda^{j_2} - a_\lambda^{k_2} \times L^{k_2}\left(\lambda, x_{k_2}^2, y_{k_2}^2\right) - b_\lambda^{k_2} \\ \vdots \\ a_\lambda^{j_m} \times L^{j_m}\left(\lambda, x_{j_m}^m, y_{j_m}^m\right) + b_\lambda^{j_m} - a_\lambda^{k_m} \times L^{k_m}\left(\lambda, x_{k_m}^m, y_{k_m}^m\right) - b_\lambda^{k_m} = 0 \end{Bmatrix}$$

$$P_1\mathbf{X} = p_1$$

$$P_2\mathbf{X} = p_2$$

$$C = \min_c \frac{\omega}{2}\|P_1\mathbf{X} - p_1\|_2^2 + \frac{1}{2}\|P_2\mathbf{X} - p_2\|_2^2$$

$$s.t.\quad A\mathbf{X} \le \mathbf{b}$$

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Results

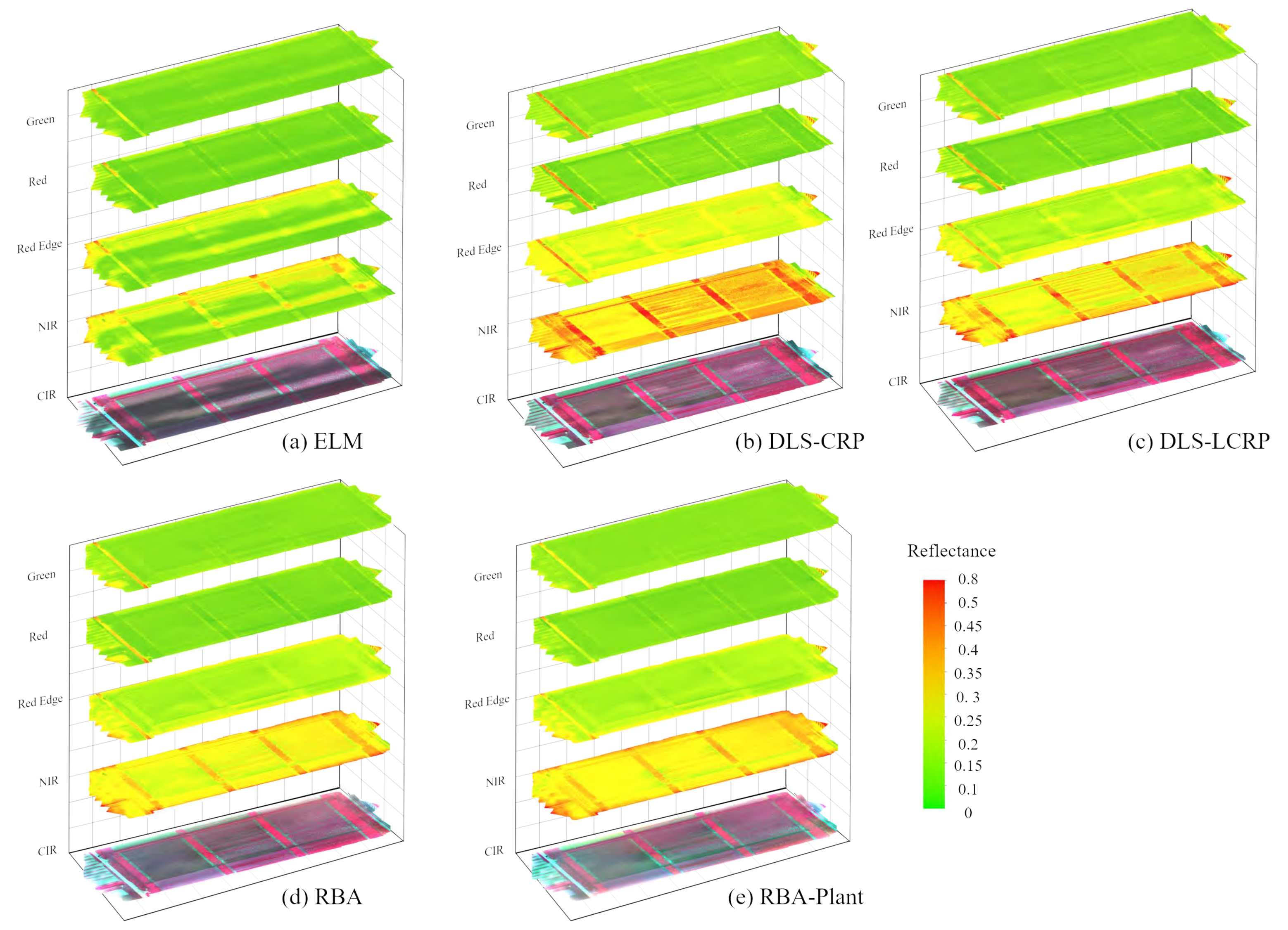

Figure 3. Overview of all the reflectance orthomosaics for each method-ELM, DLS-CRP, DLS-LCRP, RBA and our proposed RBA-Plant-across the green, red, red edge and NIR bands. The bottom layer displays the false color composite image (color infrared, or CIR).

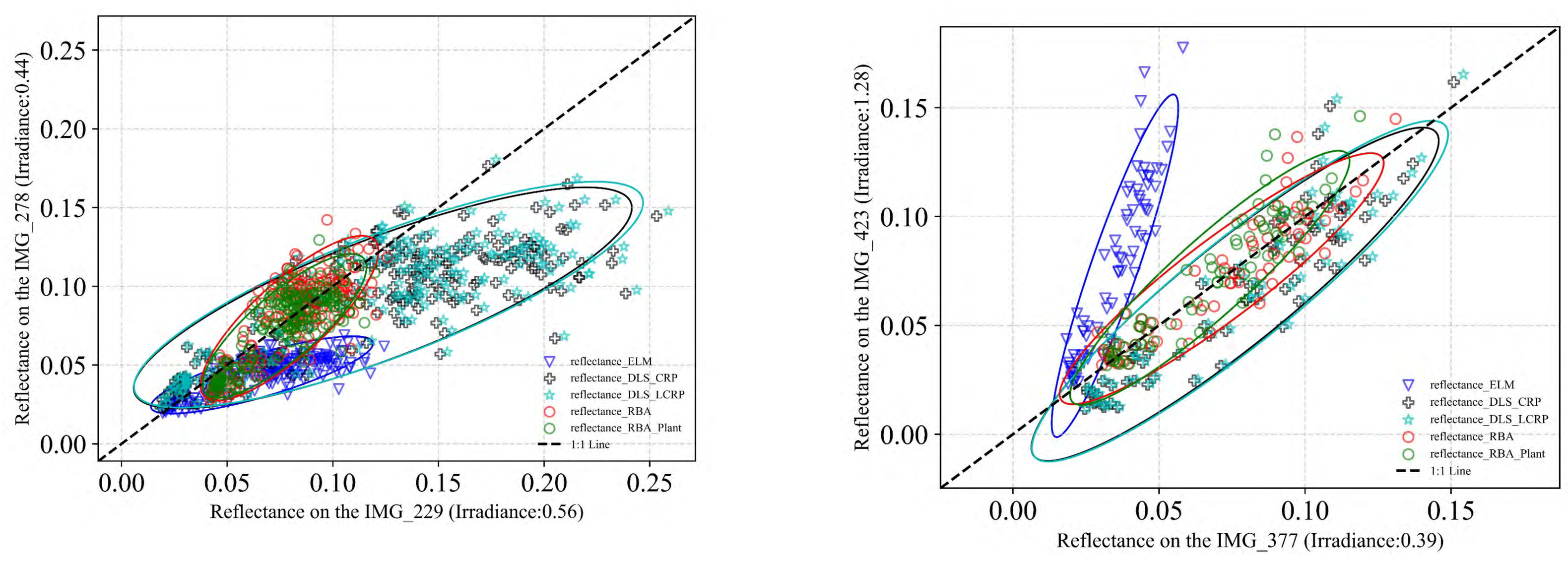

Figure 4. Adjustment for single image.

Table 1. Result of the RMSE values between ground-measured reflectance and corrected orthomosaic-extracted reflectance in the monoculture and stripcropping fields, respectively.

Field/RMSE	Bands	ELM	DLS-CRP	DLS-LCRP	RBA	RBA-Plant
Monoculture Field	Green	0.021	0.048	0.020	0.016	0.014
	Red	0.021	0.023	0.015	0.028	0.028
	NIR	0.235	0.158	0.095	0.116	0.088
	Red Edge	0.059	0.084	0.032	0.027	0.025
	Mean	**0.084**	**0.078**	**0.041**	**0.047**	**0.039**
Stripcropping Field	Green	0.03	0.043	0.015	0.013	0.011
	Red	0.017	0.024	0.015	0.024	0.019
	NIR	0.311	0.147	0.099	0.174	0.126
	Red Edge	0.091	0.075	0.031	0.055	0.054
	Mean	**0.112**	**0.072**	**0.04**	**0.066**	**0.052**

Conclusions

- In this article, we introduce a lightweight radiometric block adjustment method designed to achieve accurate and robust reflectance image conversion under varying illumination conditions.
- Moreover, we demonstrate the effectiveness of extracting tie points solely from the area of interest in the RBA method. The optimized RBA-Plant method further enhances the accuracy of plant reflectance by constructing tie-point equations using tie points selected from vegetation regions.

Acknowledgements

We gratefully acknowlege the sponsors of this research:AGD project and China Scholarship Council (NO.201913043) and Hainan University.

Unlocking Soil Health: Are Microbial Functional Genes Effective Indicators?

PhD Student: Jiyu Jia   Supervisors: Junling Zhang; Rachel Creamer; Ron de Goede; Guangzhou Wang

Background

Soil biota is a critical component and drive numerous processes that are crucial for maintaining soil quality and health. There have been increasing efforts to incorporate soil biological measurements into monitoring soil quality and health. Soil microbial communities form the lifeblood of soil ecosystems and as such are involved in various soil functions, such as carbon cycling and storage, nutrient cycling and primary production. Numerous studies suggest that soil microbial diversity and communities are associated with carbon (C), nitrogen (N), and phosphorus (P) cycling. Analyzing functional genes rather than taxonomic diversity offers a glimpse into the genuine functional capacity within the whole microbial community, thereby acknowledging potential redundancy at the community rather than at the individual level. Unraveling these intricate interactions between soil microbial functional gene(s) abundance, soil properties and soil functioning would allow us to better predict and manage soil quality and improve soil health in agricultural ecosystems.

Objectives

This study aims to investigate the relationship between the abundance of a range of microbial functional genes, soil nutrient and carbon cycling and their effects on crop yield. We hypothesized that: (1) Soil nutrient and carbon cycling indicators and the abundances of microbial functional genes are highly correlated, but the response of functional genes to fertilization will be more pronounced, i.e. exhibit greater variability between treatments, than the corresponding proxy indicators for element cycling; and (2) compared to chemical fertilization only, organic fertilization will increase the abundance of microbial functional genes, which will promote soil carbon and nutrient cycling, thereby increasing crop yields.

Methods

This study was based on soil samples collected from a long-term field experiment with an annual rotation of winter wheat and summer maize in Quzhou Experimental Station (36°42′ N, 114°54′ E; 40 m a.s.l.) of China Agricultural University, Hebei province. Field plots (50 m^2, 5 m × 10 m) were established in 2010. There are five treatments with four replicates: (1) CK, no fertilizer; (2) NPK, chemical fertilizer only; (3) NPKM, chemical fertilizer plus manure compost (6000 kg ha-1 yr-1, dry weight); (4) NPKSW, chemical fertilizer plus straw return (wheat straw: 6.0 Mg ha-1 yr-1; maize straw: 6.8 Mg ha-1 yr-1); (5) MNPKSW, chemical fertilizer plus manure compost and straw return (wheat straw: 7.3 Mg ha-1 yr-1; maize straw: 6.9 Mg ha-1 yr-1), provided in yearly gifts. All treatments were based on a nitrogen-equivalent application design, i.e. all treatments except the control received approximately 250 kg N ha-1 yr-1. Microbial functional genes related to carbon, nitrogen and phosphorus cycling were quantified and their corresponding proxy indicators were summarized through literature review (Table. 1).

Table 1. Microbial functional genes, the soil ecological processes in which they participate, and soil properties that can be used as proxy indicators for the soil ecological processes.

Microbial functional gene		Soil ecological process	Soil proxy indicator	Reference
Carbon	*CBBL*	encoding RubisCO I of Calvin cycle	TC, SOC, POXC	Zhang et al., 2023
	GH31	starch degradation	AG, BG, BX, BC, CO_2	Talbot et al., 2015
Nitrogen	*nifH*	N_2-fixation	TN, NH_4^+-N, NO_3^--N	Keshri et al., 2015
	ureC	Urea hydrolysis (Urea - NH_3/NH_4^+)	NO_3^--N	Fisher et al., 2017
	chiA	Chitin degradation	NAG	Zhang et al., 2023
	AOA	Nitrification (NH_4^+-NH_2OH)	NO_3^--N	Levy-Booth et al., 2014
	AOB	Nitrification (NH_4^+-NH_2OH)	NO_3^--N	Levy-Booth et al., 2014
	narG	Denitrification (NO_3^--NO_2^-)	NO_3^--N, N_2O	Lin et al., 2023
	nirK	Denitrification (NO_2^- -NO)	NO_3^--N, N_2O	Lin et al., 2023
	nirS	Denitrification (NO_2^- -NO)	NO_3^--N, N_2O	Lin et al., 2023
	norB	Denitrification (NO-N_2O)	NO_3^--N, N_2O	Lin et al., 2023
	nosZ	Denitrification (N_20-N_2)	NO_3^--N, N_2O	Lin et al., 2023
Phosphorus	*gltA*	Phosphorus dissolution	Phosphatase, AP	Jian et al., 2022
	BPP	Phytic acid mineralization	Phosphatase, AP	Wan et al., 2021
	phoD	Organic P mineralization (Alkaline phosphomonoesterase)	Phosphatase, AP	Cao et al., 2022
	phoC	Organic P mineralization (Acid phosphomonoesterase)	Phosphatase, AP	Cao et al., 2022
	pqqC	Inorganic P dissolution (Pyrroloquinoline-quinone synthase)	Phosphatase, AP	Yang et al., 2023

Results

In general, the abundance of the soil microbial functional genes and proxy indicators were significantly affected by the fertilization treatments (Fig. 2) . The CV values of the proxy indicators calculated at the experimental field level related to the carbon cycle varied between 8-36%, whereas this was 36-51% for the related functional genes CBBL and GH31 (Fig. 2). For the proxy indicators related to the nitrogen cycle, the CVs combining all treatments varied between 10-54% and strongly overlapped with the CV values for the functional microbial genes (23-55%). Also the CV values of the proxy indicators related to the phosphorous cycle combined for all treatments (11-62%) overlapped with those of the microbial functional genes (21-63%). In general, all CVs of the functional genes values combined for all treatments were >20%, whereas 62% of the soil proxy indicators had a CV≤ 20%.

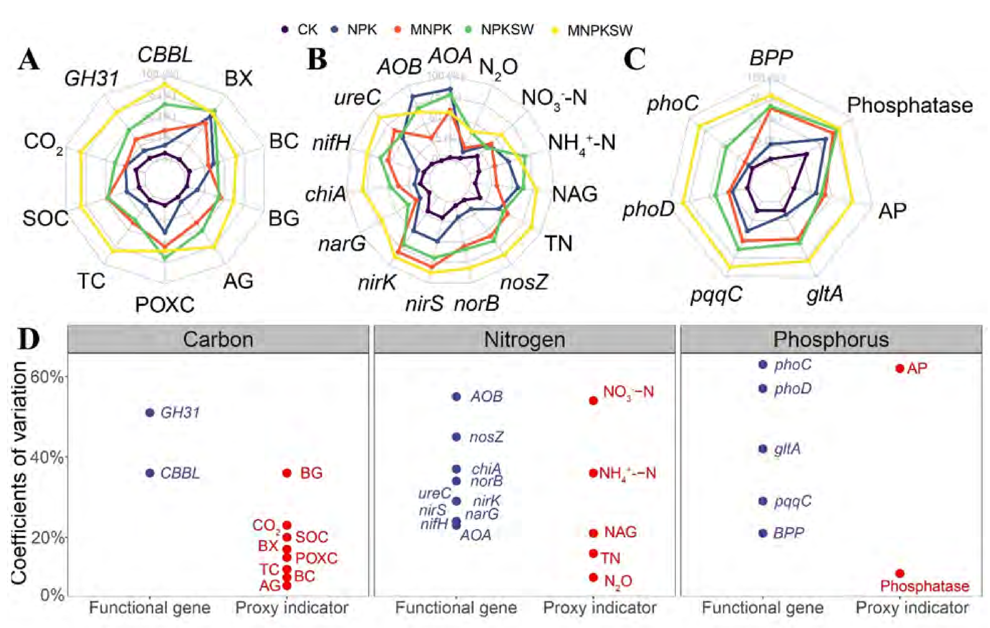

Fig. 2. Fig.1. Radar diagram of microbial functional genes (in italics) and soil proxy indicators for the carbon (A), nitrogen (B) and phosphorus (C) cycling process and their coefficients of variation (D).

Structure equation modelling showed that soil carbon and nutrients inputs enhanced microbial functional gene(s) abundance, which promoted carbon, nitrogen and phosphorus cycling and stimulated crop yield.

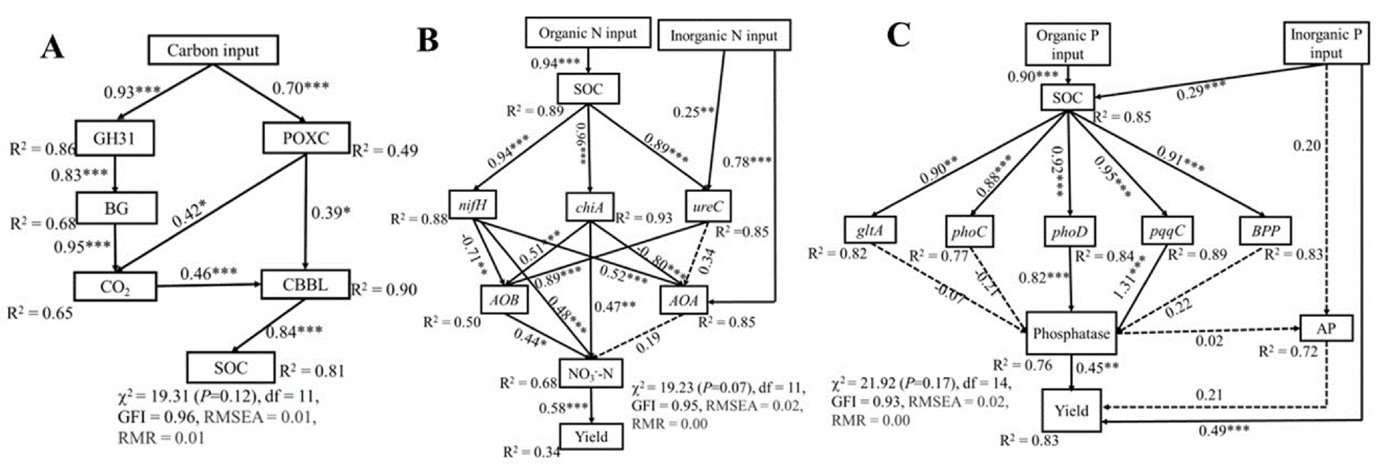

Fig. 3. Structural equation models describing the effects of carbon input on the carbon cycling process (A); and the effects of organic and inorganic nitrogen (B) and phosphorus (C) input on the nitrogen and phosphorus cycling process and crop yield, respectively. * indicates $p < 0.05$; ** indicates $p < 0.01$, *** indicates $p < 0.001$, respectively. Continuous and dashed lines indicate significant and nonsignificant relationships, respectively. R2 denotes the proportion of variance explained.

Conclusions

We found that fertilization significantly affected the abundance of soil microbial functional genes involved in carbon, nitrogen and phosphorus cycling. Functional gene abundances and the corresponding proxy indicators were strongly correlated. Most functional genes showed higher variability among treatments than their corresponding proxy indicators, indicating that functional genes could be more responsive to fertilization than the selected proxy indicators that are generally selected as indicators for soil functioning. Structure equation model analysis showed that the carbon and nutrient inputs increased soil microbial functional gene abundance, which promoted the soil carbon, nitrogen and phosphorus cycling process indicators, resulting in an enhanced soil organic carbon sequestration and crop yield. Overall, functional gene abundances were found to contribute more to explaining the effects of fertilizer application on crop yield than the proxy indicators for nutrient cycling. This study strongly endorses that functional genes can serve as pivotal biomarkers for understanding the intricate dynamics of soil processes and as indispensable biological indicators for assessing soil health.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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A soil-based decision support system to assess primary productivity in double cropping system: A case study in the North China Plain

Yizan Li, Carmen Vazquez, Junling Zhang, Ron de Goede, Rachel Creamer

Background

Soil is a vital natural resource. Among the multiple functions soil performs, **primary productivity** stands out as a crucial element, pivotal for ensuring food security as the basis of the agricultural system. The North China Plain, a major food-producing region in China, faces challenges from intensive field management and soil degradation. Current methods for evaluating soil primary productivity often focus solely on soil properties, overlooking management practices and the underpinning soil processes, or require extensive agronomic knowledge background and complex model validation processes. The EU Soil Navigator offers a nice example in assessing multiple soil functions and assisting field-scale decision-making, while its direct application in the North China Plain is constrained by different crop systems and regional conditions. Adapting a similar comprehensive approach could be beneficial for optimizing soil primary productivity in this region.

Objectives

This research is to develop a decision support model to evaluate the capacity of soil primary productivity of the wheat-maize rotation system in the North China Plain, with the specific objectives to **1)** establish develop a knowledge-based model for the assessment of soil primary productivity; **2)** calibrate the model and perform sensitivity analysis using data from long-term field experiments; and **3)** validate the model with data from nearby smallholder farms.

Methods

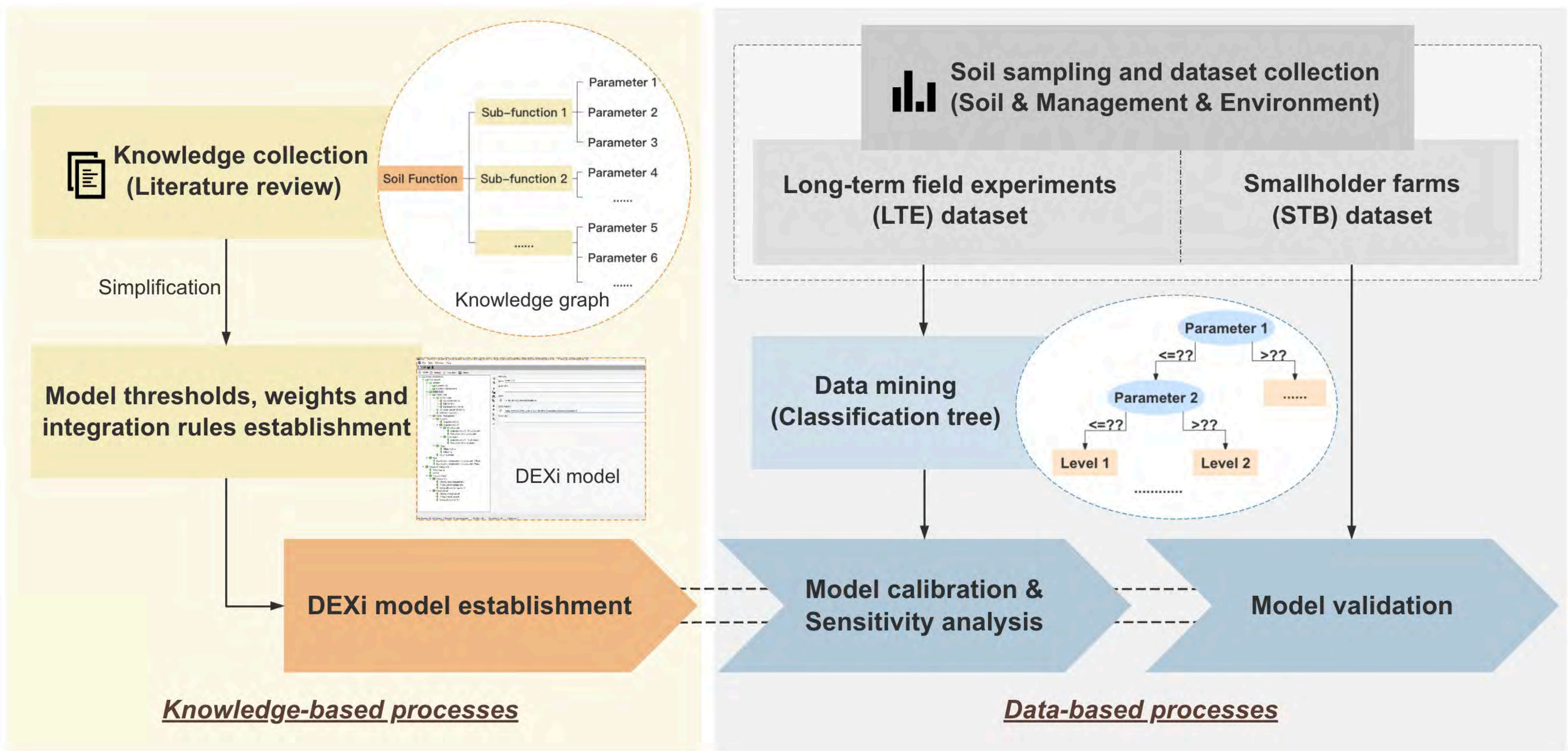

Figure 1. Flowchart of methodology to build the soil primary productivity model.

This research followed the Decision Expert (DEX) integrative methods to refine classification of soil primary productivity into a hierarchical tree structure, categorizing it into three levels: Unsuitable, Neutral, and Suitable. The soil productivity model was developed through knowledge-based (DEXi model establishment) and data-based processes (model calibration, sensitivity analysis, and validation, illustrated in Figure 1). Dataset encompassing soil properties, management practices, and meteorological conditions were gathered from Long-Term field Experiments (LTE) and Science and Technology Backyard (STB) farms in Quzhou County in 2020.

Results

We partitioned the soil primary productivity function based on current knowledge into 2 sub-functions: 1) Crop growth (including Water & air provision, Nutrient provision, Heat provision, and Soil structure for root expansion), and 2) Threats to crop growth (including pests, competition with weeds, waterlogging and drought, soil salinization, and heavy metal pollution) (Figure 2).

Table 1. Performance of the Primary Productivity model at different modelling stages.

Phase of modelling	Dataset	Model accuracy for each actual yield level			Overall accuracy
		Suitable	Neutral	Unsuitable	
Before calibration	LTE	90.0%	37.4%	47.1%	**51.6%**
After calibration	LTE	70.0%	70.3%	72.6%	**70.9%**
Validation	STB	67.7%	45.5%	-	**62.2%**

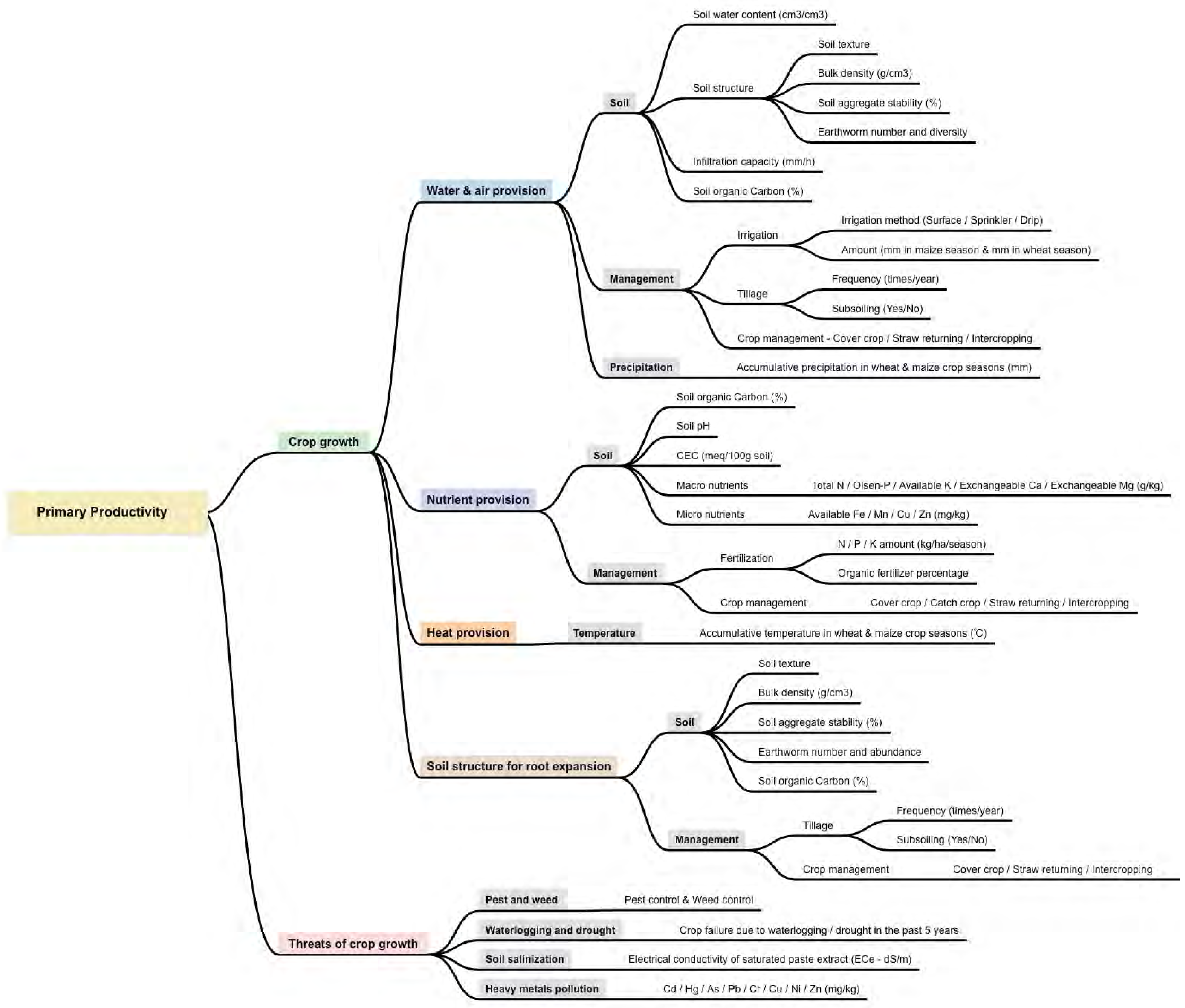

Figure 2. Knowledge graph of soil primary productivity function.

The classification tree (Figure 3) generated from data mining selected key factors influencing the soil primary productivity function, notably N, SOC and Zn, and they were used to improve our model by adjusting attribute weights and thresholds.

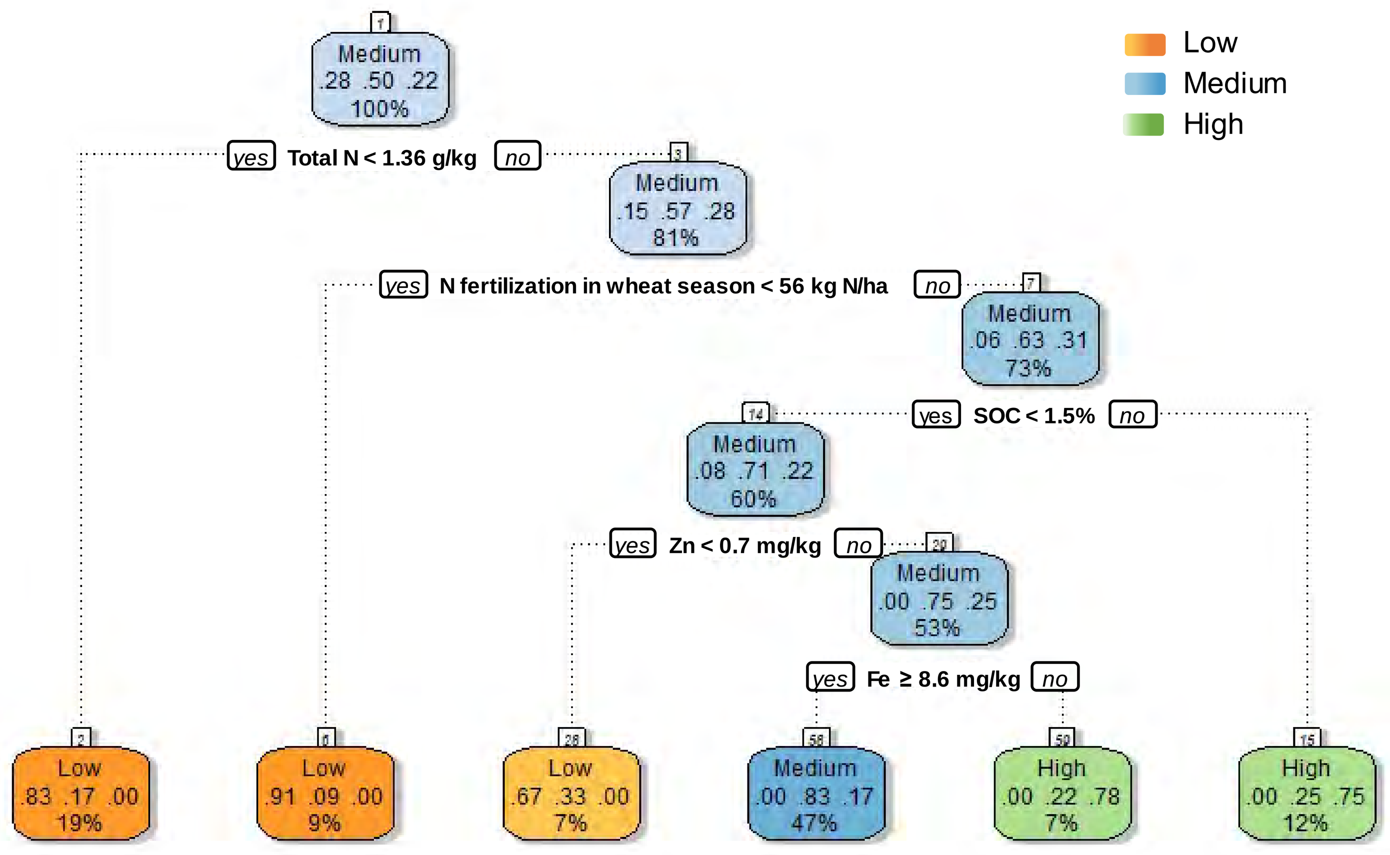

Figure 3. Classification tree from data mining to predict crop yield levels.

By comparing the predicted soil primary productivity levels and the actual yield levels (proxy indicator), the initial knowledge-based model achieved an accuracy of 51.6%, while the calibration based on data mining and sensitivity analysis improved the model to 70.9%. Besides, the validation with smallholder farms' data achieved an accuracy of 62.2% (Table 1).

Conclusions

This study integrates knowledge-based approach and data mining to develop a model evaluating soil primary productivity. Utilizing data from long-term field experiments and smallholder farms, the model underwent calibration, sensitivity analysis, and validation, achieving accuracy rates of 70.9% and 62.2%, respectively. It represents a successful application of the Decision Expert integrative method, paving the way for an integrated soil health decision support system to optimize on-field management and enhance soil function understanding.

Acknowledgements

We gratefully acknowledge the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University.

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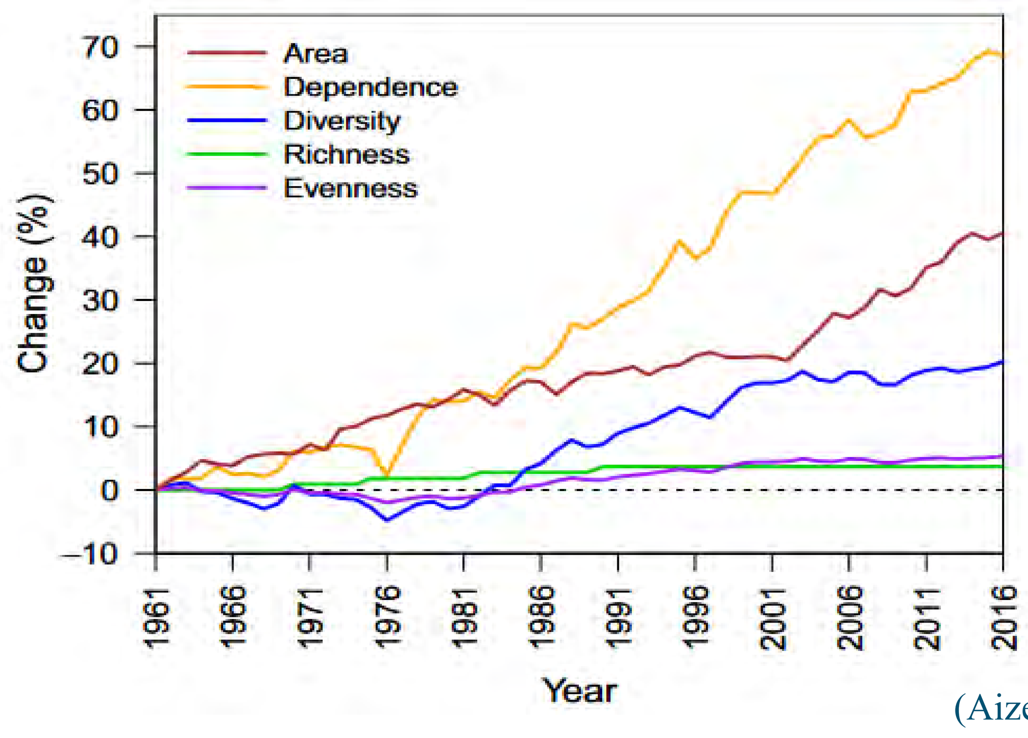
What's the composition of pollinating insects in the North China Plain?

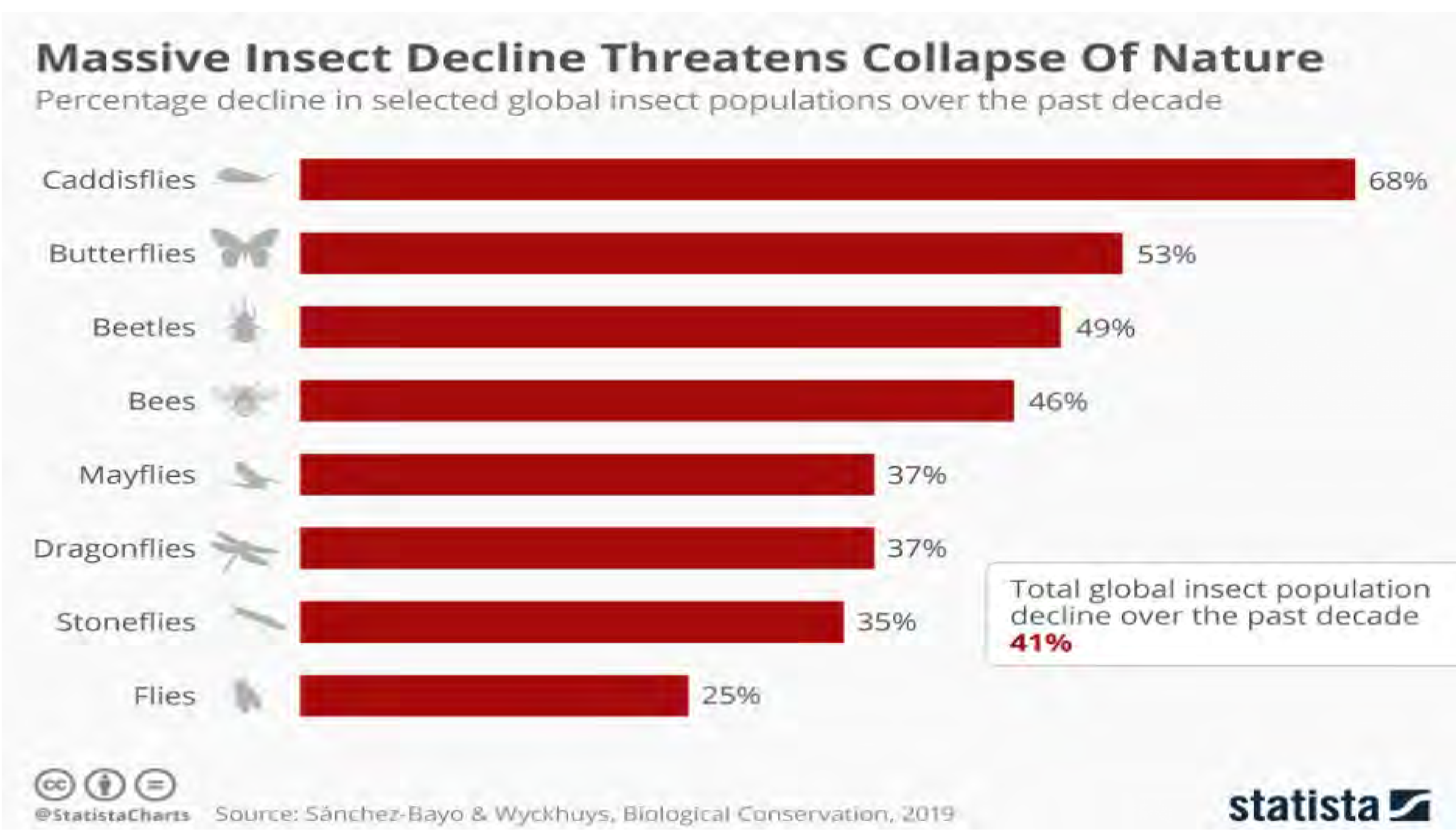
PhD candidate: Yanjie Chen (2+2)
CAU supervisors: Chaochun Zhang, Wenfeng Cong
WUR supervisor: Wopke van der Werf

Background



The proportion of total agricultural area occupied by pollinator-dependent crops increased by 70% from 1961 to 2016 globally.

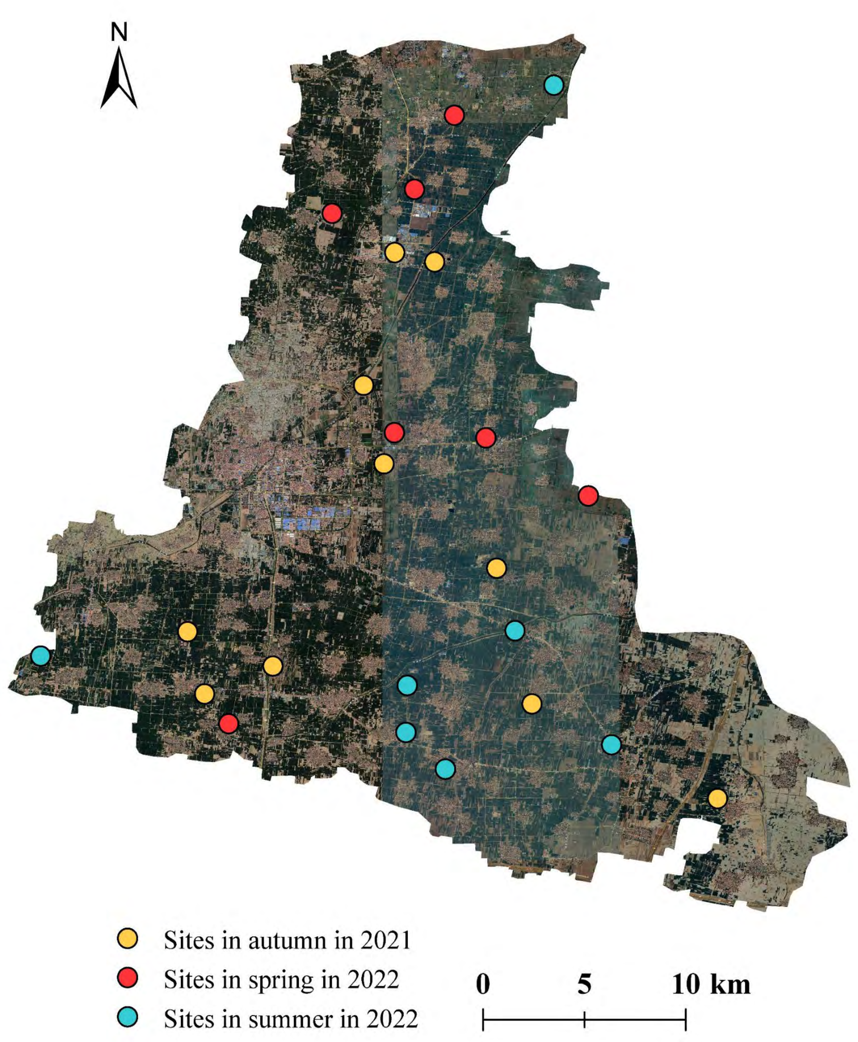
(Aizen et al., Glob Chang Biol, 2019)



(Sánchez-Bayo & Wyckhuys, Biol Conserv, 2019)

41 percent of the world's insect populations are declining while a third are endangered, and pollinators are the most affected.

Methods



Pan trap stations used to collect pollinator samples

Potted buckwheat plants were put close to the pan trap stations at each site

A two-year field experiment was established in Quzhou County to estimate the composition of pollinators in the intensive cereal production landscape. We chose 24 sites in three seasons (autumn, spring and summer). At each site, pan trap stations were installed to collect the pollinators in this region.

Results

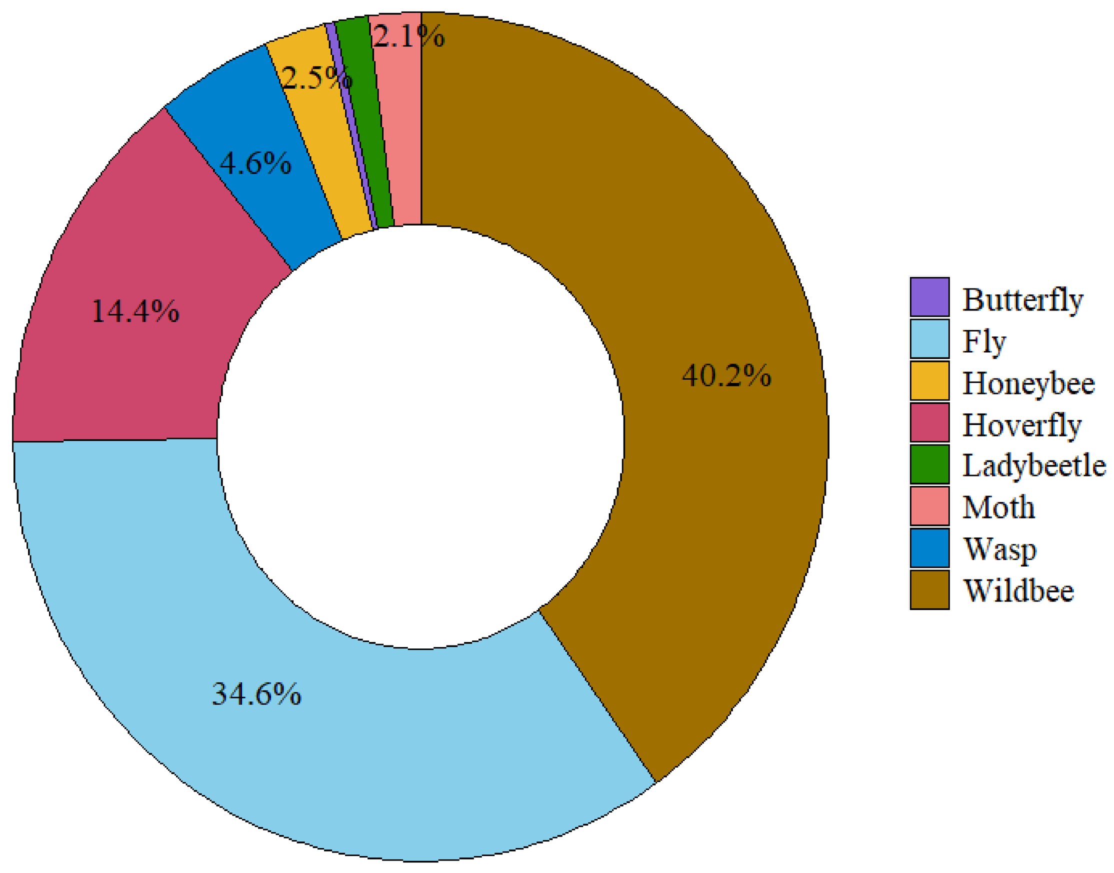


Fig. 1 The proportion of different pollinator groups

Wild bees, other flies, and hoverflies were the dominant pollinating insects in this cereal production region (Fig. 1).

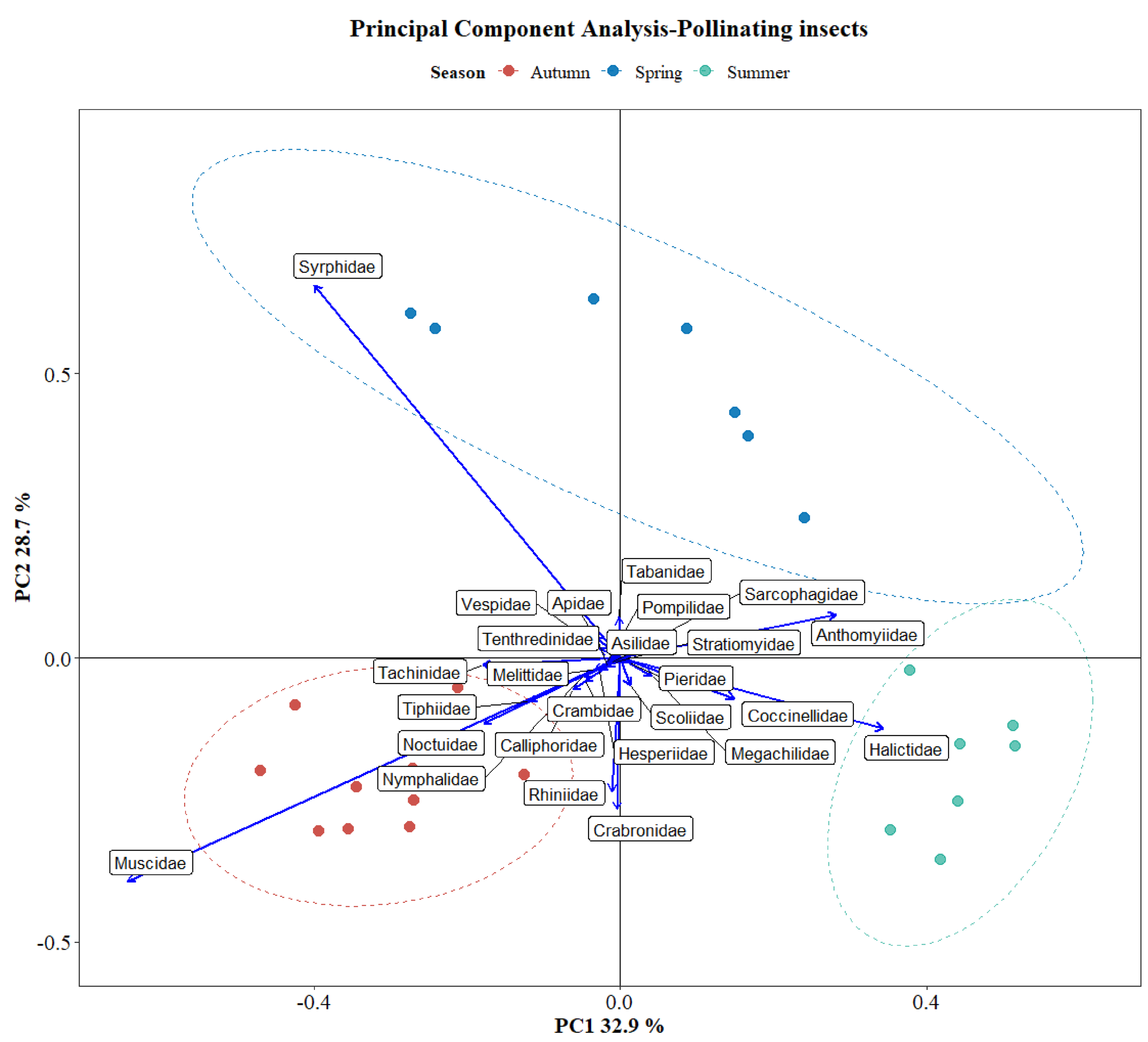


Fig. 2 The biplot of PCA on the composition of pollinators

There was an apparent seasonal effect on the composition of pollinating insects. More Syrphidae in the spring, more Halictidae in the summer and more Muscidae in the autumn (Fig. 2).

Conclusions

a) Hoverflies (Syrphidae) and wild bees from Halictidae were the main wild pollinators in this region.
b) There was an apparent phenology pattern in pollinating insect composition.
c) Sampling insects across seasons can give a more comprehensive understanding of pollinator composition.

Acknowledgements

We gratefully acknowlege the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University.

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Diversified crop rotations improve crop water use and subsequent cereal crop yield through soil moisture compensation

PhD candidate: Bo Wang   Supervisors : Xiaolin Yang, Jos van Dam, Coen J. Ritsema

Background

(1) Agricultural intensification has significantly increased crop productivity but also caused environmental issues, including excessive groundwater extraction, the release of climate-affecting greenhouse gases, and a loss of biodiversity .

(2) The typical cropping system in the NCP is winter wheat (Triticum aestivum L.) and summer maize (Zea mays L.) double cropping (WM), which consumes 700–1000 mm of water per year. About 70% of the water requirement for winter wheat comes from irrigation, resulting in an annual decline in the groundwater table of nearly 1 m.

(3) Crop diversification has emerged as a strategy to increase crop production, reduce groundwater overextraction, and enhance agroecosystem services and resilience, but Prior research has indicated that diversified crop rotations can increase crop yields and water productivity (WP).

Objectives

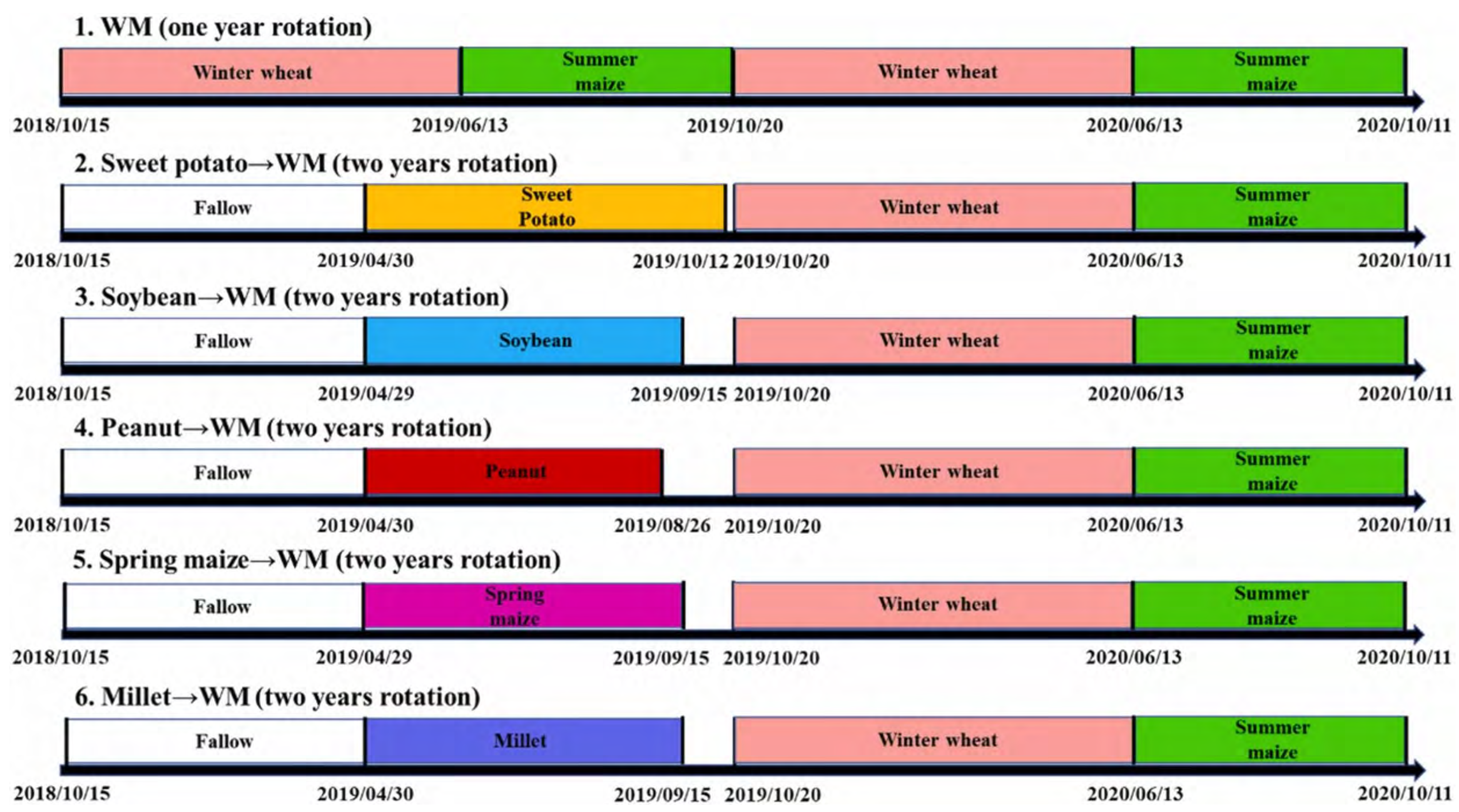
(1) Quantify water consumption (ETc act) and net groundwater use in each rotation.

(2) Assess differences in system productivity with various aspects of water productivity.

(3) Investigate the ‘lag effect’ in diversified crop rotations, where the preceding crop diversification impacts the grain yield and WP of succeeding cereal crops.

(4) Examine the temporal and spatial complementarity of soil moisture by combining shallow and deep-rooted crops in diversified crop rotations.

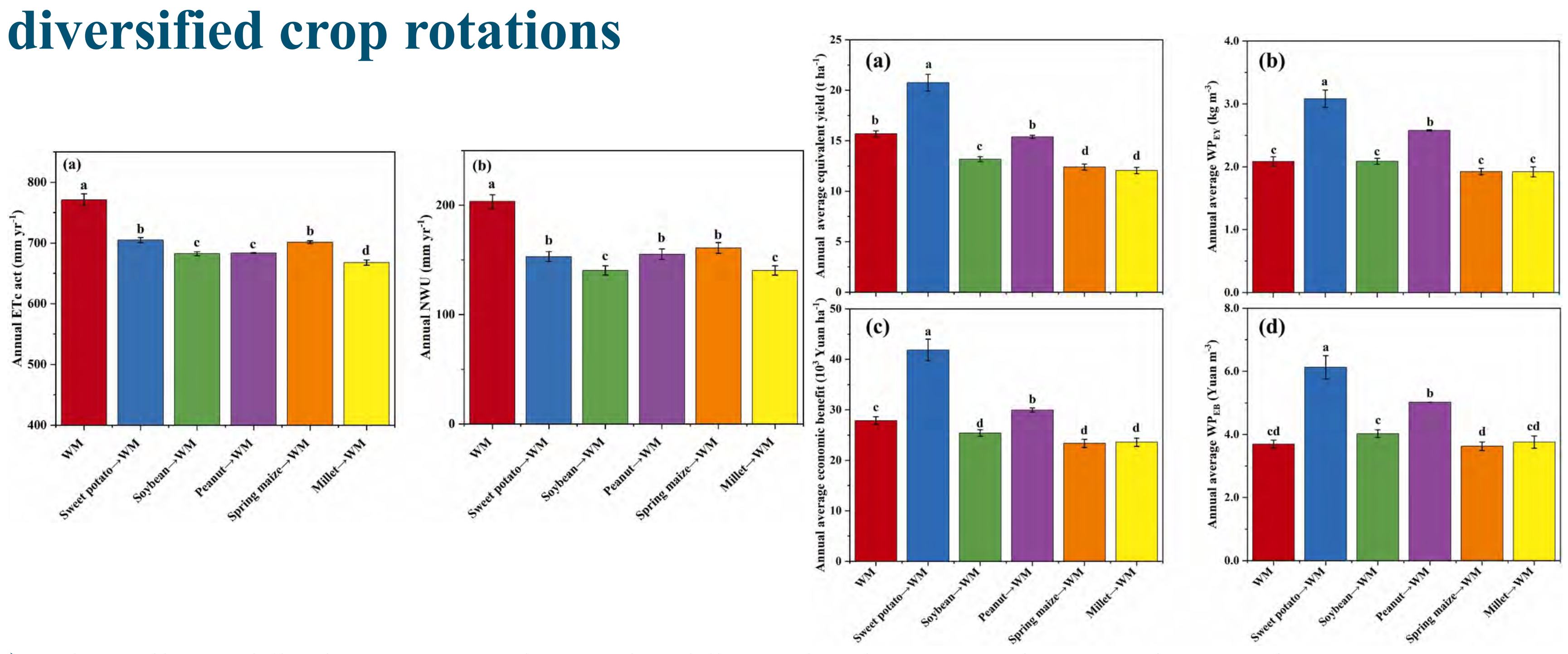
Methods



The experiment had a completely randomized design with three replicates. Each plot measured 6 m × 7 m. The treatments included six different crop rotations.

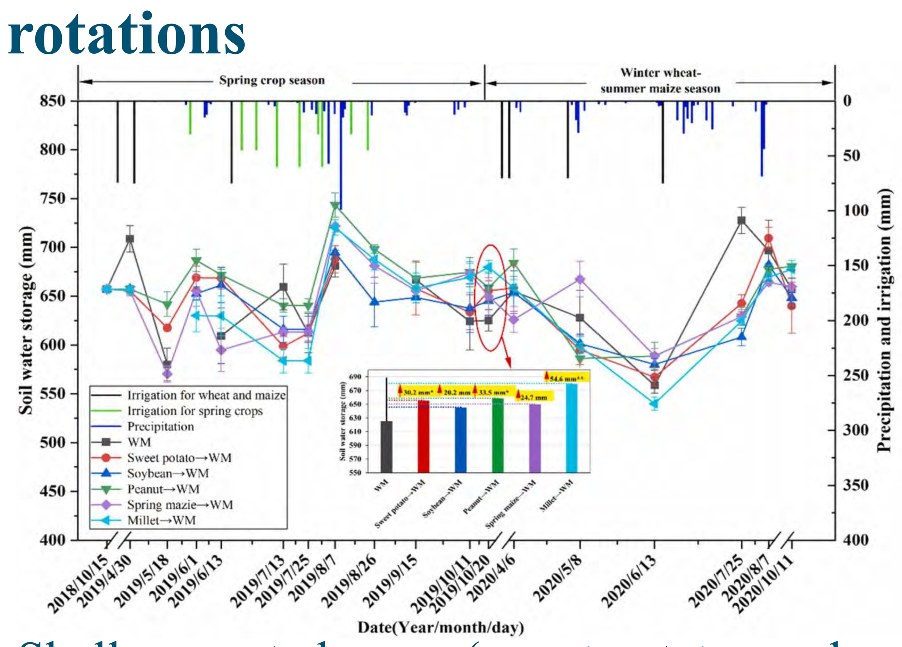
Results

1.Water consumption and annual system outputs of diversified crop rotations



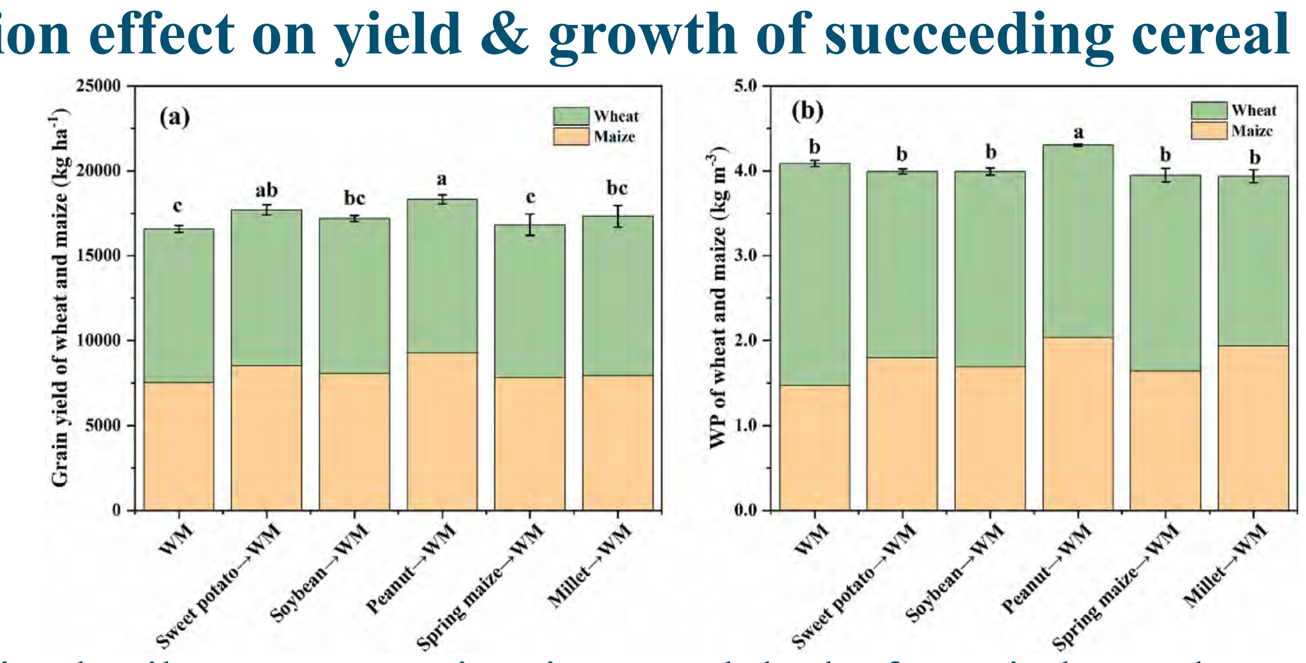
- ➢Five diversified crop rotations significantly decreased annual actual crop evapotranspiration by 7–12% and net groundwater use by 21–31% compared to the conventional WM.
- ➢Sweet potato and peanut-based rotations significantly enhanced annual average equivalent yields up to 32% and economic benefit (+50%, +7%) while improving water productivity by 24–68% compared to WM.

2.Soil water carryover and profile complementary in diversified crop rotations



- ➢ Compared to WM. Shallow-rooted crops (sweet potato, soybean, peanut, and millet) improved soil water storage in the 0–180 cm soil layer at the start of the succeeding wheat planting season by 3–9% as the preceding crop.

3. Rotation effect on yield & growth of succeeding cereal crops



- ➢ This optimal soil water use regime increased the leaf area index and aboveground biomass of the succeeding wheat and maize crops, increasing total grain yields by 4–11%.

Conclusions

Diversified crop rotations enhance crop water use efficiency and subsequent crop yields by introducing shallow-rooted crops into continuous cereal cropping systems. A two-year field experiment with six crop rotations in the NCP demonstrated diversified crop rotations significantly decreased annual ETa and net groundwater use. Shallow-rooted crops rotated deep-rooted crops produced soil moisture complementarity. This complementary allows for the efficient use of deep soil moisture, benefiting the growth of succeeding grain crops.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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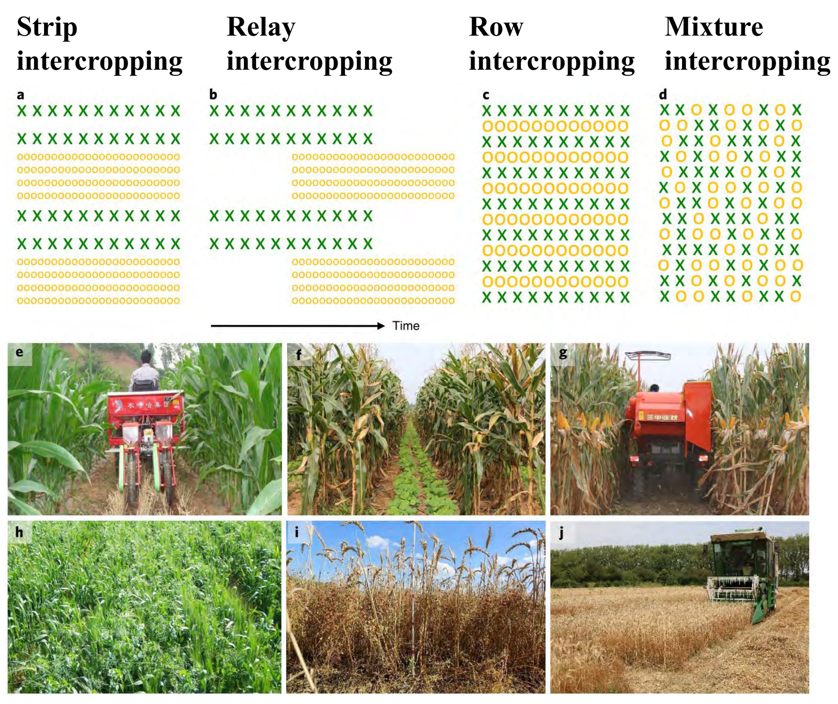
Nitrogen input strategies impact fertilizer nitrogen saving by intercropping: a global meta-analysis

Yalin Liu*, TjeerdJan Stomph, Fusuo Zhang, Chunjie Li, Wopke van der Werf

Background

- Overuse of nitrogen (N) fertilizer in intensive agricultural production results in low N use efficiency and high N surplus.
- Intercropping may play a crucial role in reducing N input while maintaining land productivity.
- The N-saving potential of different functional species groupings in intercrops around the globe remains unexplored.



Objective

Explore how different N input strategies in intercropping experiments have different effects on N saving in different functional group combinations?

Methods

- Meta-analysis
- Key words: intercrop* and (nitrogen or N)
- Database: ISI Web of Science Core Collection (WoSCC) and the China National Knowledge Infrastructure (CNKI) using the CAU library

A global database of fertilizer N input and yield data was built with 600 data records representing the results of 136 independent experiments from 80 publications with four main types of species functional combinations (SFCs): C3-cereal/legume, maize/legume, C4-non-maize/legume and maize/C3-cereal and four main N input strategies in the intercrop and sole crops: (1) zero fertilizer N input (Nic=N1=N2=0), (2) equal fertilizer N input (Nic=N1=N2>0), (3) intermediate fertilizer N input (N1≥Nic≥N2 and N1>N2), and (4) transgressive fertilizer N input (Nic>N1≥N2), where N1, N2 and Nic represent the N input in sole crop 1, sole crop 2 and the intercrop.

Results

The average value of the FNER in the whole database was 1.19 [95% confidence interval (CI): 1.13, 1.26] while the average value of the LER in the whole database was 1.26 [95% CI: 1.21, 1.32], meaning that intercrops saved on average 16% N fertilizer and 21% land to achieve the same production as sole crops. N fertilizer saving with transgressive N input substantially lowered N saving compared to intercrops with equal and intermediate N inputs.

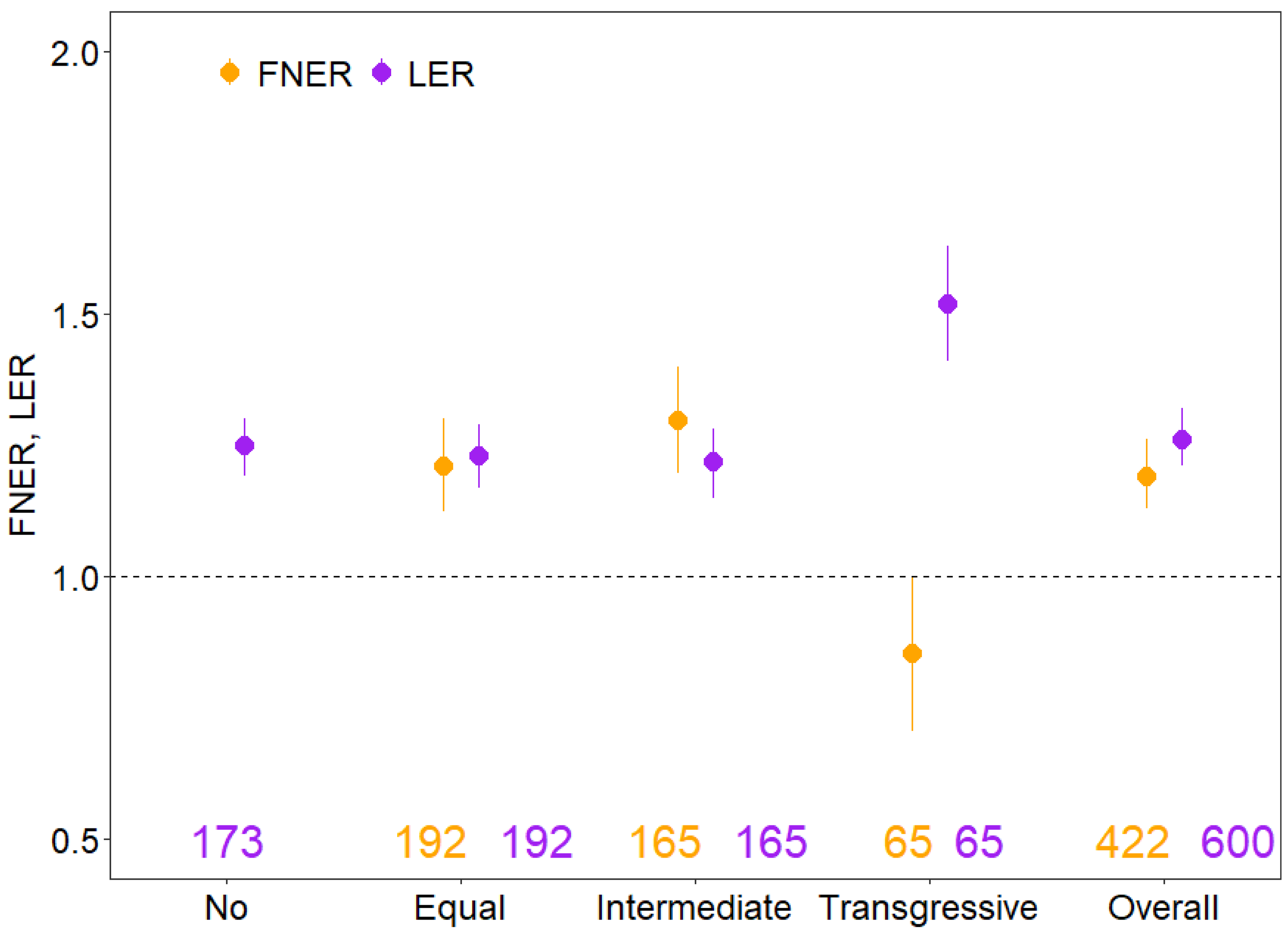


Figure 1 Observed average values of fertilizer N equivalent ratio (FNER) (a) and land equivalent ratio (LER) for different N input strategies (Table 2). Symbols represent estimated means and whiskers show 95% confidence intervals (95% CI). Numbers represent the number of data records for each N input strategy.

With the equal and intermediate N input strategies, higher FNER and LER were obtained in SFCs with a C4 species (maize/legume, C4-non-maize/legume and maize/C3-cereal) than in combinations of a C3-cereal and a legume. The transgressive N input strategy was mostly applied in maize/legume and achieved a LER that far exceeded the FNER.

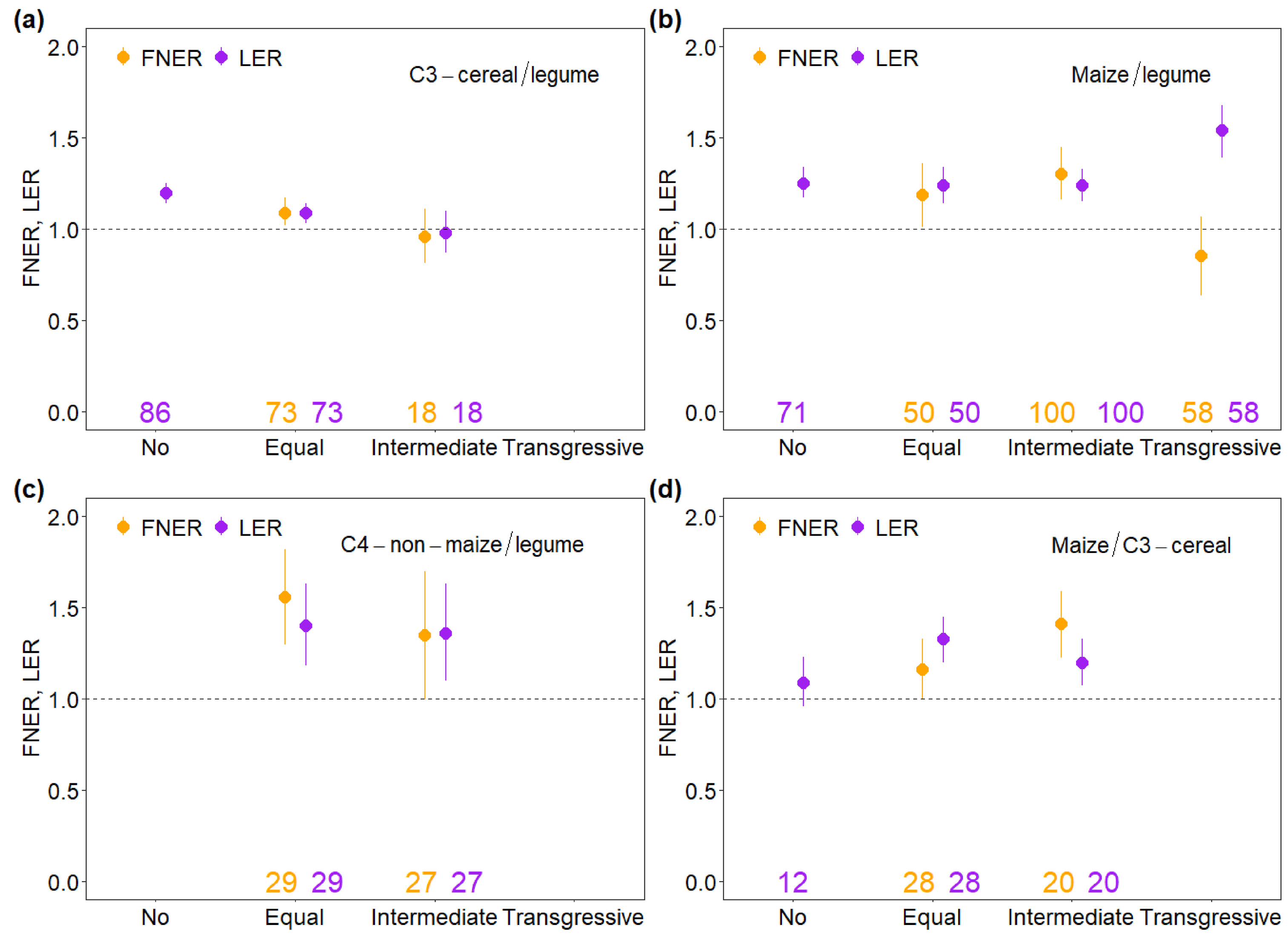


Figure 2 Observed fertilizer N equivalent ratio (FNER) and land equivalent ratio (LER) for four species functional combinations: C3-cereal/legume (a), maize/legume (b), C4-non-maize/legume (c) and maize/C3-cereal (d) for four different N input strategies

This indicates that the balance of FNER compared to LER switched in dependence of the N input strategy from FNER larger than LER when less N is used in the intercrops than the combined sole crops to FNER smaller than LER when more N is used in the mixture than the sole crops.

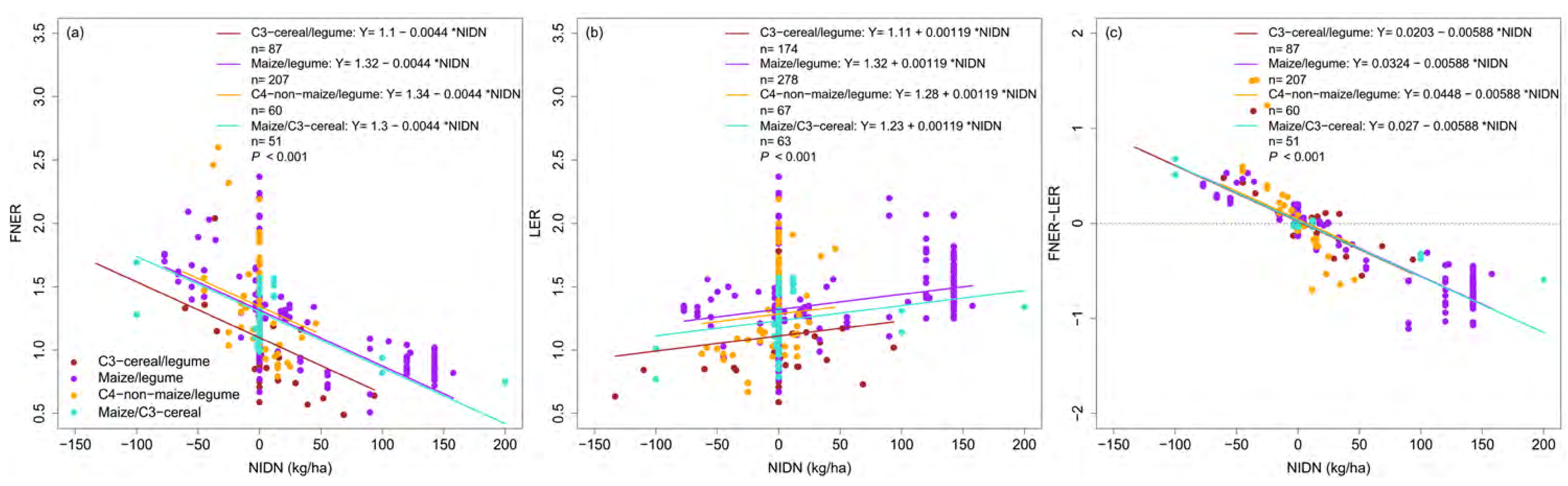


Figure 3 Relationship between fertilizer N equivalent ratio (FNER) and net input difference for N (NIDN), land equivalent ratio (LER) and NIDN, and the difference between FNER and LER and NIDN across SFCs. P-values relate to the slopes of the regressions.

Conclusions

- Intercrops save N as well as land for the same product output.
- Land saving appears the main contributor to N saving regardless of species combinations, but only when N fertilization strategies avoid transgressive N input in intercrops.
- While all species mixtures make more efficient use of N fertilizer and land than their sole crops, maize/legume, C4-non-maize/legume and maize/C3-cereal had larger N fertilizer and land saving than C3-cereal/legume intercrops with equal or intermediate N input, which means the intercrops with C4-cereals (maize and non-maize) are more recommended than C3-cereal/legume intercrops for pursuing high N and land saving.

Acknowledgements

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Overview PhD projects – starting year 2021

Posters, May 2024

Theme: Green and nutritious food provision & governance

Name	Model*	Project
1. Yutong Jiao	1+3	Adjusting China's Agricultural Subsidies to Transform its Agro-food Systems for Better Nutrition and Health

Theme: Green animal production

Name	Model*	Project
2. Yuan Feng	1+3	China's agriculture green development: conceptual framework, quantitative assessment and future policy interventions
3. Haixing Zhang	2+2	China's agriculture green development: conceptual framework, quantitative assessment and future policy interventions
4. Wenqi Lou	2+2	Developing sustainable breeding strategies for dairy cattle in China with emphasis on improved resilience
5. Yuhang Sun	1+3	Exploring pathways towards more sustainable farming systems in the North China Plain from a circular economy perspective
6. Chuanlan Tang	1+3	Exploring pathways towards more sustainable farming systems in the North China Plain from a circular economy perspective
7. Xiaoying Zhang	2+2	Exploring pathways towards more sustainable farming systems in the North China Plain from a circular economy perspective

Theme: Green ecological environment

Name	Model*	Project
8. Weikang Sun	1+3	Assessment of national fertilizer and manure policies in China on farm income, food production, soil quality and environment
9. Ling Zhang	2+2	Assessment of national fertilizer and manure policies in China on farm income, food production, soil quality and environment
10. Rong Cao	1+3	Benefits of large-scale agricultural ammonia emission reduction strategies for air quality, ecosystems and human health
11. Jianan Chen	2+2	Benefits of large-scale agricultural ammonia emission reduction strategies for air quality, ecosystems and human health
12. Yinan Ning	1+3	Quantifying the large-scale impact of agricultural measures on land and water quality using coupled agricultural-hydrological modelling
13. Jichen Zhou	2+2	Quantifying the large-scale impact of agricultural measures on land and water quality using coupled agricultural-hydrological modelling
14. Songtao Mei	1+3	Sustainable management of agricultural chemicals and pathogens for green eco-environment: A systematic modelling approach
15. Hanyue Zhang	1+3	Sustainable management of agricultural chemicals and pathogens for green eco-environment: A systematic modelling approach
16. Mingyu Zhao	2+2	Sustainable management of agricultural chemicals and pathogens for green eco-environment: A systematic modelling approach

Theme: Green plant production

Name	Model*	Project
17. Xueyuan Bai	2+2	China's agriculture green development: conceptual framework,quantitative assessment and future policy interventions
18. Yuze Li	1+3	Deciphering plant-microbiome communication for sustainable crop production
19. Mingxue Sun	2+2	Deciphering plant-microbiome communication for sustainable crop production
20. Yijun Li	1+3	Designing and optimizing sustainable food supply chains for healthy diets in China
21. Xin Zhang	2+2	Designing and optimizing sustainable food supply chains for healthy diets in China
22. Tao Song	2+2	Diversity of intercropping systems across China: tailoring species combinations in intercropping to soils and climates and the future needs of society
23. Mengxue Mao	2+2	Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production
24. Man Pu	1+3	Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production
25. Xiaofan Ma	1+3	The mechanisms of plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction involved in stimulating AM symbiosis and plant performance
26. Zihang Yang	2+2	The mechanisms of plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction involved in stimulating AM symbiosis and plant performance
27. Wenying Huo	1+3	Uncovering how plants discriminate mutualistic microbes
28. Pugang Yu	2+2	Uncovering how plants discriminate mutualistic microbes
29. Zewen Hei	2+2	Understanding and manipulating the rhziobiont to enhance crop productivity and nutrient use efficiency
30. Shunran Hu	1+3	Understanding and manipulating the rhziobiont to enhance crop productivity and nutrient use efficiency

Model*: There are two different types of PhD candidates, hence 2 models.
2+2 model: Graduates at CAU; project starts and ends in China; stays for two consecutive years in Wageningen.
1+3 model: Graduates at WU; project starts in China; stays for three consecutive years in Wageningen.

E-commerce value chain of non-Taobao smallholders in rural China

Yutong Jiao
Agricultue Green Development (AGD) program
Chair group: Development Economics & Marketing and Consumer Behaviour
Supervisors:,dr. Paul T.M. Ingenbleek, dr. ir. MM (Marrit) van de berg, prof. Nico Heerink, prof. Shenggen Fan

Background

E-commerce is viewed as a powerful strategy for rural poverty alleviation and re-organizes resources of smallholders to foster a new value chain in agricultural industry (Chao et al., 2021; FAO, 2016). From 2014 to 2020, there was a notable surge in rural online sales from USD 27.99 billion to USD 278.25 billion, accounting for 15.2% of the total national digital transactions. The growth has consistently increased by around 30% annually since 2015 (CIECC, 2020; Chen et al., 2022). Compared to conventional offline markets, e-commerce eliminates intermediates, enhancing smallholders' bargaining power for direct communication with end consumers (Gao et al., 2018; FAO and ZJU, 2021). In general, this digital channel has positive effects on smallholders' well-being, including increased income, additional market channels, and enhanced employment opportunities. Rural economy can be accordingly improved by e-commerce to anti-poverty and stimulate agricultural production and sales (Li and He, 2024). Therefore, the government increasingly recognizes e-commerce as a pathway to alleviate rural poverty and enhance commercial production of local smallholders. (Chao et al., 2021; Li et al., 2019).

Nevertheless, market participation in the e-commerce market demonstrates uneven patterns among regions in China, leading a widening wealth gap between regions (Li et al., 2021). Market participation concentrates along the eastern coastal areas, fostered by Taobao Villages—an Alibaba project aimed at enhancing the rural economy through the e-commerce channel (Liu et al., 2015). A Taobao Village is defined by having at least 10% of its residents operating online stores or more than 100 live online stores on its e-commerce platform, generating an annual turnover at least RMB 10 million for each joint village (The World Bank, 2020; Qi et al., 2019). This project facilitates smallholders in transitioning from scattered production to clustered sales through the e-commerce channel, reaching nationwide customers. However, since over 90% of existing Taobao Villages are in the eastern coastal areas, it raises uncertainty about whether smallholders from the West and Central regions can benefit from e-commerce (Xu et al., 2017). This underscores the need for attention to address and rectify this imbalance issue (Wei et al., 2019).

So far, numerous current studies on rural development centered around Taobao Villages. Those studies revealed the contributions of Taobao Village to rural development and researched in the aspects of poverty alleviation (Tang et al., 2022), sustainability (Lücke, 2021), technology evolution (Zhou et al., 2021), entrepreneurship (Zang et al., 2023), and migration (Qi et al., 2019), etc. Regarding imbalance regional market participation, researchers attributed this to farmers' technical illiteracy at individual level and deficient infrastructure at villages level. However, rural conditions vary between regions in China, leading complex situation to alleviate poverty of smallholders. This underscores a knowledge gap in understandings beyond current regions and examine the efforts of e-commerce on smallholders there. Whether smallholders exclusively from the Taobao Villages project are equivalent to benefiting from e-commerce is still questionable. Since smallholders primarily make market decisions based on profit maximization, mapping the value chain of e-commerce can address the research gap and provide additional information on smallholders from other regions outside Taobao Village project.

Research objective

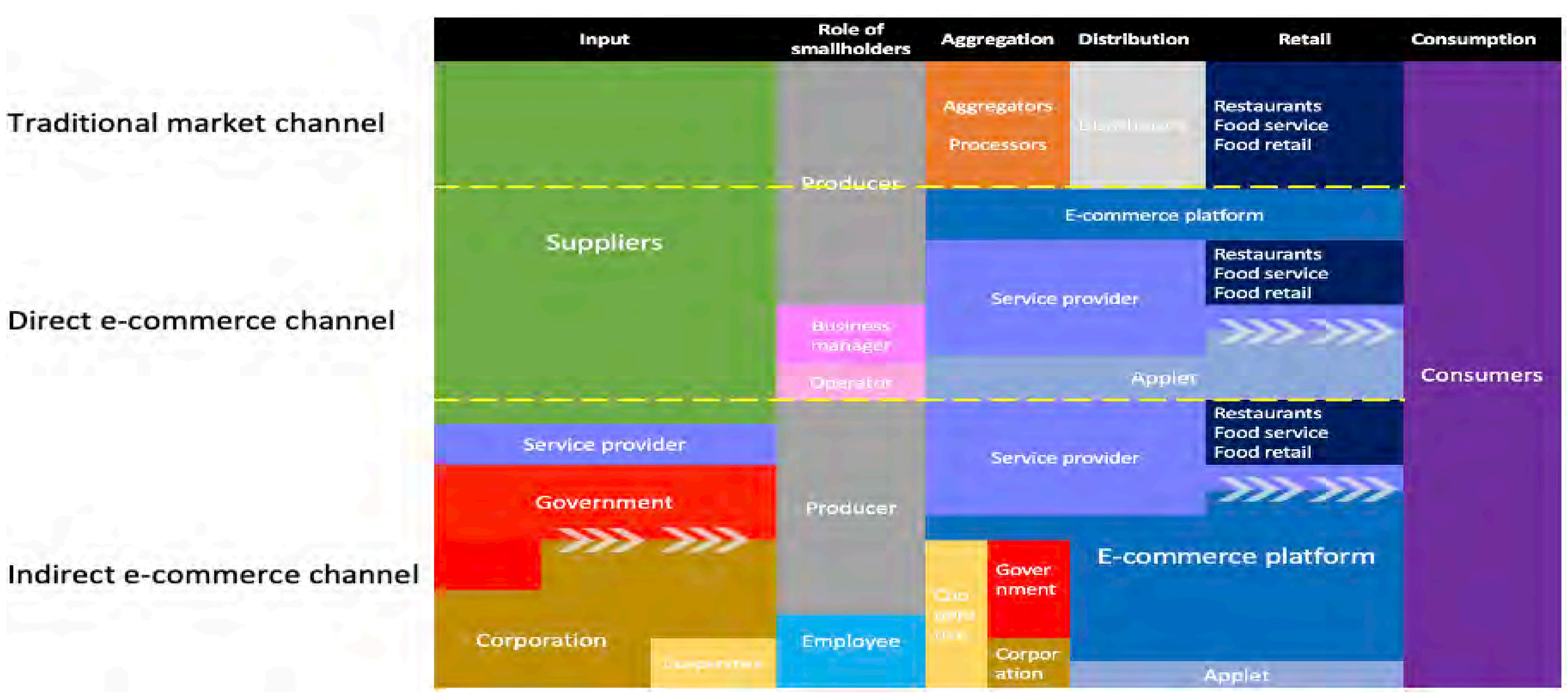
This paper aims to explore the rural e-commerce value chain, focusing on smallholders in non-Taobao villages. The paper presents an exploratory and qualitative study addressing the research question: How does the e-commerce value chain function for non-platform villages in rural China?

Methodology

This paper adopted a qualitative methodology of case study. Two cases were selected from non-Taobao villages in the southern part of China. According to the "China Rural E-Commerce Development (2011-2022)" report, e-commerce sales in Guangdong Province accounted for 12.2% of national agricultural online transactions, while Yunnan Province only contributed 3%. However, in terms of growth rate, Yunnan province ranked among the top five with an annual growth rate of 13.1%, surpassing Guangdong's 10.1% (CIECC, 2022). This suggests potential for developing commercial farming through e-commerce in Yunnan Province. Consequently, one case was selected from the developed southeastern region of Guangdong Province, while the other was chosen from the underdeveloped southwestern area of Yunnan Province.

Result

The interviews of two cases revealed two options for selling agricultural products of smallholders: traditional offline markets and digital online sales. In the traditional offline channel, products are sold through intermediaries such as aggregators, distributors, and food retailers before reaching end consumers. In digital online channels, products are through two methods within rural e-commerce: a direct online channel and an indirect online channel. Figure below illustrates the value chain of the three market channels in rural agribusiness for non-Taobao Villages. The value chain structure of e-commerce channels reveals complexity in networking and role functions among involved stakeholders, surpassing that of the traditional offline channel.



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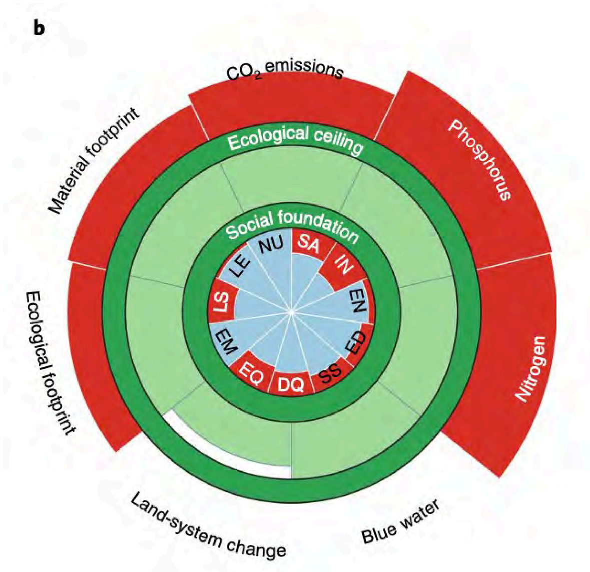
China Agriculture Green Development: conceptual framework and its contribution to global sustainable development

Yuan Feng

CAU Supervisors: Zhu, Qichao, PhD; Hou, Yong, PhD; Zhang, Fusuo, PhD

WUR Supervisors: Hans-Peter Weikard, PhD; Xueqin Zhu, PhD

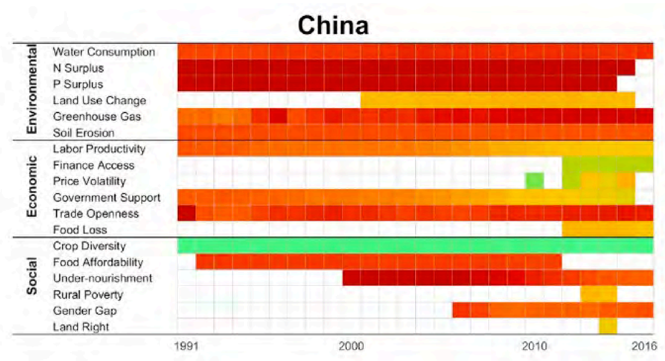
Background



Global performance relative to the biophysical boundaries and social thresholds (2015) (Fanning et al. Nature sustainability, 2021)

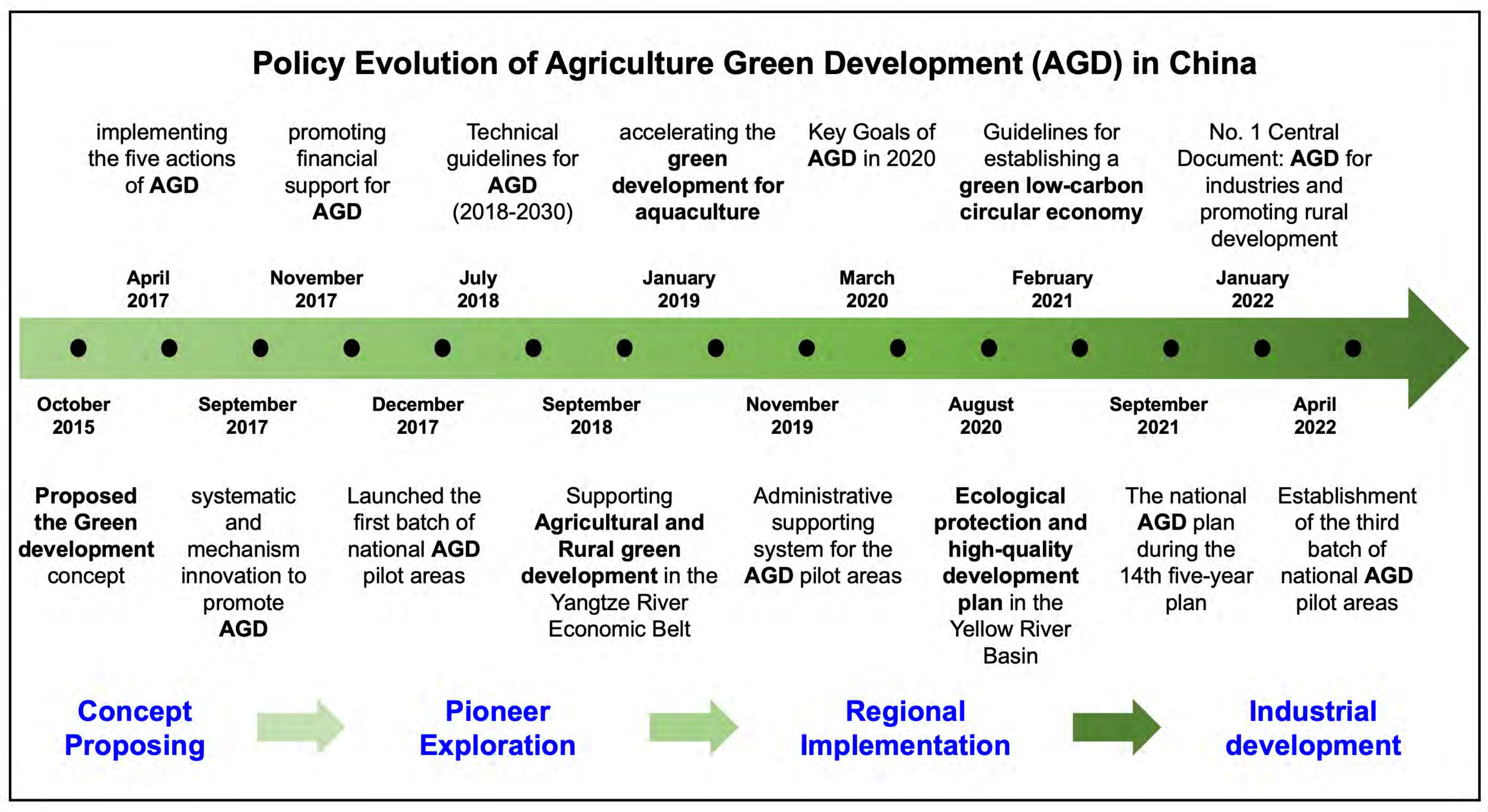
Global sustainability is facing a double burden of social wellness and environmental pollution. Agriculture is essential to many social goals and environmental boundaries such as Nitrogen, Phosphorus, Carbon, and Ecological footprint.

Sachs et al., SDG Index and Dashboards Reports, 2021



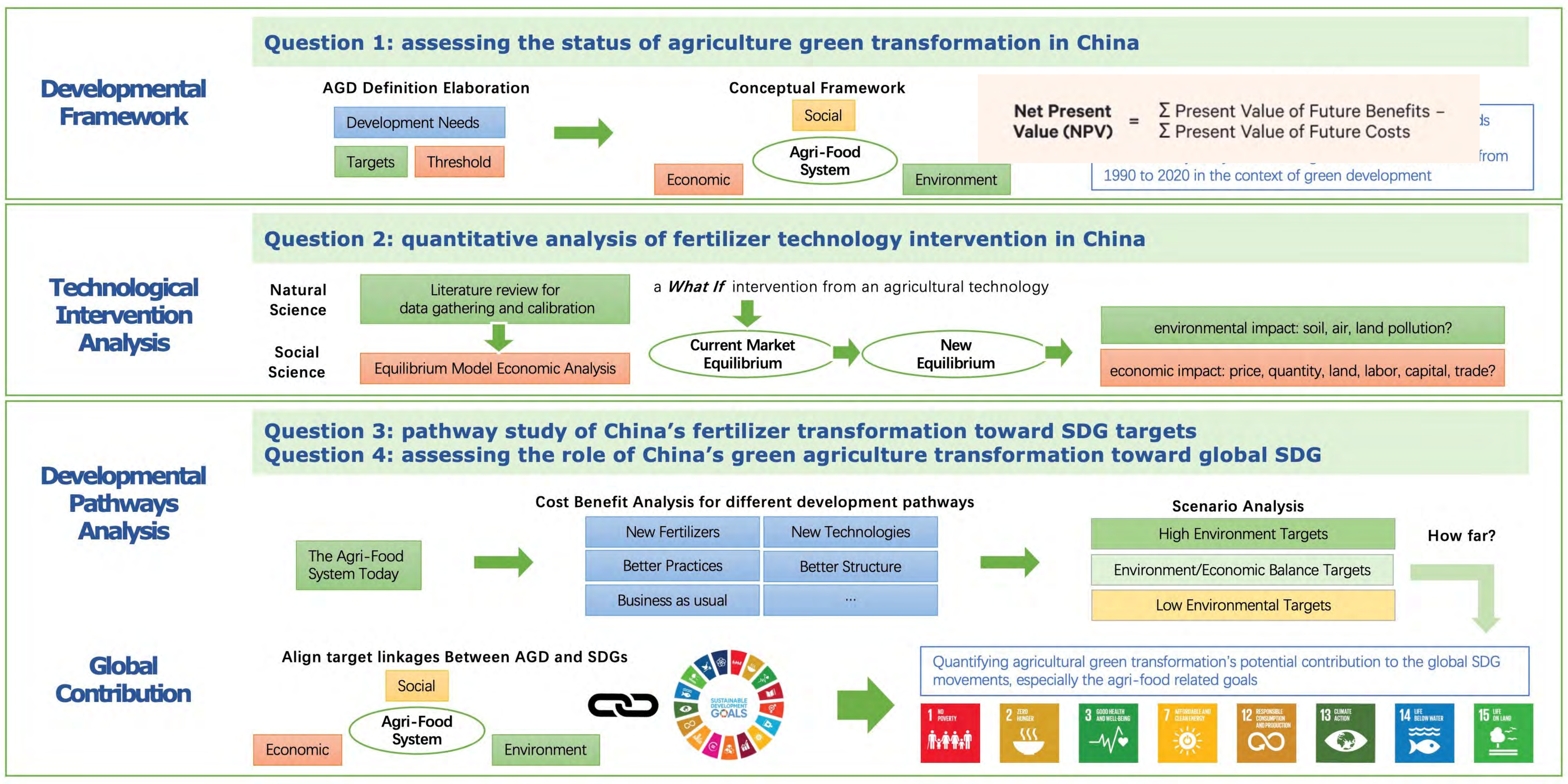
Zhang et al., One Earth, 2020

Studies showed that China's overall performance on UN SDGs increased over time. However, neither the SDGs nor agricultural sustainability have developed synergetically – that the socio-economic development is not aligned with environmental development.



In 2016, the Chinese government promoted Agriculture Green Development (AGD) as a national strategy for agriculture, aiming to increase resource use efficiency, decrease agricultural non-point source pollutants, and encourage rural revitalization.

Scientific objectives and research design



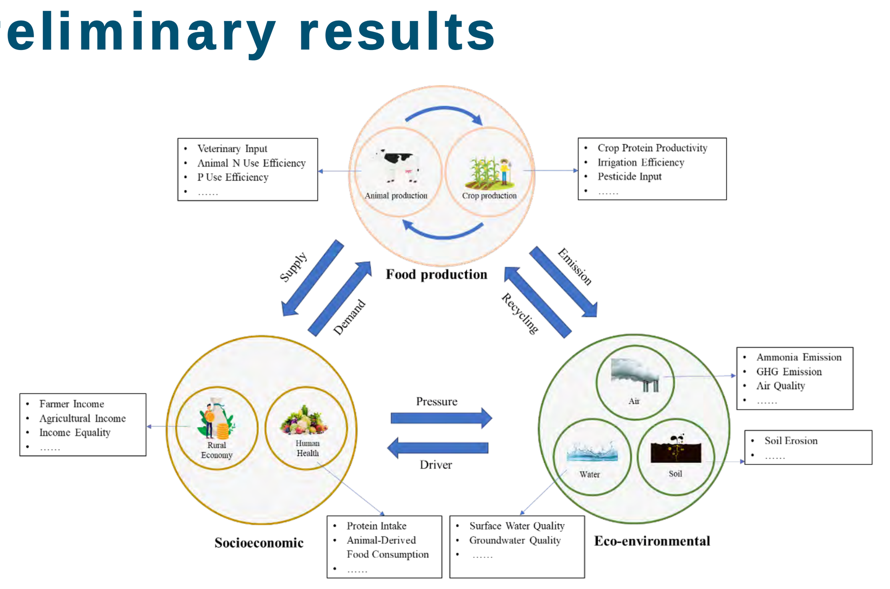
First, the project aims to establish a comprehensive evaluation framework for assessing China's agricultural transformation towards green development from 1990 to 2020. It draws on concepts like planetary boundaries and integrates social dimensions to construct a national-level assessment tool in order to identify sustainability gaps compared to global benchmarks.

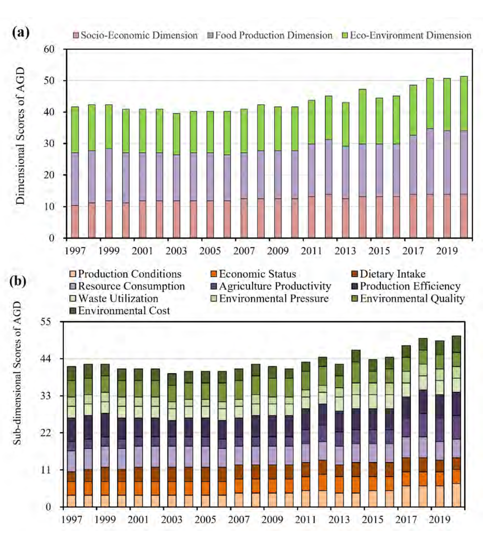
Second, on the project aims at quantitatively assessing the impacts of improvements through green agricultural technology, such as fertilizer inhibitors, on China's agricultural sector using an applied general equilibrium model. The goal is to simulate the economic and environmental outcomes of widespread inhibitor application, offering insights for policy and technology adoption.

Third, the project aims to assess China's fertilizer pathways towards achieving Sustainable Development Goals (SDGs) using optimal control theory and the Net Present Value (NPV) framework. By setting key temporal milestones, this analysis explores economic and environmental trade-offs of different technological pathways. The study aims to identify strategies that align with both SDG food production and environmental goals.

The final aim is to evaluate AGD's contribution to UN SDGs. This chapter relates SDG goals (specified in a total of 169 targets) to the impacts of AGD. Specific attention is given to synergies and trade-offs.

Preliminary results





We first conceptualized a flow framework that depicts the relationship of our agri-food system with food production, socio-economic outcome, and environmental impact.

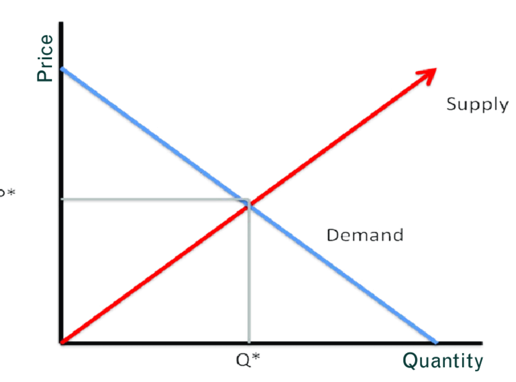
Indicator evaluation: A **target-threshold** indicator evaluation system is proposed to measure China's agriculture transformation, for the areas of: **Social**: agri-food system's impact on human society, such as income, nutrition, health, etc.; **Environmental**: environmental impact from food production, especially land, air, and soil related indicators; **Food production**: key productivity indicators along the agriculture industry chain.

Results:

1. China is currently at a medium level in the Agriculture Green Development initiative
2. There was a trend for increasing development scores for 2010-2020 compared to 1997-2010
3. Trade-offs between eco-environmental factors and socioeconomic/food production factors were found to be the major barriers to the transformation
4. More effort is needed to address the insufficient and uneven development to provide coordinated improvement

Methodology basis for future chapters

General Equilibrium Theories



General equilibrium theory attempts to explain supply, demand, and prices in a whole economy with several or many interacting markets, aiming for an overall state where supply equals demand in all markets simultaneously

Welfare Maximization

$$W^* \doteq \max_{s,\mu} \sum_{i=0}^{\infty} \frac{U(C(i), L(i))}{(1+\rho)^{\Delta i}}$$

subject to

$$(CLI) - (EI), (3) - (4)$$

$$\mu(i), s(i) \in [0,1], \forall i \in \mathbb{N},$$

(DICE model as an example for welfare maximization)

Welfare maximization in economics refers to the optimal allocation of resources to maximize the overall well-being or utility of society, ensuring that the sum of individual utilities is as high as possible

Cost Benefit Analysis

Net Present Value (NPV) = Σ Present Value of Future Benefits – Σ Present Value of Future Costs

$$NPV_p = \sum_{i=0}^{t} \frac{(B-C)_t}{(1+r)^t}$$

Cost-Benefit Analysis (CBA) involves comparing the total expected costs and benefits of a decision, using Net Present Value (NPV) to determine the profitability by discounting future cash flows to their present value

Acknowledgements

We gratefully acknowledge the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University.

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Assessment System and Pathway Analysis for the Sustainability of Agricultural Food Systems Based on Sustainable Development Goals in China

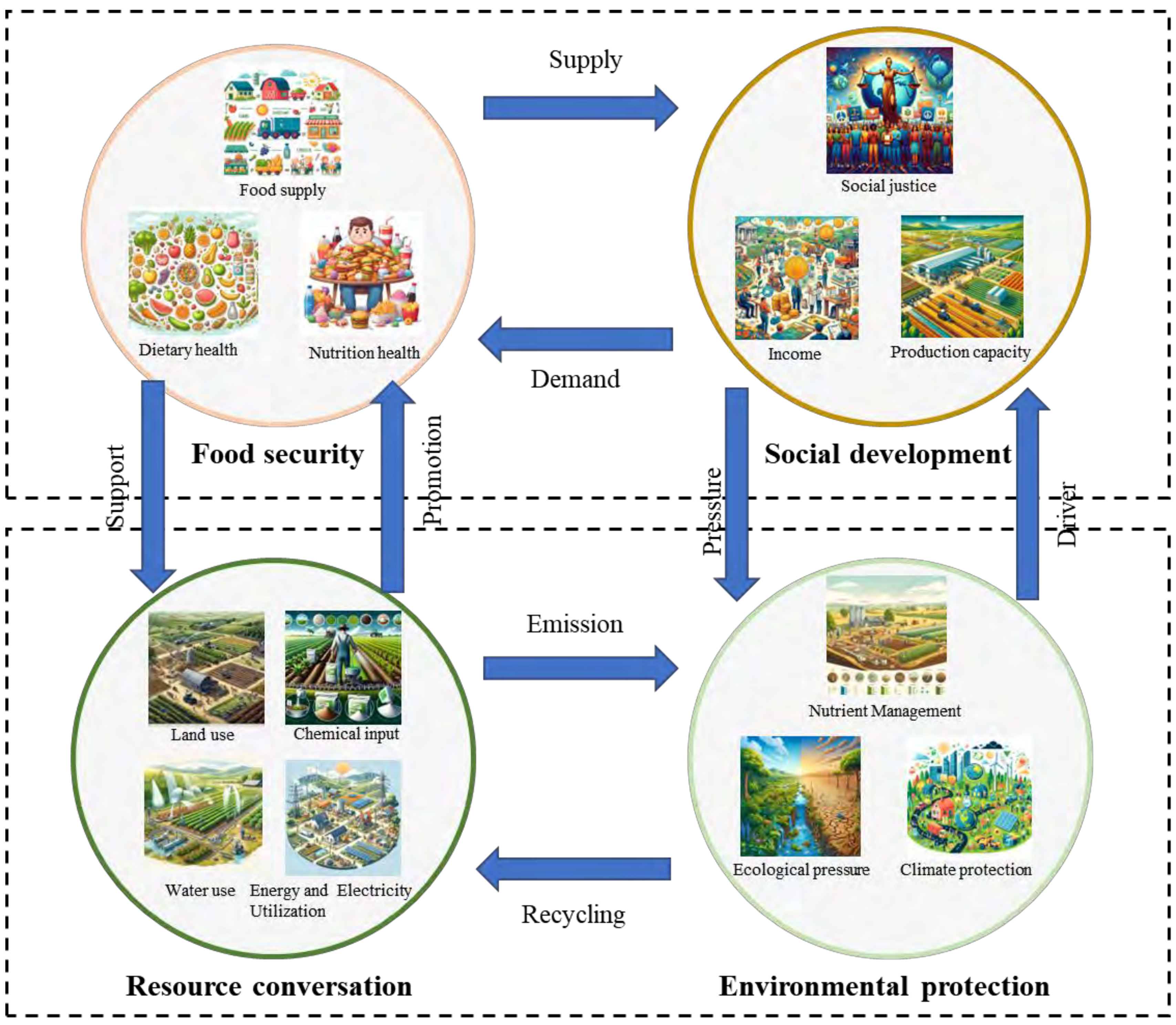
PhD candidate: Haixing Zhang

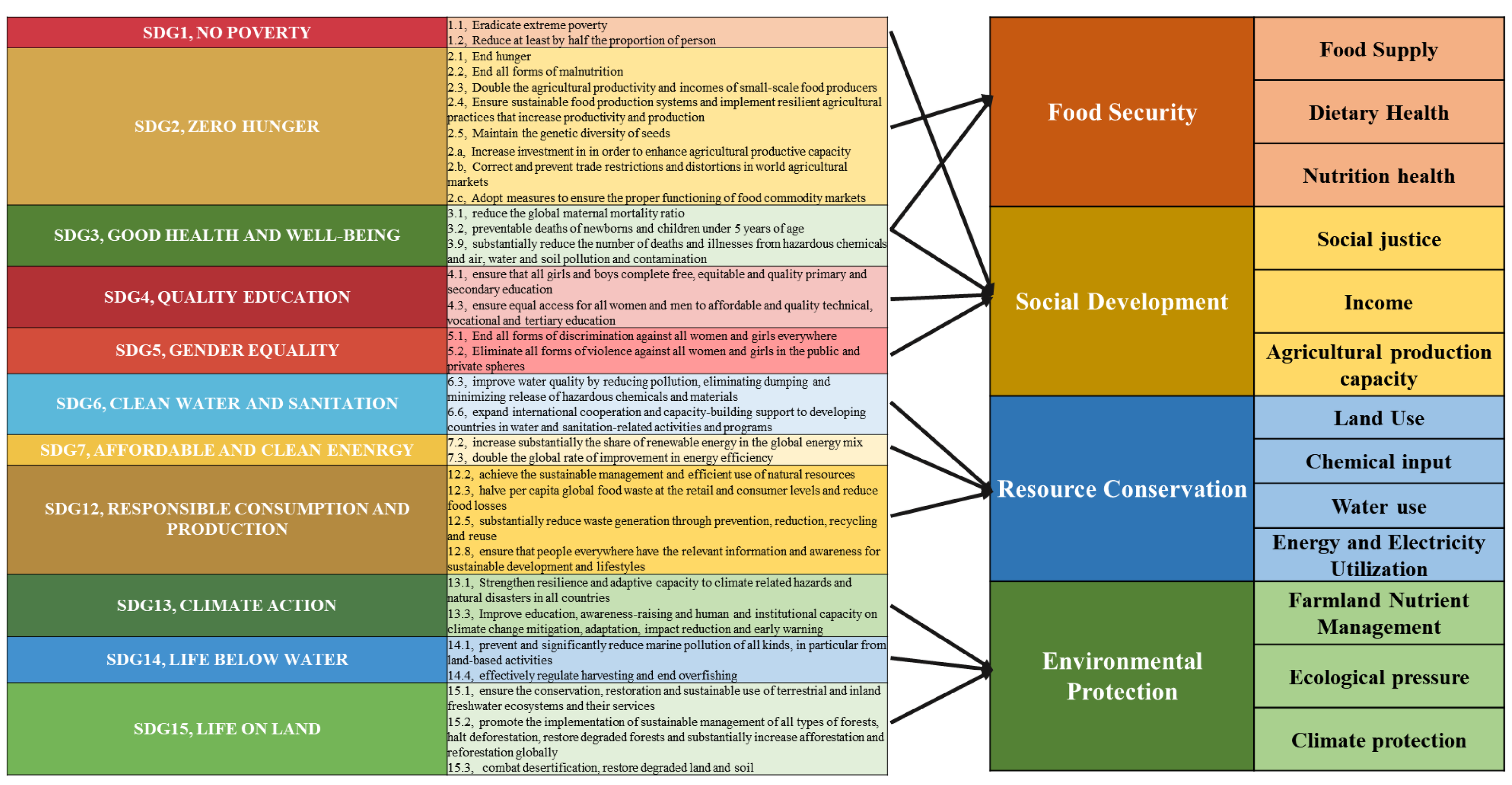
Supervisors: Qichao Zhu, Yong Hou, Fusuo Zhang, Xueqin Zhu , Hans-Peter Weikard

Background

- Agricultural food systems, key to the global food supply, face major sustainability challenges such as resource overuse, climate impacts, and social and economic inequalities. Issues like land erosion, water scarcity, and extreme weather directly threaten agricultural production, while global disparities in resource distribution further weaken sustainability.
- This study develops a sustainability evaluation system for agricultural food systems based on the SDGs to assess their sustainability. This is crucial for improving system resilience, reducing environmental emissions, and achieving sustainable development.

System framework and the indicator system





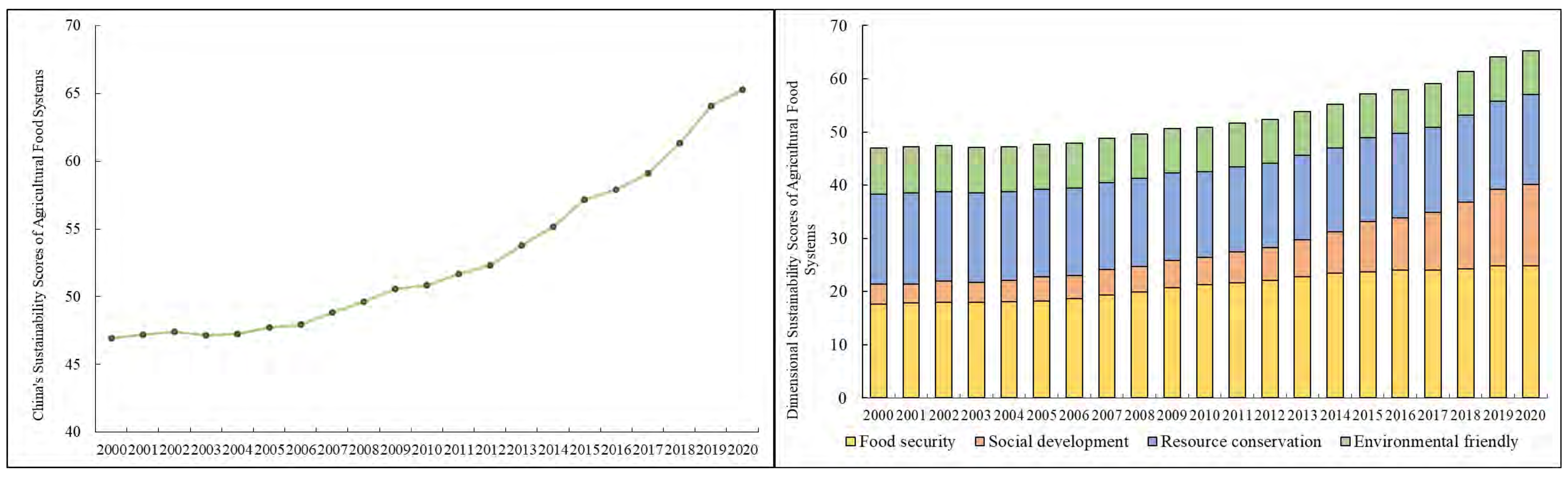
Mainly analysis methods

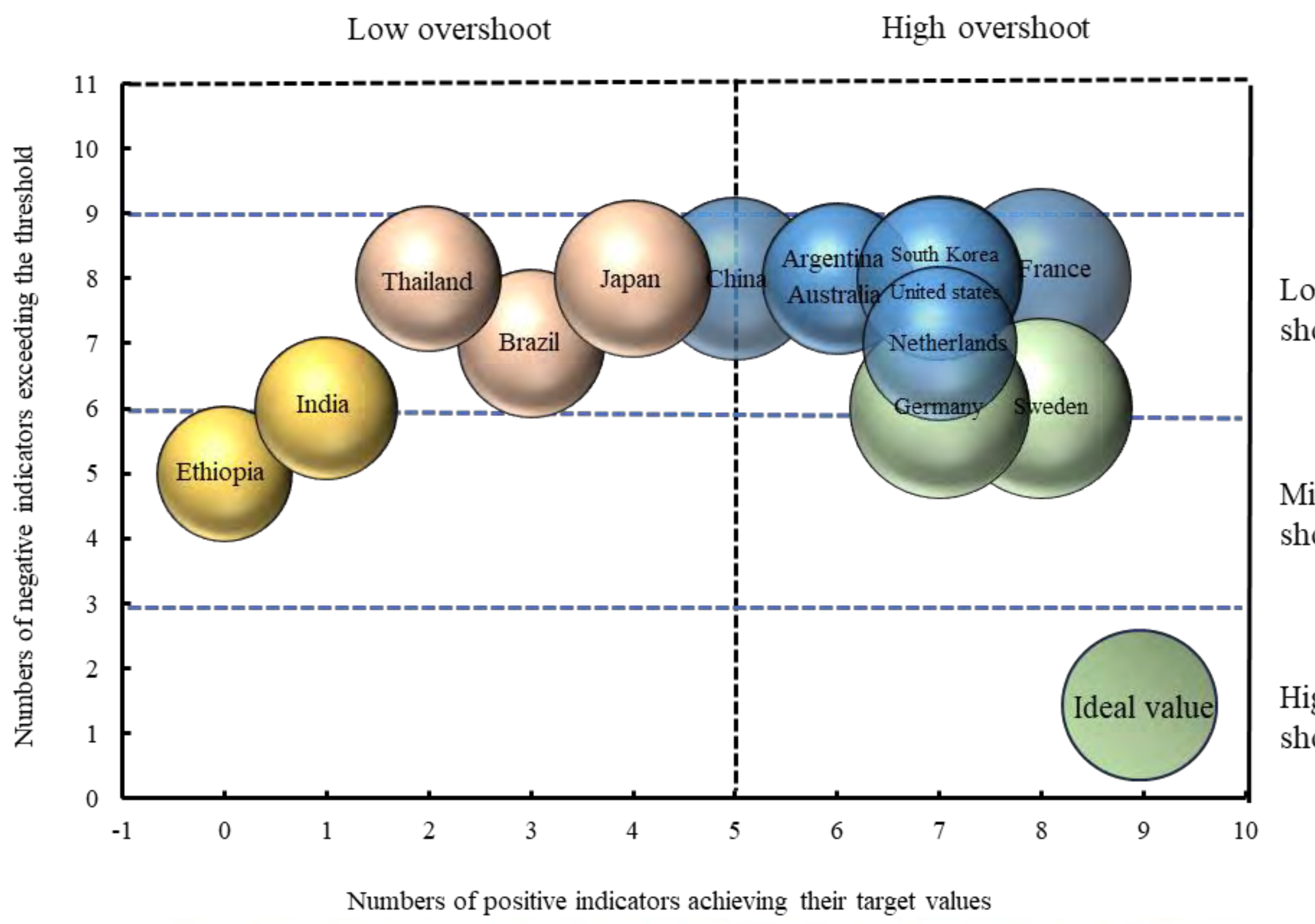
- Target value method
- Coupling coordination degree model
- Spearman correlation coefficient analysis
- Network analysis

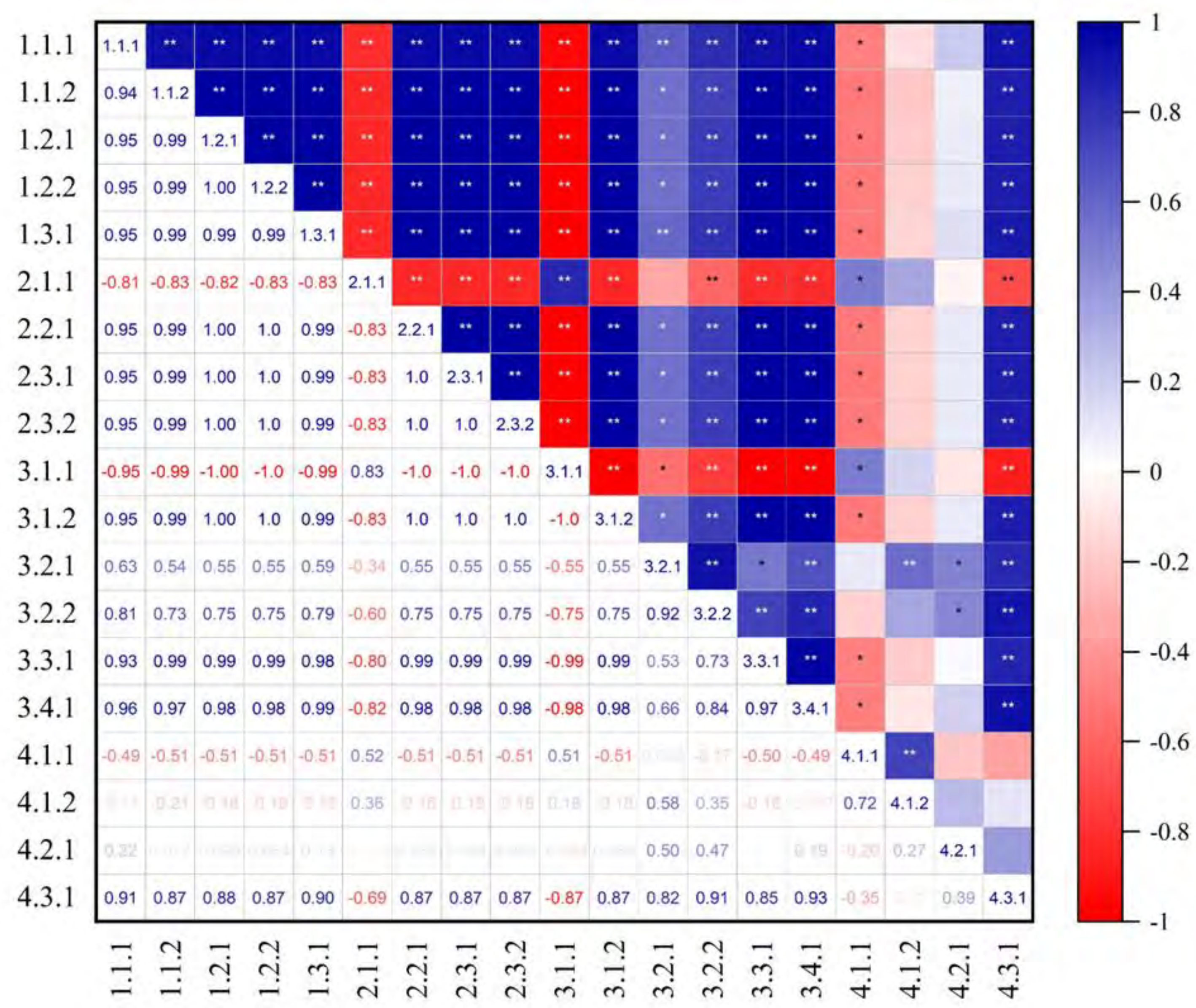
Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

Results







* p<=0.05 ** p<=0.01 **The spearman analysis between the indicators**

- From 2000 to 2020, China's agricultural food systems sustainability score showed an increasing trend, but the transformation of China's agricultural food systems can be divided into two stages. From 2000-2006 and 2006-2020.
- From the perspective of dimensions, the primary reasons for the significant improvement in the sustainability score of agricultural food systems are enhancements in the dimensions of food production and social development.
- From 2000 to 2020, more countries reached their targets for positive indicators, but the number of negative indicators exceeding thresholds also rose. Developed nations generally achieved more positive and exceeded more negative thresholds.
- Food production exhibits a good synergistic relationship with social prosperity and Resource conservation. And the dimension of social prosperity and Resource conservation also in synergy. But the Environmental Friendly does not show a good relationship with other dimensions.

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Can daily rumination time be used to breed for resilient Holstein cows?

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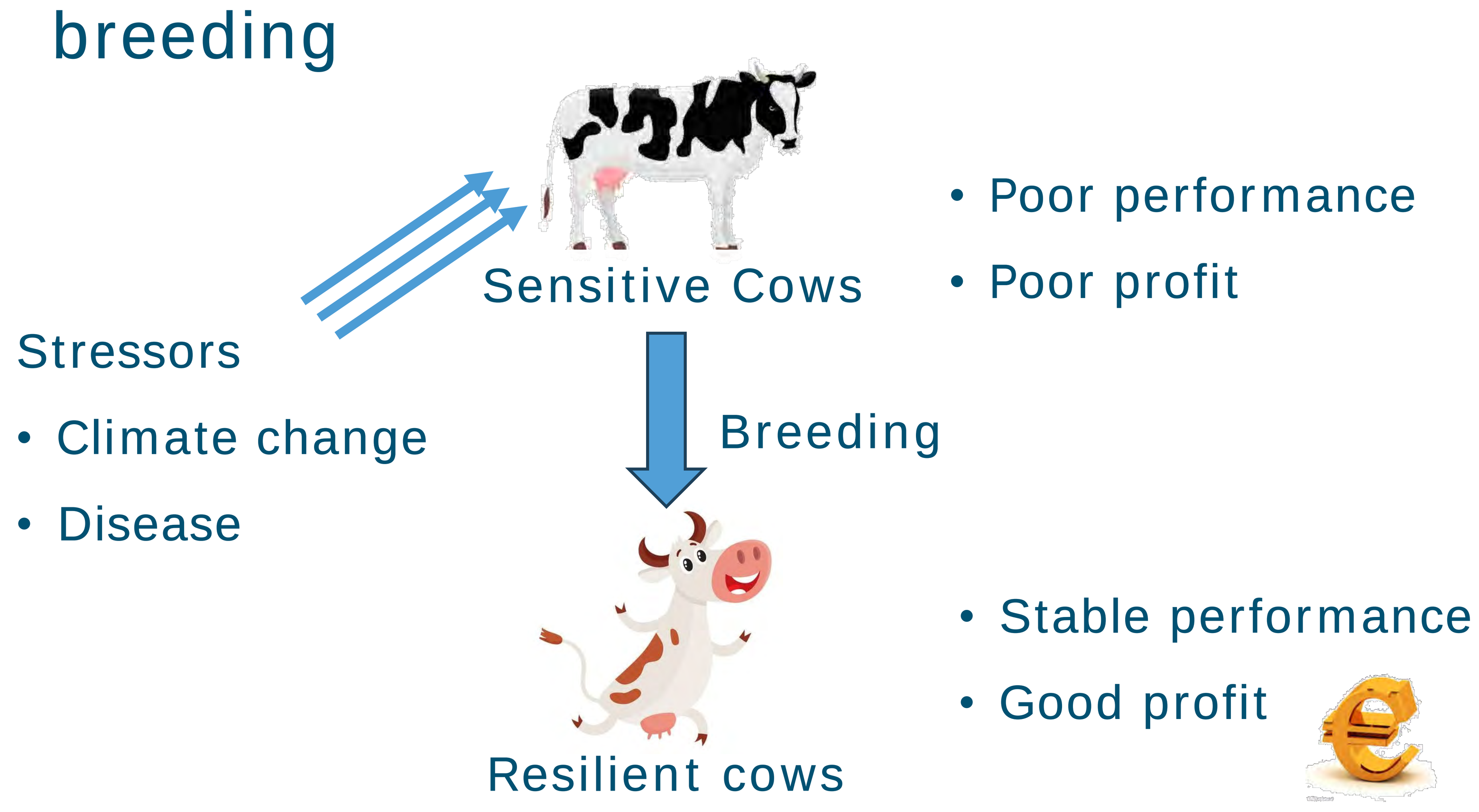
Background

- Resilient cows are less affected by stressors
- Resilience could be improved by selective breeding

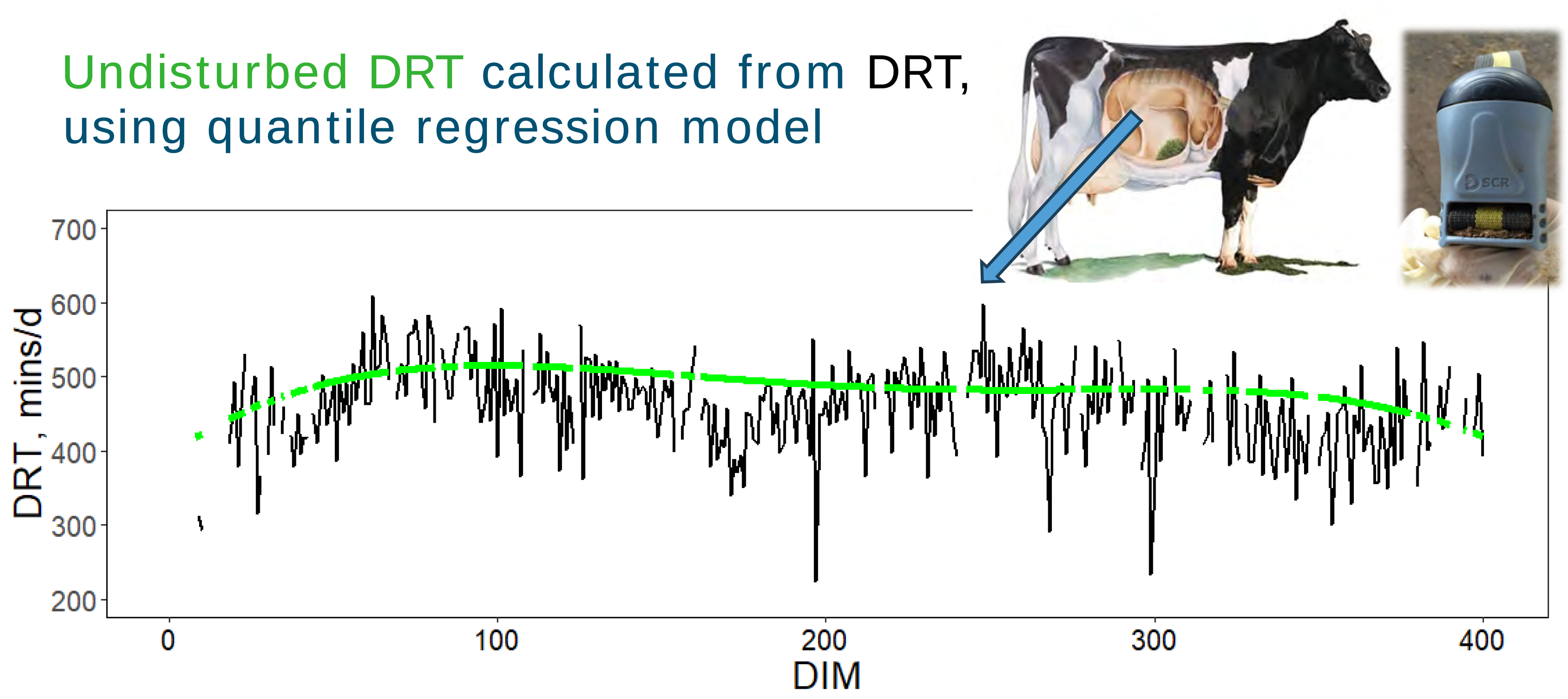


Objective

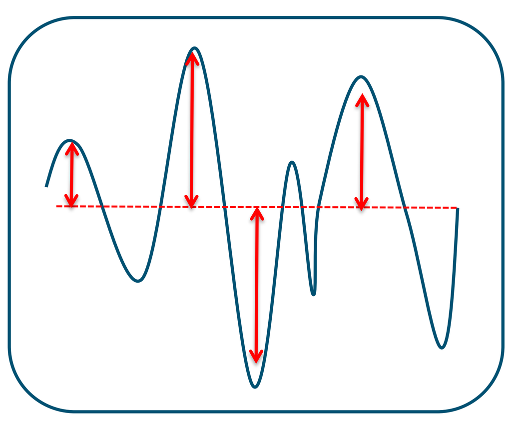
Access whether daily rumination time (DRT) can be used to breed for resilient Holstein cows

Methods

- Calculate undisturbed DRT patterns of ~6,000 Holstein cows



- Define resilience indicators



✓ Variance of deviations (LnVar)
✓ Autocorrelation of deviations (Autocorr)
✓ Resilience: low LnVar and autocorr

- Genetic analysis
  - Univariate repeatability animal model
  - Uni- and bivariate animal models

Conclusions

Resilience indicators derived from DRT patterns

- are heritable traits
- have favorable genetic correlations with functional traits
- can be used to breed more resilient cows with better health and fertility

Results

1. Genetic parameters

✓ Moderate heritability and repeatability of DRT, LnVar and Autocorr

Traits	Heritability (SE)	Repeatability
DRT	0.21	0.41
Undisturbed DRT	0.40	0.76
LnVar	0.23	0.44
Autocorr	0.10	0.14

2. Genetic correlations

✓ Favorable genetic correlations with body condition score, disease frequency and fertility
✓ Autocorr has higher correlations with functional traits than LnVar, except for insemination frequency

Traits	LnVar	Autocorr
Calving ease	0.04	0.39
Interval from calving to first insemination	0.02	0.33
Insemination frequency	0.19	0.08
Body condition score	-0.09	-0.25
Disease frequency	0.10	0.15

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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A typology of farms and spatial patterns in the North China Plain to support crop-livestock integration

Yuhang Sun, Antonius G. T. Schut, Yong Hou, Martin K. van Ittersum

Backgroung

- In China, agriculture has intensified and specialised. In this process, crop and livestock production have been decoupled at household level. While the benefits of integrated crop-livestock systems (ICLS) have been widely discussed, their application remains limited.
- ICLS-studies predominantly focused on regions neglecting the farm level and also other stakeholders. They did not provide specific strategies tailored to particular regions. It is crucial to include the farm level, as key decision-making units, to understand drivers of specialisation in a regional analysis. There is a considerable heterogeneity across or within counties in terms of farm structure, management practices, farm assets, farm diversity and environmental characteristics. Quantifying the diversity of farming systems, their spatial distribution and farmers' characteristics is an essential step towards effective policies that enable ICLS.

Objectives

- Capture the diversity of farms by using farm-level data. We introduce a farm typology that is spatially explicit, data-driven, and oriented towards local farmers.
- Quantify regional farm diversity and map the distribution of identified farm types over the study area.
- Discuss how identifying farm types and their distribution may help to contextualize future ICLS designs to local conditions and how these findings can support agricultural transition policies in the North China Plain (NCP).

Key Results 1

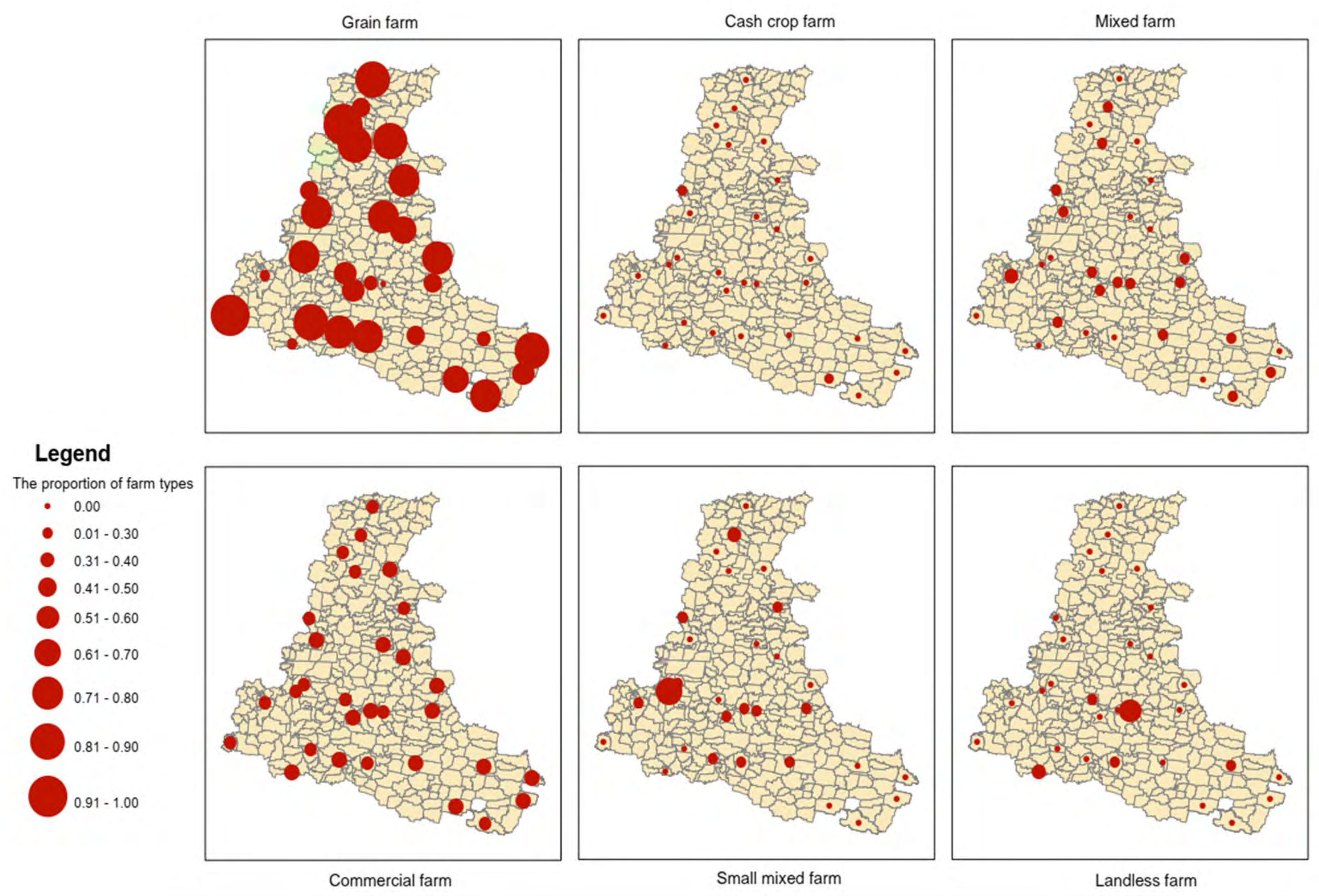

Fig.2 The proportion of farm types in sampled villages

- Grain farms were nearly evenly spread across the county and emerged as the dominant type in most surveyed villages, with proportions ranging from 0.3 to 1.0 (Figure 2). Cash crop farms were also evenly distributed but with much lower proportions, generally less than 0.2. Small mixed farms were concentrated in a few locations in the centre and north part of the county, with shares reaching up to 0.7. Landless farms featured mostly in the south in a few locations.
- The farm types were not evenly distributed across the region, indicating regional specialisation with a spatial decoupling of crop and livestock production.
- Using hierarchical cluster analysis, we identified six distinct farm types (Table 1) characterized by the degree of specialization, management, and farm size --- grain (66%), cash crop(2.7%), mixed (11%), commercial (7.3%), small mixed (8.3%), and landless farms (4.7%)
- Three features in these types were identified as being relevant in the context of ICLS, i.e. overuse of fertilizer, the decoupling of crop and livestock production and a strong dependence of specialized livestock farms on feed import (Table 2).

Conclusions

- Six major farm types featured in Quzhou county: grain, cash crop, mixed, commercial, small mixed, and landless farms. The farm types were not evenly distributed across the region, indicating regional specialisation with a spatial decoupling of crop and livestock production.
- Farm management strategies were suboptimal with an overuse of chemical fertilizer, a low proportion of recycled manure that is used on cropland, and a strong dependency of specialised livestock farms on feed imports.
- Our study suggests that in designing ICLS, having a balanced ratio of crop areas and livestock counts, as well as the number of crop and livestock farms and ensuring their even spatial distribution within the region are essential to efficiently recycle nutrients and enhance regional agricultural circularity.
- Driven by the Chinese dietary shift towards more animal-based products, the number and scale of livestock farms will likely increase. To minimize disruptions of circularity, the location of livestock farms matters as the capacity of surrounding croplands to produce feed and utilize manure is critical.
- We conclude that new guiding policies are needed to coordinate specialisation and facilitate ICLS to ensure a proper animal-to-cropland ratio at local level. This study can further complement model-based explorations to design, incentivize and develop locally adapted ICLS.

Materials and methods

- The case study focused on Quzhou county, located in the central part of the North China Plain (Figure 1 a-b). To establish a representative sample of farms from Quzhou county, a random selection process was employed using ArcGIS 10.8.
- Three villages from each of the ten townships were randomly chosen (Figure 1 c). Within each selected village, ten farm households were randomly chosen for the survey. In total, there were 300 households surveyed.
- We first developed a farm typology, based on farm-structure related variables. In a second step, we incorporated new stratifying variables related to farming practices and socio-economic information to further refine and categorize the initial farm typology, providing a more comprehensive understanding of the identified farm types. Finally, we used ArcGIS10.8 to map the distribution of each types.

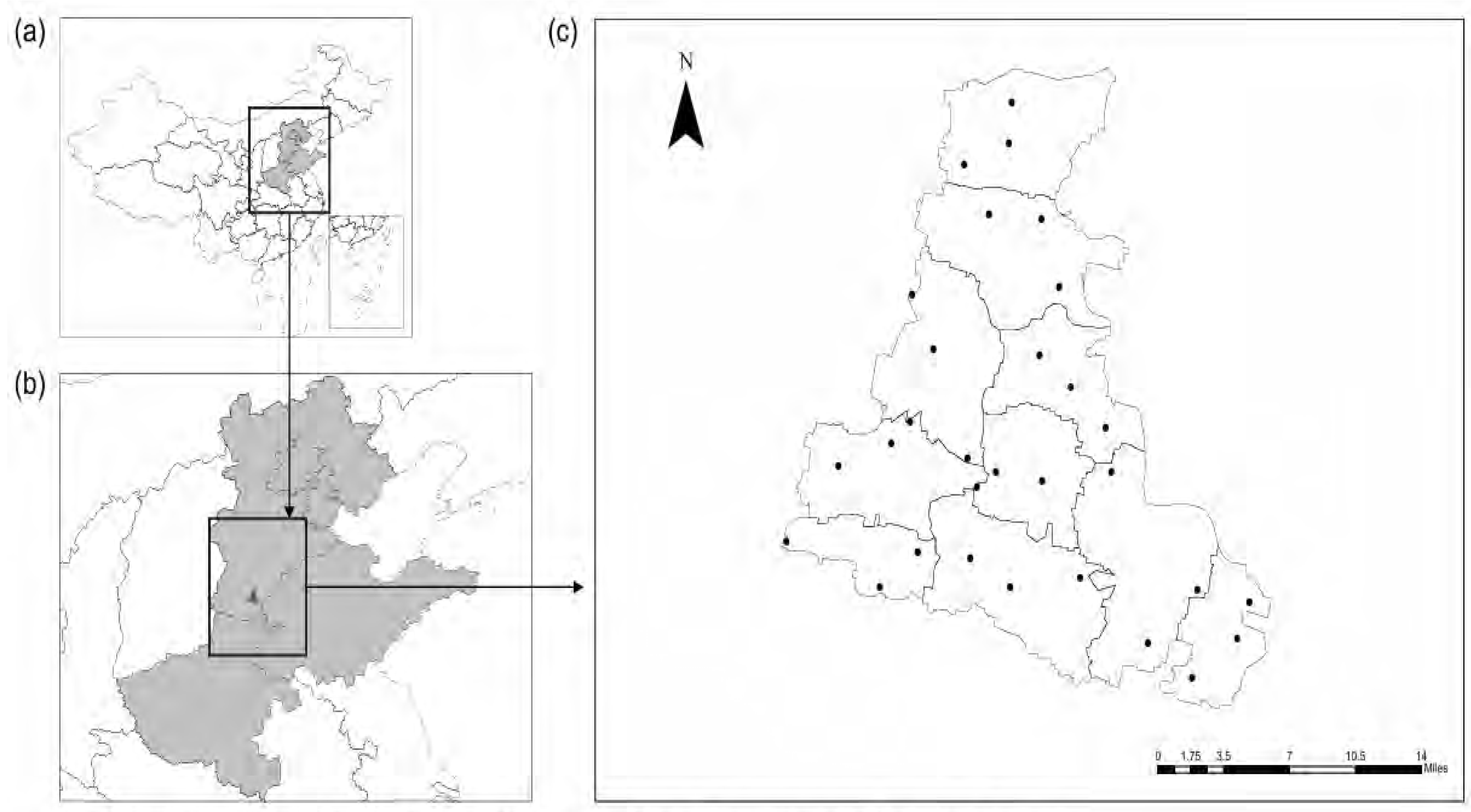

Fig.1 Geographic location of North China Plain (a), Quzhou county (b) and villages (c) randomly selected for farm survey.

Key results 2

Table 1. Means of selected structural and socio-economic variables for each farm type, the percentage of farms producing poultry, pigs, or beef cattle and percentage of farmers whose income completely depends on farming within each farm type.

	Farm type					
	Grain	Cash crop	Mixed	Commercial	Small mixed	Landless
The number of farms[1]	198	8	33	22	25	14
Percentage of farms (%)[1]	66.0	2.7	11.0	7.3	8.3	4.7
Farm-structure variables						
Mean number of fields[1]	4.0^{b}	2.6^{ab}	3.3^{ab}	5.0^{c}	2.5^{a}	-
Mean total land area (ha)[1]	0.8^{b}	0.3^{a}	0.8^{b}	1.3^{c}	0.8^{b}	-
Mean area with grain (%)[1]	99.0^{c}	0.2^{a}	92.7^{b}	48.0^{a}	100.0^{c}	-
Mean area with cash crops (%)[1]	2.2^{a}	64.6^{b}	4.3^{a}	52.7^{b}	0.0^{a}	-
Mean livestock units[1]	-	-	152.6^{b}	-	30.8^{a}	383.4^{c}
Farms producing poultry (%)[2]	-	-	100.0^{b}	-	0.0^{a}	92.9^{b}
Farms producing pig (%)[2]	-	-	0.0^{a}	-	68.0^{b}	7.1^{a}
Farms producing beef (%)[2]	-	-	0.0^{a}	-	32.0^{b}	0.0^{a}
Socio-economic variables						
Number of years of education[1]	7.1^{a}	7.1^{a}	8.6^{b}	7.2^{a}	8.8^{b}	8.8^{b}
Family size (persons)[1]	4.8^{b}	5.1^{b}	4.2^{ab}	5.0^{b}	4.1^{ab}	3.1^{a}
Age of household head [1]	59.3^{a}	55.9^{a}	57.3^{a}	56.6^{a}	55.8^{a}	58.8^{a}
Farmers with single income (%)[2]	21.3^{a}	12.5^{ab}	33.3^{ab}	59.1^{b}	24^{ab}	42.9^{ab}

Table 2. Average nitrogen (N) and phosphorus (P) application and frequency of manure and feed management options in each farm type.

	Farm type					
Farming practice variables	Grain	Cash crop	Mixed	Commercial	Small mixed	Landless
Fertilizer management						
Mean N application (kg/ha/year)[1]	396^{b}	195^{a}	411^{b}	261^{a}	422^{b}	-
Mean P application (kg/ha/year)[1]	89.9^{b}	49.9^{a}	80.9^{ab}	71.1^{b}	80.5^{ab}	-
Manure management & sources						
Use manure on croplands (%)	8.1	62.5	100	81.8	100	-
Use processed organic fertilizer (%)	8.1	50	0	45.5	0	-
Use manure from animal farms (%)	0	12.5	0	36.4	0	-
Use on-farm manure (%)	0	0	100	0	100	-
Use all on-farm manure on lands (%)	-	-	54.6	-	100	-
Using some on-farm manure and sell the rest (%)	-	-	3	-	0	100
Sell all manure to processing plants (%)	-	-	42.4	-	0	0
Crop (by-) product management						
Sell crop products/straw to animal farms (%)	2.5	0	0	18.2	0	-
Feed sources						
All feed purchased (%)	-	-	0	-	0	100
Combine purchased and on-farm feed (%)	-	-	100	-	100	0

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Towards nitrogen circularity in food systems in the North China Plain

PhD candidate: Chuanlan Tang
Supervisors: P. J. Gerber, S. J. Oosting and O. van Hal (WUR-APS), Y. Hou (CAU)

Background

- Chinese food systems need to enhance nitrogen (N) circularity urgently to mitigate the environmental and health impacts of N losses (Wang et al., 2020).
- Substance flow analysis (SFA) with circularity indicators is underused for assessing N circularity in Chinese regional food systems.
- Previous SFA studies often overlook animal-related sectors (such as parent and young stock of livestock, aquaculture and companion animals) and food loss and waste along the supply chain.
- Most research on N circularity in food systems focusses on a single spatial scale. Therefore, knowledge about heterogeneity of circularity of food system within Chinese regions is still lacking.

Research objectives

1. To assess the N circularity of a Chinese regional food system by applying an SFA with detailed animal sectors and food loss and waste, using a comprehensive set of circularity indicators.
2. To assess and explain the variation in N circularity among cities within the region.

Material and methods

- Study area

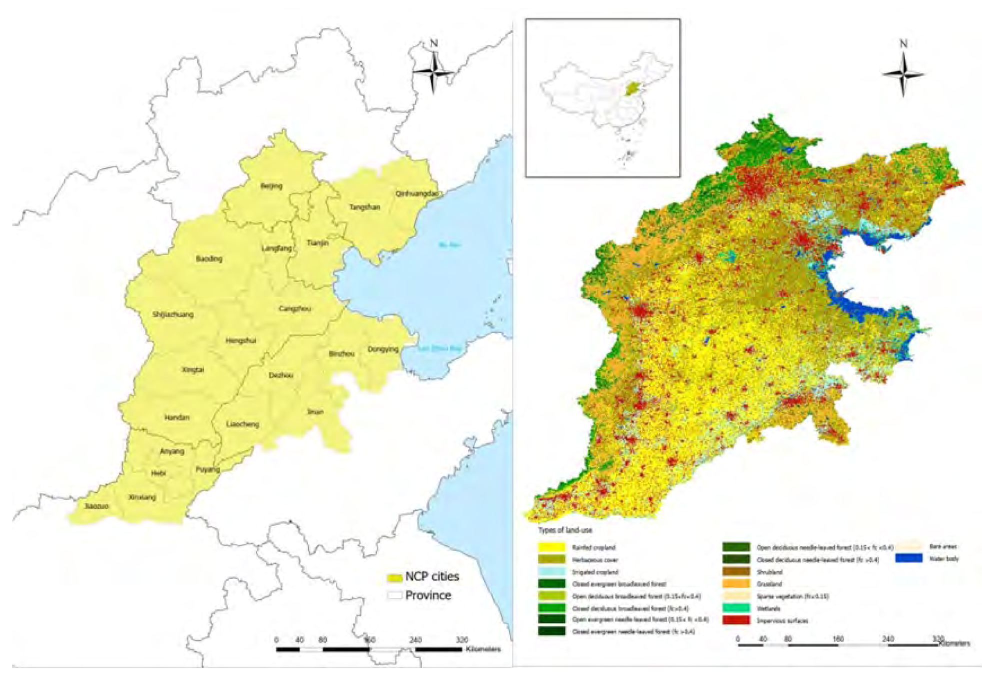

Figure 1. Geographical location and land use type of the North China Plain (NCP)

- System boundary

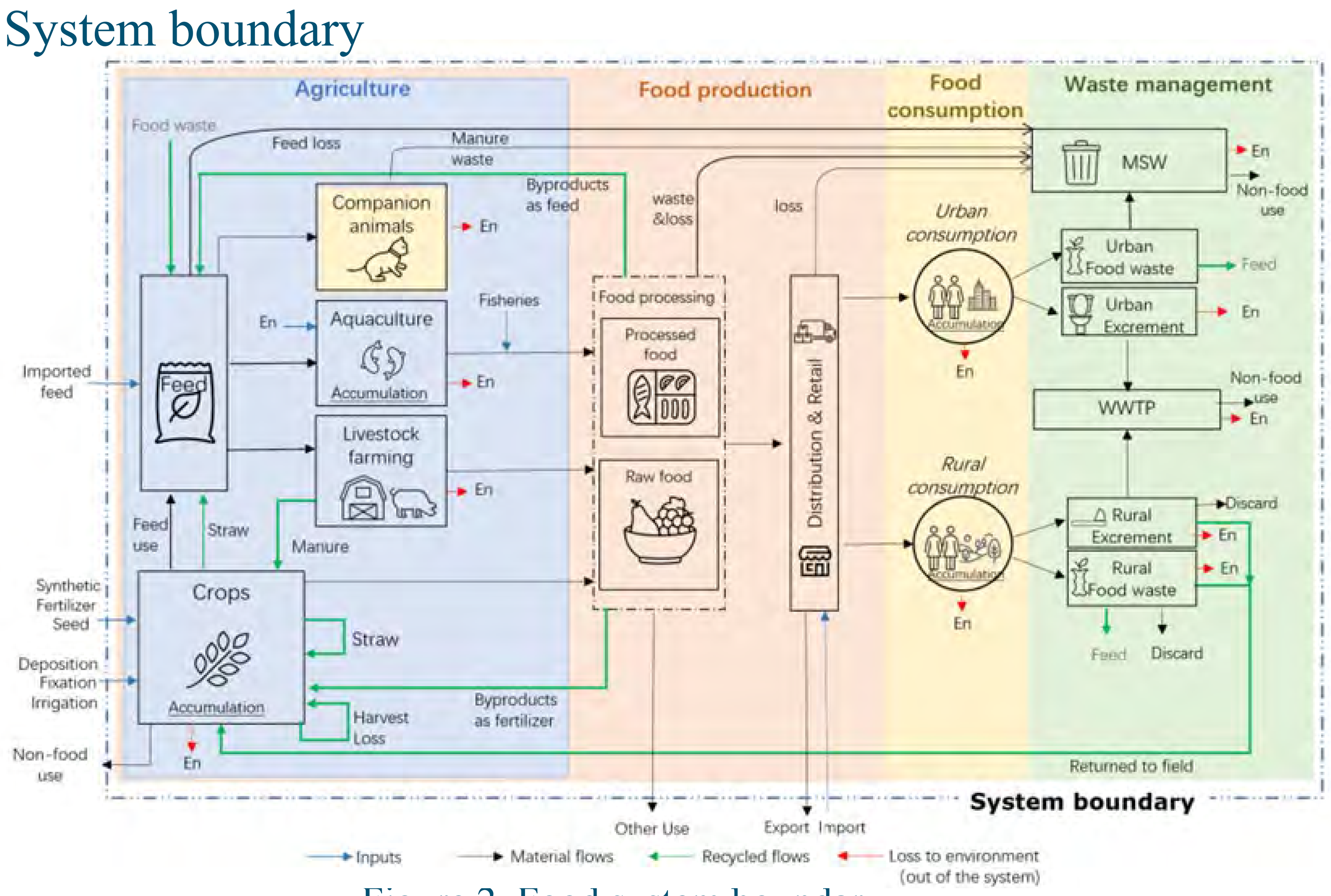

Figure 2. Food system boundary

Results

- **Nitrogen circularity of the North China Plain as a whole**

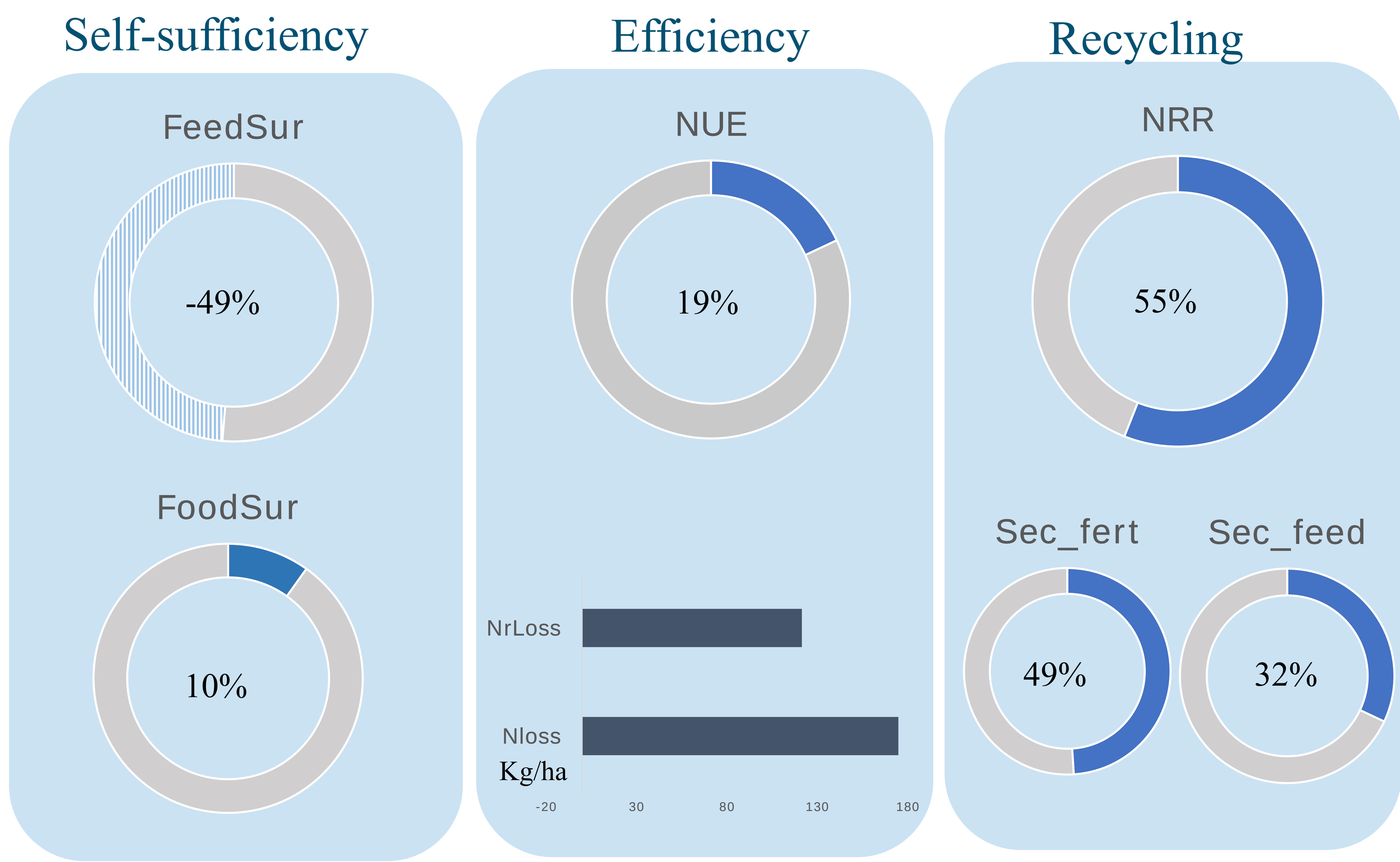

Figure 3. Feed N surplus rate (FeedSur), Food N surplus rate (FoodSur), N use efficiency (NUE), N loss, reactive N loss (NrLoss), N recycling rate (NRR), Secondary fertilizer N share (Sec_fert), Secondary feed N share (Sec_feed) of the NCP food system.

- **Comparison of N circularity of food systems among city clusters**

Table 1. City clusters and characteristics

Characteristics	Unit	Cluster 1 (n=11) balanced	Cluster2 (n=8) production	Cluster3 (n=2) consumption
Population density	cap/ha	5.7(0.6)	7.5(0.4)	12.5(0.9)
Urbanization rate	%	62.3(2.3)	56.1(1.6)	86.1(1.4)
Agriculture product density	kg N/ha	82.6(6.9)	155.8(7.7)	31.5(23.1)

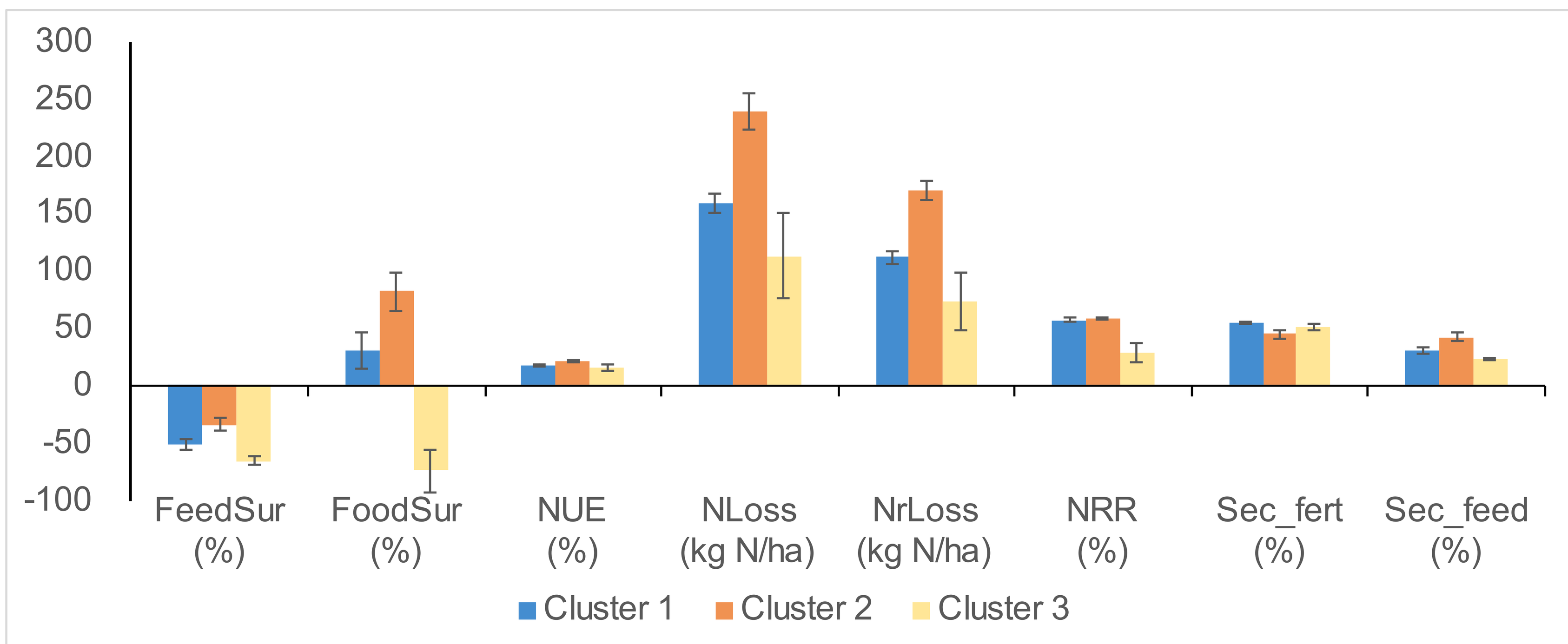

Figure 4. N circularity performance of three city clusters.

Conclusions

- SFA is a useful tool to comprehensively assess circularity but requires
  - ➢ multiple complementary **indicators**, and
  - ➢ detailed **animal sector** and **food loss and waste**
- "Production" cities exhibited better circular performance but faced higher N loss (kg N/ha) performance. "Consumption" cities demonstrated contrasting patterns.
  - ➢ Future research should focus on tailored strategies

Reference

Wang, X., Bodirsky, B. L., Müller, C., Chen, K. Z., & Yuan, C. (2022). The triple benefits of slimming and greening the Chinese food system. Nature Food, 3(9), 686–693.

Acknowledgements

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Centralized manure management operation reduces environmental impact of crop-livestock production systems in China

Xiaoying Zhang Supervisors: Y. Hou and HL. Wang (CAU)
M.K. van Ittersum and A.G.T. Schut (WUR-PPS) P.J. Gerber and S.J. Oosting (WUR-APS)

Background

- The Erhai Lake basin grapples with serious environment pollution.
- A centralized manure composting operation was established in Erhai lake basin.
- From the perspective of soil-crop-livestock integration system, a further improvement in the manure management is urgently needed.

Objectives

Take Erhai Lake basin as an example：

1. To quantify the N and P flows characteristics of the current manure management system;
2. To evaluate the N and P use efficiency, losses and soil surpluses of different manure management operations under current situation;
3. To explore scenarios to improve manure management and reduce N and P losses.

Methods

Step1: A quantitative model is used to quantify inputs and outputs of N and P, their flows for each town in study area using the mass-balance method.

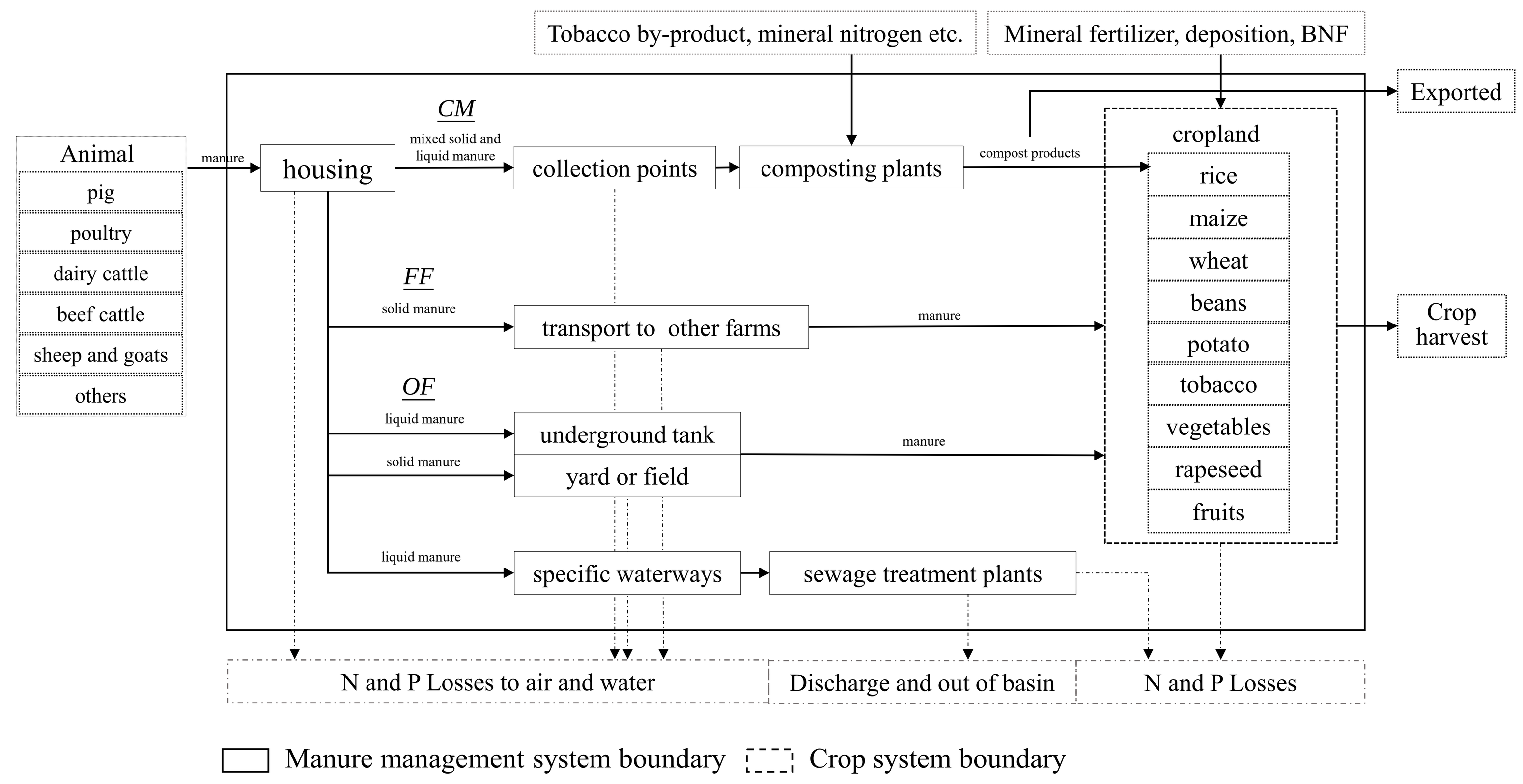

Figure 1. The current manure management system boundary with on-farm recycling (OF) flows, farm-to-farm exchange (FF) flows and flows to centralized management (CM)

Step2: Three alternative manure management scenarios.

SFF, all manure is applied to cropland by farmers within the region, no manure export.
Improved Manure Management (SIMM), centralized composting of all manure, where the ratio of exported compost is kept the same as in the current situation.
Improved Manure Management and Soil-crop management (SIMMS), built on SIMM, with balanced fertilizer application on cropland, all excess manure is exported.

Main Results

1. The N losses in CM were mainly through gas emissions, but losses into water had a significant contribution to the total N losses from OF and FF flows (see Table 1).
2. SFF will increase the N losses in cropland, and the P losses from all stages.
3. SIMM increased N, P losses to water from cropland, but decreased losses from storage.
4. In SFF the manure application rate increased, which increased soil nutrient surpluses.
4. SIMM and SIMMS increased compost and hence N and P exports.
5. SIMMS reduced losses, surplus and improved efficiency driven by large N and P exports.

Balancing N and P supply to crop demand is key to reduce environmental pollution in Erhai Lake. Composting manure together with by-products to optimize N and P ratios combined with a substantial manure export reduces N and P surplus by 51 and 111% and losses by 24 to 49%.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Table 1. N and P flows and losses in the current situation.

Indicators	Manure flows OF	FF	CM
Total manure N collection (kg·ha^{-1}·yr^{-1})	83	73	86
Total manure P collection (kg·ha^{-1}·yr^{-1})	34	41	49
By-products N (kg·ha^{-1}·yr^{-1})	0	0	37
By-products P (kg·ha^{-1}·yr^{-1})	0	0	11
Total N losses (%)	66	57	51
Total P losses (%)	48	16	8
Storage and treatment losses (%)			
NH_3	13	12	29
N_2O	0.4	0.5	0.8
Others to air	3	5	7
N losses to water	35	21	7
P losses to water	45	11	5
Cropland losses (%)			
NH_3	9	11	0.4
N_2O	0.5	0.6	0.4
Others to air	0.3	0.3	0.7
N losses to water	5	6	5
P losses to water	3	5	3

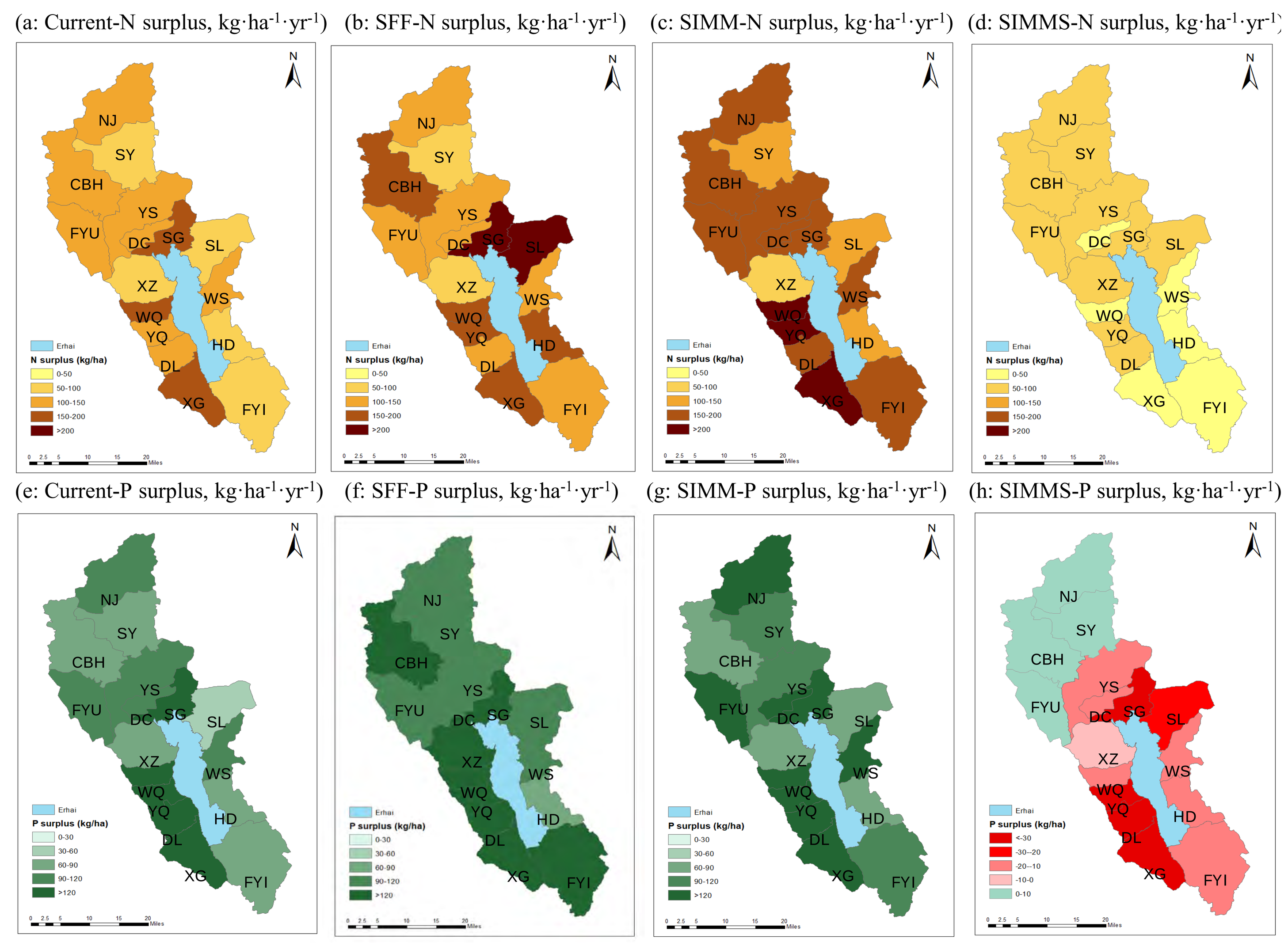

Figure 2. The average nitrogen (N, a-d) and phosphorus (P, e-h) surplus at townships under current situation and scenarios. Positive values represent accumulate and negative values represent negative surpluses.

Table 2. The estimated N and P balances under current situation and the changes in scenarios SFF, SIMM and SIMMS compared with current situation.

Indicators	Current N	Current P	SFF N	SFF P	SIMM N	SIMM P	SIMMS N	SIMMS P
Input (kg·ha^{-1}·yr^{-1})								
Mineral fertilizer	122	32	24%	54%	25%	60%	-7%	-99.5%
Bulking agents	37	11	-100%	-100%	115%	172%	240%	210%
Excreted manure	373	130	0%	0%	0%	0%	0%	0%
BNF	39	0	0%		0%		0%	
Deposition	38	0	0%		0%		0%	
Total input	609	174	-1%	4%	12%	22%	13%	-5%
Output (kg·ha^{-1}·yr^{-1})								
Crop harvest	144	22	-2%	-1%	-1%	-1%	0%	0%
Exported	25	21	-100%	-100%	266%	157%	888%	537%
Total output	169	43	-16%	-49%	38%	76%	130%	263%
Losses (kg·ha^{-1}·yr^{-1})								
Loss to air	203		-9%		-9%		-11%	
Loss to water	86	30	19%	25%	-32%	-47%	-64%	-59%
Discharge and out of basin	32	6	0%	0%	0%	0%	0%	0%
Total losses	321	35	-1%	21%	-14%	-39%	-24%	-49%
Nutrient surplus (kg·ha^{-1}·yr^{-1})	120	95	18%	22%	46%	20%	-51%	-111%
Nutrient use efficiency (%)	28	25	-15%	-51%	23%	45%	103%	283%

[a]Exported mean compost products sold from the basin and applied elsewhere.
The red color indicates an increase and a blue color indicates a decrease.

Conclusions

Successful manure management strategies must consider aspects of soil nutrient balance and crop nutrient uptake. Mitigation of nutrient losses in the upper part of management chain may lead to overloading of nutrient in cropland. In the lake basin, the imbalance of N:P in soil-crop-manure needs to be paid more attention. In this study, centralized manure management systems with mitigation measures can be good options to reduce the N and P pollution simultaneously in the Erhai lake basin.

Recoupling livestock and cropland on a regional scale could reduce manure N loss from 10.3 Tg yr^{-1} to 1-1.2 Tg yr^{-1} and P losses in the entire food chain by 41-54% (Ma et al., 2022; Zhang et al., 2019). Furthermore, it leads to lower soil acidification rates compared to the decoupled crop and livestock system (Carvalho et al., 2018).

Impacts of changes in manure management on crop nutrient availability and nutrient losses in Quzhou City, China

PhD student: Weikang Sun
WUR supervisors: Wim de Vries, Gerard H. Ros
CAU supervisors:Qichao Zhu, Yong Hou

Background

In China, the rise in livestock numbers has generated a large amount of manure (3.8 billion tons annually). Despite its huge potential for cropland fertilization, the average manure recycling rate is lower than 40% and a substantial amount of nutrients is lost to air and waterbodies. Improved manure management presents a high opportunity for reducing nutrient losses. To date, hardly any studies have quantified the separate and combined impacts of changes in manure production rates, manure recycling rates and manure treatment technologies on nutrient availability from manure and related nutrient losses.

Objectives

In this study, we assessed the impacts of changes in livestock numbers (LN), manure recycling rates (MR) and manure treatment technologies (MT) on nutrient availability and losses in Quzhou city in China. The two sub-objectives are:

- Quantifying the combined impacts of changes of LN, MR and MT on nutrient availability from manure and nutrient losses in the recent past (2011-2020).
- Assessing the individual impacts ILN, IMR and IMT and the combination (COM) of them in the near future (2021-2030).

Methods

This study is conducted in Quzhou city which is a major city for livestock breeding in Zhejiang province, primarily focusing on pig and poultry production. The nutrient flows for animal manure, current manure treatment technologies and the system boundary are shown in **Fig. 1**. We quantified manure nutrient supply and nutrient losses in response to changes in livestock numbers, manure recycling rates and improved manure treatment technologies, accounting for replacement of fertilizer by manure, via material flow analysis.

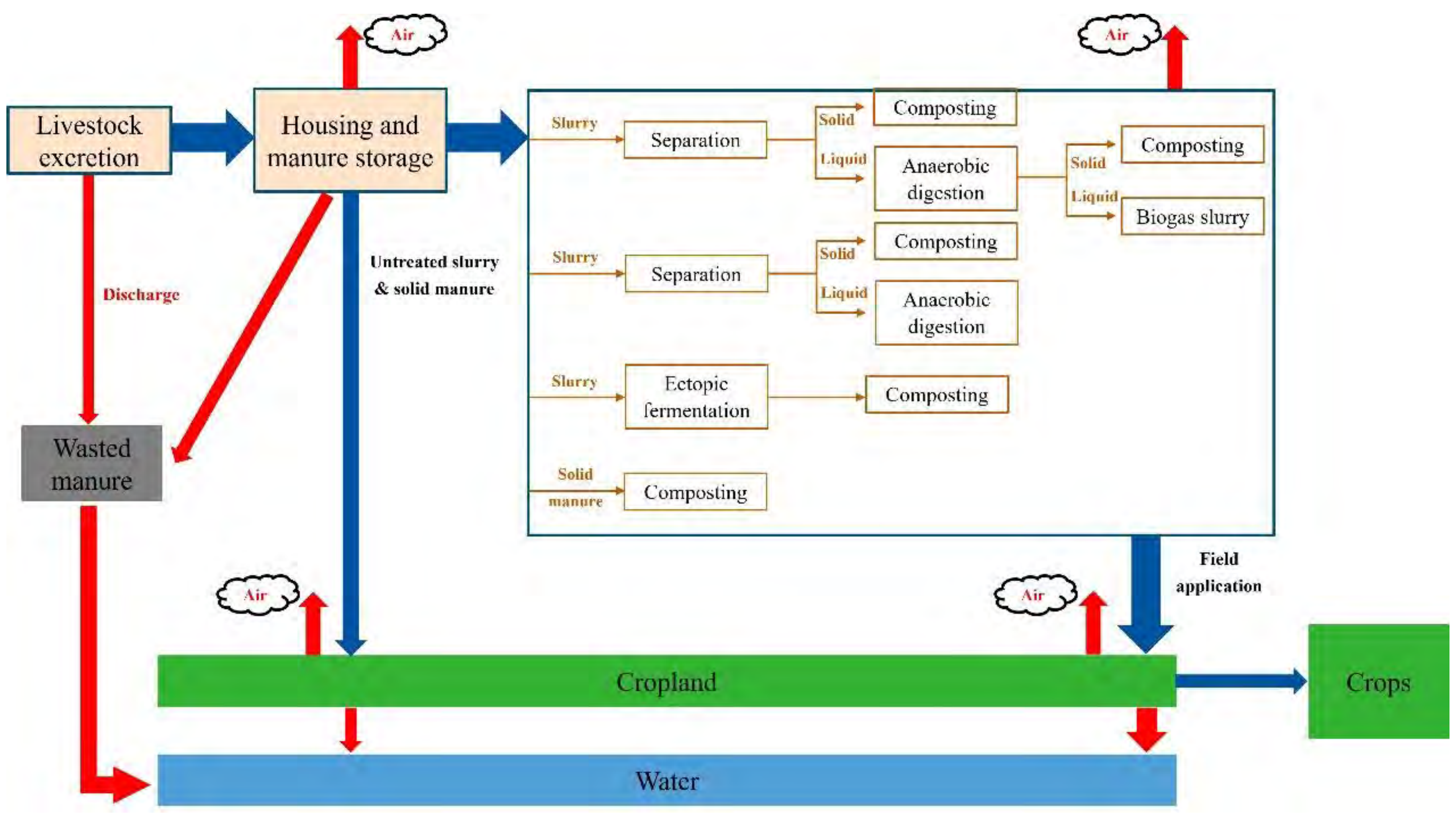

Fig. 1. Graphic representation of the manure management chain with manure treatment technologies used in this study. The red arrows indicate the nitrogen losses to air (NH_3, N_2O, N_2) and water (leaching and runoff). The blue arrows represent the nutrient inputs from manure.

Results

From 2011-2020, Quzhou city experienced a 20% reduction of cropland area and a halving of livestock production, shifting from primarily pig farming to a mix of pig and poultry farming.

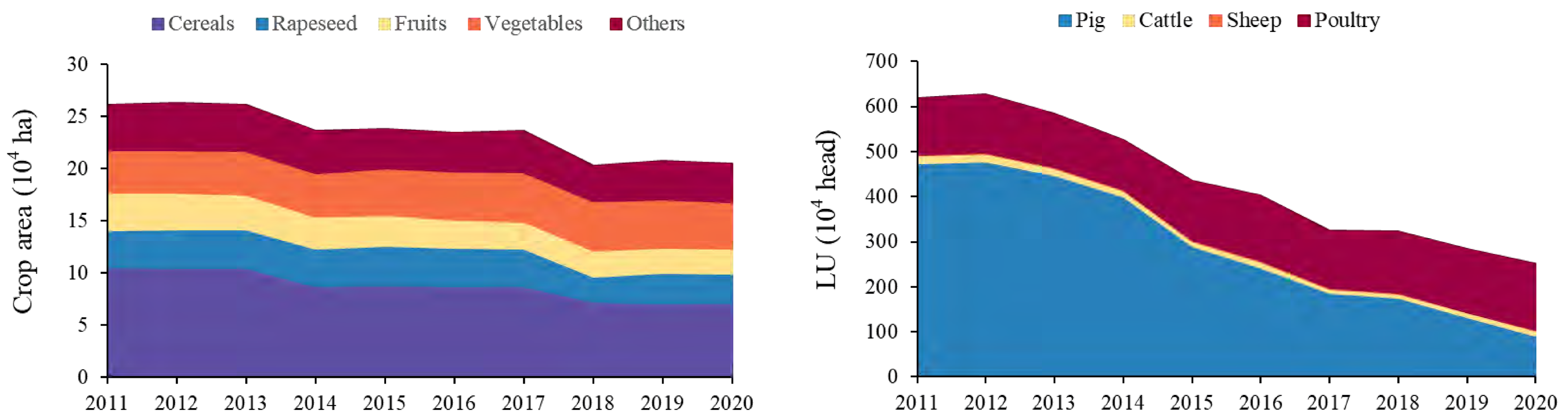

Fig. 2. Trends for cropland area and livestock production from 2011-2020 in Quzhou city,

During 10 years, the total nitrogen (N) losses decreased by 53%. From this total N loss about 51% was emitted as NH_3 and 7% as N_2O. The contribution of N losses via leaching and runoff reduced from 35% to 23% due to restricting direct manure discharge whereas the contribution of N_2 increased from 10% to 22%.

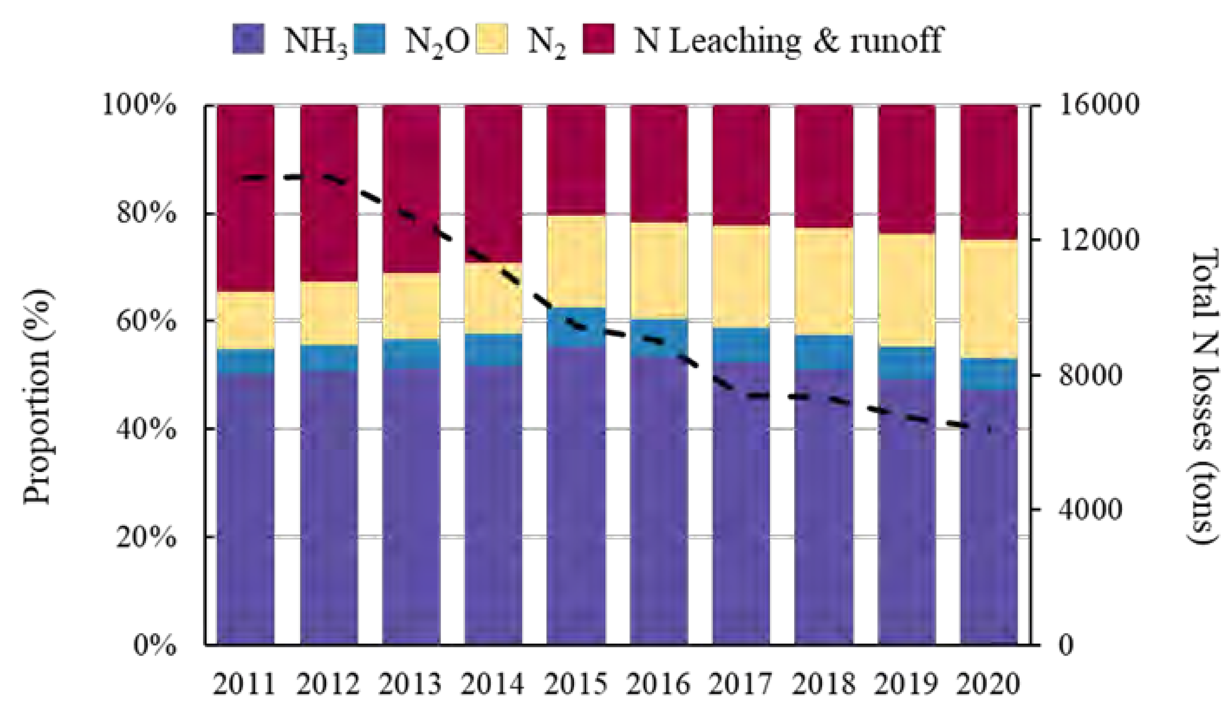

Fig. 3. Total N losses (in tons) and proportions of N compounds (in %) from 2011-2020 in Quzhou city.

In Quzhou city, crop N demand cannot be met by only manure. Increasing the manure recycling rate is the most effective single strategy in reducing the fertilizer N demand. The combination of increasing livestock numbers, manure recycling rates and implementing advanced manure treatment technologies reduced the required additional N input by fertilizers by 33%

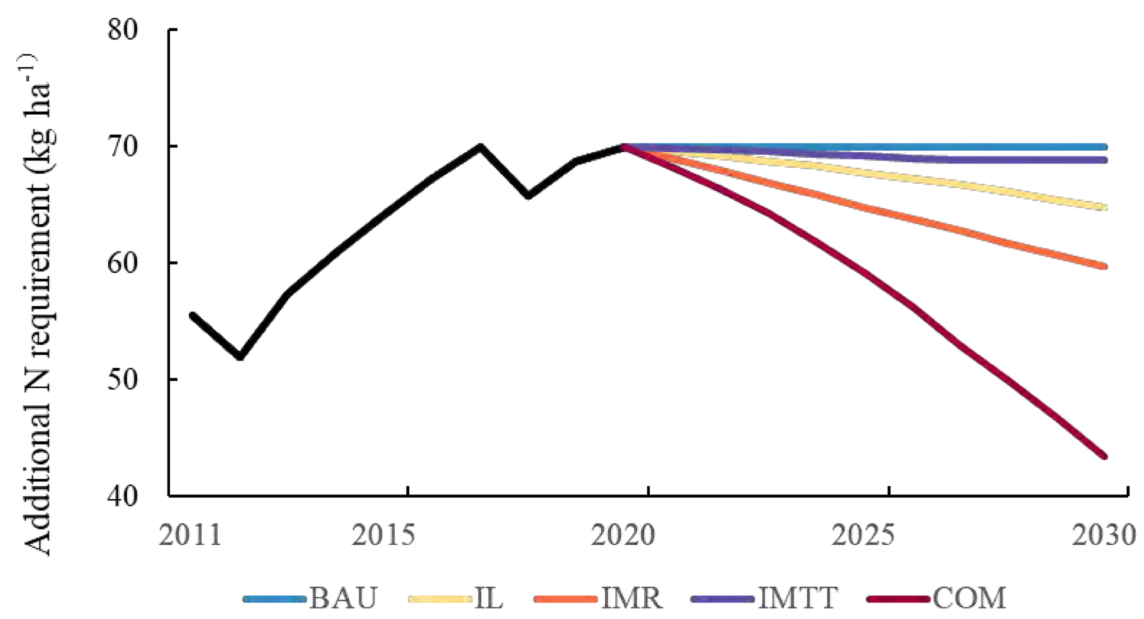

Fig. 4. Additional N requirement (crop N demand minus manure N supply) by fertilizers during 2011-2020 and for the future scenarios from 2021 to 2030, i.e., BAU: business as usual; IL: increasing livestock numbers; IMR: increasing manure recycling rates; IMTT: increasing the implementation of advanced manure treatment technologies; COM: combination of IL, IMR and IMTT.

Acknowledgements

We gratefully acknowledge the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University

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Sustainable development of China’s agriculture driven by fertilizer policy

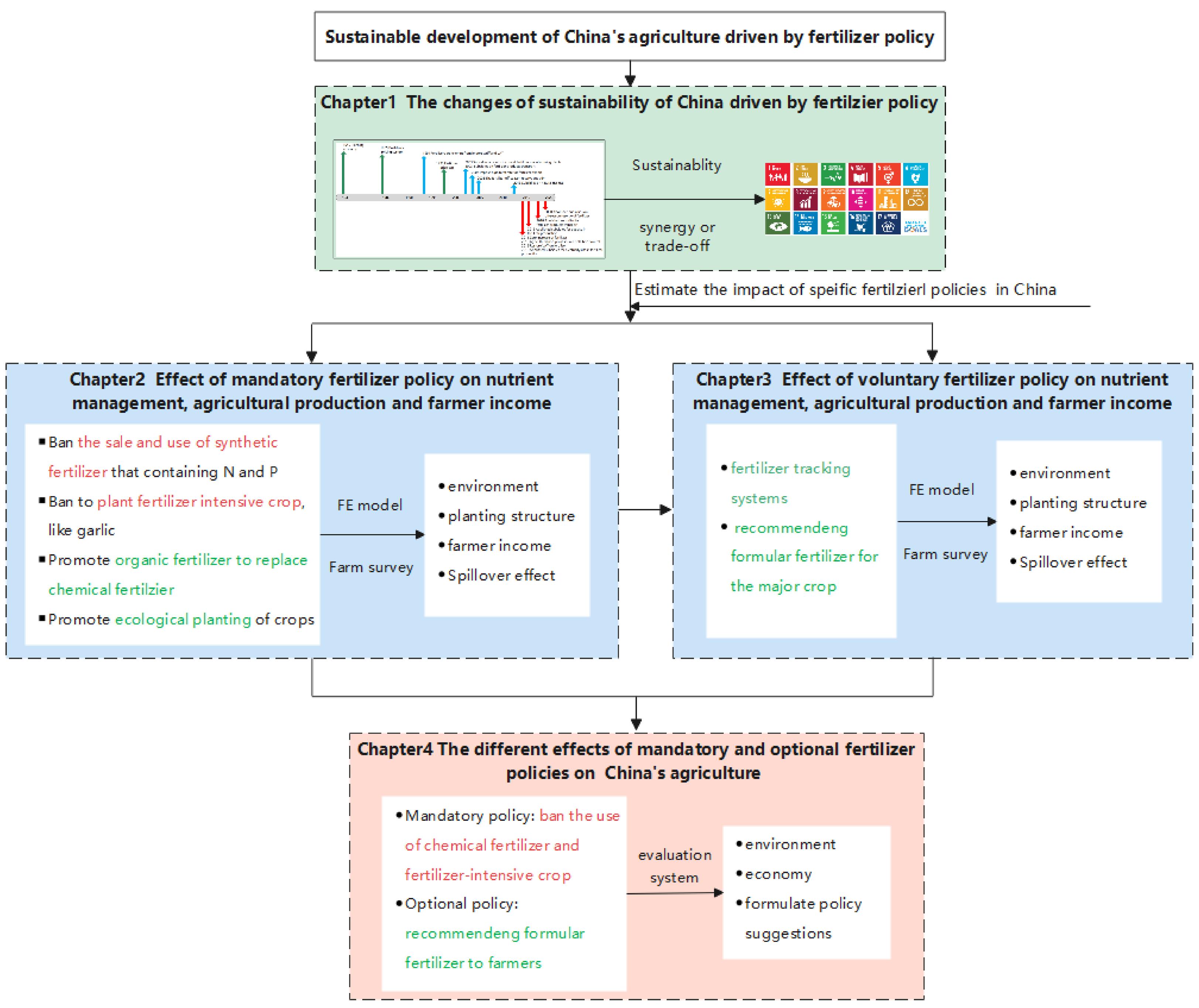
PhD student: Ling Zhang

Supervisors: Qichao Zhu, Yong Hou, Nico Heerink, Marrit van der Berg, Wim de Vries, Gerard H. Ros

Background

The widespread use of fertilizers has contributed significantly to the substantial increase in food and feed production during the last seven decades[1]. In 2010, China consumed 30% of the fertilizer in the world, with only 7% of the global cropland area[2], resulted in low nitrogen (N) use efficiency in crop production (30%), dramatic lower than the world average (50%)[3, 4]. The inefficient use of N and phosphorus (P) fertilizer in agriculture led to massive nutrient losses into water bodies and atmosphere, threatening ecosystem and human health[5-8]. To address this issue, the central government of China launched the ‘Action Plan for Zero Increase of Fertilizer Use’ in 2015, to curb the growth of fertilizer input without reducing food production. Given this context, many specific and regional policies were issued to achieve this target, such as ‘Fertilizer and pesticide real-name purchase system and overuse warning system’ in Zhejiang Province, as well as the mandatory fertilizer policy ‘ban the sale and use of chemical fertilizer and ban the planting of fertilizer-intensive crop’ in Erhai Basin. The comprehensive assessment of the fertilizer policy on the local environment and economy was needed.

Framework

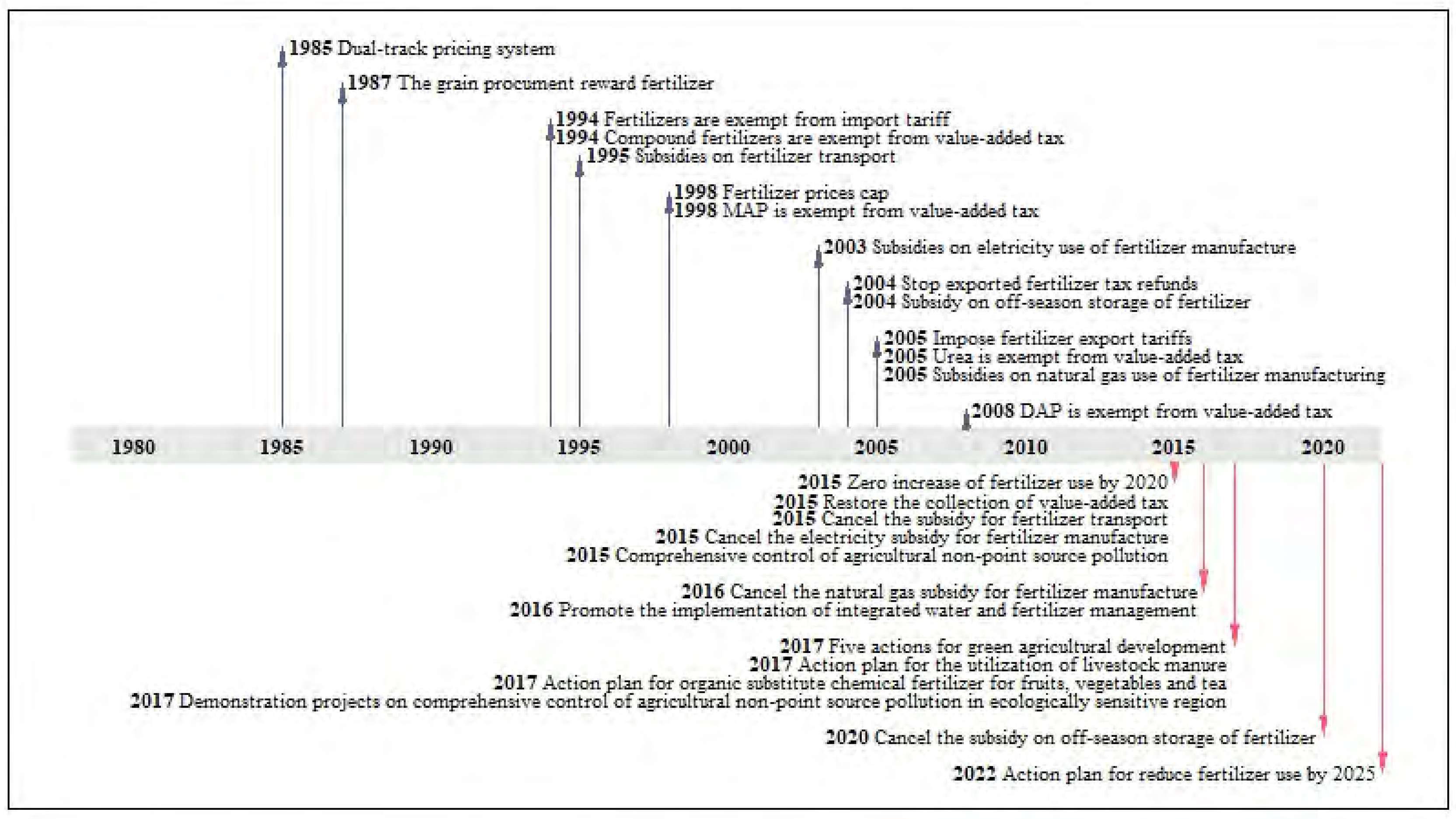


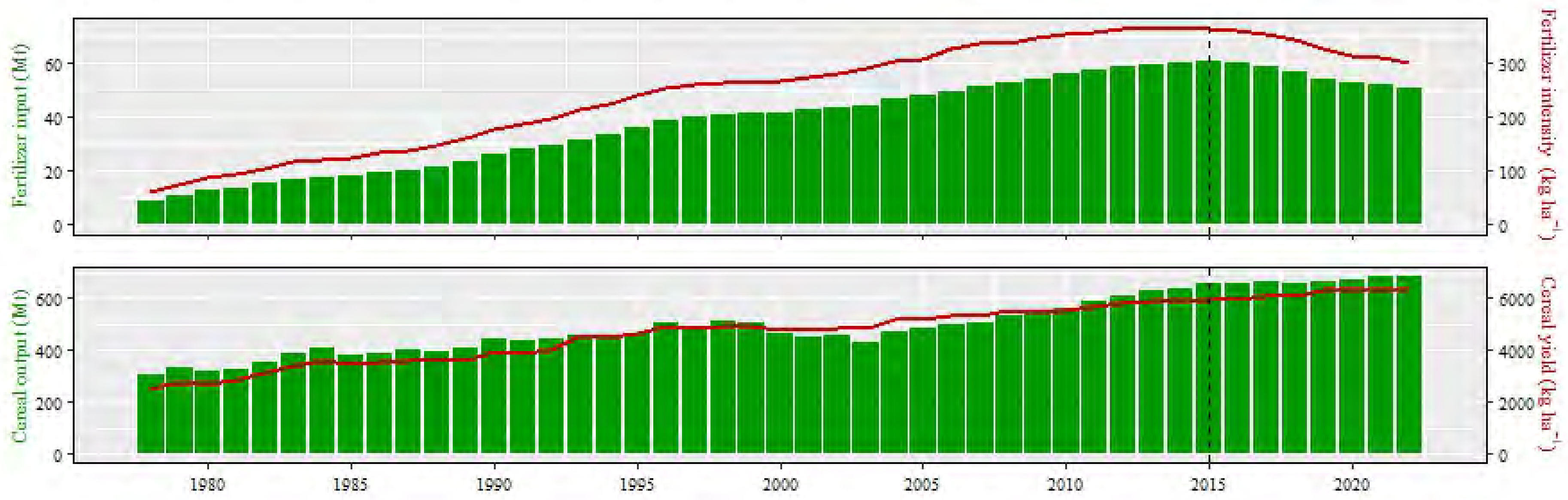
Contents and methods of Chapter 1

- Overview of nutriment management policies in China from 1978 to 2021, and the following changes in synthetic fertilizer manufacturing and agricultural use.
- Building the relationship between fertilizer manufacturing and agricultural use practices with sustainable development goals (SDG), elucidating positive, negative, and bidirectional relationships based on the existing literature.
- Quantitative assessment of the contribution of fertilizer manufacturing and agricultural use to changes of SDGs based on machine learning.

Results of Chapter 1

- The nutrient management policies issued before 2015 aimed to ensure the accessibility and affordability of synthetic fertilizer for farmers. The policies can be categorized into two aspects, i.e. price control and subsidy programs.
- Since 2015, there has been a gradual phase-out of subsidy programs, accompanied by efforts to promote the substitution of manure for synthetic fertilizers, all aimed at achieving zero growth in synthetic fertilizer use. This shift is in response to the heightened attention directed towards environmental issues related to nutrients.
- Following the policies implementation, fertilizer usage in agricultural production increased before 2015, and subsequently decreased.





- The fertilizer manufacturing and its agricultural use affects at least 58% (10 out of 17) of the SDG goals and 17% (29 out of 169) of the SDG targets. Notably, SDG1, SDG2, SDG6, SDG7, and SDG13 demonstrate stronger connections to this relationship.

SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1	16.1	17.1
1.2	2.2	3.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2	11.2	12.2	13.2	14.2	15.2	16.2	17.2
1.3	2.3	3.3	4.3	5.3	6.3	7.3	8.3	9.3	10.3	11.3	12.3	13.3	14.3	15.3	16.3	17.3
1.4	2.4	3.4	4.4	5.4	6.4	7.a	8.4	9.4	10.4	11.4	12.4	13.a	14.4	15.4	16.4	17.4
1.5	2.5	3.5	4.5	5.5	6.5	7.b	8.5	9.5	10.5	11.5	12.5	13.b	14.5	15.5	16.5	17.5
1.a	2.a	3.6	4.6	5.6	6.6		8.6	9.a	10.6	11.6	12.6		14.6	15.6	16.6	17.6
1.b	2.b	3.7	4.7	5.a	6.a		8.7	9.b	10.7	11.7	12.7		14.7	15.7	16.7	17.7
	2.c	3.8	4.a	5.b	6.b		8.8	9.c	10.a	11.a	12.8		14.a	15.8	16.8	17.8
		3.9	4.b	5.c			8.9		10.b	11.b	12.a		14.b	15.9	16.9	17.9
		3.a	4.c				8.10		10.c	11.c	12.b		14.c	15.a	16.10	17.10
		3.b					8.a				12.c			15.b	16.a	17.11
		3.c					8.b							15.c	16.b	17.12
		3.d														17.13
																17.14
																17.15
																17.16
																17.17
																17.18
Positive relevance			Negative relevance			Bidirectional relevance										17.19

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Spatial patterns of current ammonia emissions from agriculture using a newly developed bottom-up method in China

PhD student: Rong Cao
WUR Supervisors: Wim de Vries, Gerard H. Ros CAU supervisors: Wen Xu

Background

Chinese agricultural sector emits large amounts of ammonia (NH_3) due to large-scale application of fertilizer and manure. The consequent high deposition and concentrations of NH_3 cause damage to ecosystems by eutrophication and acidification, and to human health by increasing particulate matter exposure. Spatially explicit information on current and critical ammonia emissions is crucial to optimize agricultural management strategies minimizing this gap. However, reliable information on spatial variation in agricultural NH_3 emission is still limited in China.

Objectives

Improvement of spatial patterns of NH_3 emissions based on bottom-up modelling methods by:

1) Improvement of spatial variation in livestock numbers
2) Improvement of spatial variation in NH_3 emission factors

Research methods

- Improve existing methods to assess the spatial variation in numbers of different livestock types in China
- Meta-regression based on an intensive literature search to improve spatial patterns of NH_3 emission factors
- Combine spatial variation in fertilizer application rates, livestock numbers and ammonia emission factors to assess the spatial variation in ammonia emission

The AMEMCHIN Framework

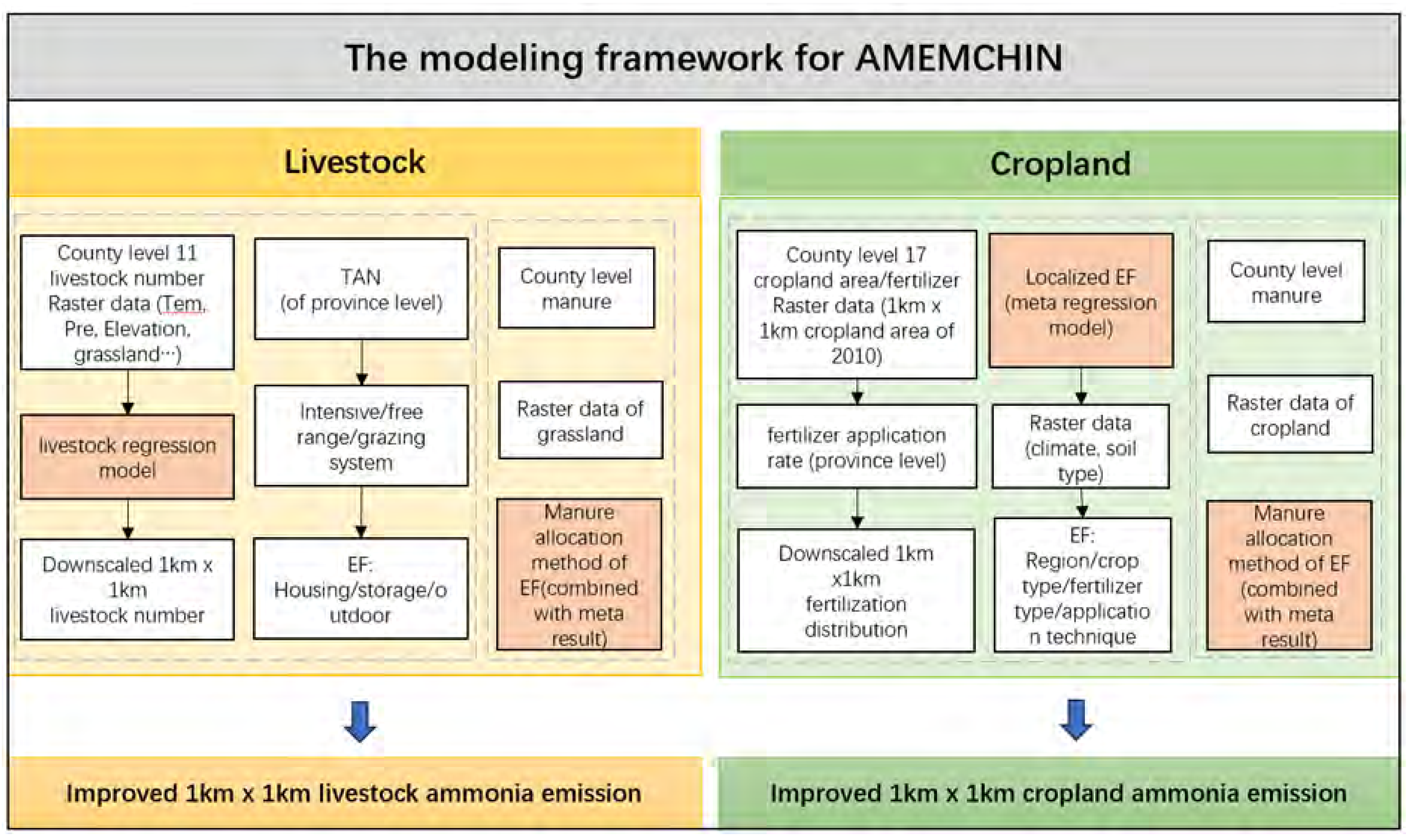

Figure 1. Details of research framework.

Results

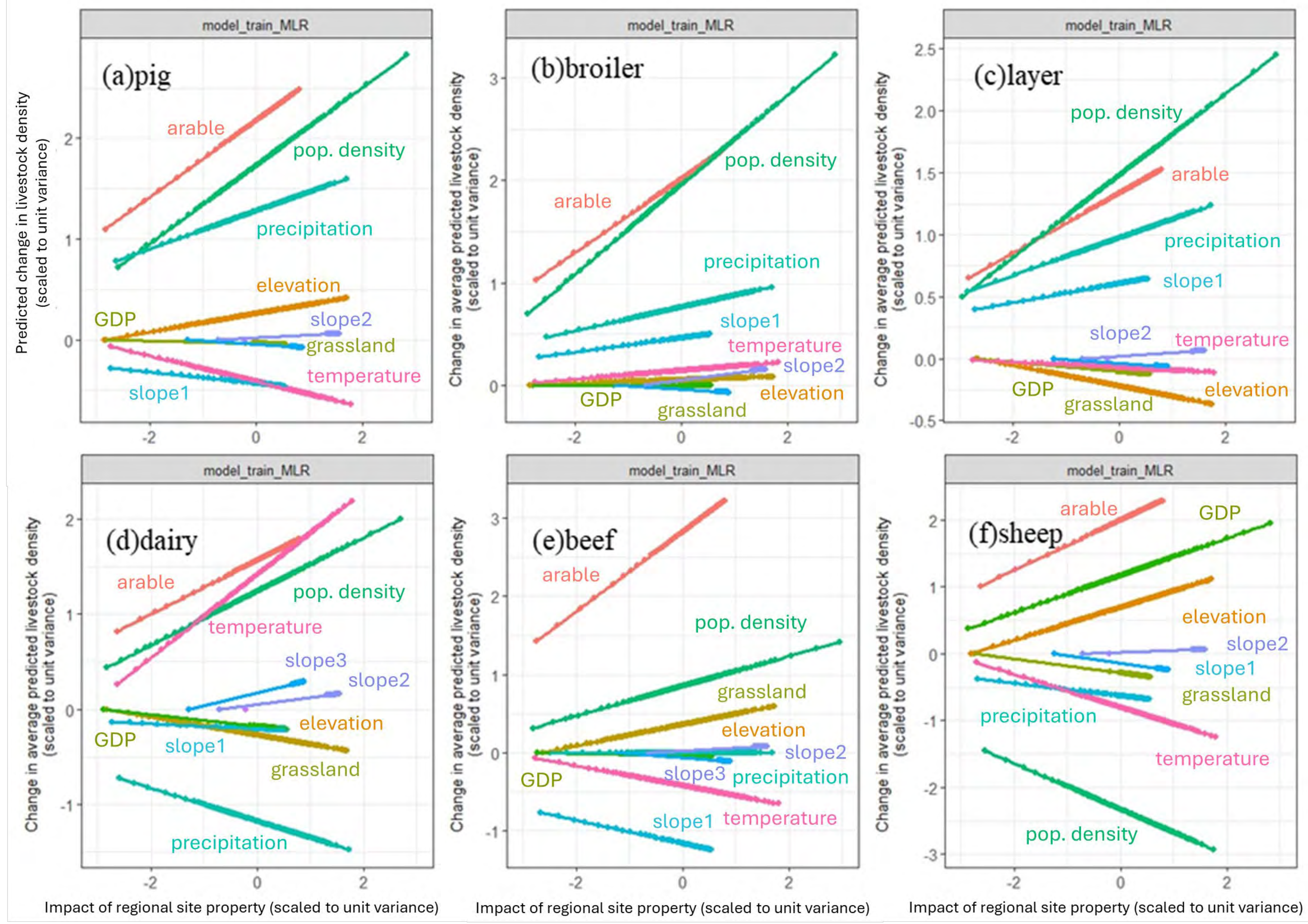

Figure 2. Factors explaining the variation in livestock numbers per county for pigs, poultry broilers, poultry layers, beef cattle, dairy cattle and sheep. Through this approach, an improved down-scaling of livestock at a high (1km x 1km) resolution is possible

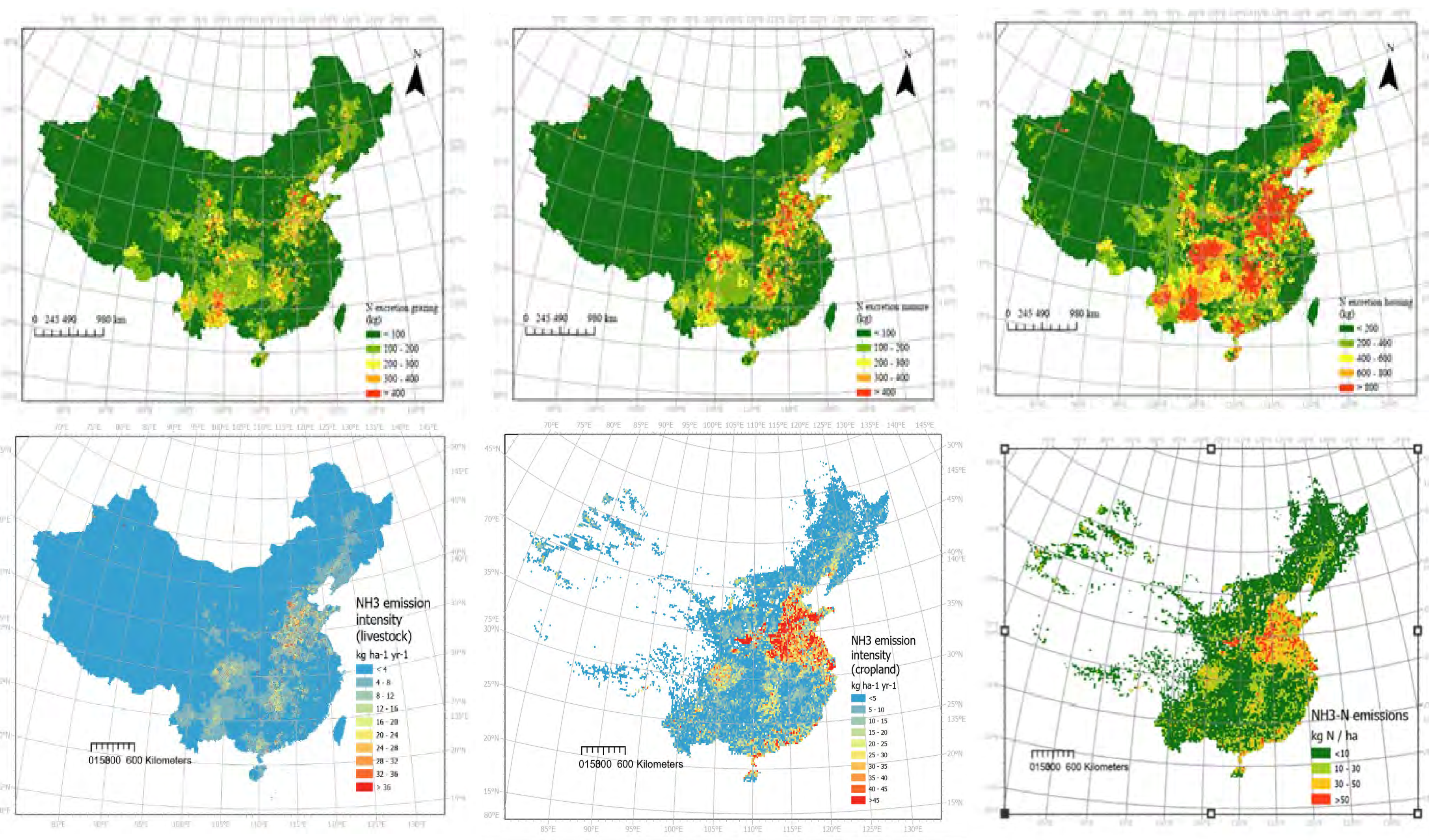

Figure 3. Predicted spatial distribution of NH_3 emissions from livestock systems (housing and manure storage systems and grazing animals) and cropland (manure and mineral fertilizer application) and the combination

Acknowledgements

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IASI satellite shows: NH_3 emissions over China is underestimated in Summer

Phd candidate: Jianan Chen

Supervisor: Wen Xu (CAU), Maarten Krol (WUR)

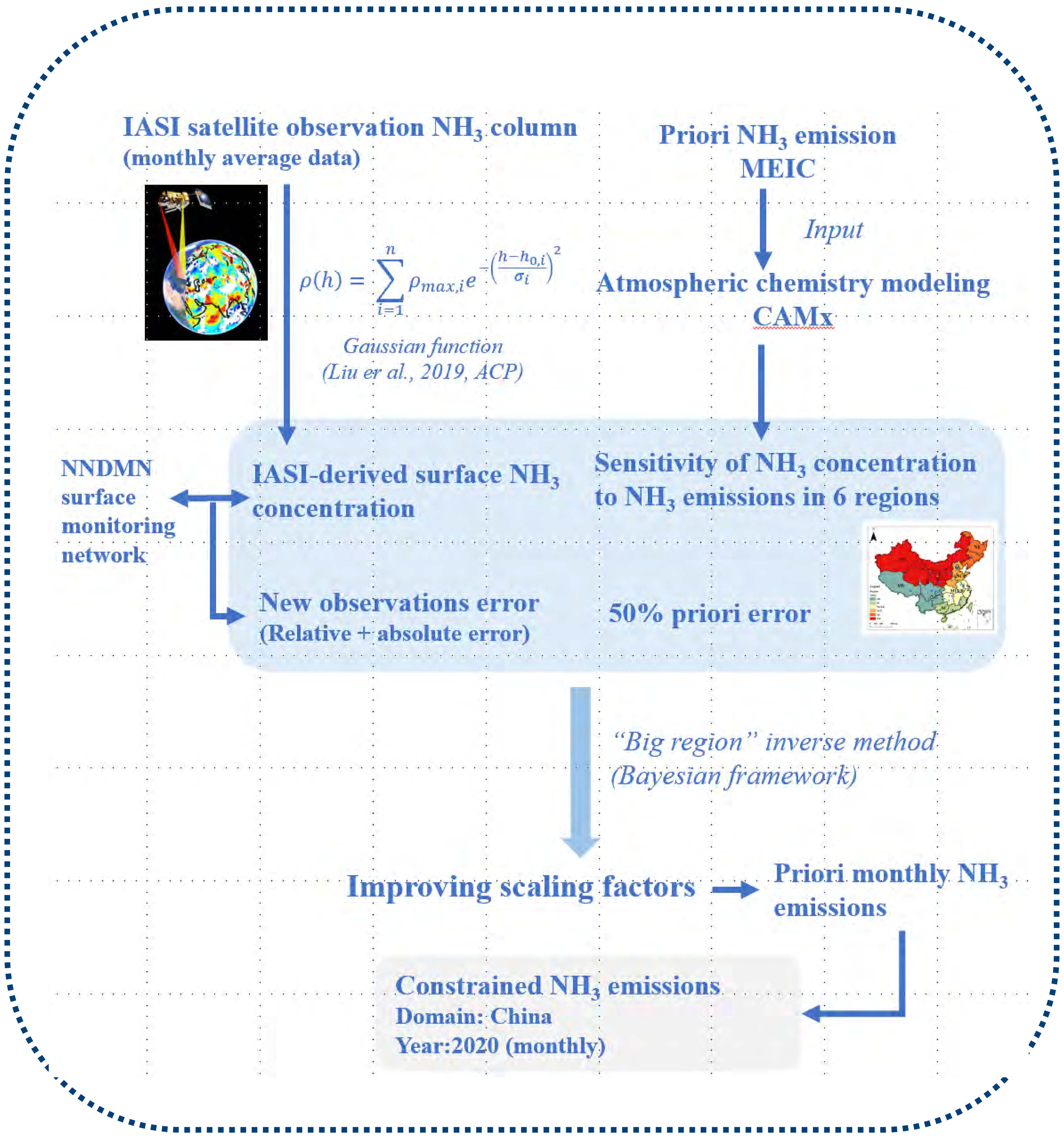
Background

Ammonia (NH_3) plays a crucial role in the formation of $PM_{2.5}$ as a primary alkaline gas in the atmosphere. NH_3 emission inventory is an essential component of chemical transport numerical models for scenario simulations and developing mitigation strategies. The significantly NH_3 hotspots located in China can be seen either compiled inventories or satellite observations. However, almost previous emission estimates report that NH_3 emissions from China remain have large uncertainty, due to their large spatiotemporal variability resulting from the diverse nature of agricultural sources

Objectives

- Optimizing annual estimates of NH_3 emissions in China
- Improving monthly variations in six mainly regions
- Evaluating the impact of NH_3 emissions on modeled NH_3 concentration, nitrogen deposition and $PM_{2.5}$ conformation

Methods



Results

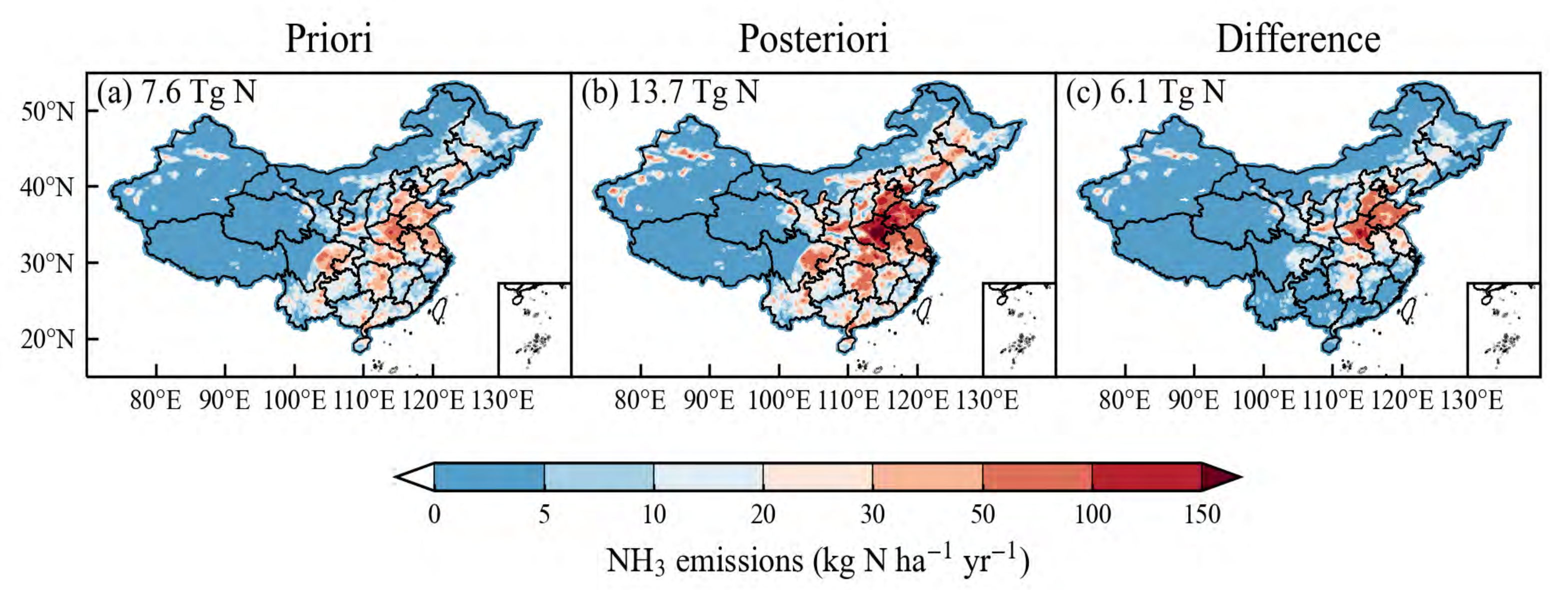


Figure 1. Spatial distribution of (a) a priori and (b) a posteriori annual NH_3 emissions over China in 2020, as well as the (c) difference between posteriori and a priori estimates..

- Figure 1 provides a snapshot of the a priori and a posteriori annual NH_3 emissions and the increments between them. The posteriori annual emissions are 13.7 Tg N yr^{-1}, demonstrating a substantial 80 % increase compared to the priori estimate of 7.6 Tg N yr^{-1}.
- High emissions are consistently observed in the NCP, MLYR and Sichuan basins in both a priori and a posteriori estimates, and the posteriori estimates revealing significantly higher emissions in these regions.

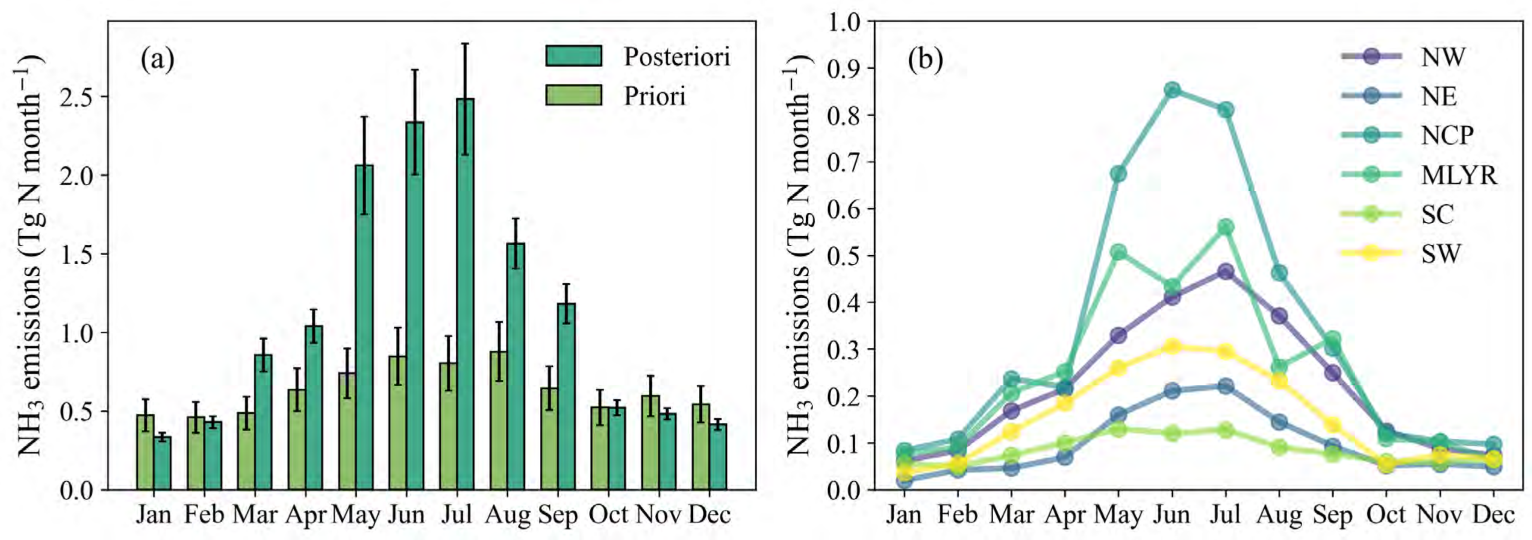


Figure 2. Monthly variations in a posteriori NH_3 emissions in China (a) and over different regions of China (b).

- The a posteriori NH_3 emissions exhibited more distinct seasonal and monthly variations, as depicted in Figure 1 (a), with 6.9 Tg N of emissions during the summer months (May-July) and 1.2 Tg N during the winter months (October–February).
- The posteriori emissions reveal varies seasonal fluctuations in the six regions, as shown in Figure 2 (b).

Conclusions

- **IASI-derived surface NH_3 captured generally the spatial-temporal distribution of NH_3 concentrations, setting reasonable observations error is important in constraining NH_3 emissions**
- **Priori NH_3 emissions (7.6 Tg N yr^{-1})are significantly underestimated, compared to posteriori (13.7 Tg N yr^{-1}) mainly in hotspots regions (NCP and MLYR) in summer**
- **The optimized NH_3 emissions present more apparent monthly variations and vary over different regions, compared to priori monthly emissions.**

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Droughts and drought–flood abrupt alternations under the operation of cascading reservoirs over 40 years

Presenter: Yinan Ning
Supervisors: Xuejun Liu, Lihua Ma, Xinping Chen, Fusuo Zhang
Joao Nunes, Jantiene Baartman, Coen Ritsema

Background

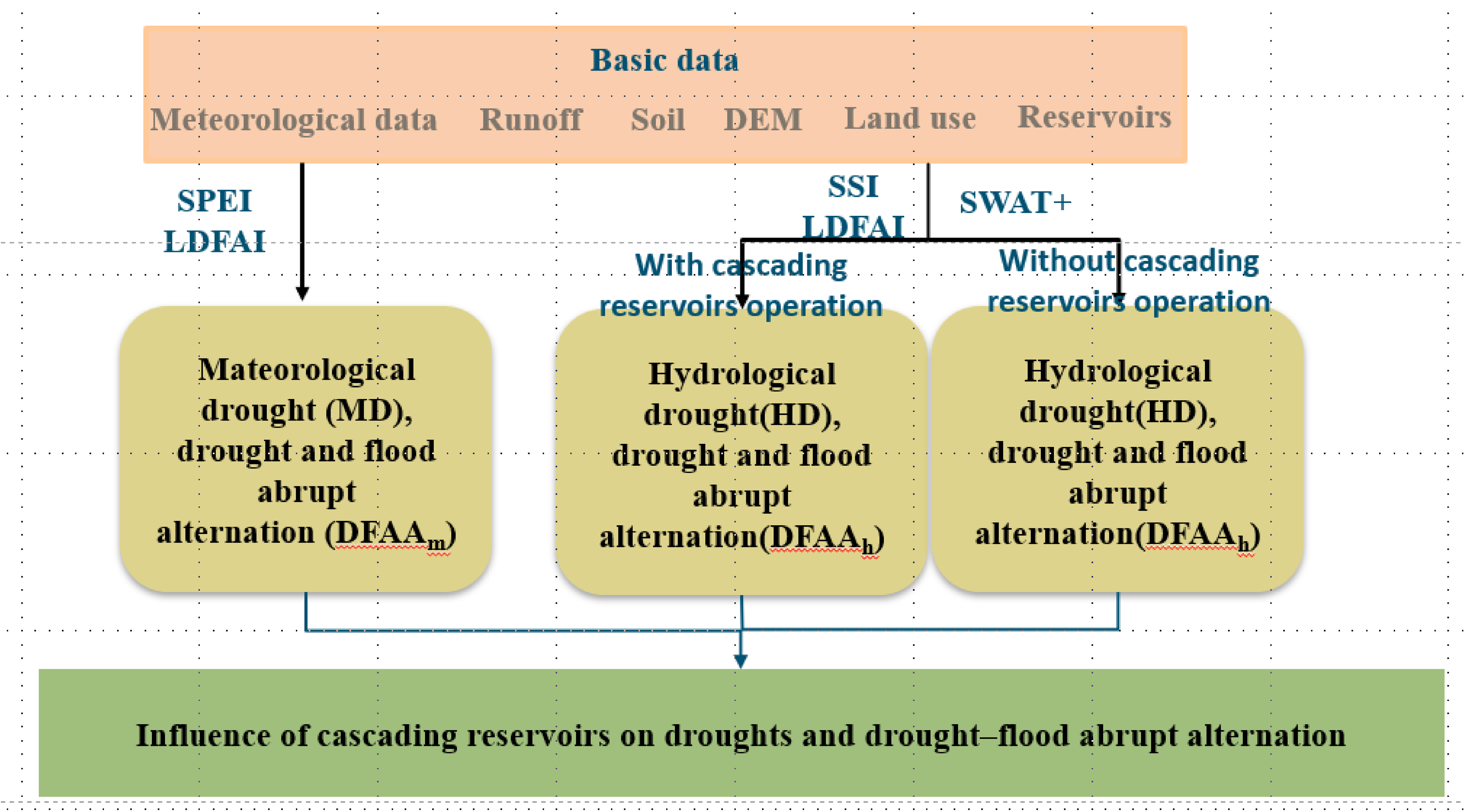
The Yangtze River, ranked as the third-longest river in the world and characterized by numerous cascading reservoirs, which has been consistently afflicted by frequent meteorological droughts, hydrological droughts and drought-flood abrupt alternations events. Furthermore, the proliferation of numerous cascading reservoirs has significantly increased the complexity of studying these events in the. Previous research on extreme events in the YRB has primarily concentrated on characteristic analysis, and how those cascading reservoirs influence them across the entire YRB is still unclear.

Objectives

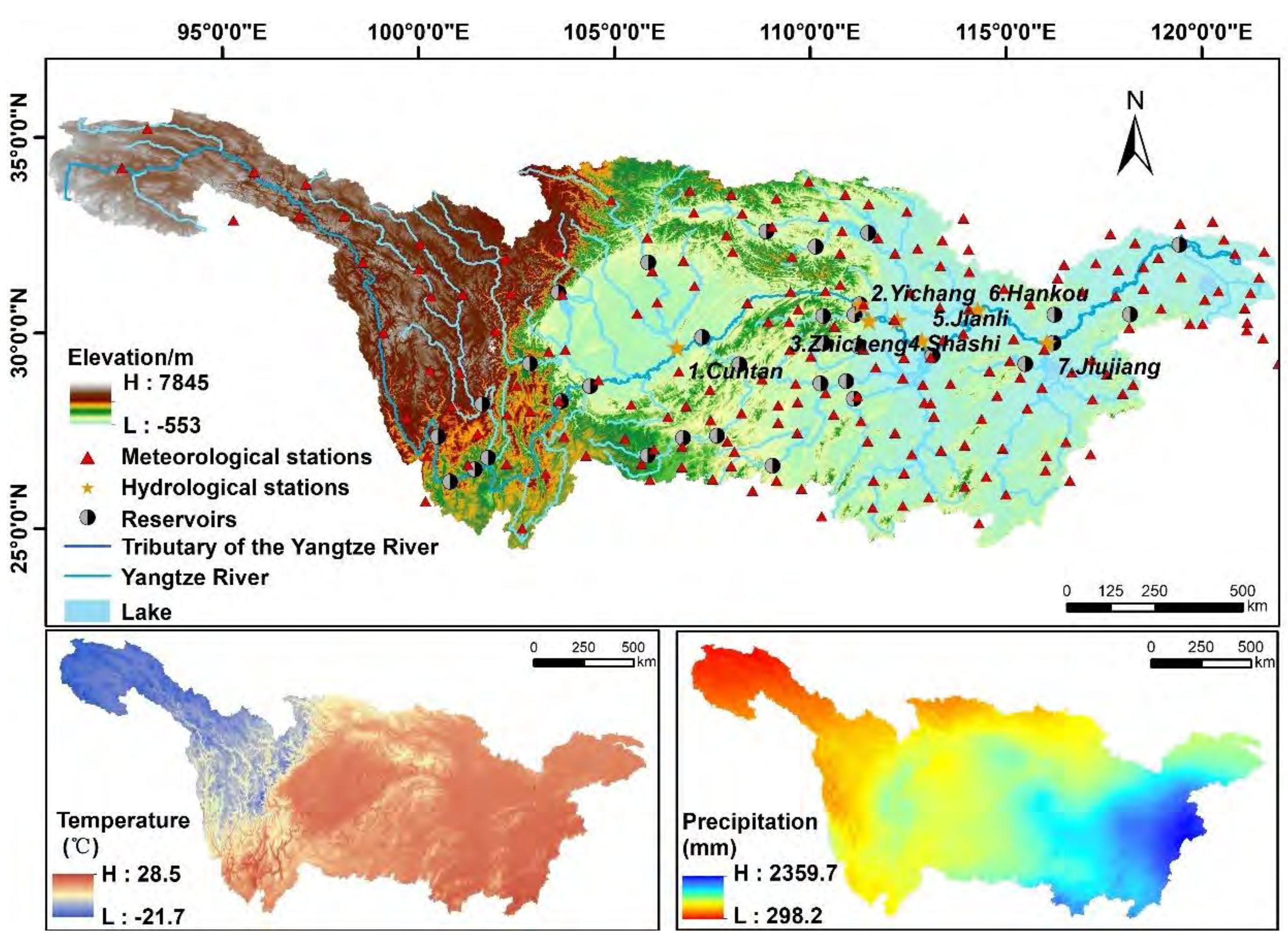
1. Identify the characteristics of daily and monthly meteorological and hydrological events;
2. Analyze the specific variations in meteorological and hydrological drought-flood abrupt alternation events;
3. Investigate the impact of cascading reservoirs on the occurrence and propagation between these events.

Methods

● Research framework



● Study area



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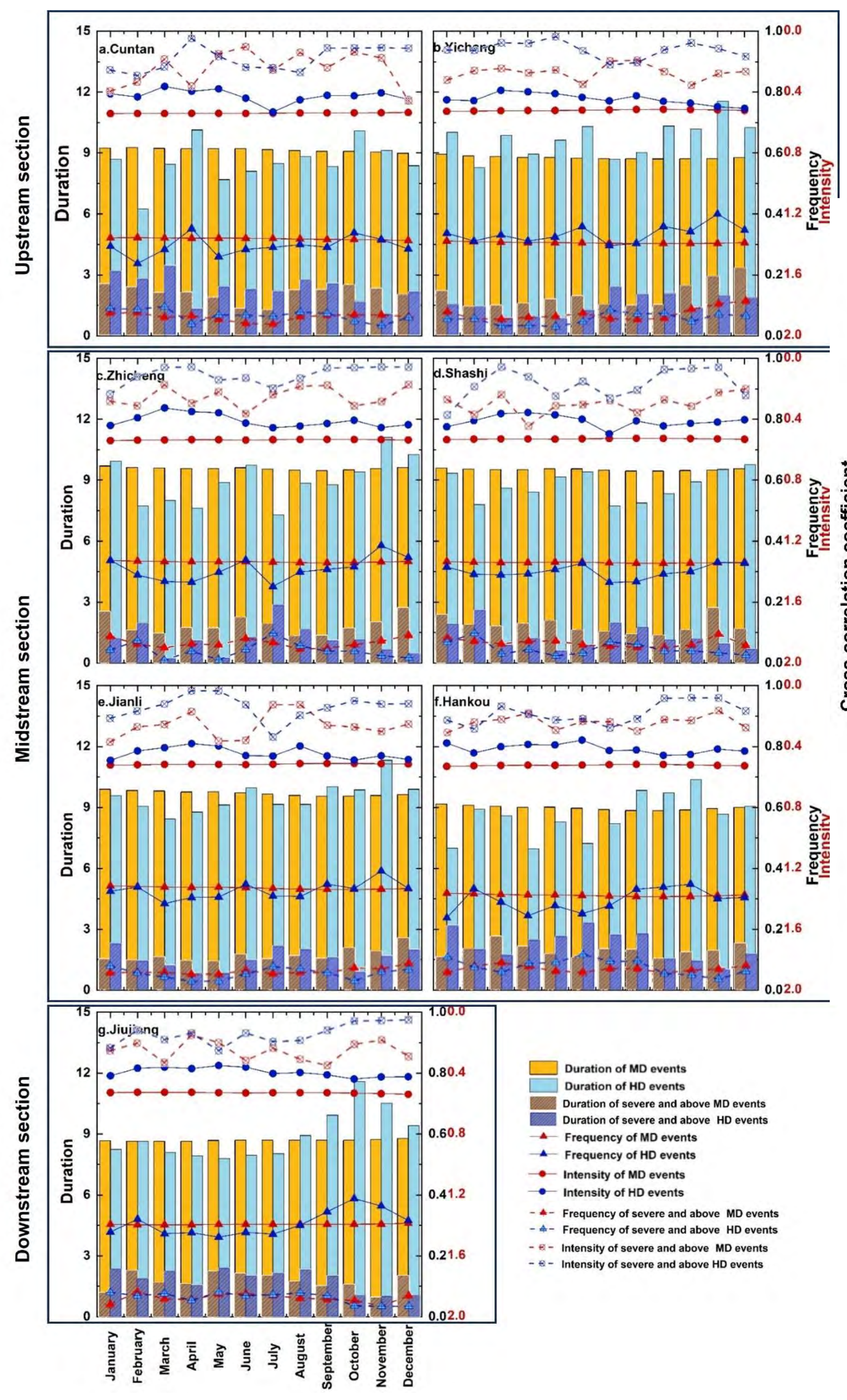
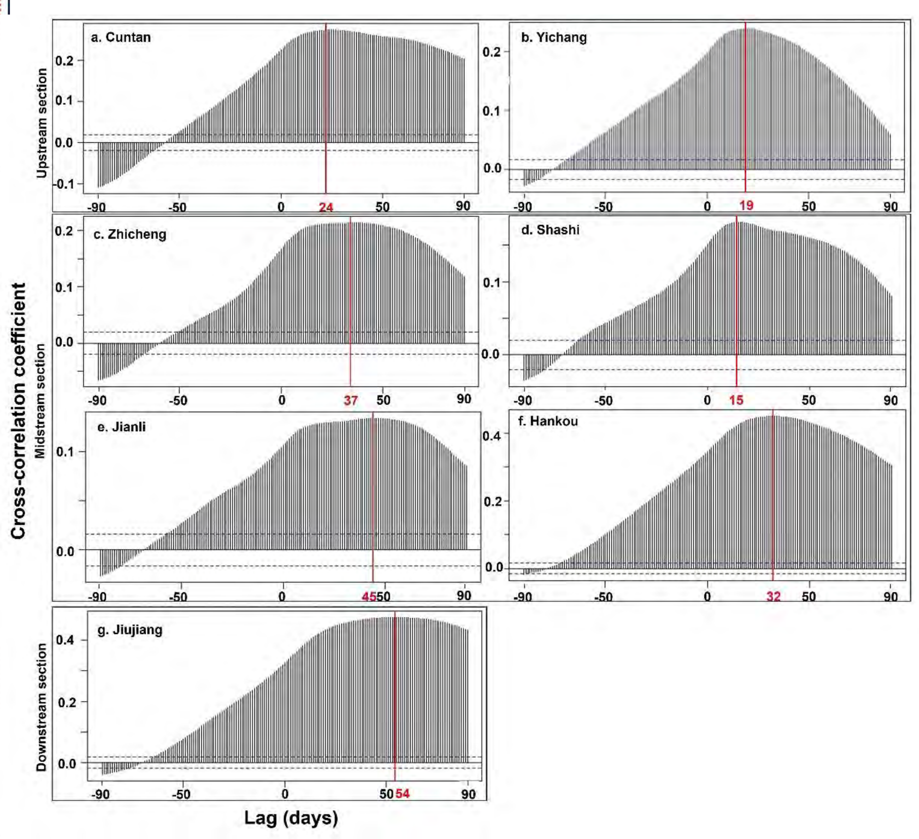
Results

● Characteristics of daily drought events

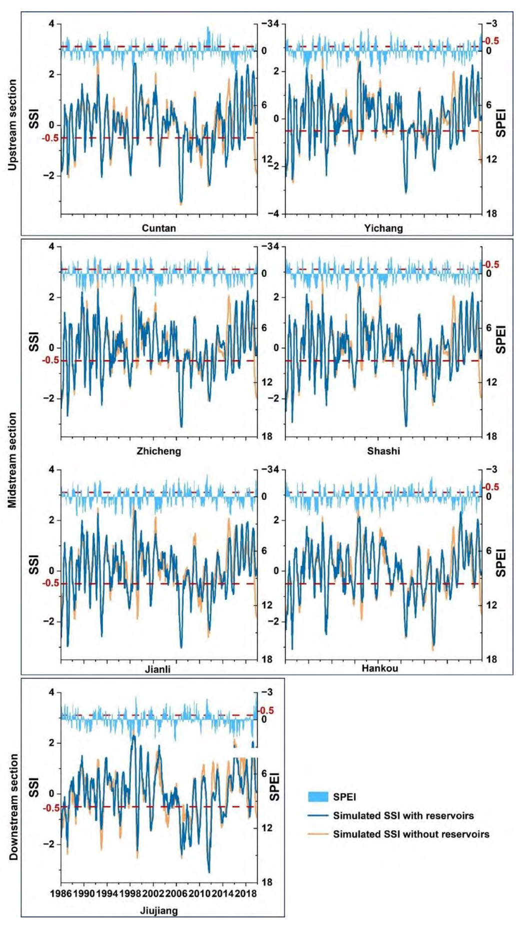


Distribution characteristics of daily MD and HD events in each month in the YRB during 1980--2020 (Duration, Frequency, and Intensity).

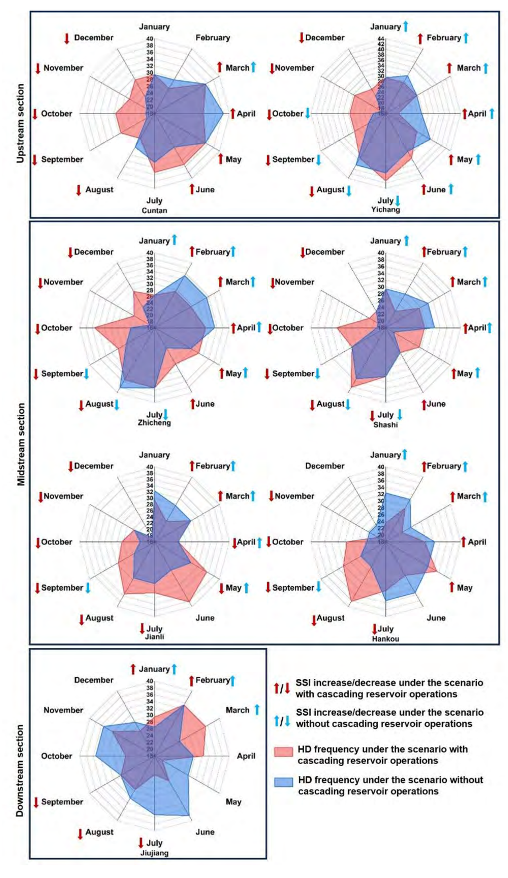


Lag between daily meteorological drought and hydrological drought at each station in the YRB.

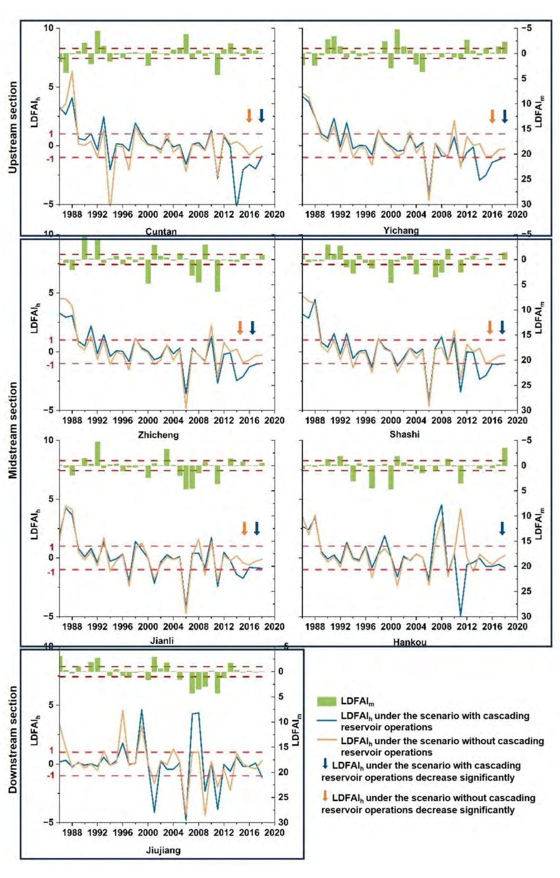
● Influence of cascading reservoirs on drought events



Monthly SPEI and SSI with and without reservoirs at 7 stations from 1986–2020



The radar plots show the frequency of HD under the two scenarios within each month at 7 stations.



$LDFAI_m$, $LDFAI_h$ under the scenario with cascading reservoir operations, and $LDFAI_h$ under the scenario without cascading reservoir operations for 7 stations

Conclusions

1)While the characteristics of daily MD events were evenly distributed within the year and between the years, the frequency and duration of daily HD events during the year were the largest from October to December.

2)The lag days between MD and HD events increases from 22 days in upstream section to 54 days in downstream section.

3)Monthly statistics revealed that MD were most prevalent in the autumn (August to November), while HD were predominantly concentrated in the summer (May to August).

4)The operation of cascading reservoirs increased the frequency and duration of HD events during the year while decreased their intensity.

5)The $LDFAI_h$ in the YRB exhibited a significant declining trend, indicating an overall shift from flood to drought conditions.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

Quantifying above-ground biomass, SOC and erosion with a detailed crop map and PESERA model in the Yangtze River Basin

Author : Jichen Zhou

Supervisor: Xuejun Liu, Lihua Ma, Jantiene E. M. Baartman, Joao Carvalho Nunes, Coen Ritsema

Background

Soil erosion represents a primary threat to soil systems with adverse implications for ecosystem services, crop production, potable water and carbon storage. While numerous studies have quantified the spatial distribution of Above-Ground Biomass (AGB), soil erosion and Soil Organic Carbon (SOC) in the Yangtze River Basin (YRB), limited attention has been given to assessing the contributions of different land use types and especially crop types to AGB, soil erosion and SOC. In most studies, cropland is taken as a land use class, while detailed crop types and rotation patterns, and their effect on soil erosion and SOC, vary significantly.

Objectives

Seven single crop types and seven common crop rotation types were incorporated into the land use map using the Metronamica model to create a detailed crop map.

Using this new land use and crop distribution map, the revised Pan-European Soil Erosion Risk Assessment (PESERA) model was applied to spatially quantify soil erosion, SOC, and soil biomass patterns in the YRB.

Study site

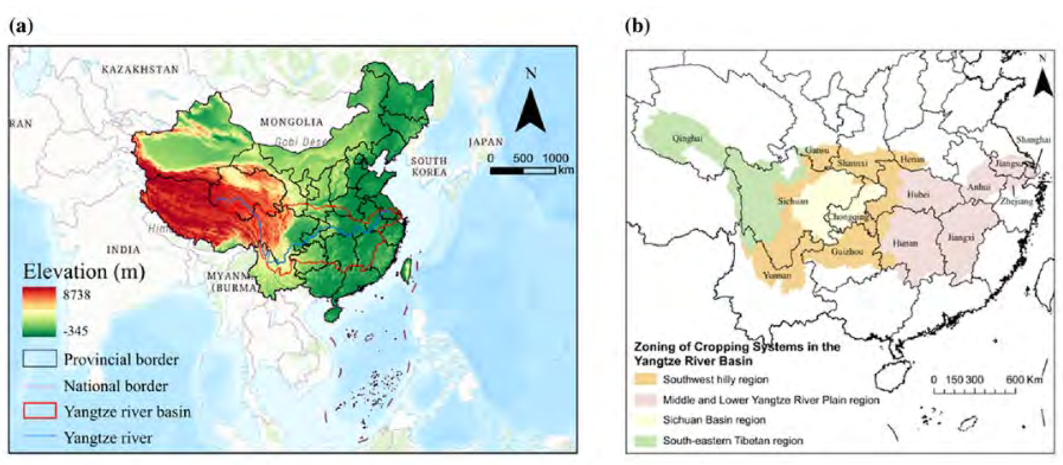


Fig. 1 Elevation for Yangtze River Basin, for China, with the Yangtze River Basin highlighted by the red frame (a). Climate zones as used for Yangtze River Basin to vary crop calendars by agroclimatic zone (b).

Methods

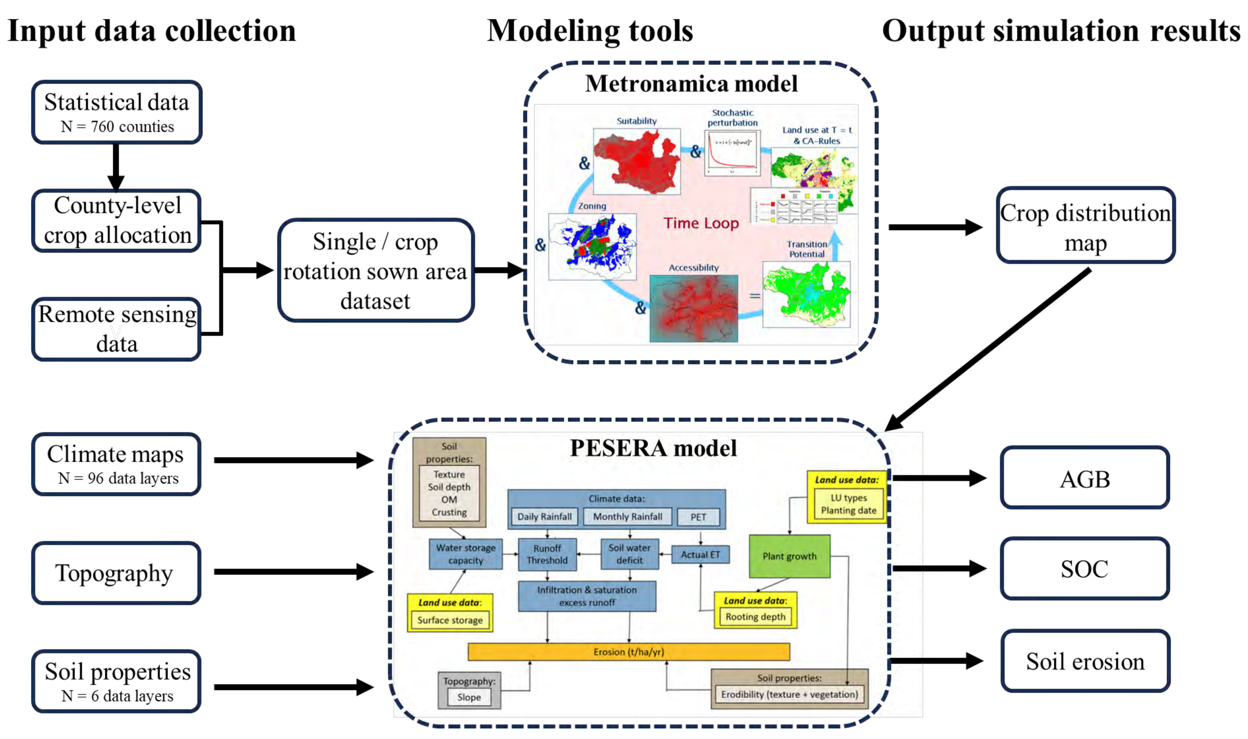
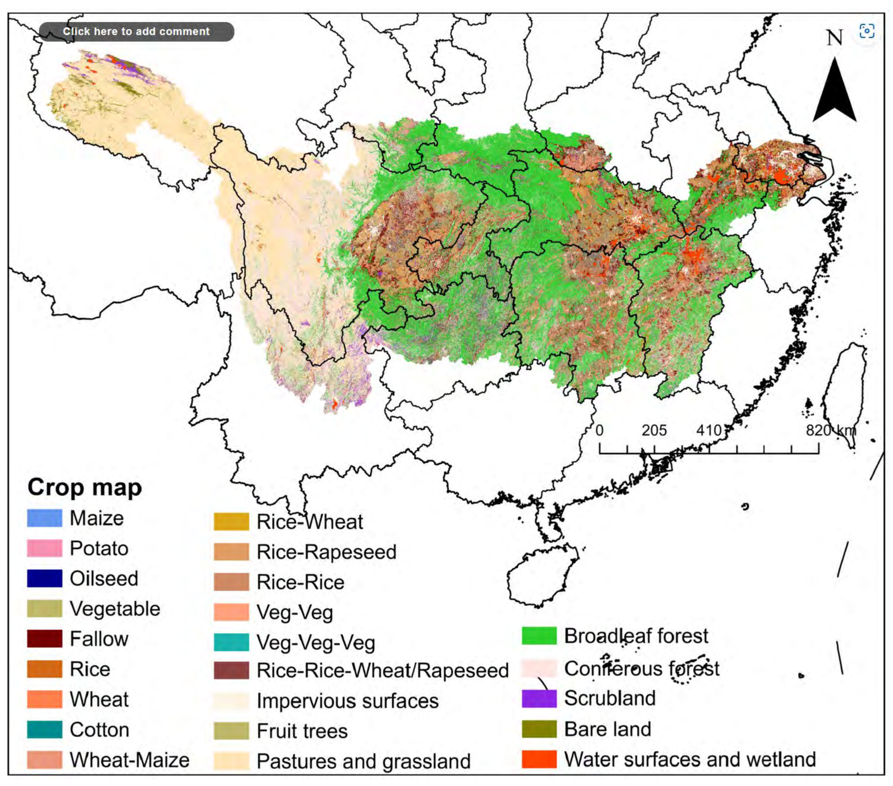


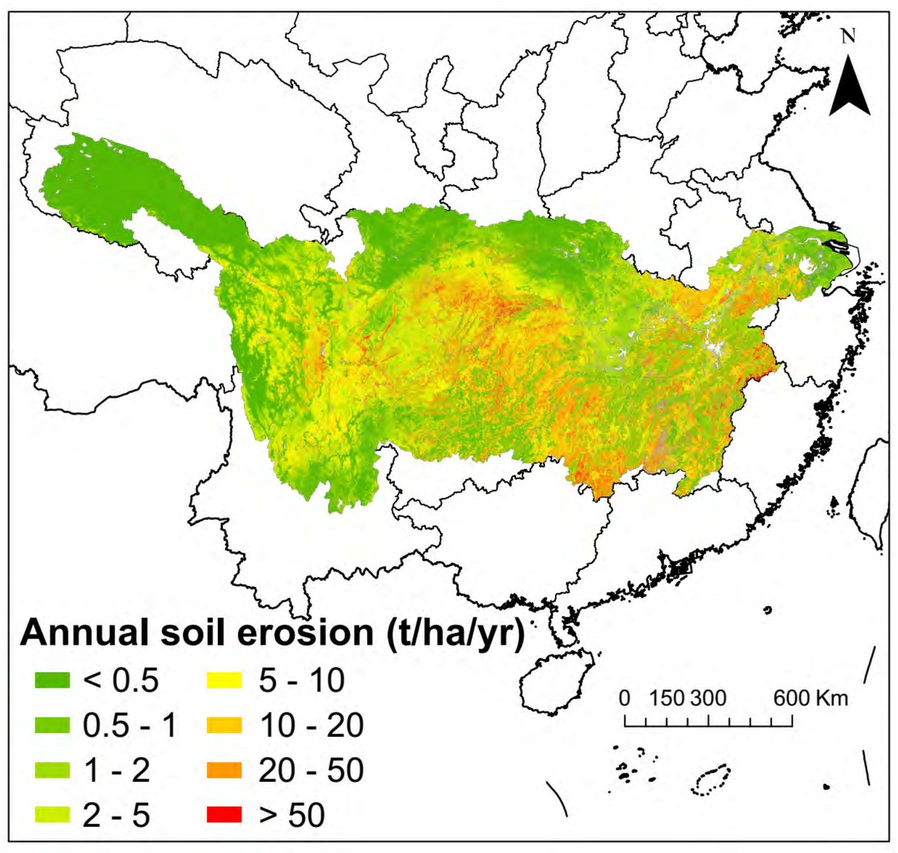
Fig. 2 A schematic workflow for the spatiotemporal distribution assessment of soil erosion, soil organic matter and biomass using the Metronamica and Pan-European Soil Erosion Risk Assessment (PESERA) models.

Results



Within cropland, across the entire YRB, the most prevalent cropping patterns, excluding fallow lands, are rice-rice (16.3%), rice-rapeseed (10.9%), wheat-maize (10.6%) and rice-wheat (7.6%). Monoculture crops such as rice (3.3%), maize (1.3%) and wheat (1.1%) constitute a smaller proportion.

Fig. 3 Land use and crop map for Yangtze River Basin.



Overall average erosion for the entire YRB was simulated at 8 t/ha. Hotspots of soil erosion were concentrated in the Sichuan Basin and the Central-southern region while lower rates of soil erosion were found in the Northwestern region and the Yangtze River Delta.

Fig. 4 Simulated long-term average erosion rates across Yangtze River Basin using the PESERA model.

Table. 1 The amount of SOC/soil erosion/AGB for each land use type.

Land use/ crop	SOC (g/kg)	Soil erosion (t/ha)	Soil erosion (%)	AGB (t/ha)
Artificial	-	1.62	0.56	-
Fruit trees and berry plantations	16.27	9.07	2.24	37.23
Pastures	21.33	2.64	6.93	1.25
Forest - broadleave	23.86	5.22	19.06	93.76
Forest - coniferous	26.28	3.54	8.09	171.78
Shrubs	16.59	5.86	1.38	14.20
Bare land	0.00	2.17	0.20	-
Arable land	9.04	17.61	61.79	4.91

Artificial land, bare land and pastures showed the lowest erosion rate, while arable land and fruit trees showed the highest erosion rate. Forests had the highest AGB and SOC, while pasture had the lowest AGB.

Table. 2 The amount of SOC/soil erosion/AGB for each crop type.

Land use/ crop	Soil erosion (t/ha)	Soil erosion (%)	biomass (t/ha)
Maize	21.41	1.02	5.64
Potato	29.33	2.32	0.97
Oilseed	22.24	1.63	3.03
Vegetable	13.27	3.32	1.84
Fallow	32.48	26.63	0.01
Rice	12.06	1.39	5.36
Wheat	12.64	0.50	4.15
Cotton	8.84	1.20	3.29
Wheat-Maize	17.86	6.70	7.98
Rice-Wheat	7.10	1.90	10.14
Rice-Rapeseed	10.00	3.84	6.30
Rice-Rice	12.58	7.25	8.47
Veg-Veg	12.72	1.32	3.06
Veg-Veg-Veg	13.46	1.04	4.15
Rice-Rice-Wheat/Rapeseed	8.81	1.48	8.55

Within the arable land, the highest erosion rates and the lowest AGB were simulated in fallow land and potato land, while the lowest erosion rate and highest AGB were simulated in rice-wheat rotation land.

Conclusions

Crop distribution map on the YRB was built using Metronamica model.

Soil erosion, SOC and AGB were simulated by PESERA model.

Erosion hotspots concentrated in the Sichuan Basin and the Central-southern region.

Our findings enable a better understanding of the spatial-temporal distribution of SOC, AGB and soil erosion, as well as the contributions of different land use and crop types to them.

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We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043)

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Modelling *Escherichia coli* concentrations in rivers in China: hotspots and sources

PhD candidate: Songtao Mei
CAU supervisor: Kai Wang
WUR supervisor: Nynke Hofstra, Carolien Kroeze
External supervisor: Heike Schmitt (RIVM)

Background

Escherichia coli (*E. coli*) is identified as a bacteria of international concern by WHO, as being resistant to commonly used antibiotics in the clinic. Certain *E. coli* strains are pathogenic, such as *E. coli* O157:H7, that could cause a variety of diseases including diarrhea, hemolytic uremic syndrome and hemorrhagic colitis, etc. There is a lack of data on concentrations of *E. coli* in rivers in many regions in China due to the difficulty of monitoring. To better understand the *E. coli* pollution in rivers in China, a water quality model for *E. coli* simulating the bacteria load to rivers and the concentrations in rivers in China is developed.

Research objective

To contribute to a better understanding of *E. coli* pollution in rivers in China, gain insights into hotspots of high concentrations and the contribution of various sources.

Methdology

The Global Waterborne Pathogen (GloWPa) model (Vermeulen et al., 2019) is adapted for the simulation of *E. coli*. The model is developed with a spatial resolution of 0.5°×0.5° on a monthly time step and represent the year of 2020.

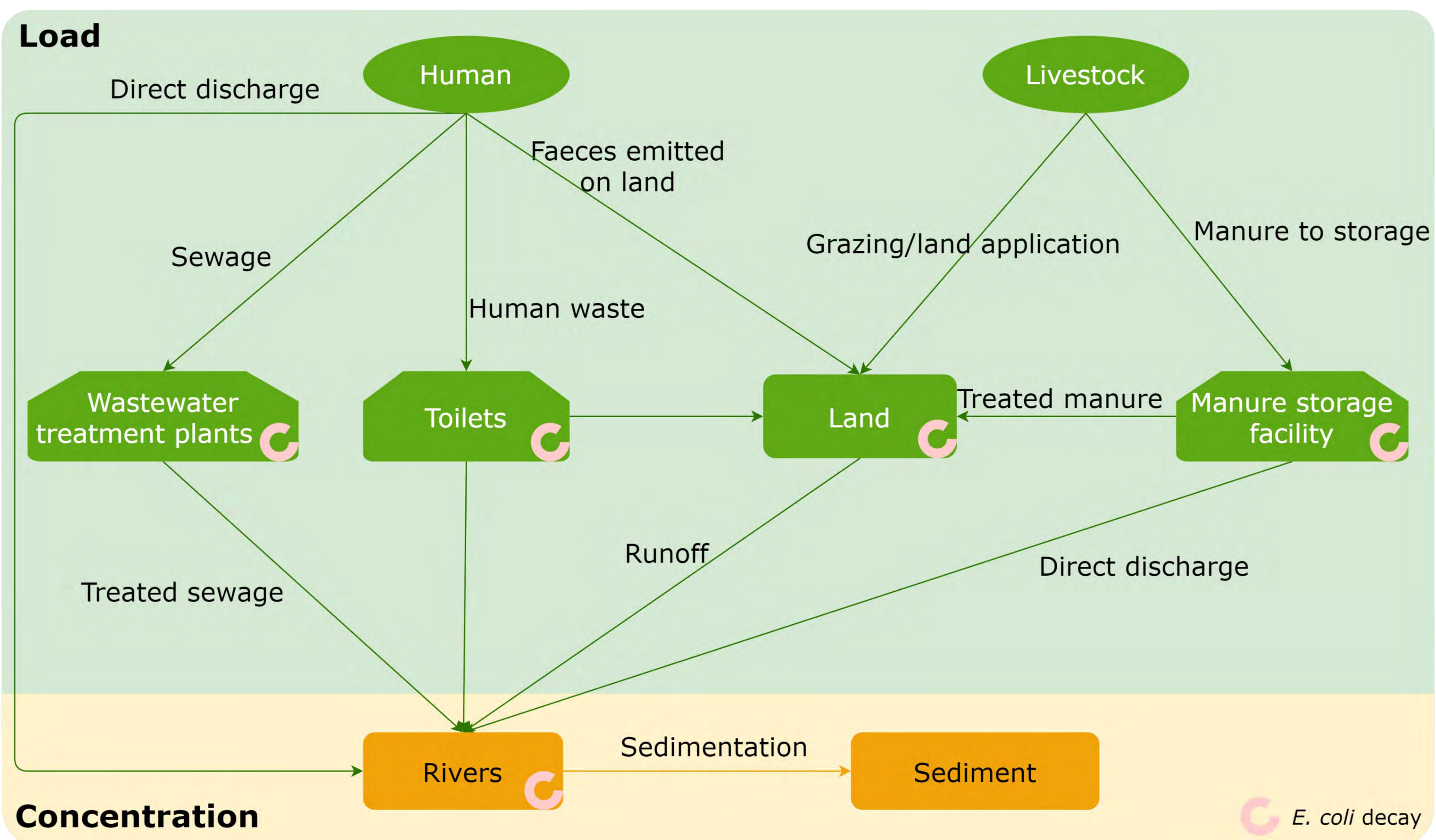

Figure 1. Framework of the *E. coli* model

Results

- Hotspots of *E. coli* pollution are Haihe, Huaihe and Pearl River Basins, middle and downstream areas of Yellow and Yangtze River Basins.

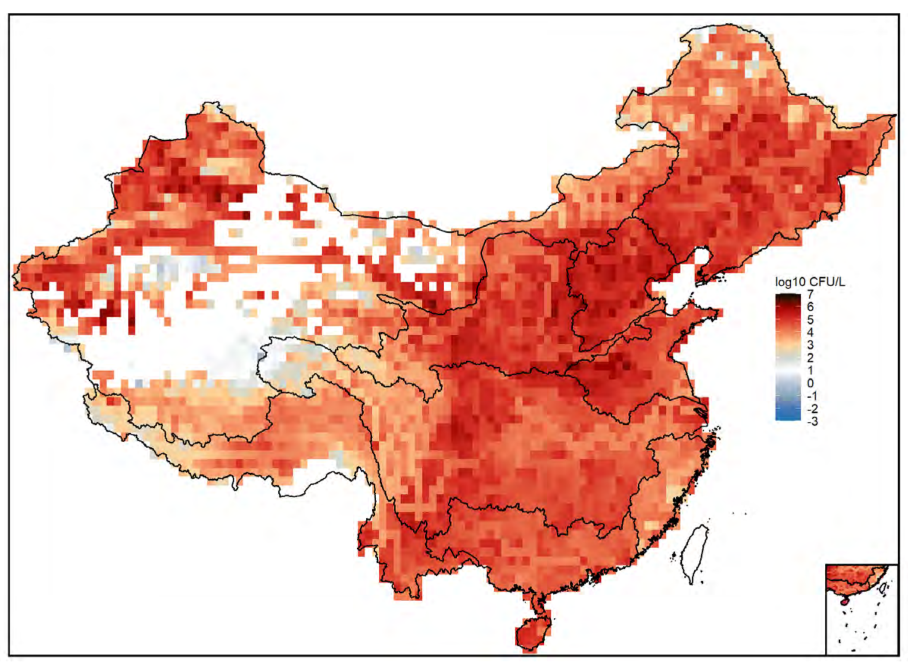

Figure 2. Annual average *E. coli* concentrations in rivers

- Water quality assessment based on modelled *E. coli* concentrations indicates inferior results compared to evaluations reported in China Ecological Environment Quality Bulletin.

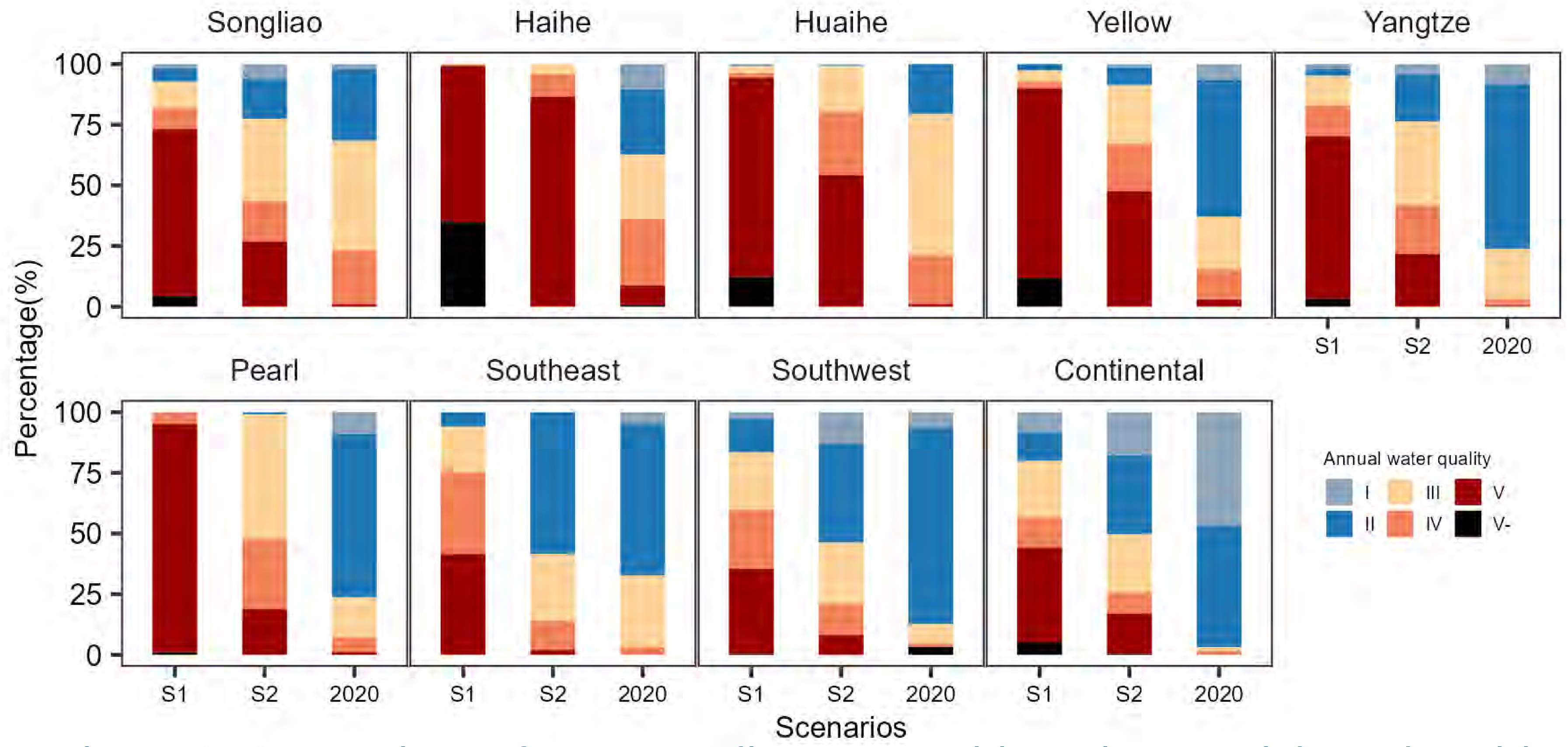

Figure 3. Comparison of water quality assessed based on model results with China Ecological Environment Quality Bulletin (S1: part of human and livestock waste is directly discharged into rivers; S2: no waste is directly discharged)

- Main source of *E. coli* in rivers are direct discharges from human and livestock and emissions from wastewater treatment plants (WWTPs).

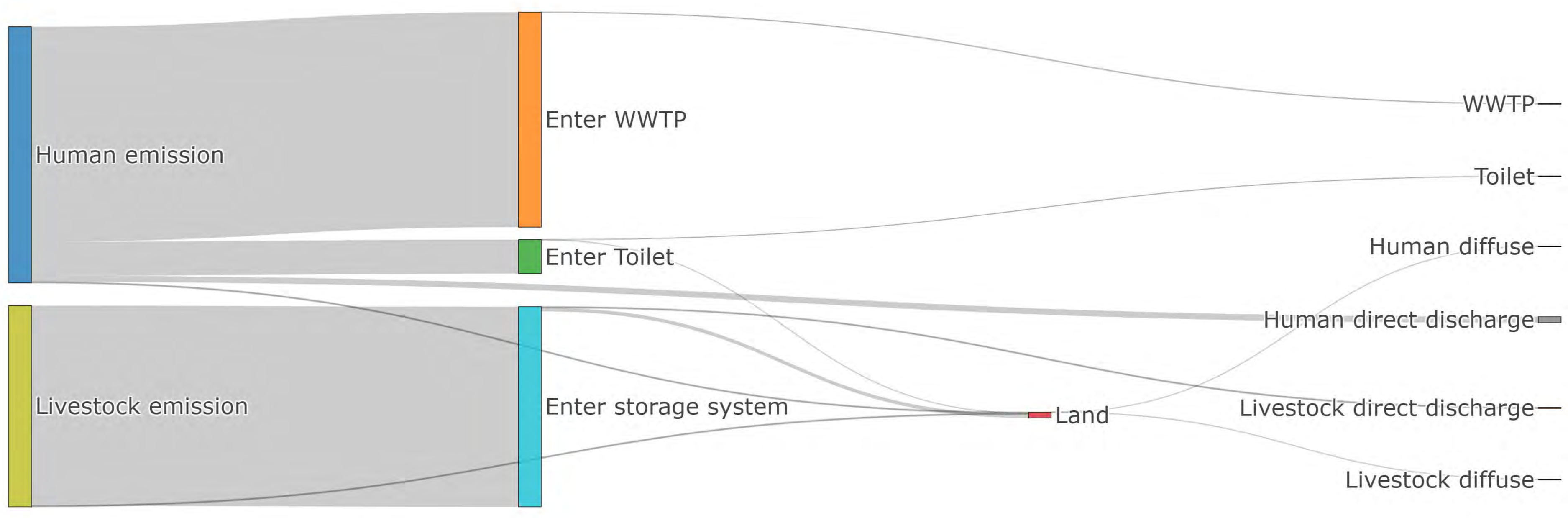

Figure 4. *E. coli* load flow from sources to rivers

Conclusion

- Hotspots of high *E. coli* concentrations are Haihe, Huaihe, Pearl, middle and downstream areas of Yellow and Yangtze River Basins.
- Direct discharge of fecal waste from human and livestock to rivers are the predominant *E. coli* sources, followed by WWTPs.
- The priority to reduce *E. coli* concentrations in rivers in China is the proper collection and treatment of human and livestock waste.

References

Vermeulen, L. C., van Hengel, M., Kroeze, C., Medema, G., Spanier, J. E., van Vliet, M. T., & Hofstra, N. (2019). Cryptosporidium concentrations in rivers worldwide. *Water research*, *149*, 202-214.

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Macro- and micro-plastic accumulation in soils under different intensive farming systems: a case study in Quzhou county, the North China Plain

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Background

Macroplastics (MaPs) and microplastics (MiPs) pollution in agricultural soil raise great concern. However, the knowledge gap persists regarding the diagnosis of MaPs/MiPs in soil among different farming systems. Farming systems play a pivotal role in influencing the occurrence and characteristics of MiPs and MaPs, as various agriculture management practices could effect on the input of MiPs and MaPs, as well as fragmentation processes of plastics in farmlands (such as tillage frequency and UV exposure).

Objectives

- Compare abundance of MiPs and MaPs among six farming systems.
- Analyze the distribution characteristics of MiPs in terms of size, shape and polymer type.
- Explore the regularities in MiP distribution across different farming systems.

Study sites

We selected Quzhou county, a typical agricultural county in the North China Plain, as a case study to investigate the occurrence characteristics of MiPs and MaPs in six land-use types. They include fields with wheat-maize rotation (n=9), cotton fields (n=6), vegetable fields (n=4), greenhouses without mulching practices (n=4), greenhouse with mulching practices (n=3), and orchards (n=4).

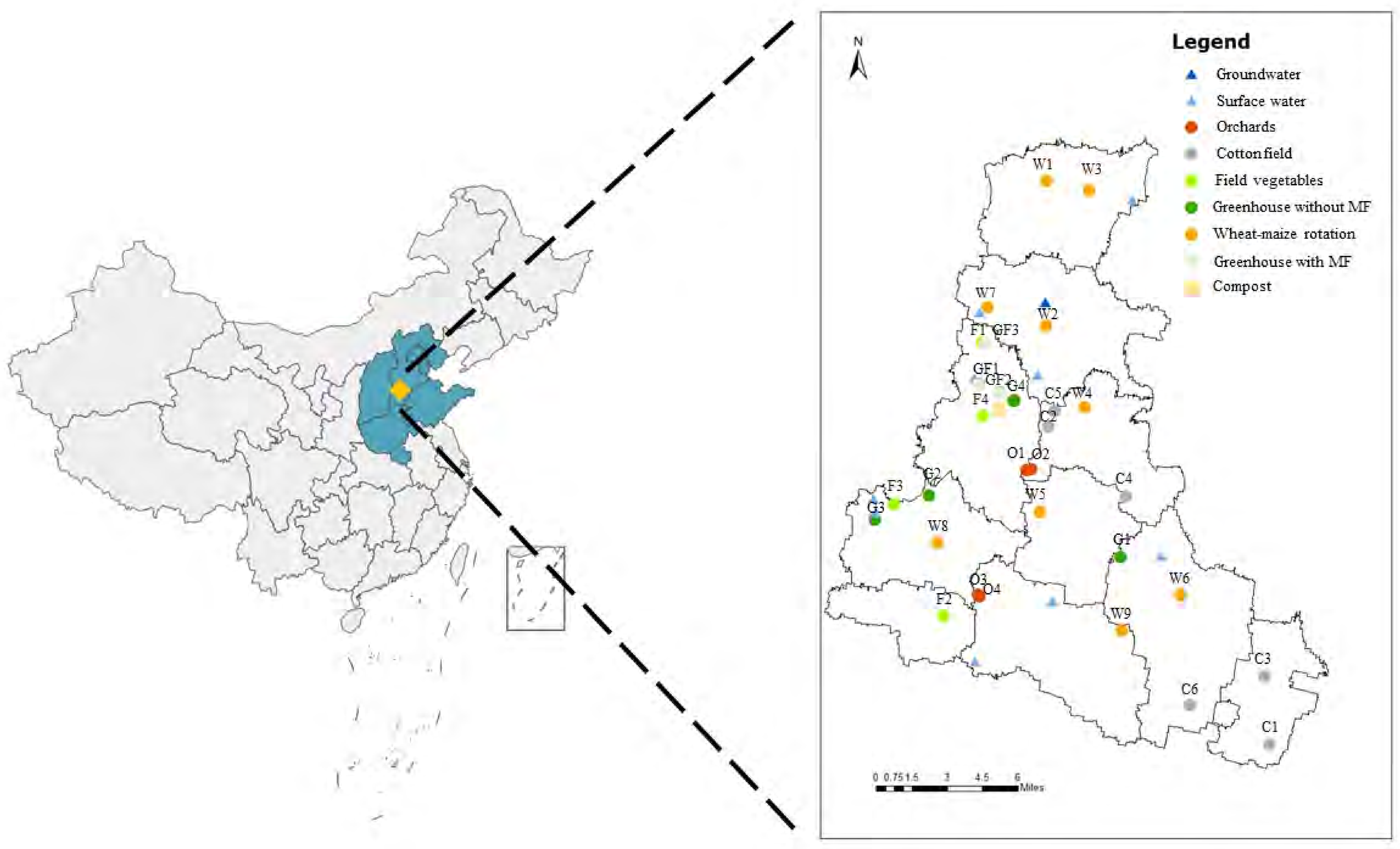

Fig. 1. The location of Quzhou county and the sampling sites of soil, irrigation and compost.

Results 1

- The concentration of MaPs in farmlands ranged from 0.2 to 46.8 kg/ha, with an average value of 20.1 kg/ha.
- A strong significant linear correlation was identified between MaPs and plastic usage over the past five years in Quzhou county.

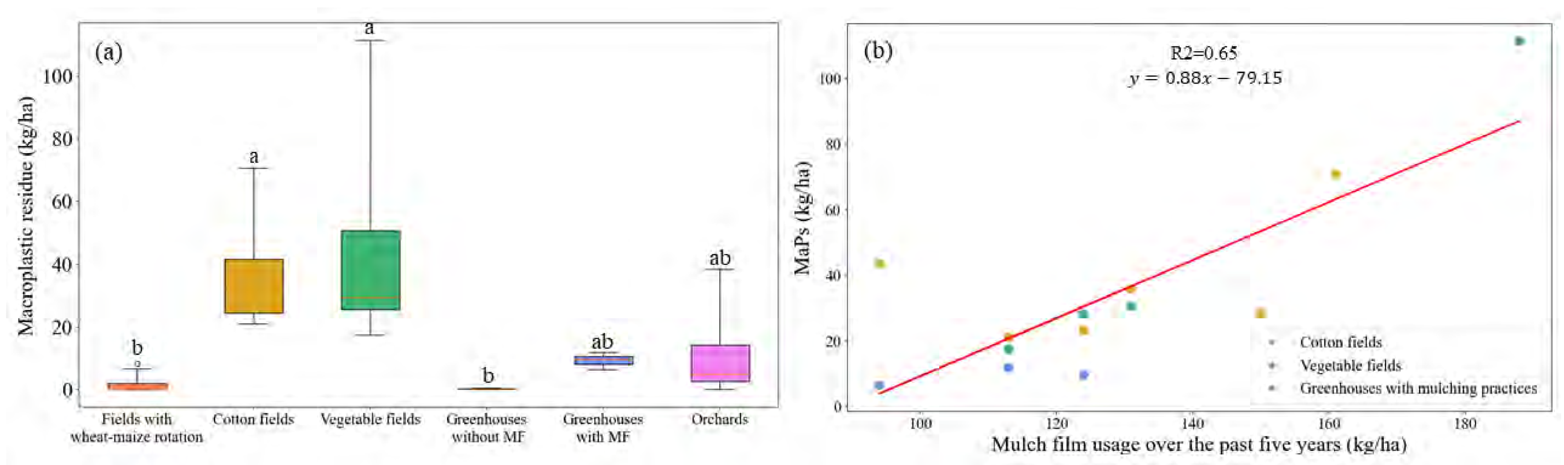

Fig. 2. Concentration of MaPs in six farming systems (left), and the linear correlation between MaPs (kg/ha) and plastic usage over the past five years (kg/ha) (right).

Results 2

- The abundance of MiPs in Quzhou county at depths of 0–30 cm ranges from 4085 to 37669 items/kg. The highest abundance of MiPs was found in cotton fields, followed by orchards and vegetable fields.

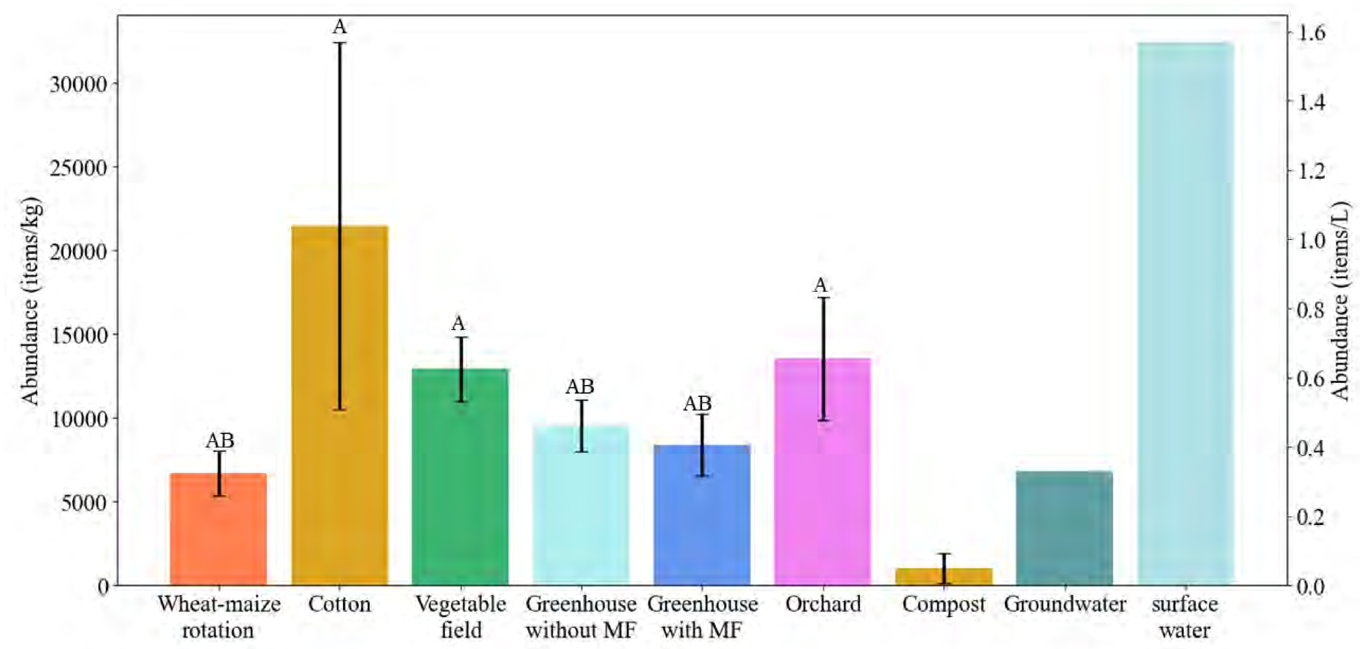

Fig. 3. MiPs abundance in samples of the six land-use types, compost, groundwater and surface water. Different letters indicate significant differences between land-use types ($p < 0.05$).

- The dominant size of soil MiPs was < 1 mm (98%–99%), the main shape was fragment (45%–62%), and the major polymer type was polyethylene (37.5%–42.86%).

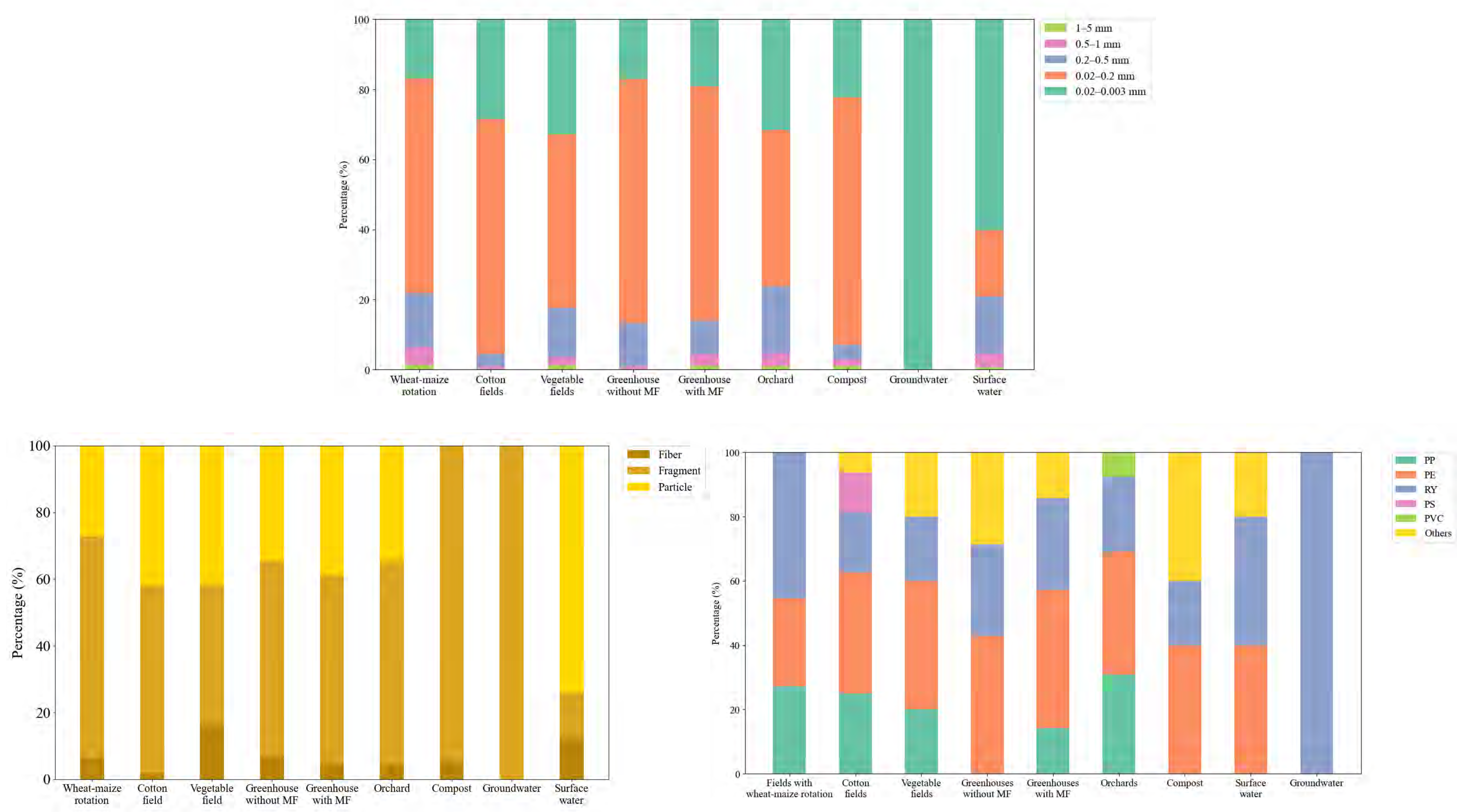

Fig. 4. Size distribution (upper), shape distribution (lower left), chemical composition (lower right) of MiPs in different land-use types.

Conclusion

- Based on the results of MaP distribution, it is noteworthy that plastic films might be the major sources of MaPs in agricultural soil.
- The predominant shape, size and chemical composition of soil MiPs were fragments (45-62%), < 1 mm (98-99%), and polyethylene (38-43%), respectively, indicating that MPs and MaPs in this region might undergo severe fragmentation processes mainly derived by frequent tillage.

Acknowledgements

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Occurrence, distribution, and sustainable environmental management of pesticides in the North China Plain

Mingyu Zhao, Kai Wang, Daniel Figueiredo, Coen Ritsema, Violette Geissen

Background

Pesticides are widely used in crop production to meet global food demand but are also ubiquitous environmental pollutants, causing adverse effects on soil, air, and water quality, biodiversity, and human health. Data acquisition for pesticides is always expensive and labor-intensive through fieldwork. The model approach has become increasingly popular in environmental monitoring methods because of its time-saving and low cost. At present, the loading of pesticides in the North China Plain (NCP) has not been well studied, hindering our understanding of the impact of pesticides on the environment and human health. To quantify the flow of pesticides and assess their adverse impacts, a systematic modeling approach for the sustainable management of pesticides needs to be developed.

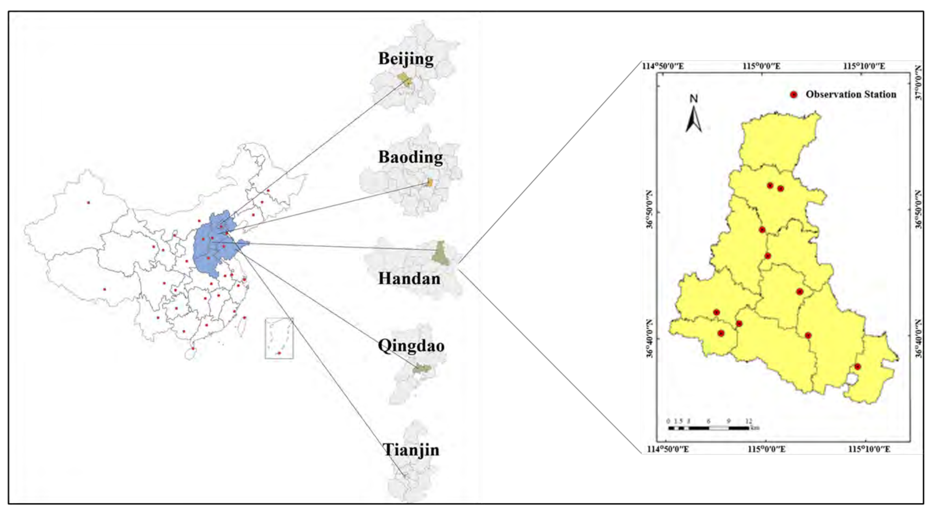
Objectives

Combining field work and modeling to obtain the distribution patterns and potential risks of atmospheric pesticides in the North China Plain.

- Explore the spatial-temporal variations of pesticides across the NCP
- Develop the wind erosion model for particle-phase pesticide
- Assess the risks of pesticides to ecological and human health

Methods

- Field observation: passive air sampling across the NCP



- ➢ Ultrasonic-assisted extraction
- ➢ Rotary evaporation
- ➢ Solid phase purification

Fig. 1 Locations of sampling sites and the analytical procedure

- Modeling approach: Wind erosion model for particle-phase pesticides

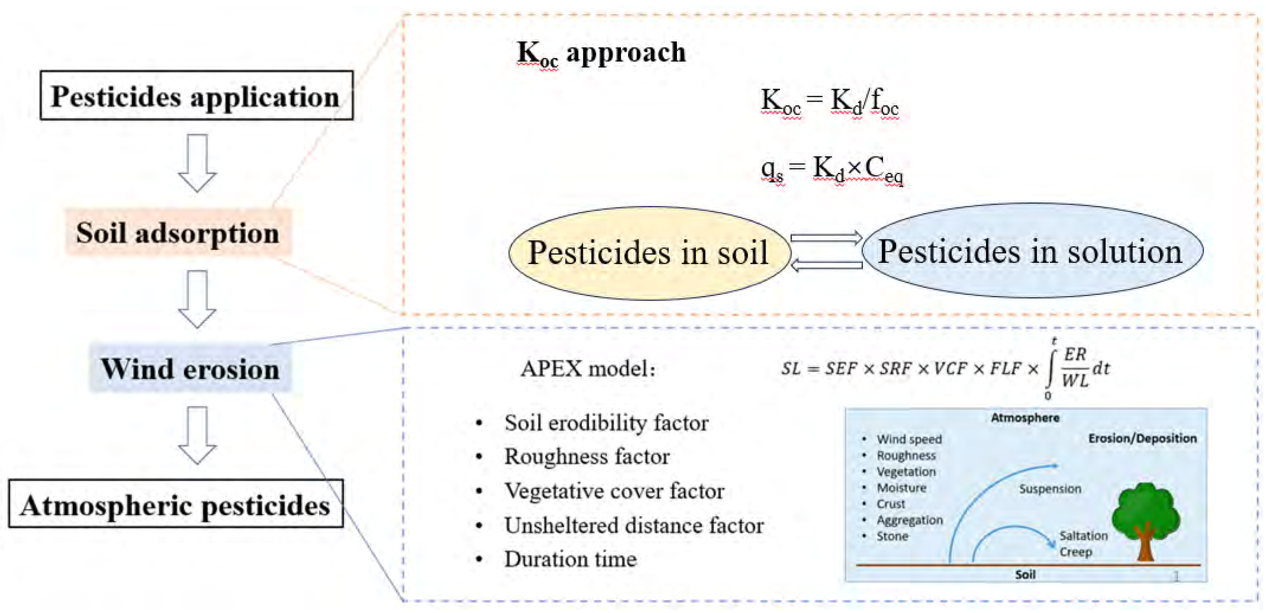


Fig. 2 Framework of wind erosion model for atmospheric pesticides

- Risk assessment: Ecological and human health

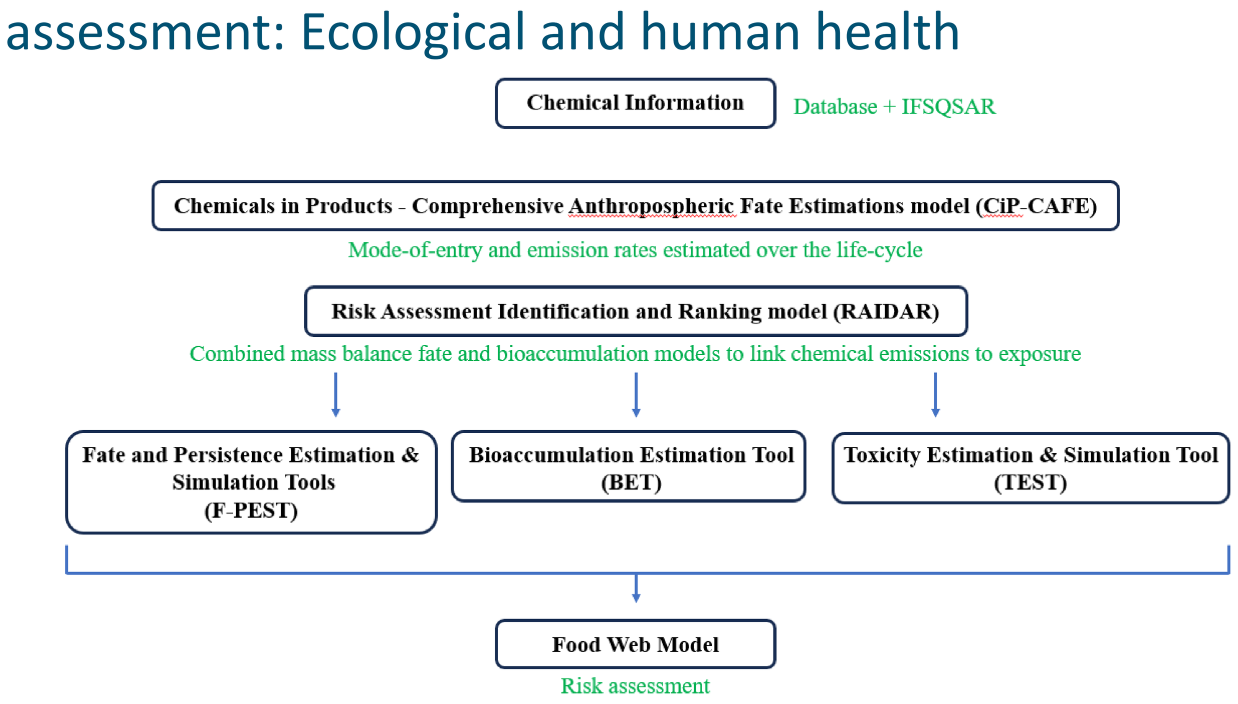


Fig. 3 Framework of the improved risk assessment of pesticide

Results

- Fifty pesticides were detected in the ambient air, all air samples contained at least one pesticide residue
- Chlorpyrifos (97%) and tebuconazole (96%) were the pesticides the most frequently quantified in the NCP
- The concentration of total pesticides in a certain sampling period (months) was in the range of 157–18343 pg m^{-3}

Fig. 4 Spatial-temporal distribution of atmospheric pesticides in the NCP

- Modelled concentrations are within the same order of magnitude as the measured values
- The calculate bias between measured and modelled values was in the range of 0.01–15.44 ng m^{-3}

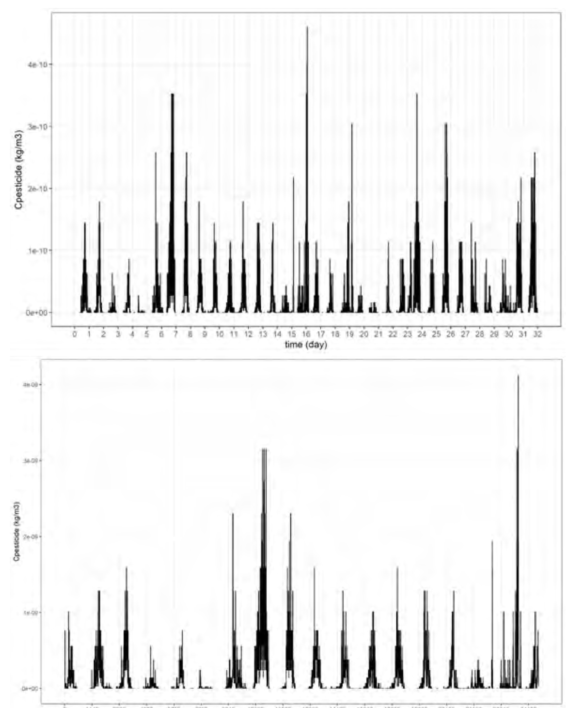


Fig. 5 Model output of particle-phase concentration of pesticides

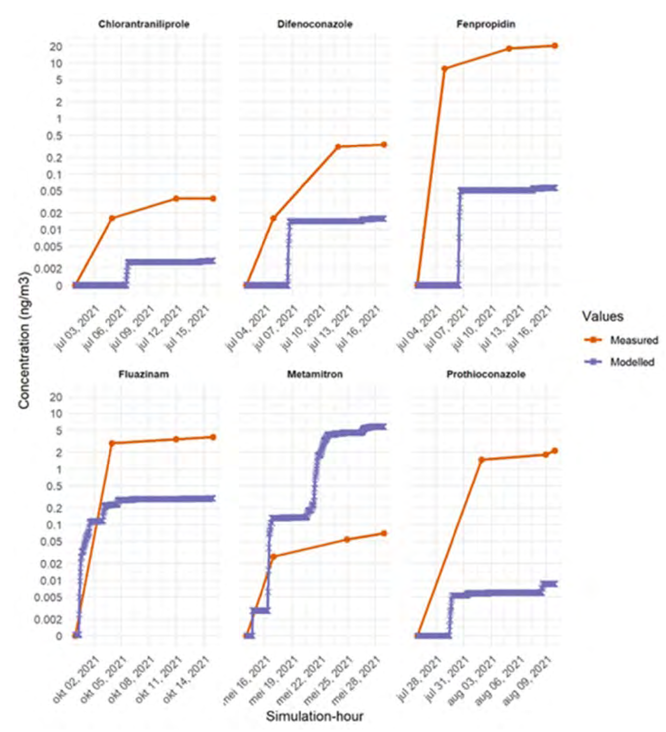


Fig. 6 Modelled and measured cumulative particle-phase pesticides concentration

Conclusions

- ➢ The concentration of total atmospheric pesticides was significantly higher during the warm season compared to the cold season.
- ➢ Fungicides are more prevalent in the megacities of Beijing and Tianjin.
- ➢ The wind erosion model performed well given the available data and for the set of simulated pesticides.
- ➢ The variability of the input data and how this affects the magnitude of the outcome will be explored.

Acknowledgements

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China's efforts in improving cultivated land productivity: A path toward sustainable agriculture

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Supervisors：Dr. Jie Zhang, Prof. Fusuo Zhang, Dr. Luuk Fleskens, Prof. Coen Ritsema

Background

Cultivated land plays an important role in ensuring food security, which is of great significance in achieving the Sustainable Development Goals (SDGs). In recent years, global food security face great challenges with climate change, epidemics, armed conflicts, and other adverse factors. Enormous pressure to maintain food security spurred the implementation of a portfolio of national cultivated land improvement programs (NCLIP) aimed at improving cultivated land productivity (CLP). Developing a framework for quantifying the NCLIP contributions can summarize China's experiences in improving CLP and explore effective pathways for future CLP improvement.

Objectives

- Develop a multi-source data and ensemble learning based framework for analyzing NCLIP contributions;
- Quantify the contribution of NCLIP from 1990 to 2020 in the Huang-Huai-Hai Plain ;
- Analyze the effect and importance of agricultural production conditions, agricultural input and cultivated land soil fertility on cultivated land productivity improvement.

Framework

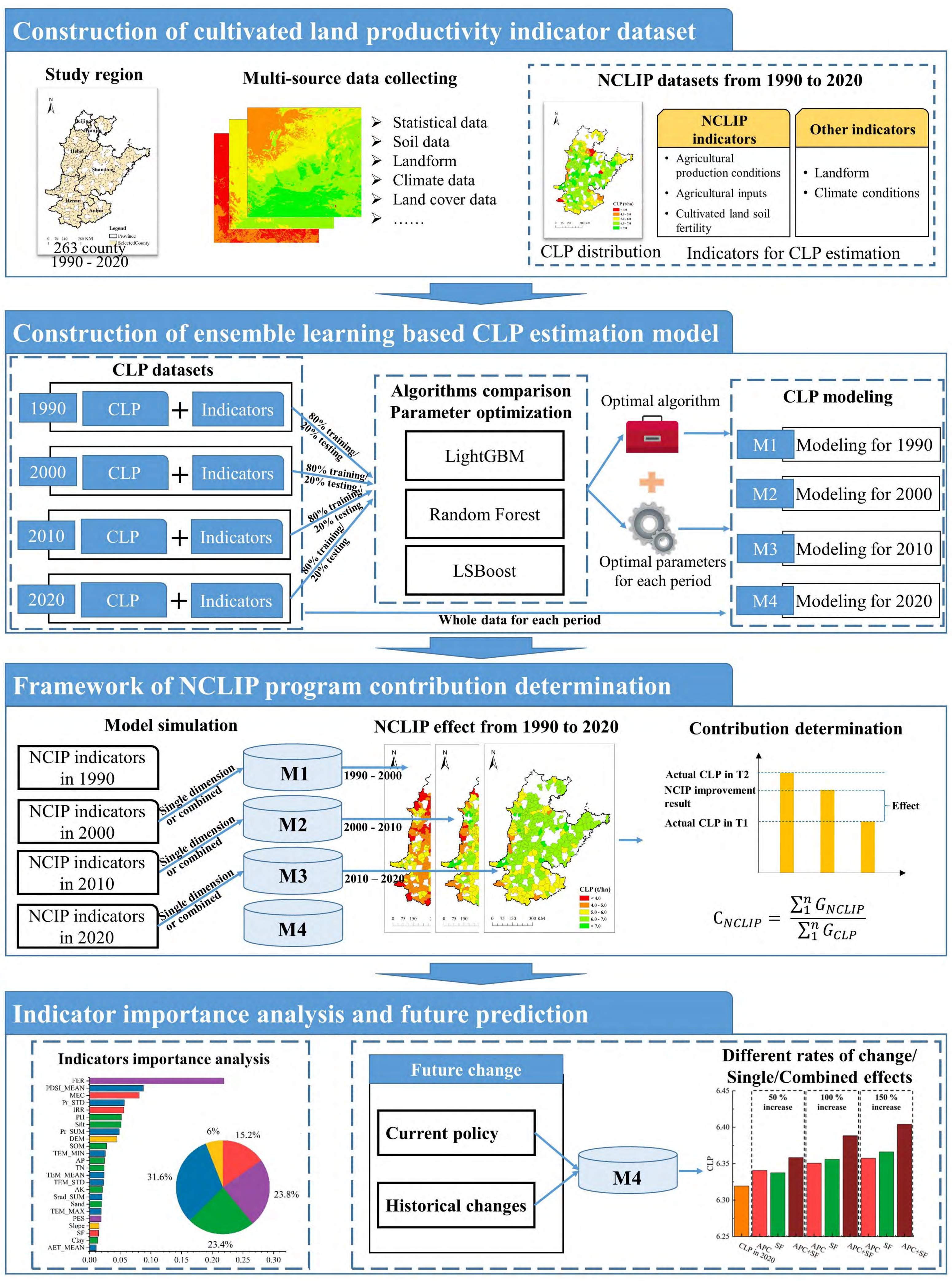

Fig. 1. Framework for analyzing NCLIP contributions.

Result

Total contribution of NCLIP

Based on the LightGBM model, this study estimated the CLP improvement under NCLIP implementation from 1990 to 2020 in Huang-Huai-Hai Plain (Fig.2). Over the past three decades, the NCLIP contributed 53% of total CLP improvement (1.31 t/ha). Spatially, from 1990 to 2000, the NCLIP contribution was more pronounced in the middle region of HHH Plain. After 2000, the NCLIP showed a remarkable effect in the northern and southern regions.

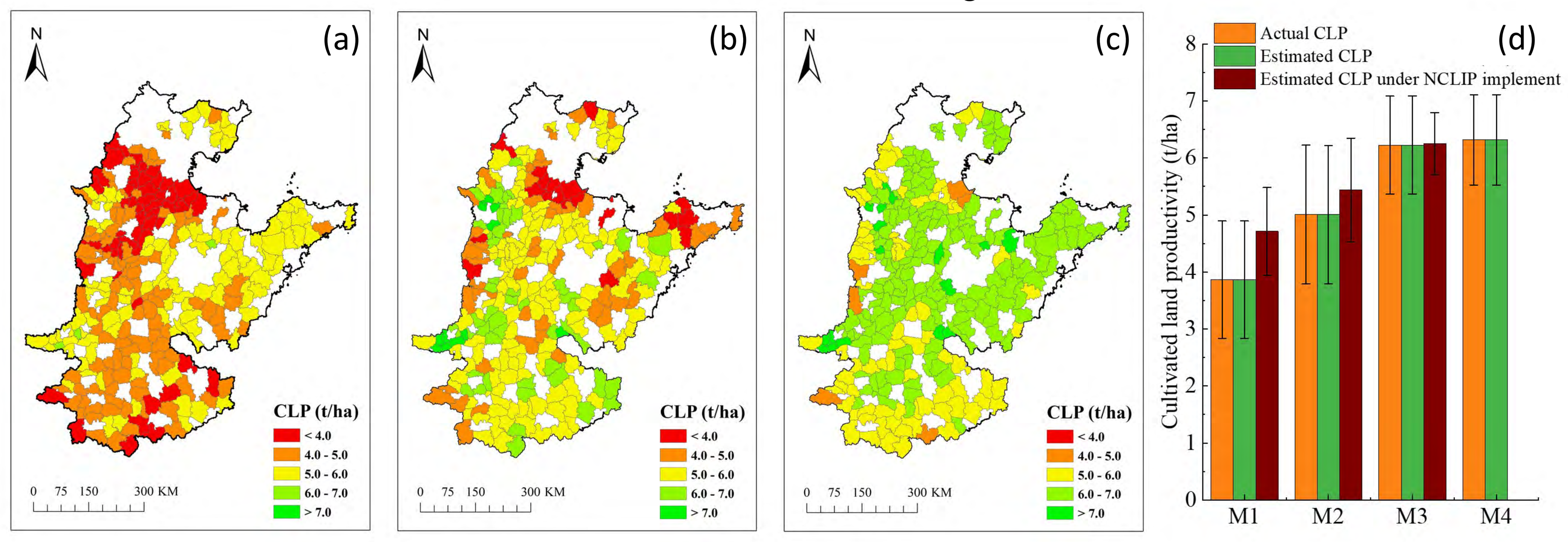

Fig. 2. estimated CLP under NCLIP implement: (a) 1990 - 2000; (b) 2000 - 2010; (c) 2010 – 2020; (d) Statistical result

Dimensional contributions of NCLIP

The effect of three dimensions (agricultural production condition, agricultural inputs and cultivated land soil fertility) of NCLIP programs on CLP were analyzed (Fig. 3). From 1990 to 2020, the effects of agricultural production conditions, agricultural inputs, and cultivated land soil fertility to CLP improvement were 0.42, 0.47, and 0.38 t/ha, respectively. After 2000, cultivated land soil fertility became the primary contributing factor.

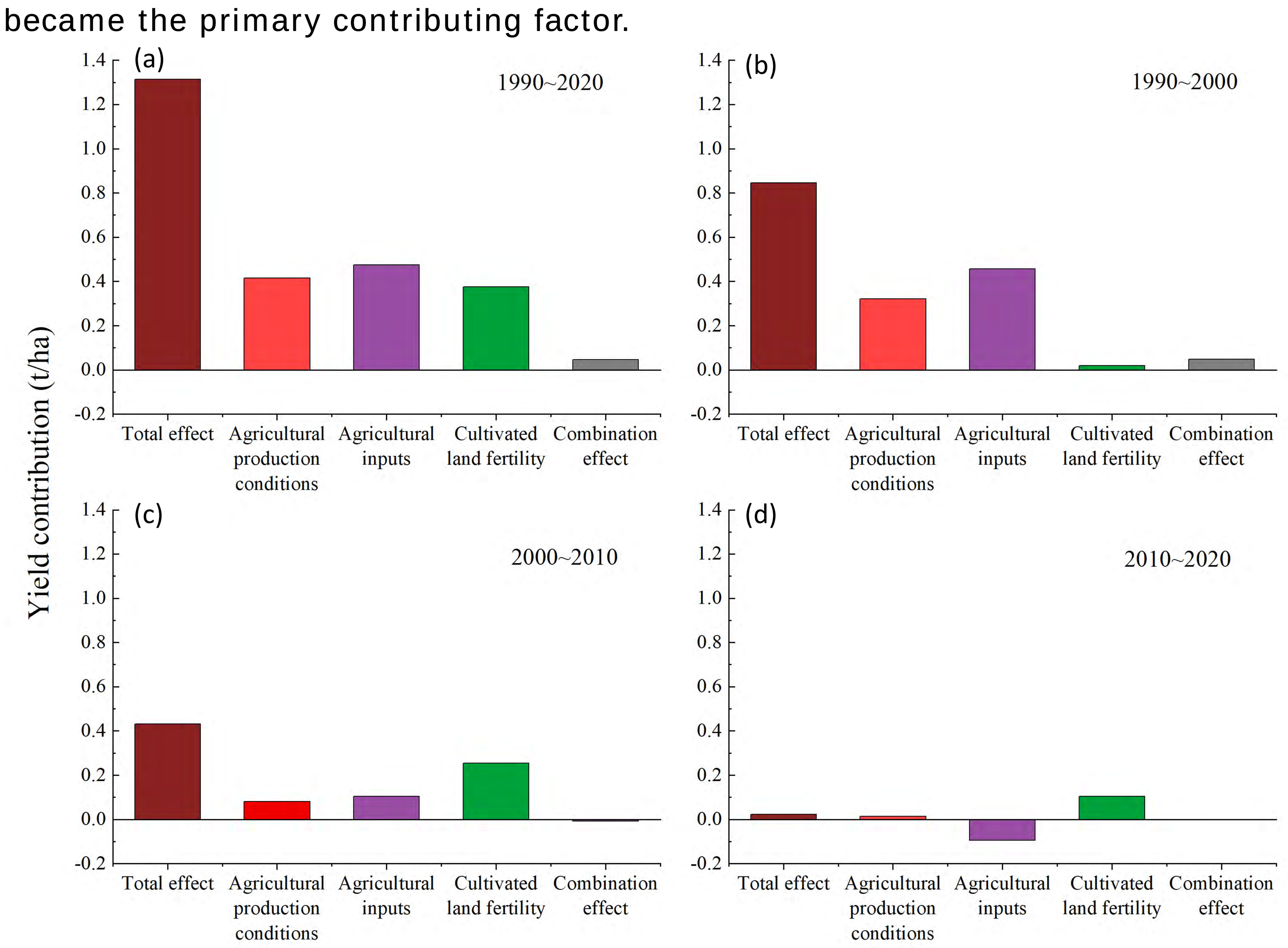

Fig. 3. CLP increase under NCLIP implement and agricultural production condition, agricultural inputs and cultivated land soil fertility improvement, respectively: (a) 1990 – 2020, (b) 1990 – 2000, (c) 2000 – 2010, (d) 2010 – 2020.

Summary

This study developed a framework for analyzing NCLIP contributions. The contribution of NCLIP to cultivated land productivity improvement from 1990 to 2020 were analyzed, which was essential to exploring effective path to improving cultivated land productivity.

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We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043)) and Hainan University.

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Predicting Rhizosphere-Competence-Related Catabolic Gene Clusters with RhizoSMASH

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4. College of Resources and Environmental Sciences, China Agricultural University, Beijing, China

Scan to Check **rhizoSMASH** on WUR GitLab

Background

- The capability of a soil microorganism to colonize the rhizosphere of a plant, known as **rhizosphere competence**, significantly influences the benefits a host plant could receive from their interaction.
- The ability of **catabolizing the compounds in root exudates** is one of most important determinants of rhizosphere competence.
- The diversity of catabolic pathways and the redundancy of catabolic genes have made it challenging to interpret catabolism from a (meta)genomic perspective.

Objectives

- Develop **rhizoSMASH**, a bioinformatic tools to analyze catabolic capacity to utilize root exudate compounds *in silico* based on bacterial genomic sequences.
- Characterize **r**hizosphere-**c**ompetence-related catabolic **g**ene **c**lusters (**rCGCs**) identified by rhizoSMASH and demonstrate their power in prediction of rhizosphere competence.

Methods

Detection of rCGCs is done by capturing enzyme domains with profile hidden Markov models and limiting the combination of these domains with a set of logical rules (detection rules). (Fig 1)

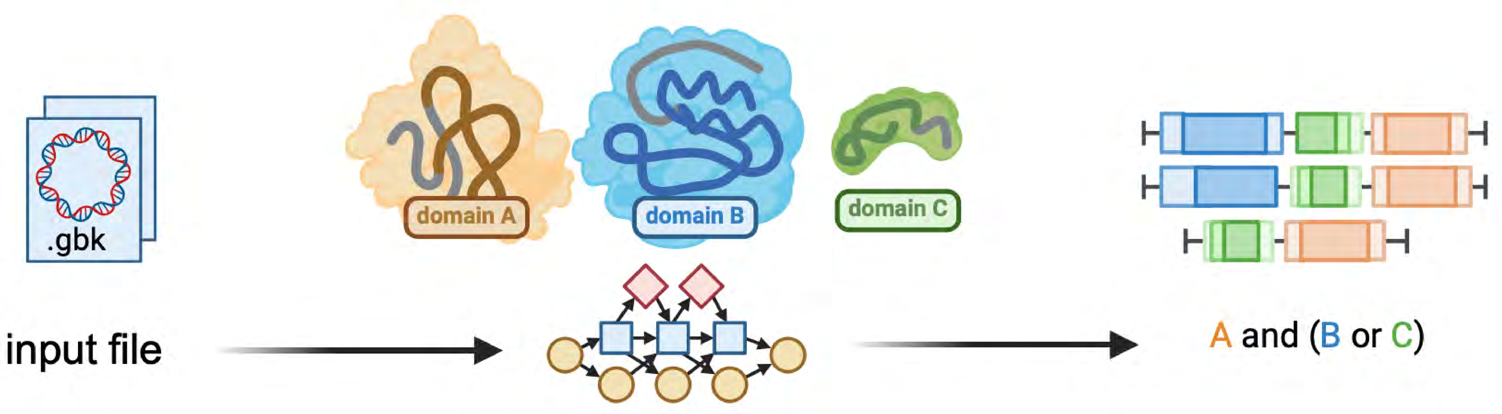


Fig 1. Diagram of the gene cluster detection workflow used by rhizoSMASH.

To compose the detection rules for rhizoSMASH, we ran a literature survey to collect known gene clusters that have 4 levels of confidence on their relation to rhizosphere competence. (Fig 2)

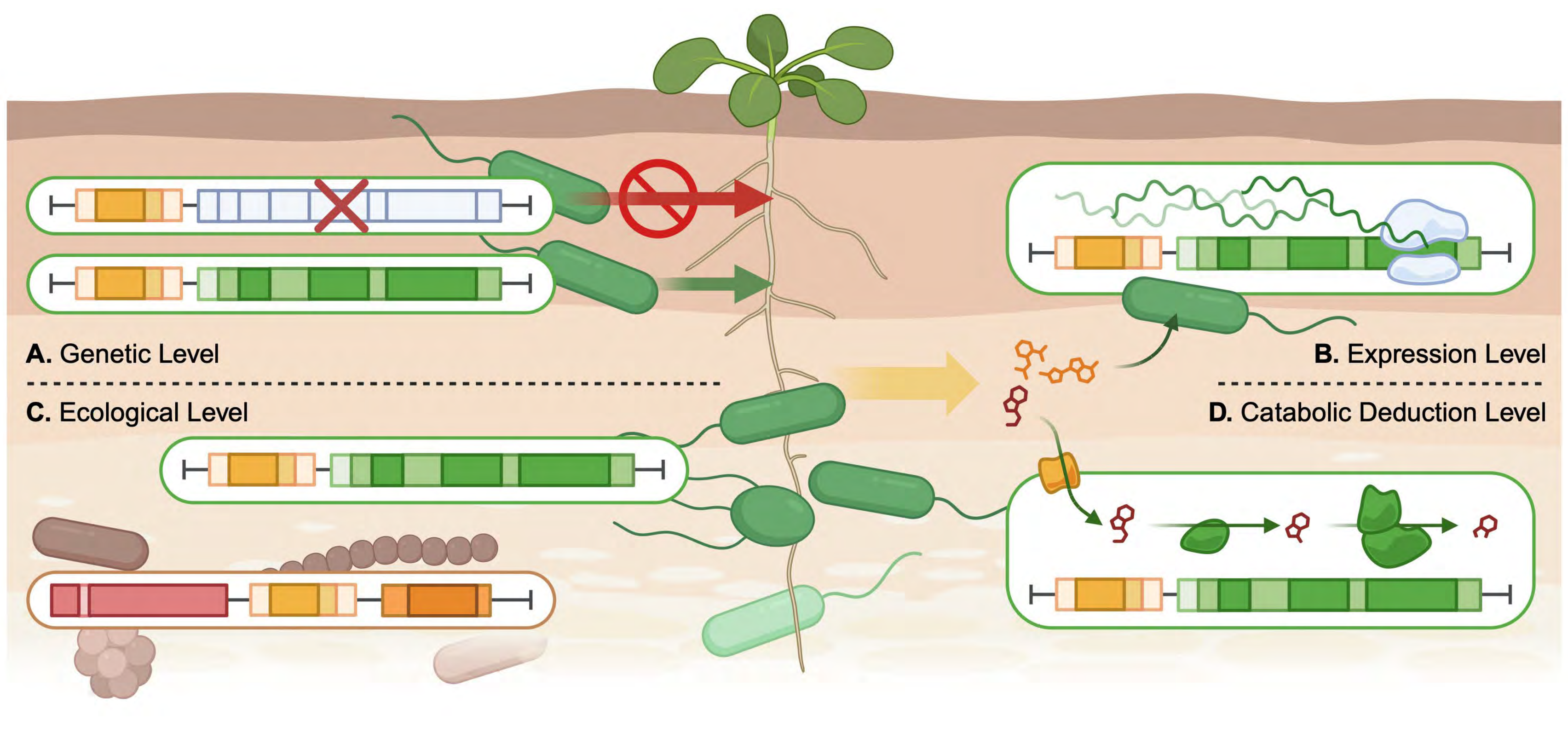


Fig 2. Schematic representation of 4 levels of known rhizosphere-competence-related catabolic gene clusters. **(A)** genetic inactivation of the gene cluster causes rhizosphere incompetence; **(B)** treatment of root exudate (or component) triggers expression of the gene cluster; **(C)** the gene cluster were more often found in rhizosphere-dwelling bacteria; **(D)** the gene cluster encodes a catabolic pathway utilizing a major root exudate component.

The Working Version of rhizoSMASH contains 54 detection rules covering catabolic pathways of carbohydrates, organic acids, amino acids, amines, phytohormones and other secondary metabolites found in root exudates.

Conclusions

RhizoSMASH provides an extensible bioinformatic framework to study catabolism in rhizosphere bacteria, offering new possibilities in agriculture green development via designing of more rhizosphere-accessible synthetic microbiomes or through rhizobacteria-targeted plant breeding.

Results

rhizoSMASH rCGCs revealed diversity and heterogeneity across taxa.

We characterized rCGCs detected by rhizoSMASH from all bacterial genomes in the RefSoil soil microbial genome sequence database. *Pseudomonas* and *Burkholderia* species (abundant genus in the rhizosphere) show the highest rCGC counts and diversity, while *Geobacter*, *Desulfovibrio* and *Dehalococcoides* (anaerobic metal reducers found in deep soils and sediments) show the opposite. (Fig 3)

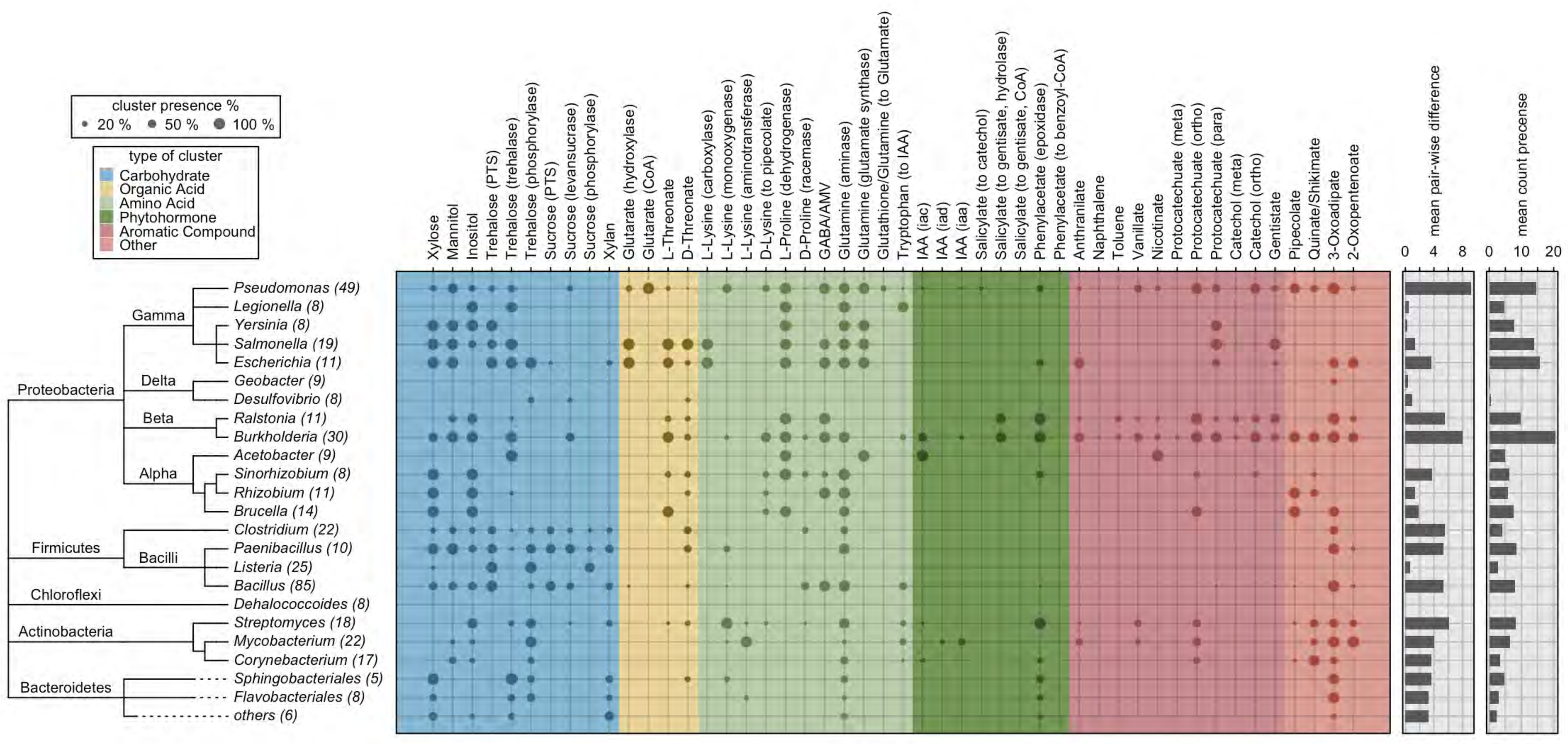
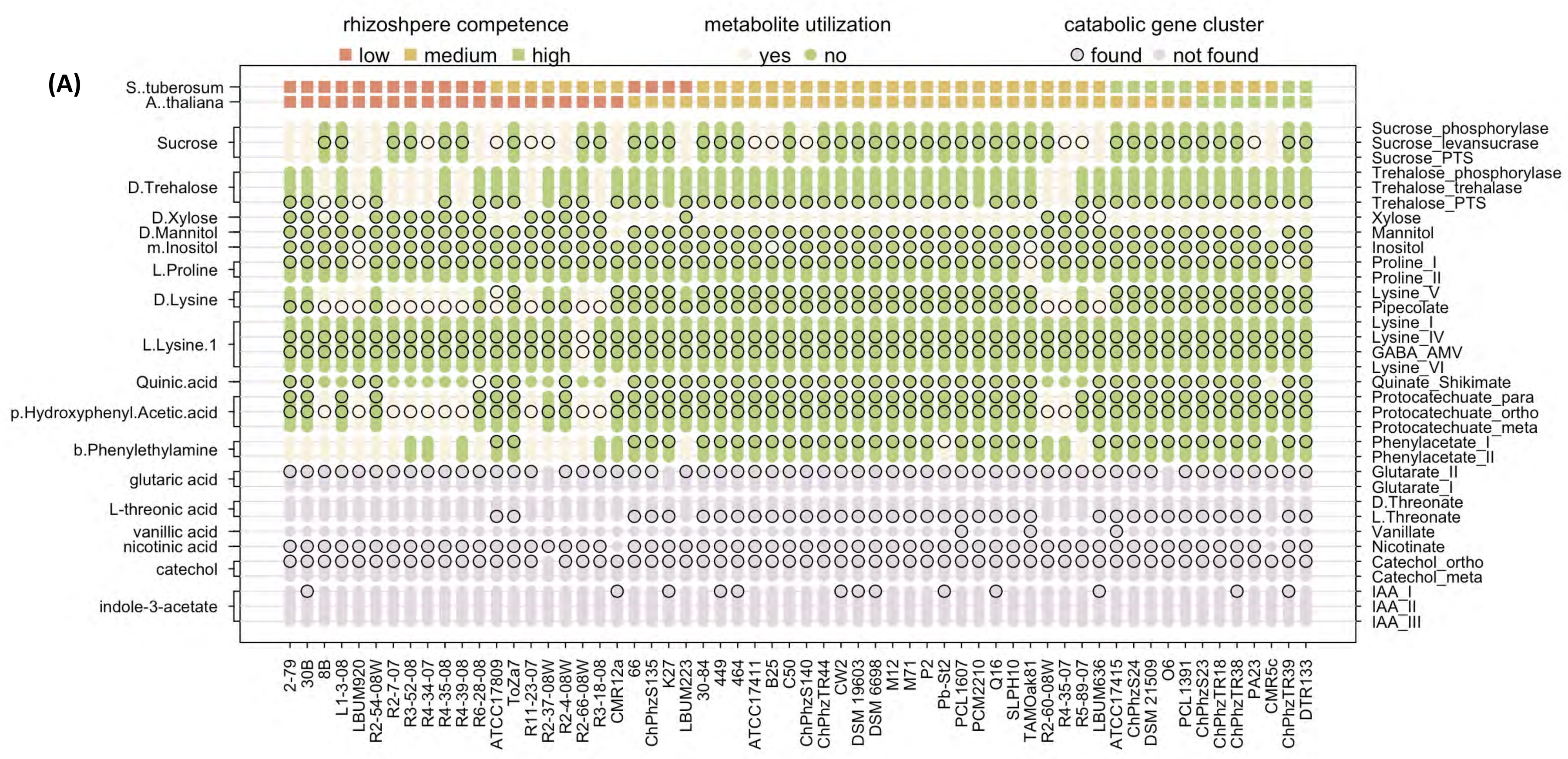


Fig 3. Distribution of rhizoSMASH-detected rCGCs in soil bacteria genomes (RefSoil database). Size of the dots represents the number of genomes in a genera in which a type of rCGC has been detected. On the right panels, the rCGC abundance and the rCGC diversity of a genera is represented by the average number of rCGC types and the average pair-wised difference of detected rCGCs in the genomes of the genera, respectively.

rhizoSMASH rCGCs predicts rhizosphere competence.

We aligned presence/absence of rhizoSMASH rCGCs with the catabolic capacities of their corresponding substrates in 60 *Pseudomonas* strains originally reported by Zboralski *et al.* in 2020, and the outcome shows a decent match of detection and experimental results (Fig 4A). We then trained machine learning models to predict the rhizosphere competence of these *Pseudomonas* strains reported in the same above-mentioned study using the presence/absence of rhizoSMASH rCGCs. The random forest classifiers achieved 85% and 78% accuracies for the rhizosphere competence in *Arabidopsis thaliana* (Fig 4B) and potato respectively (Fig 4C).



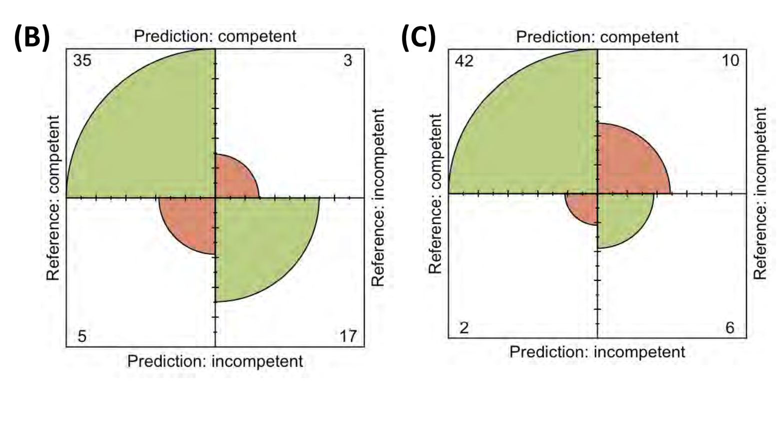


Fig 4. **(A)** Alignment of detection of rCGCs and experimental data. Color of dots/bars indicates the catabolic capacity measured by BIOLOG chips and circles represents the presence of rCGC in a *Pseudomonas* strain. **(B)** The confusion matrix of the prediction on rhizosphere competence of *A. thaliana*, and **(C)** that of potato.

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Unveiling the influence of domestication on taxonomic and functional microbiome composition in foxtail millet

PhD Candidate: Mingxue Sun

Supervisors: Chunxu Song (CAU); Marnix Medema; Liesje Mommer (WUR); Jos Raaijmakers (NIOO-KNAW; Leiden University)

Background

- Plant domestication alters microbiome composition and functions, with "missing microbes" potentially reinstating beneficial plant-microbe associations to boost crop productivity.
- Foxtail millet (*Setaria italica*) was domesticated from its wild relative, green foxtail (*Setaria viridis*), over 16,000 years ago in northern China (Doust & Diao, 2017). Recent studies reveal significant findings in millet improvement genes and intricate microbe-agronomic trait relationships through pan-genome and mGWAS analysis (Wang et al., 2022; He et al., 2023).
- However, the influence of foxtail millet domestication on root-associated microbiomes, including connections between root exudates, developmental traits, and microbiome functions, remains unclear.
- This study examines how changes in foxtail millet root exudates affect rhizosphere microbiome functions, aiming to deepen our understanding of plant-microbe interactions and their environmental implications for sustainable agriculture.

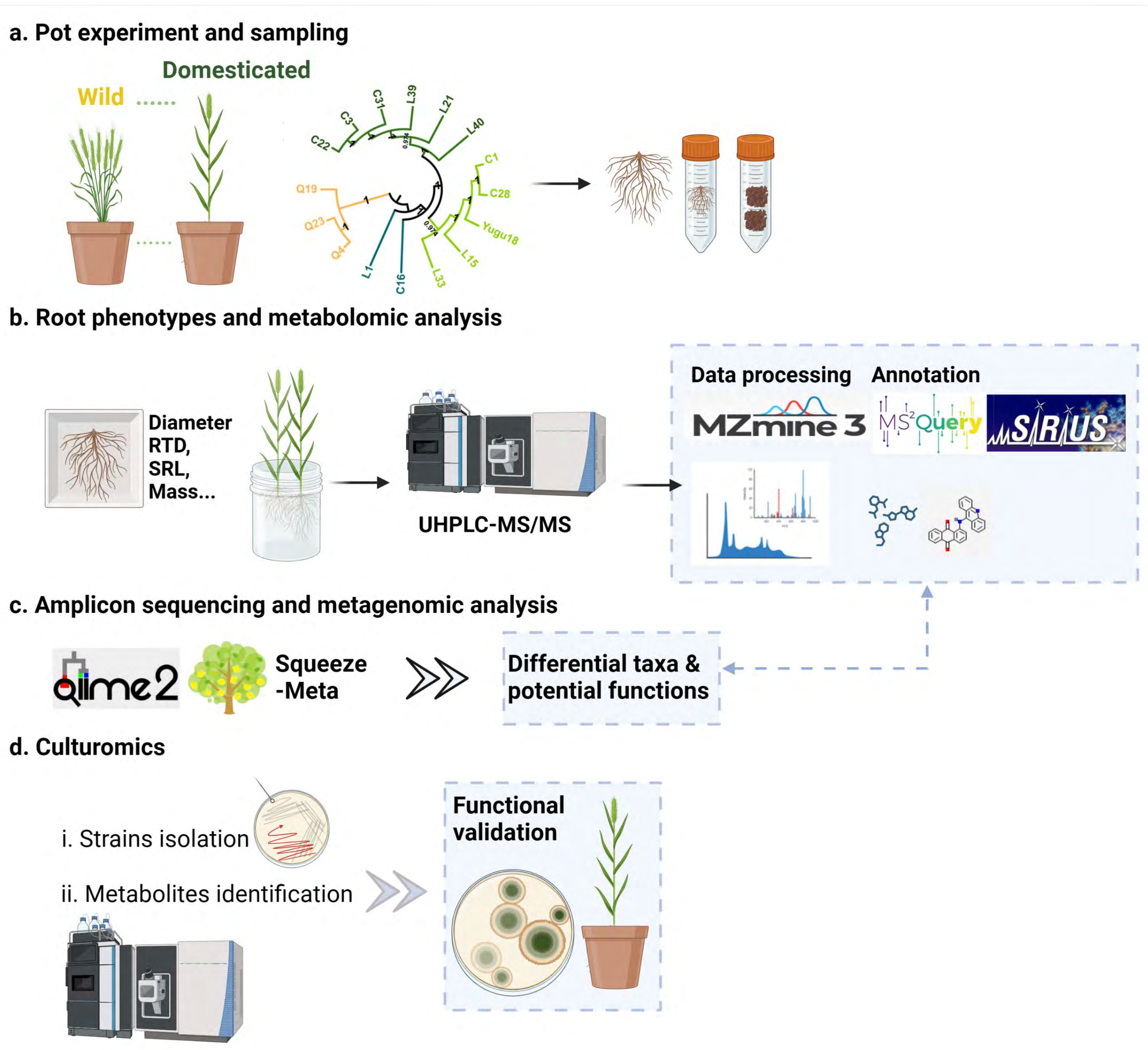
Objectives

I. Investigate the evolutionary changes in root phenotypes of foxtail millet during domestication.

II. Decipher the molecular and chemical signaling mechanisms underlying foxtail millet-microbiome interactions during domestication.

III. Uncover the potential contributions of "missing microbes" to plant growth and health.

Experimental workflow



Results

- Domestication and plant genotypes influenced on both rhizosphere and root endosphere microbiome compositions.
- Wild cultivars with higher SRL (Specific Root Length) and smaller RTD (Root Tissue Density) exhibited significant associations with specific ASVs of *Devosia*, *Pseudomonas*, *Massilia*, *Allorhizobium-Neorhizobium-Pararhizobium-Rhizobium* and the fungal symbiont *Funneliformis*.

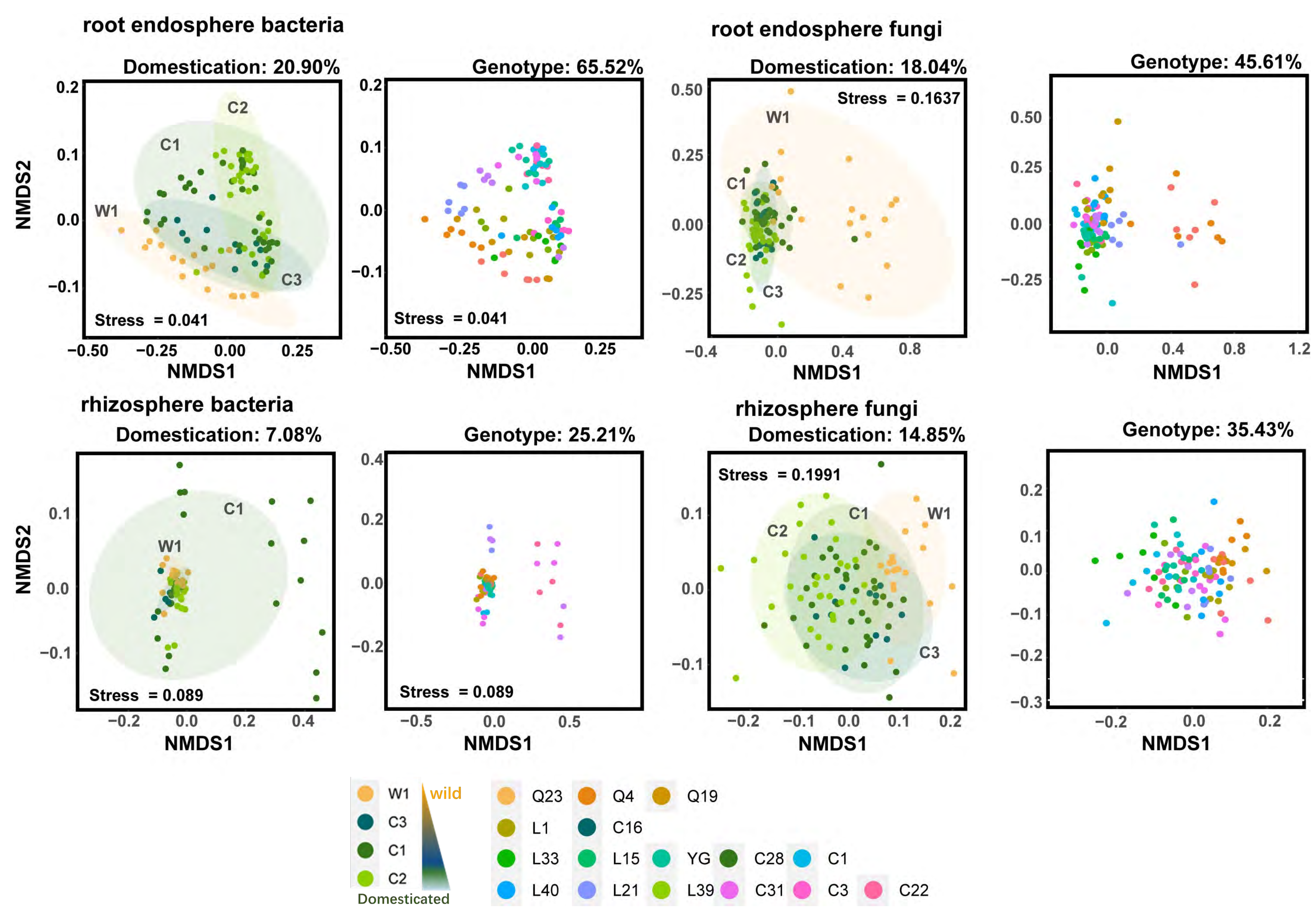


Figure 1. Variation of bacterial and fungal communities constrained by domestication status and genome types. All Non-metric Multi-Dimensional Scaling (NMDS) analyses yielded significant results (PERMANOVA, $p < 0.05$).

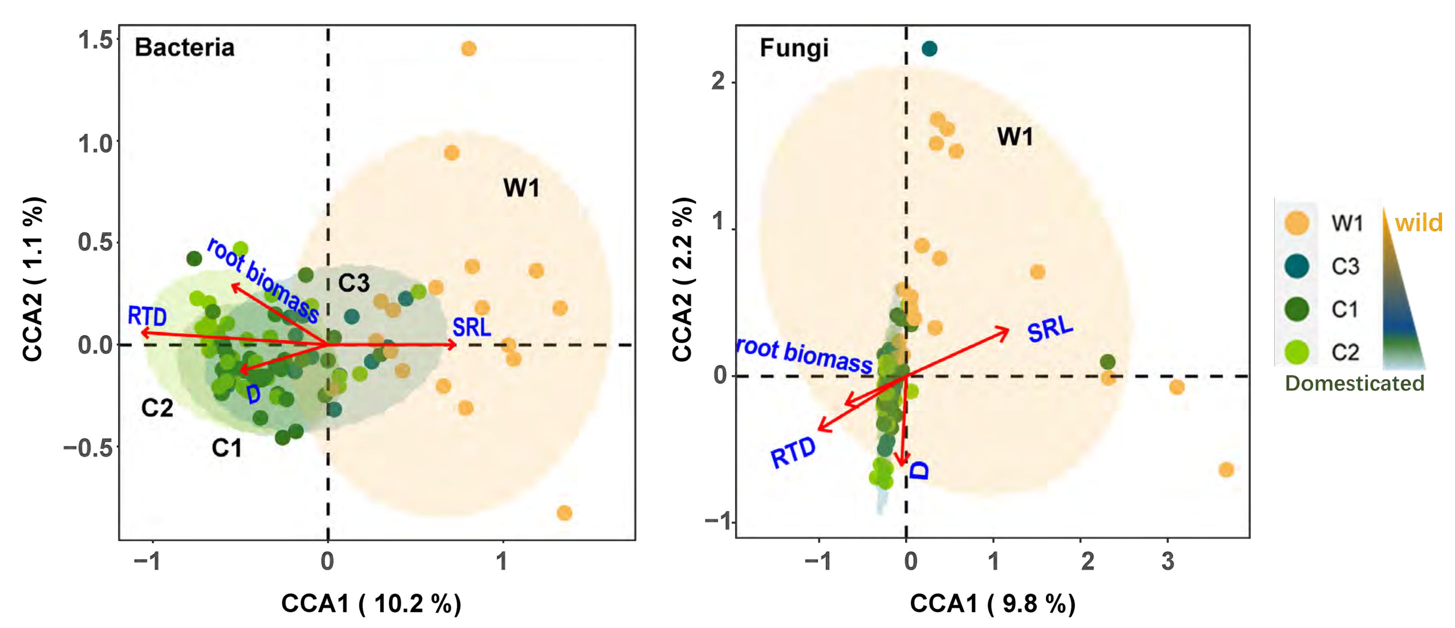


Figure 2. Canonical Correspondence Analysis of Amplicon sequencing data and root morphological traits

Conclusions

We found domestication exerted strong selection power on the root microbiome assembly and there were significant associations between the root-associated microbes and specific root phenotypic traits.

References

[1] Andrew Doust, and Xianmin Diao, Genetics and Genomics of *Setaria*: Domestication of Foxtail Millet. Switzerland: Springer International Publishing, 2017

[2] Qiang He, Sha Tang., Hui Zhi, et al. A graph-based genome and pan-genome variation of the model plant *Setaria*. Nature Genetics, 2023, 55, 1232–1242.

[3] Yayu Wang, Xiaolin Wang, Shuai Sun, et al. GWAS, MWAS and mGWAS provide insights into precision agriculture based on genotype-dependent microbial effects in foxtail millet. Nature Communications, 2022, 13, 5913.

Acknowledgements

We gratefully acknowledge the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Optimizing supply chains for healthy diets in China

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CAU supervisors: Wenfeng Cong, Shenggen Fan, Mo Li, Fusuo Zhang

Background

Shifting towards more plant-based diets is crucial for health and environmental benefits [1, 2, 3, 4], yet the potential of plant-based foods to sustainably fill the micronutrient supply-demand gap remains underexplored. This research investigates to what extent and how plant-based foods can alleviate the gap between food supply and malnutrition in a sufficient, diverse, and sustainable way in China.

Objectives

- Analyzing possible measures across crop supply chain stages to contribute to nutrition security and sustainability in China and other countries.
- Assessing the role and potential of plant-based food supply in fulfilling dietary needs for energy and 17 nutrients in China.
- Exploring how to boost underutilized cereals and beans in China to contribute to micronutrient availability and supporting environmental and economic sustainability.

Methods

- Network theory: bipartite network linking crops and nutrients
- Linear programming + multi-objective optimization
- Methods used to quantify environmental impact

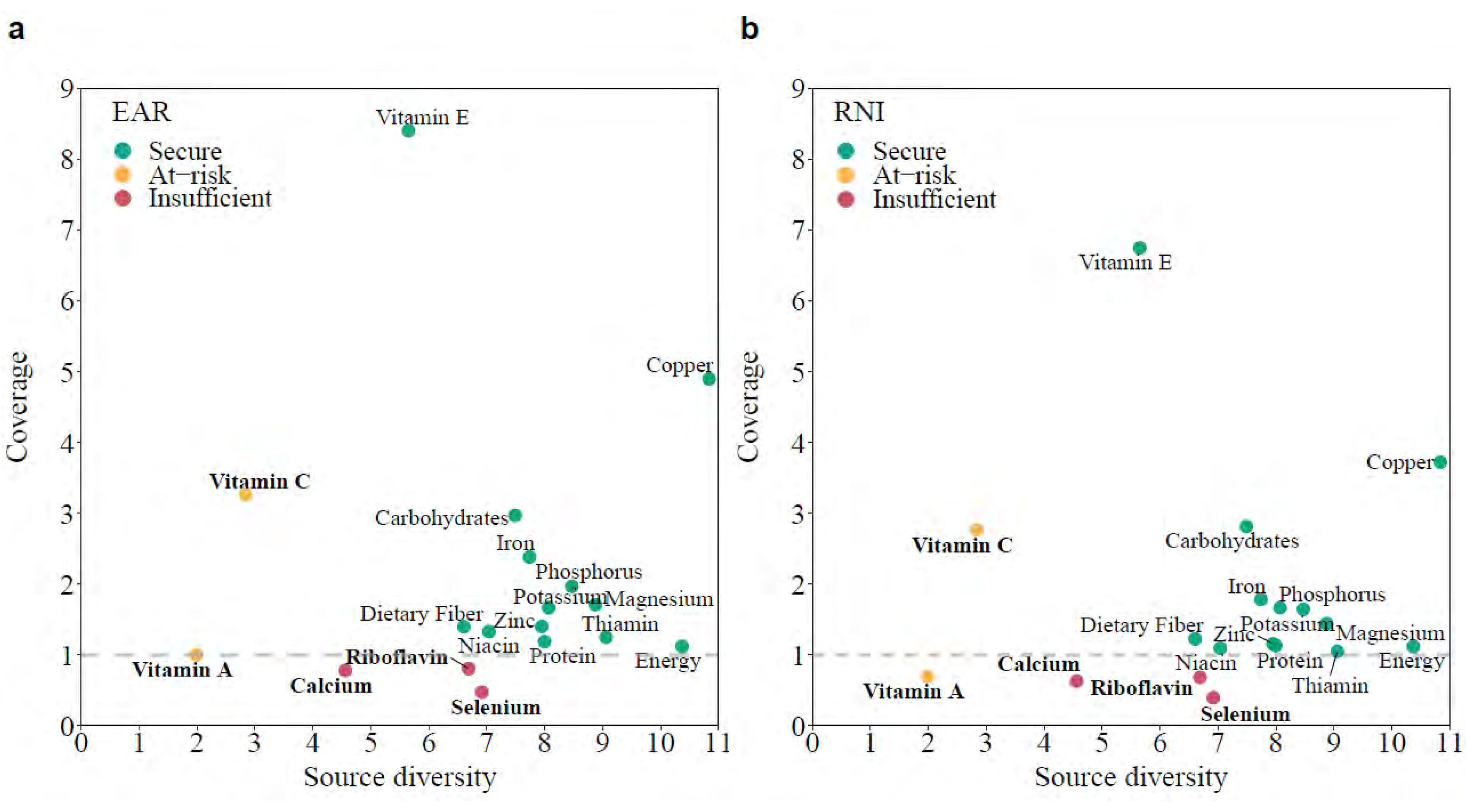

Fig. 1 | Coverage and source diversity from plant-based food supply in 2016 in China.

Results

- The current plant-based food supply has challenges in fulfilling the dietary needs of 5 micronutrients: selenium, calcium, riboflavin, and vitamins A and C (Fig. 1).
- Reducing avoidable nutrient losses, repurposing feed to food consumption via reducing red meat intake, coverages of all nutrients increased by 29%. The increased coverage mainly from vegetables, maize, wheat, and rice (Fig. 2).

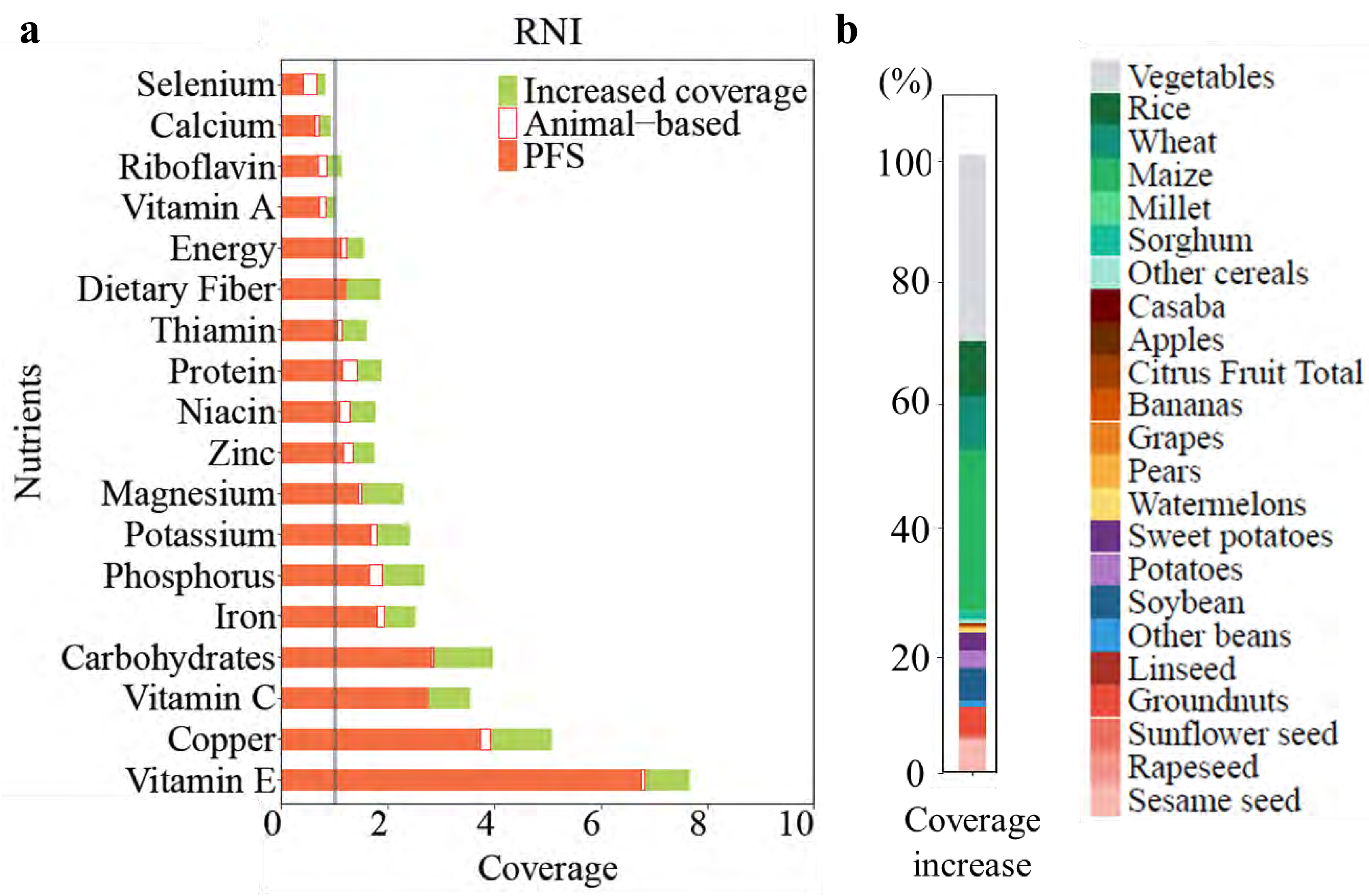

Fig. 2 | Nutrient coverage when halving avoidable nutrient losses, and repurposing feed to food via reducing red meat intake. a, the coverage from plant-based food supply (PFS), animal-based food sources, and the increased coverage. b, the increased coverage contributed by each crop sources.

- Overall, producing the same amount of dietary calcium, the total water consumption and GHGE from the six coarse grain crops are lower than those from the major staple crops (Fig. 3).

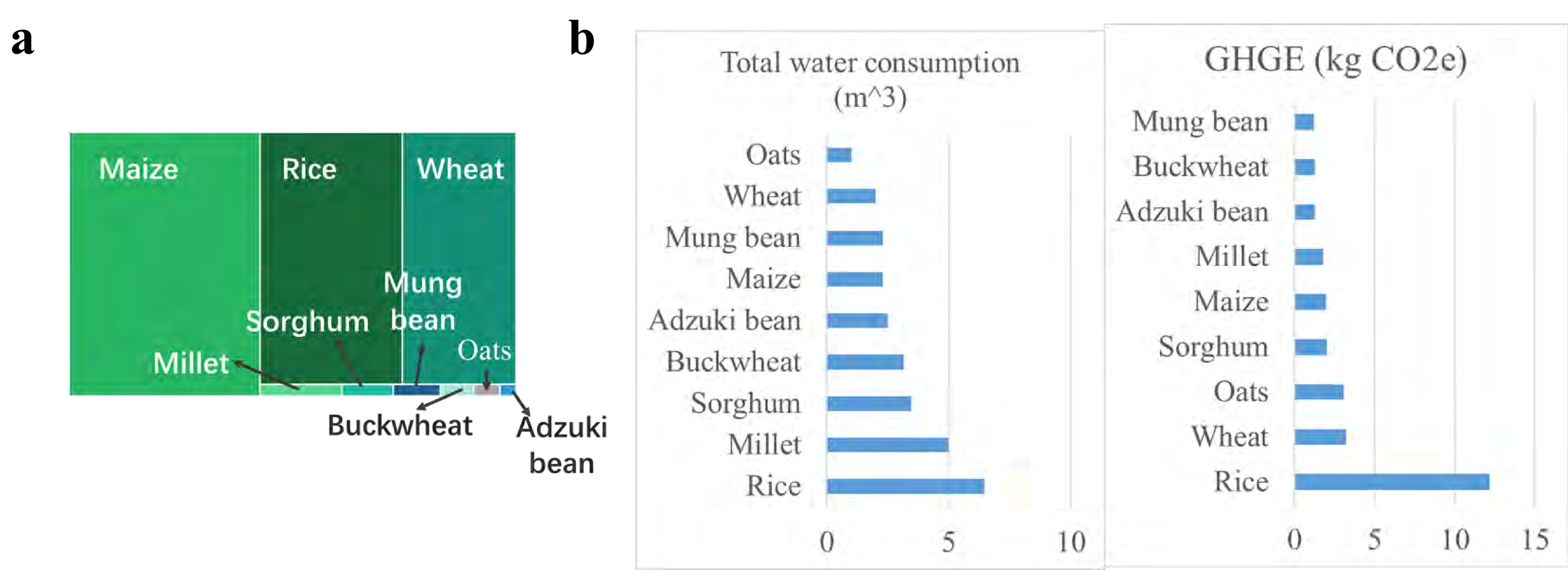

Fig. 3 | Comparing underutilized crops and major crops in terms of harvested area (a), total water consumption, and GHG emissions for producing the same amount of dietary calcium (10^3 mg) (b).

Conclusions

Plant-based food supply can meet the dietary needs for all nutrients except selenium with transformations such as reducing avoidable losses, repurposing feed to food by reducing red meat intake, and reallocating crop use. These transformations provide opportunities for more sustainable, diverse, and healthy diets in China. By replacing some of the harvested areas of major crops (e.g., rice, maize) with underutilized cereals and beans, the same amounts of dietary nutrients can be produced with a lower environmental impact.

References

[1] Willett, Walter, et al. "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems." *The lancet* 393.10170 (2019): 447-492.
[2] Poore, Joseph, and Thomas Nemecek. "Reducing food's environmental impacts through producers and consumers." *Science* 360.6392 (2018): 987-992.
[3] Hu, Yuanchao, et al. "Food production in China requires intensified measures to be consistent with national and provincial environmental boundaries." *Nature Food* 1.9 (2020): 572-582.
[4] Yu, D. M., et al. "Status of energy and primary nutrients intake among Chinese population in 2015–2017." *Food Nutr. China* 27 (2021): 5-10.

Acknowledgements

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The potential impact of increased whole grain consumption among Chinese adults on reducing healthcare costs and carbon footprint

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Supervisor: Shenggen Fan, Jingjing Wang, Edith Feskens, Frederick Duan
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Background

- **Whole grains are a key component of a healthy and sustainable diet**
- The EAT-Lancet Commission's initiative on healthy diets from sustainable food systems recommends that 32% of our daily calories should come from whole grains.

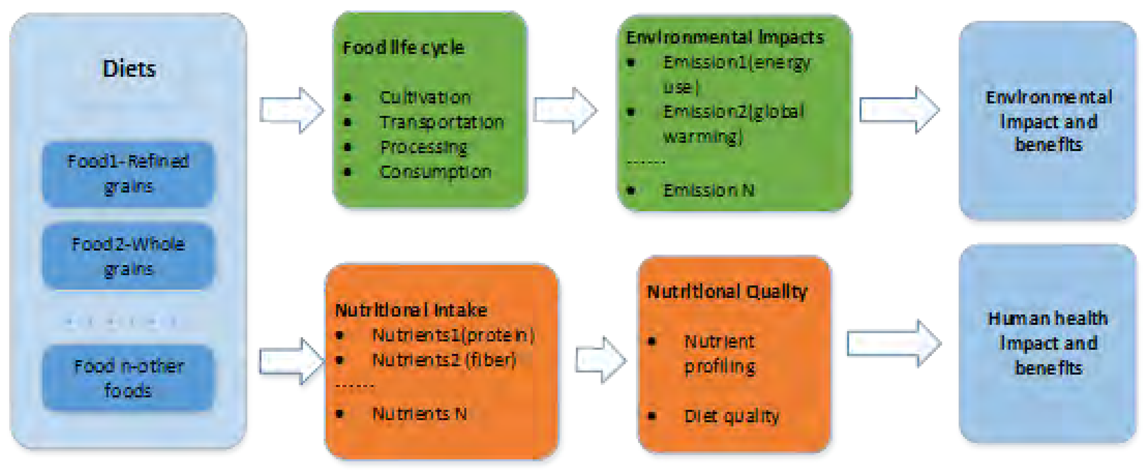
- Compared to refined grains, whole grains are rich in dietary fiber, B vitamins, and bioactive substances that are difficult to obtain from other foods. Previous studies have suggested that proper intake of whole grains can be effective in reducing the burden of disease.

- As a sustainable alternative to refined grains, increasing whole grain consumption has a potentially important role in ensuring food security and reducing carbon emissions to help China reach its grain security and carbon-neutral goal.

- **Consumption gap**
- **The average whole grain consumption of Chinese adults is 19.8g/d,** far below the CDG daily recommendation level of 50–150g (Chinese Nutrition and Health Surveillance Survey,2015). **More than 80% of Chinese adults seriously under-consuming whole grains** (NCHS Bureau of Disease Prevention and Control, 2020; Chinese Nutrition Society, 2021).

Objectives

- **This paper aims to quantify the potential savings in healthcare costs and reductions in food-related carbon footprints that could result from increasing the consumption of whole grains following the CDG dietary recommendations.**



A conceptual framework for diet-level integration of nutritional and environmental impacts assessments

Methods

- **Methods to estimate healthcare costs**
- **Health Economic Model.** In this section, we estimate the annual direct costs (in terms of healthcare expenditure) and indirect costs (in terms of lost productivity) associated with T2DM, CVD, and CRC prevention in China based on Disability Adjusted Life Years (DALYs) lost and on the relative risk estimates for disease incidence associated with whole grains derived previous studies and other available data.

- Data input
1) Risk estimates of disease incidence and whole grain consumption (Table S1)
2) Direct cost data: Annual direct medical cost data from the China Health Statistical Yearbook 2021
3) Indirect cost data: Estimates of DALYs from Zhou et al. (2019)

Table S1 Summary of the input parameters for the reduction in risk of diseases with the consumption of whole grains

Outcome	Relative risk reduction per 15 g whole grains (95% confidence interval)	Relative risk reduction per 30.2 g whole grains (95% confidence interval)	Reference
T2DM incidence	0.075 (0.065, 0.085)	0.15 (0.13, 0.17)	Ghanbari-Gohari *et al*. 2022
CVD incidence	0.02 (0.01, 0.04)	0.04 (0.02, 0.08)	Reynolds *et al*. 2019
CRC incidence	0.03 (0.01, 0.05)	0.06 (0.02, 0.1)	Reynolds *et al*. 2019

- **Methods to calculate the CFs of whole grain foods**
- **LCA model.** In this section, we have adopted a method that considers both the nutritional contents and weight to calculate the CFs of four food categories: refined rice, brown rice, refined wheat flour, and moderately processed whole wheat flour.

- Functional units
  Weight-based; Single nutrient-based; Nutrition density (ND)- based, ND was defined as the ratio of the nutrient content present in a food item to the daily nutrient requirements of an individual.

- System Boundaries
  The system boundaries for the LCA of CFs in this analysis include grain cultivation, transportation, storage, and manufacturing processes.

- Emission factors
  The carbon emissions factors used in this section are derived from previous studies

- The entire life cycle carbon footprint of food groups (whole wheat flour, refined wheat flour, polished rice, and brown rice) is divided into four stages: 1) grain cultivation, 2) transportation, 3) storage, and 4) manufacturing process. Equation (4) was used to estimate emissions at each stage and for the production-to-processing life cycle of food products:

$$E = \sum_i^n \sum_j^m Q_{ij} * C_{ij}$$

Results

- **Estimates annual healthcare cost savings**

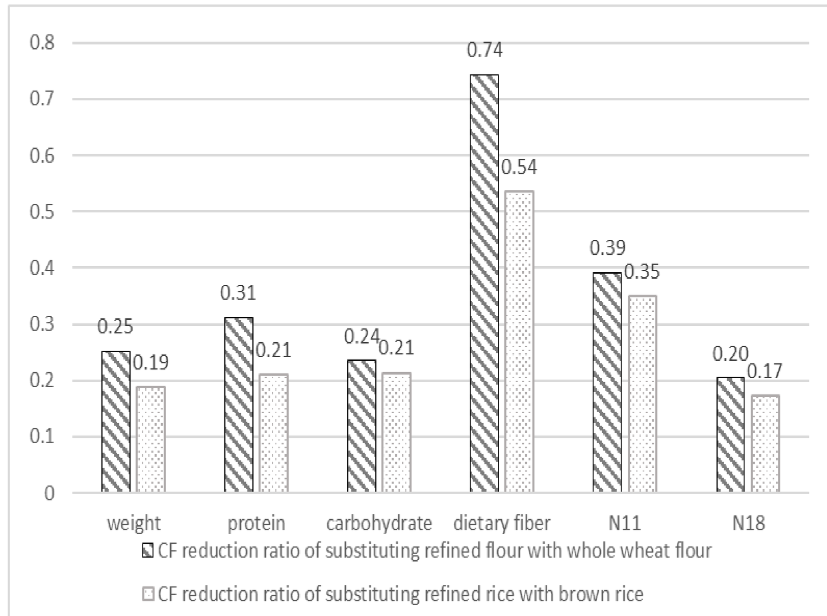
- The total healthcare cost savings attributable to the reduced risk of three health outcomes is estimated to be USD 56.37 (95% CI 32.99, 96.92) billion.

Table 1 Direct and indirect healthcare cost savings associated with different levels of whole grains consumption among Chinese adults (≥20 years old)

	Diseases	Current healthcare cost (USD billions)	Annual healthcare cost savings of increasing 30.2 g d^{-1} whole grains (USD billions)
Indirect cost	T2DM	98.5	14.87 (12.81, 16.75)
	CVD	835.64	33.65 (16.71, 66.85)
	CRC	41.8	2.52 (0.84, 4.18)
	Three diseases total	975.94	51.05 (30.35, 87.78)
Direct cost	T2DM	5.92	0.89 (0.77, 1.01)
	CVD	60.6	2.44 (1.21, 4.85)
	CRC	32.93	1.99 (0.66, 3.29)
	Three diseases total	99.44	5.32 (2.64, 9.15)
Total cost		1,075.38	56.37 (32.99, 96.92)

- **Estimates CF reduction ratio achieved by substituting refined grains with whole grains**

- Carbon emissions from refined wheat flour were 1.34 times greater than those from whole wheat flour. Similarly, compared to brown rice, refined rice contributes to carbon emissions that are 1.23 times greater.



- **Simulation of the impact of whole grain consumption on healthcare costs and carbon emissions**
- With an increasing population (5–100%) following the 50 g d^{-1} recommendation, total annual healthcare cost savings are predicted to range between USD 2.82 (95% CI 1.65, 4.84) billion and USD 56.37 (95% CI 32.98, 96.92) billion.
- If the whole grain consumption gap were filled with half wheat and half rice, annual carbon emissions would be reduced by 0.24 to 4.88 million tons of CO_2eq. The projected annual carbon footprint decrease is bigger if the Chinese utilize brown rice substitutes (0.29 to 5.72 million tons of CO_2eq) than whole wheat substitutes (0.20 to 4.0 million tons of CO_2eq).

Table 3 Potential savings in annual healthcare cost and carbon emissions if Chinese adults (≥20 years old) increase whole grain consumption by 30.2 g d^{-1}

	Scenarios in which a certain percentage of the adult population increases their whole grain consumption by 30.2 g d^{-1}				
	Very pessimistic 5%	Pessimistic 20%	Optimistic 50%	Very Optimistic 80%	Universal 100%
Savings in annual healthcare cost (USD billions)					
T2DM	0.79 (0.68, 0.89)	3.15 (2.71, 3.55)	7.88 (6.79, 8.88)	12.6 (10.84, 14.2)	15.77 (13.57, 17.75)
CVD	1.8 (0.9, 3.58)	7.22 (3.58,14.34)	18.04 (8.96,35.85)	28.88 (14.32, 57.36)	36.09 (17.92, 71.7)
CRC	0.23 (0.07, 0.37)	0.9 (0.3, 1.49)	2.26 (0.75, 3.74)	3.6 (1.2, 5.96)	4.51 (1.49, 7.47)
Three diseases total	2.82 (1.65, 4.84)	11.27 (6.59, 19.38)	28.18 (16.5, 48.47)	45.08 (26.36, 77.52)	56.37 (32.98, 96.92)
Reduction in annual carbon footprint (Million tons of CO_2eq)					
Half wheat & half rice substitute	0.24	0.98	2.44	3.91	4.88
All whole wheat substitute	0.20	0.81	2.02	3.23	4.04
All brown rice substitute	0.29	1.14	2.86	4.58	5.72

Conclusions

- **This study proves that increasing the proportion of consumers who consume the recommended amount of whole grains can be a win-win solution for benefiting both public health and the environment**. With an increasing number of Chinese adhering to the recommended minimum intake level of 50 g d^{-1} for whole grains, it is anticipated that there will be a significant reduction in healthcare expenses associated with T2DM, CVD, and CRC, at USD 2.82–56.37 billion, and the carbon emission levels are also projected to decrease by 0.24–5.72 million tons.

- **Even a small percentage of consumers shift to consume whole grain aligned with the CDG, can lead to notable savings in healthcare costs and reductions in carbon footprints, underscoring the importance of altering grain consumption habits in China.**

Acknowledgements

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Intercropping practices of smallholders in the Hanggin Rear Banner County, Northwest China

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Background

Numerous literature certify various advantages of intercropping at experiment level.

There is unfortunately little knowledge available on the management and performance of intercrops in China, and there is also little insight in what drives farmers to use intercropping.

Highlights

- Across the area, 14% of the arable land was used for intercropping.
- Intercropping resulted in higher gross margin, but increased the workload per mu from 8 to 12 hours.
- The time for weeding intercropping is 2-3 times that of monoculture.
- Soil type, subsidy, distance to market, and production risks will influence farmers motivation to select specific crop system.

Methods

Activity data were collected from face-to-face interviews with 317 smallholders from 24 villages in Hanggin Rear Banner. We surveyed 150 monocrop farms and 167 intercrop farms. Some provided information on more than one plot (i.e. 2 or more). In total, we got plot information for 277 monocultural and 200 intercropping plots.

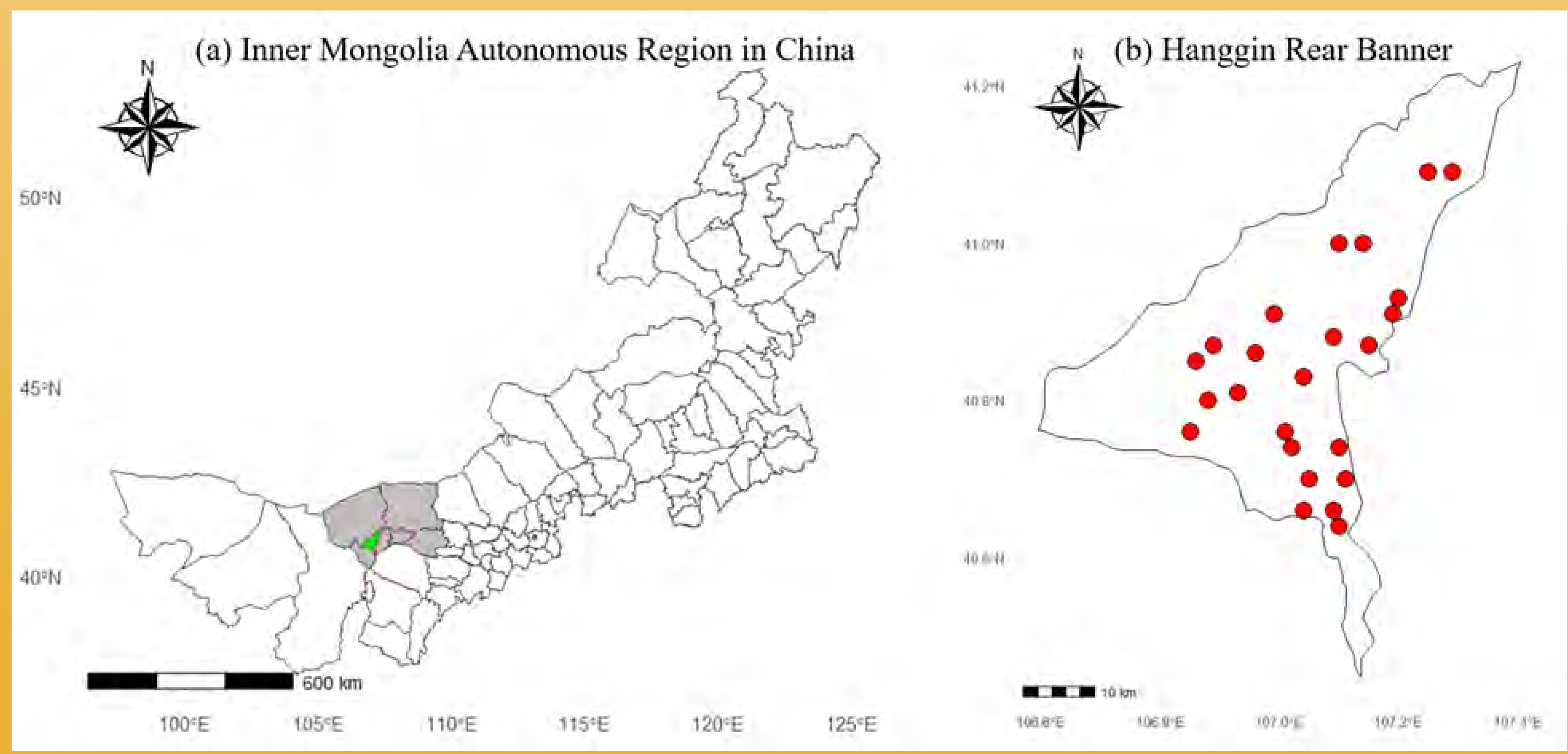

Fig.1 (a) The map of China Inner Mongolia Autonomous Region (The black grid represents the county), with Bayannur City marked in grey and Hanggin Rear Banner marked in green; (b) The map of Hanggin Rear Banner, and the red dots represent the locations of the surveyed villages.

Results

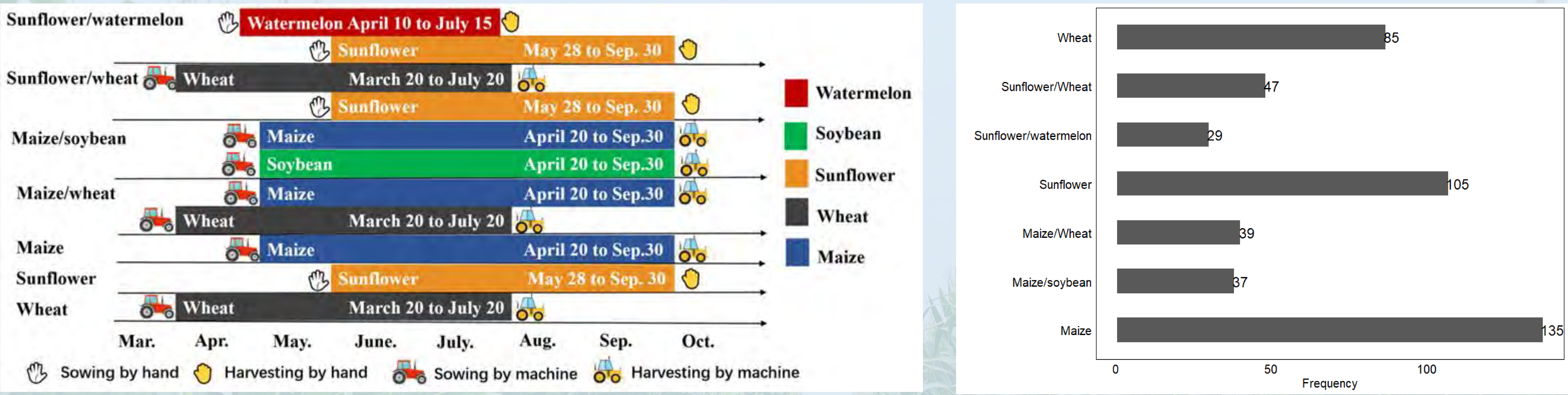

Fig.2 Growth periods and sowing and harvest methods of surveyed cropping systems, and their frequency.

Overall performance of each systems	Unit	Monocrop			Intercrop			
		Maize	Wheat	Sunflower	Maize/ soybean	Maize/ wheat	Sunflower /wheat	Sunflower/ watermelon
Yield	Kg/mu	828.9±9.2	454.7±17.5	240.0±10.4	666.7±17.1 43.1±31.3	492.2±15 314.7±28.2	163.3±11.6 365.2±21.2	235.4±20 2575.0±37
Sale Price	CNY/kg	4.9±0.1	5.8±0.1	14.7±0.1	4.05±0.2 8.1±0.05	5.5±0.2 6.0±0.04	16.5±0.2 6.02±0.03	14.2±0.3 2.4±0.1
Gross margin*	CNY/mu	1,497±57	964±109	1,418±64	1,364±106	1,375±95	1,763±72	4,130±125
Costs	CNY/mu	612±12	481±24	347±14	691±23	963±21	733±16	760±27
Total labor hours	Hours/mu	8.24±0.18	6.53±0.33	8.18±0.2	11.17±0.32	10.79±0.30	12.95±0.22	14.41±0.38
Gross margin/ labor hours	CNY/Hours	74.27	73.66	42.42	61.86	89.25	56.60	52.74

Note: The number is mean ± sd in the table 1. *Gross margin = Income from yield + subside - total cost. *The normal price in local labor market is 120 CNY/hour. 1 mu= 667m^2

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We acknowledge colleagues who participated in the household survey and data entry. This study was financially supported by the China Scholarship Council (No.201913043) and Hainan University.

Phosphorus Mobilization by LMWOAs in Calcareous and Red Soils After Receiving Long-Term Fertilizations

phD : Mengxue Mao
Supervisor : Kemo Jin, Liping Weng, Walter schenkeveld

Background

- Phosphate fertilizer is widely applied in agriculture to maintain crop yield. When applied to soil, the efficiency of P fertilizers is greatly reduced due to fixation in soils as a result of strong adsorption and formation of precipitates with metal ions
- Plants have developed P acquisition strategies in order to make soil P more bioavailable. One of these strategies involves root exudation of low molecular weight organic acids (LMWOAs) like citric and malic acid.
- In any soil, P is present in multiple species varying in solubility and P releasing kinetics. So far, it is unclear how the P speciation changes with the P fertilization in soils with different pH, from which species P is mobilized by LMWOAs and how LMWOAs enhance P bioavailability in compacted soils.

Objectives

- To establish P speciation in soils covering a wide pH range which have received long-term P fertilization at different levels.
- To determine which P species are mobilized from calcareous and red soils by LMWOAs, thereby enhancing P availability.

Methods

- A red soil from China (pH=4.2) and a Chinese calcareous soil (pH=7.5) are selected, on which long-term (about 10 years) P fertilization experiments have been conducted, involving 4 different P application rates. Through sequential extraction we have attempted to determine P speciation in the soils. However, the selectivity of extractants for specific P species is limited. the Beijing Synchrotron Radiation Facility (BSRF) analysis will help to verify the results from the extraction and to better identify the change of P speciations.
- The above soils will be extracted with LMWOAs (oxalic acid, citric acid, malic acid and trans-aconitic acid). The concentration of P, Fe, Al and Ca dissolved in these extractions will be measured. The solid phase will be analyzed by BSRF and the results will be compared to those of the original soils to establish the change in P speciation due to LMWOAs extraction.

Results

Table 1. Physical and chemical properties of soil samples

Soil type	Fertiliser treatment (kg P_2O_5 ha^{-1})	pH_{water}	pH_{CaCl2}	TN (g kg^{-1})	TOC (g kg^{-1})	C/N ratio	Fe-ox (g Fe kg^{-1})	Al-ox (g Al kg^{-1})	P-ox (g P kg^{-1})	Fe-DCB (g Fe kg^{-1})	Al-DCB (g Fe kg^{-1})	P-DCB (g P kg^{-1})	$CaCl_2$-P (mg kg^{-1})	Olsen-P (mg kg^{-1})	Total-P (g kg^{-1})
Calcareous soil	0	8.15^{a}	7.41^{a}	1.08	7.70	7.13	1.32^{b}	0.05^{c}	0.33^{d}	9.26^{b}	0.51^{a}	0.72^{d}	0.41^{d}	6.78^{d}	0.71^{c}
Calcareous soil	75	8.12^{ab}	7.33^{b}	1.26	8.40	6.69	1.34^{ab}	0.05^{b}	0.48^{c}	9.63^{a}	0.57^{b}	0.86^{c}	0.48^{c}	20.17^{c}	0.93^{b}
Calcareous soil	150	8.10^{b}	7.23^{c}	1.11	7.69	6.95	1.30^{b}	0.05^{c}	0.54^{b}	8.94^{c}	0.51^{a}	0.91^{b}	0.62^{b}	30.46^{b}	0.99^{b}
Calcareous soil	300	7.97^{c}	7.16^{d}	1.17	8.71	7.58	1.41^{a}	0.06^{a}	0.82^{a}	9.71^{a}	0.62^{a}	1.21^{a}	0.70^{a}	68.01^{a}	1.28^{a}
Red soil	0	4.74^{c}	4.13^{d}	0.53	3.16	5.98^{b}	2.8	0.22^{a}	0.01^{d}	76.59^{a}	4.75^{a}	0.64	0.35^{b}	0.16^{d}	0.28^{c}
Red soil	60	5.11^{b}	4.28^{c}	0.64	5.00	7.85^{a}	2.3	0.17^{b}	0.03^{c}	73.77^{ab}	4.68^{ab}	0.64	0.34^{b}	0.35^{c}	0.30^{c}
Red soil	90	5.25^{a}	4.45^{a}	0.57	4.15	7.30^{ab}	2.34	0.19^{ab}	0.05^{b}	71.34^{b}	4.69^{ab}	0.62	0.41^{a}	0.50^{b}	0.33^{b}
Red soil	120	5.16^{b}	4.31^{b}	0.55	3.54	6.51^{ab}	2.47	0.22^{a}	0.08^{a}	72.63^{ab}	4.40^{b}	0.66	0.41^{a}	0.99^{a}	0.38^{a}

Note: Fe-DCB, Al-DCB, P-DCB: concentration of Fe, Al or P in the extraction of sodium citrate bisulfite; Fe-ox, Al-ox, P-ox: concentration of Fe, Al or P in ammonium oxalate extraction

Results

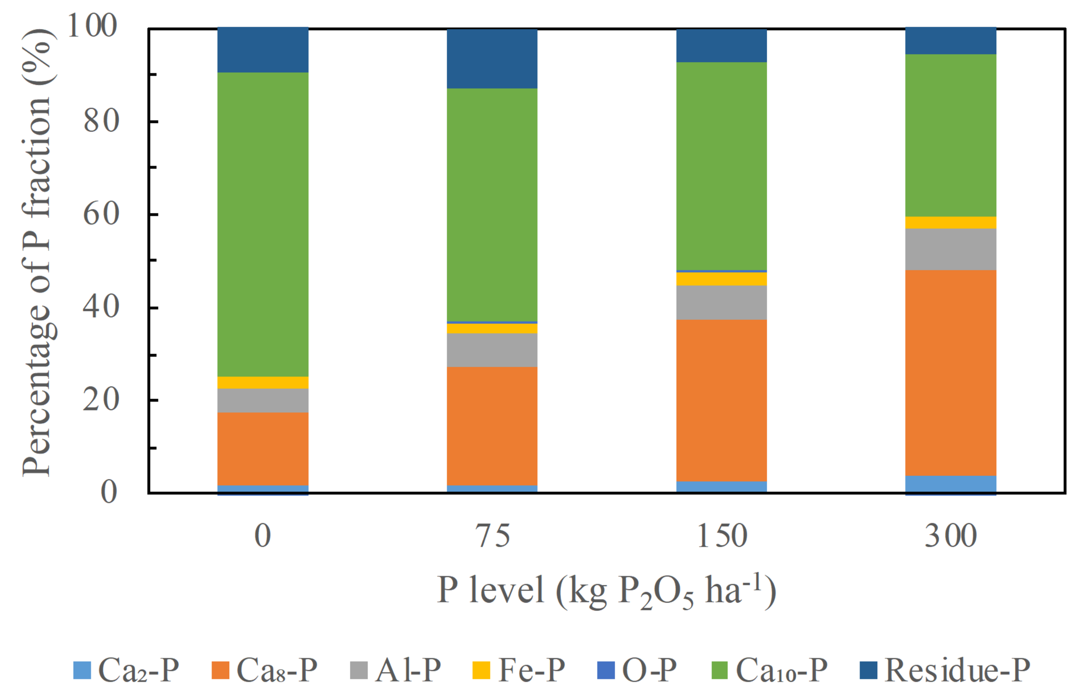

Fig 1. Proportion of phosphorus forms in calcareous soil extracted by Jianggu continuous extraction method.

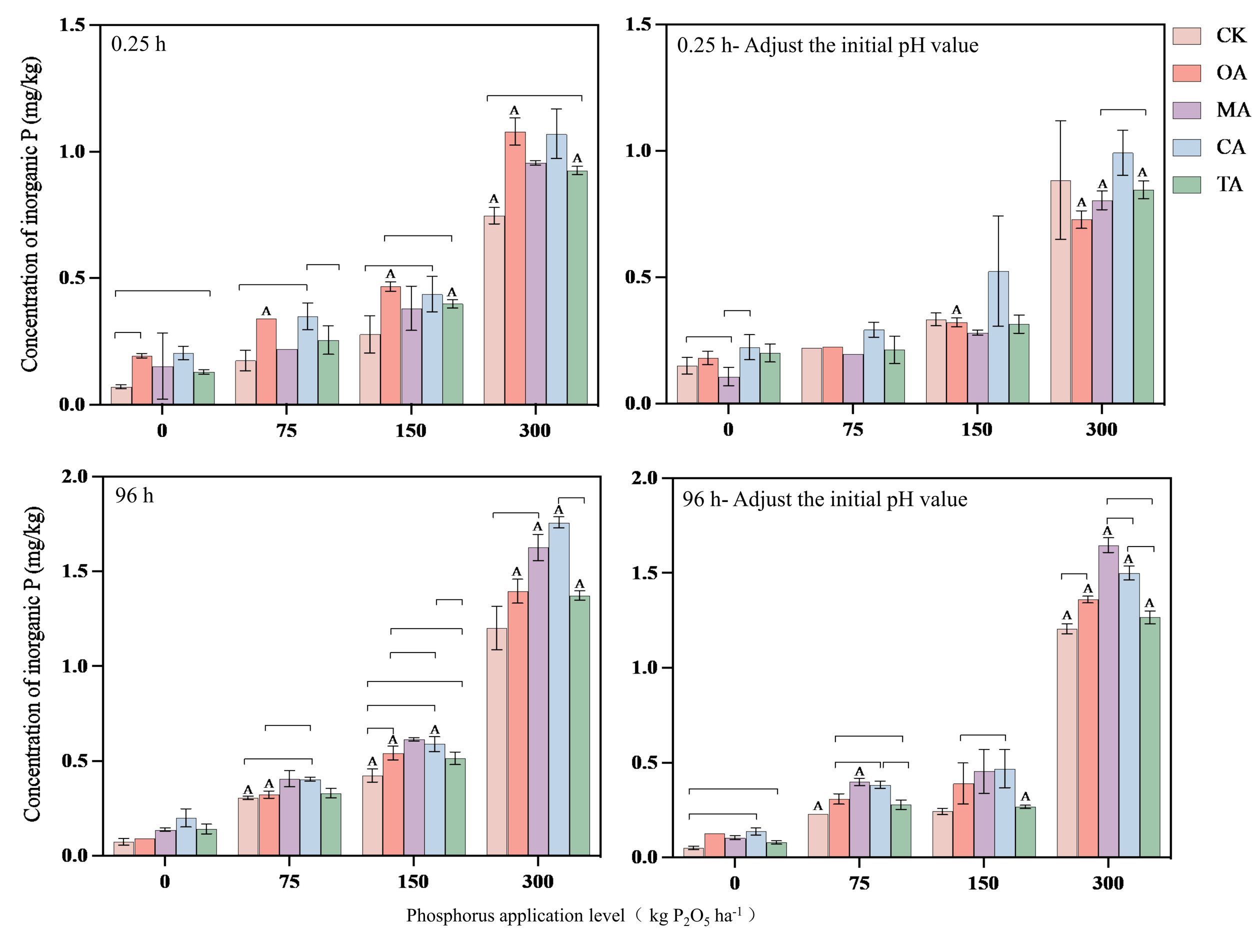

Fig 2. Phosphorus concentration of calcareous soil (phosphorus application level is 0, 75, 150, 300 kg P_2O_5 ha^{-1}) extracted by organic acid at 0.25 and 96 hours with or without adjusting the initial organic acid pH value.

Conclusions

- The study found that different phosphorus application rates significantly affected the pH, iron, aluminum and phosphorus contents of calcareous soil and red soil, but had little effect on total nitrogen and total carbon.
- The results of Jiang-Gu inorganic phosphorus grading showed that the phosphorus forms in calcareous soil were significantly affected by different phosphorus application rates, mainly Ca_8-P and Ca_{10}-P, and Ca_2-P, Ca_8-P, Al-P and Fe-P increased significantly with the increase of phosphorus application rates. There was a correlation between the phosphorus forms.
- The activation of organic acids on phosphorus varies in soils with different phosphorus application rates. The change of initial pH and different reaction time will also affect the activation of different kinds of organic acids on phosphorus.

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Geochemical mechanisms of mobilizing the natural organic matter by maize root exudated

PhD candidate: Man Pu Supervisors: Walter Schenkeveld, Liping Weng, Kemo Jin
Chair group: Soil Chemistry and Chemical Soil Quality, Wageningen University and Research
Department of Plant Nutrition, Chines Agricultural University, China

Background

- Mobilizing natural organic matter (NOM) through root exudates is critical for soil health and plant growth, supporting healthier soils and more robust plant growth in agricultural and natural ecosystems.
- Root exudation directly influences nutrient uptake by acidifying the rhizosphere, solubilizing cations, and secreting chelating substances. This enhances nutrient availability for plants.
- Root exudation alters humic substances such as humic acid (HA) and fulvic acid (FA), affecting soil fertility and biological activity. This impacts soil structure and nutrient retention.
- Low molecular weight organic acids (LMWOAs) from exudates stimulate microbial activities in the soil, enhancing nutrient cycling and organic matter decomposition. This fosters healthier soil ecosystems.

Objectives

The aim of current project is to quantitatively understand the geochemical mechanism by which root exudates, such as citric acid, malic acid, and oxalic acid, mobilize natural organic matter (NOM), namely humic acid (HA) and fulvic acid (FA), under various soil solution conditions.

Methods

Adsorption experiments

- To reveal mechanisms and quantify the interaction between LMWOAs and NOM at the interface of oxides.
- Adsorption experiments of citric acid, malic acid, oxalic acid to goethite in the presence of HA and FA, respectively, under various pH and ionic strength conditions.
- Measurements to determine adsorbed LMWOAs and NOM on goethite after equilibrium.

Surface complexation modeling (SCMs)

- To describe the competitive adsorption between LMWOAs and NOM on goethite using CD-MUSIC [1] and NOM-CD [2] models.
- The model consisted of multiple formation reactions of surface species combined with an electrostatic model to consider the influence of surface charge. Factors such as the basic charge of the mineral surface, ion concentration, pH, and salt dependency were incorporated into the model [3].
- Spectroscopic data provided surface structural information. Constraints were placed on the model considering that only a portion of the organic molecule is incorporated into the surface structure, constrained by the mineral's chemical composition.

Results

Preliminary results of the adsorption experiment.

- The adsorption of citric acid on goethite is mainly pH-dependent, with less influence from changes in ionic strength (Figure 1).
- Predictions of citrate binding by goethite with a different background electrolyte give good results (Figure 1).
- The adsorption of humic acid (HA) and fulvic acid (FA) on goethite is pH-dependent. Additionally, the adsorption of HA is influenced by ionic strength, whereas FA adsorption remains unaffected by changes in ionic strength (Figure 2).
- Affinity of citric acid (0.04-0.3 mg/m^2) is weaker than HA (0.5-1.5 mg/m^2) and FA (0.2-0.5 mg/m^2) (data not shown).
- Competitive adsorption of LMWOAs and NOM still need to be carried out.

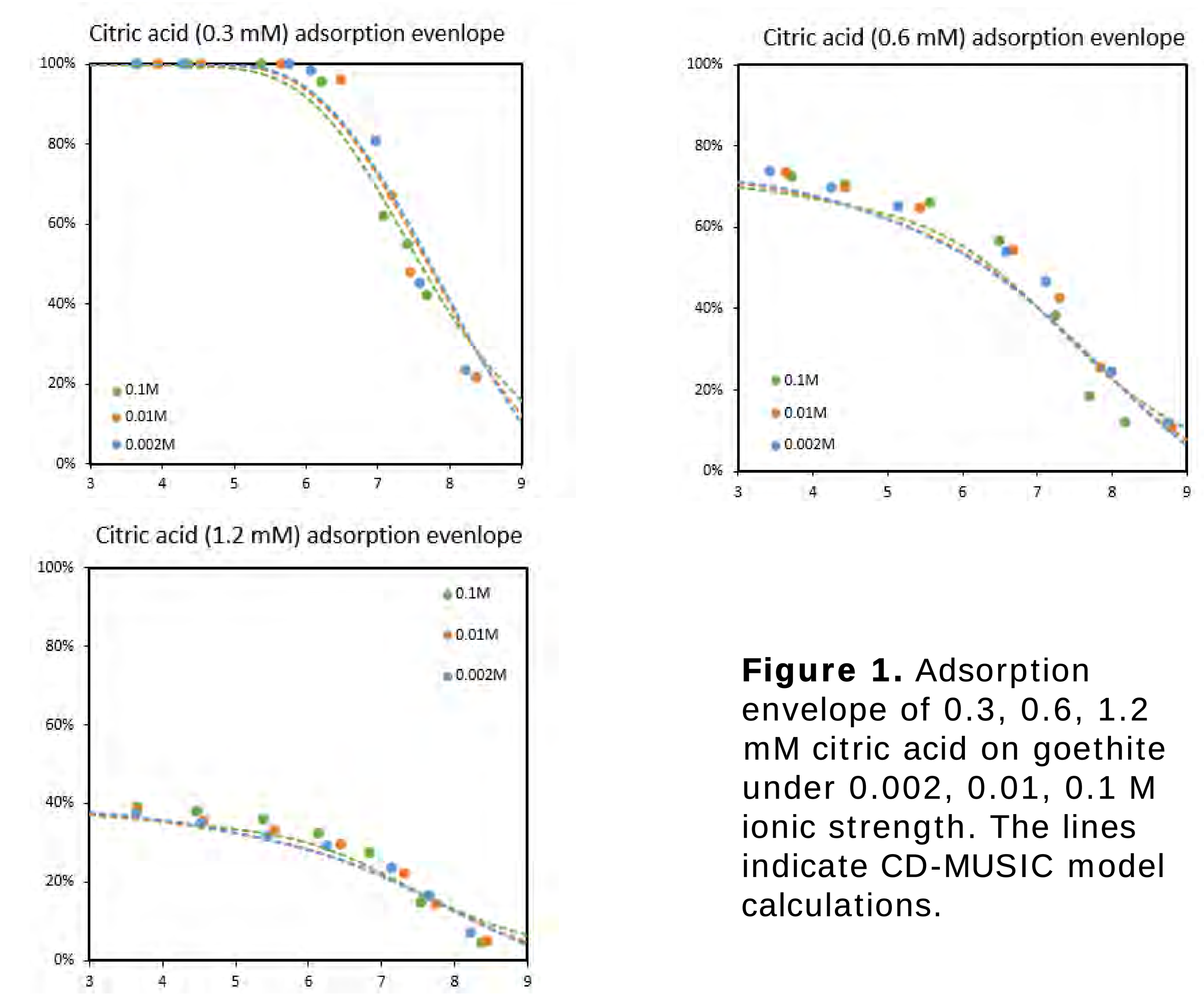

Figure 1. Adsorption envelope of 0.3, 0.6, 1.2 mM citric acid on goethite under 0.002, 0.01, 0.1 M ionic strength. The lines indicate CD-MUSIC model calculations.

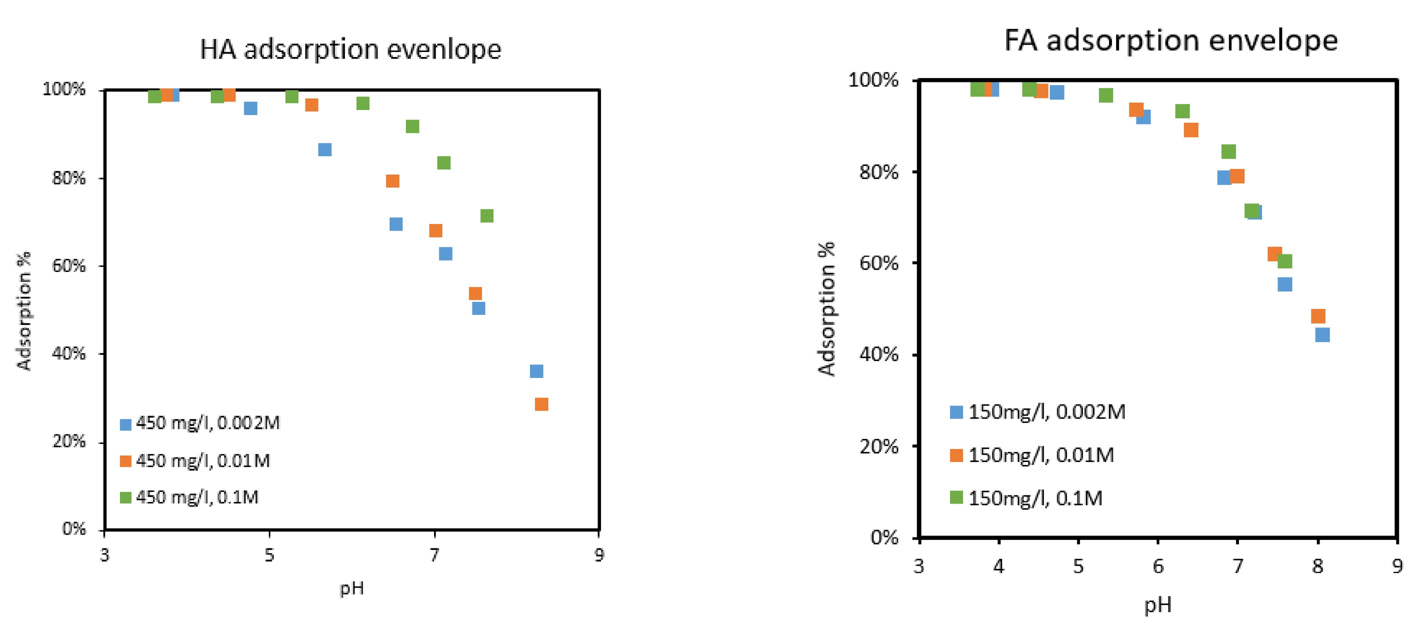

Figure 2. Adsorption envelope of 450 mg/l HA and 150 mg/l FA on goethite under 0.002, 0.01, 0.1 M ionic strength.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

[1] Weng, L., Van Riemsdijk, W. H., & Hiemstra, T. (2008). Humic nanoparticles at the oxide– water interface: interactions with phosphate ion adsorption. Environmental Science & Technology, 42(23), 8747-8752.
[2] Hiemstra, T., Mia, S., Duhaut, P. B., & Molleman, B. (2013). Natural and pyrogenic humic acids at goethite and natural oxide surfaces interacting with phosphate. Environmental science & technology, 47(16), 9182-9189.
[3] Filius, J. D., Hiemstra, T., & Van Riemsdijk, W. H. (1997). Adsorption of small weak organic acids on goethite: Modeling of mechanisms. Journal of colloid and interface science, 195(2), 368-380.

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Plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction

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Supervisors: Erik Limpens (WUR), Xu Cheng (WUR), Lin Zhang (CAU), Gu Feng (CAU)

Background

Arbuscular mycorrhizal (AM) fungi can colonize over 80% of terrestrial plants. Similar to the rhizosphere microbiome, the microbiome closely associated with AM fungi plays a critical role in the biogeochemical cycling of various mineral elements. These processes significantly affect the nutrition and overall performance of the plant-AM fungi symbiosis.

Simultaneously, different AM fungal taxa colonize a single plant root, each fostering a distinct microbiota. Additionally, varying plant-AM fungi combinations host unique hyphosphere bacteria.

However, the reasons why different host plants recruit specific hyphosphere bacteria, and the mechanisms behind these selections, remain poorly understood.

Objectives

In this project, we aim to fill this knowledge gap to improve soil nutrient-use efficiency and take best advantage of the indigenous AM fungi and bacteria in the field, which will help to realize agricultural green production.

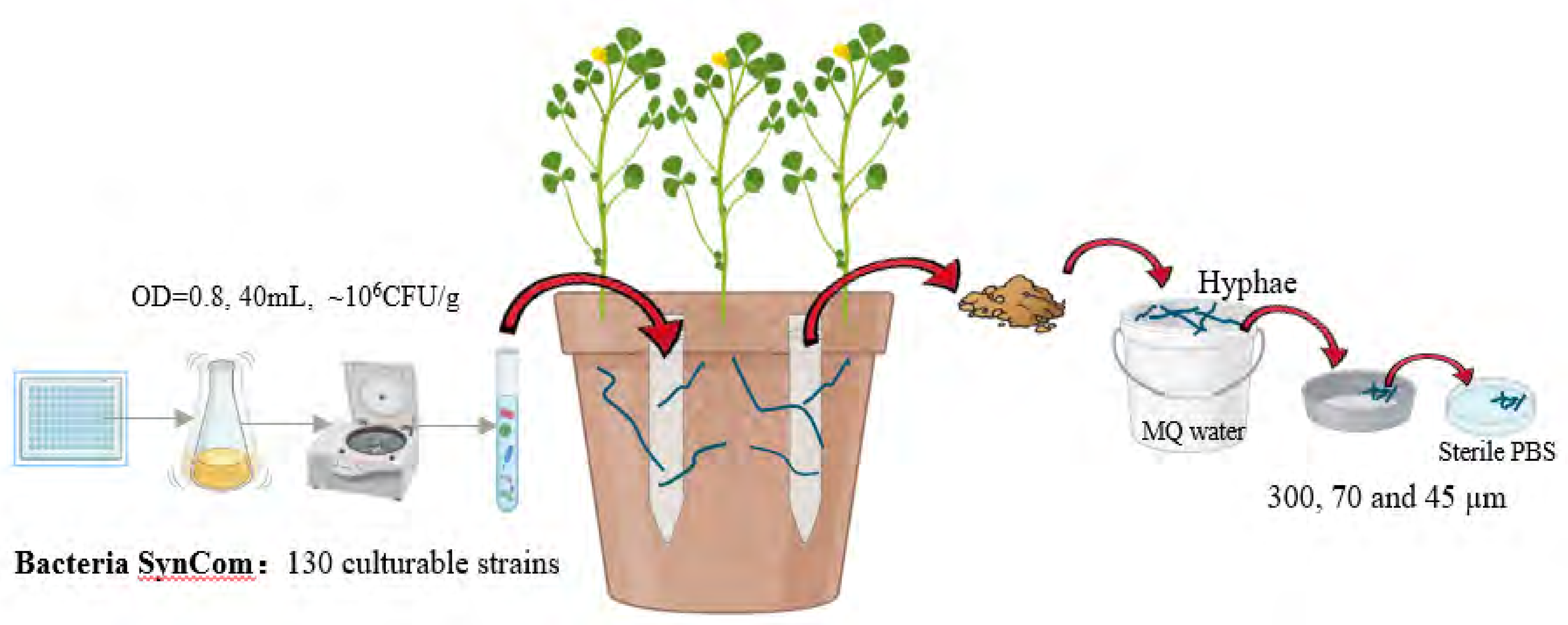
We will use different host plant species with single AM fungal species to:

1) identify the diversity and function of bacteria in AM fungal hyphosphere,

2) reveal how plant and AM fungi shape the hyphosphere microbiome at the genetic and metabolic levels;

3) uncover the mechanisms by which hyphosphere bacteria influence the fitness of AM fungi and the plant colonization

Methods



- **Sample harvest:**

  Bacteria attached to hyphae surface

  Bacteria in bulk soil (non-colonized)

- **Analysis:**

  16S rRNA gene sequencing

Results

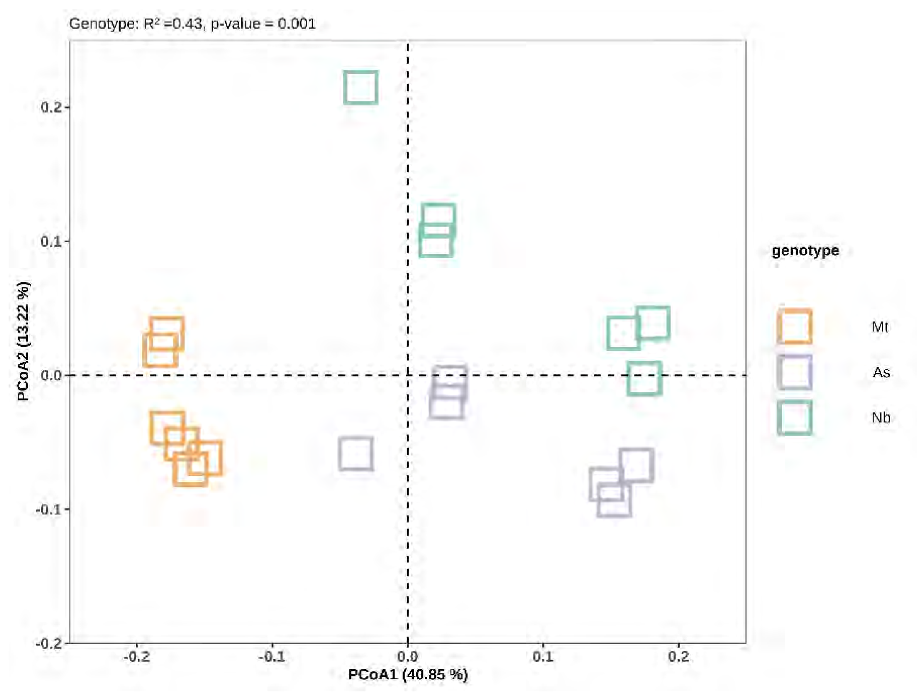


Fig 1. Different host plants shape different bacterial community in hyphosphere

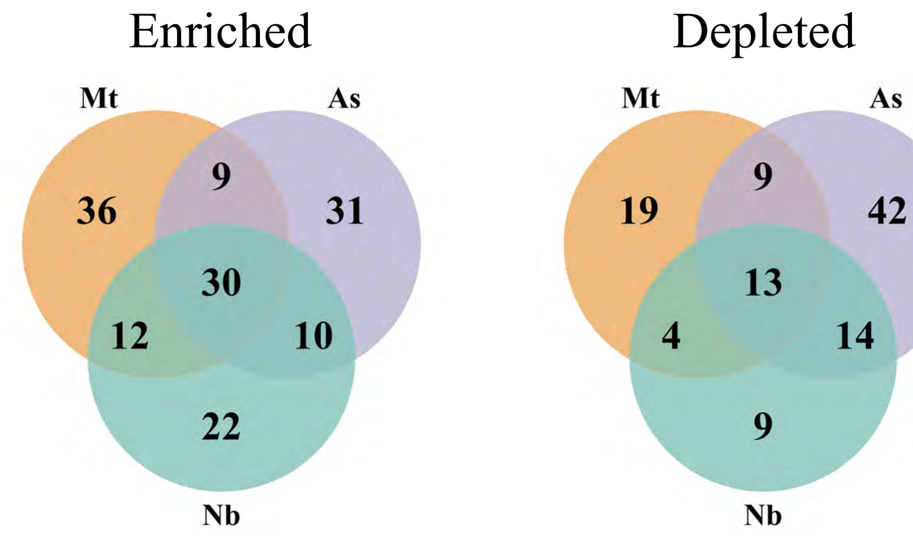


Fig 2. Bacterial enrichment and exclusion in the hyphosphere of AM fungus associated with different host plants compared with bulk soil

Fig 3. Symbiotic medicago hyphae recruit more bacteria related to nitrogen metabolism

Conclusions

❑The bacterial community structure of the hyphosphere is significantly different from that of the bulk soil, indicate the strong influence of AM fungi.

❑Different host plants recruit different bacteria to the mycorrhizal hypha.

❑Bacteria enriched in the hyphosphere of the AM fungi associated with Medicago provides functions, with respect to the nitrogen metabolism.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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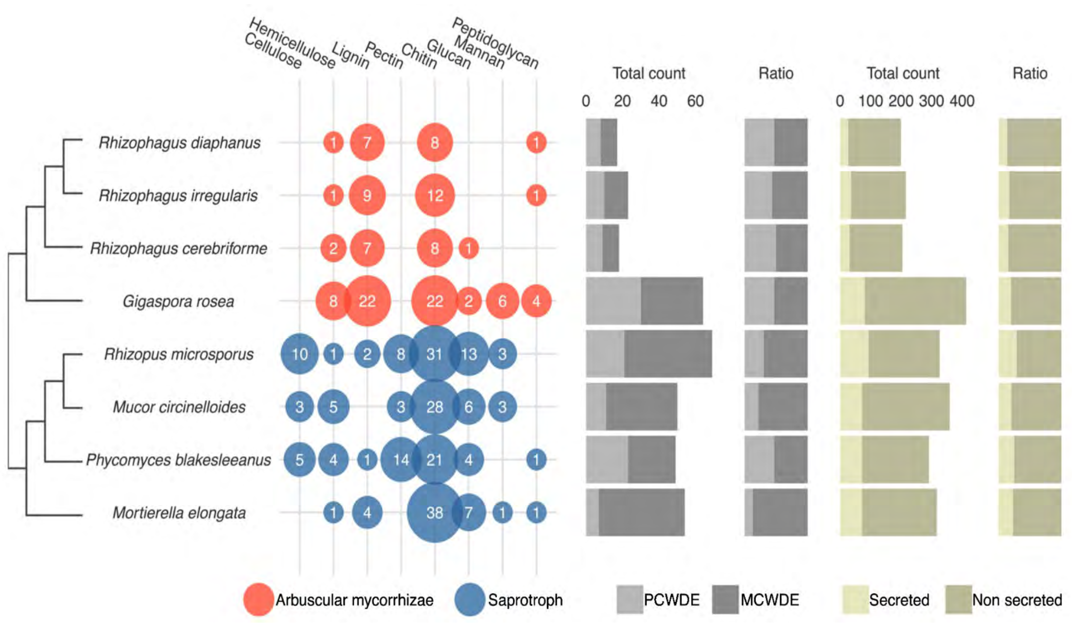
Unraveling mechanisms for arbuscular mycorrhizal fungi recruit and activate hyphosphere bacteria to improve plant phosphorus uptake

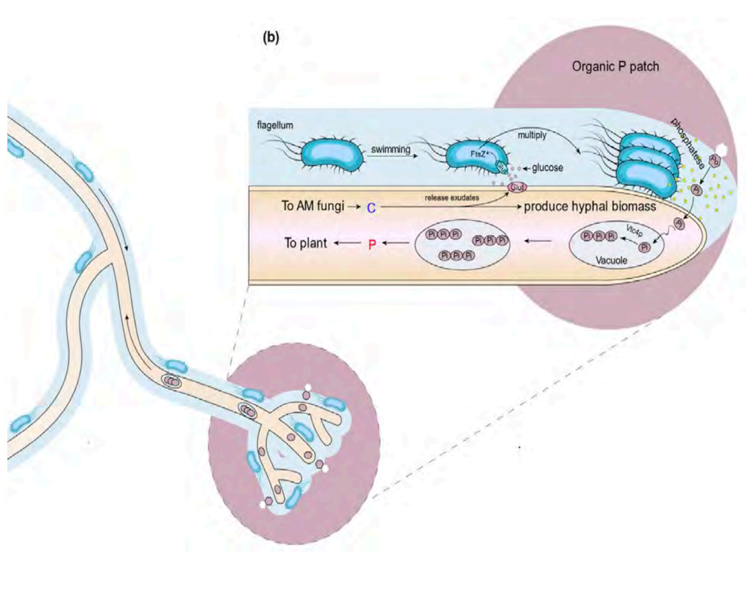
PhD student：Zihang Yang
Supervisor：Lin Zhang, Gu Feng, Erik Limpens, Cheng Xu

Background

More than two-thirds of terrestrial plants acquire nutrients by forming a symbiosis with arbuscular mycorrhizal (AM) fungi (Smith and Read, 2008). AM fungi produce extensive extraradical hyphae in the soil, not only enlarging the area to acquire nutrients and water but also creating a habitat for other soil microbes to colonize (Artursson et al., 2006). During the co-evolution with plants, AM fungi have lost some saprophytic function genes compared with other filamentous fungi, such as genes encoding plant cell degrading enzymes and phytase (Tisserant et al., 2013; Morin et al., 2019).



(Morin et al., New Phytologist, 2019)



(Jiang et al., New Phytologist, 2021)

This suggests that AM fungi have relatively weak abilities to directly mobilize soil organic nutrients compared with other kinds of fungi (Zhang et al., 2021). By colonizing the hyphosphere of AM fungi, soil microbes may significantly increase the turnover of soil organic nutrients (Falkowski et al., 2008), which complement the capabilities of AM fungi. Recently research found that AM fungi can recruit bacteria to mobilize organic phosphorus to improve plant phosphorus uptake AM fungi's spores and hyphae contain multiple nuclei in a common cytoplasm (Tisserant et al., 2013). Thus, genetically manipulating AM fungi is extremely difficult. In this study, we want to use host-induced gene silencing technology to achieve fungi function gene silencing to reveal the recruiting mechanism at the gene level.

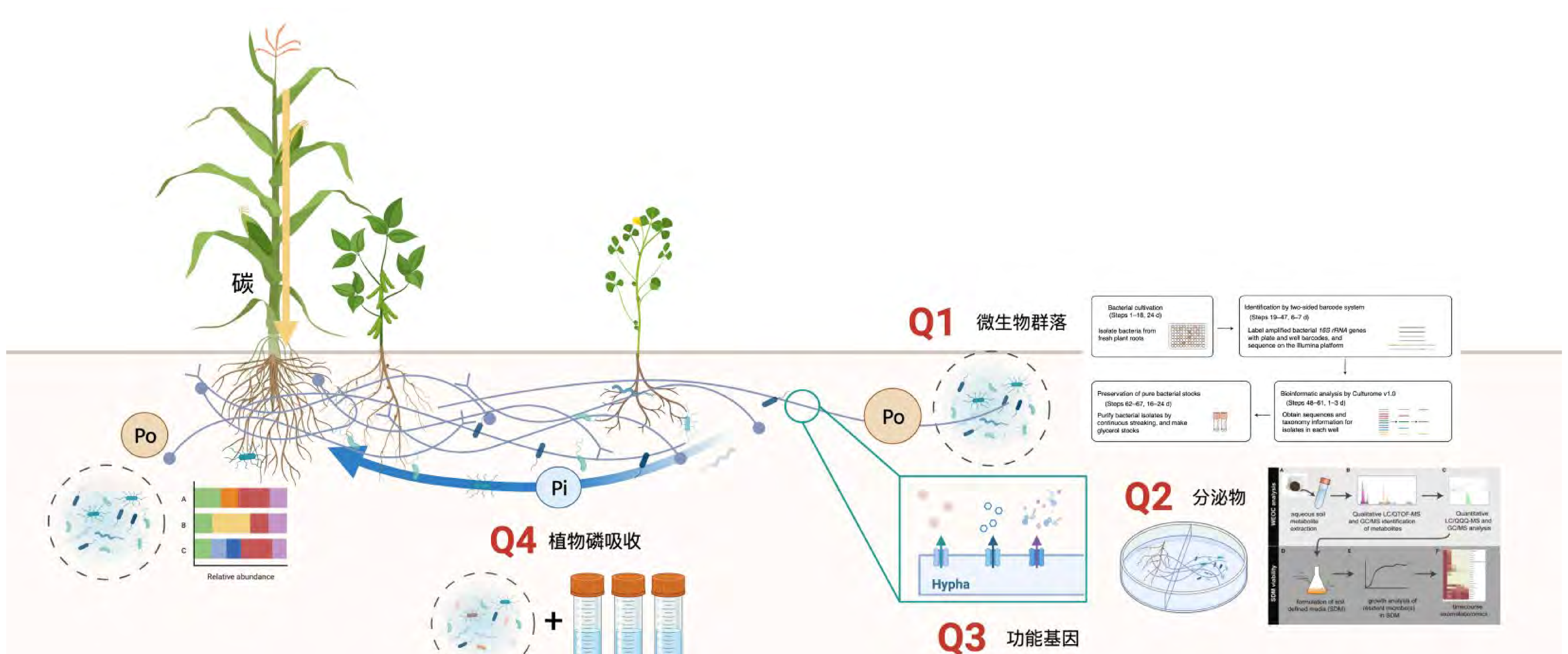
? The mechanisms by which hyphosphere bacteria are recruited and activated to improve plant phosphorus uptake are still less understood.

Objectives

- Identify the biotic effects on the hyphosphere microbiome and confirm the member of the library of hyphosphere bacteria.
- Reveal the recruitment mechanisms of hyphosphere bacteria by AM fungi
- Attempts the genetic manipulation of AM fungi and uncover its influence on the hyphosphere microbiome.

Framework

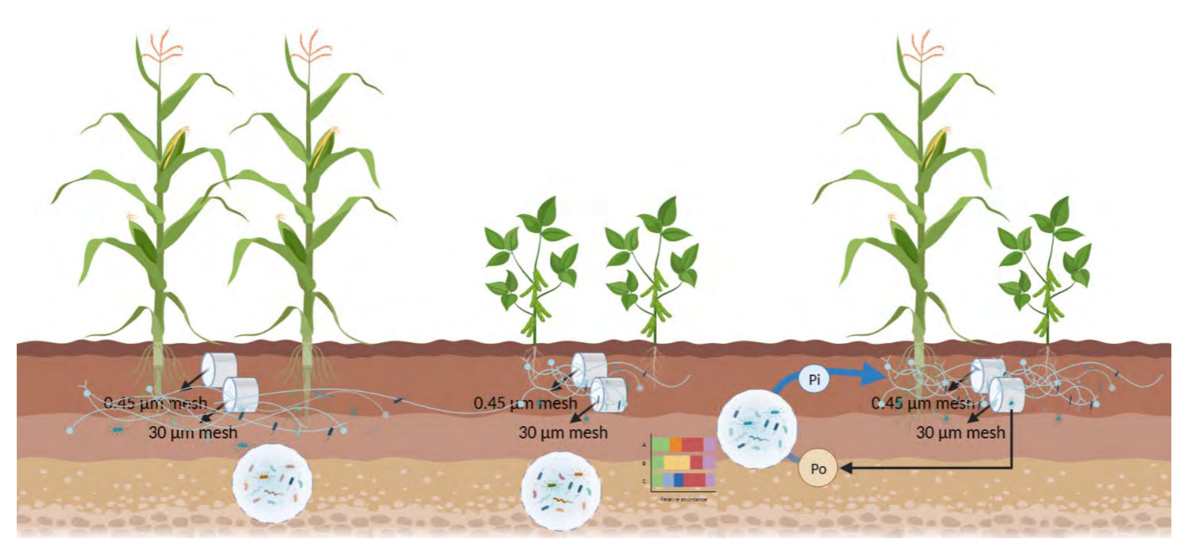
Q1: Which hyphosphere core microorganisms are recruited by AM fungi to improve plant phosphorus nutrition?
Q2: What are the essential substances for AM fungi to recruit functional hyphal bacteria?
Q3: What genes control the synthesis/secretion of essential substances in AM fungi?
Q4: How to targeted regulate the function of mycelia microorganisms to improve plant phosphorus nutrition?



(Zhang et al, 2021)

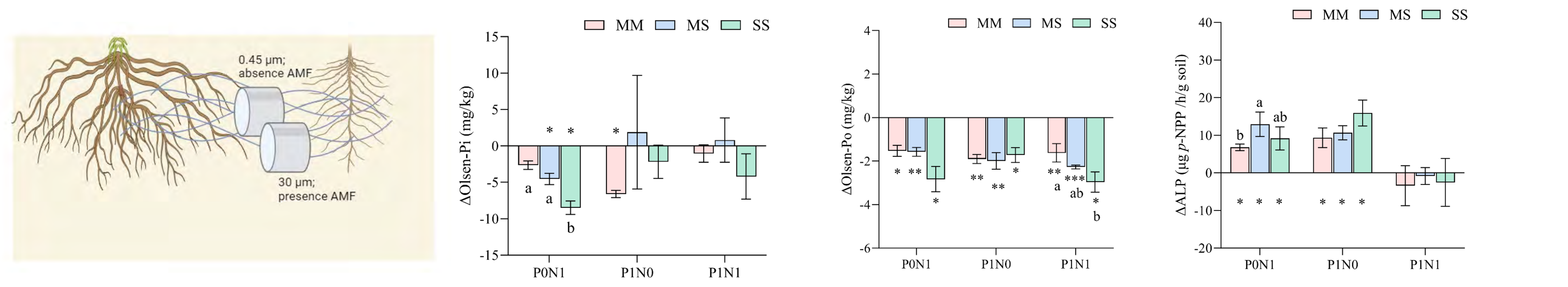
Chapter 1: Mechanism of organic-P mineralization in the interaction between AM fungi and hyphosphere bacteria under different cropping systems and nutrient supply conditions

Introduction: Interspecific facilitation of Gramineae–Leguminosae improves crop phosphorus uptake from soil. Recently researchers found that the intercropping of maize with legumes significantly increased maize productivity and P transformation and regulation (Yang et al., 2022). Furthermore, added AM fungi (*Rhizophagus irregularis*) significantly increased maize phosphorous uptake and phosphorous use efficiency and intercropping maize has advantages over monocropping (Song et al., 2021). Based on this research, we used PVC tubes to investigate the mechanism of organic-P mineralization in the hypha interface under different cropping systems and nutrient supply conditions.



Result

☐ The interaction between AM fungi and microbiome promoted the mobilization of soil organic P

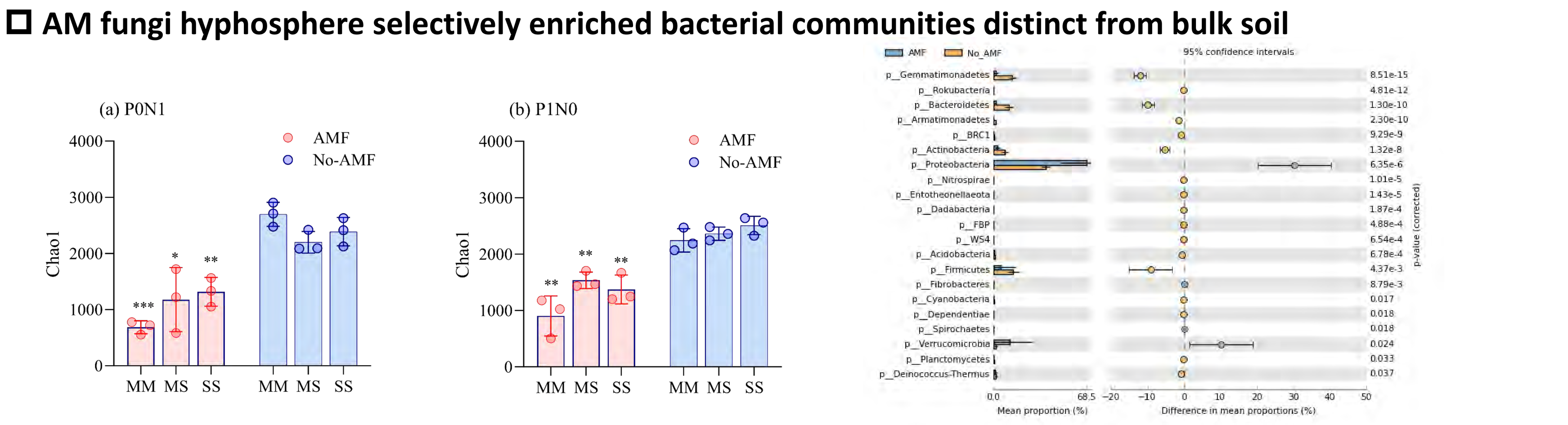


ΔOlsen-P = AMF treatment Olsen P − No_AMF treatment Olsen P
ΔALP activity = presence AMF soil ALP activity − absence AMF soil ALP activity

Asterisks indicate significant differences between with and without AMF.
Lowercase letters indicate significance between different planting systems.

- AM fungal–bacterial interactions strengthened phosphatase activity and stimulated organic P mineralization

☐ AM fungi hyphosphere selectively enriched bacterial communities distinct from bulk soil



- Compared to the No_AMF treatment, the species diversity of the hyphosphere bacterial community were consistently lower, and there were no significant differences among different treatments.
- Proteobacteria; Verricomicrobia; Fibrobacterer; Spirochartes were significantly enriched in hyphosphere.

References

Artursson V, Finlay R D, Jansson J K. Interactions between arbuscular mycorrhizal fungi and bacteria and their potential for stimulating plant growth[J].Environmental Microbiology,2006, 8 (1): 1-10.
Falkowski P G, Fenchel T, Delong E F. The microbial engines that drive Earth's biogeochemical cycles[J].Science,2008, 320 (5879): 1034-1039.
Jiang F, Zhang L, Zhou J, et al. Arbuscular mycorrhizal fungi enhance mineralisation of organic phosphorus by carrying bacteria along their extraradical hyphae[J].New Phytologist,2021, 230 (1): 304-315.
Morin E, Miyauchi S, San Clemente H, et al. Comparative genomics of *Rhizophagus irregularis*, *R. cerebriforme*, *R. diaphanus* and *Gigaspora rosea* highlights specific genetic features in Glomeromycotina[J].New Phytologist,2019, 222 (3): 1584-1598.
Smith S E, Read D J. Mycorrhizal Symbiosis, 3rd Edition[J].Mycorrhizal Symbiosis, 3rd Edition,2008: 1-787.
Song C, Sarpong C K, Zhang X, et al. Mycorrhizosphere bacteria and plant-plant interactions facilitate maize P acquisition in an intercropping system[J]. Journal of Cleaner Production, 2021, 314: 127993.
Tisserant E, Malbreil M, Kuo A, et al. Genome of an arbuscular mycorrhizal fungus provides insight into the oldest plant symbiosis[J].Proceedings of the National Academy of Sciences of the United States of America,2013, 110 (50): 20117-20122.
Yang Z, Zhang Y, Wang Y, et al. Intercropping regulation of soil phosphorus composition and microbially-driven dynamics facilitates maize phosphorus uptake and productivity improvement[J]. Field Crops Research, 2022, 287: 108666.
Zhang J, Liu Y X, Guo X, et al. High-throughput cultivation and identification of bacteria from the plant root microbiota[J]. Nature Protocols, 2021, 16(2): 988-1012.
Zhang L, Feng G, Declerck S. Signal beyond nutrient, fructose, exuded by an arbuscular mycorrhizal fungus triggers phytate mineralization by a phosphate solubilizing bacterium[J].Isme Journal,2018, 12 (10): 2339-2351.
Zhang L, Zhou J, George T S, et al. Arbuscular mycorrhizal fungi conducting the hyphosphere bacterial orchestra[J].Trends in Plant Science,2021.

Acknowledgements

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Finding adaptations of symbiosis signalling cascade:

from mycorrhizal symbiosis to nitrogen-fixing symbiosis

Wenying Huo
Supervisors: Prof. Jianbo Shen, Prof. Bin Ni, Dr. Rene Geurts, Dr. Rik Huisman

Background

Plants can establish mutualistic symbioses with soil microbes. The most ancient and wide-spread symbiosis is the cooperation between plants and arbuscular mycorrhizal (AM) fungi[1]. Some plant species, especially legumes, evolved symbiosis with rhizobia. AM fungi and rhizobia produce signal molecules with similar structures, thereby activating the same signalling network in plants, named the **common symbiosis signalling pathway** (**CSSP**)[2].

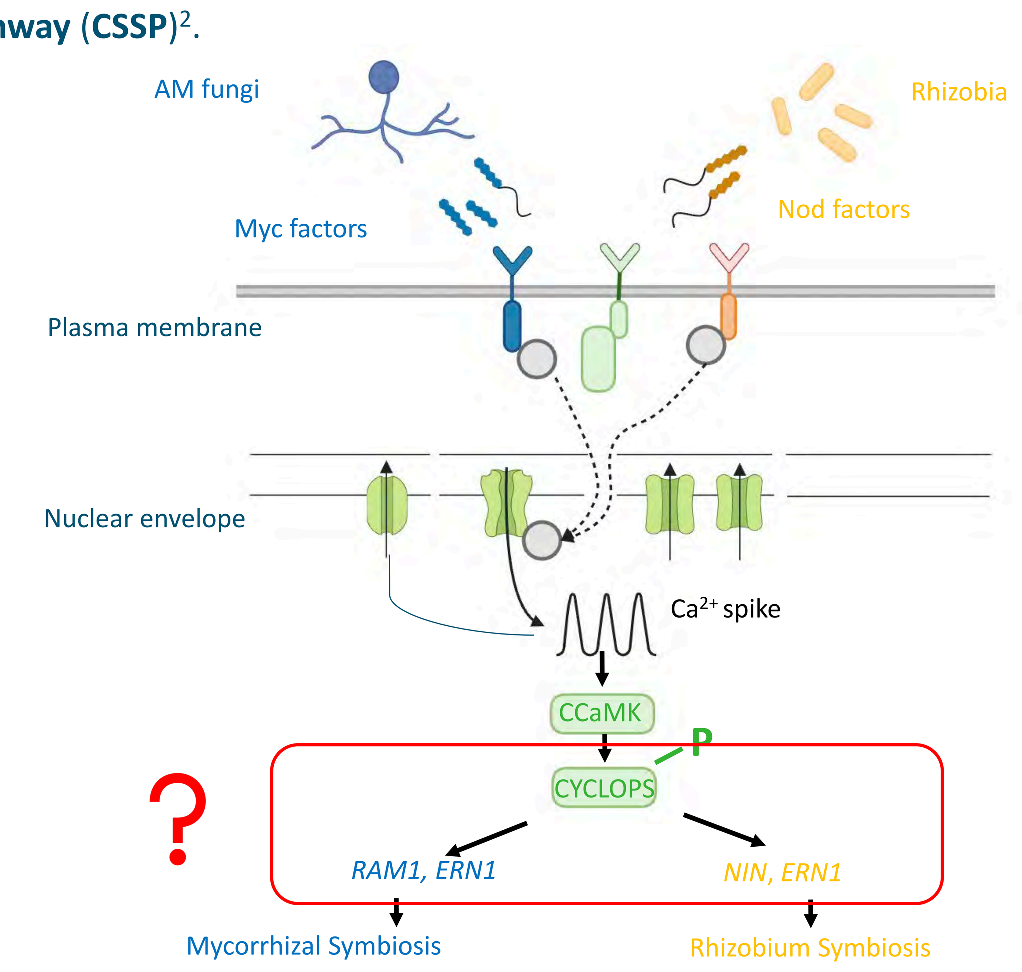

Figure 1. Common symbiosis signalling pathway

Both microbes trigger the activation of transcription factor CYCLOPS. However, During AM symbiosis CYCLOPS activates the transcription factor *RAM1*[3], whereas during nodulation CYCLOPS activates transcription factors *NIN* and *ERN1*[4,5]. As a result, the gene expression triggered by AM fungi and rhizobia shows little overlap[6-8]. it leads to the main research question of this project: How can plants discriminate between AMF and rhizobia with the same signalling pathway?

In this research, the non-legume *Parasponia andersonii* is used as research system.

Objectives

- Description of CYCLOPS-responsive elements (CYC-REs) activity.
- Confirmation of CYC-Res by transactivation assay.
- Identification of the molecular mechanism that determines which genes are activated by the common symbiotic signalling pathway.

Methods

- Transactivation assay in *Nicotiana benthamiana* leaves.
- Co-immunoprecipitation and/or Turbo-ID.

Results

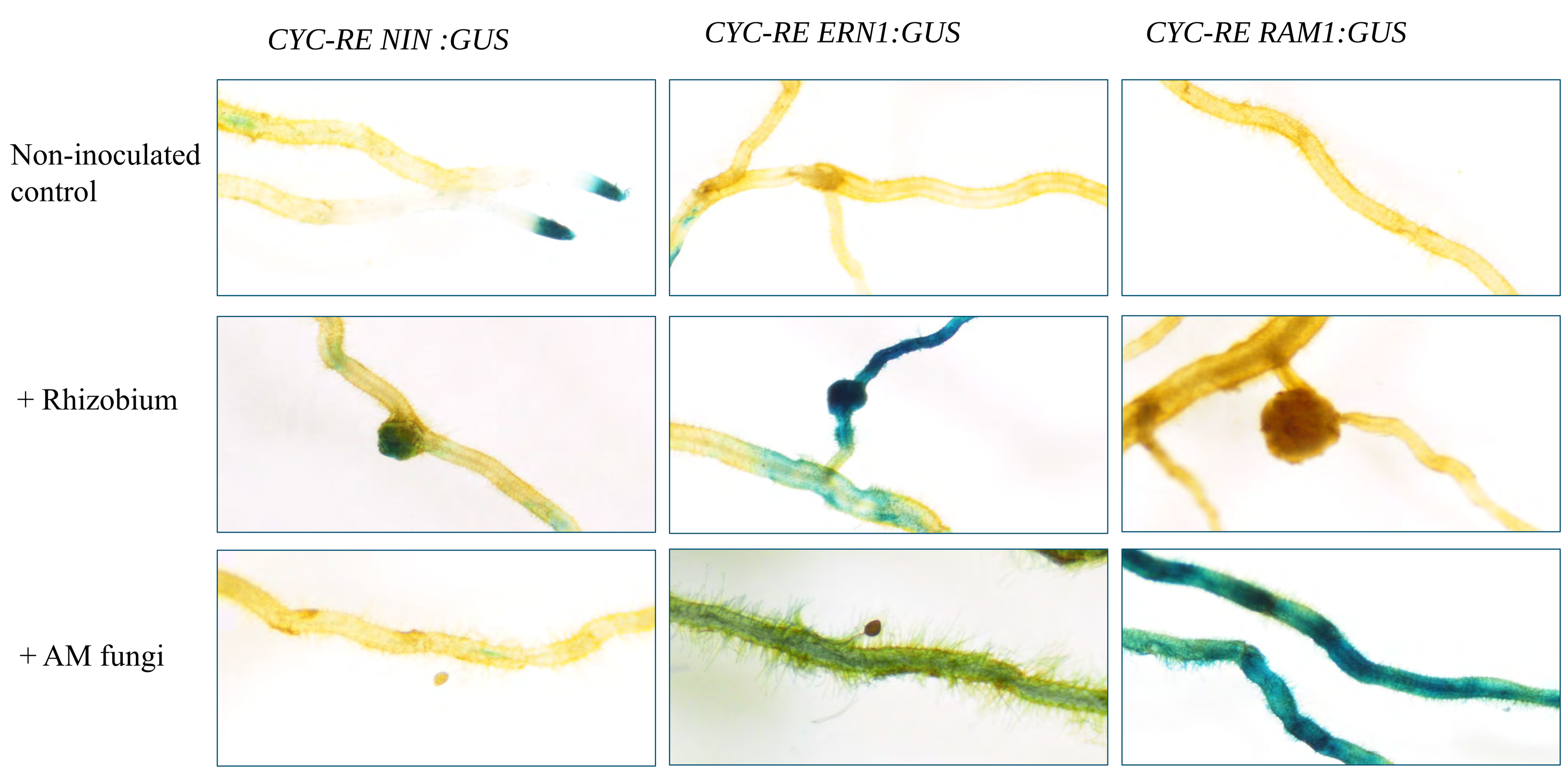

Figure 2. *CYC-REs* of *NIN* and *RAM1* specifically respond to rhizobium or AM fungi respectively, and *CYC-RE ERN1* is activated by both rhizobium and AM fungi in *Parasponia andersonii*. Wild-type parasponia were stably transformed with 5×*PanCYC-REs*:*GUS*. *CYC-REs* are 52bp cis-elements from parasponia covering the published *LjCYC-REs*. Roots were harvested and stained 4 wpi.

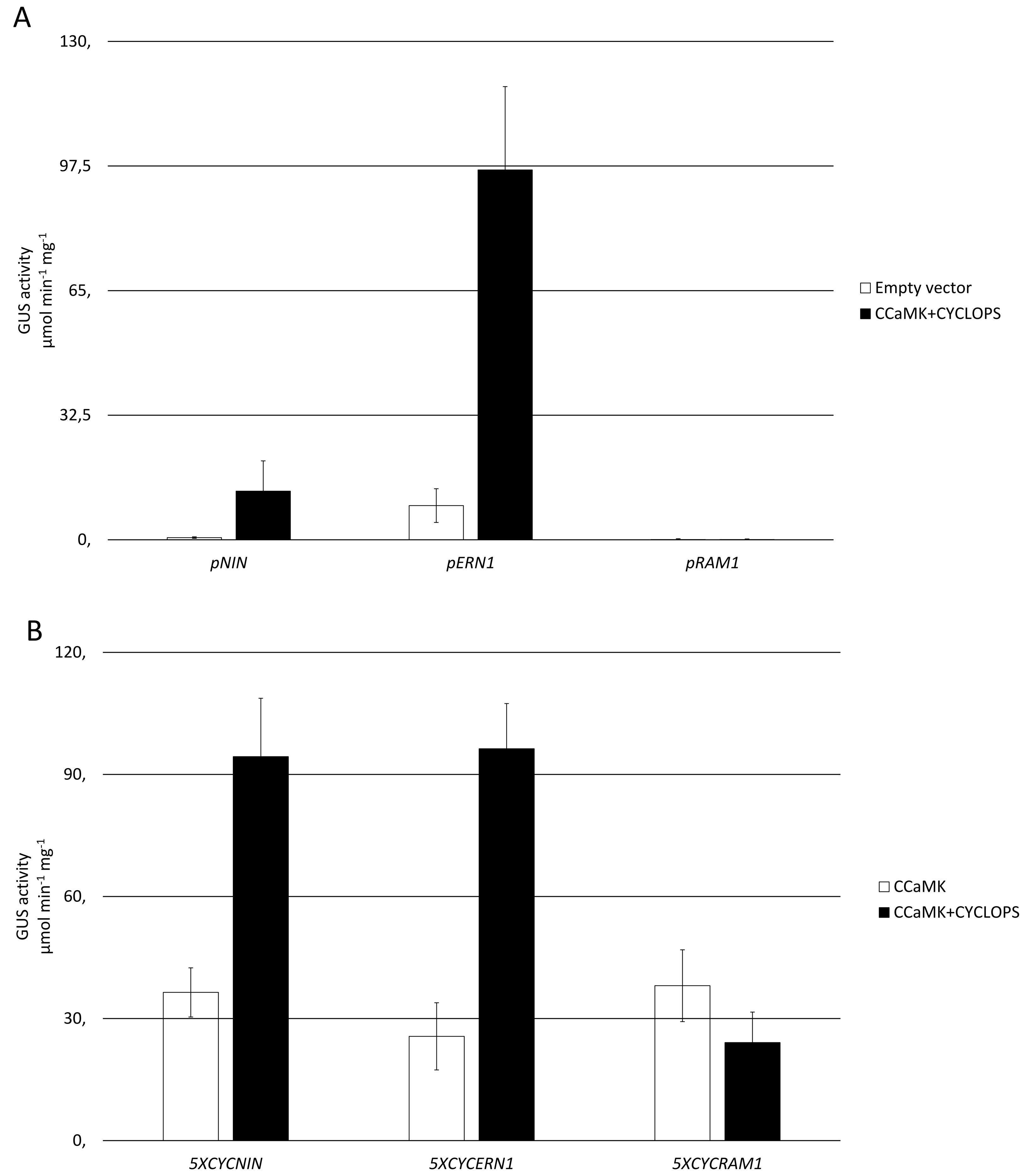

Figure 3. Promoters and *CYC-REs* of *NIN* and *ERN1* are transcriptionally activated by CYCLOPS in *Nicotiana benthamiana* leaves. (A) Transactivation assay of *Pan*CYCLOPS with the full promoters of *PanNIN*, *PanERN1* and *PanRAM1*. The *N. benthamiana* leaves were cotransformed with *pNIN*/*pERN1*/ *pRAM1*:GUS reporter, together with CYCLOPS and autoactive CCaMK, or empty vector control. *NIN* and *ERN1* promoters are transactivated by CCaMK + CYCLOPS, however RAM1 promoter does not respond to CYCLOPS. **(B)** Transactivation assay of *Pan*CYCLOPS with 5×*PanCYC-REs* of *NIN*, *ERN1* and *RAM1*. Construct of CCaMK were used as negative control. Consistently, 5×*PanCYC-REs* of *NIN*, *ERN1* are activated by CCaMK + CYCLOPS, but 5×*PanCYC-REs* of *RAM1* does not show the activation. GUS activity was determined by histochemical quantification after 3 days of infiltration. Mean values were determined from 5-7 replications, and the error bars indicate standard deviation.

Conclusions

- The specific activation of *NIN* (nodule specific) and *RAM1* (mycorrhiza specific) is encoded in their *CYC-REs*.
- The activation of CYCLOPS is not sufficient for the activation of the *RAM1* or *NIN CYC-RE*.
- *PanCYC-RE RAM1* cannot beactivated by CYCLOPS in *N. benthamiana leaves.*

References

1. Brundrett, M. C. *New Phytol.* **154**, 275–304 (2002).
2. Kistner, C. & Parniske, M. *Trends Plant Sci.* **7**, 511–518 (2002).
3. Pimprikar, P. *et al. Curr. Biol.* **26**, 987–998 (2016).
4. Singh, S., Katzer, K., Lambert, J., Cerri, M. & Parniske, M. *Cell Host Microbe* **15**, 139–152 (2014).
5. Cerri, M. R. *et al. New Phytol.* **215**, 323–337 (2017).
6. Nanjareddy, K., Arthikala, M. K., Gómez, B. M., Blanco, L. & Lara, M. *PLoS One* **12**, 1–25 (2017).
7. Limpens, E. *et al. PLoS One* **8**, (2013).
8. Manthey, K. *et al. Mol. Plant-Microbe Interact.* **17**, 1063–1077 (2004).

Acknowledgements

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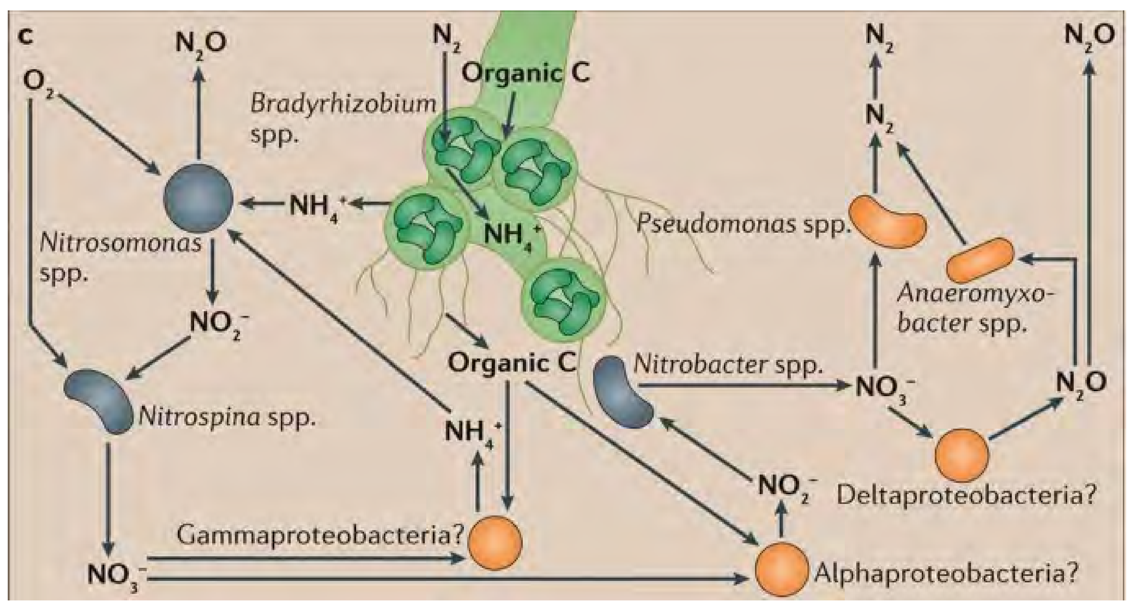
Uncovering the coordination mechanisms between plant and rhizosphere microbiome under different nitrogen levels

PhD student: Pugang Yu
Supervisors:Prof. Jianbo Shen, Prof. Bin Ni, Dr. Rene Geurts

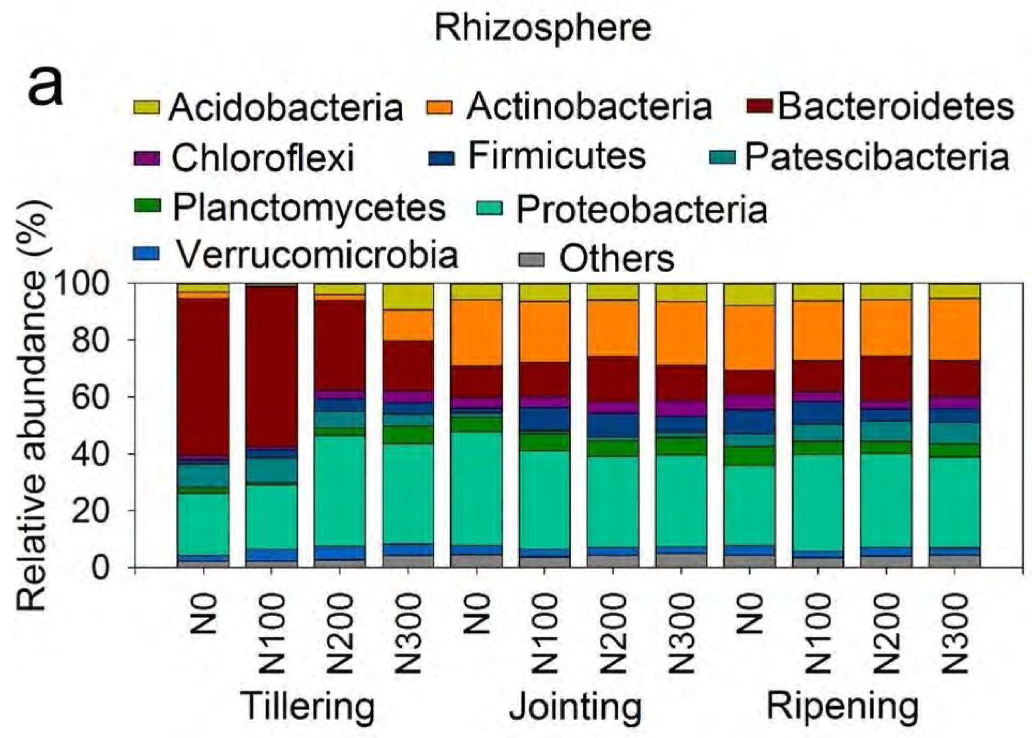
Background

✓ Microbiome drive nitrogen cycle processes including nitrogen fixation, nitrification, denitrification and so on.



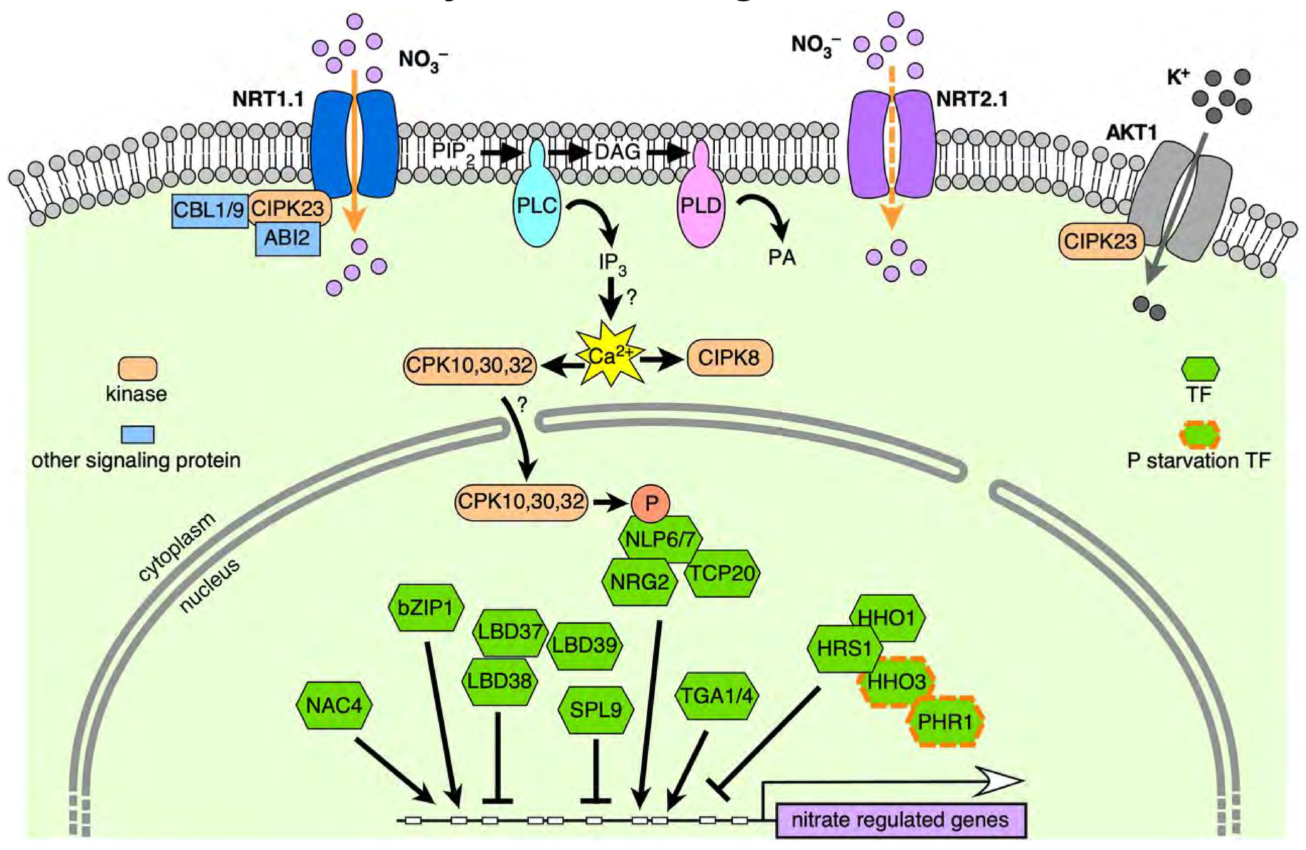
[1]

✓ Rhizosphere microbiome can response to different nitrogen input levels.



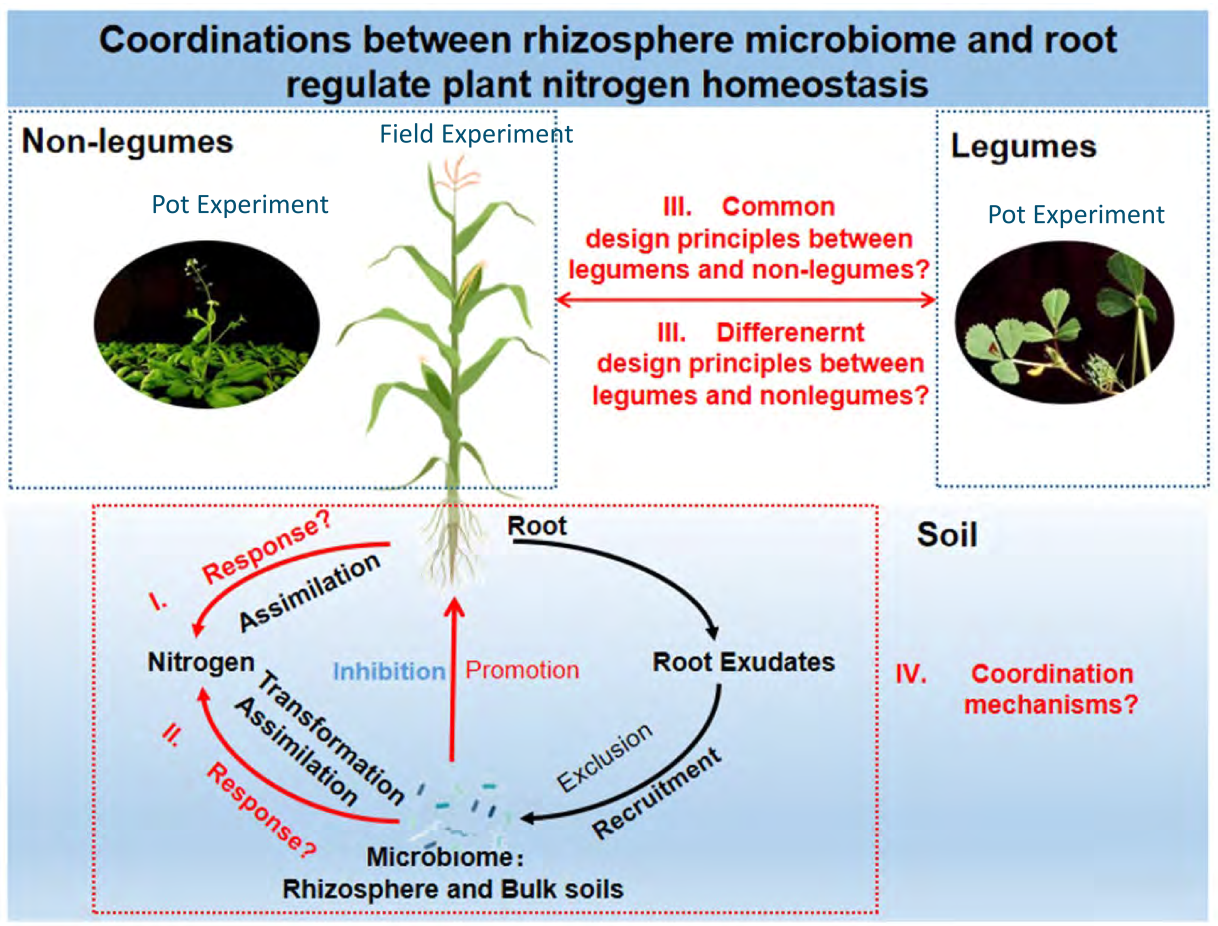
[2]

✓ For plants, nitrogen is not only a nutrient but also a systemic signal.

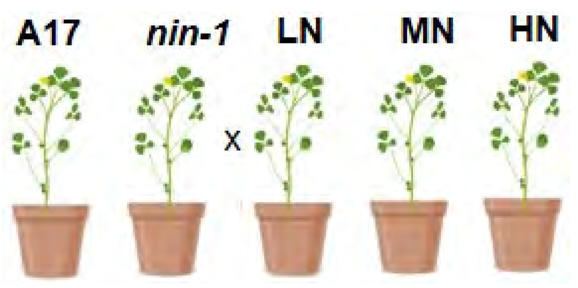


[3]

Research framework

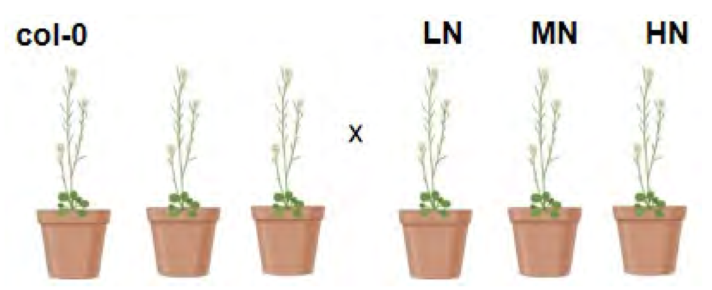


Pot Experiments 1



2 genotypes x 3 nitrogen levels
Medicago truncatula

Pot Experiments 2



3 genotypes x 3 nitrogen levels
Arabidopsis thaliana

Fields Experiments : 6 Nitrogen input levels, 2 maize Varieties

Objectives

01 To explore the changes of root gene expression level in response to different nitrogen levels.

02 To explore the changes of rhizosphere microbiome to get adapted to different nitrogen levels.

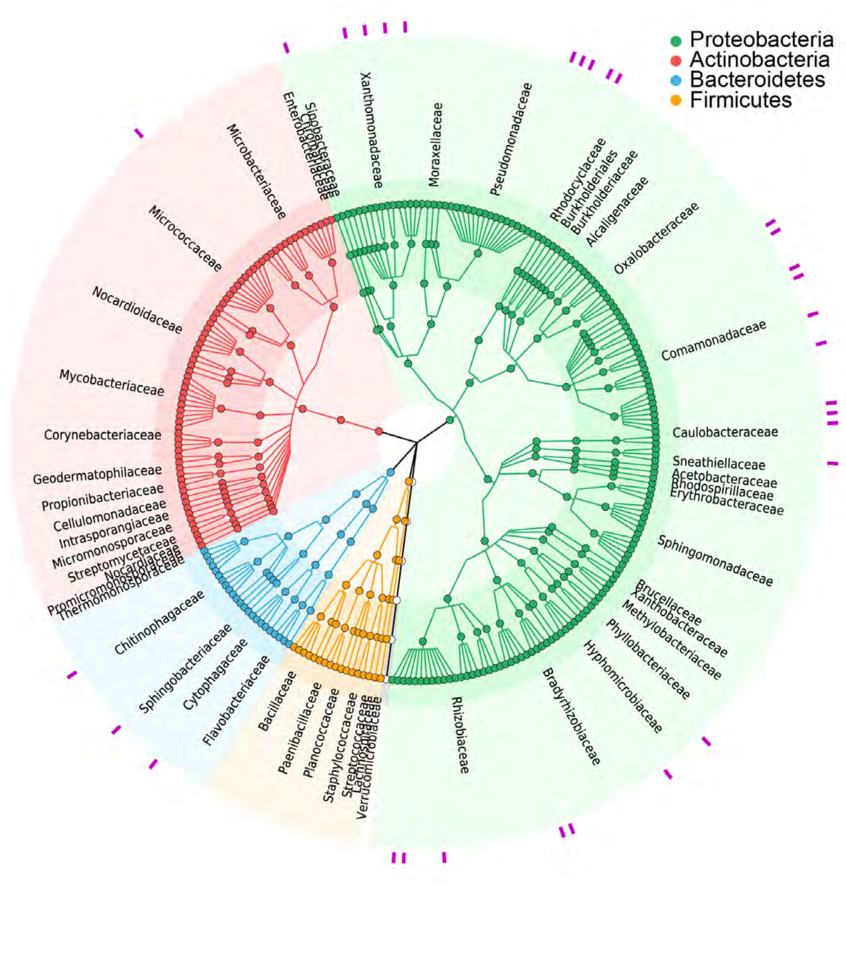
03 To explore the coordinations between rhizosphere microbiome and plant roots.

04 To find common design principles in shaping these plant-rhizosphere microbiome interactions between legumes and non-legumes?

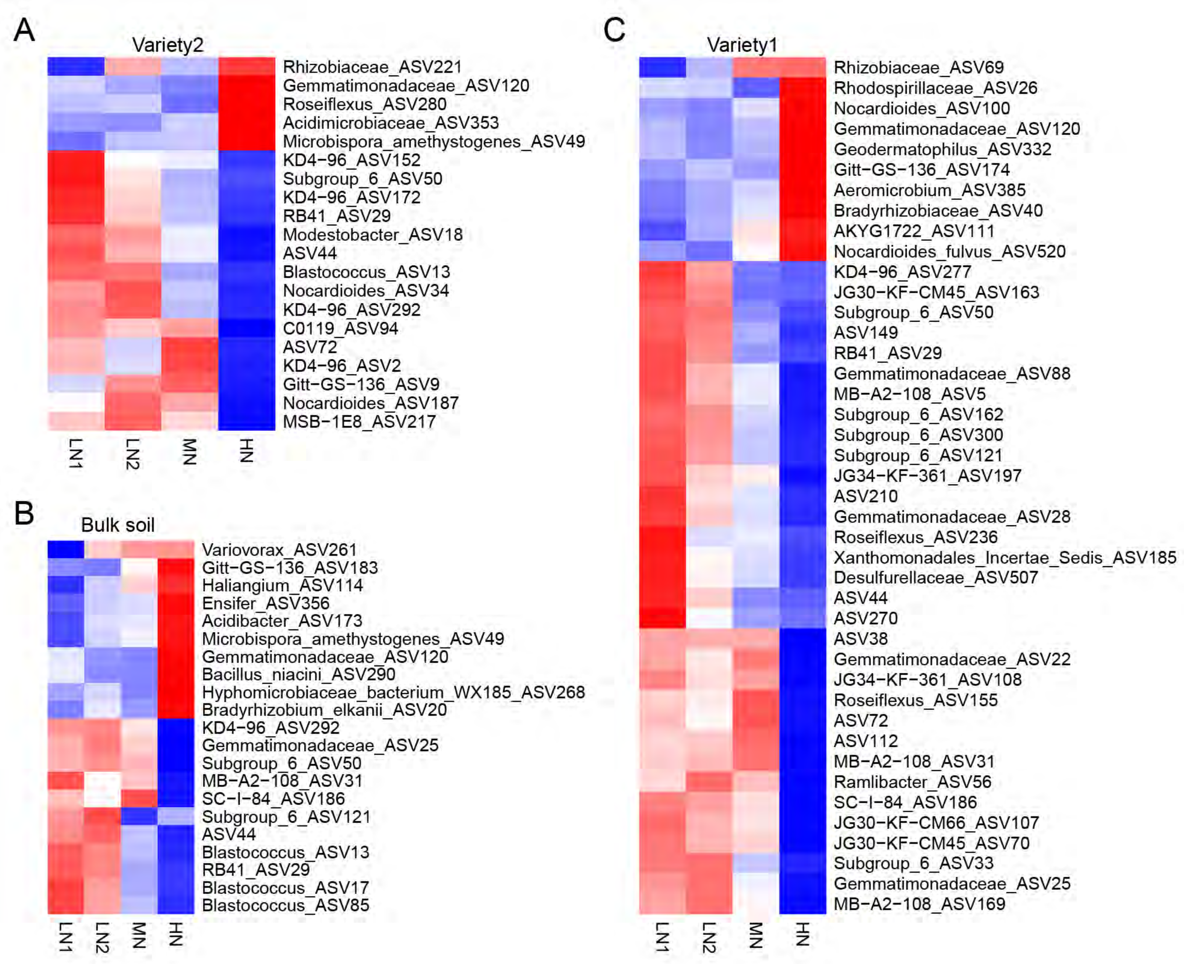
Research prospect

1. Based on the research, the coordinations between rhizosphere microbiome and plant roots under different nitrogen levels will be partly clarified.
2. To develop new crops systems: maximize the coordinations between plants and microbiome.

Results



Bacteria culturome of 8 weeks maize root from pot experiments



Relative abundances of marker ASVs under different nitrogen input levels

Maize rhizosphere soils had a more complex and stable co-occurrence networks than bulk soils

Reference

[1]. Kuypers MMM, Marchant HK, Kartal B. The microbial nitrogen-cycling network. *Nat Rev Microbiol*. 2018;16(5):263-276. doi:10.1038/nrmicro.2018.9
[2] Chen S, Waghmode TR, Sun R, Kuramae EE, Hu C, Liu B. Root-associated microbiomes of wheat under the combined effect of plant development and nitrogen fertilization. *Microbiome*. 2019;7(1):136. Published 2019 Oct 22. doi:10.1186/s40168-019-0750-2
[3] Vidal EA, Alvarez JM, Araus V, et al. Nitrate in 2020: Thirty Years from Transport to Signaling Networks. *Plant Cell*. 2020;32(7):2094-2119. doi:10.1105/tpc.19.00748.

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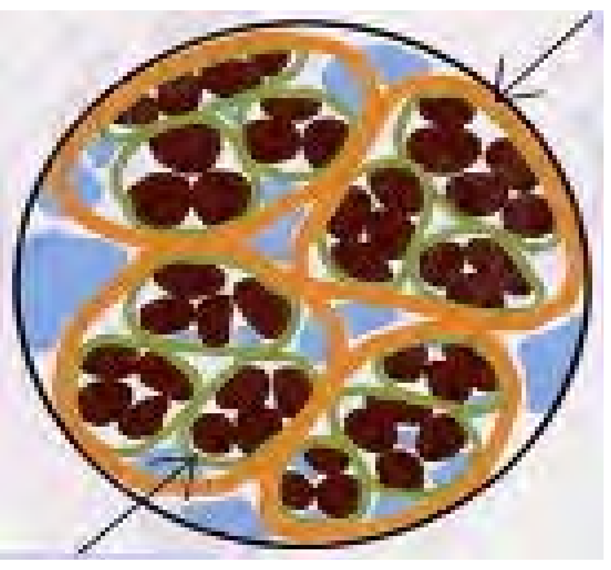
Biota in macroaggregates induced by organic fertilization facilitate crop growth and control N_2O emission

Candiate: Zewen Hei

Supervisors: Yongliang Chen; Stefan Geisen; Jan Kammenga

Background



Organic fertilization achieves a balance between satisfactory yields, soil fertility and climate mitigation. However, how organic and conventional fertilization affect the composition and function of biota in relation to plant performance and greenhouse gas emission at the aggregate scale remains largely unknown.

Objectives

In this study, we aimed to explore how fertilization practices (two application levels of conventional fertilization, and two organic fertilization levels with identical nitrogen, phosphorus and potassium nutrient contents) impact the composition and function of biota in relation to plant performance and greenhouse gas emission at the aggregate scale.

Methods

Study site and experimental design

The experiment site was located in Quzhou county (36°52′N, 114°01′E, 40 m a.s.L.), Hebei Province, China. Five treatments were arranged in a randomized complete block design with three replicates: (1) control (CK); (2) low organic manure (M6; 6000 kg cow manure ha^{-1}); (3) high organic manure (M12; 12,000 kg cow manure ha^{-1}); (4) low chemical fertilizer (C6; equivalent to the amounts of N, P and K in M6); and (5) high chemical fertilizer (C12; equivalent to the amounts of N, P and K in M12).

Soil sampling, aggregate fractionations

Bulk soil was manually fractionated through two sieves (2000 µm and 250 µm) at 150 times minute-1 for 10 min. The bulk soil was separated into into three aggregates: large macroaggregate (>2000 µm aggregates; LMA), small macroaggregate.

Pot experiment

The pot experiment was carried out in a glasshouse (40° 1′41″ N, 116° 16′49″ E) on the campus of the China Agricultural University, Beijing, China. The soil used in the experiment was collected from China Agricultural University Shangzhuang experimental station.

About 15 g fresh aggregate samples was mixed with the 2 kg sterilized soil for two weeks. Maize seed were then transplanted to the pots on 21 September 2022 after germination at 5 °C for 72 h in the dark condition

Results

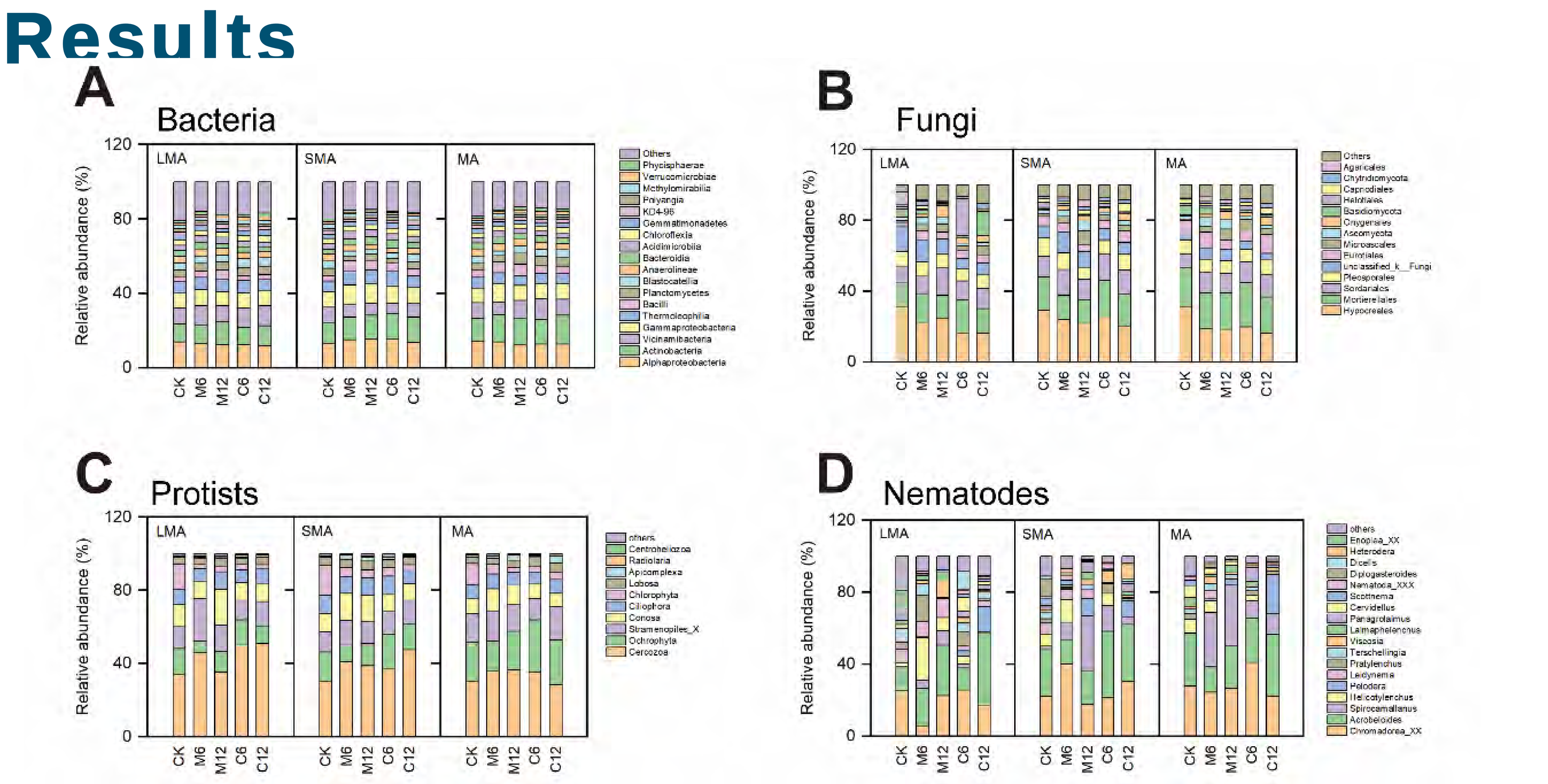
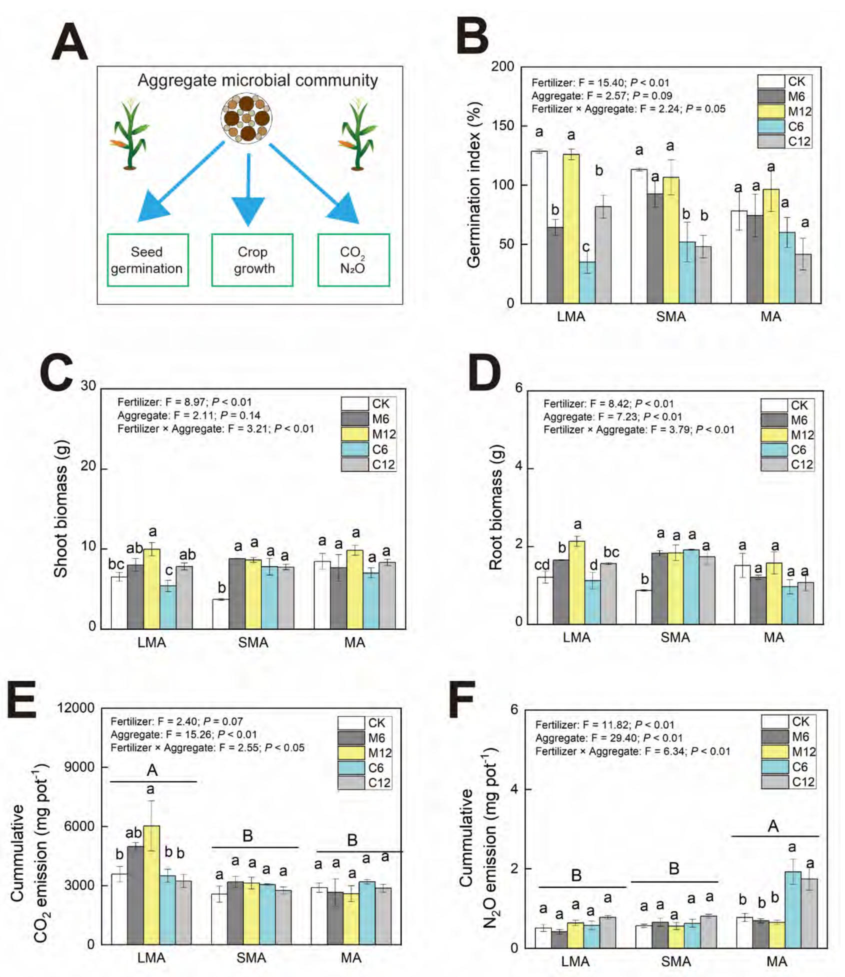


Fig. 1. Relative abundance of bacterial, fungal, protistan and nematode communities in organic and conventional fertilizations across three aggregate size fractions.

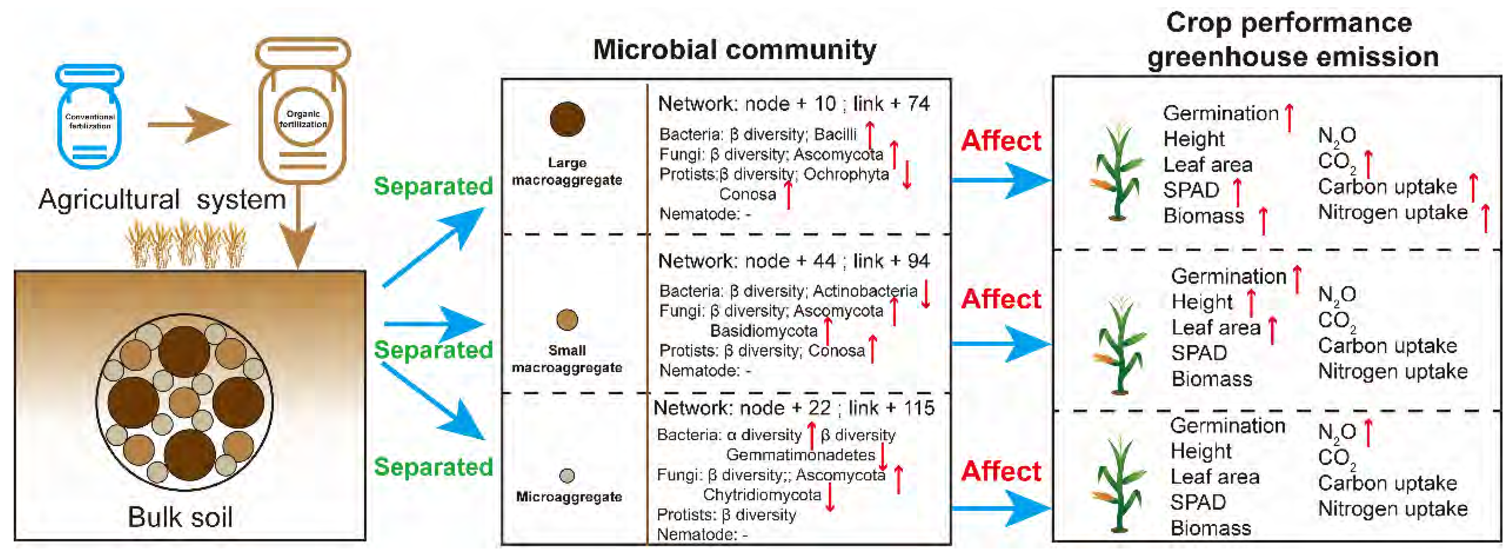


For large macroaggregate, low and high organic fertilization treatments increased the germination indexes by 83.6% and 54.0% compared to corresponding conventional fertilization treatments. Compared to conventional fertilization treatments, low and high organic fertilization enhanced the SPAD of crop by 13.1% ~ 22.8% on 40~60 days of crop growth.

For microaggregate, low organic fertilization treatment decreased the N_2O emission by 89.4% compared to low conventional fertilization treatments on 40 day of crop growth. In addition, compared to conventional fertilization treatments, low and high organic fertilization decreased the cumulative N_2O emission by 63.9% and 62.6%.

Fig.2 Crop biomass and greenhouse emission in organic and conventional fertilizations across three aggregate size fractions. Effect of the organic and conventional fertilization on shoot biomass (A), root biomass (B) CO_2 emission (C), and N_2O emission (D) in three aggregate size fractions.

Conclusions



We conclude that increasing macroaggregates indicates the best practical solution to facilitate crop productivity and control N2O emission in agricultural soil.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University.

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Diversification of crop rotation systems shift rhizobiomes to facilitate crop performance

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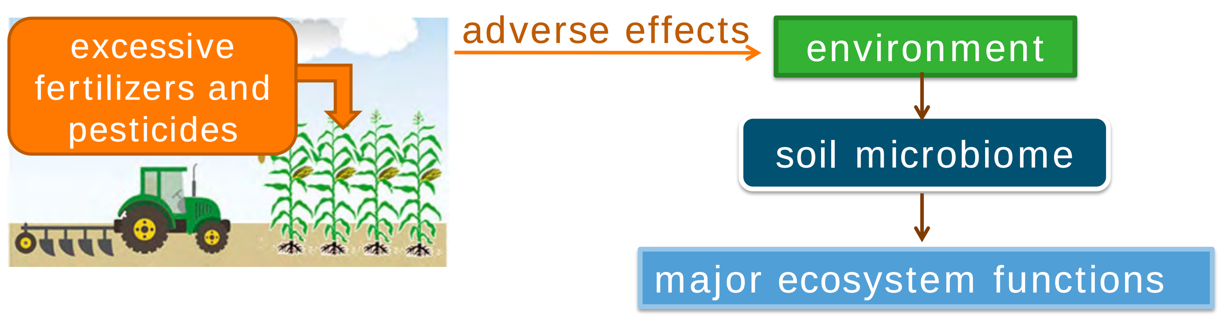
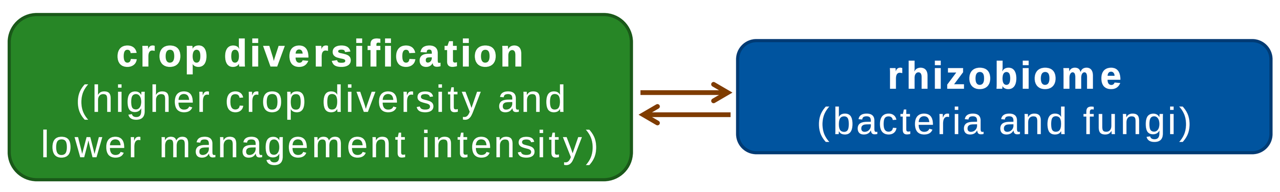
[2] : College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China

Background

- Wheat-maize rotation: the most common cropping system in North China



- Diversified rotation systems --- crop productivity and sustainability
- Tight link between crop performance and rhizobiome
- Rhizobiome functioning on crop performance remains unknown



Objectives

Decipher rhizobiome (bacteria and fungi) changes as induced by increasing crop diversification in rotation systems and resulting functional feedback on crop performance.

Methods

(a) Field Study

- samples from long-term field study with four diversified crop rotation systems.

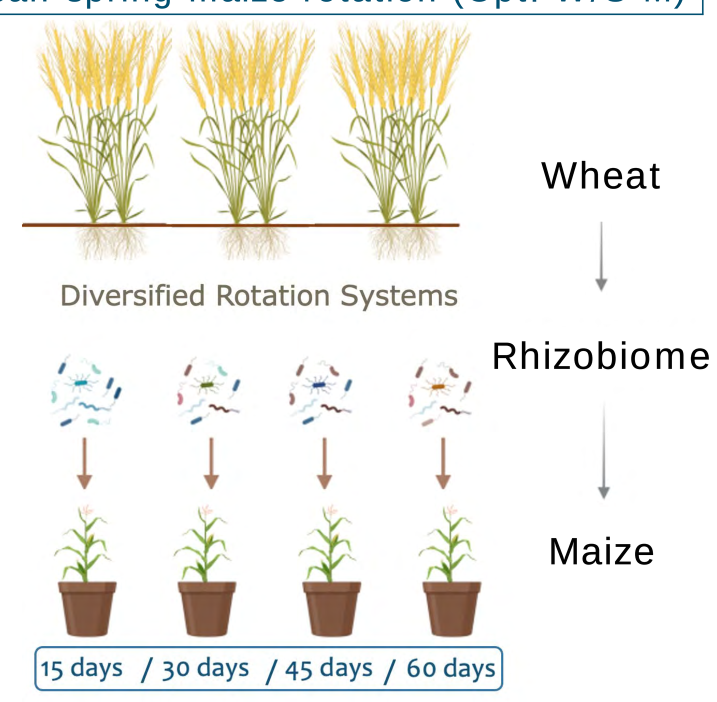
diversification increase

Crop Rotation Systems
1) Conventional winter wheat-summer maize rotation (Con. W/M)
2) Optimized winter wheat-summer maize rotation (Opt. W/M)
3) Optimized winter wheat-summer maize-spring maize rotation (Opt. W/M-M)
4) Optimized winter wheat-summer soybean-spring maize rotation (Opt. W/S-M)

(b) Pot Experiment

50 g field soils (from four rotation systems) + 1.95 kg background soil (sterilized by γ-irradiation)

- one maize grew in each pot for 60 days
- harvested every 15 days to measure: chlorophyll content (SPAD); height; leaf area; shoot and root biomass; C/N in plant
- N_2O and CO_2 measurements



Results

(a) Field Study

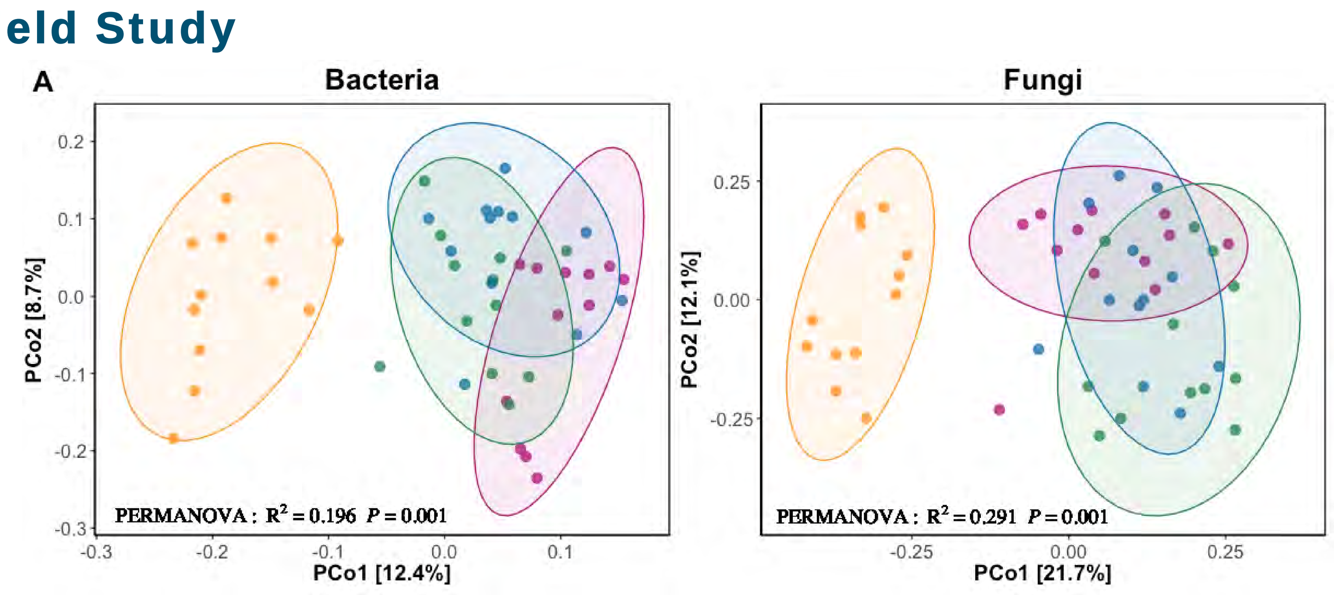


Fig.1: Optimized systems shaped bacteria and fungi communities compared to conventional system, with little differences between the optimized systems.

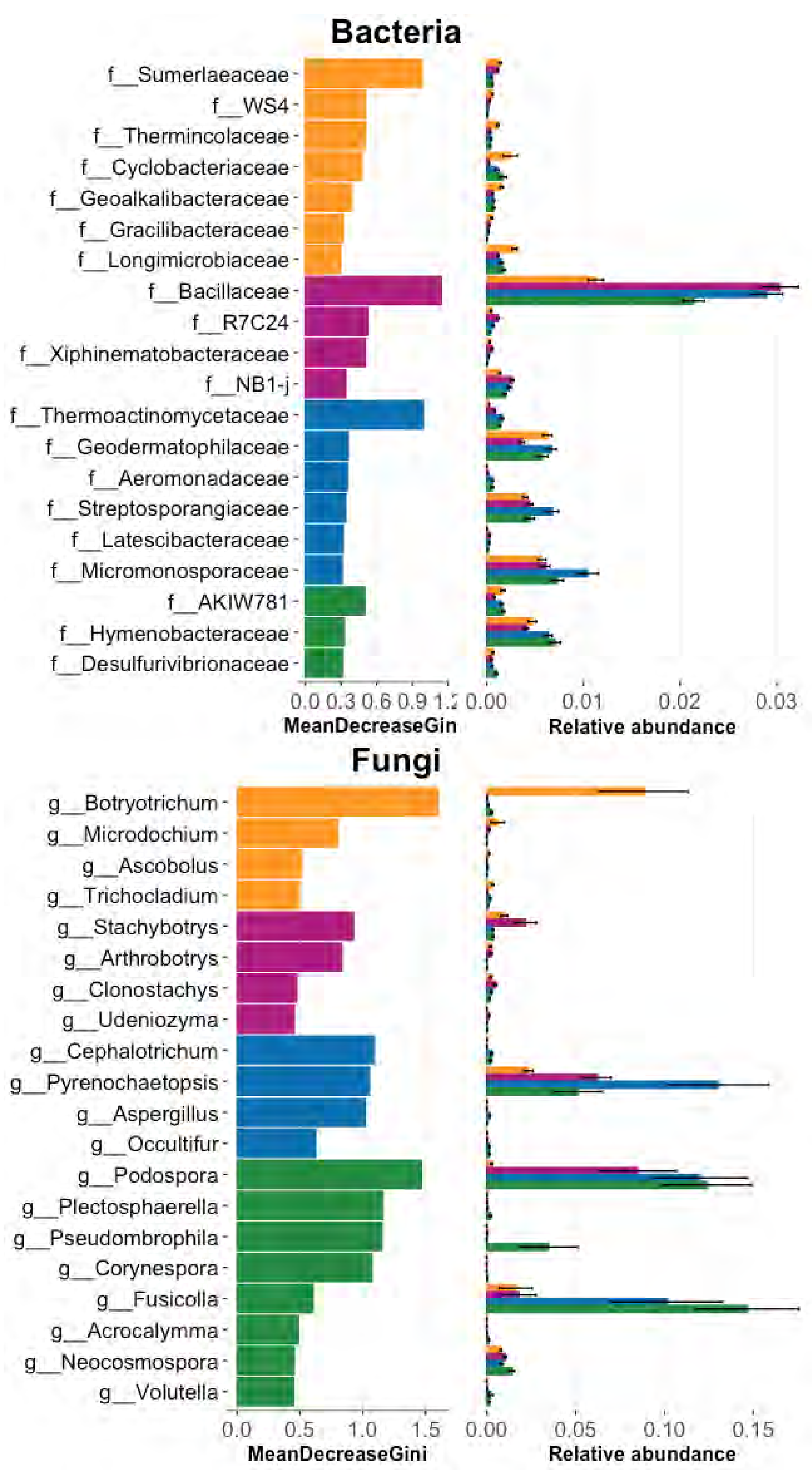


Fig.2: The significantly different abundant taxa (biomarkers) of bacteria and fungi.

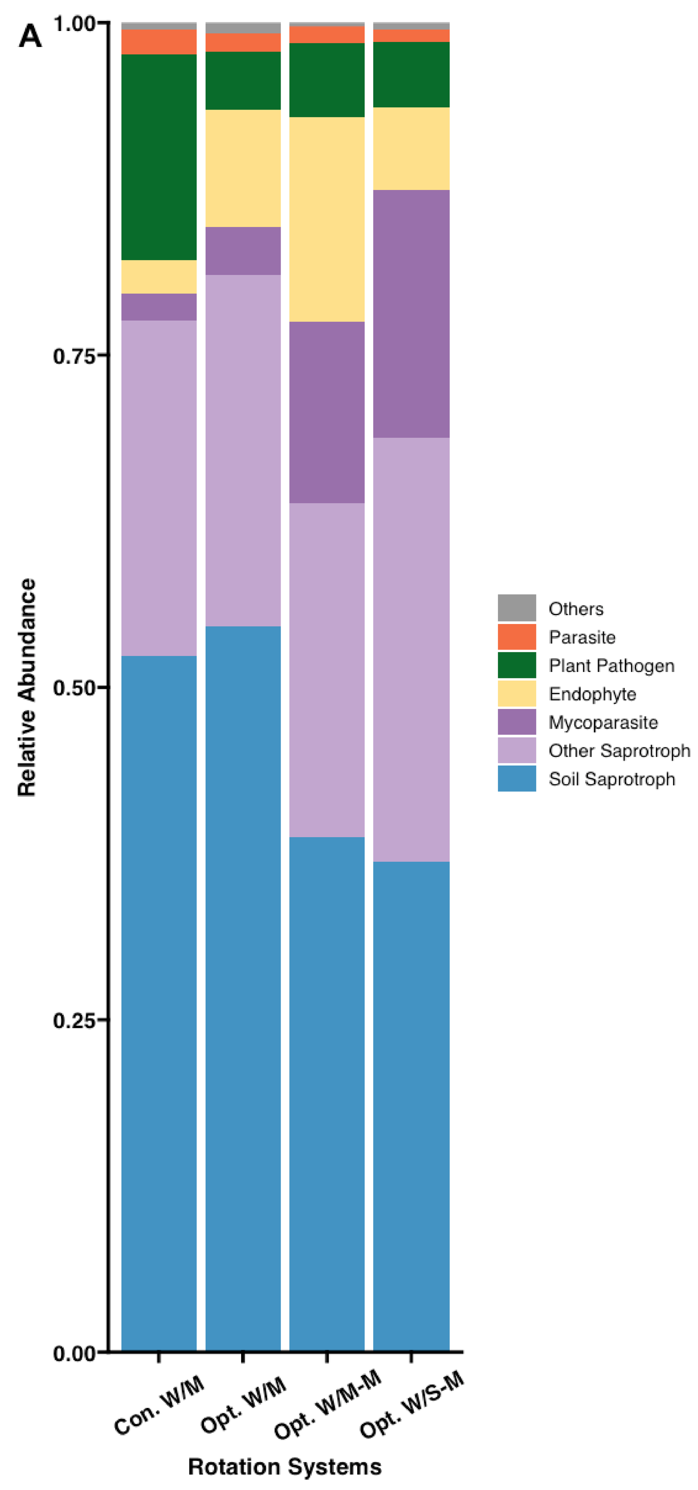


Fig.3: Fungal functional groups in four rotation systems. Higher crop diversification led to more endophyte, less soil saprotrophs and plant pathogens

(b) Pot Experiment

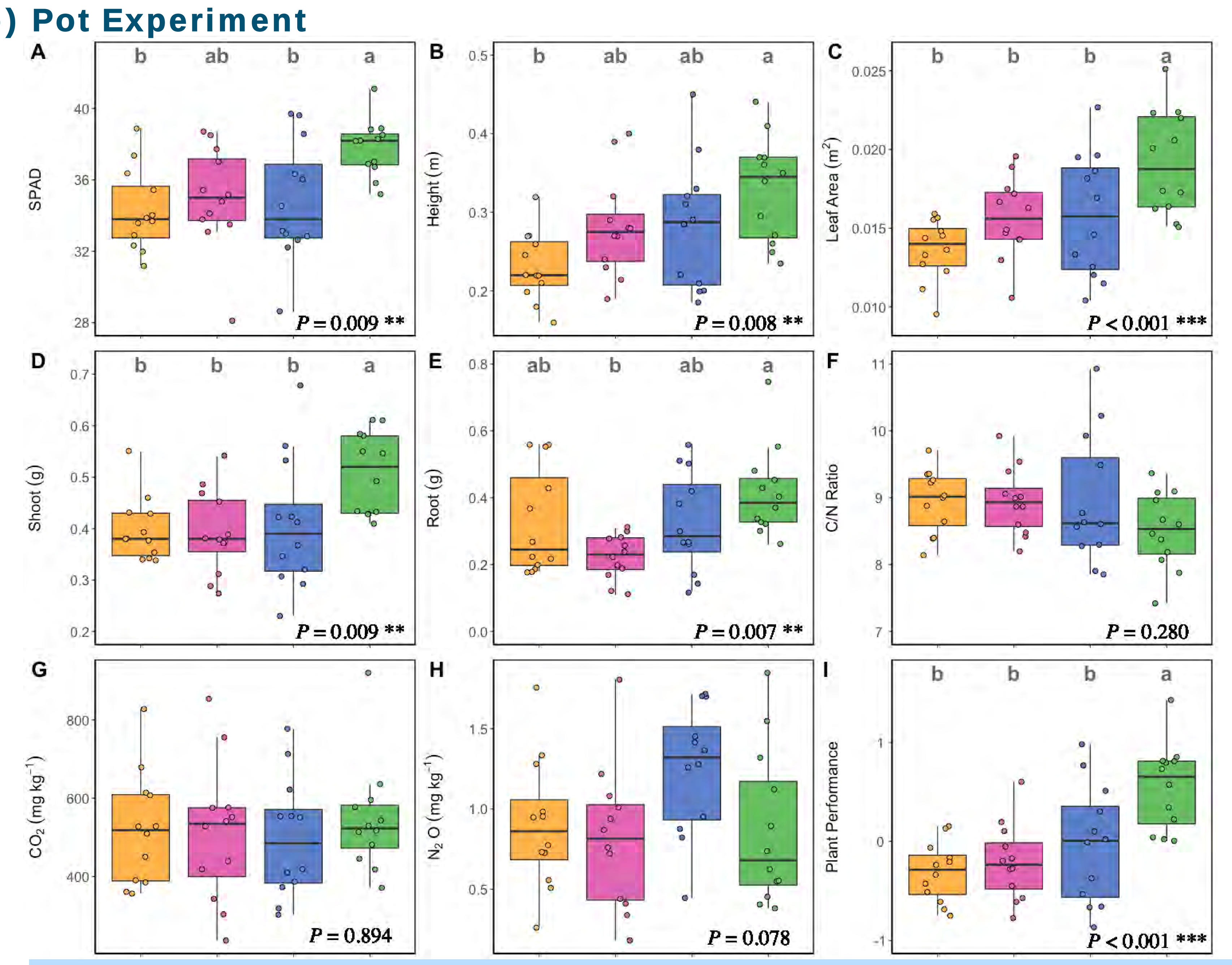


Fig.4: Rhizobiomes from the higher crop diversification systems contributed to better crop performance.

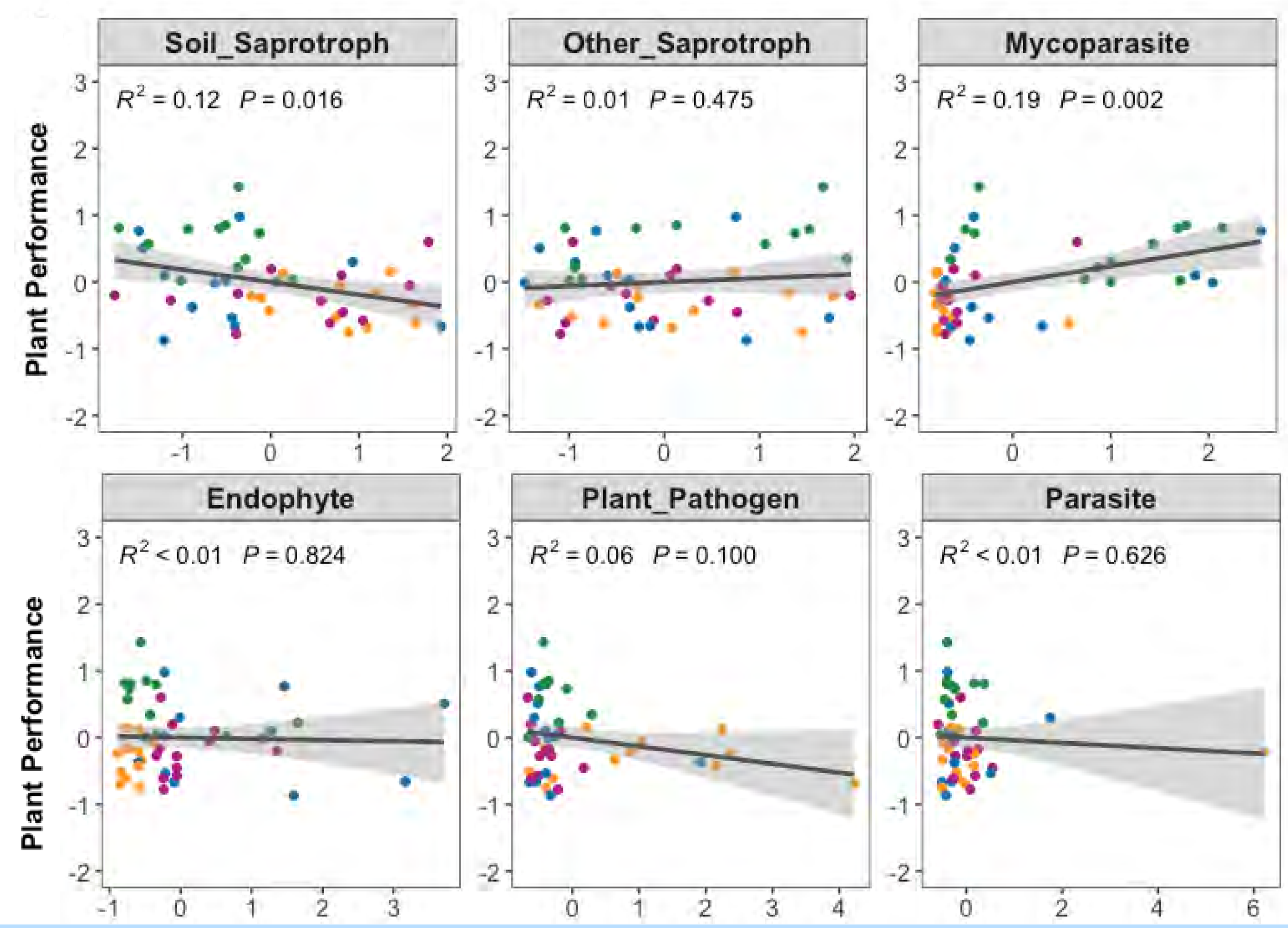


Fig.5: Crop performance was negatively correlated with soil saprotroph and positively correlated with mycoparasite.

Conclusions

1) Crop diversification altered rhizobiome composition: more plant beneficial microorganisms and less plant pathogens
2) Diversification-induced rhizobiomes facilitated subsequent crop performance

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