Current projects

Agriculture Green Development Programme

Poster overview January 2023

Wageningen University & Research

China Agricultural University

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Posters, January 2023

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. Mingzhao Han	1+3	Exploring green transformation of plant extract industry: a case study on CCGB
4. Jinghan Li	1+3	The social impact of Science and Technology Backyards (STBs) towards a rural revitalization in China
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Theme: Green animal production

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6. Guichao Dai	2+2	Optimization and designing of integrated crop-livestock systems
7. Tao Zhang	2+2	Decreasing nutrient loss from crop-livestock systems by manure redistribution with minimum cost and improved management
8. Zhenyu Wang	2+2	Improved utilization of organic wastes to develop new feed resources
9. Shiyi Zhang	1+3	Quantifying the effects of dietary fibres on protein digestibility in pigs
10. Hao Ye	1+3	Effects of protein kinetics in lactating sow diet on sow body condition losses, litter weight gain and nitrogen utilization
11. 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
12. 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*
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14. Yu Gu	1+3	Assessment of the spatial distribution in phosphate balance and the required mitigation potentials
15. DongFang Zheng	2+2	Assessment of the spatial distribution in phosphate balance and the required mitigation potentials
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18. Fanlei Meng	2+2	Agricultural Green Development in China – Integrated Assessment of green food production, green products and a green environment
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20. Zhibiao Wei	1+3	Waste2C: From Waste to Crop – Quzhou as a Living Lab for Sustainable Agro-Food systems
21. Luncheng You	2+2	Towards sustainable nitrogen and acidification management in the Quzhou and Zhaoyuan counties and the North China Plain
22. Qi Zhang	1+3	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach

Theme: Green plant production

Name	*Model**	*Project*
23. Jiali Cheng	1+3	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
24. Zhengyuan Liang	1+3	Developing sustainable diversified crop production systems for the North China Plain
25. Mengshuai Liu	2+2	Crop rotations, intercropping, and negative plant-soil feedback in Quzhou and the North China Plain
26. Zhan Xu	1+3	The implications of positive deviant farms for crop production sustainability in the North China Plain
27. Lu Liu	2+2	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
28. Jie Lu	1+3	Increasing nutrient use efficiency in maize by merging functional structural root modelling and marker assisted breeding
29. 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.

Sustainable, Healthy, Affordable, Reliable and Preferable Diets in China

Hongyi Cai
Supervisors: Pieter van 't Veer; Sander Biesbroek; Elise F. Talsma

Background

- In China, overconsumption and unhealthy diets cause a massive burden of malnutrition, which as a result leads to undernourished, overweight and non-communicable diseases, there were more than 300 deaths per 100,000 population in China in 2017 due to dietary risks. Modern diets not only impact health, but also the environment. The share in global GHG emissions of China in 2018 is 26.8%, and almost 30% anthropogenic emissions of which is caused by food systems.
- In 2010, the FAO proposed that sustainable diets are, according to the definition, diets with low environmental impacts, which contribute to food and nutrition security, and are respectful of biodiversity and ecosystems, cultural acceptability, accessibility, economically fair and affordable.
- There is thus an urgent need to transform both Chinese food production systems and food consumption patterns. This thesis focusses on the design of sustainable diets for Chinese consumers by trade-offs analysis with these five aspects.

Objectives

① LCA database | Healthy diet index | Food Price database

1997-2011 Chinese Health Nutrition Survey

Environmental impacts | Health | Diet cost

② What is the association between health and environmental impacts?

③ Are our diets getting more sustainable?

④ Can healthy and sustainable dietary patterns be identified in China?

1. Create an environmental impact database for foods consumed in the Chinese Nutrition and Health Survey.

2. Analyse the diet-related environmental impact associated with diet quality and explore the heterogeneity across regions.

3. Assessing the multiple dimension of sustainability for Chinese diets during the rapid transition time.

4. Identification of data-driven Chinese dietary patterns that benefit the environment, are healthy and low cost

Methods & Result

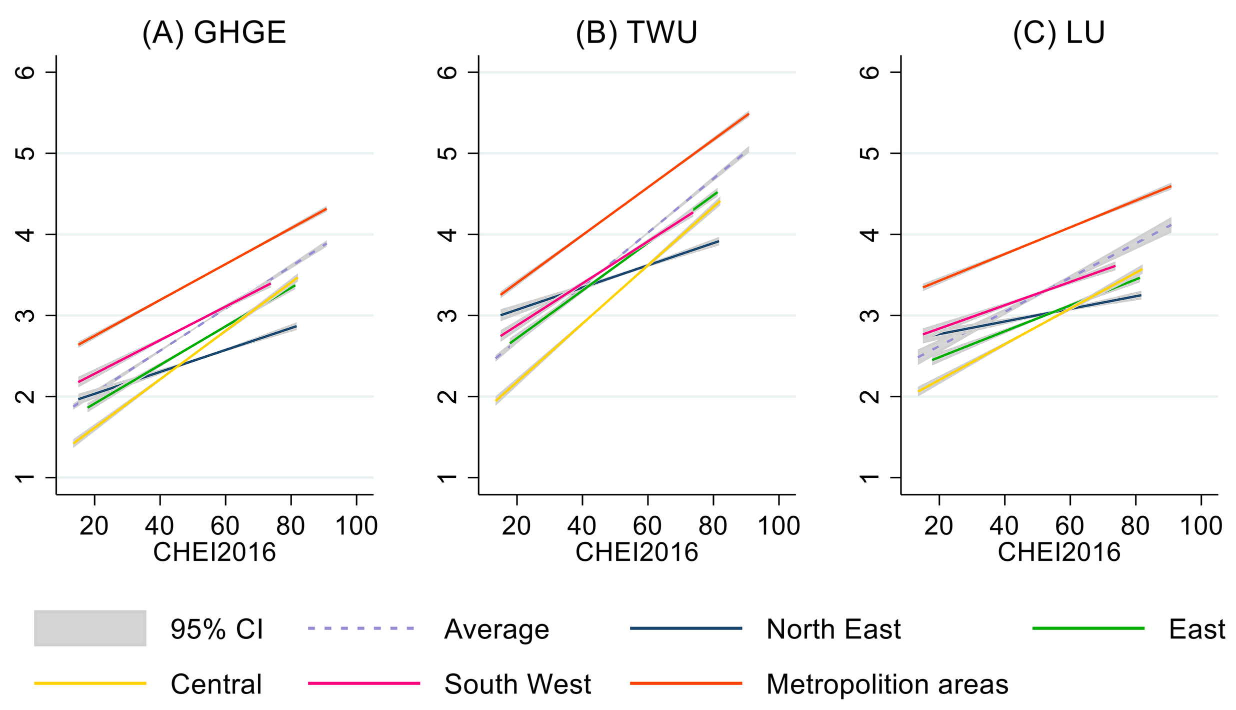
1) the Chinese Food Life Cycle Assessment Database (CFLCAD)

- This study developed a Chinese Food Life Cycle Assessment Database (CFLCAD) in which Greenhouse Gas Emissions for 80 food items, Water Use for 93 food items and Land Use for 50 food items were collected through a literature review.
- To estimate the environmental footprints of food from production to consumption, the study applied conversion factors for the edible portion of food, food loss ratio and processing, storage, packaging, transportation, and food preparation stages.

Table 1
Environmental footprints values from literature for food groups in the CFLCAD

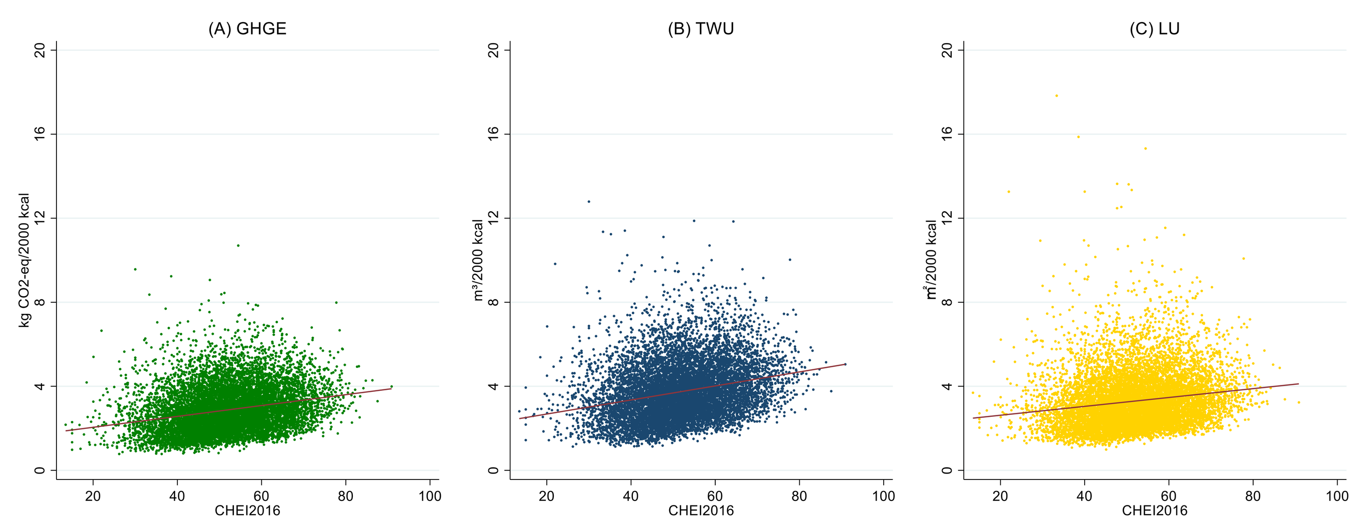
	Greenhouse gas emissions (GHGE)					Water Use (WU)					Land Use (LU)				
Food group	# Food items	# LCA studies	# GHGE values	Mean (kg CO_2-eq/kg)	Stdev	# Food items	# LCA studies	# WU values	Mean (m^3/kg)	Stdev	# Food items	# LCA studies	# LU values	Mean (m^2/kg)	Stdev
Vegetables	20	22	133	0.266	0.292	23	26	111	0.491	0.775	4	4	8	0.402	0.552
Cereals	15	60	490	1.016	0.806	8	39	468	1.290	0.856	8	6	33	1.538	0.950
Fast foods	2	2	3	1.334	1.616	2	2	3	0.813	0.076	4	1	3	1.920	1.106
Aquatic products	6	10	16	7.029	6.358	17	16	41	3.235	1.881	5	1	10	2.356	2.317
Fruits	9	18	64	0.353	0.246	8	18	53	0.574	0.445	1	1	1	0.640	–
Legumes	4	7	14	0.832	0.681	4	15	49	2.512	0.944	4	1	1	0.810	–
Meat	4	23	122	5.134	2.350	7	28	61	8.970	6.204	8	3	12	13.179	10.197
Sugars and preserves	2	3	4	0.689	0.479	1	6	7	0.797	0.559	3	1	2	1.615	0.955
Beverages	4	3	4	0.931	0.815	3	3	4	5.228	4.735	1	1	1	1.480	
Liquor and alcohol	2	3	4	0.726	0.454	2	6	9	0.803	0.998	2	1	2	1.075	1.223
Poultry	2	11	21	3.784	2.128	5	15	19	3.030	1.105	4	1	4	2.035	0.595
Dairy	3	21	67	1.297	0.404	1	13	14	1.609	0.614	4	2	12	2.911	2.945
Eggs	1	13	22	2.890	1.215	1	15	17	3.257	0.176	1	1	2	1.360	0.156
Nuts and seeds	1	2	2	0.695	0.290	2	7	23	1.400	0.345	–	–	–	–	–
Tubers, starches	3	6	7	0.291	0.367	4	13	41	0.926	0.516	–	–	–	–	–
Fungi and algae	1	1	1	0.930	–	1	1	1	0.270	–	–	–	–	–	–
Fats and oils	1	3	5	1.822	1.404	3	12	19	4.475	1.626	1	1	3	5.210	0.292
Total	**80**	**208**	**979**			**93**	**235**	**940**			**50**	**17**	**94**		

2) The association between diet quality and diet-related environmental impacts in Chinese adults:

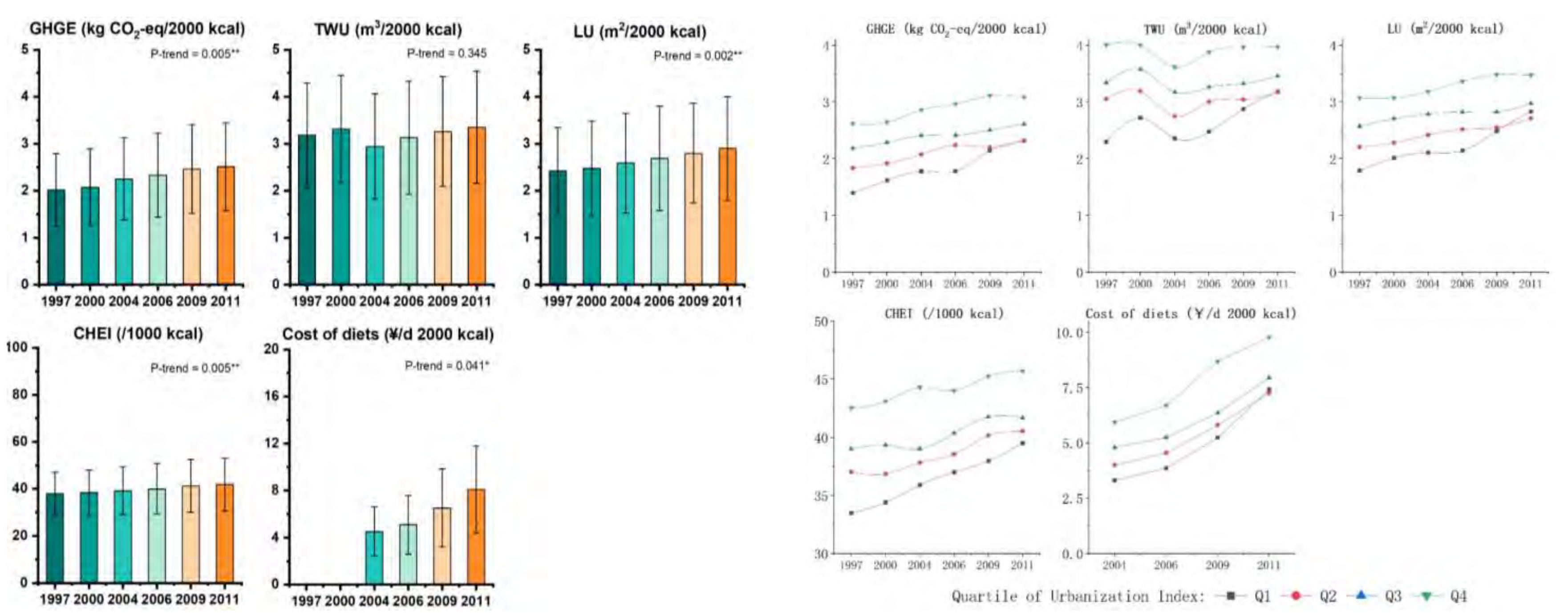


- This study used dietary consumption data of Chinese adults from the China Health Nutrition Survey 2011. Multilevel regression models were used to quantify the association of the CHEI2016 score and the diet-related environmental impacts across regions.

- Participants with higher adherence to the CHEI2016 had overall higher diet-related environmental impacts after adjustments for age, sex, and dietary energy. Among the five regions, with one standard deviation increase in CHEI2016, the dietary environmental impacts rose fastest (GHGE: 4.9%, TWU: 4.7%, and LU: 1.5%) in the Central area and slowest in the Northeast (GHGE: 4.0%, TWU: 3.9%, and LU: 0.5%) .



2) The association between diet quality and diet-related environmental impacts in Chinese adults:



- Food consumption of 8,330 participants of the China Health and Nutrition Survey cohort (1997-2011) were examined. Multilevel mixed-effects models were used to estimate associations between the time trend of dietary sustainability indicators and degree of urbanization.
- From 1997 to 2011, the CHEI2016 score increased by 10.6%, GHGE by 23.8%, LU by 29.1%, and the inflation-corrected cost of diet by 80%. Urbanization was positively associated with these time trends, which remained after adjustment for sociodemographic and lifestyle factors (all P<0·05).

Conclusions

- Diets with higher CHEI2016 scores are associated with higher diet-related environmental impacts among Chinese adults but with variation per region . Regional heterogeneities can be explained by differences in dietary habits, and distributions in sociodemographic variables such as age, urbanization, and income.

- The rapid urbanization in China over the past two decades has been followed by an improvement in the overall dietary quality, but this has been accompanied by an increase in the environmental impacts and higher cost of the diet, especially in communities with lower urbanization index.

Acknowledgements

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

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Background

Recently years, the consumption of vegetables among Chinese residents shows a decreasing trend. Both Chinese dietary guidelines and EAT-Lancet all recommended 300g per adult person per day . But more than half of the population does not meet the guidelines of minimum intake of vegetables in 2011 (Fig,1).

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.

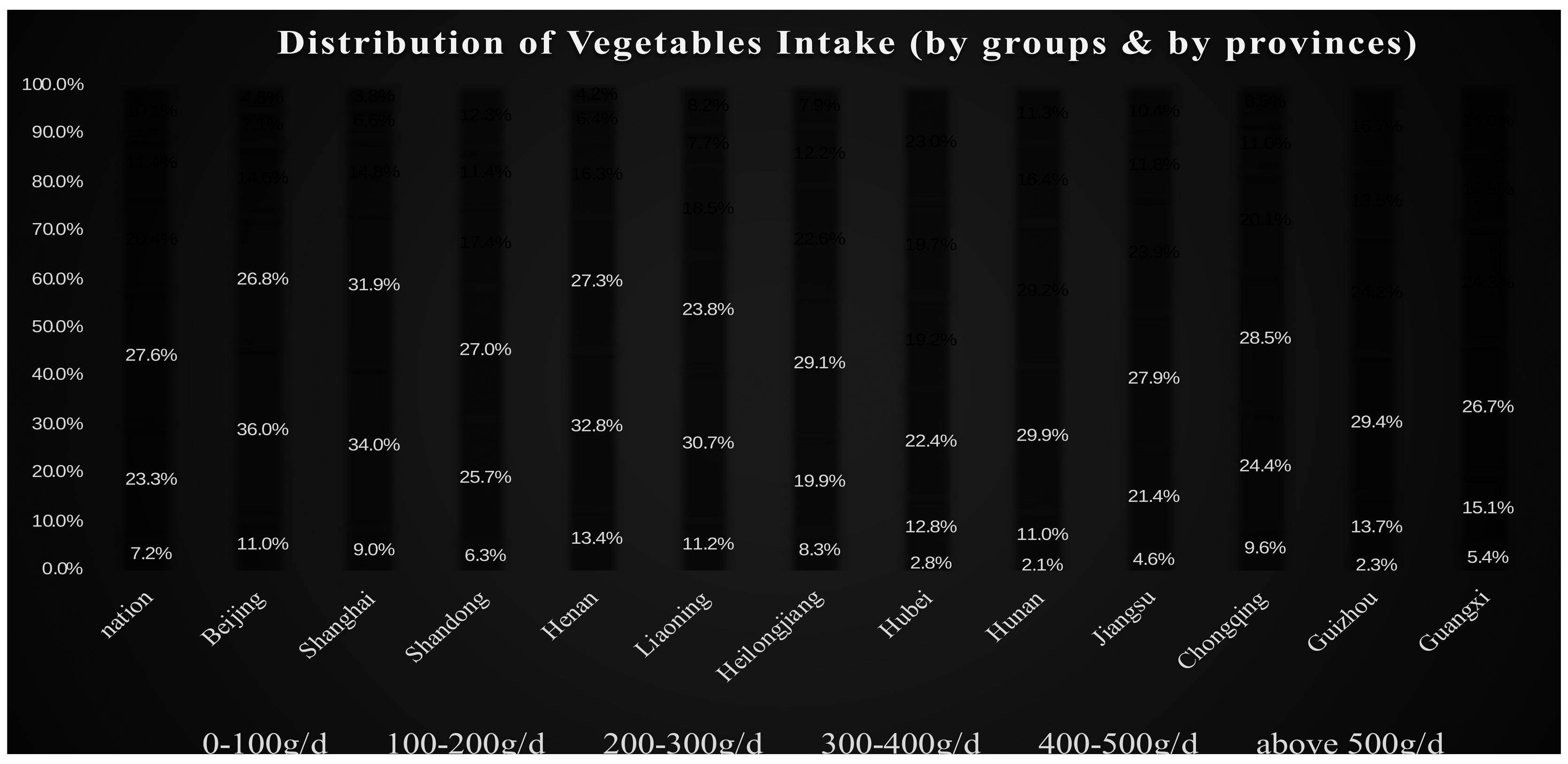

Fig.1 Distribution of vegetable intake of Chinese rural people
Source: CHNS_2011

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.

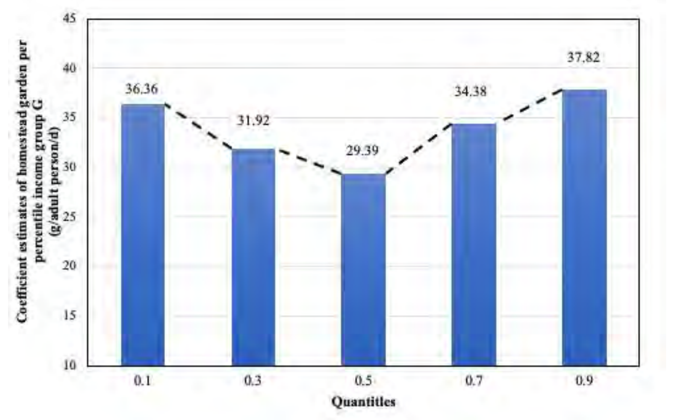

Fig.2 Distribution of vegetable intake of Chinese rural people

Further heterogeneity analysis shows that homestead garden can significantly improve inadequate vegetable consumption group(lower than 300g/adult/day) and more pronounced for dark green leaves vegetables.

Among those different income groups, we can see homestead garden have a significant effect for promoting vegetable consumption in low-income and high-income groups, which shows a U-sharp. The estimates suggest a positive and significant causal effect of homestead garden on households' vegetable consumption. This may reveal a possibility that homestead garden improve low-income group household vegetable consumption because of affordable and accessible. However, for higher income groups, the mechanism of effects of homestead garden may attribute to an awareness of a healthy and balanced diet.

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.

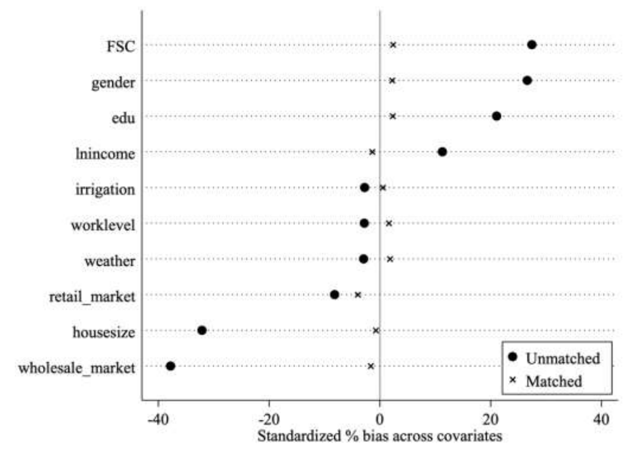

Fig.3 Normalized deviation for PSM (Kernel Matching)

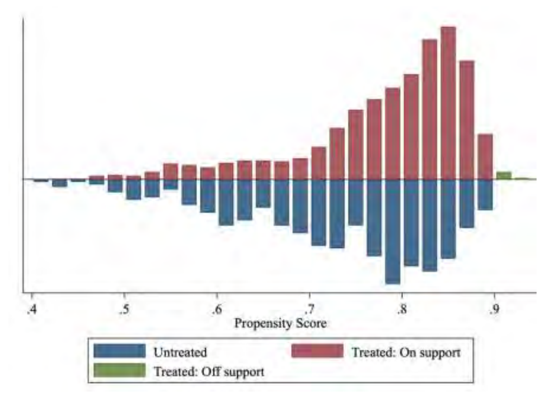

Fig.4 Common support area.

Figure 3 and Figure 4 show that the match for homestead garden passed the tests of balance and common support with Kernel matching. We also do Nearest neighbor matching with caliper 0.05 (NNM) as robustness check.

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 30.43g/adult person/day in households' vegetable consumption as compared to those without homestead gardening. Compared to the mean vegetable intake level presented in Table1, this implies an increase of 11.3%. Additionally, the heterogeneity analysis indicates that homestead gardening has a larger effect on improving vegetables consumption of households with deficient vegetable consumption and affects households in the lowest income group and the highest income group most. The impact of homestead gardening was strongest for the consumption of dark-colored vegetables.

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

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

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Exploring sustainable transformations of plant extract industry: a case study on CCGB

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Background

The growth of the global human population to 9 – 10 billion people will put a strain on our possibilities to produce sufficient food. Therefore we should make use of our harvested foods as efficiently as possible. Currently, the production of ingredients results in large side streams that are not always fully used. Chenguang Biotech Group Co., Ltd.(CCGB) is the largest pigments producer in the world, and produces significant side streams that are currently under-utilised. An example of such a side stream is the seeds of Capsicum peppers which contain around 23% oil and 21% protein, respectively. The aim of this work is to extract these components in their most functional form, by using gentle extraction, retaining the integrity of the oleosomes (oil bodies). The results will be generalized towards the potential for utilisation of other side streams of the food and ingredient industry.

Figure 1. the raw materials

Objectives

- To optimize oleosomes extraction from capsicum seeds.
- To characterise the oleosomes obtained, w.r.t. (physico)chemical properties, physical and chemical stability and techno-functional properties.
- To quantify the resource use of producing O/W emulsion by oleosomes extraction

Methods

Oleosomes and protein extraction

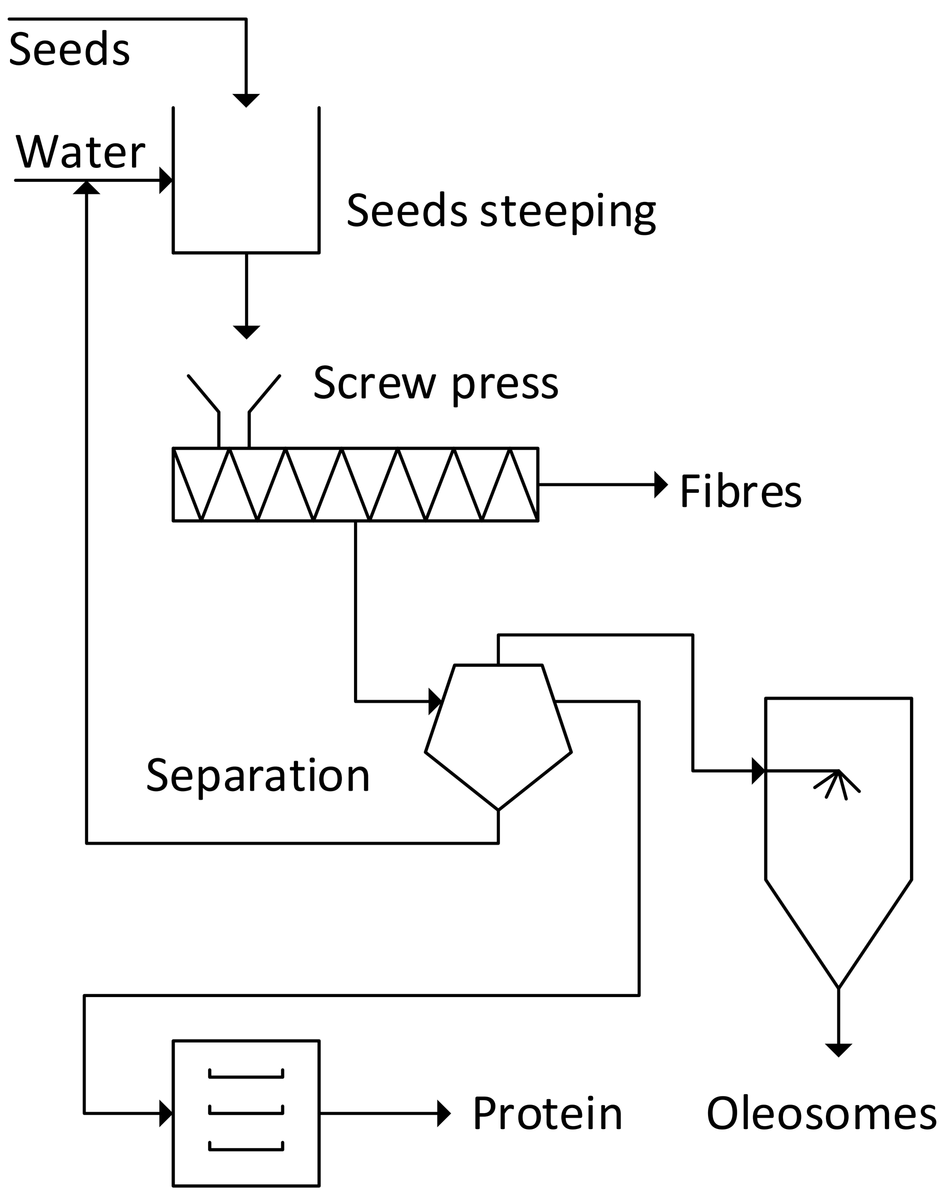

Figure 2. Gentle extraction of oleosomes from capsicum seeds

Results

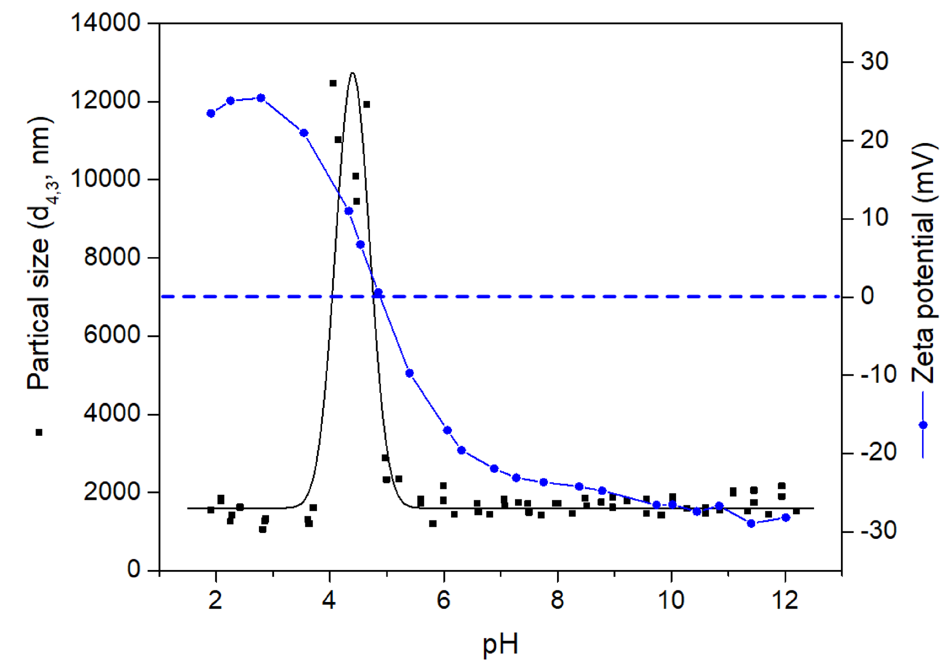

Figure 3. Particle size and zeta potential of oleosomes from capsicum seeds at pH range from 2-12.

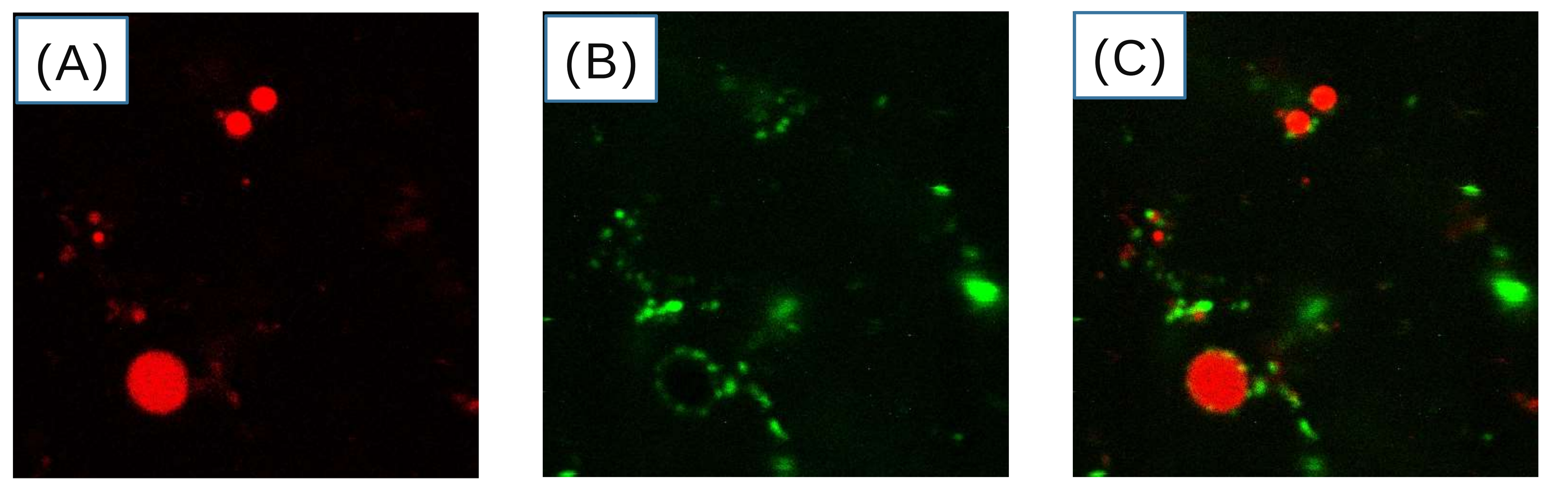

Figure 4. Confocal laser scanning microscope images of oleosomes from capsicum seeds stained with Nile red (A) and Fast green (B) as well as the merged image of these (C).

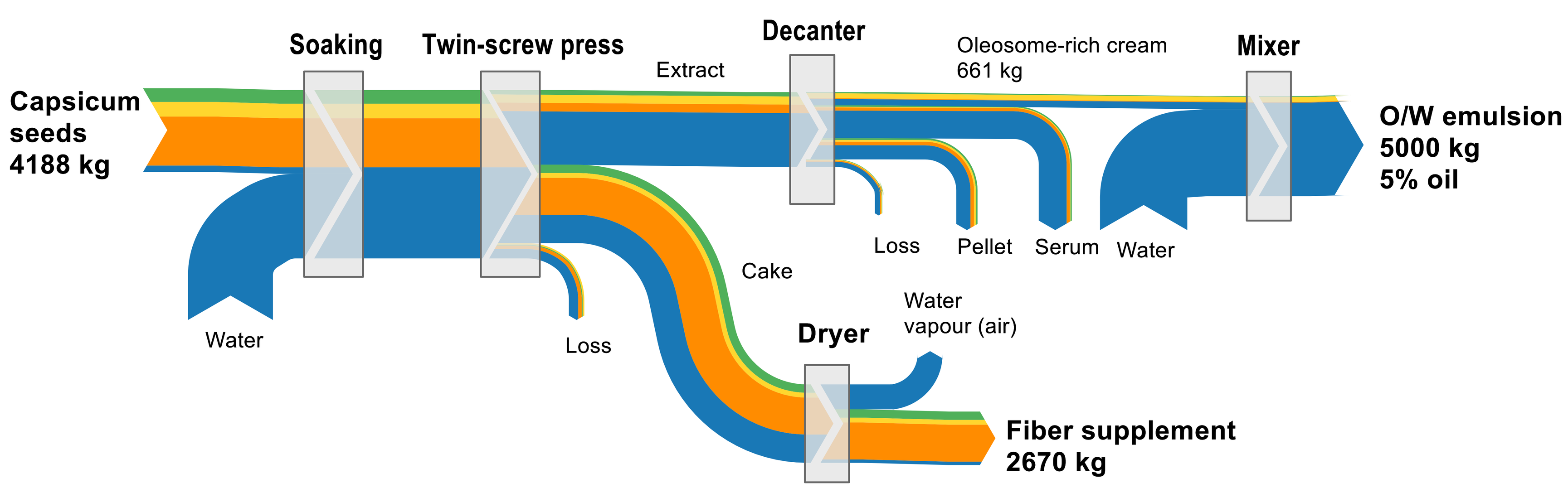

Figure 5. Process sequence for producing O/W emulsion from oleosomes.

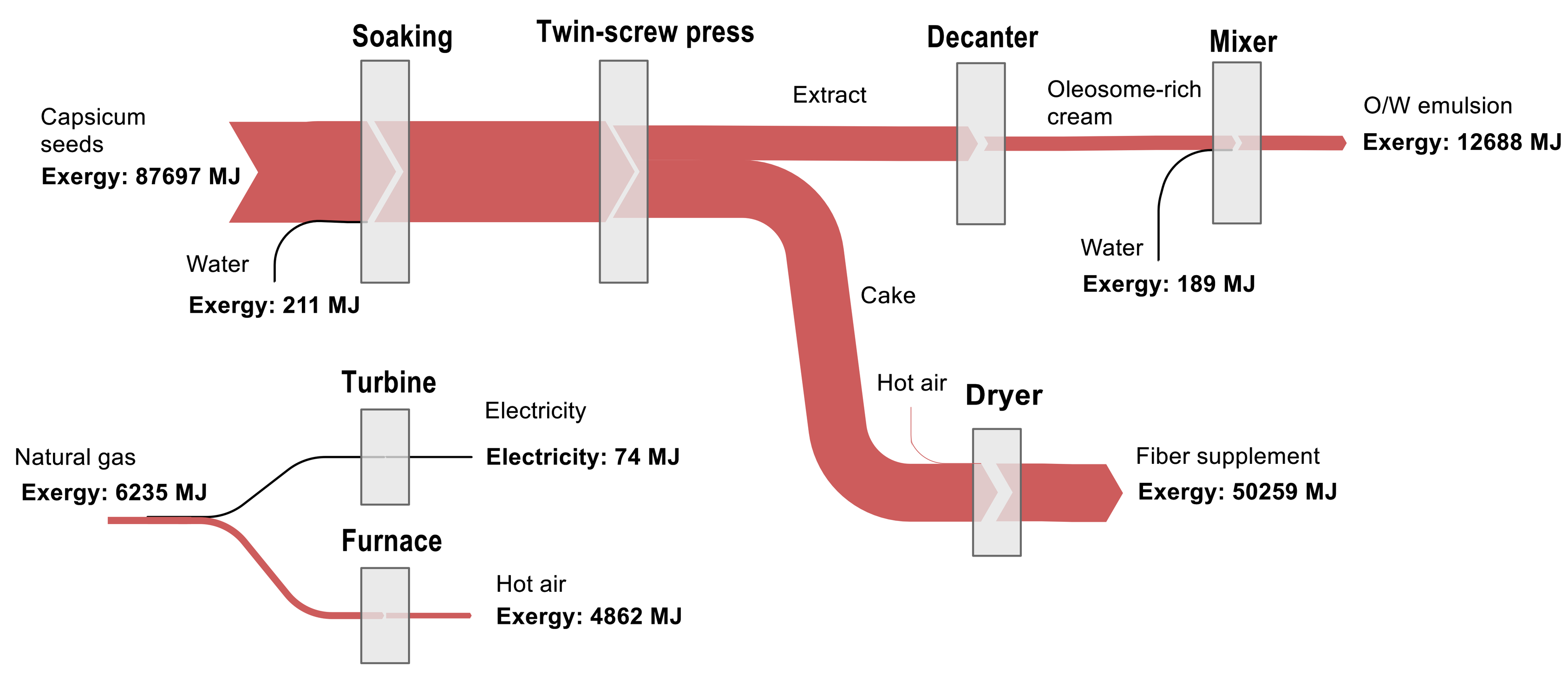

Figure 6. Grassman diagram for O/W emulsion production from capsicum seed oleosomes

Conclusion

- The yield of oleosomes is 34.36% by gentle extraction from capsicum seeds.
- The total exergy loss to produce 5000kg 5% oil concentration by oleosomes extraction is 31.4 GJ.

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晨光生物 CCGB 国家留学网 www.csc.edu.cn

Science and Technology Backyard as a local level innovation intermediary in rural China

- Strengthening co-evolution of technical change and social change

Jinghan Li; Cees Leeuwis; Nico Herrink; Weifeng Zhang

Background

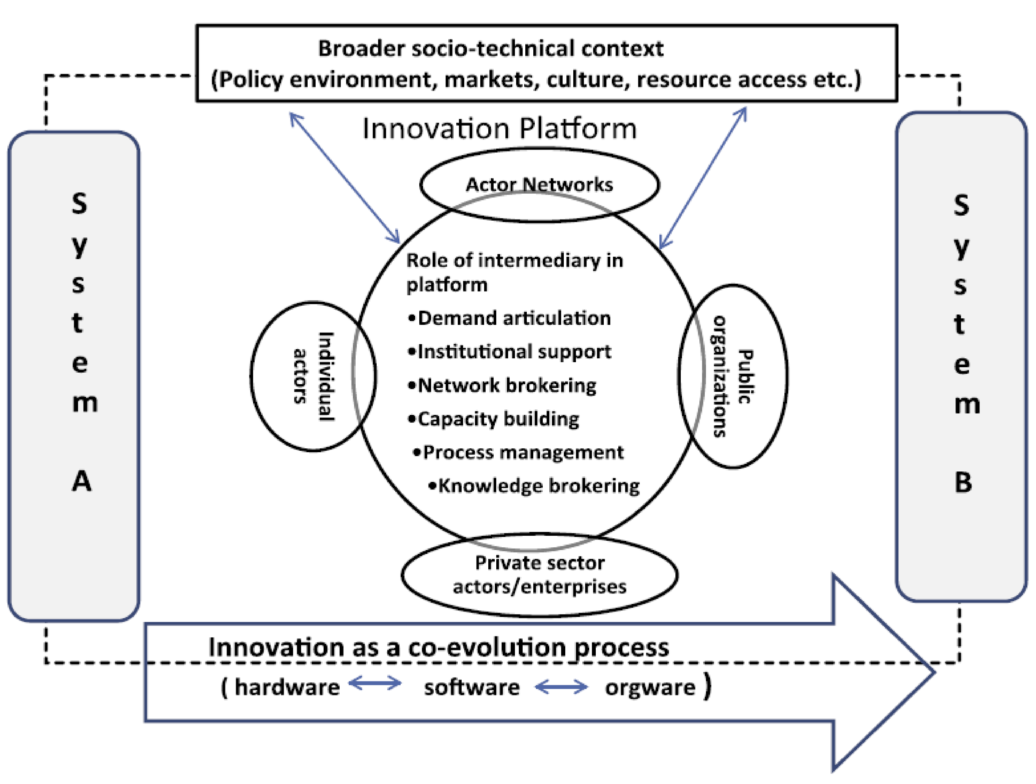
- Agricultural innovation can be described as a co-evolutionary process of technological innovation, symbolic change, and social or institutional innovation, which relies on the interactions and collaboration between multiple stakeholders.
- This view emphasizes the significance of innovation intermediaries in supporting the co-evolution process of innovation.
- Many studies have provided evidence on how innovation intermediaries play roles in supporting the co-evolution innovation process at a broader innovation system level.
- However, little emphasis has been paid to the role of innovation intermediaries in supporting the co-evolution process of innovation at the community level in rural China.

Research questions

- What intermediary roles are played by STBs to support co-evolution of innovation?
- How does this influence the outcome of the co-evolution process of innovation?

Therotical framework

- Innovation was defined as a conducive combination of "hardware" (technological innovations, e.g., new agronomic practices), "software" (symbolic innovations, e.g., changing mindset, attitude), and "orgware" (social or institutional innovation, e.g., a new organizational arrangement). These components of innovation are seen to co-evolve together in the process of continuous interaction.
- Innovation platforms have been seen as important interventions to facilitate co-evolution processes of innovation by creating a space for multi-stakeholders to interact and collaborate.
- Innovation intermediaries are defined as 'bridging organizations' that facilitate access to knowledge, skills and services, and goods from various organizations.
- Innovation intermediaries can play diverse roles in innovation platforms, including 1) demand articulation, 2) institutional support, 3) network brokering, 4) capacity building, 5) innovation process management, 6) knowledge brokering.



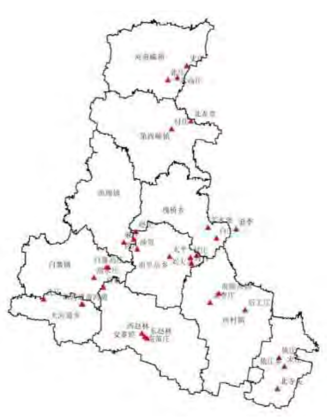
(Kilelu et al, 2011)

Methods

RQ1	RQ2
Qualitative data • In-depth face-to-face interview • Second-hands documents (STB diary from 2009-2018)	Quantitative data • Questionnaire survey in Quzhou county
Methods • Case study • Innovation journey analysis	Methods • Multivariate regression analysis

- Wangzhuang STB (WZ STB)
- established in 2011
- focus on wheat and maize

Farming practice: choosing wheat tillage method as a case



- Quzhou County, Hebei Province
- 10 township
- 34 village
- About 10 farmers per village
- Total 350 farmers
- 2019-2020 wheat production

Results

Innovation process and roles of STB

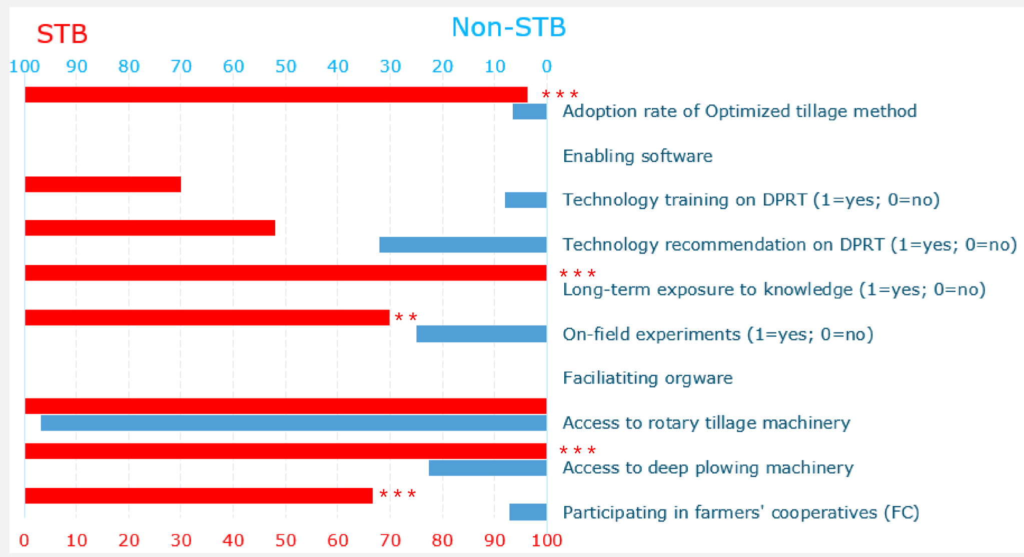
-Evolved from a knowledge broker to an innovation intermediary in STB village

-Still performed more like a knowledge broker outside the STB village

Intermediary Roles	Phase 1			Phase 2			Phase 3		
	Hardware	Software	Orgware	Hardware	Software	Orgware	Hardware	Software	Orgware
F1-demand articulation		x			x		x	x	x
F2-institutional support						x			x
F3-Networking brokering					x	x		x	x
F4-capacity building							x	x	x
F5-innovation processes management						x			x
F6-knowledge brokering	x	x			xxx	x	x	xxx	x

Note : x denotes only STB village, xx denotes STB village + STB nearby villages, xxx denotes large-scale villages

Outcome of innovation process: comparison between STB village and non-STB villages



STB village has

- Higher adoption rate
- A better environment to access knowledge and new technology
- Easier access to DPRT machinery and higher farmers' cooperative participation rate

Factors affecting farmers' adoption of DPRT in the 2019-2020 wheat season, Logit model.

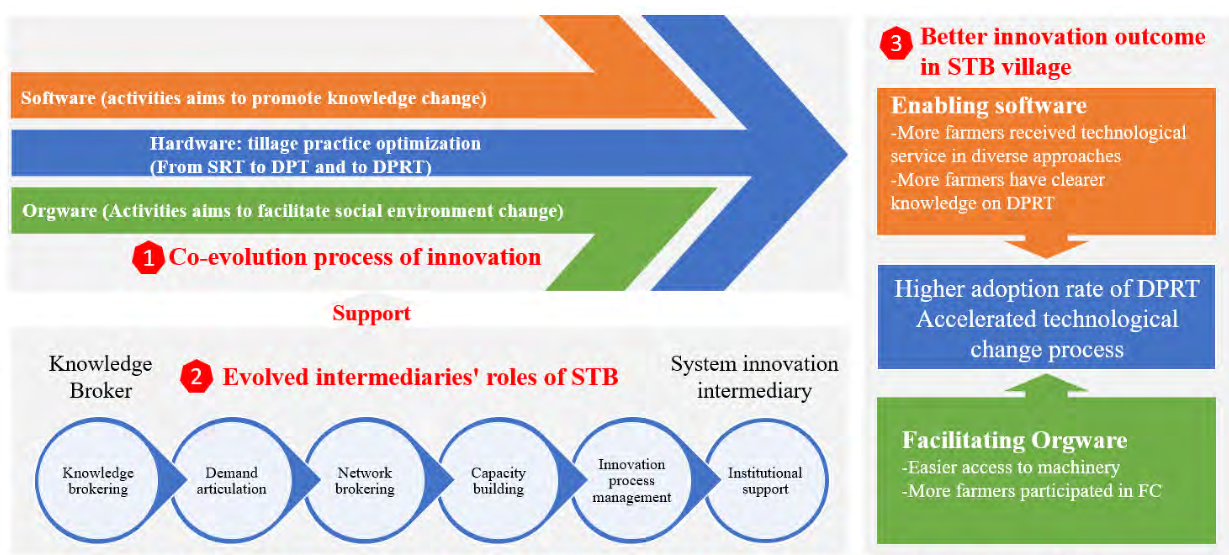
	Adoption of DPRT (1=yes; 0=no) (1)	Adoption of DPRT (1=yes; 0=no) (2)
Enabling software		
One-off training on general tillage methods	-0.00 (0.044)	0.00 (0.047)
Specific technical practice recommendations on DPRT	0.05 (0.034)	0.04 (0.033)
On-field experiments	0.05 (0.043)	0.05 (0.037)
Facilitating orgware		
Participated in farmers' cooperatives	0.31** (0.122)	0.29** (0.128)
Access to rotary tillage machinery	-0.05 (0.043)	-0.01 (0.038)
Access to deep plowing machinery	0.16* (0.086)	0.15* (0.079)
Farmer characteristics		
Gender		-0.09 (0.092)
Age		0.00 (0.001)
Education		-0.00 (0.003)
Off-farm occupation		-0.01 (0.022)
Plot characteristics of the largest plot		
Plot size		0.19** (0.085)
Plot flatness		-0.01 (0.009)
Pseudo R2	0.2770	0.3040
Observations	349	349

Note: Robust standard errors in parentheses. Clustered errors were applied at village level. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

-Participated in farmers' cooperatives, Access to deep plowing machine significantly positively affect farmers' adoption of DPRT.

Conclusions

- STB has evolved its roles from knowledge broker to innovation intermediaries at the community level as the co-evolution of the innovation process in tillage practice in wheat season in WZ STB village.
- The roles evolution also facilitates the co-evolution process of innovation, which performed as a higher adoption rate, a better learning environment, and an enabling social environment in STB village than non-STB villages.
- Creating a knowledge enabling environment is not enough for the large-scale technology change
- Facilitating a social environment change will be more effective (including access to right mechanic service and linking smallholders together in this case)



Acknowledgements

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

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When is command-and-control efficient? Evidence from straw-burning control in Northeast China

Zhiwei Yu
Supervised by: Weifeng Zhang; Nico Heerkink; Wei Si; Fan Li

Background :

The implementation and enforcement of environmental policies are frustrating. On the one hand, fragmented departments pass the buck to each other, which makes it impossible to integrate the resources within the government. On the other hand, it lacks a bridge between the government and polluters, increasing transaction costs of polluters' identification and intervention. Therefore, it is a worldwide challenge of collective action by stakeholders within and outside the government to implement and enforce environmental policies. In this paper, we provide the straw-burning control in Northeast China to answer how to promote the implementation of environmental policy.

Objectives

- Summarize the policy tools in Heilongjiang
- Estimate its policy effect

Methods:

We estimate the following for each country pair in our data:

$$Y_{imt} = \alpha + \beta_1 D_i + \beta_2 distance_i + \beta_3 distance_i \times D_i + \alpha_i + \delta_t + \theta_m + \varepsilon_{itm}$$

In this equation, Y_i is the number of straw-burning spots of the county i in the month m and the year t. A county i's treatment status is denoted by a binary indicator D: $D_i = 1$ if county i in the Heilongjiang province (treatment group), and $D_i = 0$ otherwise (control group). $distance_i$ is the distance from county i to border. β_1 indicates whether there would be a natural straw-burning discontinuity at a given location of a current border. This is how we classify borders a "political" and "natural". If we find a border discontinuity in the hypothetical natural straw burning, the border is "natural", and if we find no discontinuity, the border is "political".

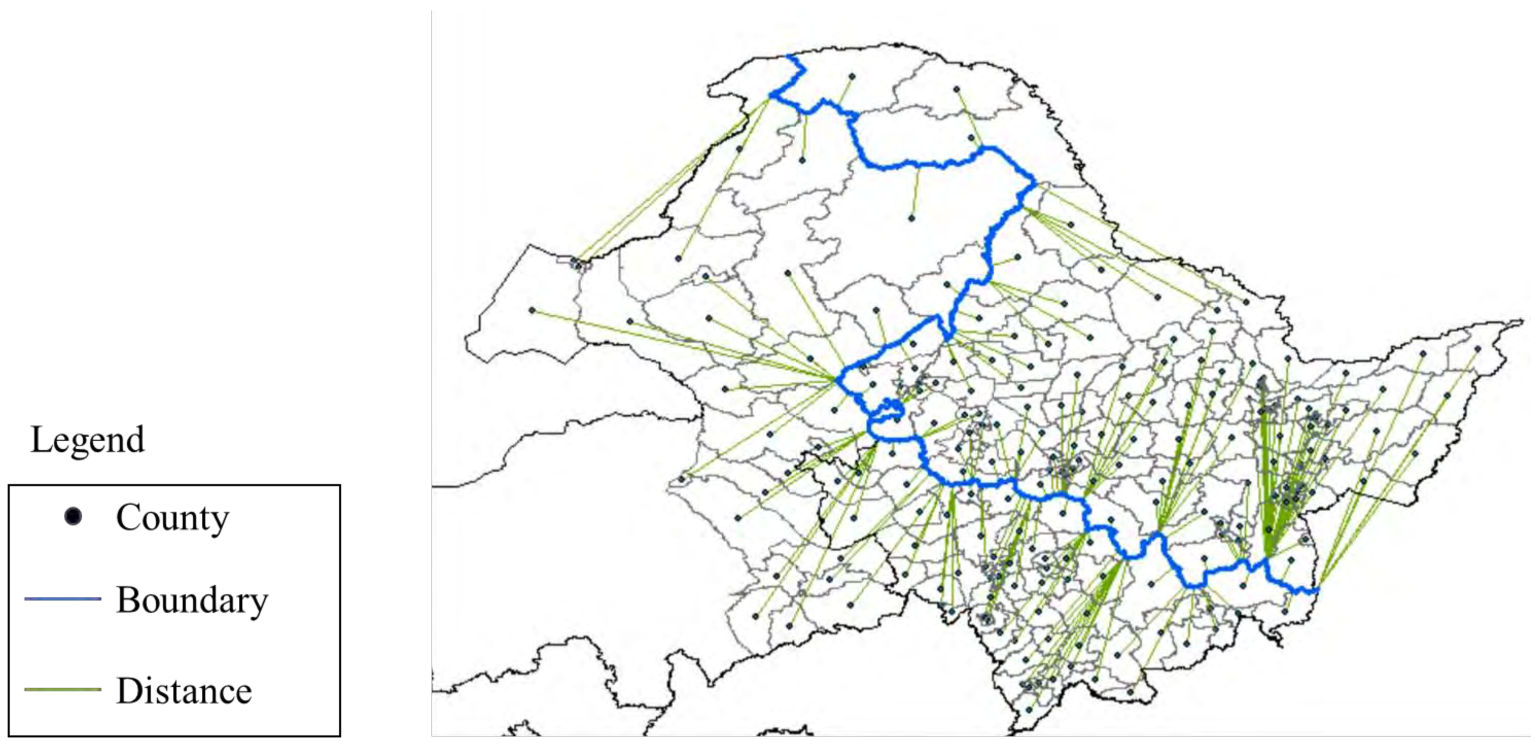
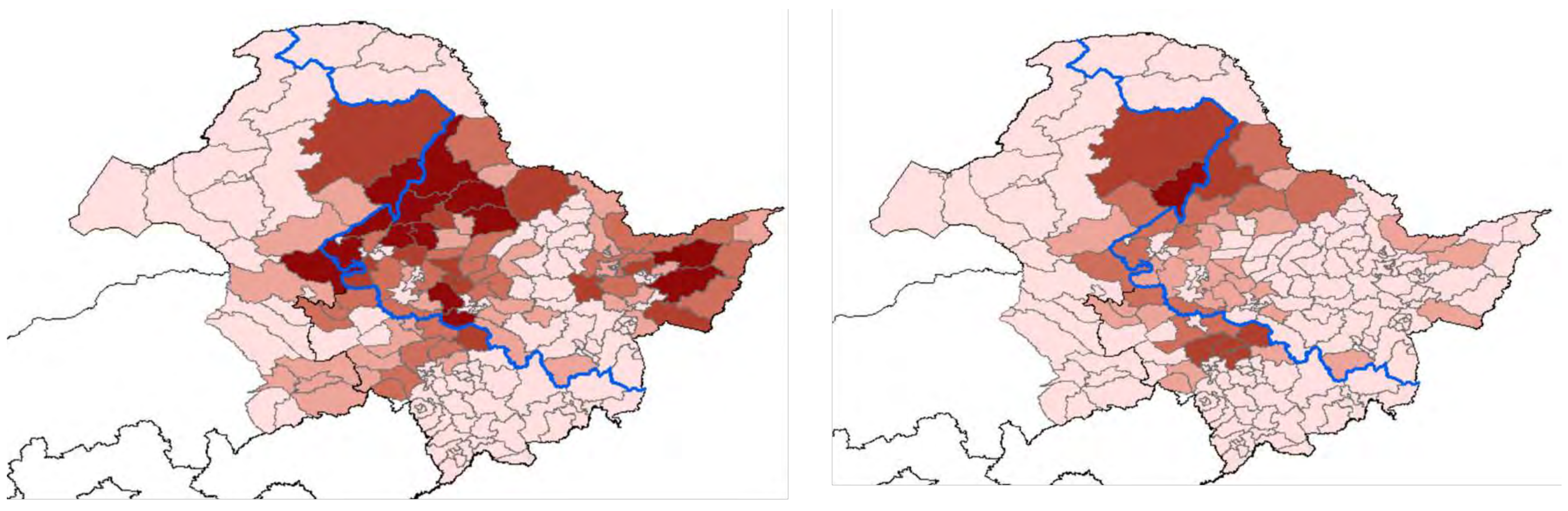


Figure 1. County-to-Border Distance Measurement

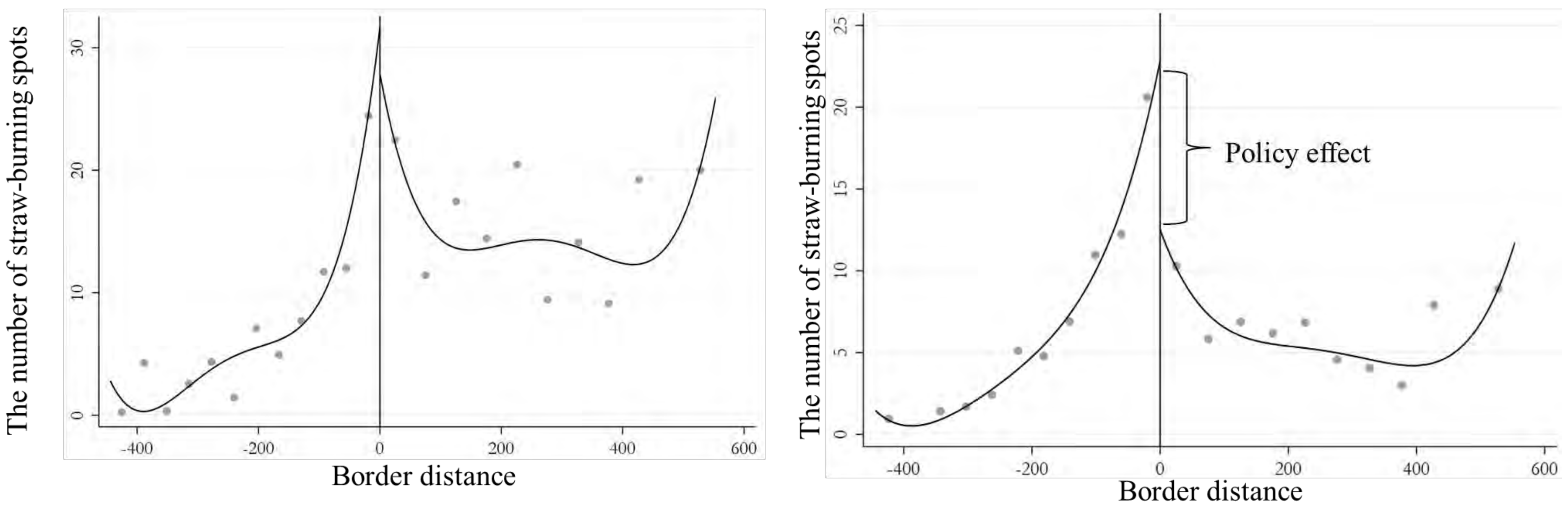
Results



(a) 2014-2017 (b) 2018-2020

Figure 2. The distribution of straw-burning spots

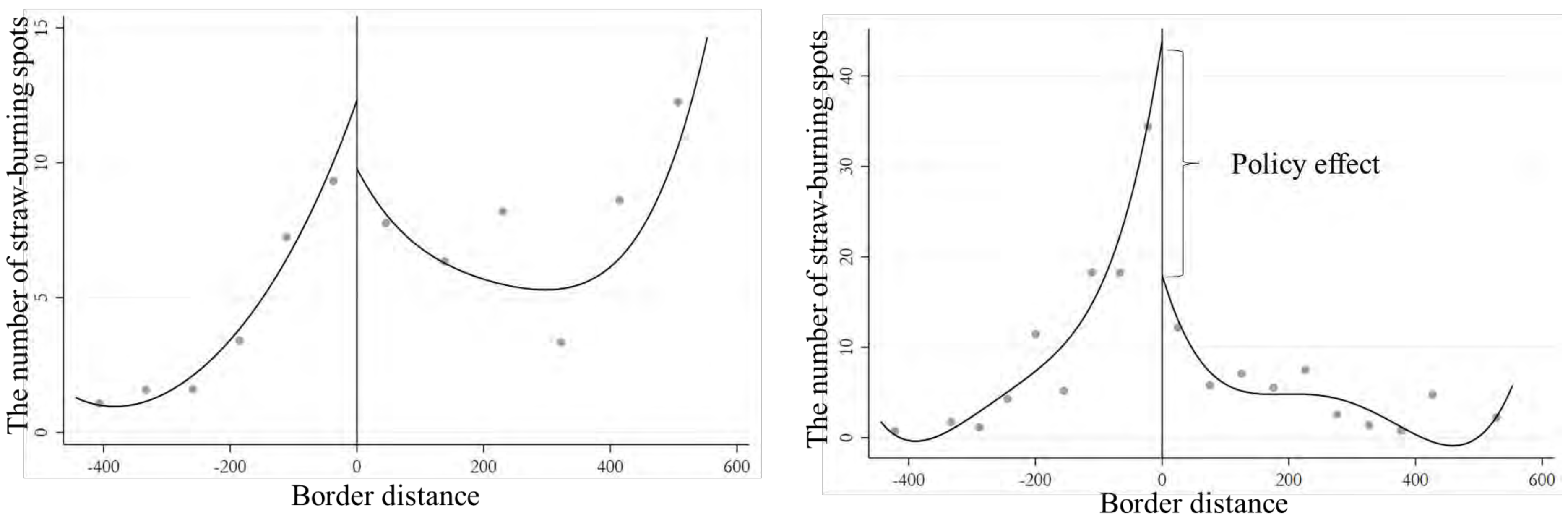
The discontinuity did not exist before the policy implementation but showed after that.



(a) 2014-2017 (b) 2018-2020

Figure 3. Policy effect in Heilongjiang

The discontinuity did not exist in the first two years of policy implementation but showed in the third year.



(a) 2018-2019 (b) 2020

Figure 4. Heterogeneity of policy impact in Heilongjiang

Conclusions

This paper shows that command-and-control tools effectively control straw burning in the short term but fail to do in the long term once monitoring starts to loosen up. Achieving long-term control effect requires effective incentives to support command-and-control .

Acknowledgements

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

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Reshaping agri-food production systems helps achieve the Lancet diet in a more sustainable way

AGD 2+2 PhD Candidate: Guichao Dai
Supervisor: Dr. Yong Hou, Prof.Oene Oenema, Dr. Xueqin Zhu, Dr. Hans-peter Weikard , Prof. Fusuo Zhang

Background

Global food security poses a massive challenge to current agri-food production systems, with between 700-820 million people currently still hungry worldwide during 2021. By 2030, it is predicted that 670 million people, or 8% of the world's population, would still lack access to sufficient food, with the majority of them living in Africa, Asia, and Latin America. Besides holding this, the sustainability of agri-food production systems has also been severely tested by the exorbitant resource input and environmental costs, with metrics like nitrogen and phosphorus inputs, cropland use, and irrigation water use all exceed the threshold for safe production. 13.7 GtCO2e of the anthropogenic greenhouse gas (GHG) emissions are brought on annually by the global food system, or 26% of total GHG emissions.

Objectives

the objectives of this study were (i) to investigate the potential benefits of structural optimization in agricultural food production systems, (ii) to explore how the structure of current agricultural food production systems could be changed to match the food requirements of the EAT-Lancet diet, (iii) Investigation of the potential impact of shifting to the EAT-Lancet diet with simultaneous structural optimization of agricultural food production systems.

Methods

(i) Intake of each food category

The energy/protein intake for food is mainly calculated based on the food intake multiplied by the energy content/protein content of the food.

(ii) Calculation of GHG emissions and irrigation water use

For the crop/livestock systems GHG emissions were mainly calculated by multiplying the crop carbon footprint by the total crop production/total animal product production.

(iii) Crop nutrient inputs and regional manure loading

Nitrogen (N) and phosphorus (P_2O_5) inputs for each crop type in various provinces were estimated mainly based on a developed linear optimization model.

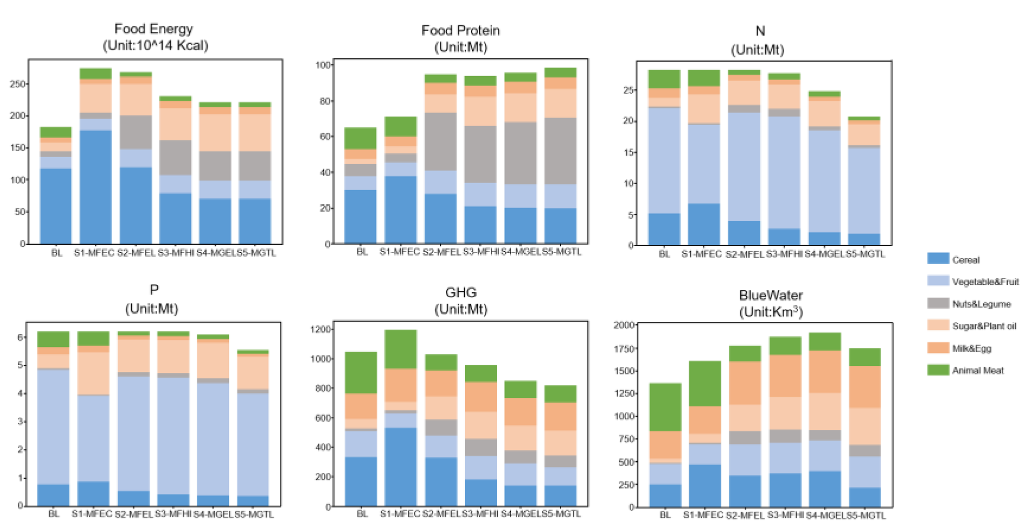
(iV) Scenario Description

we designed different scenarios to explore the potential benefits of structural optimization under different diet and different optimization objectives. Besides the baseline scenario, a total of five scenarios were designed, as S1-MFEC, S2-MFEL, S3-MGEC, S4-MGEL and S5-MGTL.

(V) Crop/livestock re-structuring model

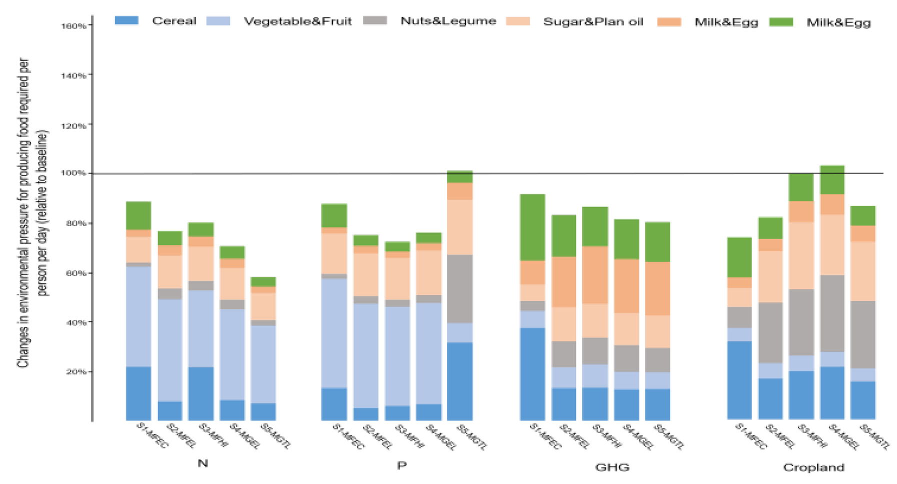
A linear optimization model was applied to maximize feed energy production （equantion 1 is applied to Scenario S1-MFEC and S2-MFEL）or minimizing GHG emissions (equation 2 (S3-MGEC, S4-MGEL and S5-MGTL) under a set of constraints through optimizing planting area of crops and the farming number of different categories of livestock in each province.

Results



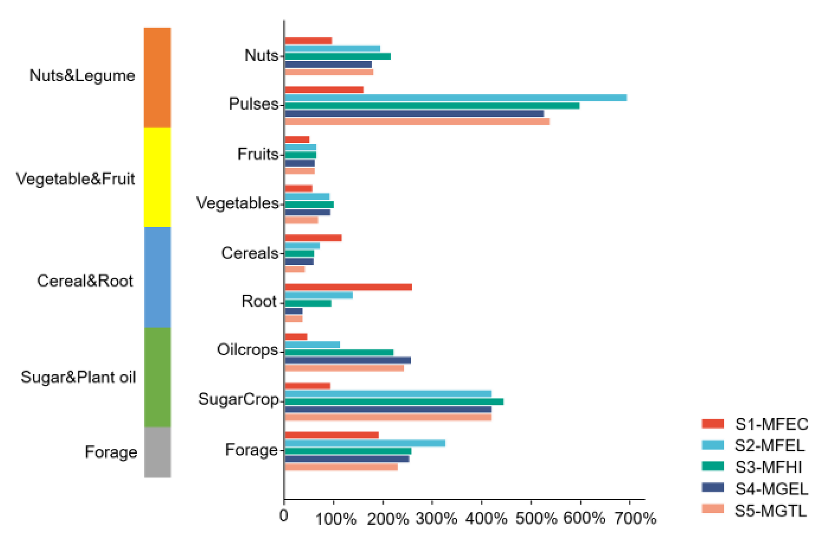
Results 1. Potential impacts of reshaping agricultural food production systems on food availability, N/P inputs, GHG emissions, and irrigation water inputs.

Reshaping agri-food production systems can increase food energy supply by 21-46% and food protein supply by 10-42%, while combined with advanced technologies nitrogen and phosphorus inputs can be reduced by 65% and 53%, respectively. In addition, irrigation water use and greenhouse gas (GHG) emissions can be reduced by 15% and 30%, respectively.

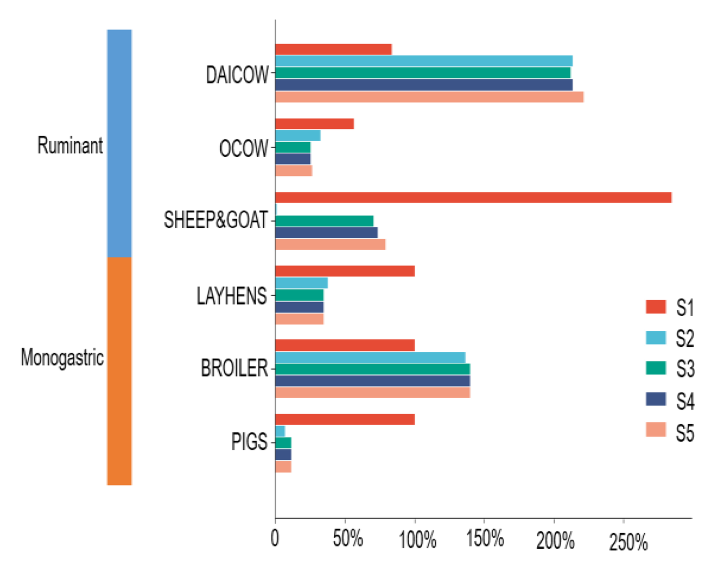


Results 2. Changes in food N and P inputs, cropland inputs, and GHG emissions required per person per day for production in different scenarios.

Compared to the baseline scenario, both nitrogen and phosphorus inputs, land resource inputs, and GHG emissions are reduced to produce the food required per person per day. Nitrogen and phosphorus inputs decreased by 19-23%, while cropland input and GHG emissions decreased by up to 28% and 34%, respectively.



Result 3. Changes in the planting area of different types of crops under different scenarios.



Result 4. Changes in the farming numbers of various types of livestock in different scenarios.

Under the Lancet diet, meeting consumption and environmental reduction targets, our acreage of nuts (+215%), pulses (597%), oilseed crops (242%), and sugar crops (419%) needs to be increased significantly. The number of dairy cattle breeding needs to increase (+221%) and the number of pigs (-88%), beef cattle (-75%), sheep (-30%) and laying hens (-63%) breeding needs to be significantly reduced.

Conclusions

- Optimizing the structure of agri-food production systems improves the country's food supply by nearly 50%.
- Adopting healthy diet with advanced agricultural production technology strategy can reduce 65%-53% of total nitrogen and phosphorus inputs and 30% of GHG emissions.
- The area planted with nuts, legumes and oil crops in China needs to be increased by 2, 6 and 4 times respectively under the demand of healthy diet, and the number of monogastric animals such as pigs and egg-laying hens needs to be significantly reduced.
- The structural adjustment of agricultural structure should be used as a key strategy for the multi-objective synergy of regional agricultural green development.

Acknowledgements

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

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Decreasing nutrient loss from crop-livestock systems by manure redistribution with minimum cost and improved management

Tao Zhang, Xueqin Zhu, Yong Hou, Hans-Peter Weikard, Oene Oenema

Background

Livestock is one of the most important sources of protein for humans but has a main source of greenhouse gas (GHG) emissions and ammonia (NH_3) in the air, as well as of nitrogen (N), phosphorus (P) and potassium (K) in water bodies. The N, P, and K emissions originate mainly from livestock excretions. Manure application to cropland is a crucial pathway to close the nutrient cycle in the crop-livestock system. However, animal manure is bulkiness, especially in the case of slurry and liquid, and has low fertilization efficiency. At the same time, rearing livestock on farm backyards has transitioned to industrial livestock farms, resulting in the concentration of manures and their nutrients in areas with little or no available cropland. As a result, the economic costs of collection, storage, transport and application of animal manure are very high per unit of nutrients, and represent a substantial barrier towards recycling manure to cropland not only for developing economies such as China, but also for high-income countries such as the United States and regions in Europe. Many studies explored the impacts of technological improvement in manure management on manure use and nutrient losses from crop-livestock systems, but the costs of manure management are usually neglected. In addition, few studies explored the impacts of manure redistribution on manure use and the nutrient losses from crop-livestock systems. Therefore, exploring cost-effective manure management and spatial distribution and how it affects manure used is crucial for decreasing nutrient losses from the crop-livestock system.

Objectives and questions

This study aims to explore cost-effective integrated technology improvement in manure management and spatial planning to reduce nutrient (N, P, K) losses in crop-livestock systems. The specific research questions include:

- What are the costs of integrating technology improvement in the manure management chain to optimize manure use and to reduce losses of N, P, and K in crop-livestock systems?
- What are the costs of redistributing manure surplus between counties to optimize manure use and to reduce N, P, and K losses in crop-livestock systems?
- What are the costs of relocating livestock production to optimize manure use and to reduce N, P, and K losses in crop-livestock systems?

Methods

We take Hebei Province (including 150 counties) in China, as the study area. The specific research methods include a novel linear optimization approach and scenario analyses.

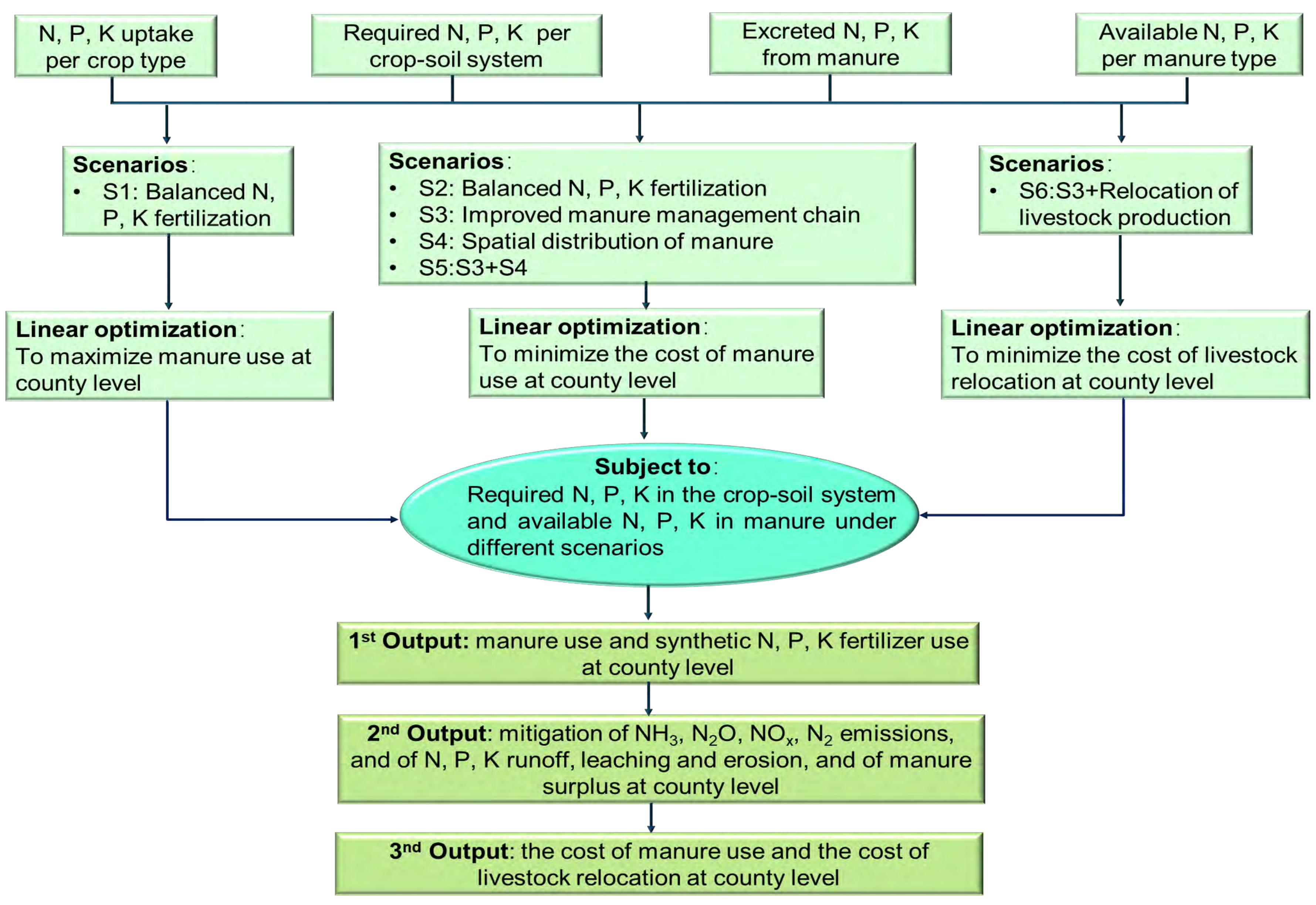

Fig 1. Conceptual framework of the optimization of manure and fertilizer use in crop production systems at the county level, as a function of nutrient uptake by crop types and the nutrient supply by soil, atmospheric deposition and manure.

Results

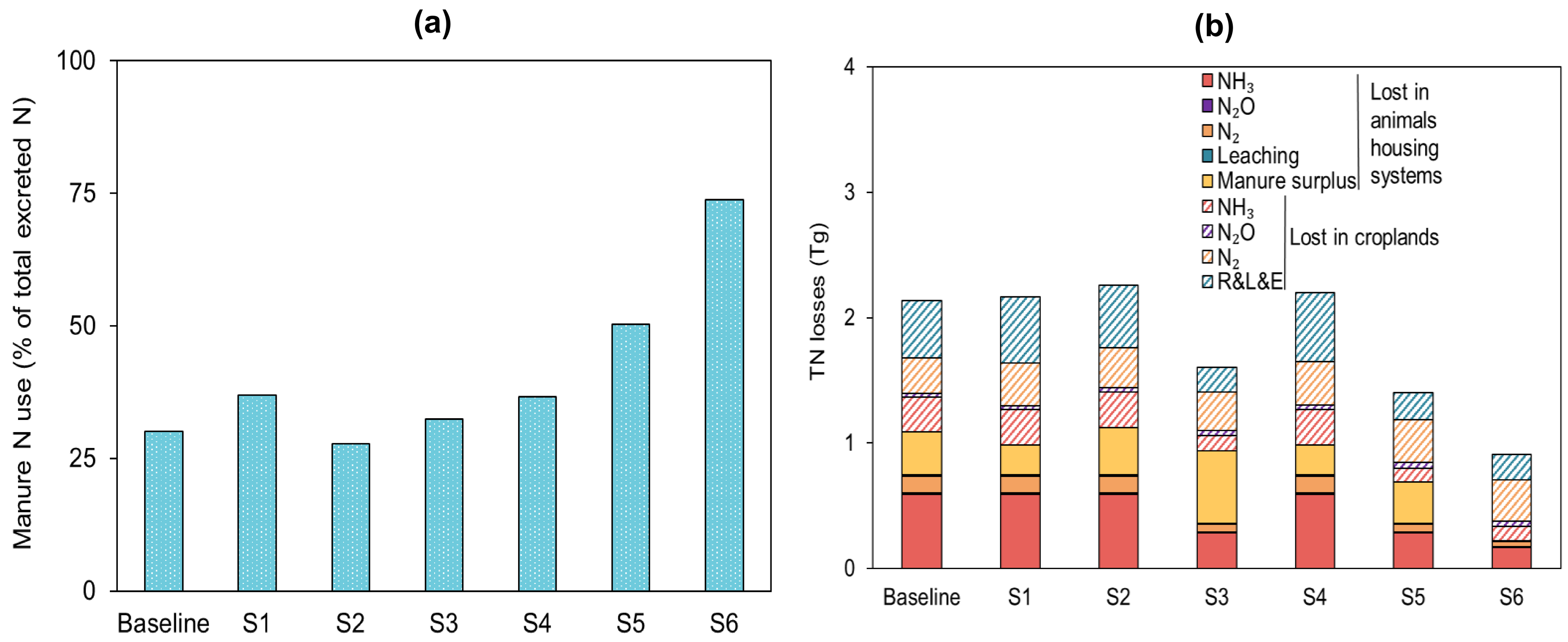

Fig 2. The manure N used in cropland, in percent of total excreted manure N in Hebei Province (a), and the total N losses from the crop-livestock system (b) for all six scenarios.

Compared to balanced fertilization (S1), balanced fertilization with the minimized cost of manure use at the county level (S2) would reduce the potential of manure recycling to cropland. There were larger amounts of manure N applied to cropland by manure redistribution among counties (S4), relative to improved manure management (S3), while the total N losses from crop-livestock systems under S4 were higher than S3. The potentials of manure N used and total N losses reduction would be further improved by combining the S3 and S4. There was the largest potential to recycle manure to cropland, and to decrease the N losses from crop-livestock systems with the relocation of livestock farms.

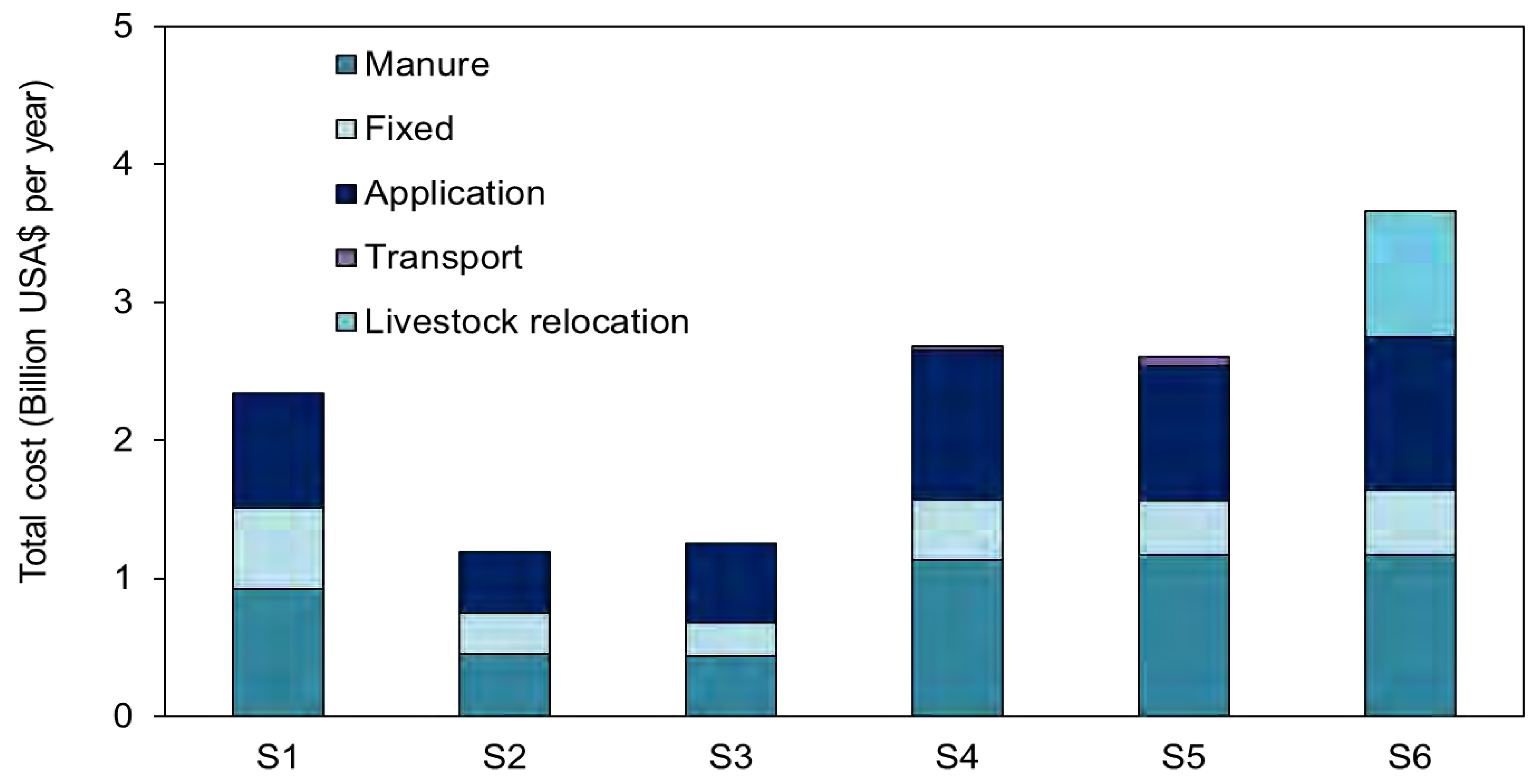

Fig 3. The cost of manure use per year, including the cost of manure products, fixed cost with manure application within the county, and the costs of manure application and transport for all six scenarios. The costs of livestock relocation per year include the operation cost, feed cost, construction and equipment cost. Here, the construction and equipment cost indicates the average annual cost of 20 years.

The total cost of manure use was up to 2.3 USA$ per year under S1. The cost of manure use could be halved under S2, relative to S1, which may be because the cheaper manure was given priority to minimize the cost of manure use. The cost of manure use was 2.6 USA$ per year by combining the integrated improvement in manure management and manure redistribution (S5). The total cost under S6 was further increased by 40%, relative to S5, mainly because of the cost of livestock relocation.

Conclusions

- The potential for manure use in cropland would be decreased, to achieve the minimum cost of manure use at the county level.
- There was a larger potential to decrease nutrient losses from the crop-livestock system by livestock relocation, relative to improved manure management and spatial redistribution, but the cost of livestock relocation was still much higher.

Acknowledgements

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

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Microbiota-mediated detrimental effect of dietary fiber deprivation in pigs

Zhenyu Wang, de Vries Sonja, Walter JJ Gerrits, Junjun Wang

Background

Emerging evidences gradually revealed dietary fiber intake sufficiency is associated with various diseases. And our previous work has shown that dietary fiber deprivation induced the extinction of probiotics such as *Lactobacillus*, *Bifidobacterium* but promoted the proliferation of potential pathogens. However, regarding the specific relationship between dietary fiber deprivation and pathogen colonization, limited information is available.

Objectives

The objective of present study is to investigate the specific relationship between dietary fiber deprivation and pathogen colonization resistance.

Methods

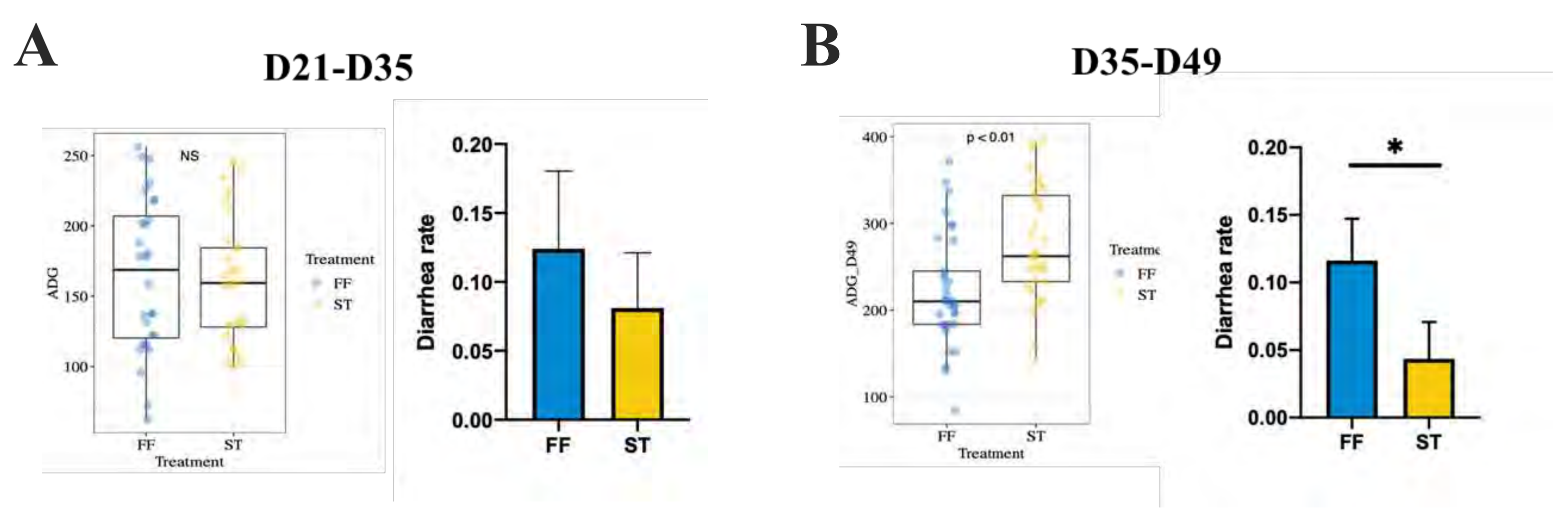
Sample collection

- At day 21, all piglets were weaned, and body weight were determined. Two weaned piglets with similar body weight were selected from each litter and randomly assigned to standard diet (SD) and dietary fiber deprivation diet (DFD).

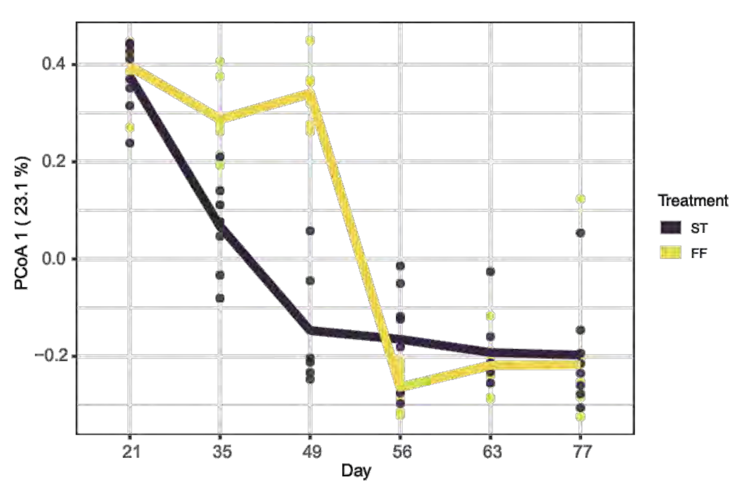
Metagenomics sequencing

- Raw data was first filtered to remove adapter and low-quality read using fastp. Then host contamination was determined and removed by mapping reads to pig genome using kneaddata. After quality control, the resulting high-quality reads were taxonomy classified using metaphlan3.

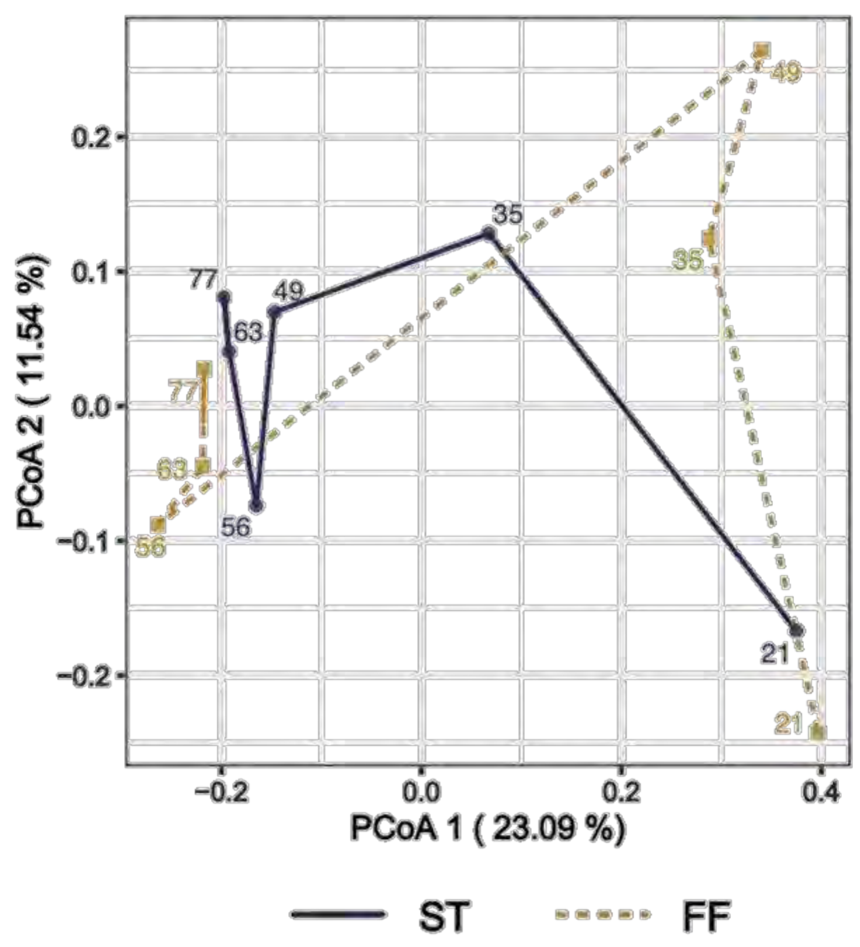
Results



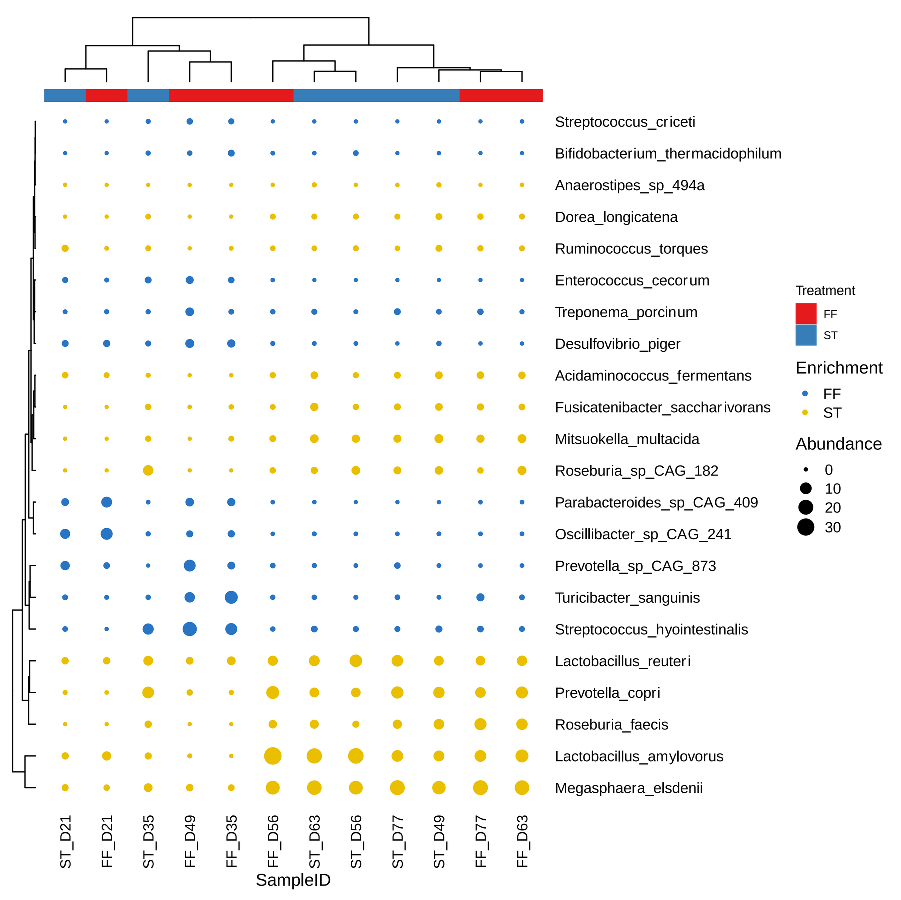
- Dietary fiber deprivation leads to compromised growth performance and increases diarrhea rate

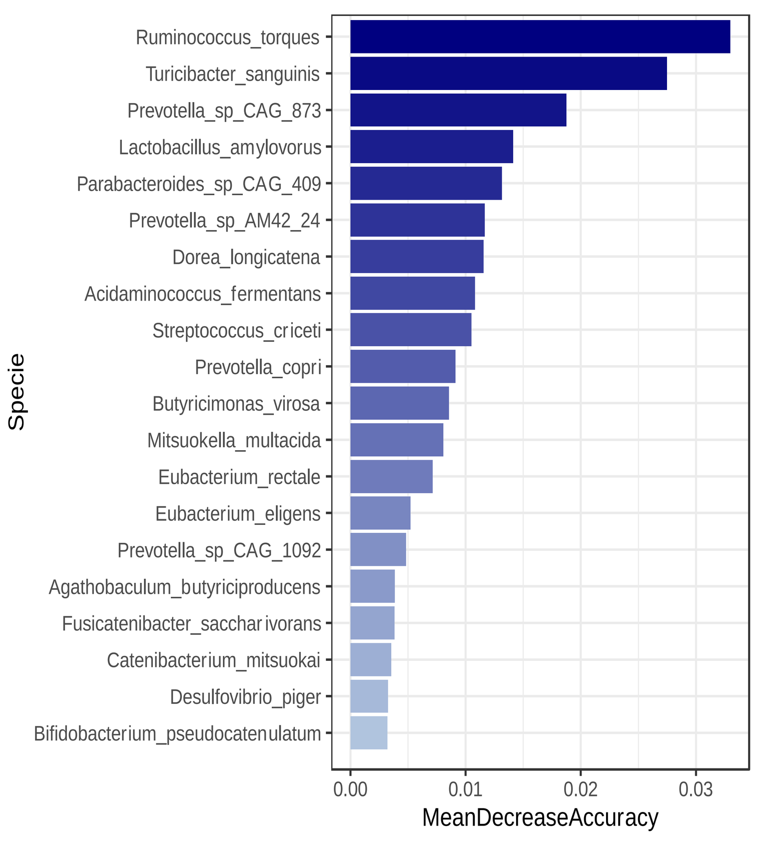


- Dietary fiber deprivation results in the delay of gut bacteria community assembly



- Comparing to standard diet, dietary fiber deprivation reshapes the gut bacteria community structure, But this shift quickly recovered after switching back to standard diet





- By using LEfSe and random forest classification model, we identified *Lactobacillus amylovorus* as important biomarker discriminating dietary fiber deprivation and standard diet.

Conclusions

In conclusion, we verified the detrimental effect of dietary fiber deprivation on gut microbiome and further found out its negative effect on growth performance. Moreover, we also identified a new biomarker of which the abundance dramatically decreased in dietary fiber deprivation. The stain could be potential probiotics to restore the negative effect induced by dietary fiber deprivation.

Acknowledgements

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

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Quantifying the effects of dietary fibres on protein digestibility in pigs

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Background

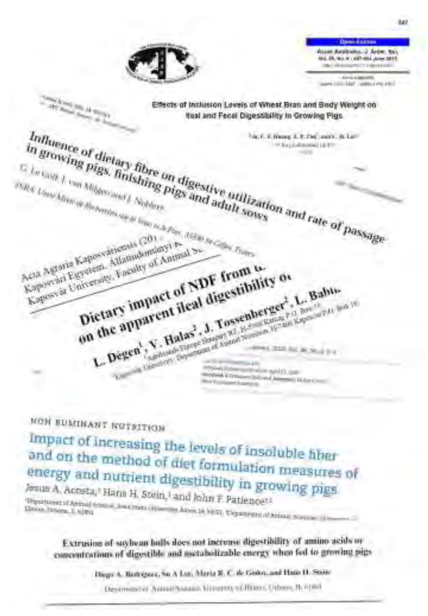
Dietary fibres may negatively affect apparent ileal digestibility of crude protein (AID CP) in different ways. Insoluble fibres (IDF) typically limit AID CP through physical hindrance of hydrolysing enzymes, whereas soluble fibres (SDF) may alter digesta viscosity to reduce hydrolysis and absorption.

Objectives

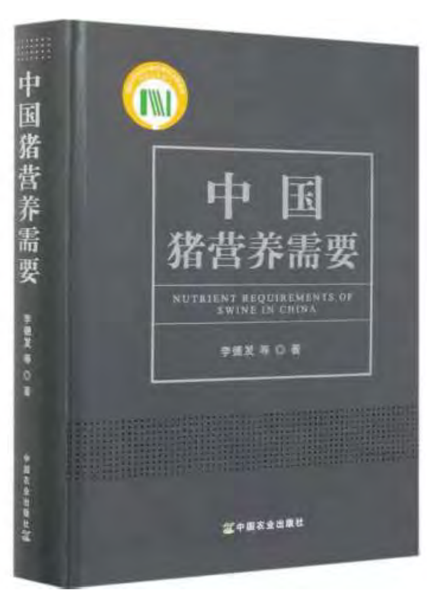
To quantify the relationship between protein digestibility and total dietary fibre (TDF), soluble dietary fibre (SDF) or insoluble dietary fibre (IDF) content based on literature values for further prediction, thereby facilitating optimal use of resources.

Methods

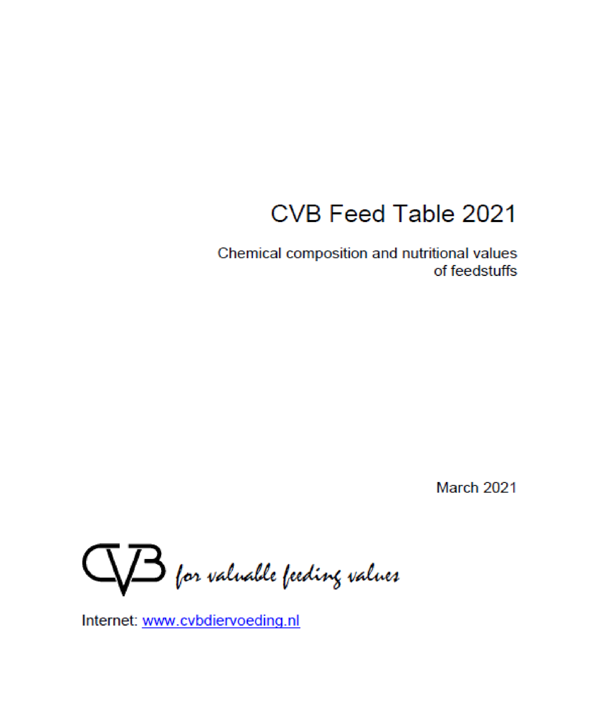
An analysis was performed to quantify the relation between total dietary fibre (TDF), SDF or IDF and AID CP. Data were collected from four databases, and analysed by ordinary least squares (OLS) with R.



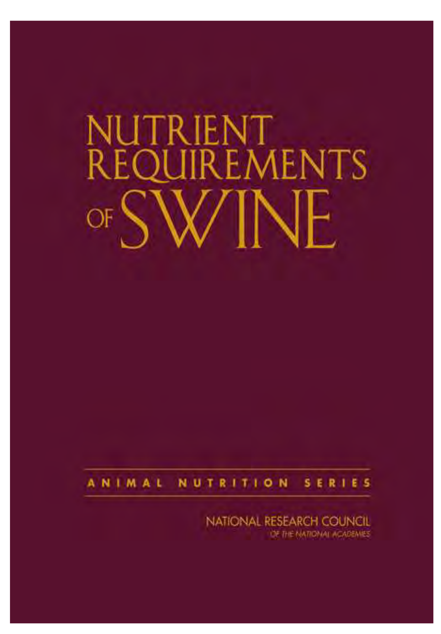
Peer-reviewed publications (PRP)
n=58



China Feed Data (MAFIC)
n=33



Centraal Veevoeder Bureau (CVB)
n=40



National Research council (NRC)
n=18

Results

Table 1 The effect of total dietary fibres (TDF) (%, DM basis) on the apparent ileal digestibility (AID) of crude protein (CP) (%) in cereals in growing pigs as estimated using linear regression, in complete diets reported in peer-reviewed publications, and in ingredients reported in various databases

	PRP	MAFIC	CVB	NRC
Slope (% per % TDF)	-0.6	-0.7	-0.8	-0.2
r	-0.70	-0.81	-0.79	-0.6
P	<0.01	<0.01	<0.01	0.05

Table 2 The effect of total dietary fibres (TDF) (%, DM basis) on the apparent ileal digestibility (AID) of crude protein (CP) (%) in noncereals in growing pigs as estimated using linear regression, in complete diets reported in peer-reviewed publications, and in ingredients reported in various databases

	PRP	MAFIC	CVB	NRC
Slope (% per % TDF)	-0.9	-0.8	-0.5	-0.5
r	-0.59	-0.75	-0.59	-0.53
P	<0.01	<0.01	<0.01	0.22

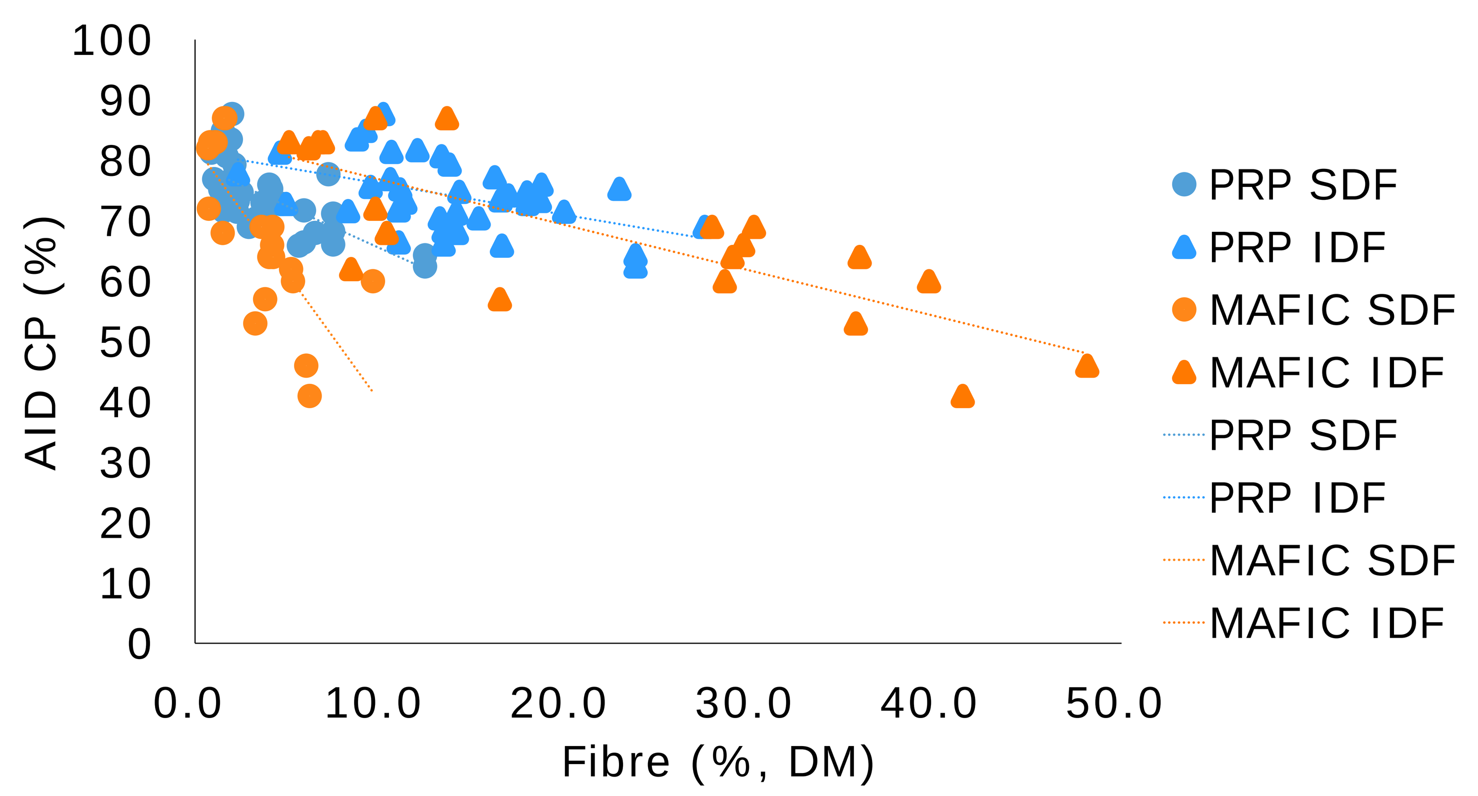


Figure 1 Relation between soluble dietary fibre (SDF), or insoluble dietary fibre (IDF) (g/100g DM) in cereals and apparent ileal digestibility of crude protein (AID CP)

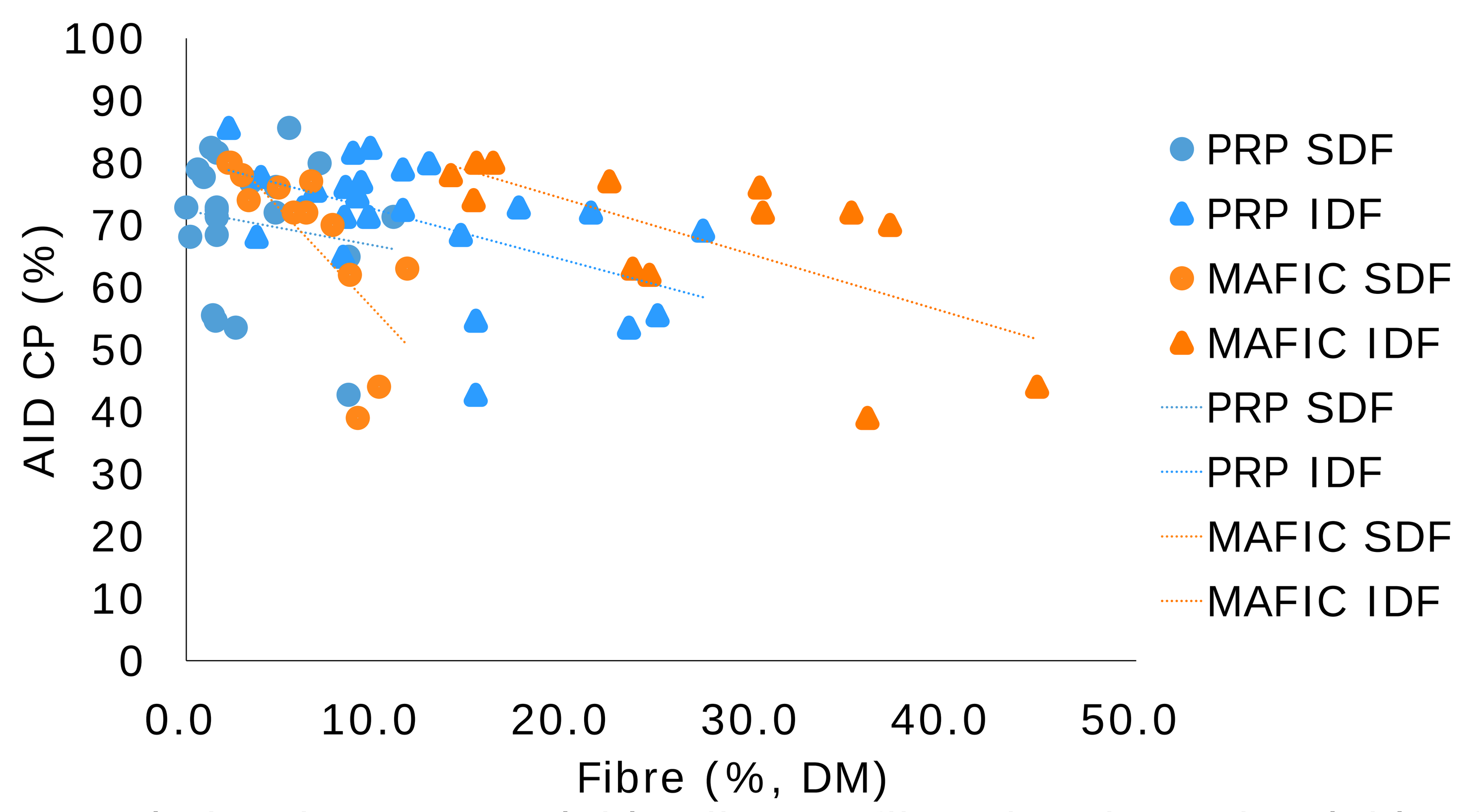


Figure 2 Relation between soluble dietary fibre (SDF), or insoluble dietary fibre (IDF) (g/100g DM) in non-cereals and apparent ileal digestibility of crude protein (AID CP)

Conclusions

- Apparent ileal digestibility of crude protein decreased by 0.5-0.9%-units per %-unit increase in TDF;
- In cereal ingredients the negative relation was more pronounced for SDF, but not for non-cereal ingredients, as expected based on the type of fibers present.

Acknowledgements

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

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Effects of protein kinetics in lactating sow diet on sow body condition losses, litter weight gain and nitrogen utilization

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Background

During lactation, sows mobilize their body reserves to support milk production as the voluntary feed intake does not cover their nutritional demands during this period. Sow body loss in lactation has been associated with negative impacts on post-lactational reproductive metrics. It has been indicated that excessive body protein tissue loss is associated with impaired follicular development and reduced milk production. Increasing dietary protein levels can be effective in saving sow body protein mobilization, but may negatively impact on environment by increasing nitrogen output. In this respect, improvement in dietary protein utilization efficiency is critical. The proteolysis pattern of proteins in the small intestine, known as protein digestion kinetics, can affect protein utilization. Previous studies in humans suggested beneficial effects of slowly degraded protein on postprandial protein utilization, while the effects of protein digestion kinetics on lactating sows and litters are not known yet.

Objectives

The main objective of this study is to increase our understanding of how dietary protein kinetics affect sow body condition losses, blood metabolites, milk compositions and litter growth performance during lactation.

Methods

To investigate the effects of protein digestion kinetics on sow and litter performance, a total of 57 large White * Landrace sows that had been inseminated with Duroc semen were used in this study. Based on the equal distribution of parity (4.6±0.7) and body weight on the day of entering the farrowing crate (263.4±2.9 kg), sows were allocated to one of three dietary treatments; low (LSP, n=19), mid (MSP, n=19), or high (HSP, n=19) levels of slow protein, in which the level of slow protein to total dietary protein was 8, 12, and 16%, respectively, based on the range of ratios found in the meta-analysis, in a complete block design.

The LSP and HSP diets were formulated accordingly and mixed in equal amounts to feed sows in the MSP group. All diets were formulated to contain equal quantities of net energy (2.25 kCal/kg), crude protein (15%), standardized ileal digestible amino acid, and apparent total tract digestible phosphorus.

The body weight, backfat thickness, and loin muscle thickness of sows and body weight of individual piglets were measured on Days 2, 7, 14, and 21 post-farrowing. The thicknesses of sow backfat and loin muscle at the last rib were measured with a linear ultrasonic probe. On Days 6, 13, and 20 post-farrowing, blood samples were collected via an ear marginal vein 4 h after the morning feeding for the analyses of plasma non-esterified fatty acid (NEFA), urea, creatinine (CREA), and insulin-like growth factor-1 (IGF-1) levels. On Days 6, 13, and 20 post-farrowing, milk was sampled by following the injection of 2ml oxytocin through the ear marginal vein for milk lactose, fat and protein analyses.

Results

The body weight loss, loin muscle loss, and estimated protein loss between Days 2 and 21 post-farrowing were lowest or tended to be lowest in sows fed with HSP. HSP sows lost significantly less body weight than MSP sows (Table 1; Δ=5.1 kg, p=0.01) and tended to lose less loin muscle thickness than sows fed with LSP (Table 1; Δ=2.2 mm, p=0.09). Estimated fat and backfat loss were not affected by dietary treatments.

Table 1. Effects of slow protein level in the lactating sow diet on sow body condition parameters on Days 2, 21, and 2−21 post-farrowing (LSmeans±SEM).

	Diets in lactation				P-value	
	LSP	MSP	HSP	SEM	D	P
Body weight loss, kg	13.5^{ab}	17.3^{a}	11.9^{b}	1.6	0.04	0.29
LM loss, mm	4.9^{x}	3.4^{xy}	1.7^{y}	1.0	0.09	0.49
BF loss, mm	2.9	2.4	3.1	0.4	0.50	0.13
Estimated protein loss, kg	1.4^{a}	2.1^{b}	1.0^{a}	0.3	0.01	0.94
Estimated fat loss, kg	6.5	7.0	6.4	0.9	0.87	0.08

D, diet [LSP/MSP/HSP]; P, parity class (4/5);LM. $^{a;b}$LSmeans within a row with different superscripts differ significantly at $p < 0.05$.$^{x;y}$LSmeans within a row with different superscripts differ significantly at $p < 0.1$.

On Day 6 and Day 13, sows in LSP sows had highest blood urea level than MSP and HSP sows (Table 2). On Day 20, both LSP and MSP sows had higher plasma urea level than HSP sows (Table 2). The plasma CREA and IGF-1 levels were not different between different groups.

Table 2. Sow plasma IGF-1 (ng/mL), urea (mmol/L), CREA (mmol/L), and NEFAs (mmol/L) concentrations on Days 6, 13, and 20 post-farrowing (LSmeans±SEM).

	Diets in lactation				P-value	
	LSP	MSP	HSP	SEM	D	P
Urea, mmol/L						
Day 6	4.9^{a}	3.6^{b}	3.1^{b}	0.3	< 0.01	0.37
Day 13	5.6^{a}	4.1^{b}	3.7^{b}	0.3	< 0.01	0.49
Day 20	5.5^{a}	4.9^{a}	4.0^{b}	0.3	< 0.01	0.28

D, diet [LSP/MSP/HSP]; P, parity class (4/5);LM. $^{a;b}$LSmeans within a row with different superscripts differ significantly at $p < 0.05$.

The litter weight gain, other blood metabolites, milk composition during lactation did not show significant differences between dietary treatments in this study.

Conclusions

In conclusion, feeding protein sources with a high fraction of slowly degradable protein to multiparous sows reduced body weight loss and protein mobilization during lactation, without affecting litter growth performance. The high level of slow protein likely reduced oxidation of amino acids, as evidenced by lower blood plasma urea level throughout lactation, thereby increasing the dietary protein utilization efficiency.

Acknowledgements

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Fermentation of endogenous protein in the colon of pigs determined by a gas production technique

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Background

Protein fermentation in the gastrointestinal tract of monogastric animals, like pigs, can yield several biologically active and often deleterious metabolites (Gilbert et al. 2018). One of the strategies to reduce the negative impact is to limit protein intake. However, not only dietary protein but also endogenous protein may contribute to fermentation as it enters the hindgut. As dietary protein digestibility increases, the relative contribution of EP to the ileal digesta protein content increases and protein fermentation will depend more and more on them as well as the degree of hydrolysis of the proteins. Therefore, the fermentation potential of porcine endogenous protein was investigated.

Objectives

Ileal digesta samples from pigs fed nitrogen (N)-free diets in 5 different studies, colonic mucus and whey protein isolate (WPI) were tested in an in vitro gas production system with porcine faecal inoculum. Nitrogen limiting microbial activity using a N - free buffer and an excess of fermentable carbohydrates. Original samples were obtained in five protein digestibility studies conducted in China (P. Li et al. 2015; Z. Li et al. 2015; Liu et al. 2015; Ma et al. 2019; Zhang et al. 2019), hereafter named study A through E.

Methods

Sealed bottles of 250 ml containing 60 ml 2% buffer-faecal solution with added test substrates containing 10 mg N and same buffer-faecal mixture (Blank) were allocated in 39°C water baths. Gas production was recorded continuously for 48 h. Lag time (h), maximum gas production rate (R_{max}, ml/h), time when maximum rate occurred (T_{Rmax}, h) and cumulative 48 h gas production (GP_{48}, ml) were calculated and compared by the MIXED model procedure in SAS.

Based on N content and solubility, samples were dissolved in same N-free buffer to prepare the supernatant for size exclusion analysis (SEC). The molecular weight distribution was analyzed by an Akta pure 25 system with Superdex 75 column. The chromatograms obtained were separated into different molecular weight ranges by calculating the eluent volumes based on the calibration curve. Pearson correlation analysis were conducted for SEC results and fermentation parameters.

Results

Compared to most of the digesta samples, mucus had a greater R_{max}, 25.0 ± 2.0 vs 18.5 ± 4.0) and shorter T_{Rmax} (5.1 ± 0.6 vs 7.2 ± 2.8) while WPI as intact protein showed the lowest R_{max} (12.2 ± 2.3) and highest T_{Rmax} (12.9 ± 5.0). Differences in R_{max} and T_{Rmax} were also found between different digesta samples ($p < 0.05$).
SEC results showed that endogenous proteins are comprised of much smaller molecules compared to WPI. However, negative correlation was found between solubility and R_{max} in ileal digesta samples. Also, higher percentage of small particles with molecular weight between 0-5 k Dalton is linked to a lower R_{max}.

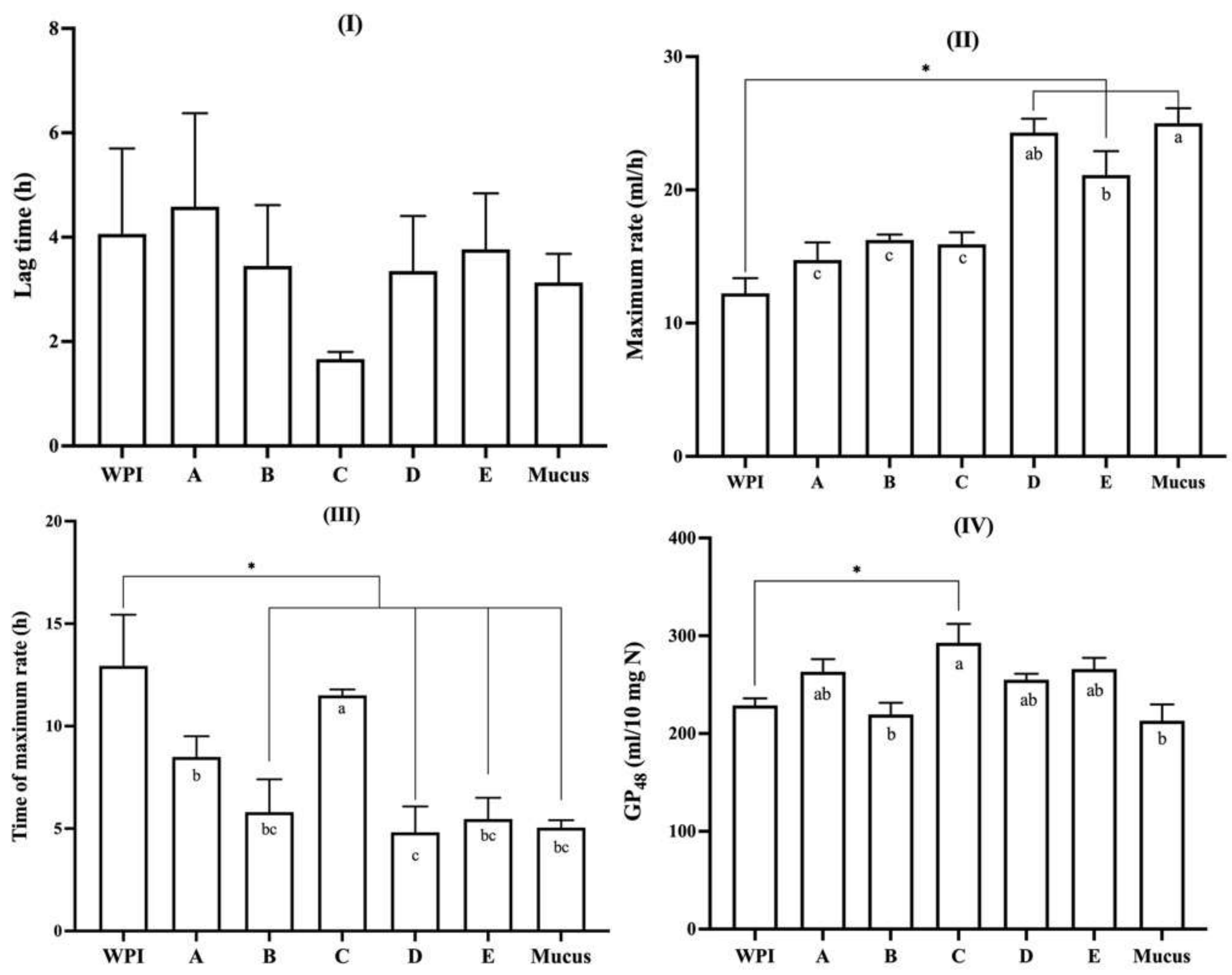

Figure 1. Lag time (I), maximum gas production rate (II), time when maximum rate occurred (III) and cumulative 48 h *in vitro* gas production (GP_{48}, IV) of whey protein isolate (WPI, n=4), colonic mucus (n=3) and five ileal digesta samples (n=3). Ileal digesta samples were obtained from pigs fed N-free diets in five separate digestibility studies. Bars with asterisk show a significant difference between WPI group and different endogenous protein groups ($p < 0.05$). Values are means ± SEMs. Bars with different subscripts within panel show significant differences between endogenous protein groups ($p < 0.05$).

Conclusions

Compared to WPI, endogenous proteins are more accessible for microbiota to utilize as due to smaller molecular weight. Although the potential fermentation of endogenous protein can vary between different animal studies. Underlying reasons still need further investigation.

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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

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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.

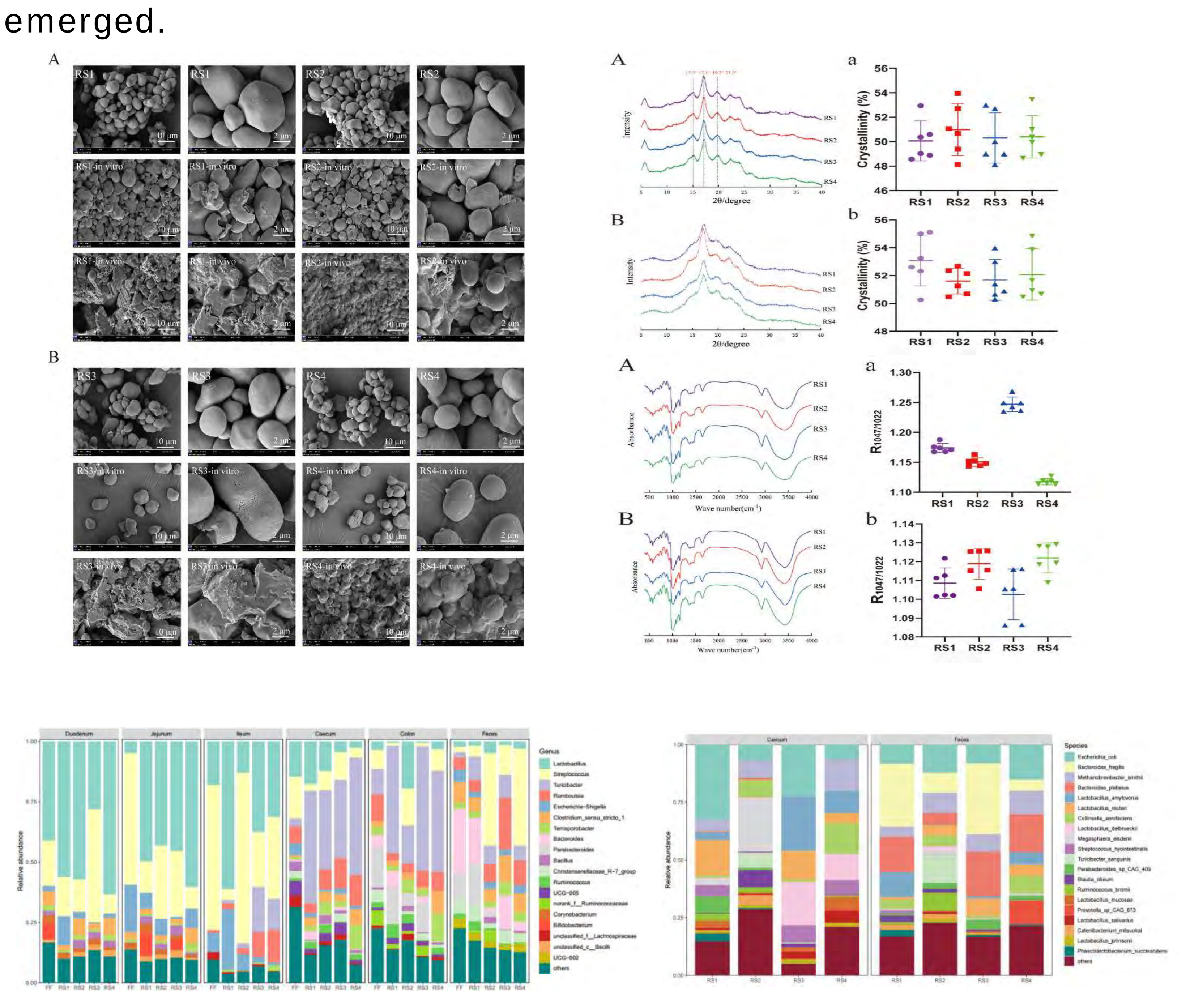

Figure 2. Resistant starch structural changes and their effects on microbiota composition of growing pigs

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

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Coherence and consistency of groundwater policies in China, 1981-2021

PhD student: Muying Duan
Supervisors: prof. Wopke van der Werf, prof. Andries Richter, prof. Nico Heerink, prof. Shaozhong Kang

Background

Food security for a growing world population requires an expansion of crop production beyond current levels. However, the groundwater resource to enable such production increase is under pressure. Therefore, groundwater policies need to address both the immediate and future demand for water.

Policy coherence is defined as the degree of synergies and conflicts within and across different sectors to achieve sustainable groundwater transition from the descriptions of Nilsson's (2012) paper. In this study, policy coherence refers to differences of topics in groundwater policies across sectors. Consistency generally appears together with coherence (Mavrot et al., 2019). To emphasize the difference, the consistency in this study refers to the topics in groundwater policy are steady over time (based on Cayton, 2017; van Engen et al., 2019; White et al., 2013).

Objectives

The importance of coherence for groundwater policies has been long recognized (Foster and Loucks., 2006; Pandey et al., 2011; Varady et al., 2012). Previous research has focused on qualitative studies of policy coherence between sectoral policies and environmental policies. On the other hand, the tremendous growth in groundwater policy documents prompts the need to synthesize information in a timely, accurate and efficient manner to understand the current major topics and guide future policy making. However, there is no study to quantify the coherence of groundwater policies.

Against this background, the main objective of this study is to examine whether to what extent groundwater policies in China are coherent and consistent.

Methods

We acquired groundwater policy documents issued by the central government and official ministries and from 01/01/1981 to 31/12/2021. The policies were retrieved from two database sources: the official website of the Chinese government (State Council of the P.R. China, 2022) and the Peking University law database (Peking University Center for Legal Information, 2022). Policies were retrieved by title and content search using the Chinese term "groundwater" as the keyword. In total, a database of 2647 national groundwater policies were obtained after removing duplicate items.

The total number of words in the database exceeds 6,610,635 (national policy database). Then, the whole content was organized into pure text format for text mining. Here we applied the LDA model to summarize and extract the groundwater policy documents into latent topics using a "bag-of-words" approach (Campbell et al., 2015). This method considers each policy document as a word frequency vector, representing a probability distribution formed by some topics, and each topic represents a probability distribution formed by word items. The main sectors in China are defined as the main official ministries related to groundwater management and utilization.

Results

Fig. 1. The number of policies issued across multiple sectors in China

As shown in Fig. 1, the Environmental Protection sector issued the largest number of groundwater-related policies (32.8%), followed by the Water Resources sector (17.1%), Urban Development sector (14.7%), Natural Resources sector (12.9%), Agriculture sector (9.5%), Finance sector (8.7%), and Industry sector (3.0%).

The lowest number was issued by the Social Security Sector (1%) and Commerce Sector (0.2). We focused on the coherence within and across the six main sectors: Water Resources Sectors (S1), Natural Resources Sectors (S2), Environmental Protection Sector (S3), Agriculture Sector (S4), Industry Sector (S5), and Urban-development Sector (S6). Since the Finance sector mainly provides financial support for other sectoral policies, while Social Security and Commerce sectors have a few groundwater policies, they were not included in our discussion.

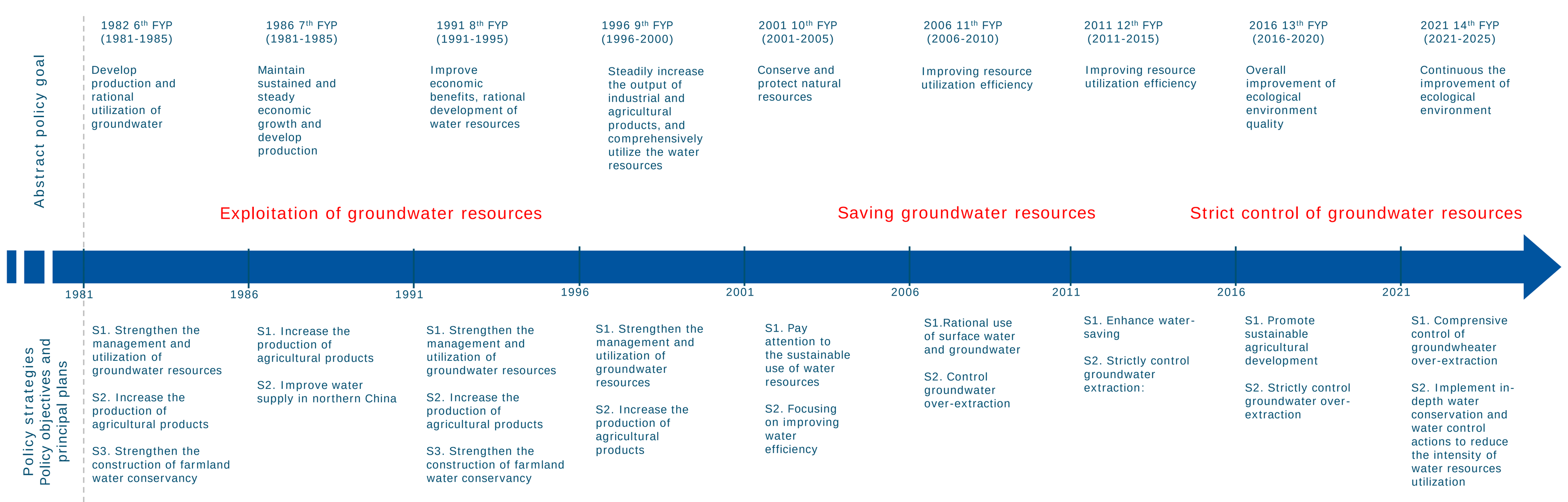

Fig. 2. The policy objectives change trend of groundwater policies from 1981 to 2021 in China

Then we created the timeline of the groundwater policy topics evolution trends in China. The abstract policy goals were divided into three changing goals from the groundwater exploitation to the groundwater saving and to sustainable groundwater use. Then, according to the abstract policy goals of each period, we determined the main policy strategies to achieve the goals. We can see that the same policy goals often correspond to similar policy strategies.

Conclusions

Groundwater policy are shifting from resource exploitation to conservation and protection.
Groundwater policies of China may be not coherent over different sectors , but they are not as effective as intended.

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

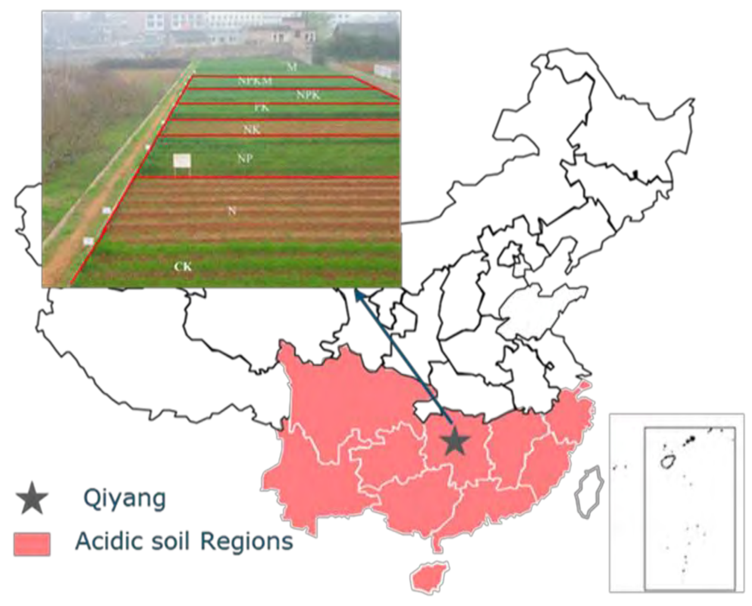
Overuse of P fertilizers causes resources waste and serious water pollution. Understanding the fate of bioavailable, reactive and stable P in soil is key to improve recommendations to optimize P fertilizer application for both agronomic and environmental objectives. A modelling approach which focuses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

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.

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.



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)

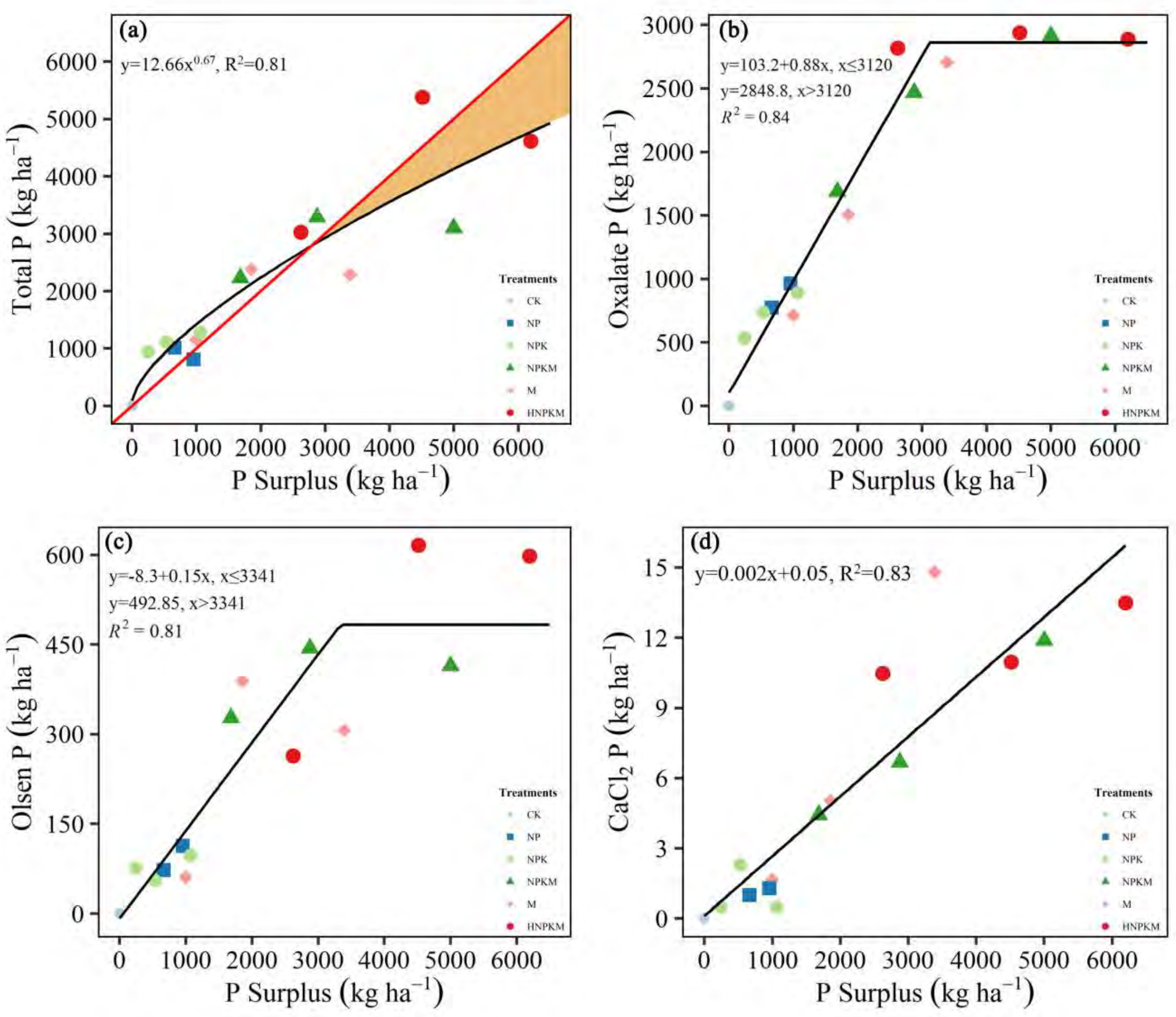


Figure 2. The relationship between changes in soil P pools and soil P surplus

- 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)

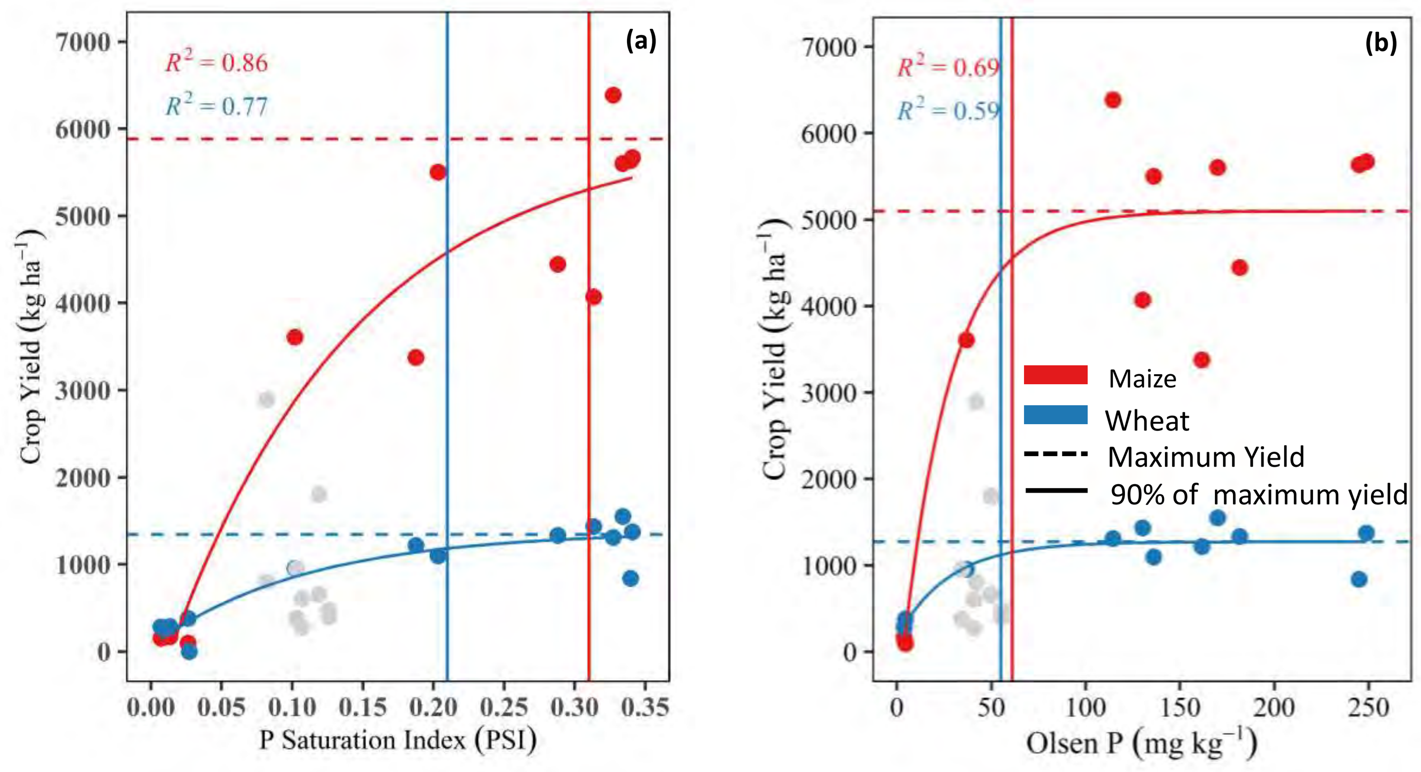


Figure 3. The relationship between crop yield and soil P indicators (Data points in grey were skipped from regression lines because of severe crop yield reduction due to acidification)

- 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)

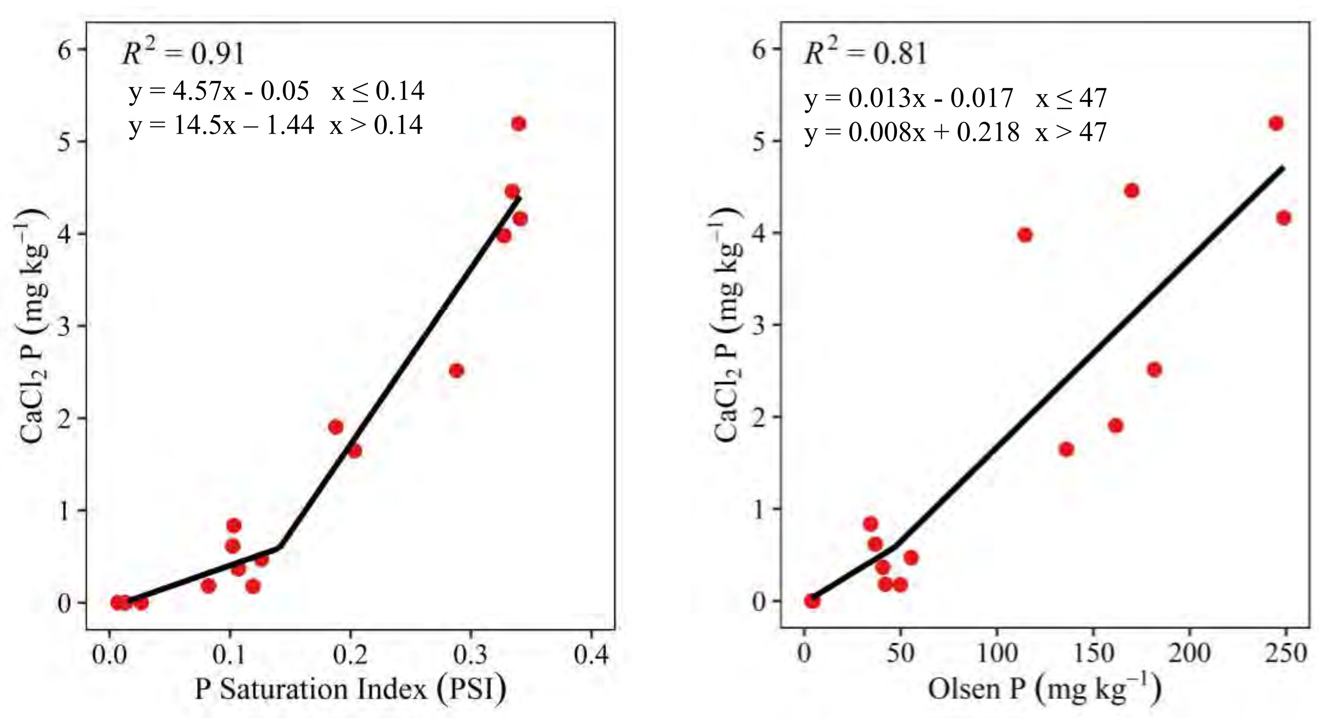


Figure 4. The relationship between $CaCl_2$ P concentration and soil P indicators

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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Impacts of soil properties on phosphorus adsorption and desorption parameters for major soils in China

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

Background

In the past decades, crop production in China has improved with increasing N and P input. While P input increased from 88 to 123 kg P_2O_5 ha^{-1} yr^{-1} during 2004-2014, 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 risk and waste of P resources. However, P transformation dynamics relative to varied soil properties remains unclear. It is crucial to optimize P management through better understanding of P adsorption and desorption processes to match soil P supply and P demand by crops.

Objectives

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

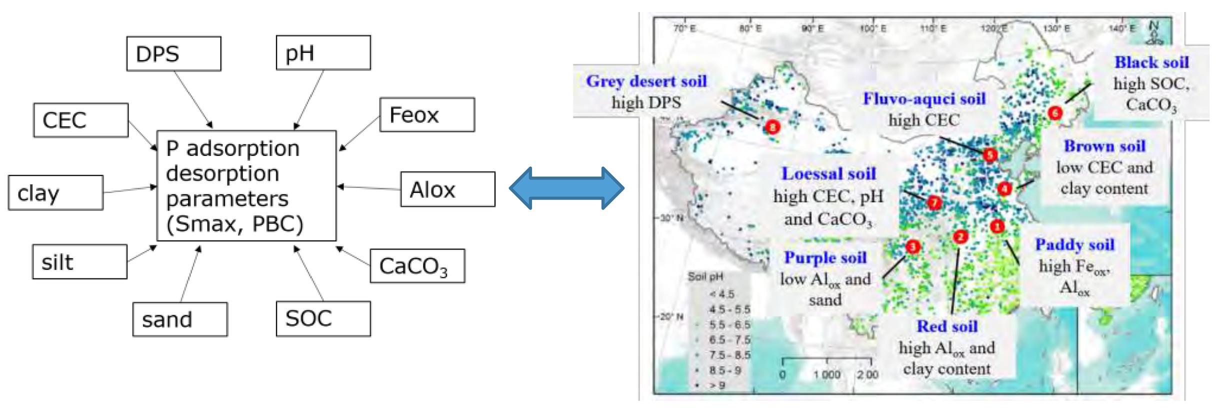

Figure 1. Sampling sites across China

Methods

The P adsorption parameters were fitted to a Langmuir isotherm :

$S = S_{max} \times K_L \times C/(1+ C \times K_L)$

where S is the adsorbed amount of P (mg P kg^{-1}), S_{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 K_L 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 desorption constants where β reflects the amount of desorbed P per unit P adsorbed.

Results

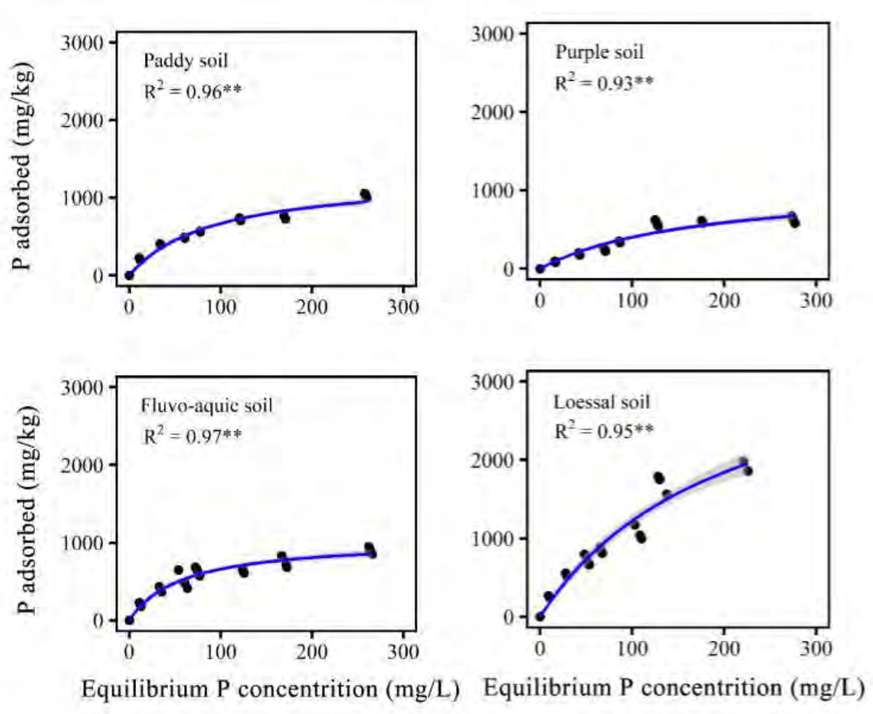

Figure 1. P adsorption isotherms

Table 1. P adsorption and desorption parameters

Location	Soil type	S_{max} (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 equation accurately described P adsorption.
- P adsorption increased with increasing P concentrations but for some soils saturation was not yet found.
- Large variations in P adsorption (up to a factor 5) were found in different soil types.

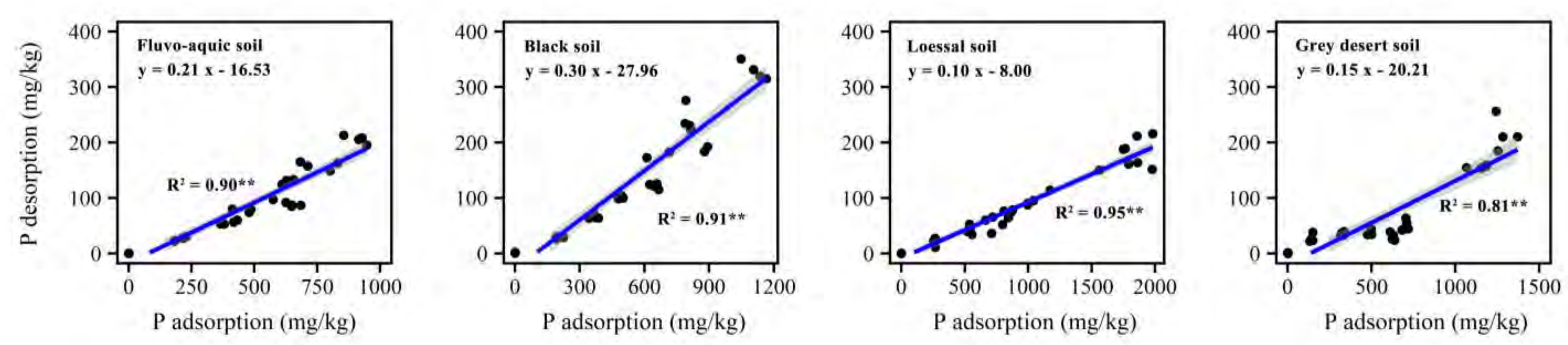

Figure 2. Relationship between P adsorption and desorption.

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%), suggesting a strong P fixation and low release of adsorbed P.

Table 2 Impact of soil properties on P adsorption and desorption

Variable	P adsorption	P desorption	Explanation / process
pH	Binomial	Binomial	Changing the electric potential of the surface and the solubility of cations
Fe_{ox}	Positive, linear	Positive, linear	important for P adsorption in soils
Al_{ox}	Positive, linear	Positive, linear	
$CaCO_3$	Positive, linear	Negative, binomial	Precipitation with Ca^{2+} and adsorption on $CaCO_3$ surface
CEC	Positive, linear	Negative, linear	Affecting the adsorption of Ca^{2+} and Mg^{2+} on soil particles
SOC	Binomial	Binomial	Competition with P thus reducing adsorption sites; formation of cationic bridges, increasing P adsorption sites.
Clay	Positive, linear		soil texture affecting the specific surface area of the soil
Silt	Positive, linear	Negative, linear	
Sand	Negative, linear	Positive, linear	

The P adsorption maximum, S_{max}, increased linearly with the content of Fe_{ox}, Al_{ox}, CEC, $CaCO_3$, clay and silt. A nonlinear relationship was found between S_{max} versus pH and SOC. The P desorption constant was positively correlated with Fe_{ox}, Al_{ox}, and sand content, while it was negatively correlated with CEC, $CaCO_3$ and silt content.

Conclusions

1. P sorption increased with increasing P addition, not yet reaching the adsorption maximum even at extremely high dissolved P concentrations.
2. The CEC, Fe_{ox}, Al_{ox}, $CaCO_3$, clay and silt were the major factors promoting P sorption, while pH and SOC had both promoting and inhibiting effects.
3. P desorption increased linearly with the increasing adsorbed.
4. The Fe_{ox}, Al_{ox} and sand content were main soil properties promoting P desorption, CEC, $CaCO_3$ and silt inhibited P desorption while pH and SOC have both promoting and inhibiting effects on P desorption.

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Mitigation of nitrogen losses and greenhouse gas emissions in a more circular cropping-poultry production system

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

Background

The amount of reactive nitrogen (Nr) released into the environment has exceeded the safe planetary N boundary (De Vries et al., 2013; Steffen et al., 2015). Crop and livestock production are the two most important drivers of the global N cycle (Uwizeye et al., 2020; Zhang et al., 2015) and together contributed 60% to the total Nr losses to water and 80% to 90% to the total ammonia (NH_3) emissions to air in China in 2010s (Yu et al., 2019; Zhang et al., 2018). Approximately half of the total amount of excreted N by the poultry sector was lost during housing and manure storage in China. The environmental impact of the poultry sector therefore demands for more efficient management practices leading to an increase in productivity and NUE on the one hand and a decrease in environmental costs on the other hand.

Objectives

The aim of this study was to quantify the benefits and trade-offs of the more circular and optimized poultry-cropping system, compared to the conventional system, in terms of NUE, Nr losses, GHGs emission, as well as farm income.

Methods

We applied a substance flow analysis, by using measured data and data from literature, to estimate the reactive nitrogen (Nr) losses and greenhouse gas (GHG) emissions from housing, manure processing and manure application to cropland in a conventional decoupled and an optimized coupled crop-poultry system.

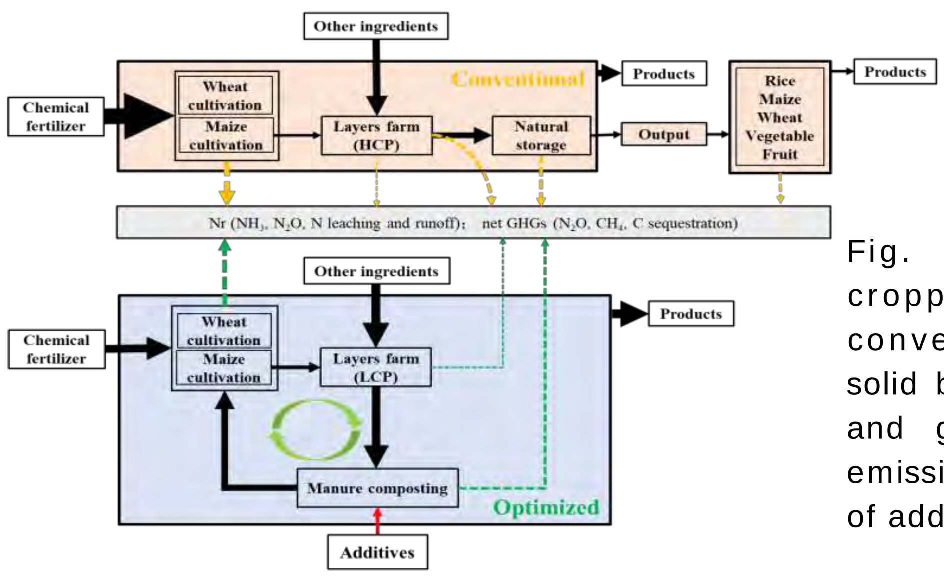

Fig. 1. Boundary for systematic analysis of cropping-poultry production in both the conventional and the optimized systems. The solid black arrows are the N flow, the dashed yellow and green arrows represent Nr losses or GHGs emission, and the solid red arrow shows the addition of additives during the composting period.

Results

NUE

For the optimized system, more products N had been produced. The NUEcrop increased from 39% in the conventional system to 57% in the optimized system (Fig. 2), mainly because the local recycling of the composted manure reduced the N input in the form of the chemical fertilizer. Although, there were no difference of NUEanimal between the two systems, the NUEwhole system substantially increased from 33% to 50%.

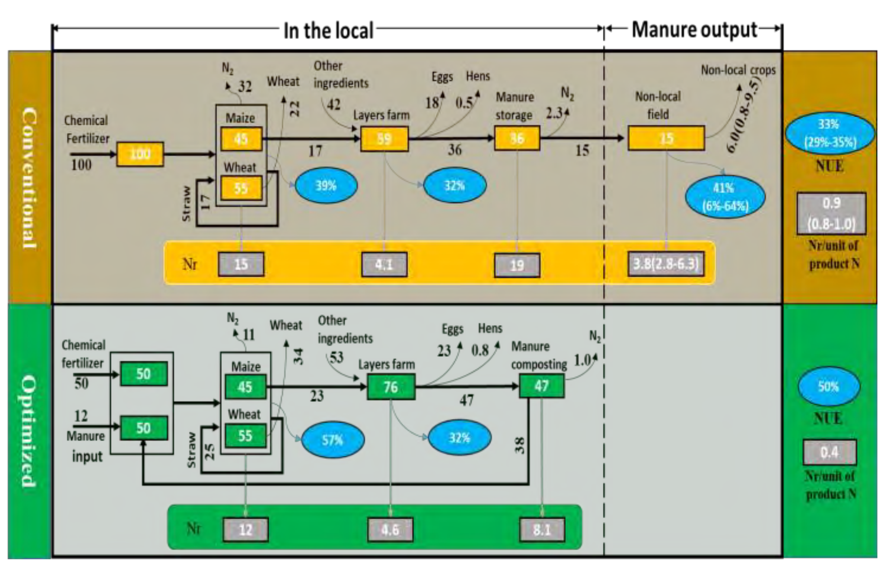

Fig. 2. Schematic of N flow in conventional (light yellow background) and optimized (light green background) cropping-poultry production systems. The values in the yellow and green boxes represent N flow in cropping-poultry production systems; the values in the blue ovals are NUE for crop cultivation, egg production and for the whole cropping-poultry production system; the values in the gray boxes represent Nr loss from each production stage per unit (kilogram) of N contained in the products.

Nr losses

The Nr losses in the conventional system ranged from 41 to 54 units, while it was only 25 units in the optimized system (Fig. 3). The cropping process and manure management were the main contributors to the Nr losses in both the conventional and the optimized systems. The total Nr loss of the conventional system was 0.9 kg Nr (kg product N)$^{-1}$, while it was only 0.4 kg Nr (kg product N)$^{-1}$ in the optimized system.

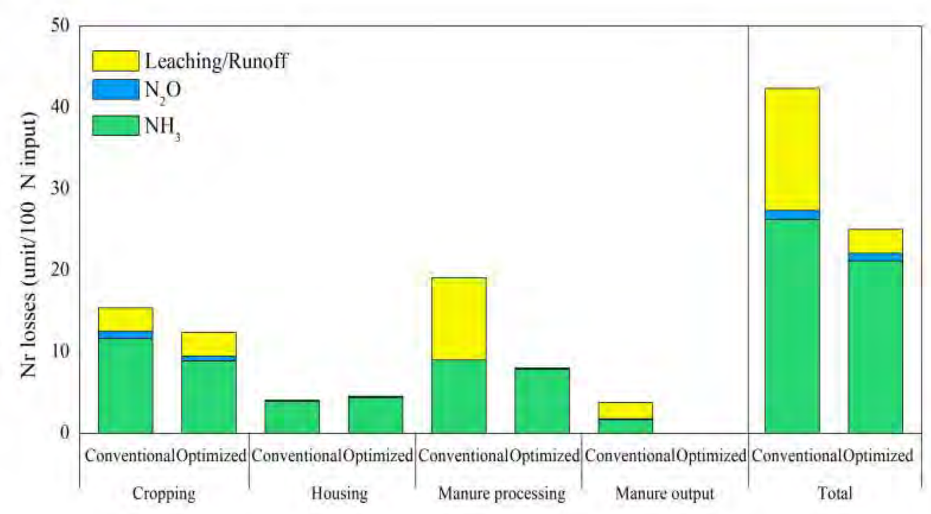

Fig. 3. Nr losses in form of ammonia (NH_3), nitrogen dioxide (N_2O) and leaching/runoff at each stage of the conventional and optimized cropping-poultry production systems (Note: Nr losses to the environment is relative to 100 units (kilograms) N input into the local cropping system).

GHG emissions

As shown in Fig. 4. Emissions of N_2O accounted for 61% and 66% of the total GHG emissions from the conventional and the optimized systems, respectively. Emissions of CH_4 accounted for 16% and 18%, respectively. Indirect N_2O emissions, introduced by Nr losses in the form of NH_3 emissions and leaching, accounted for 23% and 17%, respectively. Emissions of N_2O were mainly attributed to crop production, while CH_4 emissions were mainly attributed to the housing stage.

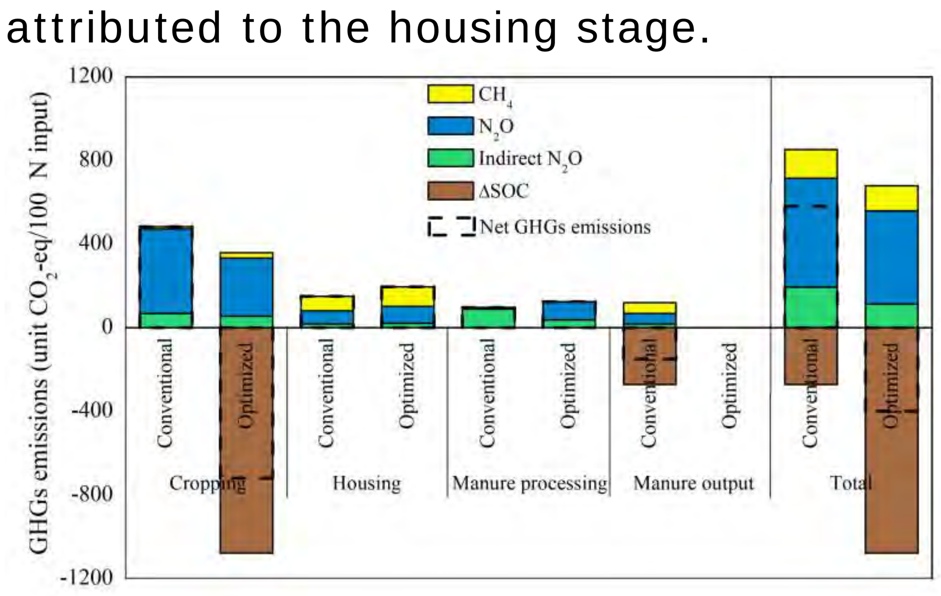

Fig. 4. Net GHG emissions, including direct and indirect N_2O emissions, CH_4 emissions and soil organic carbon (SOC) changes at each stage (cropping, housing and manure processing) in the conventional and optimized cropping-poultry production systems. (Note: GHG emissions to the environment are relative to 100 units (kilograms) kg N input into the local cropping system).

Cost-revenue

Given a 100-unit N input into the cropping system, there was a cost of 8,616 (7,865–10,296) and 10,883 RMB Yuan in the conventional and the optimized systems, respectively (Fig. 5). The revenue in the optimized systems was 19,125 RMB Yuan, which was 14% more than in the conventional system. The net benefits were 8,616 and 10,883 RMB Yuan in the conventional and the optimized systems, respectively, implying that 21% (5%–28%) more net benefit was obtained in the optimized system, with same N input.

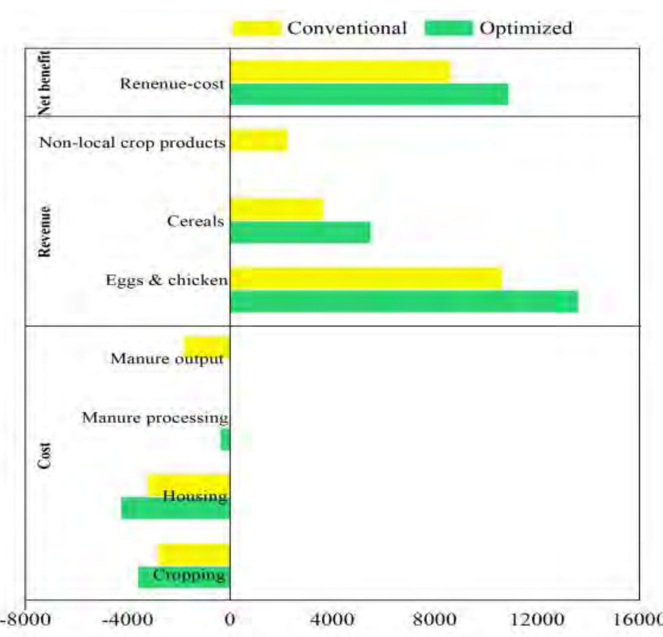

Fig. 5. Costs, revenues and net benefits in the conventional and optimized cropping-poultry production systems. (Note: cost-revenue is in relative to 100 units (kilograms) N input into the local cropping system).

Conclusions

The Nr losses resulting from 100 units (kilogram) N input into local cropping system were 42 and 25 units in the conventional and optimized systems, respectively. Maize-wheat cultivation and manure processing stages are the two main contributors to Nr losses. The greater efforts in decreasing Nr losses should be at first in the optimization of crops production and manure processing. The transition from the conventional to optimized system for cropping-poultry production has the huge potential for system NUE increasing (increased from 33% to 50%) and N losses reduction (decreased from 0.9 to 0.4 units N losses per unit N product) as well as net GHGs exchange reduction, in relation to 100 units (kilogram) N input into local cropping system. Moreover, it would raise net economic benefit by 21% in the optimized system.

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FUTURE WATER POLLUTION REDUCTION REQURES ACCOUNTING FOR MULTIPLE POLLUTANTS

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Background

- ❖ Waters often contain multiple pollutants
- ❖ Pollutants can come to waters from common sources
- ❖ Urbanization and agriculture are important common sources of water pollution

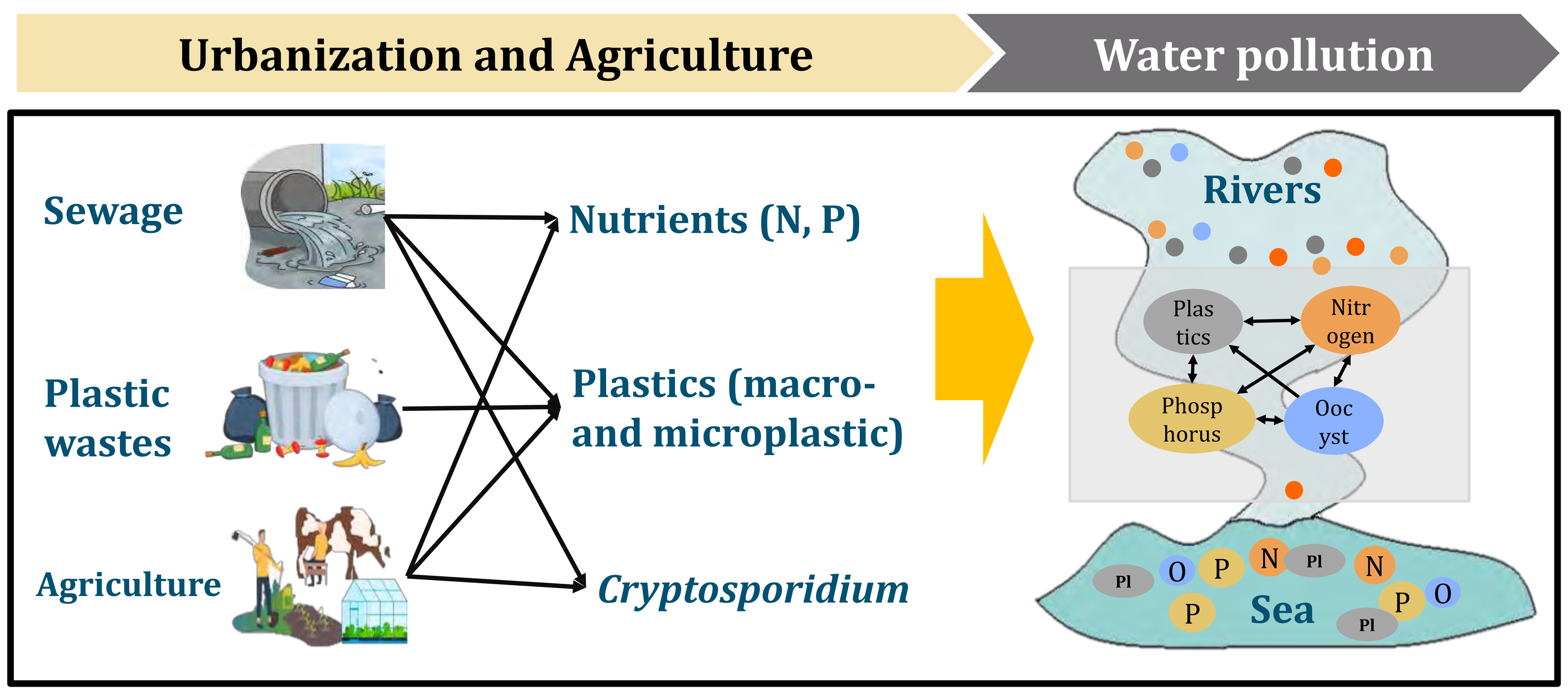


Fig. 1 Multiple pollutants in rivers from urbanization and agriculture

Research objective

Explore future trends in river pollution with nutrients, *Cryptosporidium* and plastics in 395 Chinese sub-basins

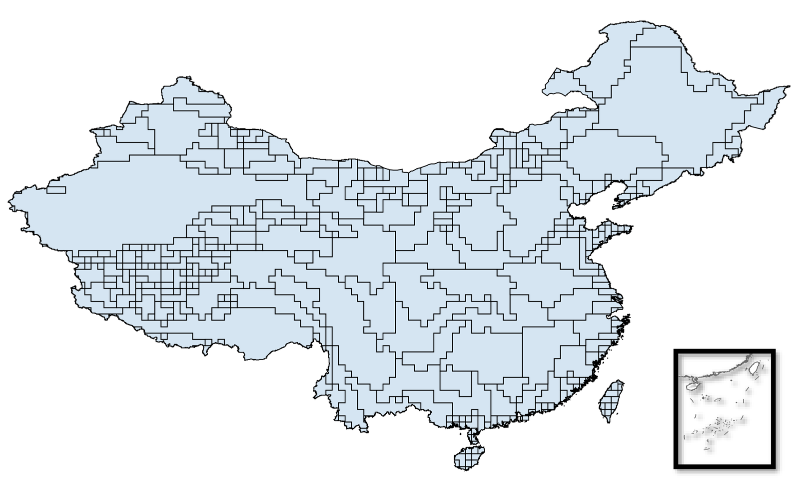


Fig. 2 Chinese sub-basins

Methods

Integrated existing MARINA models

- **Time step: 2010, 2015 and 2050**
- **Nutrients, *Cryptosporidium* and plastics export to rivers in sub-basins**

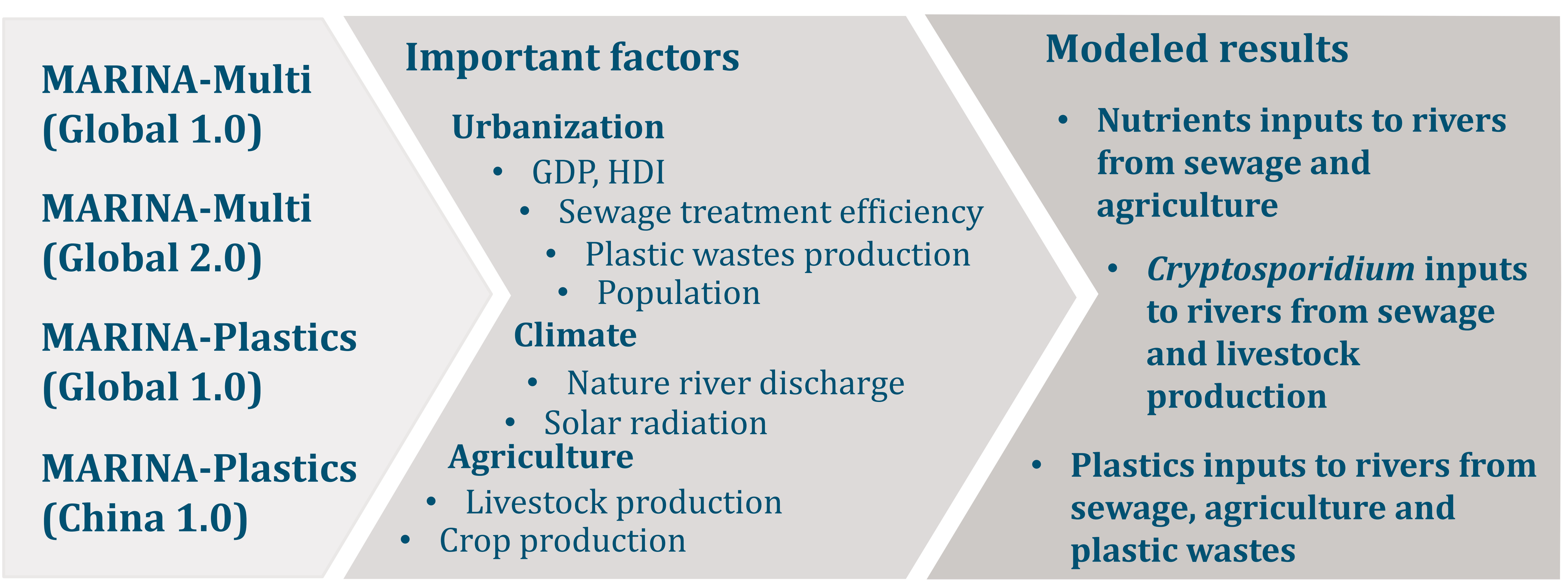
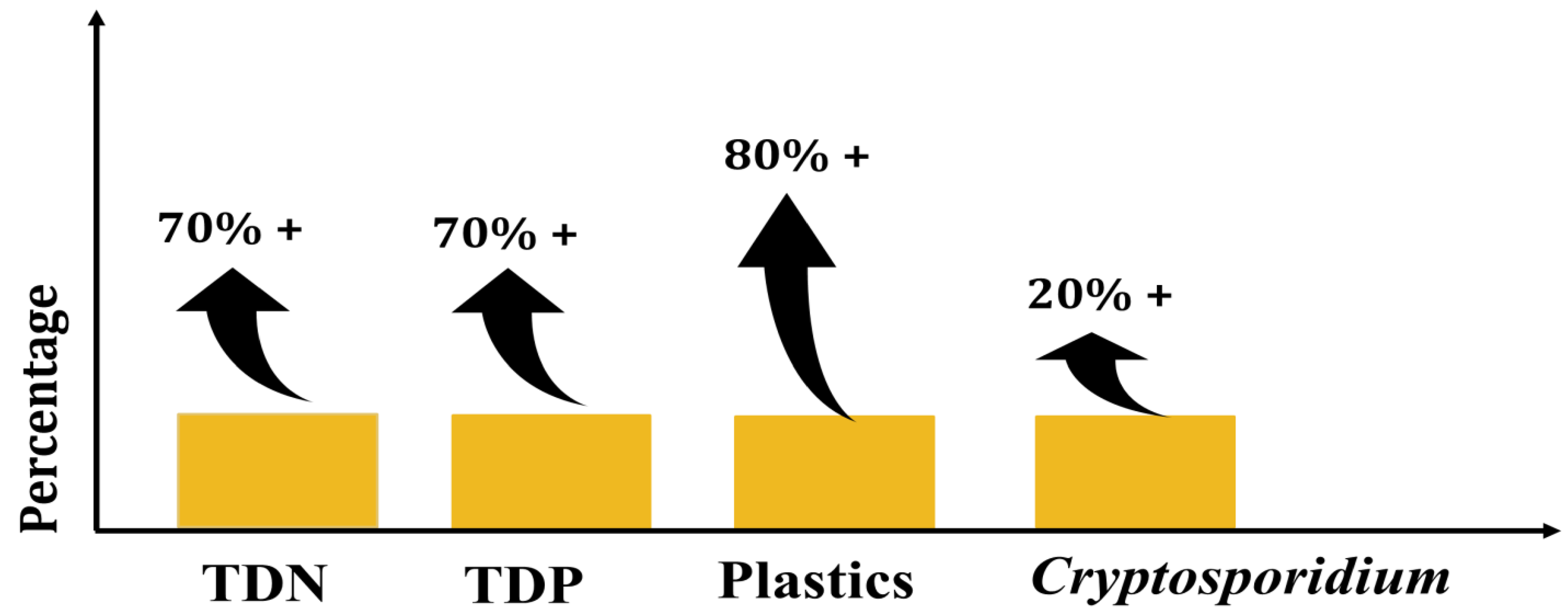


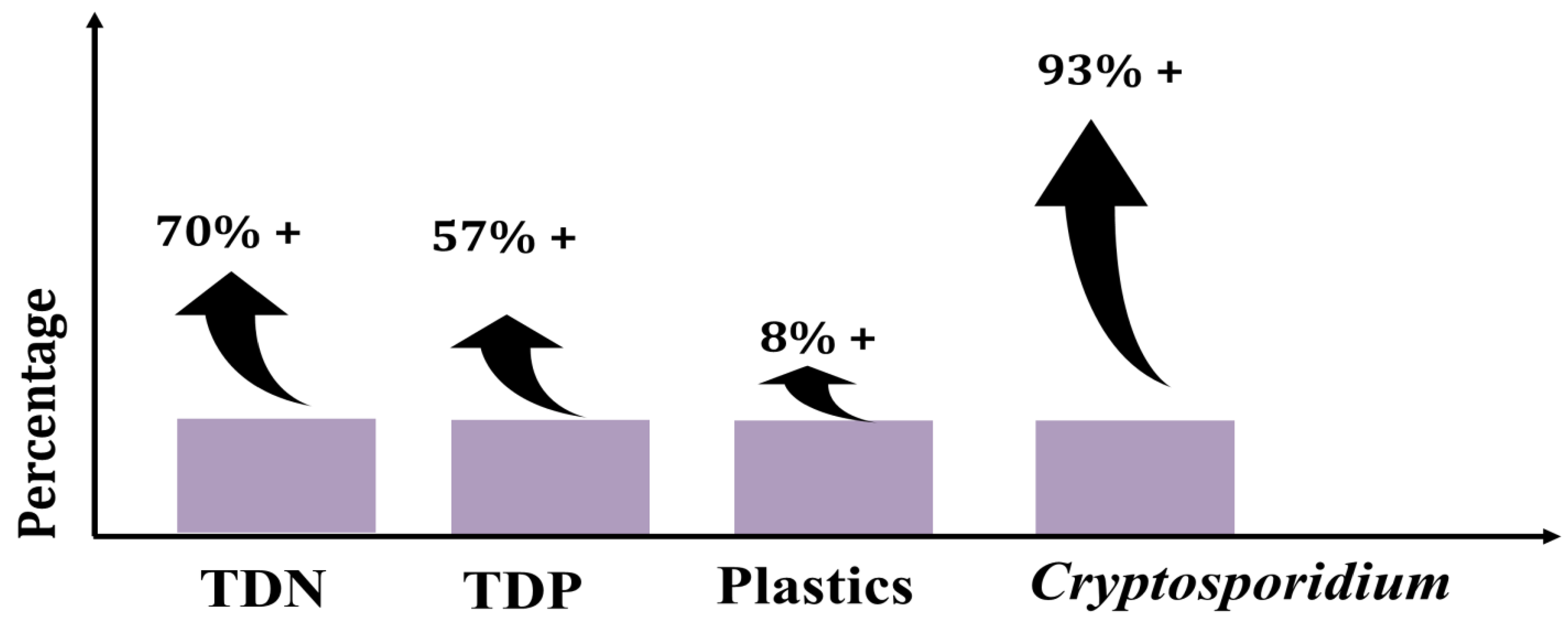
Fig. 3 MARINA models (Model to Assess River Inputs of pollutaNts to seAs)

Results

a. Increases in inputs of pollutants in rivers as a result of urbanization in China during 2010-2050



b. Increases in inputs of pollutants in rivers as a result of agriculture in China during 2010-2050



Conclusions

- ❖ Future water pollution reduction needs to account for multiple pollutants
- ❖ Plastics in Chinese rivers are expected to be increases as a result of future urbanization in the year 2050
- ❖ *Cryptosporidium* (pathogen) in Chinese rivers is expected to increase as a result of future agricultural activities in the year 2050
- ❖ Nutrients in Chinese rivers are expected to increase as a result of future urbanization and agricultural activities in the year 2050

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Nitrogen losses from food production in the North China Plain transgressed the environmental targets

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Background

Intensive food production in the North China Plain (NCP) has led to large nitrogen(N) losses to the environment, degradating air and water quality. Improved N management is required to effectively reduce agricultural N losses while ensuring food production. For this, it is important to analyze N losses from the food production and compare them to the environmental targets for N losses.

Objective

To quantify N losses from food production to air and water, and to develop environmental targets for these N losses in Quzhou, a typical agricultural county in the NCP.

Methods

First, N losses from the food production in Quzhou is estimated by the food chain approach. Next, we developed an environmental target for ammonia (NH_3) emission from agriculture based on the concentration of $PM_{2.5}$ to avoid negative health effects using an air quality model. We developed an environmental target for N leaching to groundwater based on the concentration of nitrate (11.3 mg N L^{-1}) to avoid contamination of drinking water.

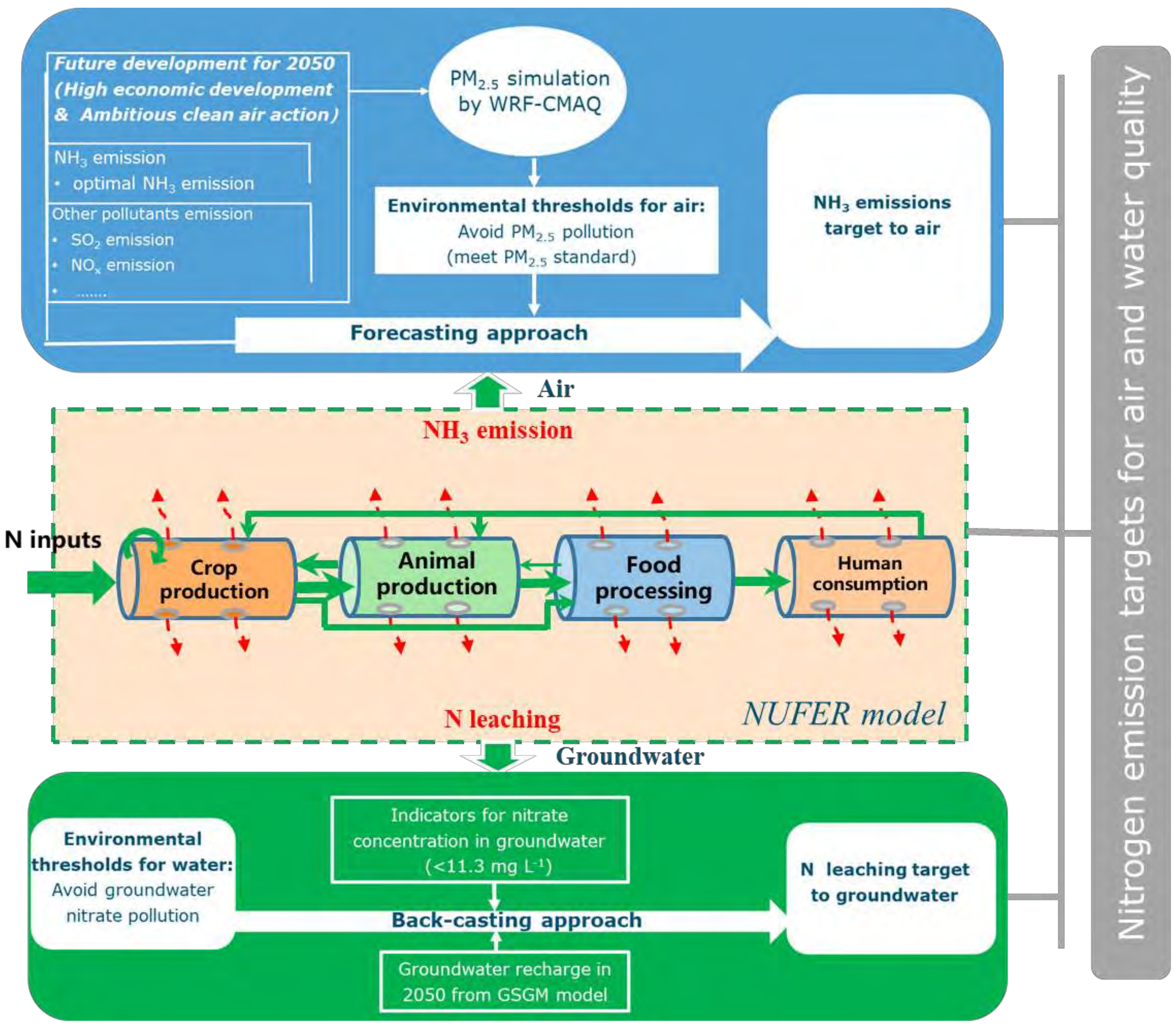

Figure 1. The methodological framework combined food chain approach-air quality model-groundwater model (NUFER is NUtrient flows in Food Chains, Environment,and Resource use model(Meng et al., 2022a). WRF-CMAQ is Weather Research and Forecasting model and Community Multiscale Air Quality model(Meng et al., 2022b); GSGM is Global-scale surface water-groundwater model(de Graaf et al., 2019)。

Acknowledgements

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

N losses from the food production in Quzhou

- N losses to the envrionment from the food production were ~9 kt in Quzhou in 2017
- NH_3 emssions to air (4.1 kt N) and N leaching to groundwater (2.1 kt N), and direct discharges of manure to water (1.9kt N) are main contributors to the N losses.

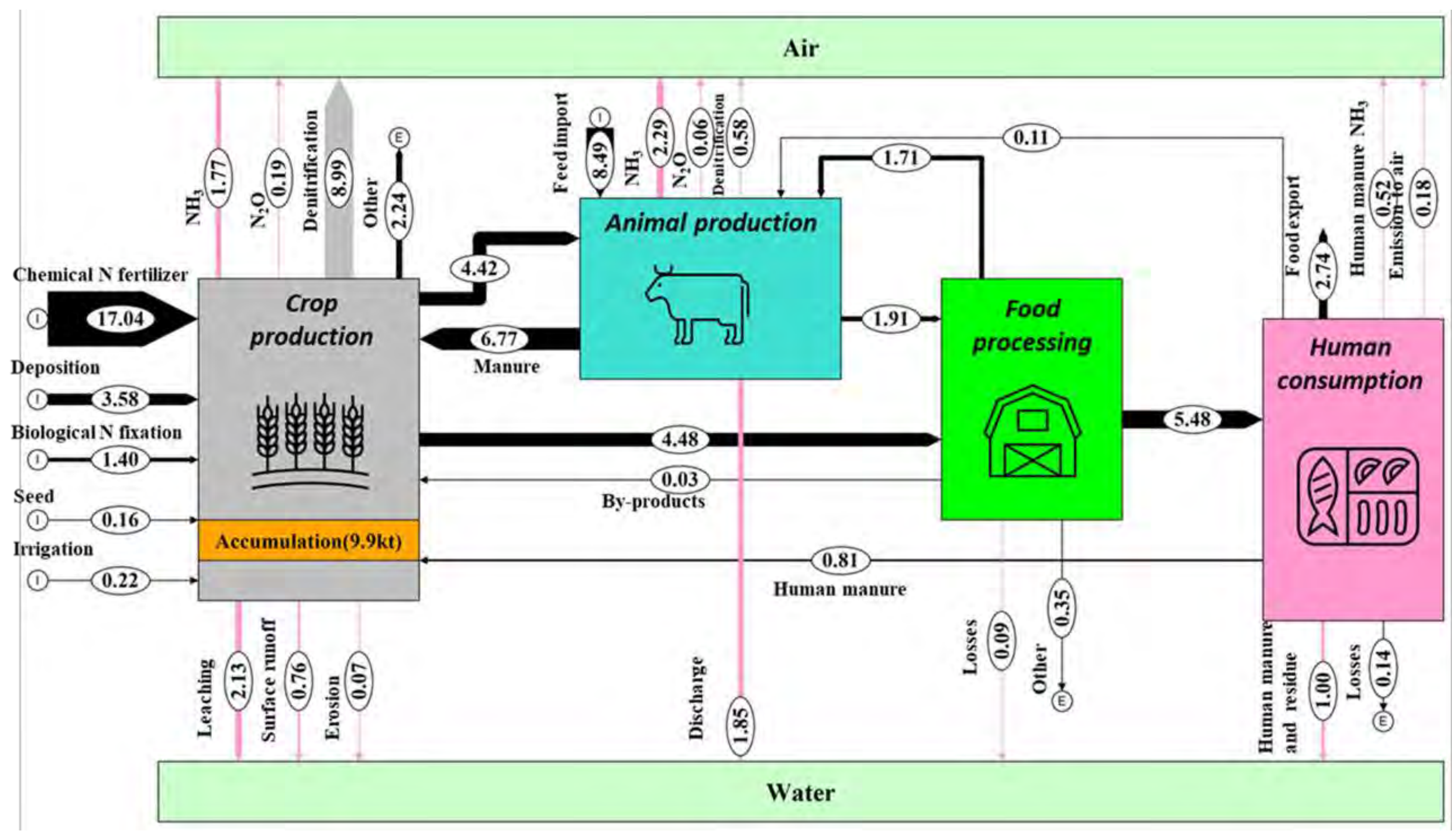

Figure 2. The nitrogen flow in food production in Quzhou county in 2017.(Unit:kt)(Meng et al.,2022)

N emission targets to meet air and water quality

To meet the environmental targets for air quality($PM_{2.5}$) and groundwater quality NH_3 emissions and N leaching from the food production need to be reduced by 55% and 21-50%, respectively.

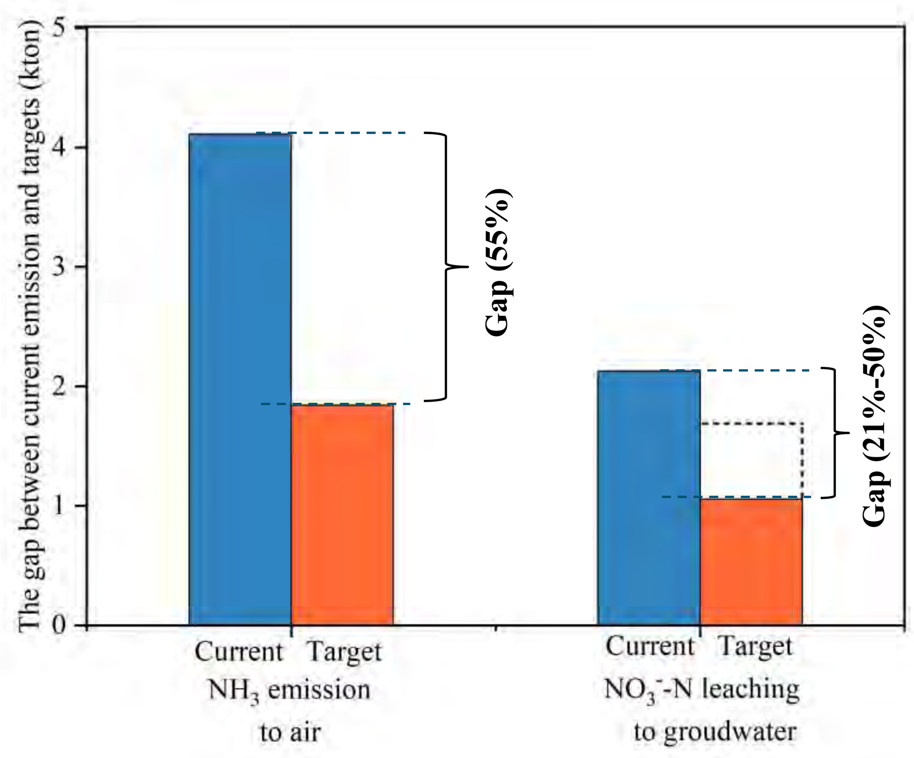

Figure 3. The gap between current N emission and environmental targets in Quzhou in 2017.

Findings

- N losses to the environment from food production were high in Quzhou The main N losses in Quzhou are NH_3 emission, N leaching, and direct discharges of manure.
- NH_3 emissions and N leaching need to be reduced by 55% and 21-50% to meet targets, respectively.

References

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Pesticide screening and health risk assessment of residential dust to rural residents in the North China Plain

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

Background

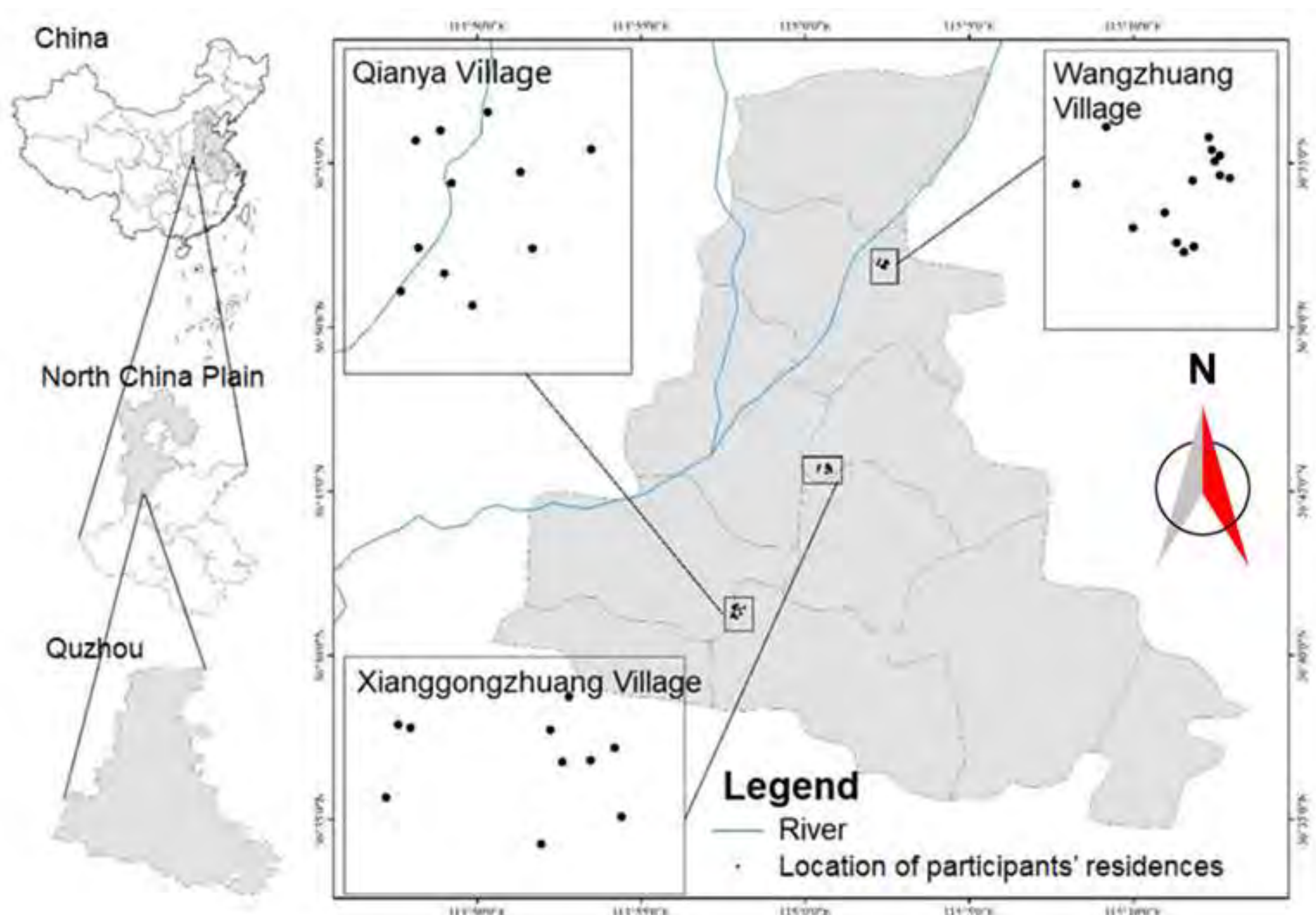
- Pesticides have been intensively applied in the North China Plain (NCP)
- Being exposed to pesticides can lead to multiple negative impacts in physical health including acute poisoning symptoms, chronic body functioning impairments and even cancer
- Pesticides enriched in topsoil can be blown into air and transported into residential area, further enter human body via ingestion and dermal contact

Objectives

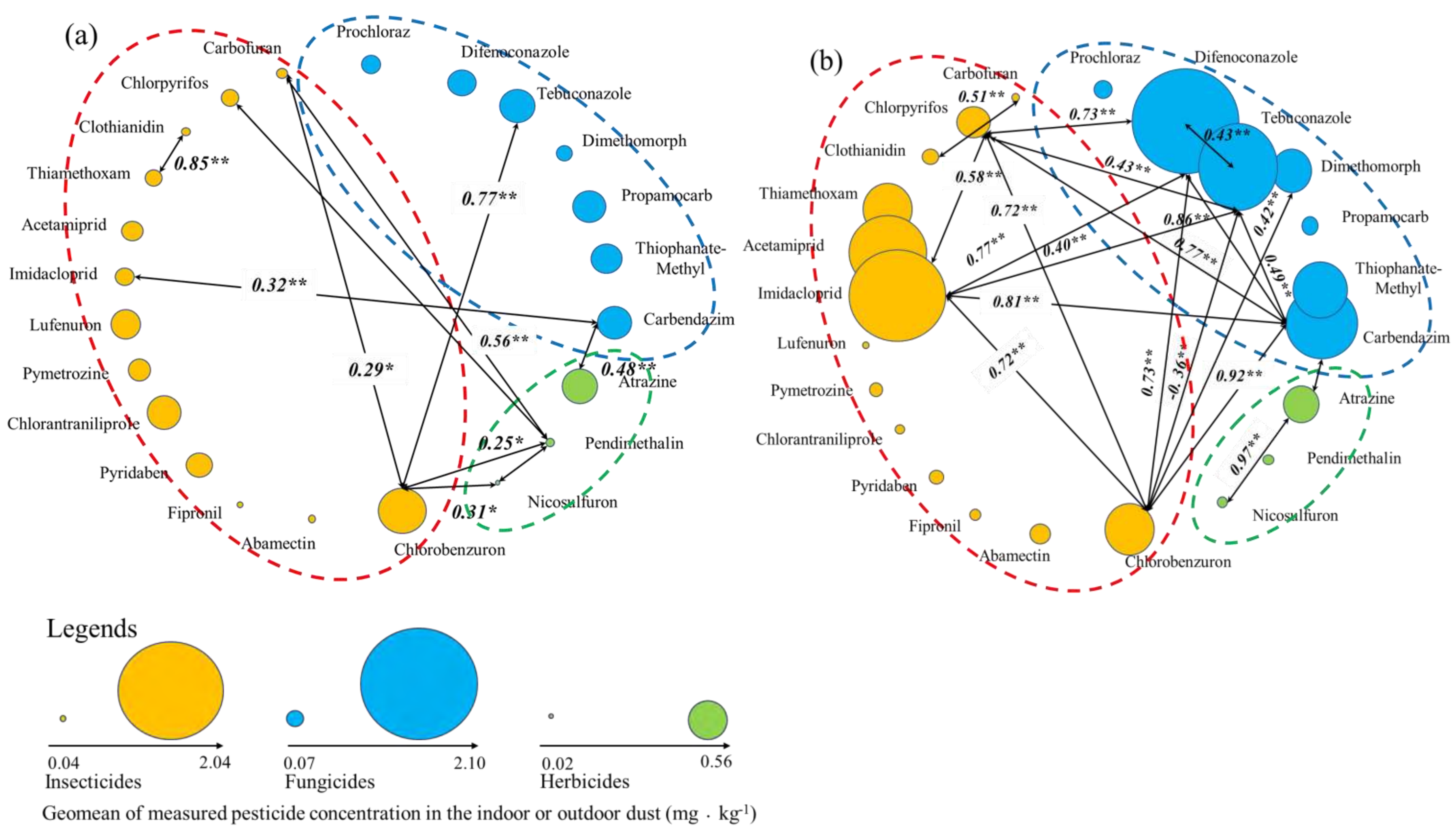
- Monitor the accumulation levels of pesticides in the residential dust (indoor and outdoor dust) during summer peak seasons for pesticide application
- Assess the chronic health risks of pesticides in the indoor and outdoor dust to rural residents
- Identify possible determinants of personal pesticide exposure

Methods

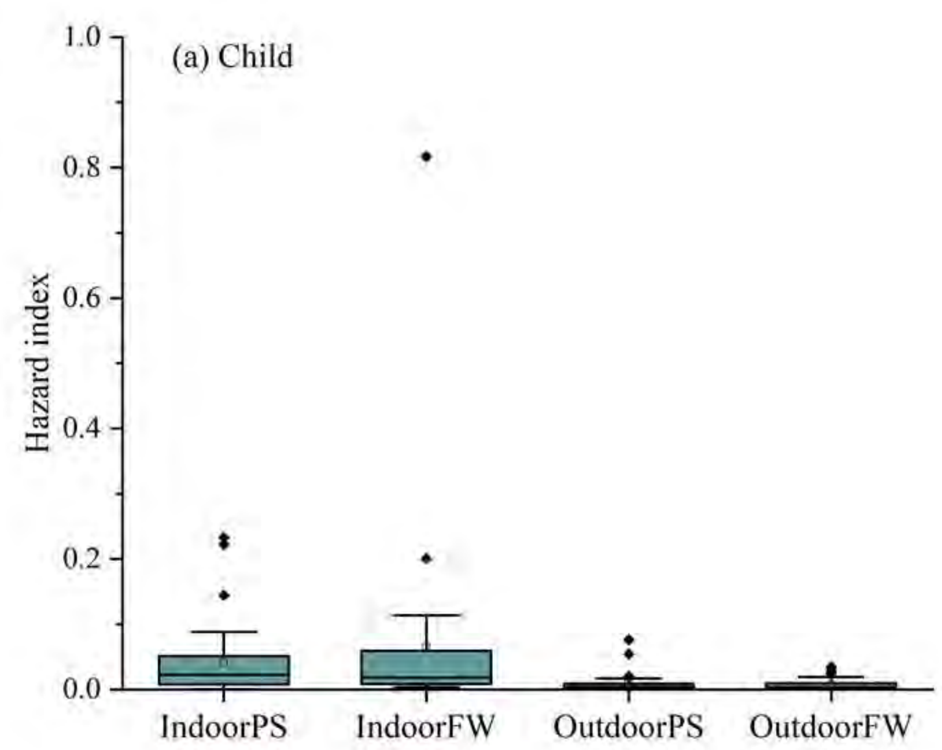
- Recruit farmers and bystanders in the villages in Quzhou county, NCP
- Using vacuum cleaner to collect indoor and outdoor dust samples
- Questionnaires were used to interview participants regarding their lifestyle and personal pesticide handling and management habits



Results



Network graph of pesticides in the outdoor (a) and indoor dust (b)



Health risks of pesticides in the residential dust to residents

- Multiple residues were detected in all dust samples
- Pesticides were found to be concentrated in the indoor dust with higher exposure risks
- The health risks to child should be aware due to the calculated hazard indices
- Pesticide preparation in homes is significantly correlated with their exposure levels

Conclusions

- The health risks posed by the daily contact with pesticide-contaminated dust to child should be aware
- Farmers should prepare pesticides in open fields to reduce the exposure risks in the indoor environment

Acknowledgements

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

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Towards circular nitrogen use in the agri-food system at village and county level

Authors: Zhibiao Wei, Minghao Zhuang, Petra Hellegers, Zhenling Cui, Ellis Hoffland

Background

Increased nitrogen (N) losses from linear agri-food systems cause severe environmental issues. These problems can be mitigated by circular N use. Yet, circularity is a scale-specific problem. To promote circularity, an area needs to be sufficiently small to capture the local circumstances, enable transport and facilitate N exchange, but also large enough to include all compartments of the agri-food system. The feasibility of options towards N circularity at different scales is unclear.

Objectives

- To evaluate N circularity of a complete agri-food system.
- To assess potential and feasible options towards circular N use bridging the gap between village and county scale.

Methods

- As a case study, we used Quzhou County which is a typical county in China. To account for the heterogeneity in N flows in a feasible way, we grouped the 342 villages in Quzhou into four types: (a) cereal villages, (b) cash crop villages, (c) livestock villages and (d) land-limited villages (Figure 1).

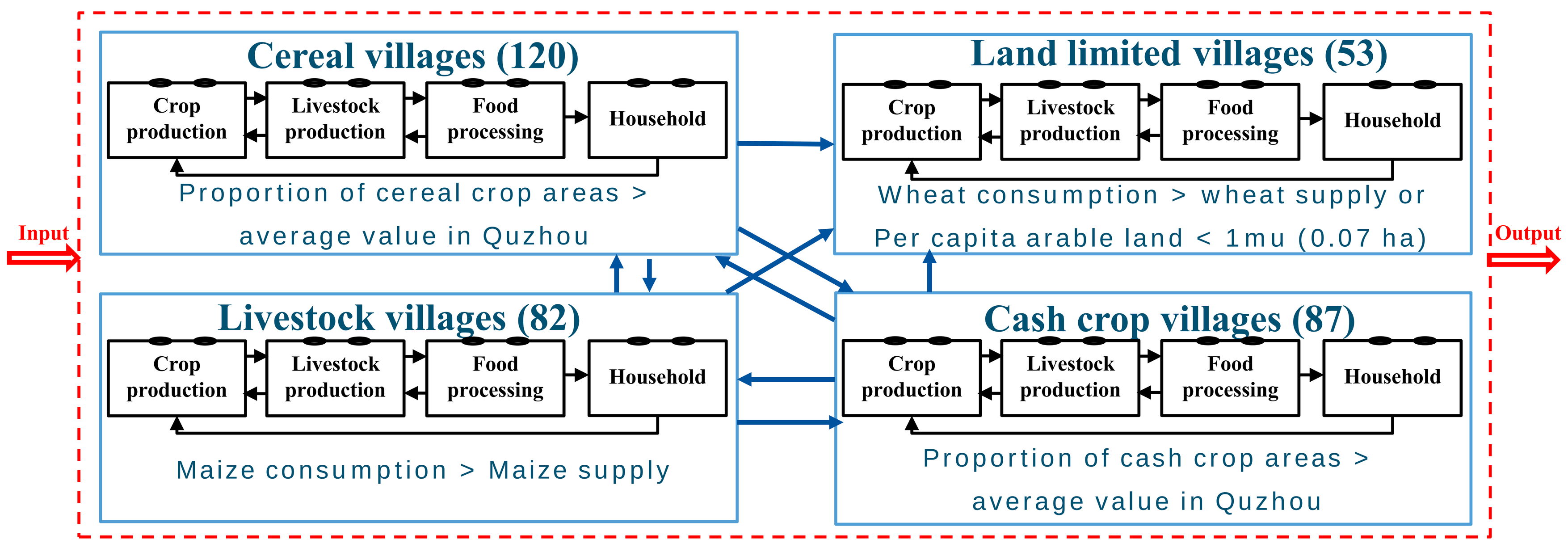

Figure 1. The system

- The N flows were analyzed with the modified NUFER (Nutrient flows in Food chains, Environment and Resources use) model. Village level N flows were firstly quantified and then upscaled to county level.

- Scenario analysis was adopted to explore options to close N cycle
  - S0- Baseline
  - GMP- good management practices for crop production compartment, better feed conversion ratio for livestock feeding compartment, healthy diet for the household compartment
  - GMP+WR1: same as previous, plus improved recycling of waste from crop and livestock production
  - GMP+WR2: same as previous, plus improved recycling of household waste
  - GMP+WR+STL: same as previous, plus switching to legumes
  - GMP+WR+STL+RL: same as previous, plus reducing livestock

- Four key performance indicators (KPIs) in line with principles of circular agriculture are used to evaluate the system performance: N import, N loss, N use efficiency, N recycling rate.

Results

The four KPIs clearly differed between the different village types. Total N import and N loss were almost three times the figure for cereal villages. The NRR in different village systems was inversely related to their N loss. Cereal villages showed the highest NUE of the agri-food system (41%), compared to 32% and 26% in cash crop and livestock villages, and as little as 17% in land-limited villages.

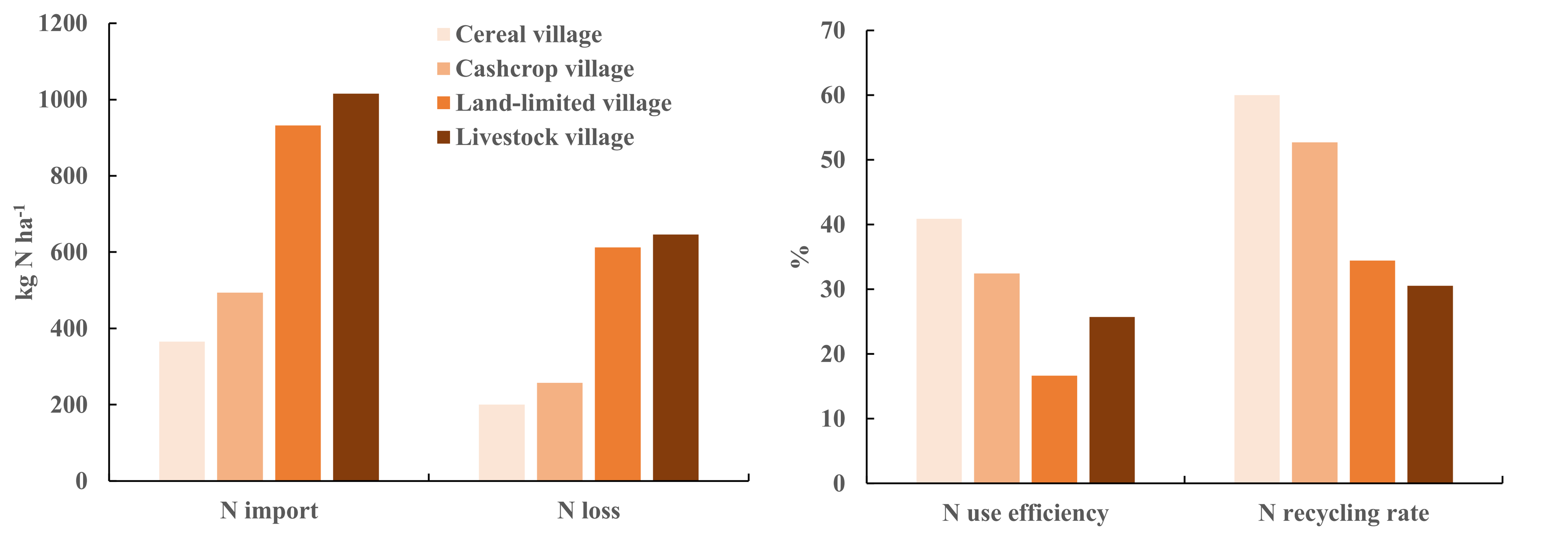

Figure 2. Key performance indicators of the N circularity for different village types in Quzhou

To explore the extent to which agri-food systems can achieve N circularity, we evaluated five scenarios, using the KPIs. Among our scenarios, the most complete package of measures (GMP+WR+STL+RL) roughly doubled the agri-food system's NUE and NRR while reducing N import and N loss by 68% and 77%. GMP allowed the greatest reduction of N import and N loss.

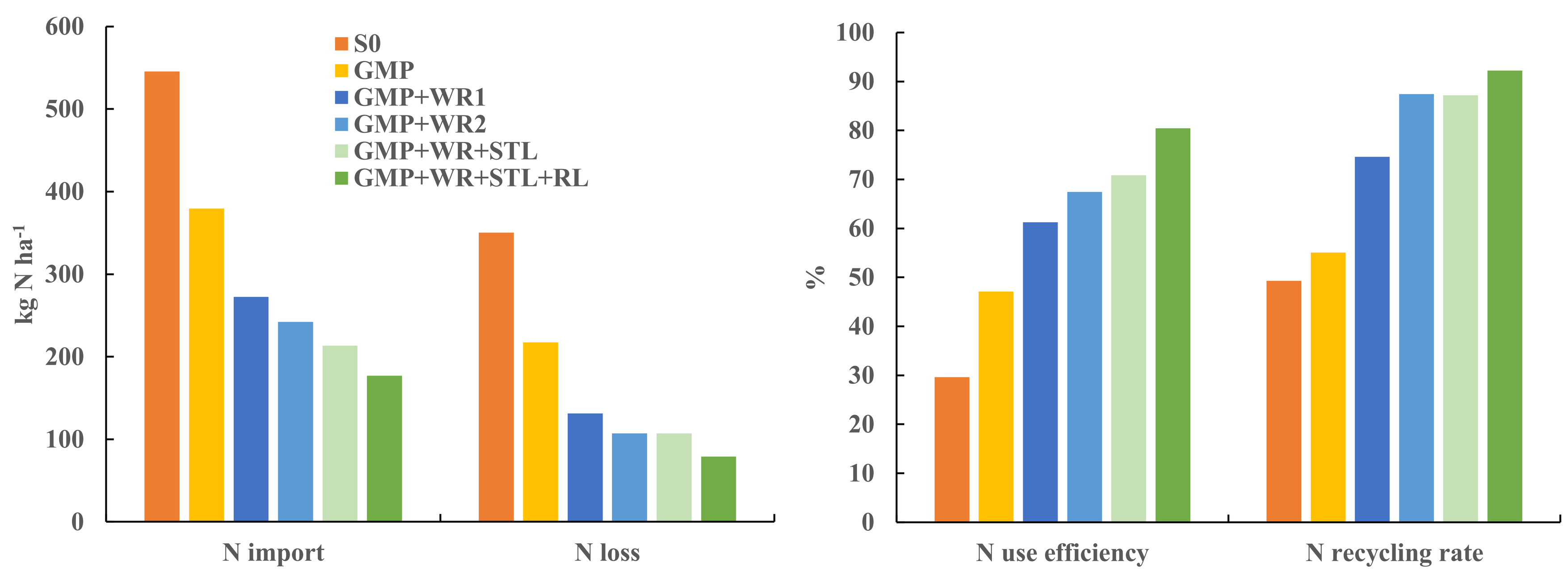

Figure 3. Key performance indicators of N circularity in Quzhou under different scenarios

Conclusions

- The Quzhou agri-food system is far from circular due to the large external inputs and high environmental losses
- The villages rank in circularity performance as follows: cereal village > cash crop village > livestock village > land-limited village.
- Good management practices and recycling of organic waste are effective and feasible measures to move the agri-food system towards N circularity.

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Global assessment of optimal nutrient, crop and soil management practices on nitrogen use efficiency

Luncheng You, Gerard H. Ros, Maddy Young, Yongliang Chen, Qi Shao and Wim de Vries

Background

An increase in nitrogen use efficiency (NUE) is crucial to reconcile food production with acceptable N losses to air and water in view of environmental health. However, a systematic and comprehensive assessment of agricultural management practices on NUE is still missing.

Objectives

In this study, we developed and applied meta-analytical and meta-regression models to predict the impacts of management practices and site conditions on NUE at global scale.

Methods

We first developed a meta-model, predicting the change in NUE in response to agronomic measures and its dependency on site conditions based on 34 global meta-analytical studies. We compared these outcomes to the results of a meta-regression model, based on 2762 paired observations from 466 underlying studies of the 34 aforementioned meta-analytical studies. We finally evaluated the impact of three meta-regression models, and applied the most appropriate model to predict the potential of agronomic management measures and site conditions to improve NUE at global scale.

Results

Impacts of management practices on NUE

Most of the agricultural management practices had positive responses on NUE (Fig. 1). Using meta-analytical data, four out of the twelve management practices showed significant impacts on NUE. When underlying data were used, eight management practices significantly changed NUE.

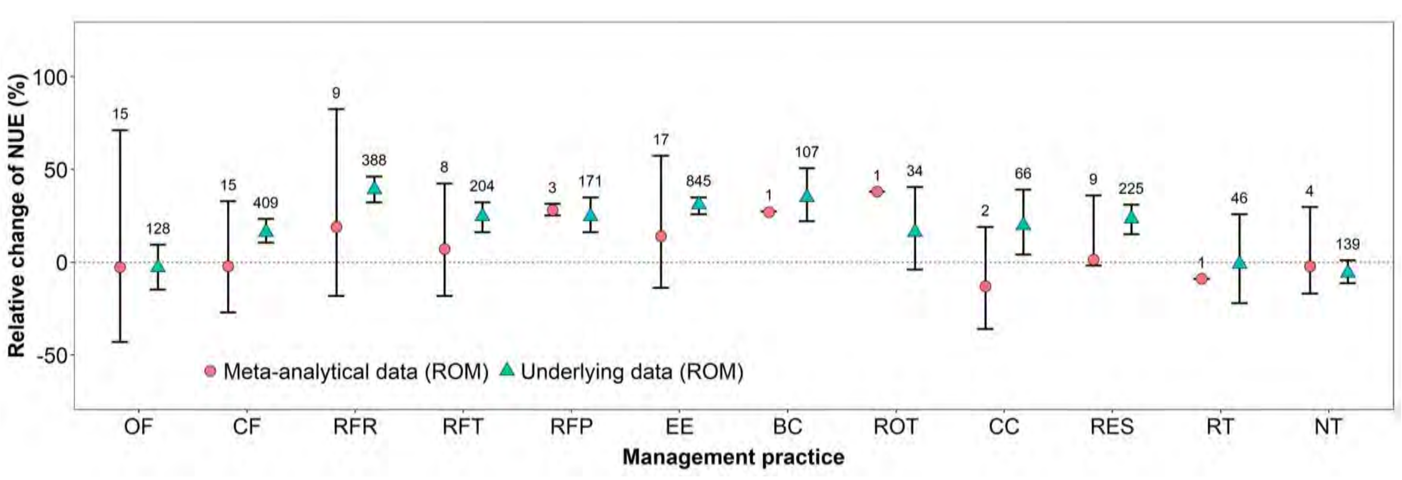

Fig. 1 NUE responses to agricultural management practices based on the meta-analytical data and underlying data of meta-analyses, expressed as the relative change of NUE as compared to a control/treatment situation. Nutrient management includes organic fertilizer (OF), combined fertilizer (CF), right fertilizer rate (RFR), right fertilizer timing (RFT), right fertilizer placement (RFP), enhanced efficiency fertilizer (EE), and biochar (BC). Crop management includes crop rotation (ROT) and cover cropping (CC) and residue retention (RES). Soil management includes reduced tillage (RT) and no tillage (NT).

Impacts of site conditions and management impacts on NUE

The variation in NUE was strongly affected by crop type and it increased with an increase in pH and mean annual precipitation (MAP), while it decreased with increased clay content (Fig. 2).

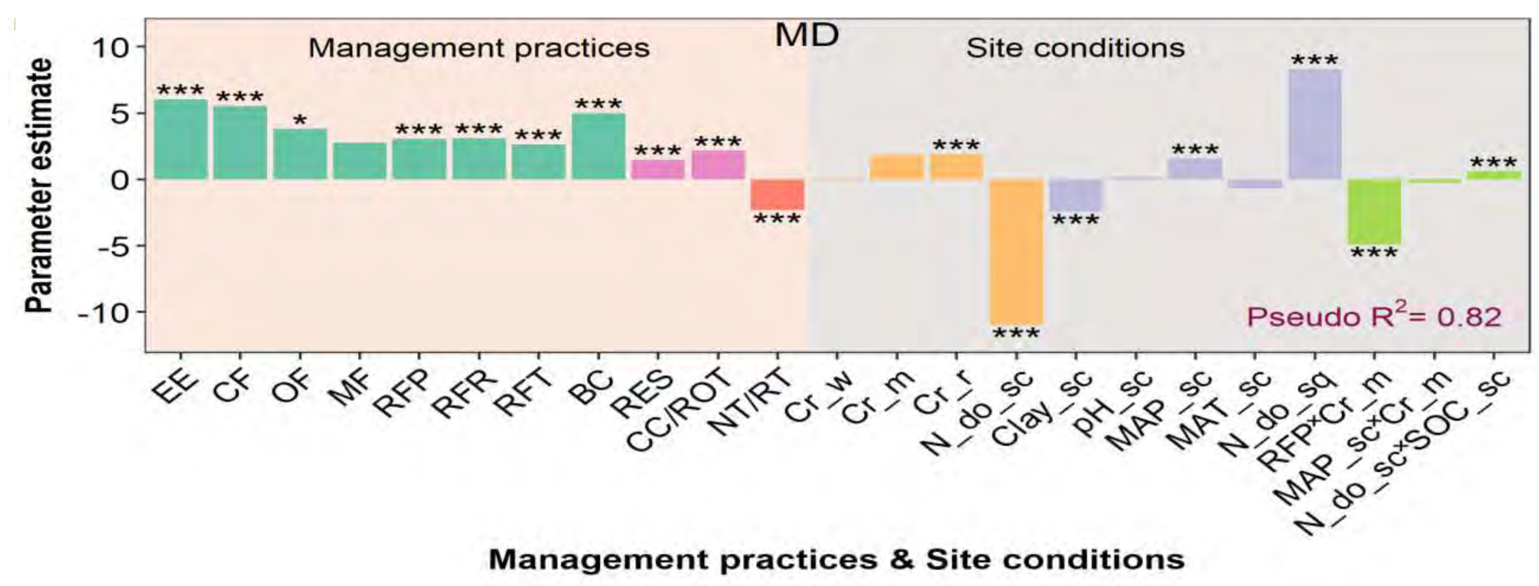

Fig. 2 Parameter estimates for the NUE model.

Global potential of optimal measures to increase NUE

By upscaling the regression model, we predicted that the global absolute mean NUE can increased by 30% by optimal combinations of nutrient management (26%), crop management (4.2%), and soil management (0.6%) (Fig. 3). The predicted increase in NUE was below average in most agriculturally developed regions but was above average in agriculturally developing regions.

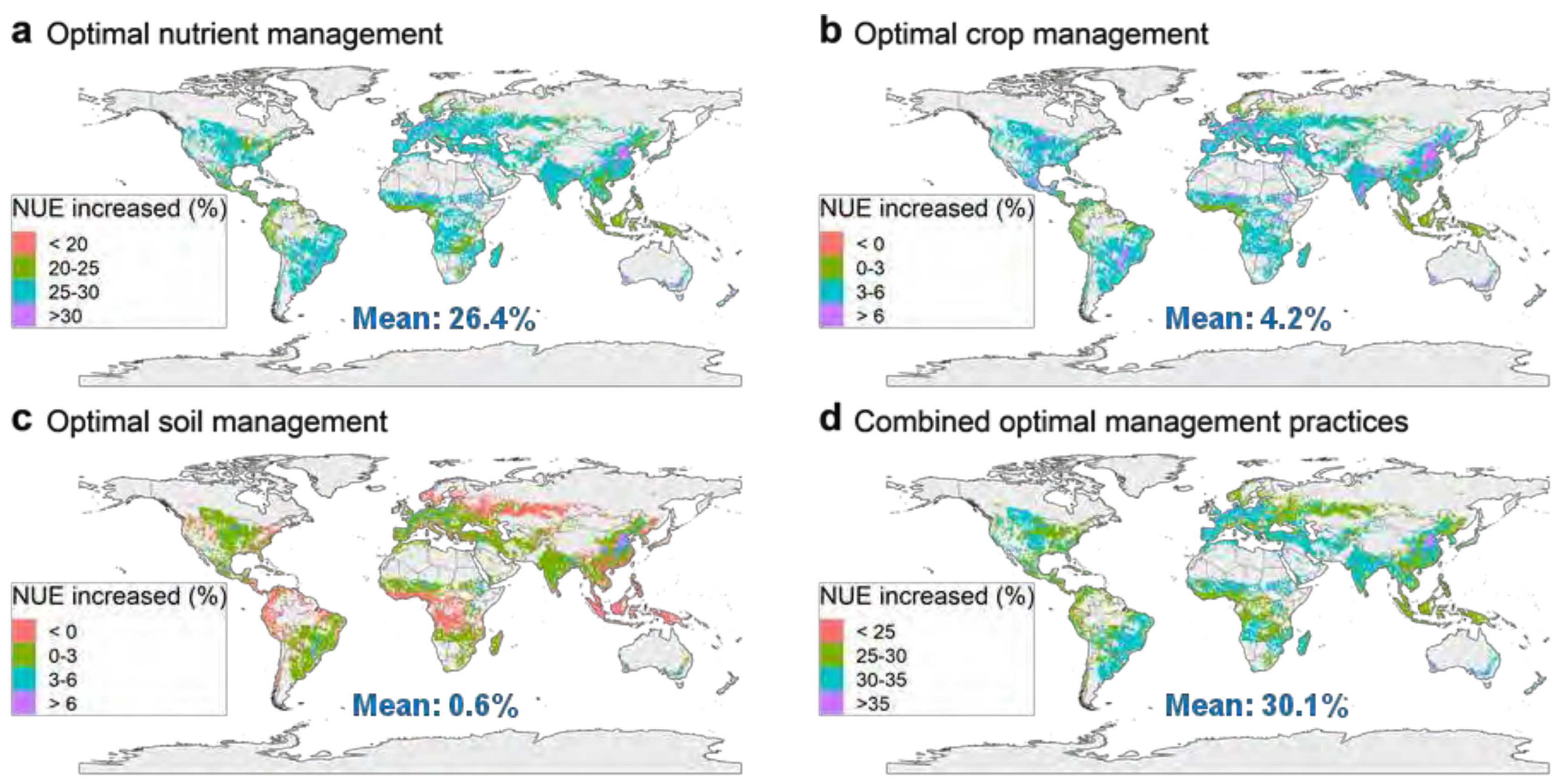

Fig. 3 Upscaled results for the global impacts of management practices on absolute NUE changes (%).

Conclusions

- Individual measures increase NUE by 4 to 10%.
- Upscaling projections showed that optimized management practices could increase crop NUE by 30% on average.
- The effect of all management practices was highly controlled by site conditions.

Acknowledgements

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

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ASSESSMENT OF ANTIBIOTIC POLLUTION IN RIVERS FROM LIVESTOCK PRODUCTION IN CHINA

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Background

- Many water systems in China are polluted with antibiotics.
- Livestock production contributes to antibiotic pollution in rivers.
- Different pathways are for antibiotics entering rivers such as erosion, runoff, and direct discharges of manure.

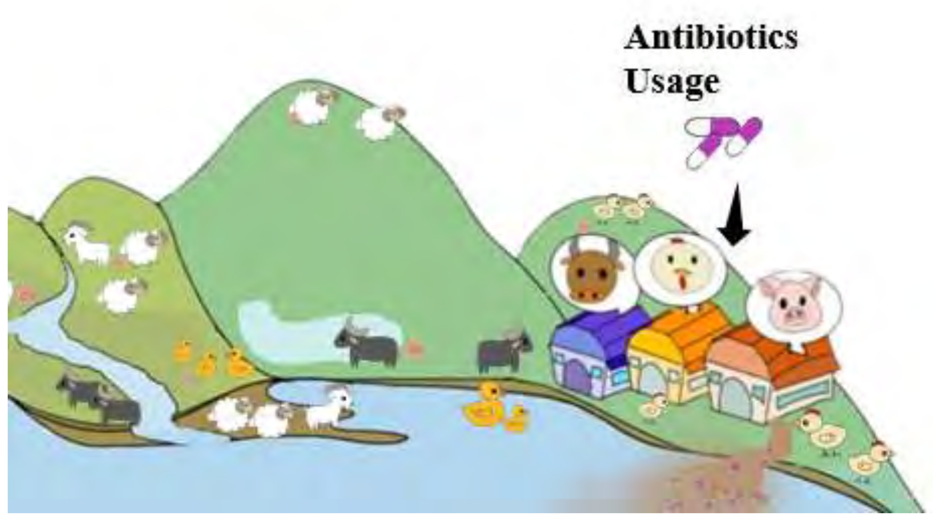

Fig. 1. Antibiotic transport to rivers from livestock production

Objectives

To quantify annual flows of antibiotics to rivers by livestock species and antibiotic types at the sub-basin scale in China using a new version of the MARINA-Antibiotics model (Fig. 2);

Methods

- MARINA-Antibiotics: Model to Assess River Inputs of pollutaNts to seAs
- 395 sub-basins in China
- Annual, 2013

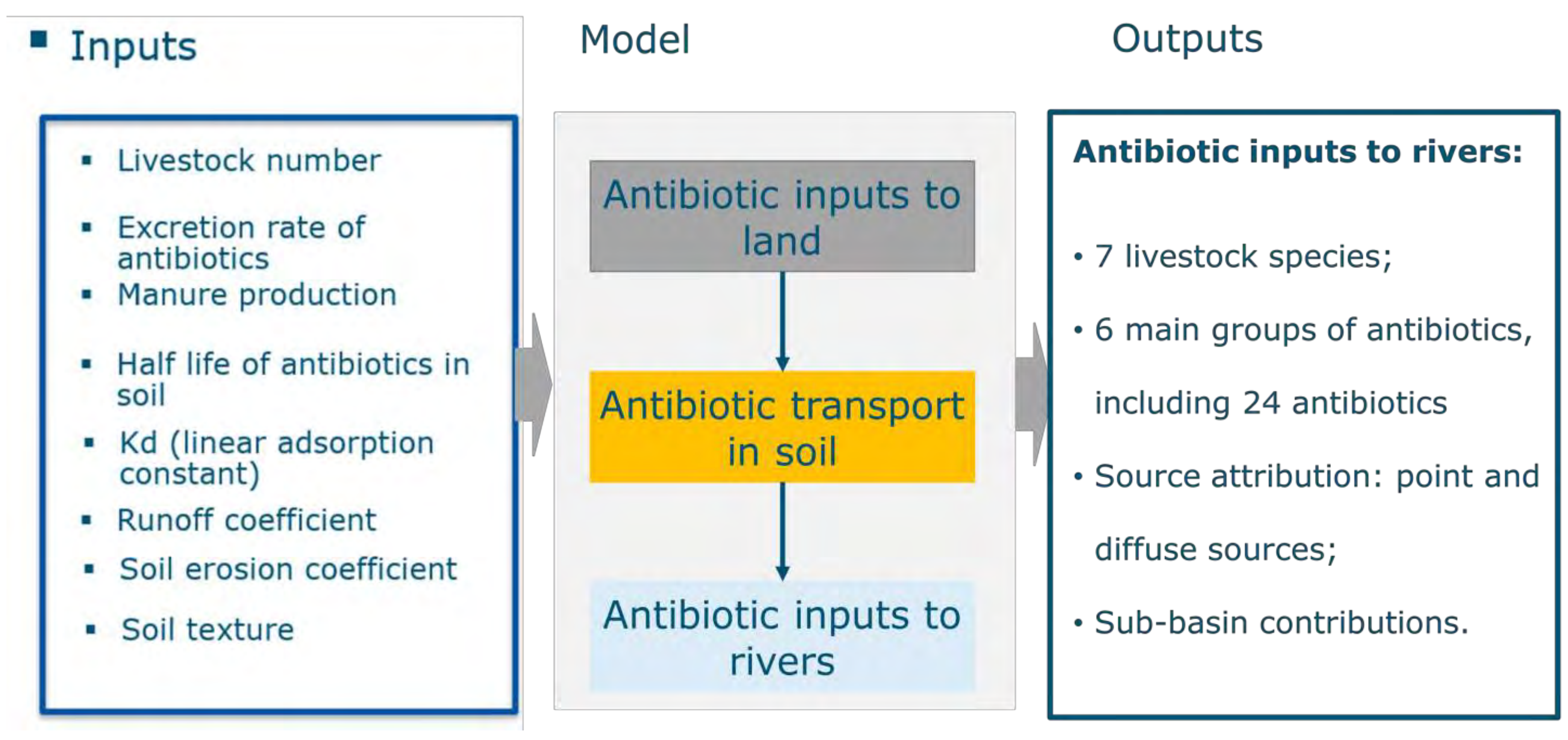

Fig. 2. MARINA-Antibiotics model in China

Results

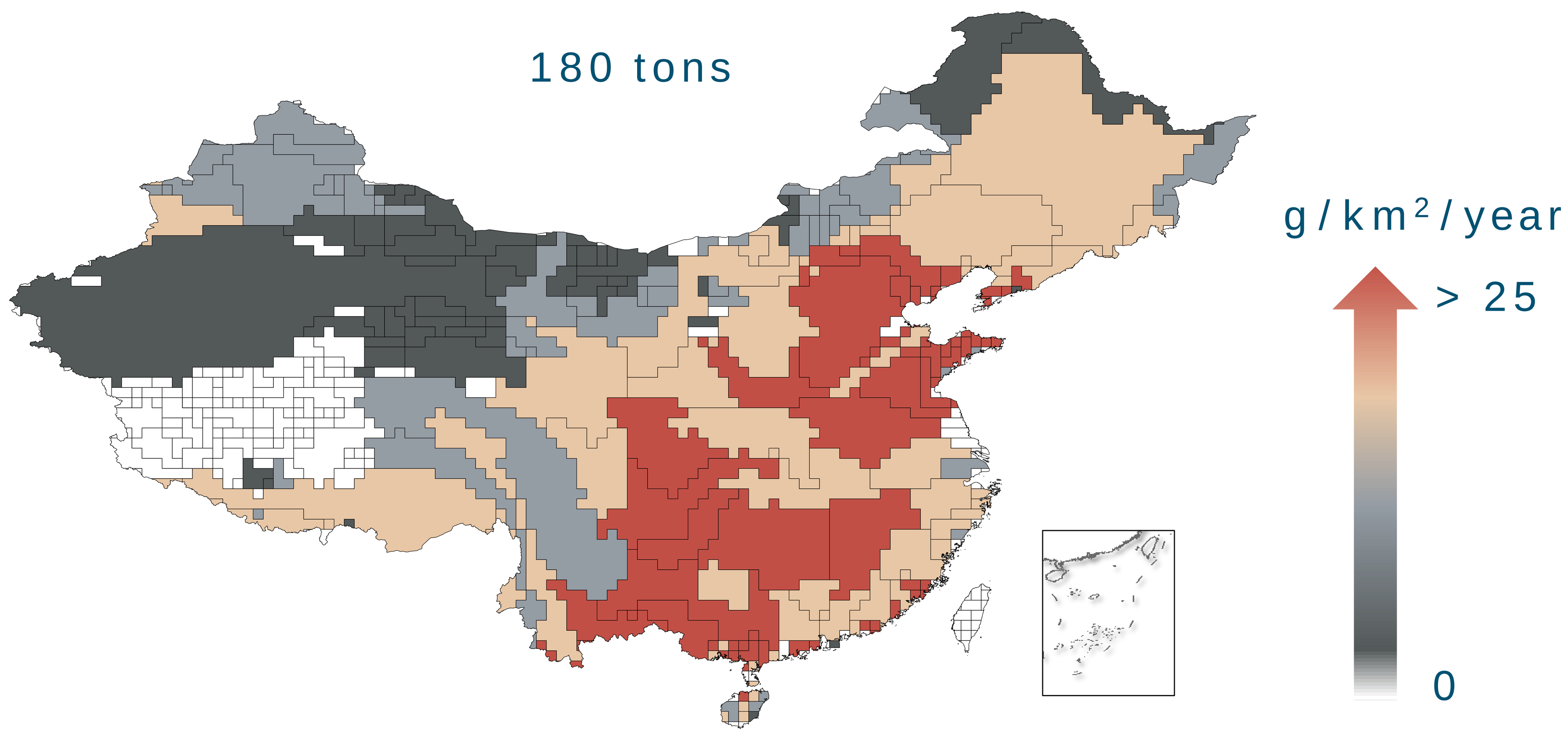

Fig. 3. Antibiotics in rivers from livestock manure as a result of erosion processes in 395 sub-basins for the year 2013 (kg/km²/year)

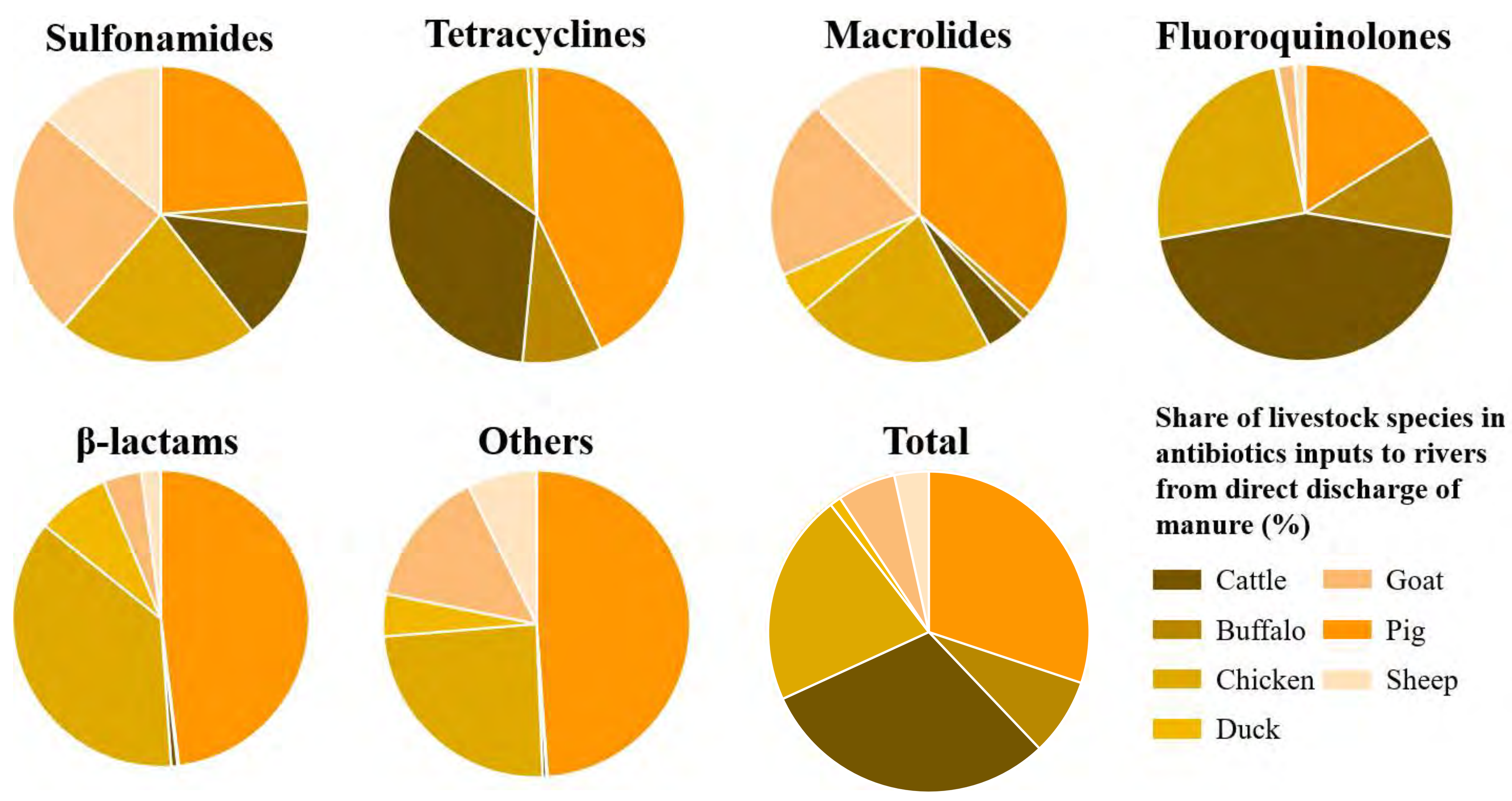

Fig. 4. Shares of individual livestock species in antibiotic inputs to rivers from the direct discharge of manure in China for the year 2013 (%).

Conclusions

- Antibiotics in rivers from the erosion process were around 180 tons for the year 2013.
- Pigs, chickens, and cattle are responsible for over 80% of antibiotics in rivers.
- The shares of livestock production in river pollution from direct discharge differed among antibiotic groups for the year 2013.

Acknowledgements

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Ecosystem services and dis-services in agricultural landscapes of the North China Plain: patterns, trends, and relations

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

- The North China Plain (NCP) is a typical intensive crop production area critical to China's food security, however, the intensive double cropping system (winter wheat- summer maize) resulting ecosystem service decline and also dis-services.
- It is crucial to comprehend and evaluate current **agroecosystem services and dis-services (AES&DS)** as a first step toward integrating ecosystem services into agricultural landscape planning, management, and decision-making (de Groot et al., 2010). Nevertheless, There is little information on the current provisioning levels of AES&DS and their relations with explanatory factors in the NCP.

Objectives

The main objective is to assess farmers' perception regarding the delivery of agroecosystem services and dis-services in a landscape dominated by intensive cropping systems in a county of the NCP. The more specific objectives are:

1) To quantify the perceived supply of these services and the changes therein during the last five years to anchor the key issues.
2) To identify the relation between explanatory factors and multiple agroecosystems (dis)services.
3) To compare the difference of agroecosystem (dis)services in different village types

Methods

Case study area

The surface area of Quzhou is 676.68 km2, which includes 525.23 km^2 of cropland (NBSC, 2017). The landscapes in Quzhou County are mainly homogenous agricultural landscapes for arable cropping with little area of non-crop habitat. Winter wheat, summer maize and cotton are the main crops. The forest cover area in Quzhou county is 86.67 km^2, which is mainly composed of linear windbreaks.

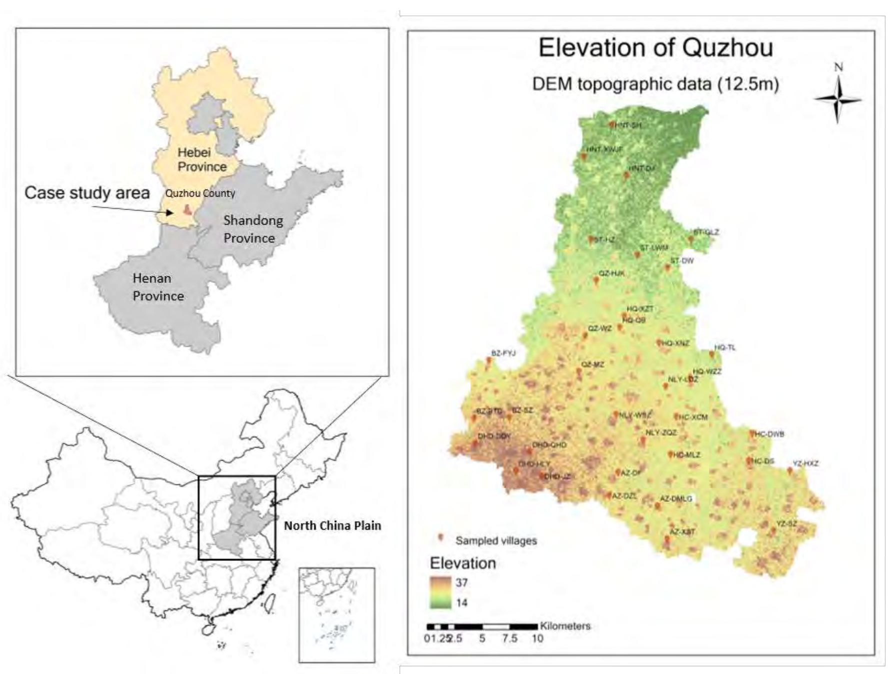
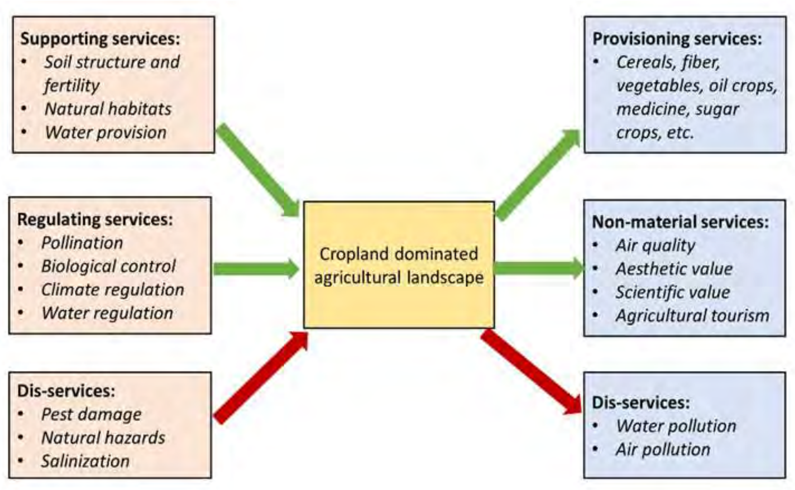


Figure 1. The location of the North China Plain and Quzhou county (left) and of sampled villages within Quzhou County (right)



Framework and indicators

The framework (Figure 2) and a literature review were used to create a list of proxy indicators for relevant AES&DS and to thereafter formulate a questionnaire to assess perceptions of the state of AES&DS in 2020 and the perceived trend of change in the period between 2015 and 2020. .

Figure 2. The main interrelations between agroecosystem services and dis-services (AES&DS) and crop production in the agricultural landscape of Quzhou county. AES&DS in orange boxes affect the agricultural landscape, while services and dis-services in blue boxes are affected by agriculture. The green arrows indicate services, whereas the red arrows indicate disservices.

Sampling and survey

- Quzhou has 7 village types according to the results of village typology (Xu et al., in prep).
- Five villages were randomly sampled from each village type, resulting in 35 selected villages in total.
- In each village, we selected five smallholder farmers, two leader farmers and the village head to participate in the survey.
- In total, 267 farmers were interviewed by structured questionnaire with Likert Scale.

Relations between village characteristics and agroecosystem (dis)services

- The explanatory variables representing village characteristics were selected.
- A Monte Carlo permutation test (1000 permutations) was performed to determine the significance of the associations between village characteristics and (dis)services.
- The RDA analysis was used to determine the relations between village characteristics and agroecosystem (dis)services.

Difference of agroecosystem (dis)services among village types

Kruskal–Wallis analysis and Dunn's Test for the pairwise comparison.

Results

Farmers' perception of current AES&DSs conditions and trends from 2015 to 2020

- The inadequate amount or the declining tendency of regulating services and supporting services, e.g., natural enemies, earthworms and ground water (Figure 3).
- The dis-services generated from agricultural production were observed by only 14-22% of the farmers (Figure 4).

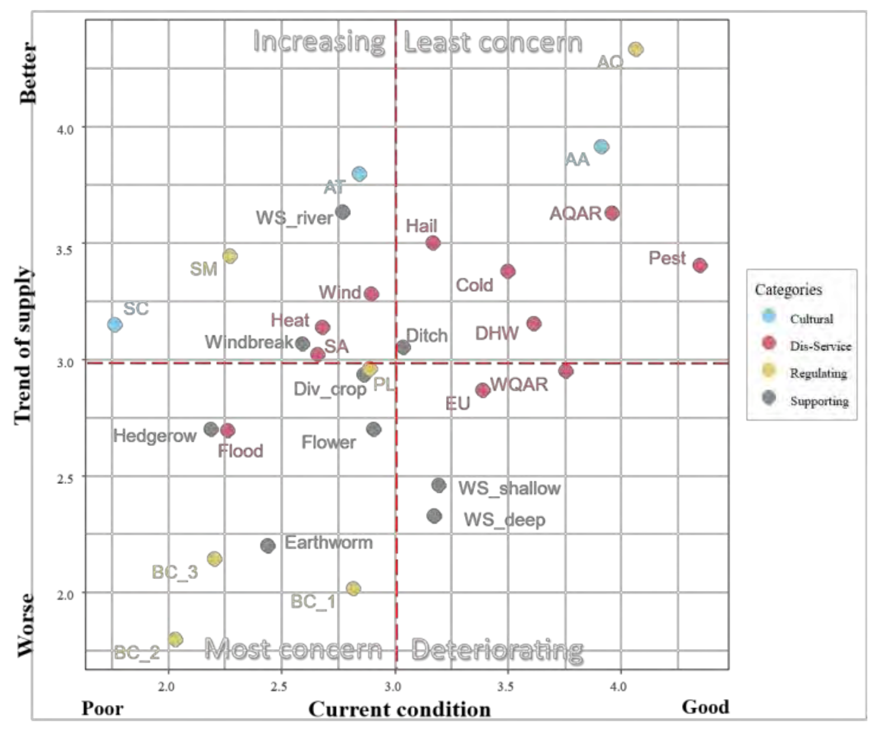


Figure 3. Summary of farmers' perception of current AES&DSs conditions and trends (from 2015-2020)

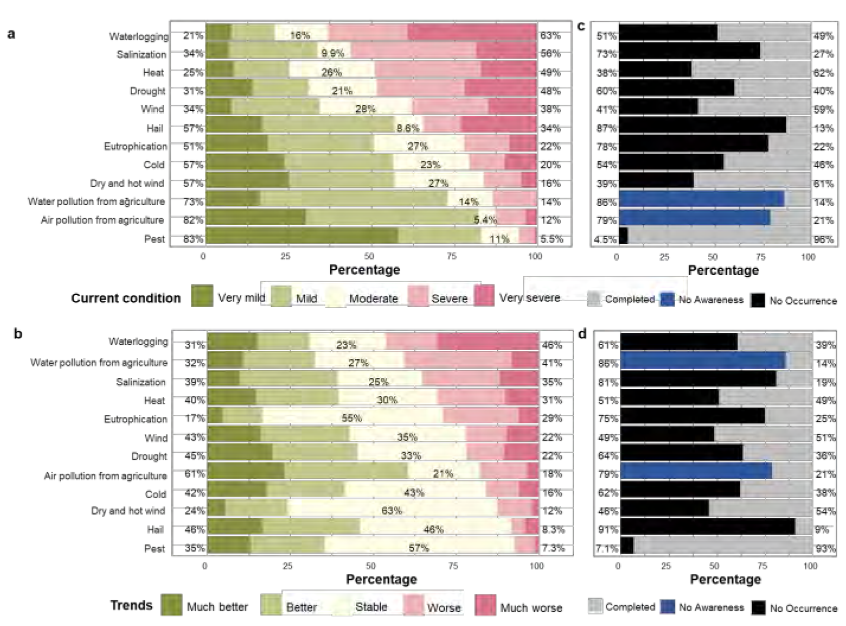


Figure 4. Perceived damage level in 2020 (a) and changes in the damage between 2015 and 2020 (b) of ecosystem disservices. Panels (c) and (d) present the number of respondents providing a scoring. "No awareness" means that the disservices are not easily visible, and the farmers may not be aware of them. "No occurrence" means that the disservices can be noticed but the farmers did not perceive the occurrence of those

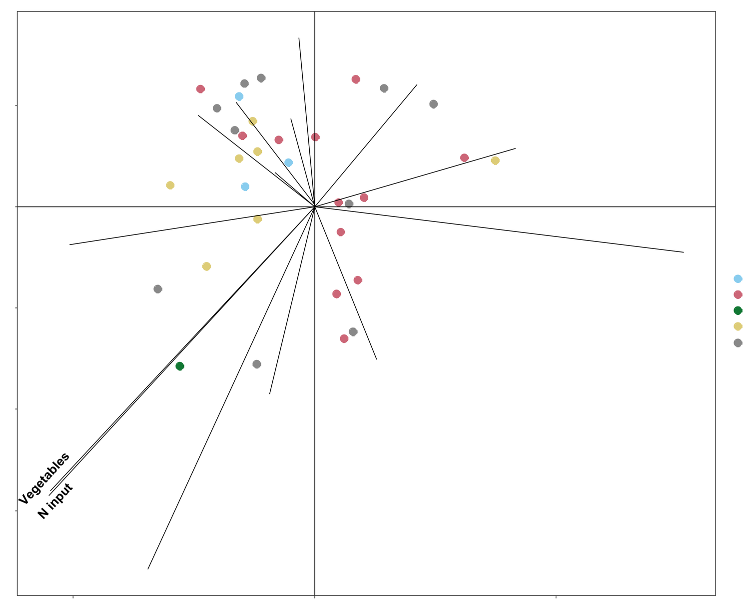


Figure 5. Redundancy analysis plot. The plot shows the relationships between respondents' perceptions of supply of AES&DSs and variables related to the characteristics of villages as explanatory factors.

The relations between AES&DSs supply and explanatory factors (Figure 5)

- The crop area ratio (Vegetables, Fiber, Sugar Crop, Fruit tree) and distance to the city center (Distance_center) have main impact driving the variation of AES&DSs supply.
- The area ratio of vegetables (Vegetables) had a positive relation with some of the provisioning services, supporting and regulating services (Revenues, Earthworms, Pollination, etc.). These features were negatively correlated with the area ratio of fibers (Fibers).

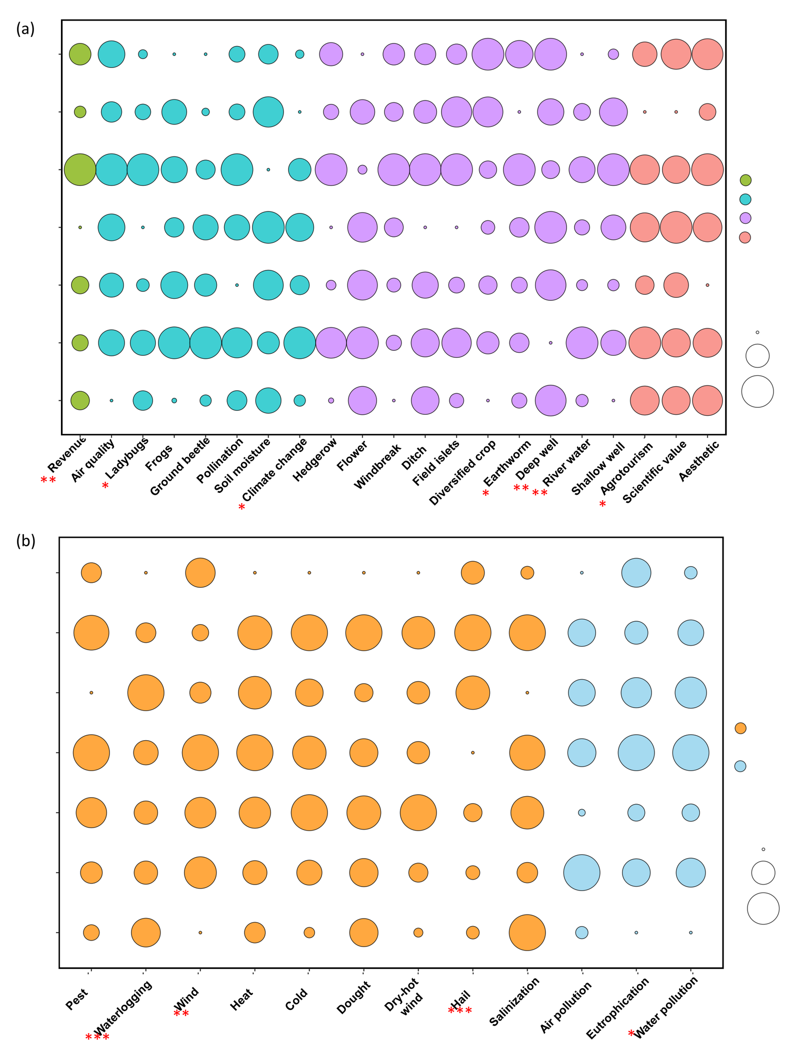


Figure 6. Differences in ecosystem services (a) and disservices (b) among village types.

Difference of AES&DSs supply among village types (Figure 6)

The vegetables-dominated villages (Village type 4) had generally better performance in provisioning, regulating, and supporting services. The fiber-dominated type (Village type 6), however, had relatively lower service deliveries but higher dis-services damages.

Conclusions

- In the case study area, the inadequate amount or the declining tendency of natural enemies, earthworms and groundwater-related ecosystem services were commonly perceived by farmers. However, the dis-services generated from agricultural production were observed by only 14-22% of the farmers.
- The land use composition and the location advantages mainly shape the difference of AES&DS in different villages, and the AES&DS are different among village types.
- This study provides a scientific basis for decision-makers to tailor the agricultural landscape planning and corresponding measures to enhance the ecosystem services according to village-specific socioecological conditions, suggesting incorporating stakeholders' perceptions during the decision-making phase.

Acknowledgements

We gratefully acknowledge the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University, and the contribution of Fan Li, Zhan Xu, Zhengyuan Liang on this research.

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Designing alternative crop rotations to advance agricultural sustainability in the North China Plain

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

Background

- Intensified wheat-maize system dominates farmland in the North China Plain, which contributes to food security but causes low farming income, and tremendous resource and environmental costs.
- Well-planned crop rotations have a great potential to improve cropping sustainability performance from the socio-economic, human-nutrition, and eco-environmental perspectives.
- Crop rotation generator model is a systematic and objective approch to designing promising alternative rotations in an explicit manner.

Objectives

- To generate all possible crop rotations with major crops in Quzhou and *ex-ante* evaluate their sustainability performance;
- To select and characterize rotations with acceptable compromises across multiple sustainability objectives from all possible rotations.

Methods

- ROTAT model-based crop rotation design based on 10 local major crop species and expert-defined agronomic rules, in terms of 11 indicators relevant to local sustainability challenges.

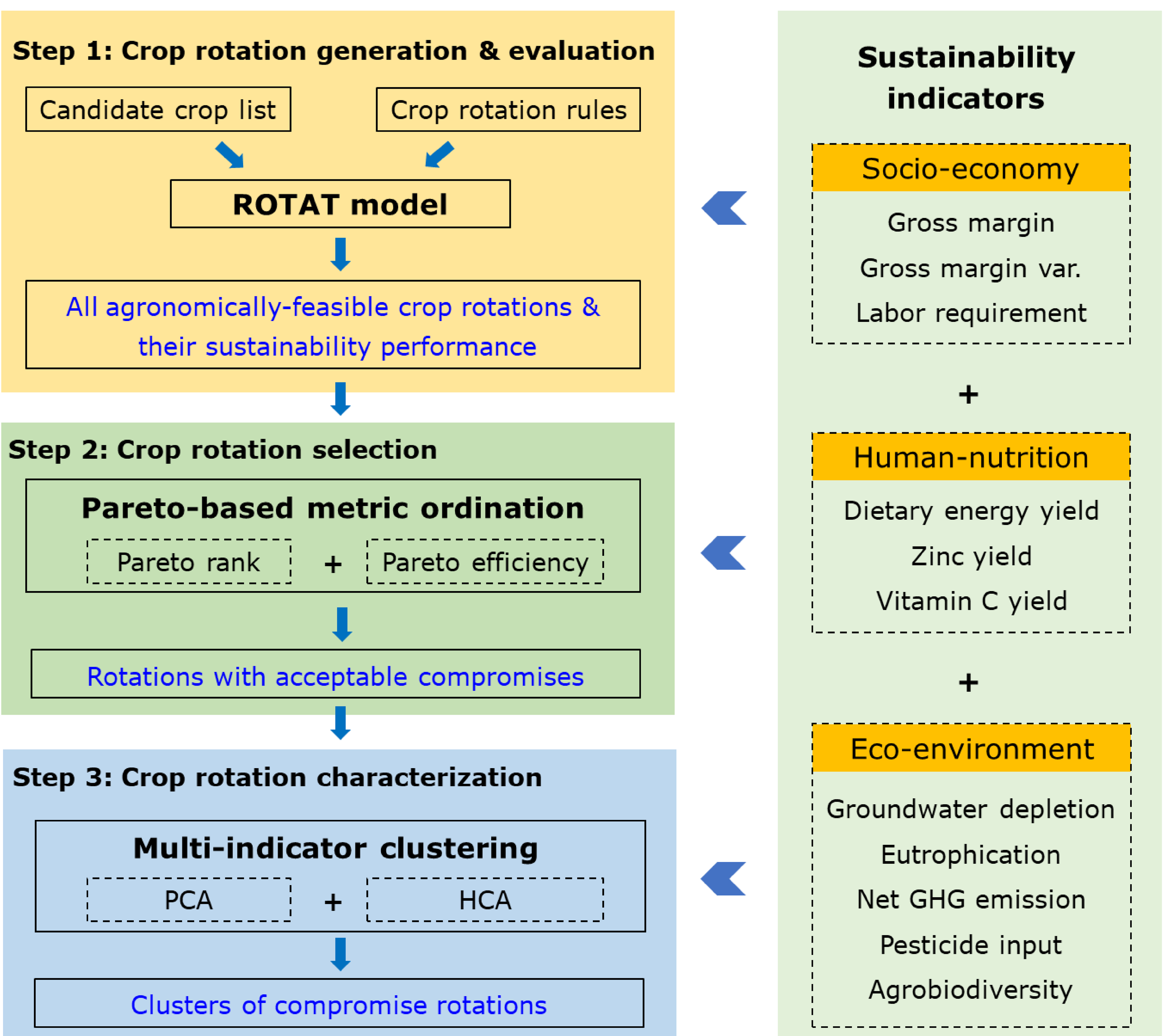

Fig.1 Stepwise approach to designing alternative rotations with acceptable compromises across multiple sustainability domains for Quzhou.

Results

- ROTAT generated 3,011 possible rotations but none of them outperformed the wheat-maize in all indicators.
- 188 rotations were identified as "compromise rotations", since their Pareto efficiency (6-9) is not higher than the wheat-maize's (9).
- Compromise rotations did not include Pareto-optimal ones that extremely underperformed in terms of most of indicators.

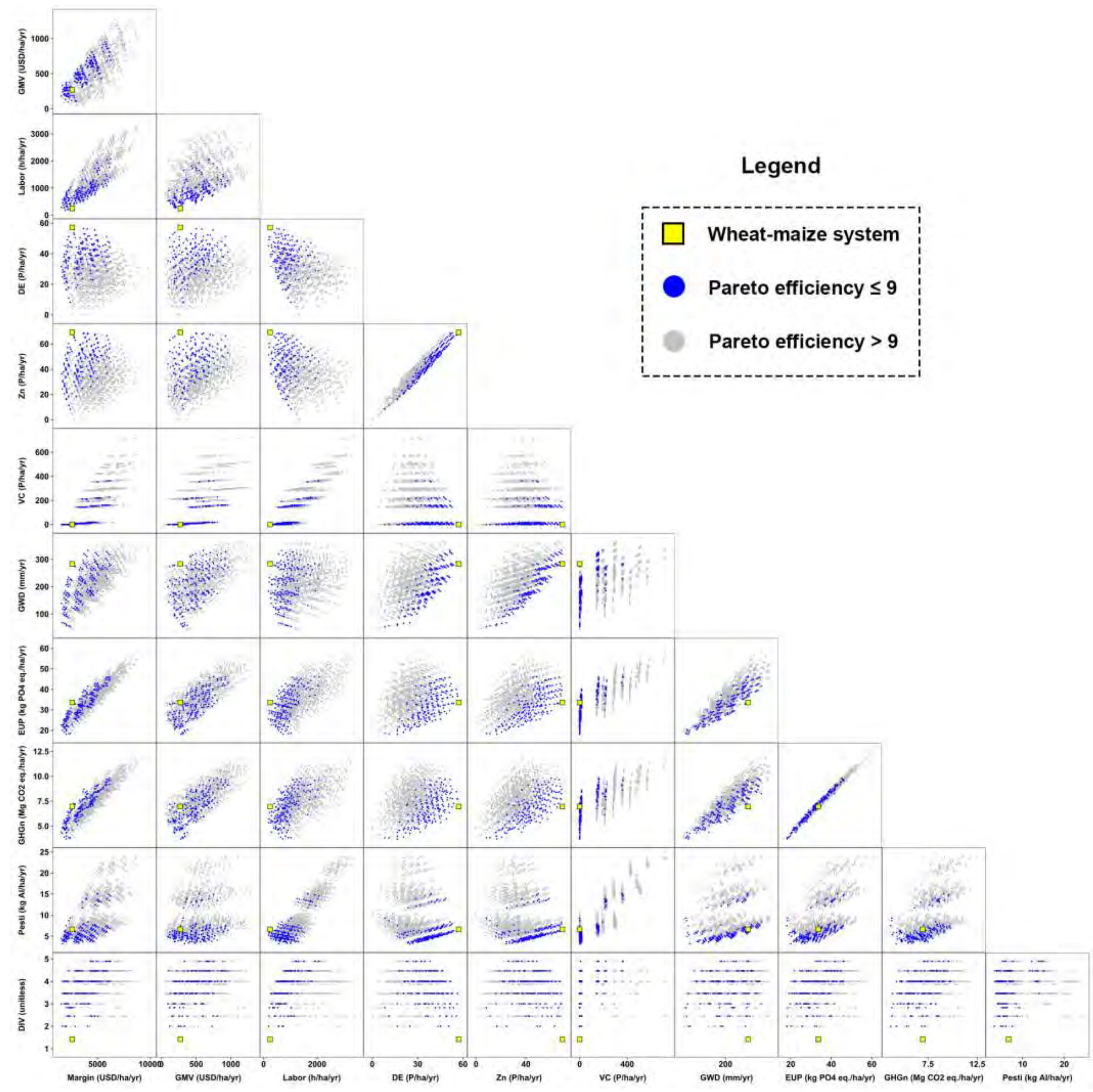

Fig.2 Indicator biplot matrix of Pareto-optimal rotations grouped into two efficiency set.

- Compromise rotations can be sorted into nine clusters representing contrasting sustainability profiles: profitability-oriented (C1&C2); nutrition-oriented (C3&C4), environment-oriented (C5&C6), and balanced clusters (C7-C9).

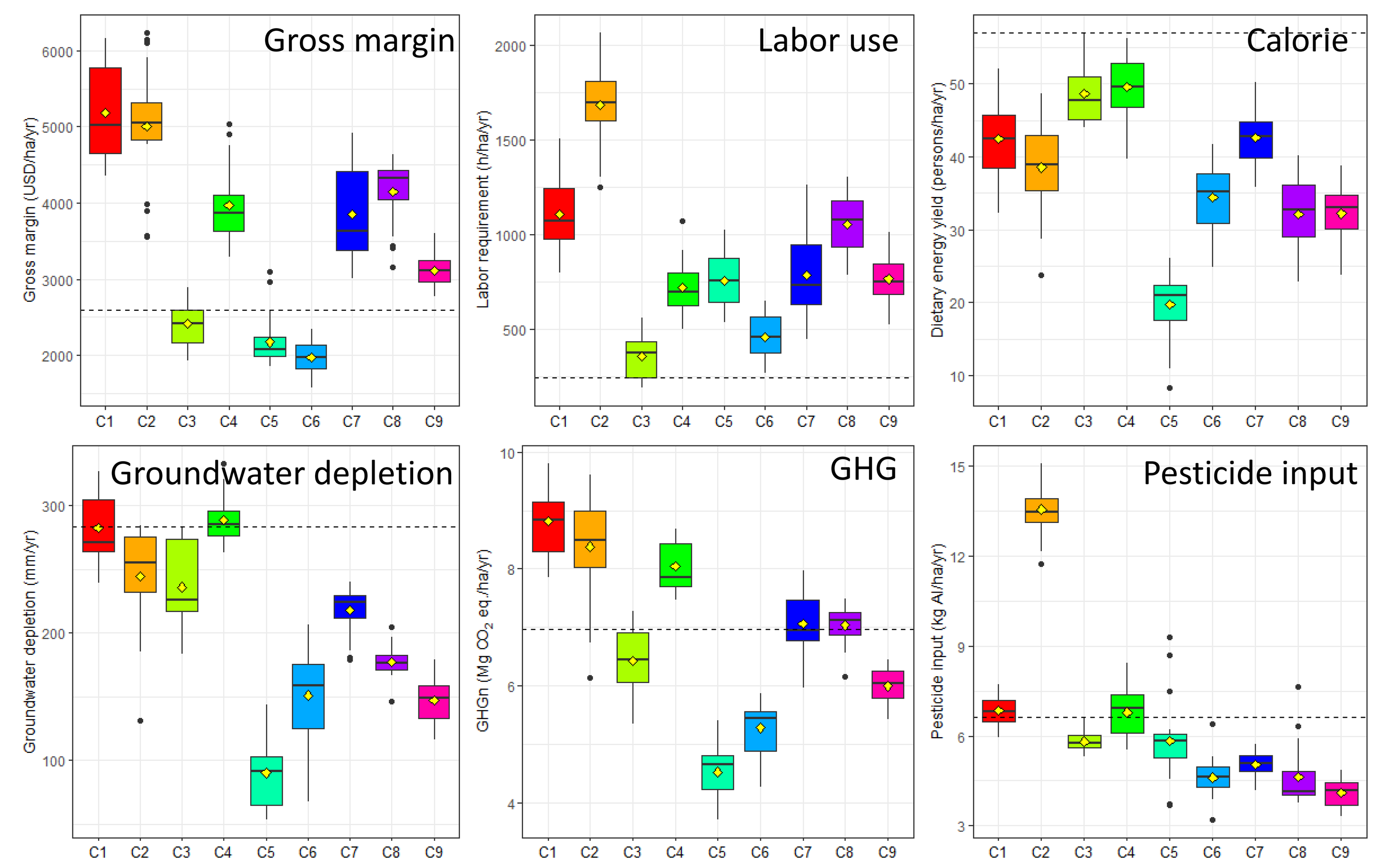

Fig.3 Sustainability performance of nine clusters of compromise rotations for Quzhou.

Conclusions

- Not any single rotation could completely replace the wheat-maize;
- Compromise rotations could not only manage trade-offs among sustainability domains in an acceptable degree, but also meet diverse sustainability demands from stakeholders, which can complement with the wheat-maize in future agricultural landscapes.

Acknowledgements

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Global and regional distribution of soil-borne fungal pathogens: effects of host availability and environmental drivers

Mengshuai Liu, Liesje Mommer, Jasper van Ruijven, 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 North China Plain (NCP), apart from a few well-known pathogens, little is known about the regional distribution of soil-borne fungal pathogens that could potentially reduce the yields of the main crops (i.e. wheat, maize and soybean). Moreover, to what extent distributions of these soil-borne fungal pathogen species are driven by climatic factors, spatial correlations and/or crop species is unclear.

Objectives

In this study, we aim to 1) identify the major soil-borne fungal pathogens that could potentially affect the main crops produced in NCP (i.e. wheat, maize, and soybean); 2) evaluate the occurrence of these pathogens in NCP as compared to their distribution at increasingly larger scales (i.e. within China and globally); and 3) identify the main biogeographic drivers of their occurrence, with an emphasis on the effect of that the availability (local intensity in their production) of the specific host crop species.

Methods

Here, by combining searches in the public databases, we identified a set of main soil-borne fungal pathogen species potentially affecting crop production in NCP based on their specificity toward the main crops produced there, then, we assessed their global distribution, and further determined the contributions of climatic, spatial and host availability conditions to the global level of their prevalence (Fig. 1).

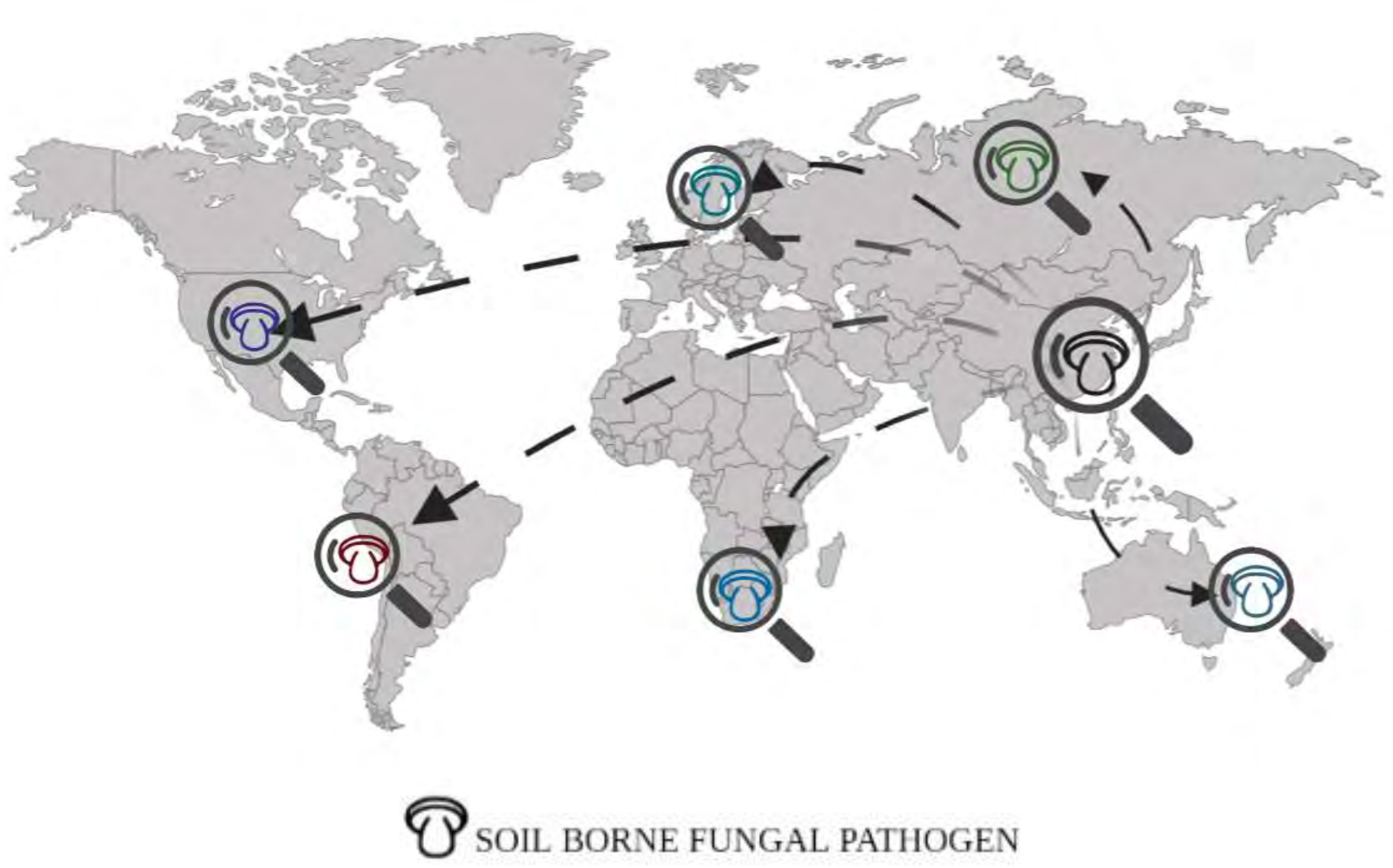

Fig. 1 Conceptual model of this study. The global distribution of soil-borne fungal pathogens that represent potential threats for main crop production in NCP and the factors driving their global distributions are assessed to provide roadmaps for potential improvements.

Results

We identified 25 soil-borne fungal pathogen species that could potentially affect the productivity of the main crops produced in NCP. Most of these species had widespread distributions across the globe, but a few showed occurrence patterns somewhat associated with NCP (Fig. 2).

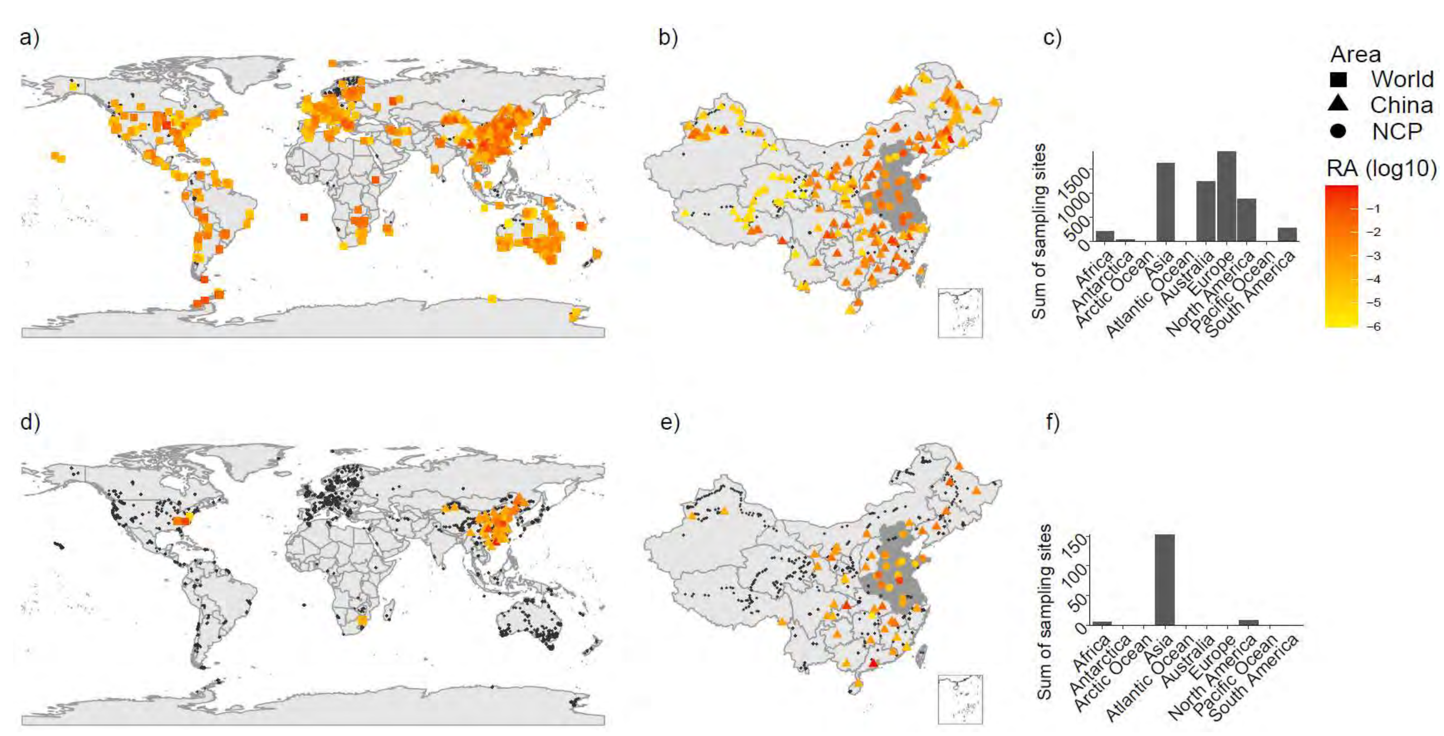

Fig. 2 Examples of the distribution of soil-borne fungal pathogens at global and regional scales (China and NCP): *Fusarium oxysporum* (a-c) and *Phomopsis longicolla* (d-f).

An assessment of the potential ecological factors driving the distribution of these pathogens did not reveal any consistent relationship between the occurrence of fungal pathogens and climatic or spatial variables. Interestingly, the availability of the focal host crops did not explain a significant variation in the pathogen's distribution (Fig. 3).

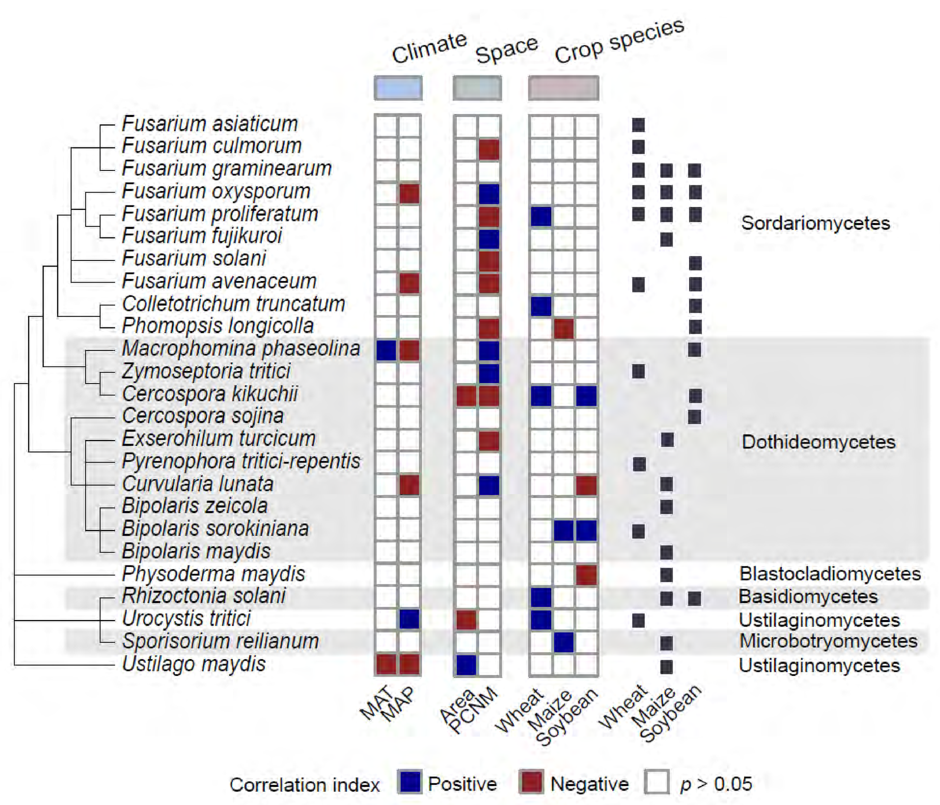

Fig. 3 Relationship between ecological drivers and the prevalence of selected soil-borne fungal pathogen species.

Conclusions

Our work opened the 'black box' of main soil-borne fungal pathogens from the intensive agricultural region-NCP, as well as factors influencing their global distribution. Our results propel an important next step for potential improvements in agricultural green development.

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The implications of positive deviant farms for crop production sustainability in the North China Plain

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Background

Sustainable agricultural production on smallholder farms is a worldwide concern. Smallholder farmers manage about 70% of the farmland in the North China Plain. Therefore, boosting smallholder farms' sustainability will significantly improve agricultural sustainability on the North China Plain. Here we analyse production practices of positive deviant farms to identify promising pathways towards increasing sustainability.

Objectives

- Group smallholder farms with the same sustainability performances;
- Identify farms with outstanding sustainability in each group;
- Assess the implications of learning from outstanding farms.

Methods

In July 2020, we conducted a farm household survey in 35 villages of Quzhou and got 486 smallholder farms. We developed a farm-level positive deviance approach based on the dataset, including empirical multi-criteria assessment, heretical cluster analysis, and Pareto ranking to find positive deviant farms. We used scenario analysis to assess the implications of learning from positive deviant farms. Three farm clusters were identified based on environment, economics, and social sustainability. Scenario 1 assumes the optimization of management practice of main cropping systems at a positive deviant level while not changing the cropping system allocation. Scenario 2 assumes optimizing the allocation of the cropping system as positive deviant farms while keeping the management practice of each cropping system as original.

Results

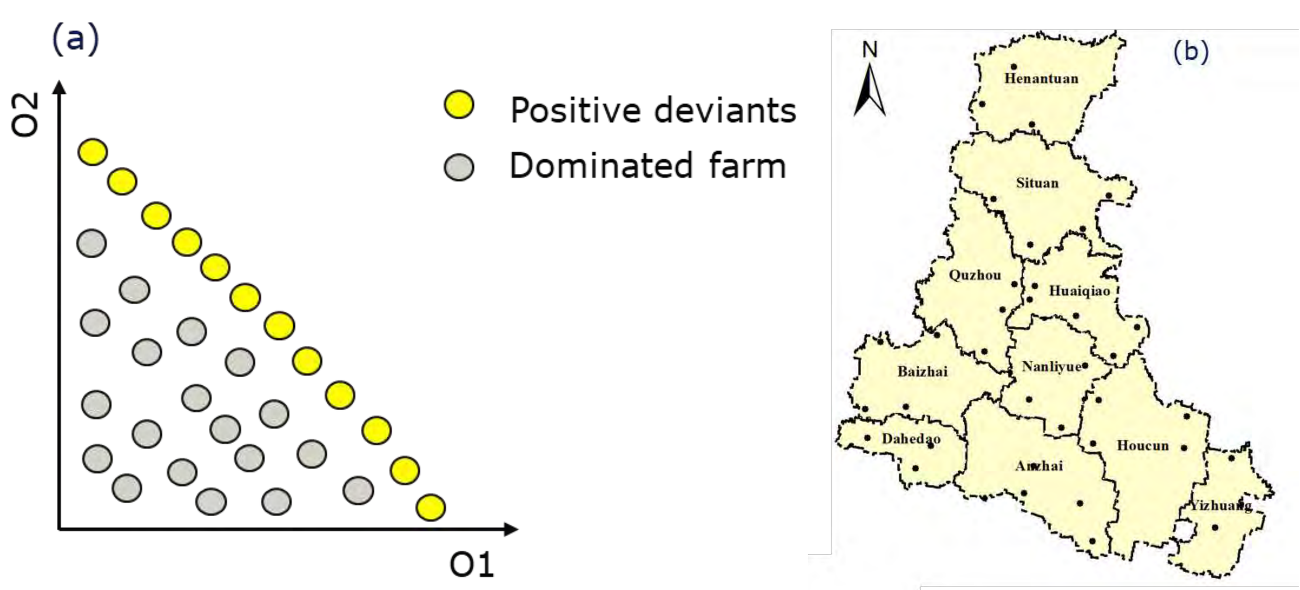

Fig. 1 Visual representation of positive deviants and dominated farm. Each circle represents a farm observation. O1 and O2 denote two competing objectives. (a). Geographic distribution of surveyed villages in Quzhou county (b) and black circles indicate the surveyed villages.

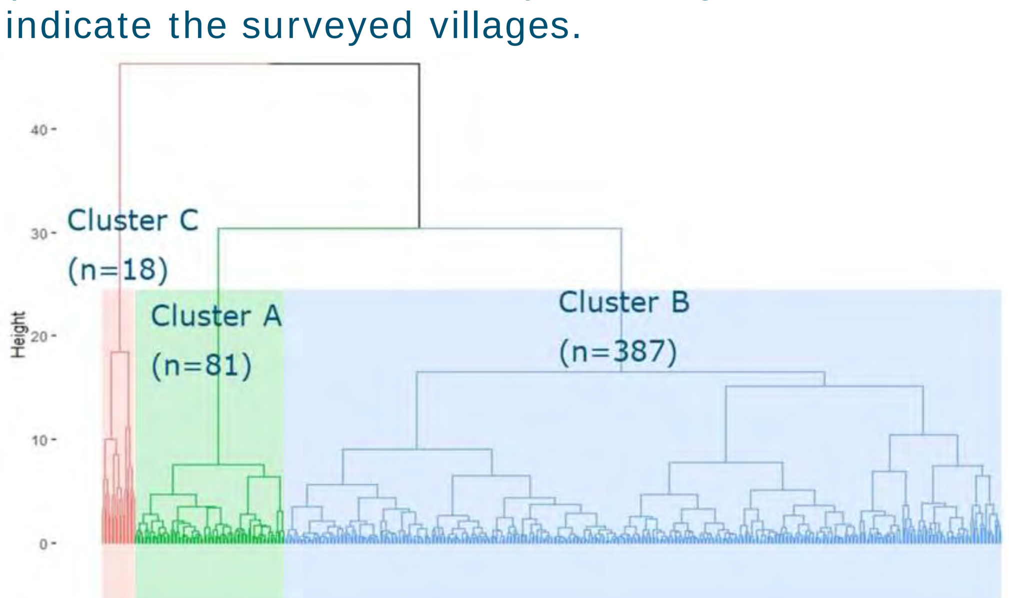

Fig. 2 Hierarchical clustering dendrogram of smallholder farms' sustainability performance.

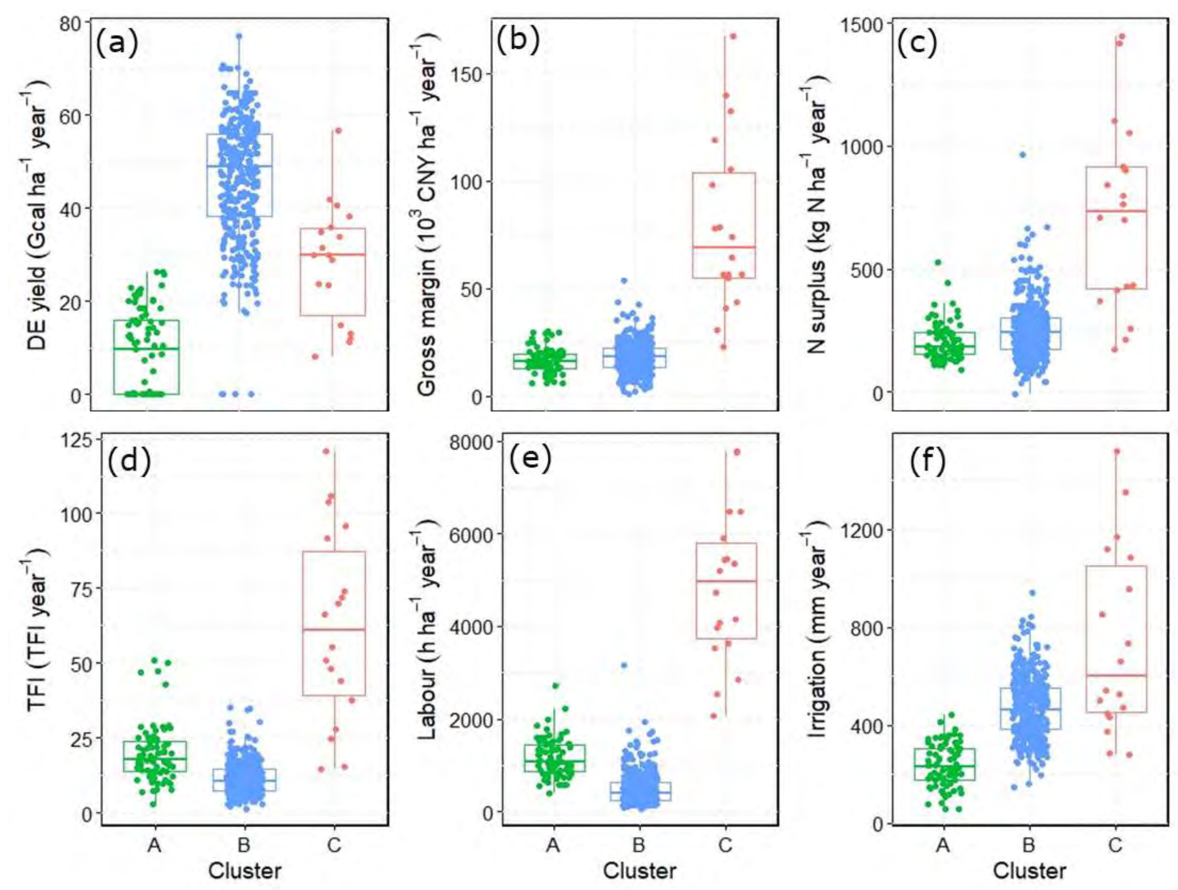

Fig. 3 Indicator performance of smallholder farms in Quzhou. All cases were grouped into clusters.

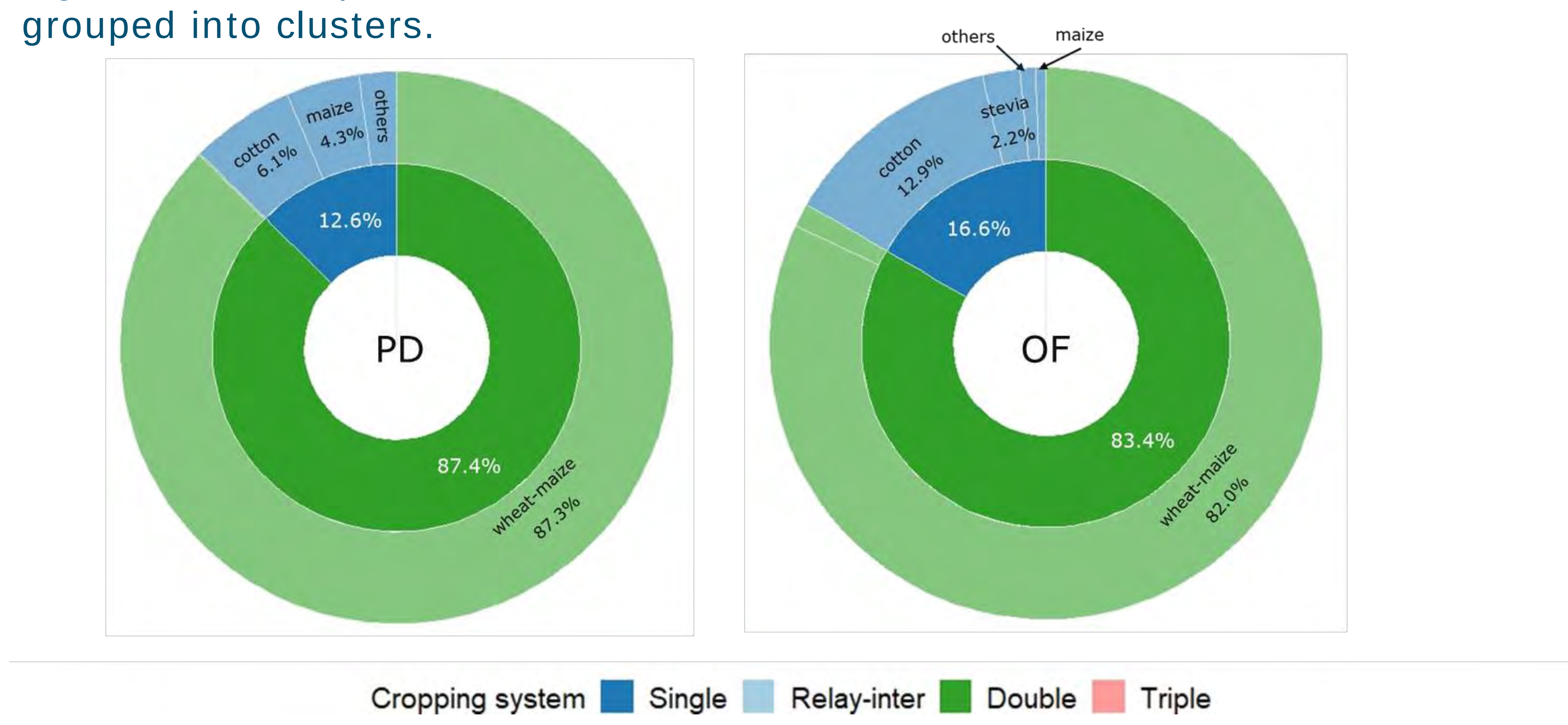

Fig. 4 Cropping system allocation of positive deviant farms (PD, n=63) and other farms (OF, n=322) in cluster B.

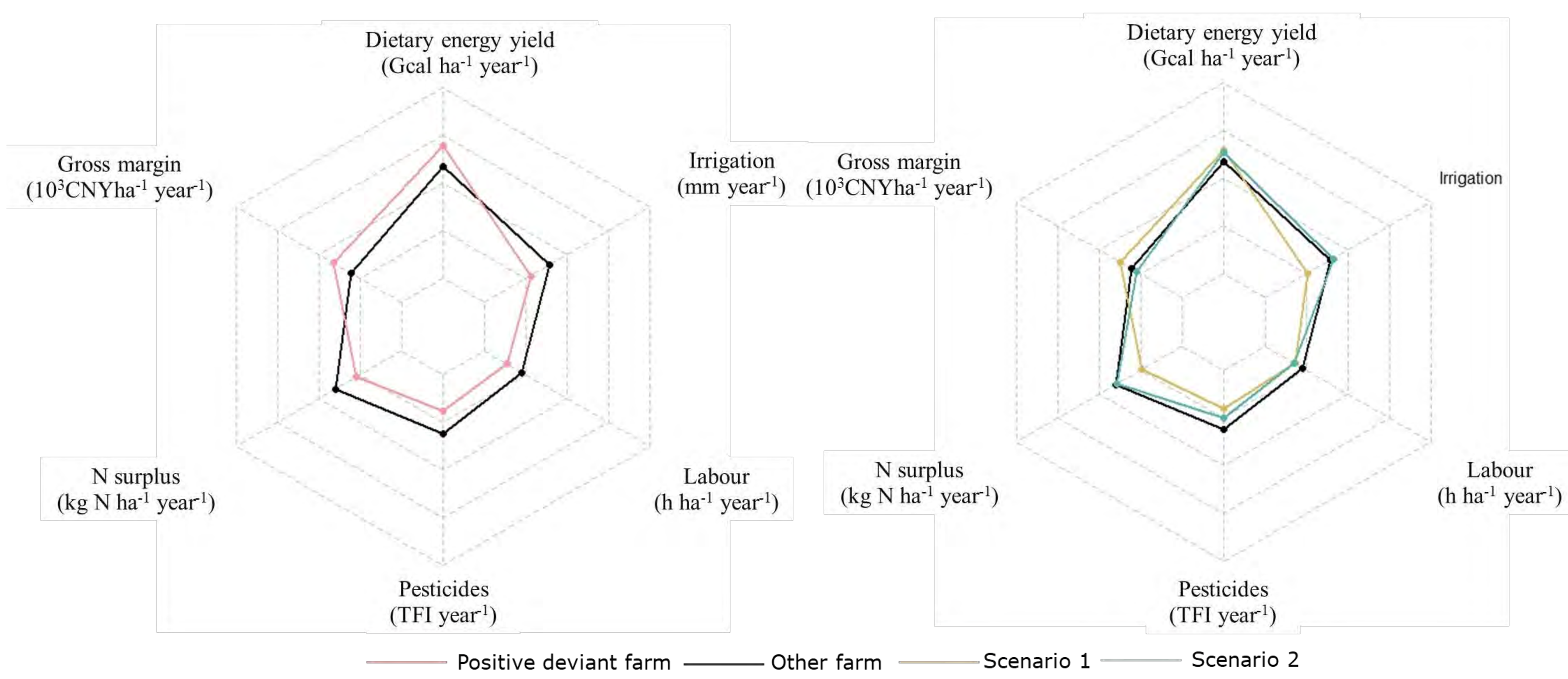

Fig. 5 Sustainability performance of positive deviant farms, other farms, and scenario 1 and scenario 2 in cluster B.

Conclusions

- There were significant variations in sustainability performances over the whole population of smallholder farms in Quzhou.
- Compared to other systems of cluster B, positive deviant farms performed better in multiple indicators.
- Multiple sustainability gaps might be narrowed for cluster B farms by adopting positive deviant farms' management practices and/or cropping systems allocation.

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

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Time trends of dietary Zn intake and occurrence of dietary Zn inadequacy among Chinese adults: data from the China Health and Nutrition Surveys between 2004 and 2011

Lu Liu

Supervisors: TjeerdJan Stomph, Wopke van der Werf, Wenfeng Cong, Fusuo Zhang

Background

Zn deficiency is one of the most widespread human micronutrient deficiencies, also known as 'hidden hunger'. Insufficient Zn intake is a public health concern in China as well. High risk groups comprise infants, preschoolers, pregnant and breast feeding women, and the elderly. Nutrient intake is related to dietary patterns, and determined by cultural and other socio-demographic factors. To date, it is not known which regions in China are most affected by dietary Zn intake inadequacy, or how shifts in food consumption patterns have affected dietary Zn intake over time.

Objectives

The aim of this study was to characterize differences between regions across China in the occurrence of dietary Zn intake inadequacy and identify how such differences are related to changes in food consumption patterns. We further looked for explanatory socio-demographic variables of dietary Zn intake, like sex, income level, food consumption patterns and whether people were living in urban or rural areas.

Methods

Data

The data of this study were derived from the China Health and Nutrition Survey (CHNS) which is an ongoing longitudinal survey that has been conducted every few years. For the present analysis, we extracted data for adults aged 18-50 years from the CHNS conducted in 2004, 2006, 2009 and 2011. Data were available for nine provinces in the four survey years: Heilongjiang, Liaoning, Shandong, Jiangsu, Henan, Hubei, Hunan, Guizhou, and Guangxi, as well as for three megacities only in 2011.

Inadequacy of dietary Zn intake

We estimated the proportion of individuals with a daily dietary Zn intake below their age- and sex-specific estimated average requirement (EAR), also known as the EAR cut-point method, which is a simplification of the full probability approach for calculating the prevalence of dietary intake inadequacy.

Food consumption pattern calculation

The foods and drinks in the database were classified into 19 food groups, similar to the classification in the Chinese Food Composition Table: cereals, meat, vegetables, legumes, fruits, dairy, poultry, eggs, roots & tubers, sugar, snacks, oil, nuts & seeds, fungi, fish & seafood, condiments, baby food, beverages and alcohol. For each individual, Zn intake from each food item was summed per food group, and then converted into a proportion of the total Zn intake per day.

Results

Inadequacy of dietary Zn intake

The average percentage of inadequate Zn intake in the total adult population increased from 23% in 2004 to 37% in 2011. These percentages varied strongly between provinces. Henan province, had the highest occurrence of inadequate dietary Zn intake of all provinces across all survey years, with the inadequacy in this province increasing from 37% in 2004 to 65% in 2011 (Fig. 1).

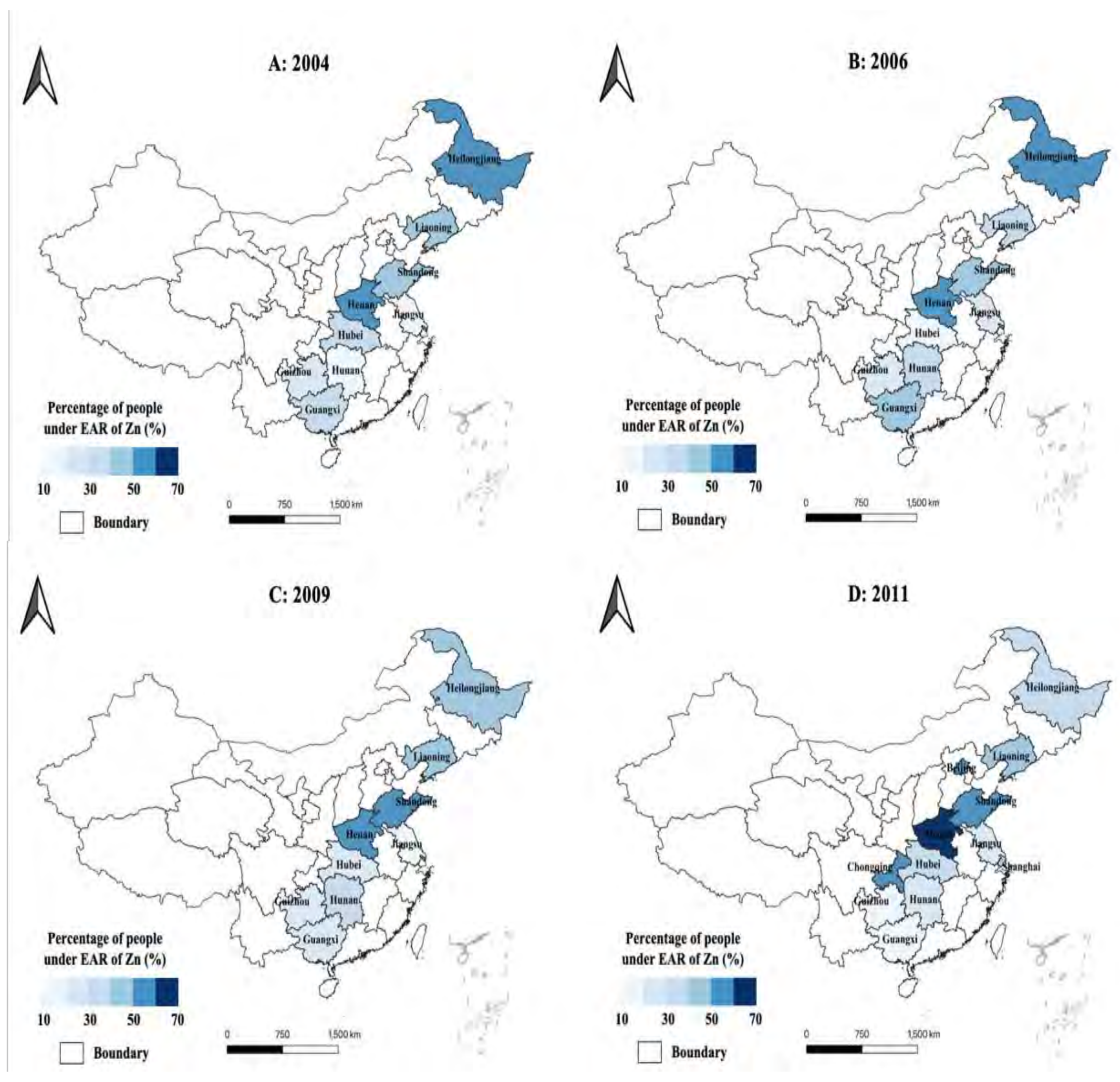

Fig. 1 Percentages of people with Zn intake inadequacy for surveyed provinces in different years. Zn intake inadequacy was defined as Zn intake below the estimated average requirement (EAR) of Zn. Nine provinces (Heilongjiang, Liaoning, Shandong, Jiangsu, Henan, Hubei, Hunan, Guizhou, and Guangxi) were involved in 2004, 2006, 2009, and 2011; and three megacities (Beijing, Chongqing, and Shanghai) were added only in 2011.

Zn intake and food consumption patterns

Cereals and meat were the two most important food sources for Zn intake. Over the survey years, there was a clear downward trend in the amount of dietary Zn intake from cereals (from 6.27 mg day^{-1} in 2004 to 4.68 mg day^{-1} in 2011, from 58% in 2004 to 48% in 2011).

Conclusions

Using data from CHNS 2004-2011, this study identified an increasing time trend of dietary Zn inadequacy of Chinese adults, which was associated with socio-demographic characteristics and shifts in food consumption patterns. The percentage of the studied population with inadequate Zn intake increased from 23% in 2004 to 37% in 2011, and the average dietary Zn intake decreased from 11.1 mg/day in 2004 to 9.89 mg/day in 2011. This decline was attributable to a reduction in dietary Zn intake from cereals, which was not sufficiently compensated by increased Zn intake from meat and other Zn-rich food items.

Acknowledgements

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Optimizing plant traits for efficient nitrogen use and high yield in maize using functional-structural plant modelling

Jie Lu

Supervised by: Dr. Tjeerd Jan Stomph (WUR), Prof. Jochem Evers (WUR), Dr. Qingchun Pan (CAU) and Prof. Lixing Yuan (CAU)

Background

Maize (*Zea mays*) is the most widely planted crop in China, and is often overfertilized. This causes environmental damage which can be mitigated by breeding for nitrogen-use efficient maize. Nitrogen use efficiency (NUE) is a complex trait, which depends on soil attributes as well as plant architectural, physiological and developmental roots and shoots traits. The relative contribution of these crop traits to NUE is not well known, but relevant to identifying breeding targets. To increase nitrogen capture, phenotypic plasticity in response to N availability also plays an important role. However, the effect of plastic responses in N uptake and utilization-related traits on NUE is not known. Here, a functional-structural plant (FSP) modelling approach was used to quantify the effects on NUE of differences in plant traits and their plasticity in relation to plant and soil N. We applied this model to quantify maize root trait values at a population level by optimizing yield and NUE.

Objectives

Identify and quantify the good root phenotype with low N losses while maintaining high yield under high planting density.

Methods

Modelling approach

We constructed an FSP model of maize to mechanistically simulate the growth and development of root and shoot driven by temperature, light and carbon and nitrogen sink-source relationships with plastic responses to plant N status.

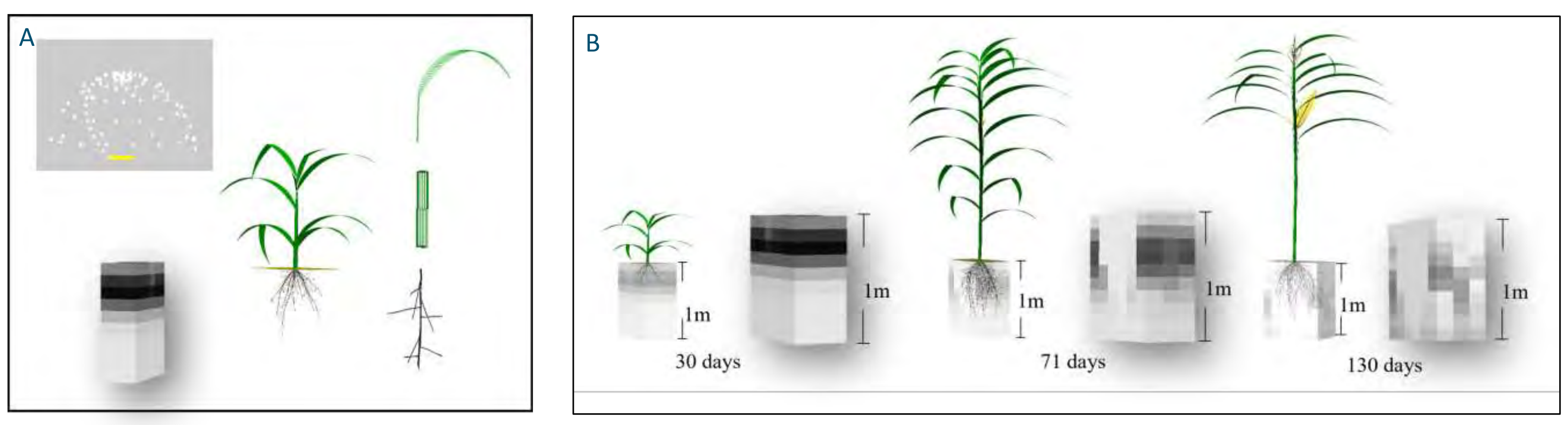


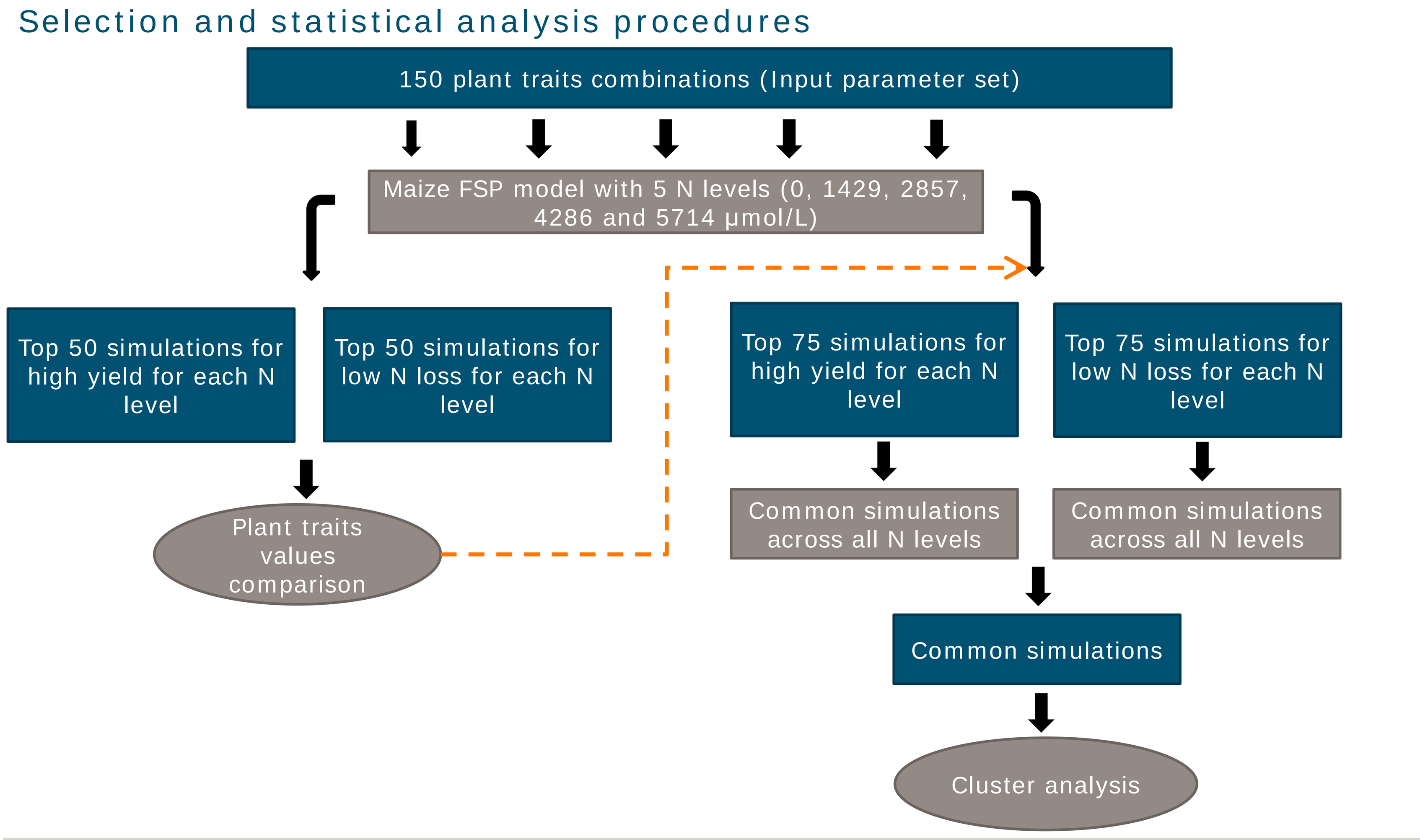
Fig. 1 Overview of maize FSP model. Panel A represents the structural components for the FSP model. Panel B presents maize different development stage in current model.

Simulation experiments

Target plant traits

Traits	Description	Min	Max
MP	Potential root number	10	75
erB	coefficient of root emergence rate in response to shoot nitrogen	0	0.1316
wmaxRoot	Potential root dry weight which is one of the model parameters to determine root sink strength (mg/plant)	7500	25000
RTD	Root tissue density (g/m³)	80	120
Dinit	Average first order root diameter (m)	0.0016	0.001
rlB	coefficient of root-to-leaf biomass partitioning coefficient in response to leaf nitrogen	0	16.482
rootAngle	initial axial root angle (°)	20	80

Selection and statistical analysis procedures



Results

Plant traits for either high yield or low N loss

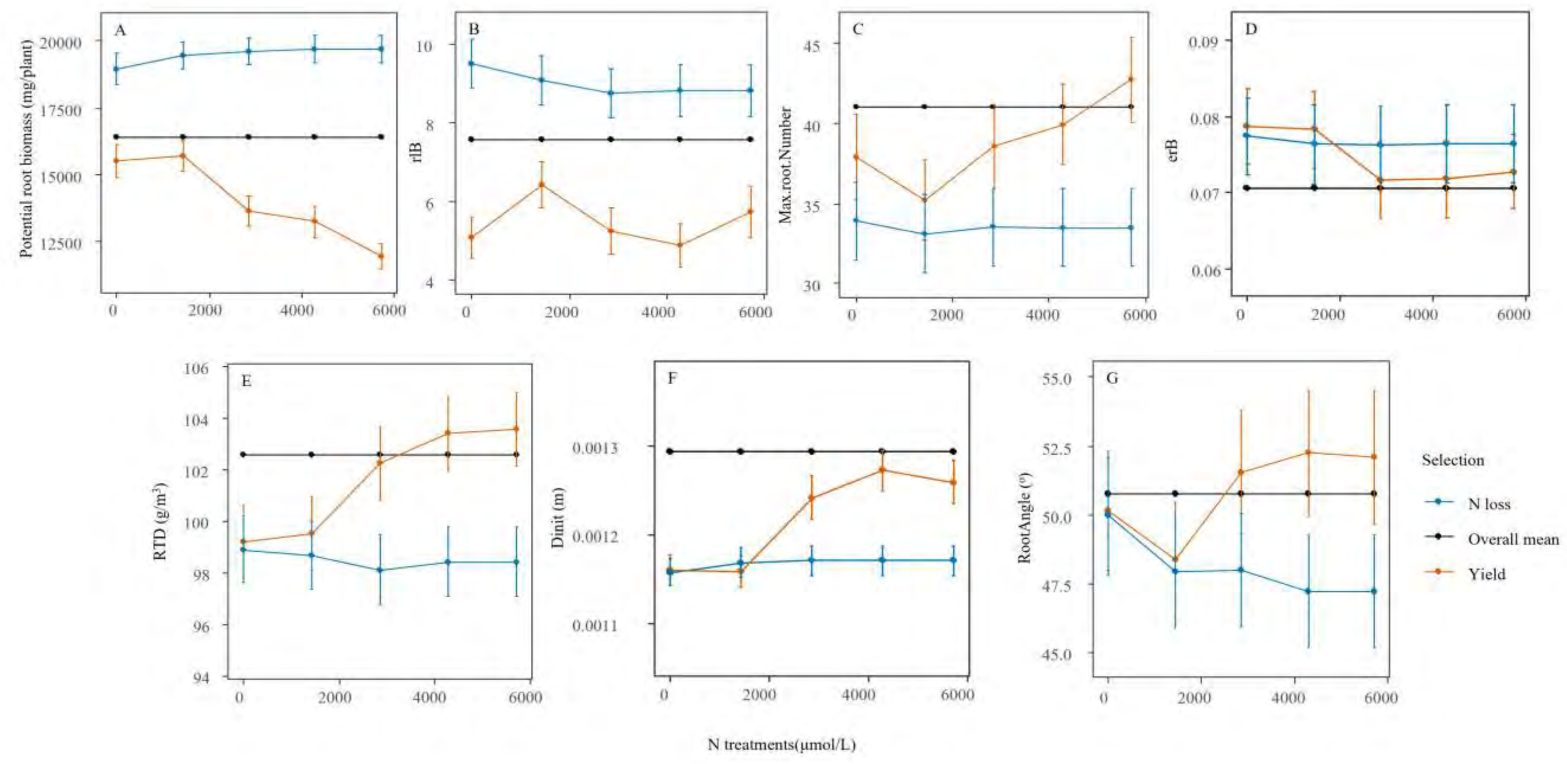


Fig. 2 The input parameter values when selecting for high yield or low N loss plants across five nitrogen (N) levels.

Plant traits for both high yield and low N loss

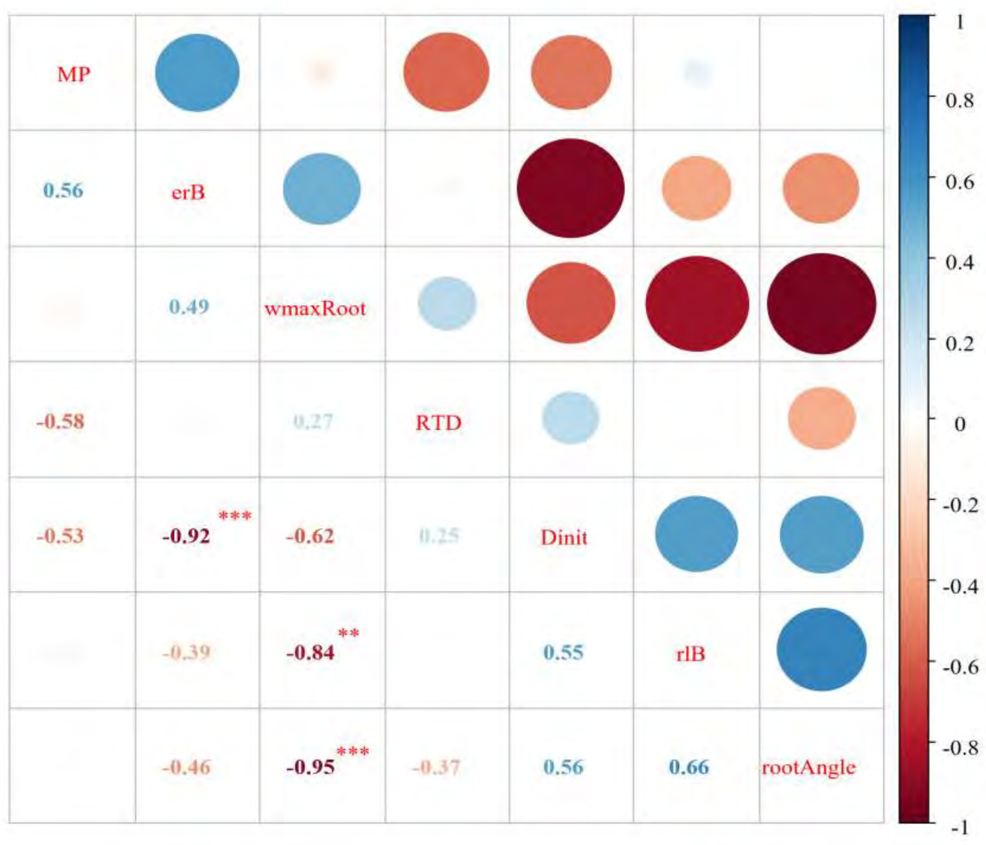


Fig. 3 The correlations among the seven plant traits for both high yield and low N loss simulations. *** represents p<0.01; ** represents p<0.05.

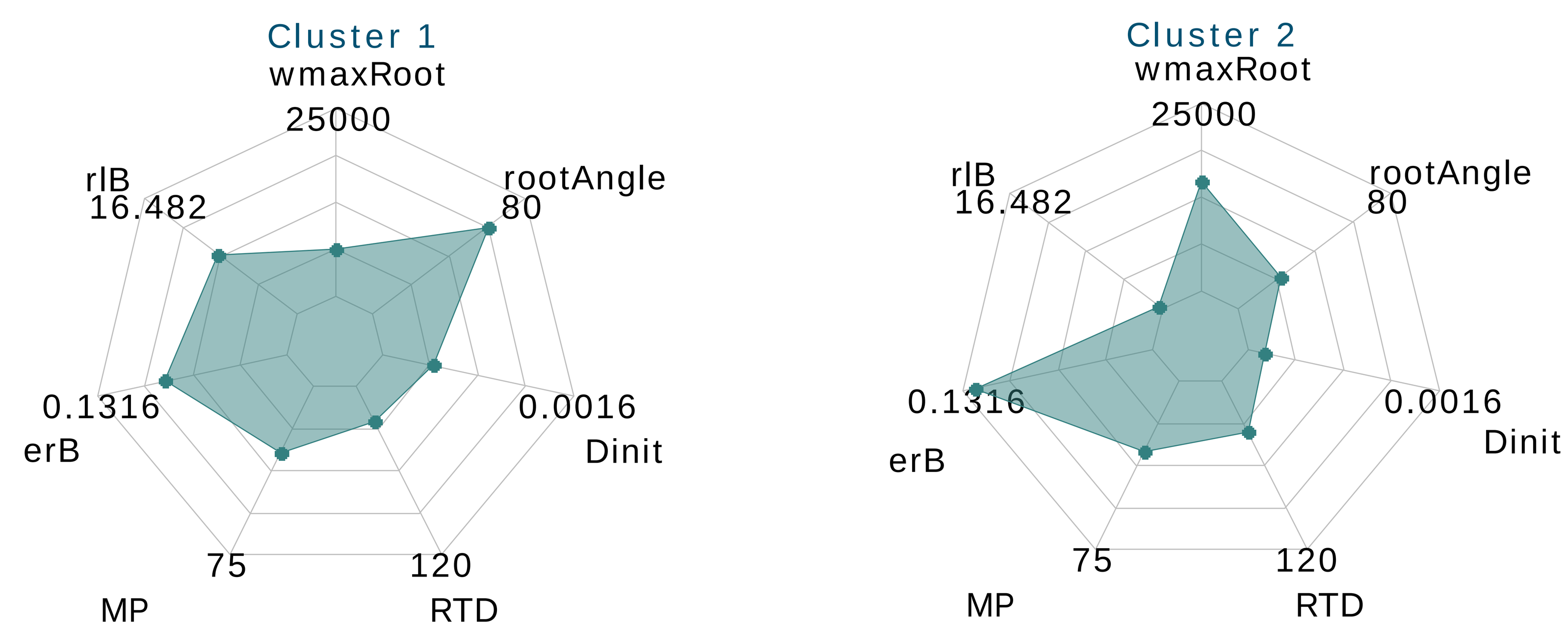


Fig. 4 Comparisons between the two clusters for plant traits combinations

Conclusions

Plant traits were more consistent for low N losses than high yield across all nitrogen levels under high planting density.

Plant traits generally showed different trends across N treatments for low N losses and high yield.

There were trade-offs between potential root biomass and root to leaf biomass. partitioning coefficient or root angles, and between root diameter and root emergence rate for both high yield and low N loss under high planting density.

There were two clusters of root traits combinations with both high yield and low N loss.

Acknowledgements

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

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Integrate models to investigate G×E×M to identify high-NUE and high-yield maize germplasm in China

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WAGENINGEN UNIVERSITY & RESEARCH

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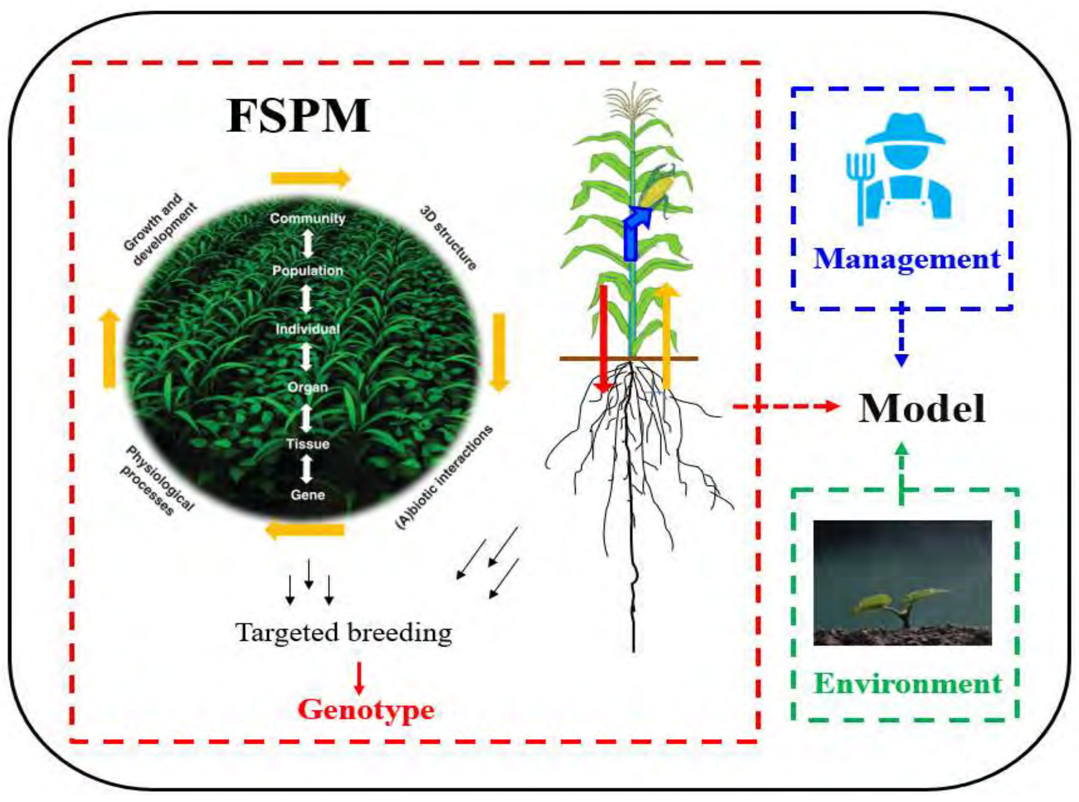
Background

In China:

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

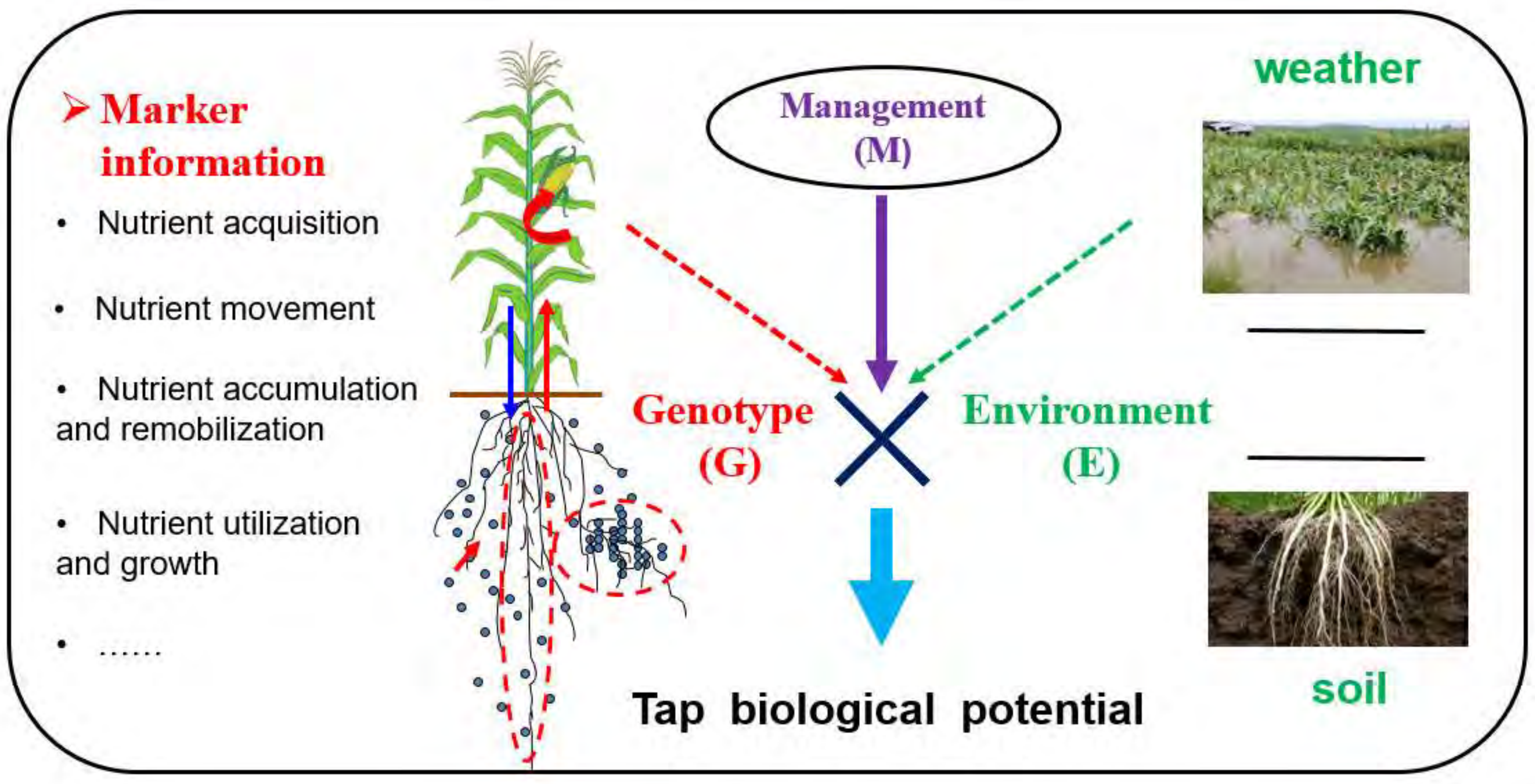
➢Environment
- Longitude and latitude
- Precipitation
- Photoperiod
- Temperature
- ......

➢Management
- Fertilizers
- Pesticide
- Planting patterns
- ......



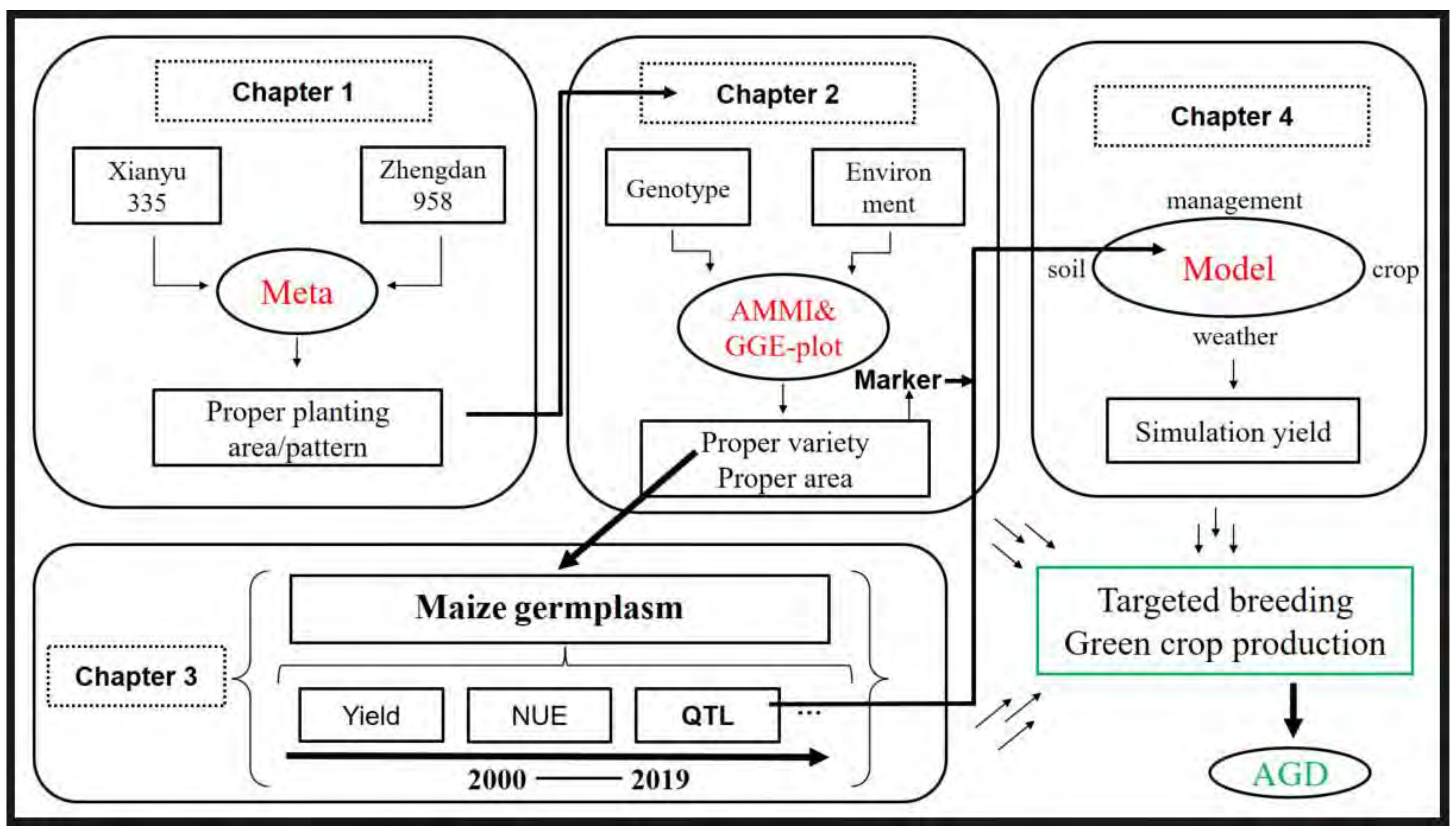
Research question: How to use GEM models to predict the potential yield of different maize varieties in different regions of China?

Objective



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

Method-roadmap



Results

A total of 1912 papers(xianyu335-559;zhengdan958-1353) were collected from Web of science and CNKI. These two cultivars are widely planted in China.

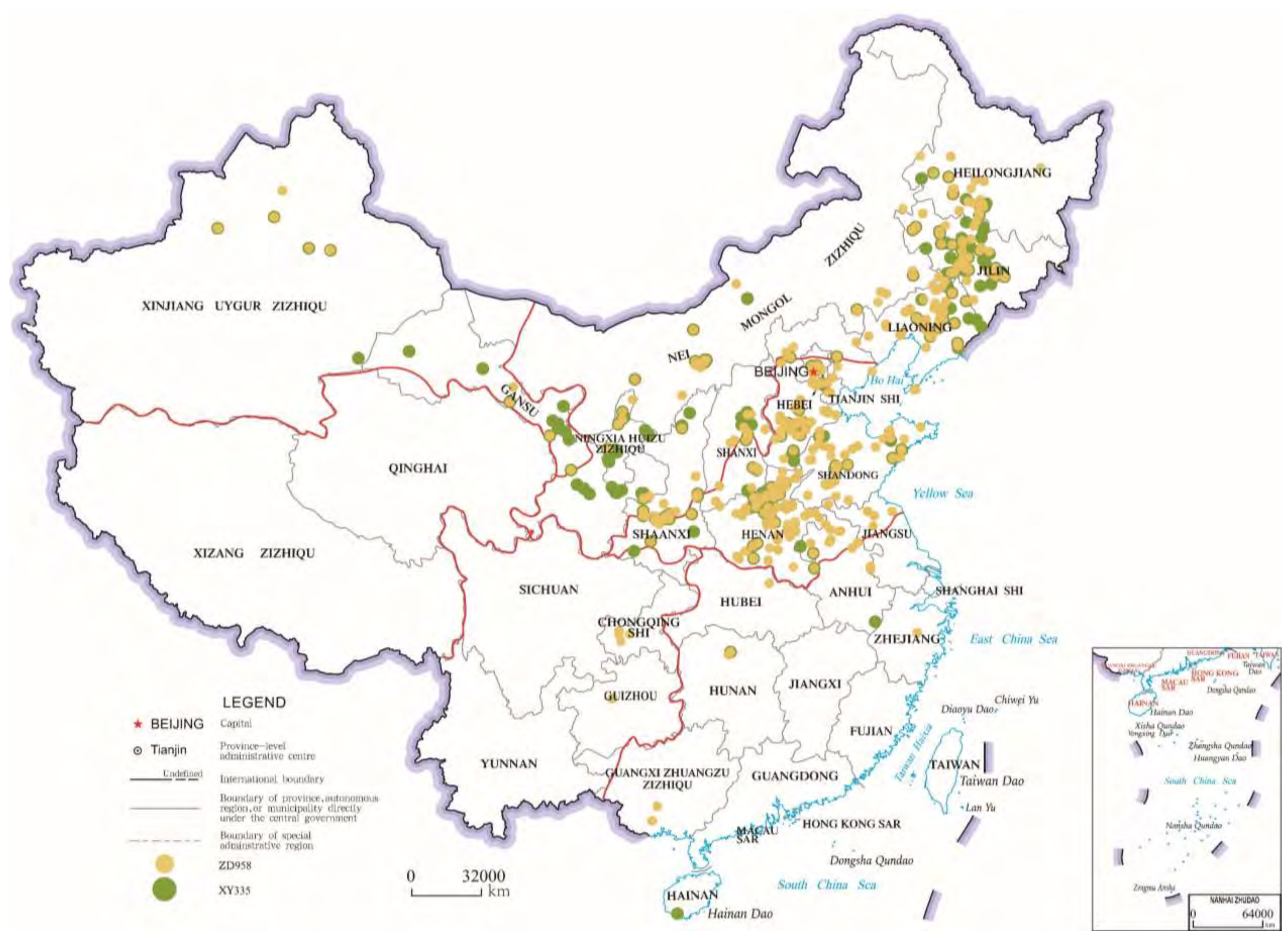


Figure 1. Distribution of Xianyu335 and Zhengdan958 in the different experimental site in China.

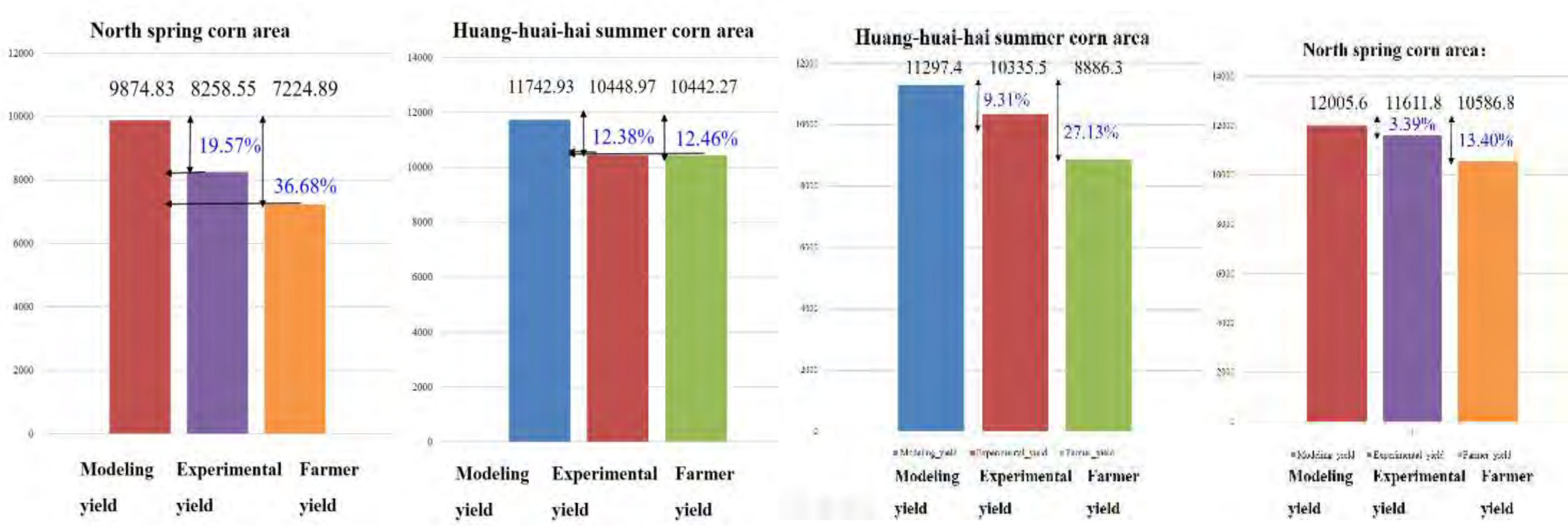


Figure 2. Yield gap of ZD958 and XY335 maize cultivars in two regions.

Conclusions

➢ 1) XY335 had 201 test sites in the spring maize area in North China, accounting for 63.41% of all sites, and 106 in the maize sowing area in Yellow-Huai-Hai Rivers Plain, accounting for 33.43%. ZD958 was more widely distributed in the summer maize area in Yellow-Huai-Hai Rivers Plain, with 457 test sites, accounting for 58.36%. ZD958 had 324 experimental sites in the spring maize area in North China, accounting for 37.37.

➢ 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.

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Overview PhD projects – starting year 2020

Posters, January 2023

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
8. Xiaodan Li	1+3	Upscaling China's Science and Technology Backyards (STB) through modified technologies and policies

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

Theme: Green ecological environment		
Name	*Model**	*Project*
16. Juhui Chen	2+2	Labelling for sustainable development: perspective from both production and marketing
17. Haorang Li	1+3	Labelling for sustainable development: perspective from both production and marketing
18. Sijie Feng	2+2	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach
19. 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*
20. Zhaoqi Bin	1+3	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
21. Ruotong Zhao	2+2	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
22. Bowen Ma	2+2	Developing sustainable diversified crop production systems for the North China Plain
23. Laiquan Luo	1+3	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
24. Yuxiang Wang	2+2	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
25. 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
26. 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
27. Yanjie Chen	2+2	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
28. Bo Wang	2+2	Towards more sustainable groundwater use for food security in Quzhou
29. 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.

Decision-making in food waste valorization: a systematic review leading to an improved holistic framework

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

Background

Food waste valorization has gradually become a research hotspot in recent years. The reason for this is the enormous amount of food wasted globally and the food security concerns of the growing population. To valorize food waste, many technologies are studied and applied. For example, anaerobic digestion (converting food waste into energy and fertilizers), drying technology (processing food side-streams into longer shelf-life livestock feed), etc. The theoretical aspect and decision-making of food waste has been stressed in recent research, such as the development of food waste hierarchies (e.g., Figure 1). However, most of the studies commonly take an individual perspective and focus on one or a few specific food loss and waste streams. There is a lack of holistic decision-making support framework.

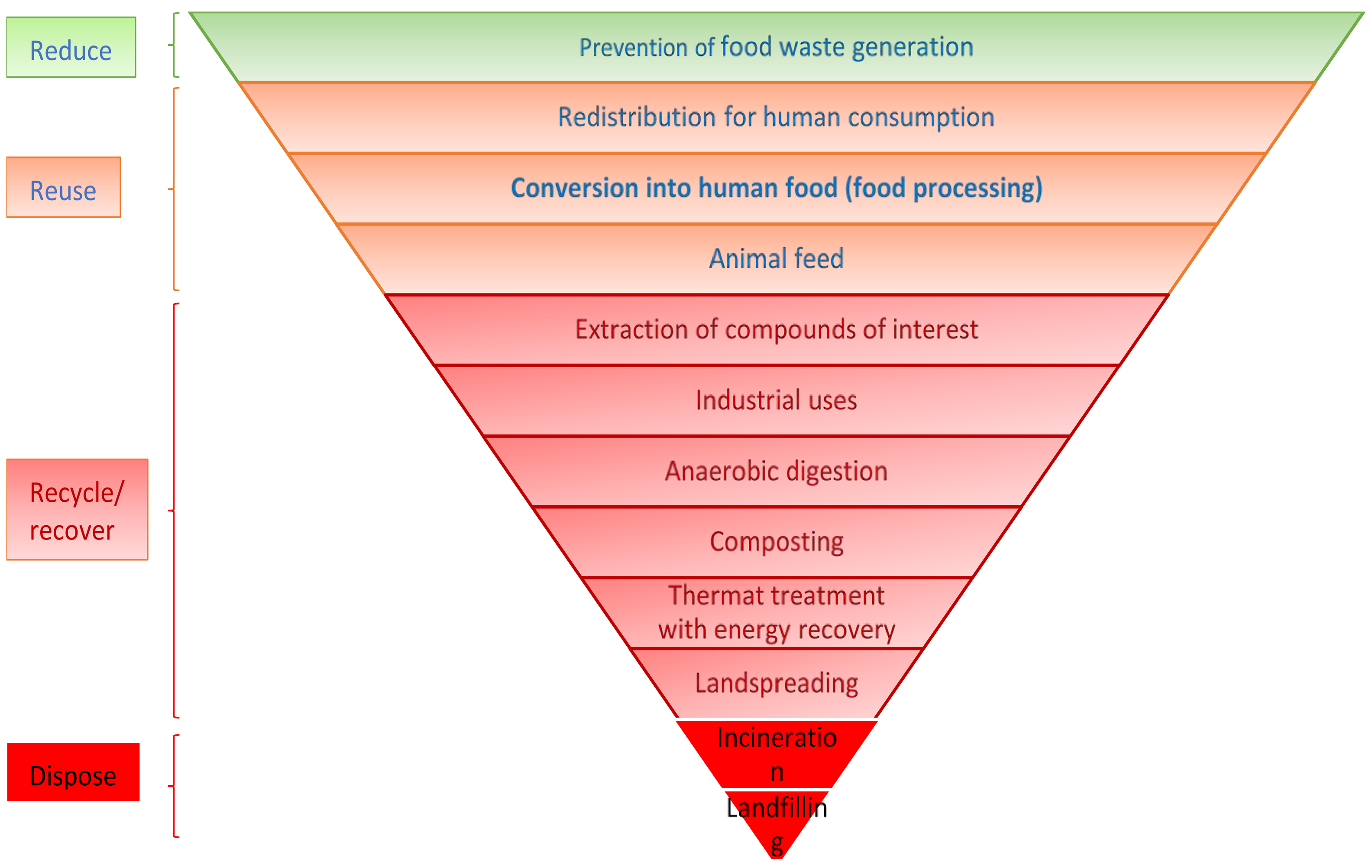


Fig 1. Waste hierarchy for surplus food and food waste including conversion into human food (highlighted in bold). Adapted from Garcia-Garcia et al.

Objectives

This research will try to achieve the following research objectives:

i) identify the generic building blocks and logic for a decision-making framework.
ii) extract useful knowledge from DSA of CE.
iii) construct an improved framework.
iv) identify the element of framework to be further developed in future study.
v) analyze coverage and limitations in the studies reviewed.

Methods

A systematic literature review is conducted to achieve the research objectives (Fig. 2). The literature search was performed via the Web of Science. After the screening, 31 food waste valorization decision support approaches from 30 articles were presented in this study.

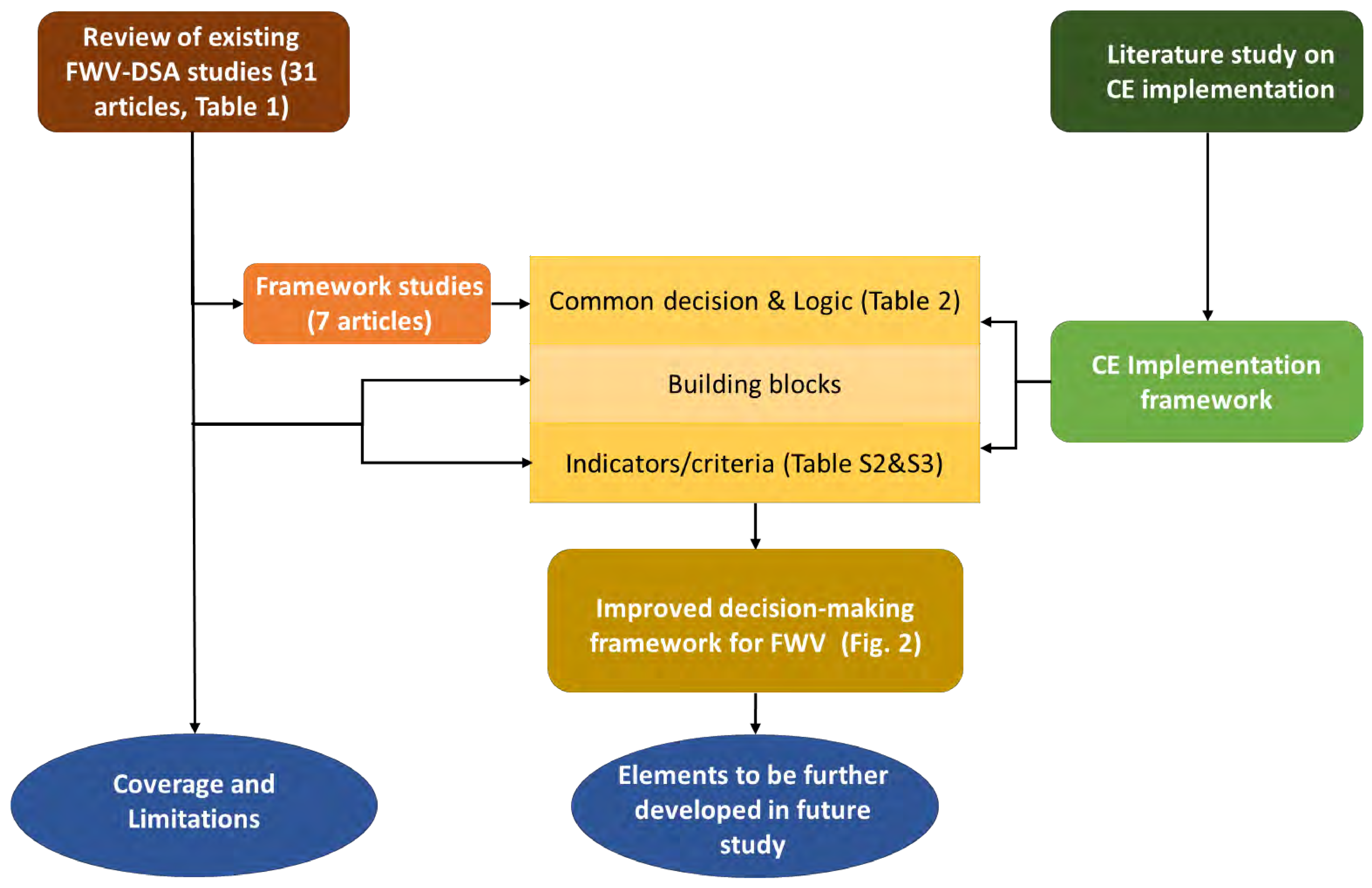
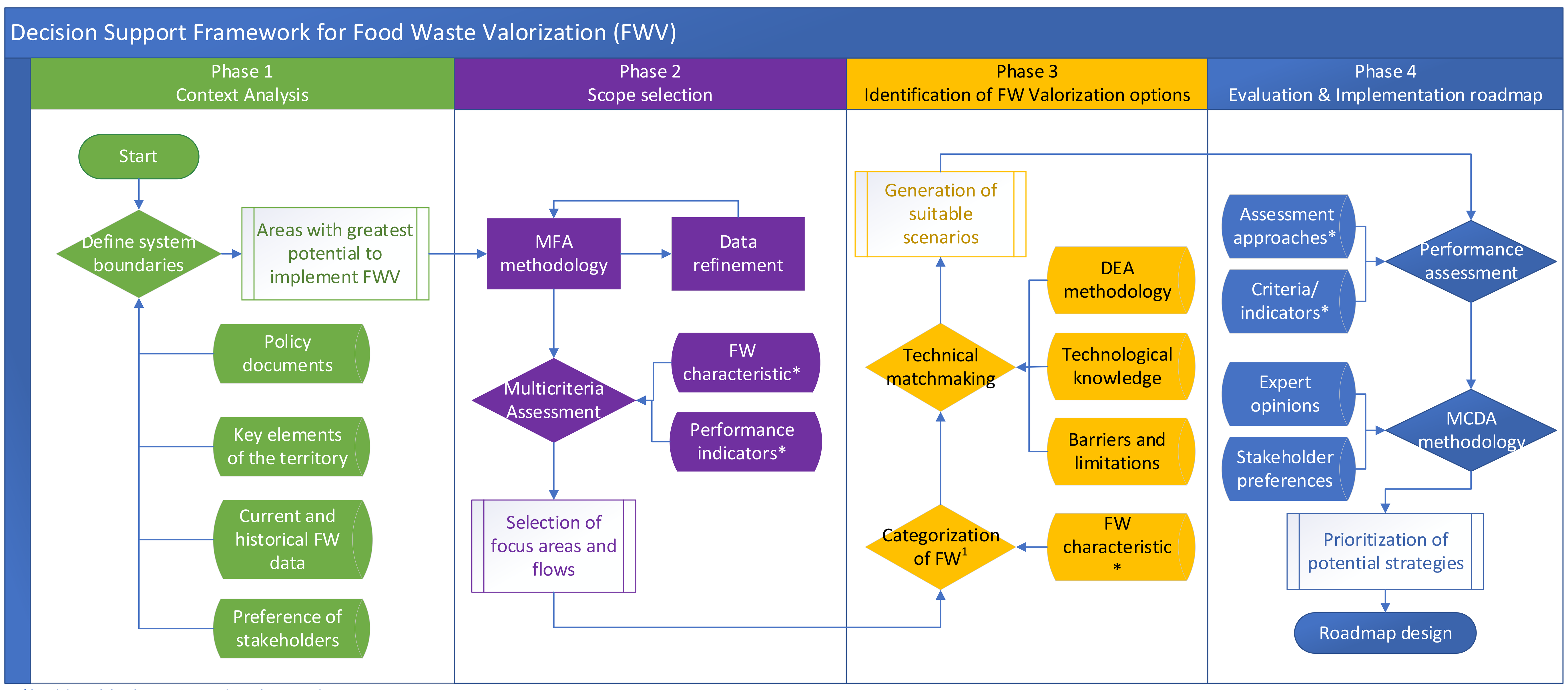


Fig 2. Overall methodological approach of this paper.

Results & conclusions



*building blocks reviewed in this study
1 Garcia-Garcia et al. (2017)

Fig 3. The improved decision-making framework for implementation of food waste valorization.

A systematic framework is constructed (Fig. 3), including four phases: context analysis, scope selection, identification of FW valorization options, evaluation and implementation roadmap. In addition, the food waste hierarchy was found too conceptual to guide the decision-making in FWV and we suggest that further research is needed in adapting the CE knowledge to food system.

Acknowledgements

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The Supply of Organic Fertilizer in China and the Impact on Green Food Agriculture Environment

Yi Zhang
Supervisors: Xuexian Li (CAU), Wei-Shan Chen (WUR)

Background

- China's Green Food companies, registered products and sales have been growing continuously in the past 2 decades


NY
中华人民共和国农业行业标准
NY/T 394—2021
绿色食品 肥料使用准则
Green Food—Fertilizer Application Guideline
2021-05-07 发布 2021-11-01 实施
中华人民共和国农业农村部 发布

- China Green Food has a set of independent implementation standards and guidelines independent of ordinary agriculture.

- China National Development Plan proposes that Green Food increase by 50% on the basis of the current scale by 2030 for the healthy diet of Chinese residents.

Green food is an agriculture production method between ordinary agricultural production and organic food production.

In a nutshell, the production guidance for input management of Green Food is based on reducing the input of chemical fertilizers by 50% on the input of ordinary agricultural production, and using organic nutrients to supplement the amount of nutrients that are insufficient(NY/T 394-2021 Green Food-Fertilizer Application Guideline). Simultaneously, the types and doses of pesticide inputs are restricted (NY/T 393-2020 Green Food-Guideline for Application of Pesticide).

Objectives

1. Establish a database of organic nutrients for Green Food in China with fertilizer data that meet the Green Food-Fertilizer Application Guideline (NY/T 394-2021)

   Organic nutrients that can be used in the Green Food Agriculture, including types, available quantities, grades of availability, nitrogen, phosphorus, potassium utilization rates and organic matter content.

2. Based on China's Green Food Agriculture data from 2018 to 2021, calculate the amount of organic nutrients required for the transformation of the whole crop from conventional agriculture to Green Food agriculture.

   The basic data of China's Green Food agriculture: crop types, planting area, yield per hectare, chemical fertilizer application amount, organic nutrient application amount, etc.

   The amount of organic nutrients required per hectare for Green Food agriculture of various crops.

3. Evaluation of self-sufficiency rate of organic fertilizer supply to Green Food agriculture in China

$M_{livestock,\ total} = \Sigma\ Q_{livestock}$ *1000(or 10,000,000 for poultry)*Manure produce(kg/d)*365/1000(t)

Results

1. Calculation of manure nutrient content and compost loss of main livestock and poultry

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

2. Calculation of China's total livestock and poultry population and total nutrients from manure sources in 2020

Total number of poultry and livestock in China in 2020 (Source: FAO STAT)

Date	Category	Index	Region	Unit	Value
2020	Camels	Quantity	China Mainland	1000 Head	411,2
2020	Horses			1000 Head	3674,01
2020	Sheep and Goats			1000 Head	306679,3
2020	Asses			1000 Head	2324
2020	Mules			1000 Head	622,8
2020	Cattles			1000 Head	61128,84
2020	Pigs			1000 Head	412172,3
2020	Rabbit			1000 Head	118255
2020	Poultry Birds			10M Head	58,57

Total nutrients from manure sources in China in 2020 (t)

Total manure weight	Organic Matter weight	Nutrient content after composting		
		N	P	K
1,063,020,821	139,822,180.4	4,133,168	1,727,207	2,765,942

3. National scale crop nutrition consumption capacity

Calculation of total nitrogen required after the conversion of ordinary agricultural main crops to Green Food agriculture

Crops	Average amount of N from organic fertilizer used(kg per mu)	Average amount of N from chemical fertilizer used(kg per mu)	Total N input (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	1.54	41,292,000	63,680.69
-Rice	11.02	9.34	1.36	30,341,784	41,197.42
Vegetables					
-Leafy vegetables	20.72	9.69	2.03	20,514,067	41,615.80
-Melons	23.27	13.82	2.47	2,197,139	5,435.36
-Nightshade	23.67	11.77	2.36	1,902,138	4,496.11
-Beans, Peas	22.48	4.59	1.81	11,292,495	20,391.26
Fruits					
-Apple	21.01	11.90	2.20	1,911,848	4,197.07
-Orange	17.87	11.12	1.93	393,598	760.98
Cash crops					
-Tea	10.90	12.24	1.54	3,365,697	5,195.42
Total	165.42	93.11	17.24	113,210,766	186,970.13

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.
- Whether animal manure can be recycled and composted due to the limitation of the scale of the animal farm or technical factors will be scenario analyzed and discussed in the follow-up research.
- According to calculations, the composted manure produced by livestock breeding in China currently has enough nutrients to meet the nutritional needs of China's ordinary agriculture transformation into Green Food agriculture.
- The environmental impact of the production process of using compost instead of chemical fertilizer after the transformation of China's ordinary agriculture into Green Food agriculture and the impact of adding it to the soil will also be carried out in follow-up research.

Acknowledgements

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Continuous extraction of oleosome from rapeseeds

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3. Wageningen Univ, Biobased Chem & Technol, POB 17, NL-6700 AA Wageningen, Netherlands.

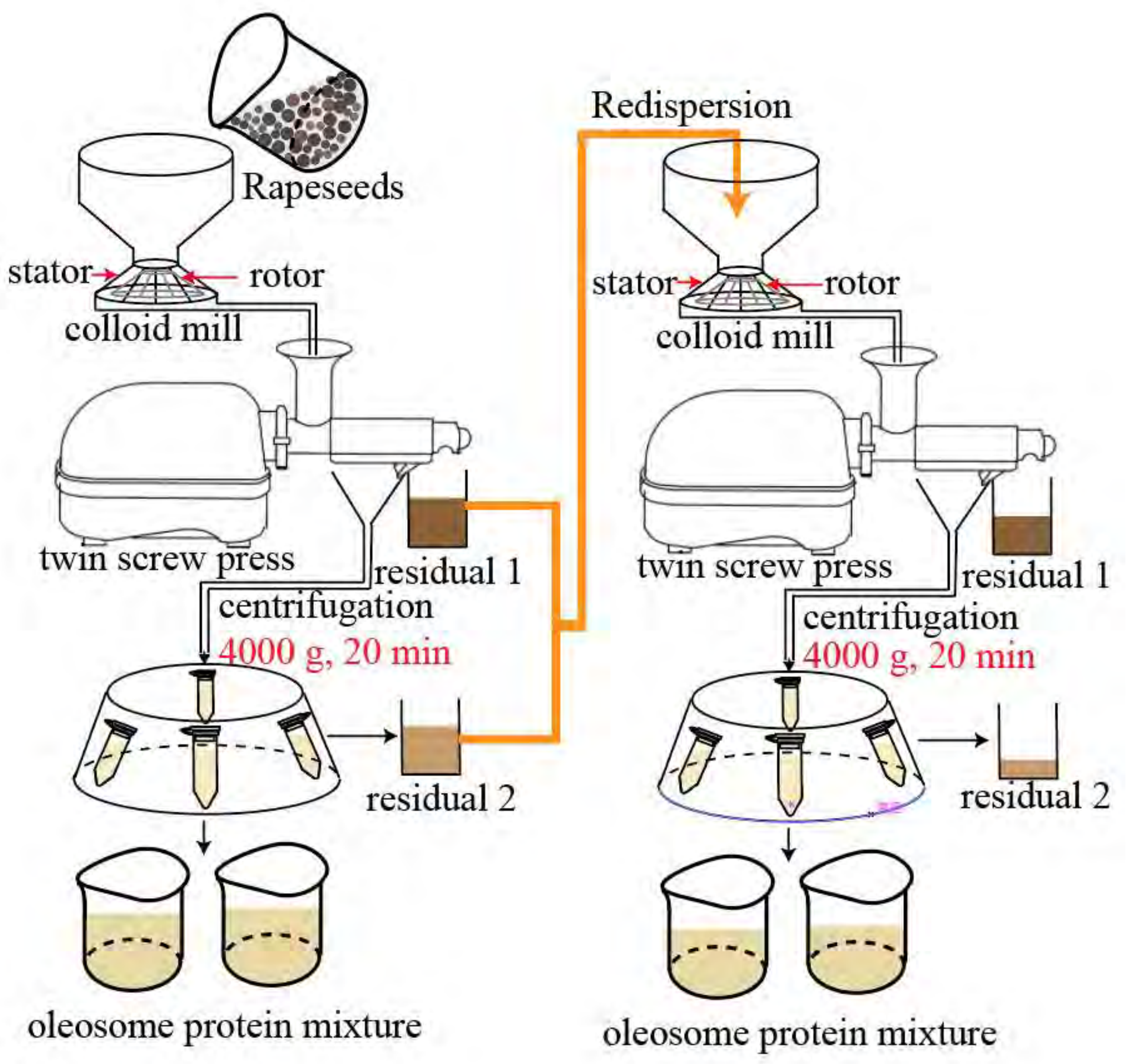
Background

- Low extraction yield of oleosome from rapeseed (~ 60%)
- Lots of research focuses on extracting oleosome from rapeseed and ignoring the co-extracted protein
- The combination of twin-screw press and colloid mill can improve the extraction yield of oleosome, and the technique has the potential to be applied in the food industry

Objective

- Improve the extraction yield of oleosomes.
- Combine twin screw press and colloid mill to extract oleosome.
- Continuous extraction of oleosomes from rapeseed.

Extraction methods

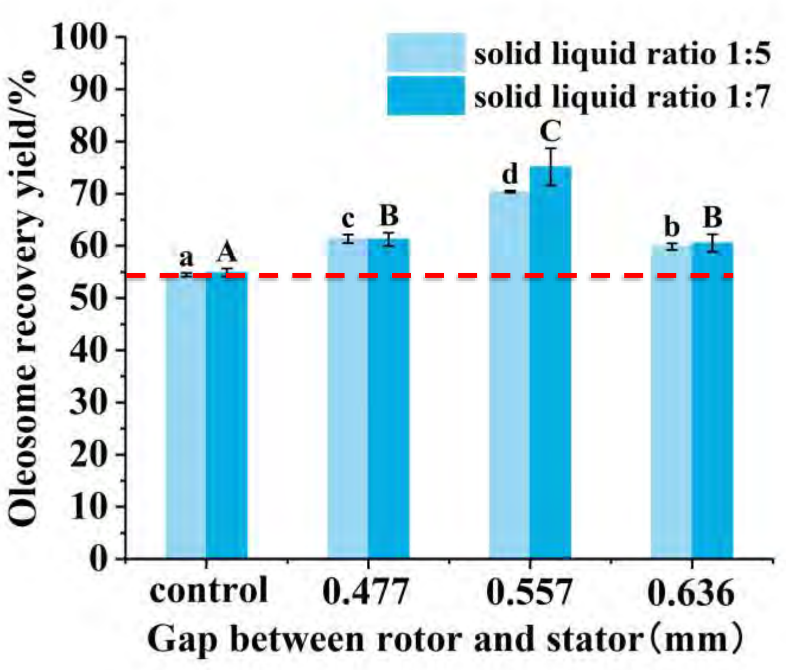


Simultaneous extraction of oleosome and protein

Results

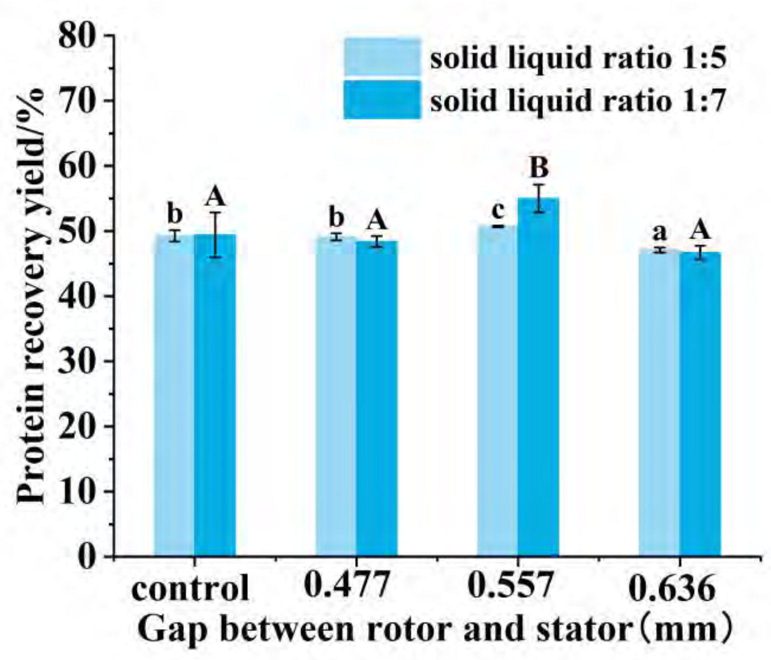
Extraction of rapeseed oleosome and proteins

Oleosome recovery yield



$$\text{Recovery yield (wt\%)} = 100 * \left(\frac{\text{oil content in mixture (g)}}{\text{oil content in rapeseed (g)}}\right)$$

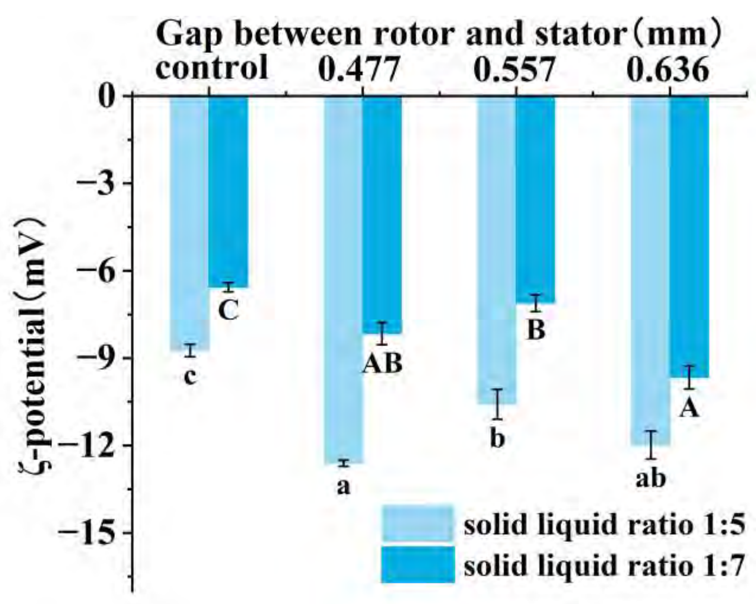
Protein recovery yield



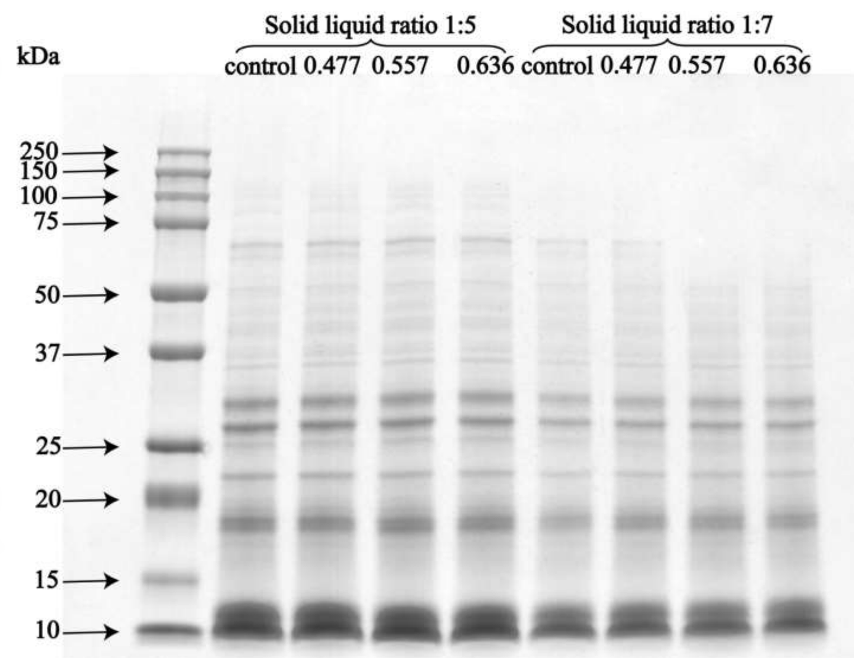
$$\text{Recovery yield (wt\%)} = 100 * \left(\frac{\text{protein content in mixture (g)}}{\text{protein content in rapeseed (g)}}\right)$$

Physico-chemical properties of the oleosome protein mixture

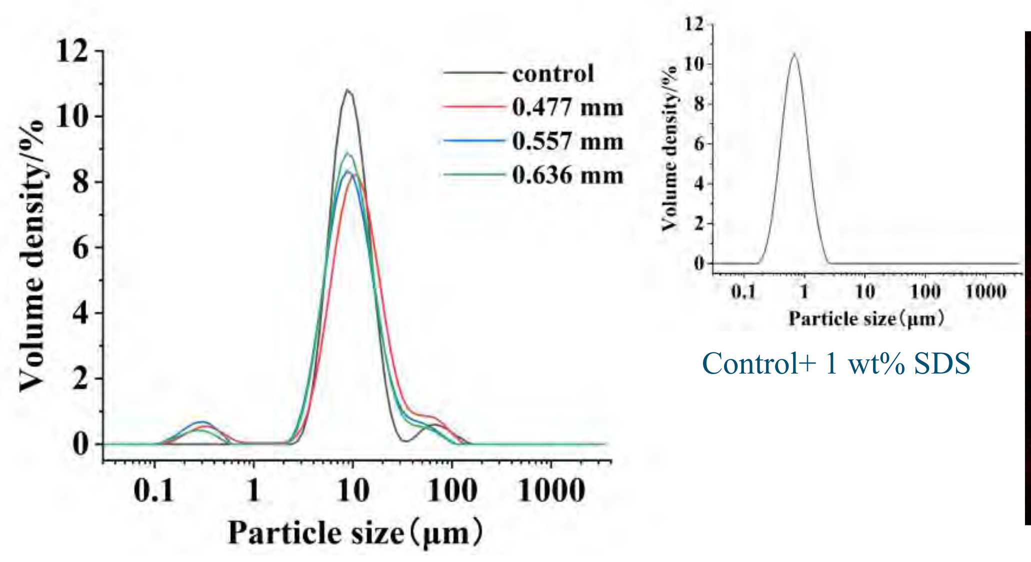
Z-potential



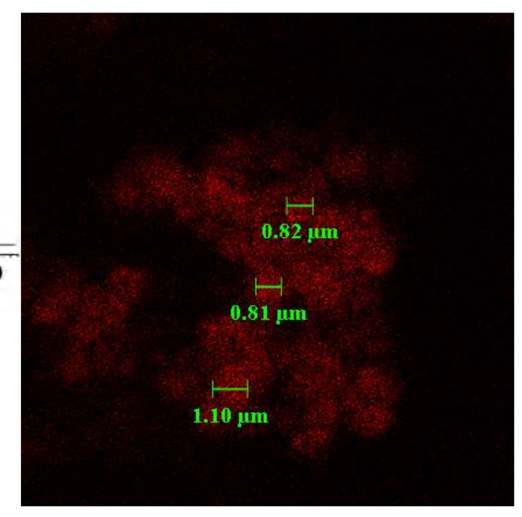
SDS-PAGE



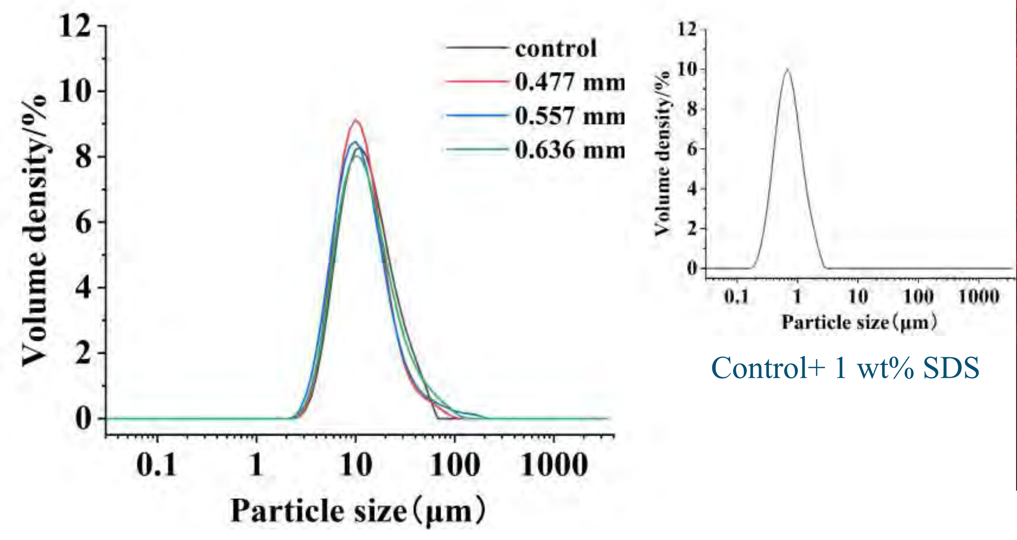
Size distribution (solid-liquid ratio 1:5)



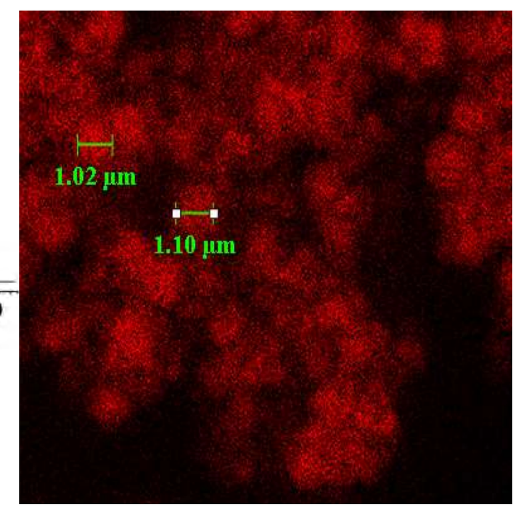
CLSM (control+solid-liquid ratio 1:5)



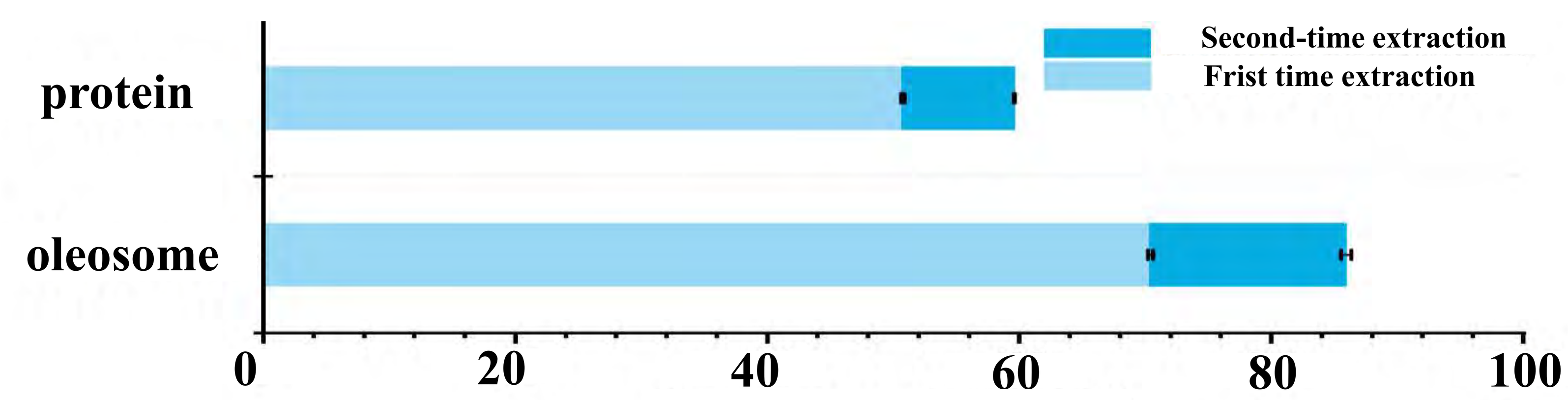
Size distribution (solid-liquid ratio 1:7)



CLSM (control+solid-liquid ratio 1:7)



Improving recovery yield by repeating the extraction process



Conclusions

- By combining colloid mill and twin-screw press the recovery yield of oleosome was improved.
- Seed-water 1:5 is found to be the best extraction condition.
- The oleosome recovery yield was achieved at 86 w/w% by repeating the extraction process.

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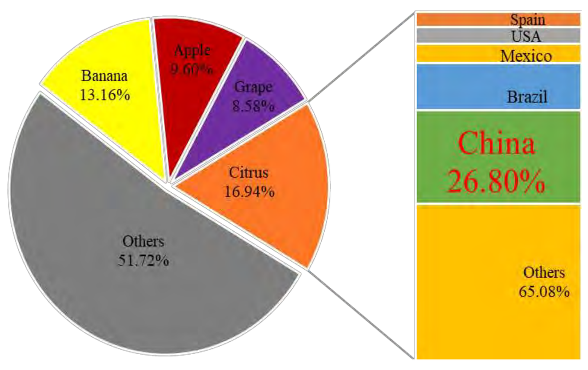
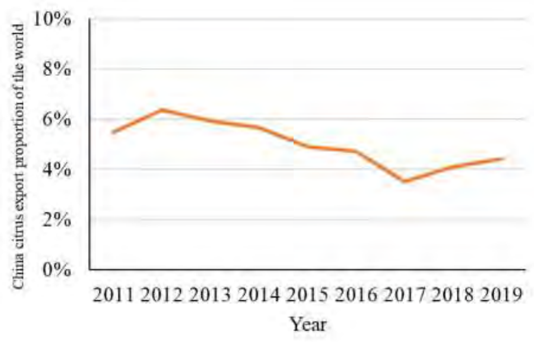
Optimization of Economic and Environmental Performance of the Green Navel Orange Supply Chain (GNSC)

Ruijin Luo*, Junhan Zhang
Supervisors: Xuexian Li, Ting Meng, 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

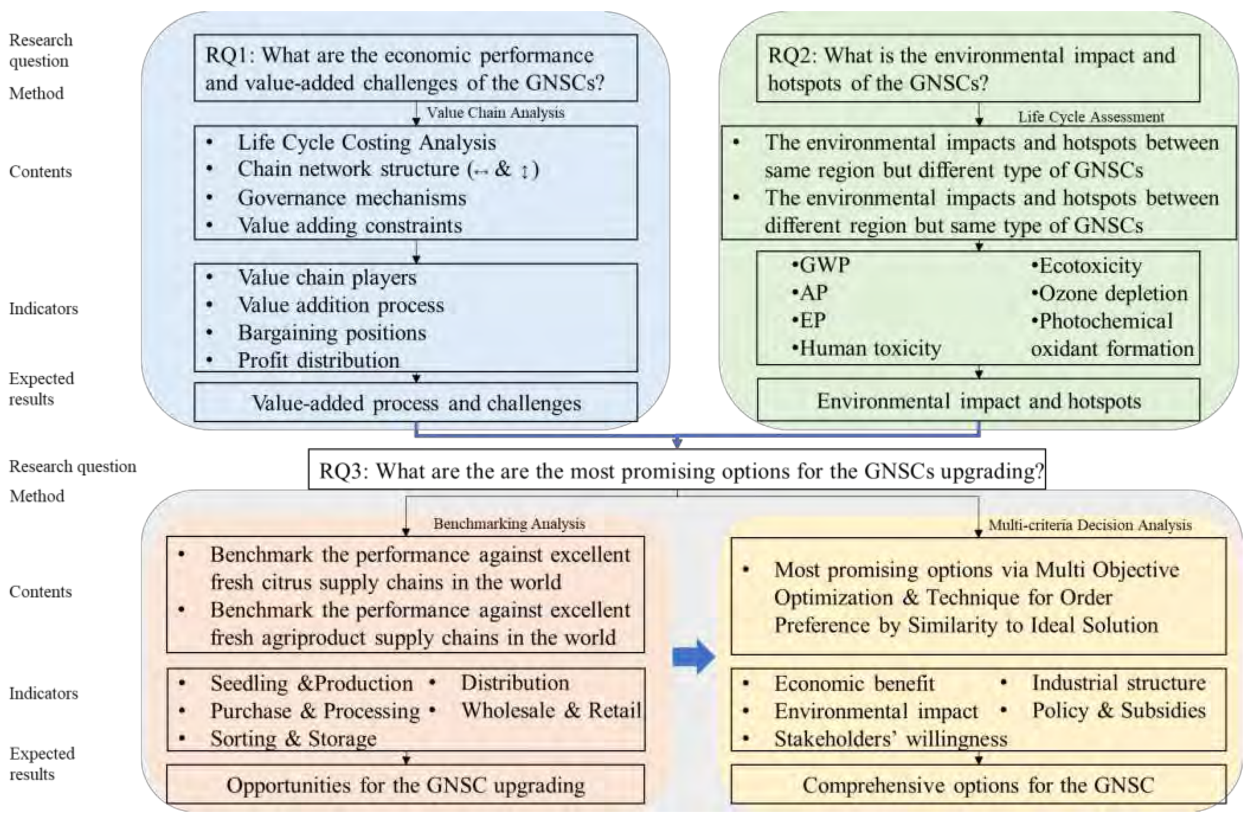


Fig.1 Technical routes

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]

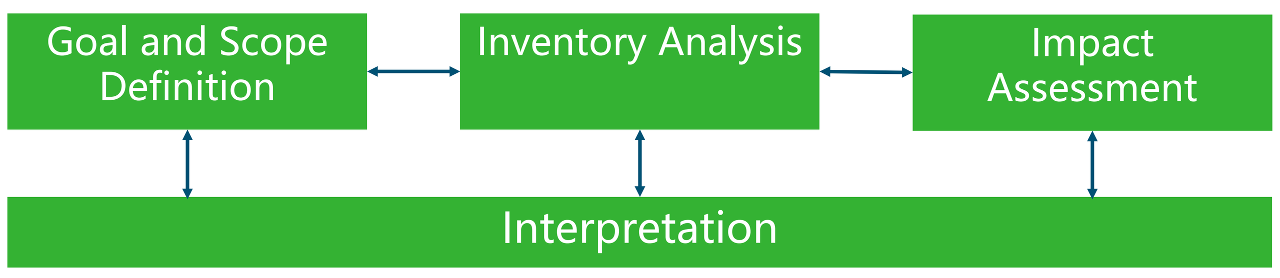


Fig.2 Illustration of the general phases of a life cycle assessment, as described by ISO 14040

2. Benchmarking Analysis

Benchmarking 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. Multi-Criteria Decision Analysis (MCDA)

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

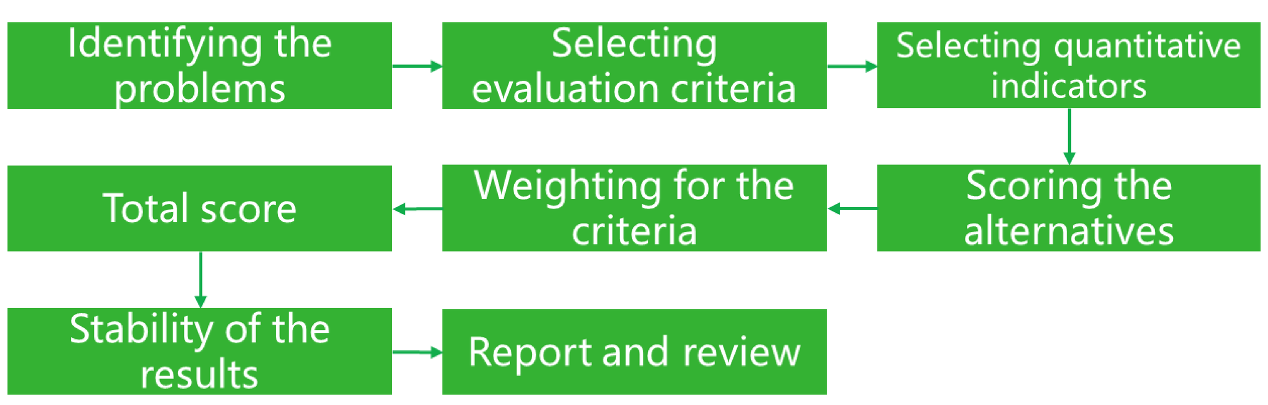


Fig.3 Multi-Criteria Decision Analysis Procedure

An Umbrella Case – Southern Jiangxi

- Most famous and valuable citrus
- Since: 1970s
- Brand value: 67.8 billion CNY (2020)
- Harvested area: 113.3 thousand ha
- Output: 1.4 million t

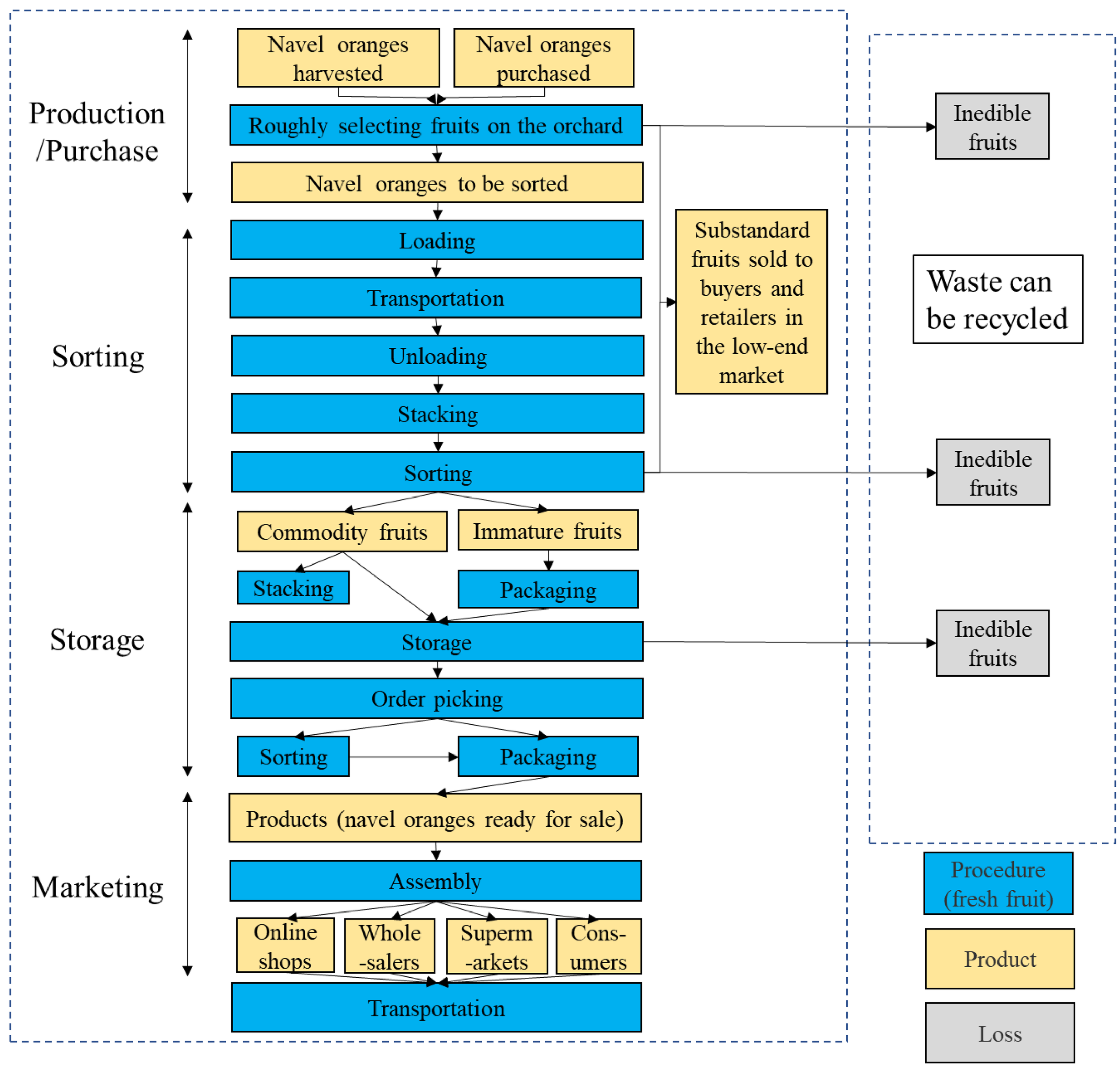


Fig.4 The green navel orange supply chain in details

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Network Design for Perishable Fresh Food Supply Chains

Case Study: A Chinese Orange Supply Chain

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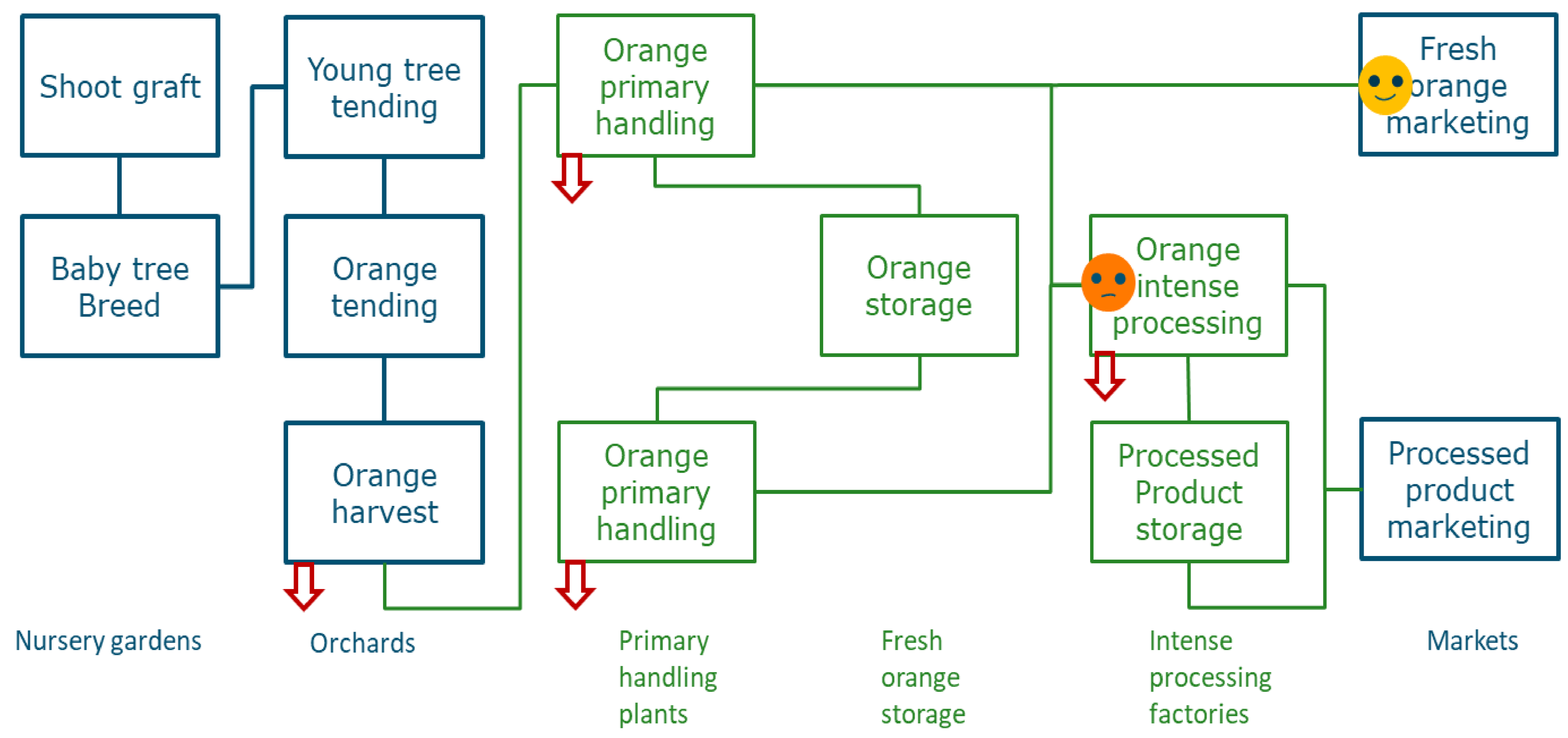
Supervisors from WUR (ORL group): Prof.dr. Sander de Leeuw, Dr.ir. Frits Claassen, Dr. Peter Kirst
Supervisors from CAU: Prof.dr. Xuexian Li, Dr. Ting Meng

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 food).

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.

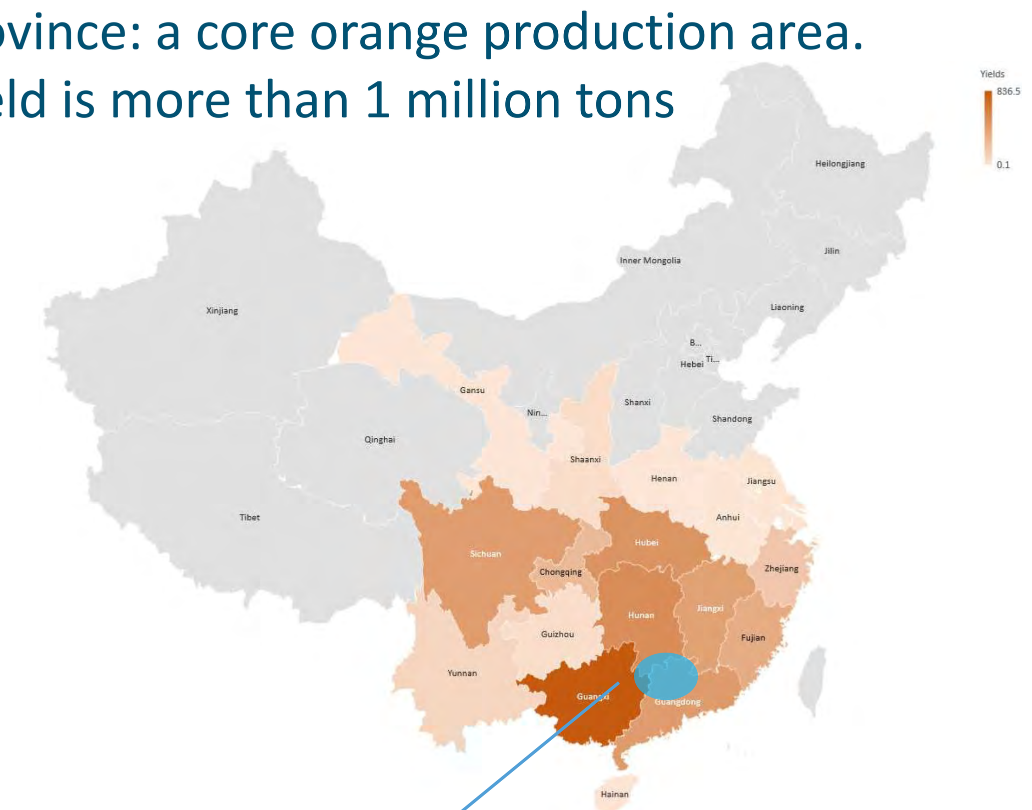
Food intensive processing is often used for fruits that are edible but not of the highest quality. In developing countries, this industry is still not fully developed yet.

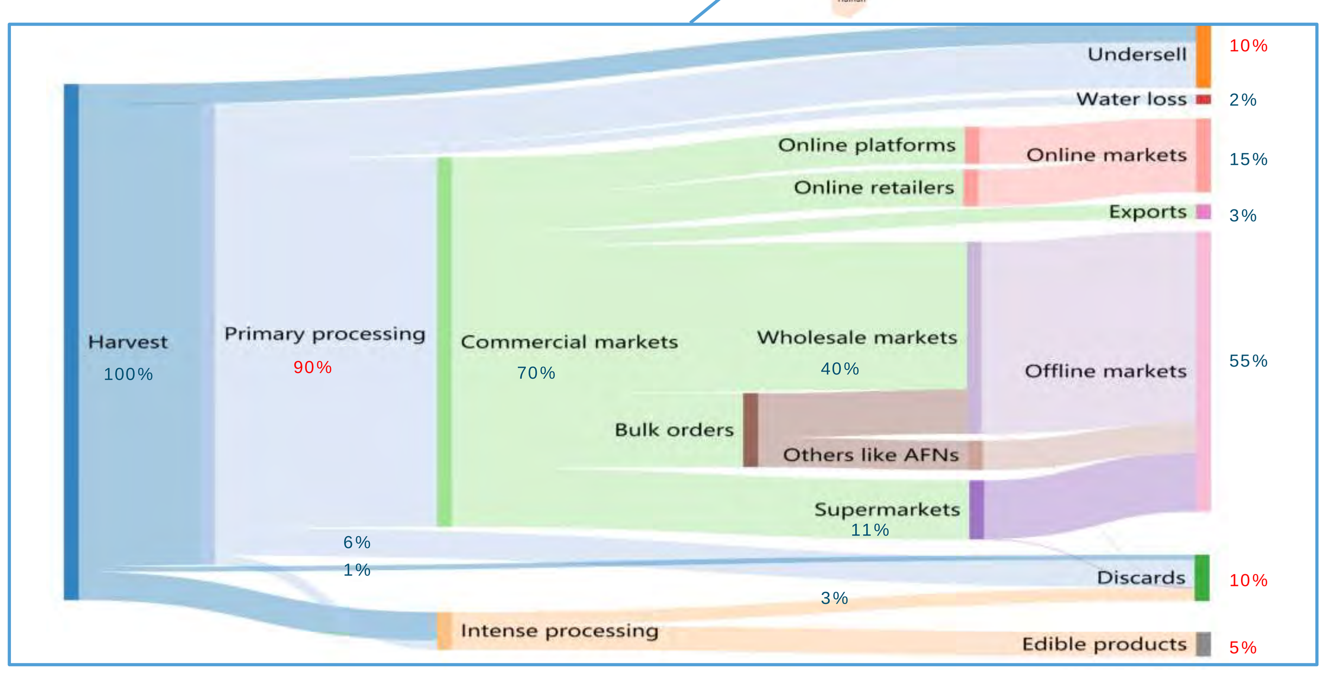


In many developing countries, fresh FSCs are combined with a segment towards food manufacturing industry. Figure shows an example of an integrated naval orange FSC in China.

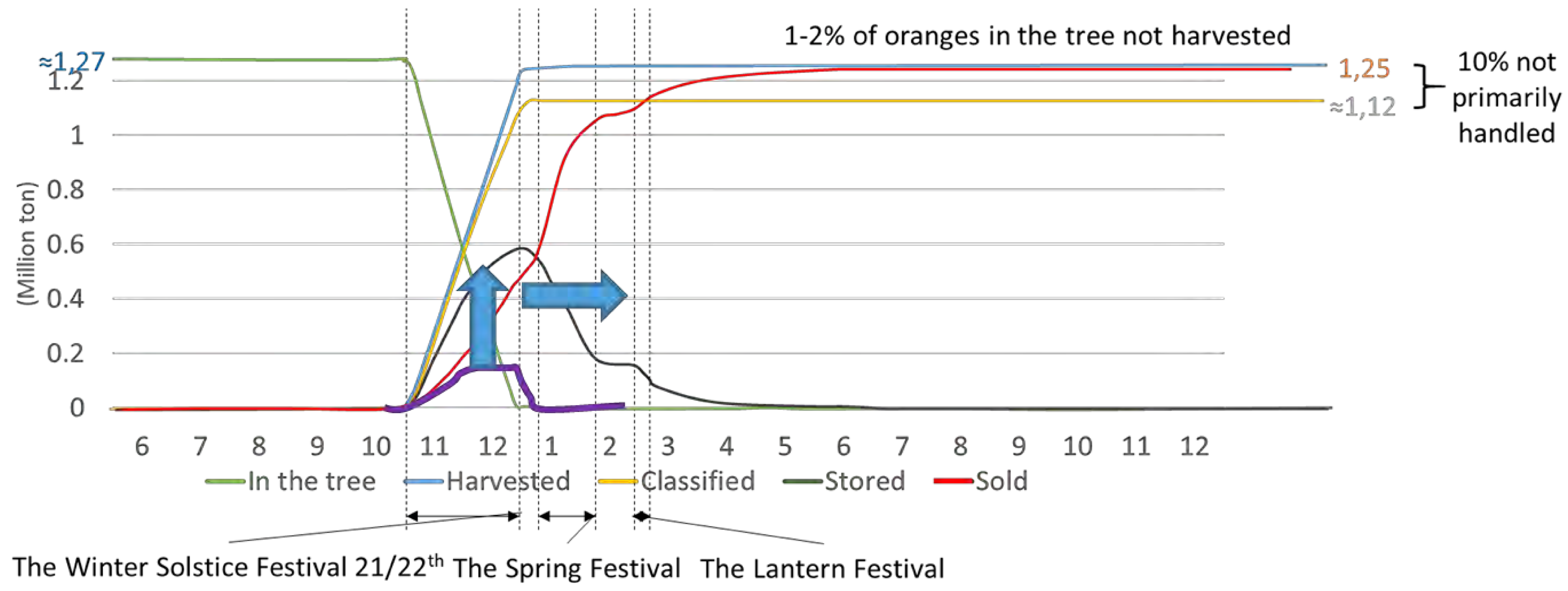
2. Case background

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

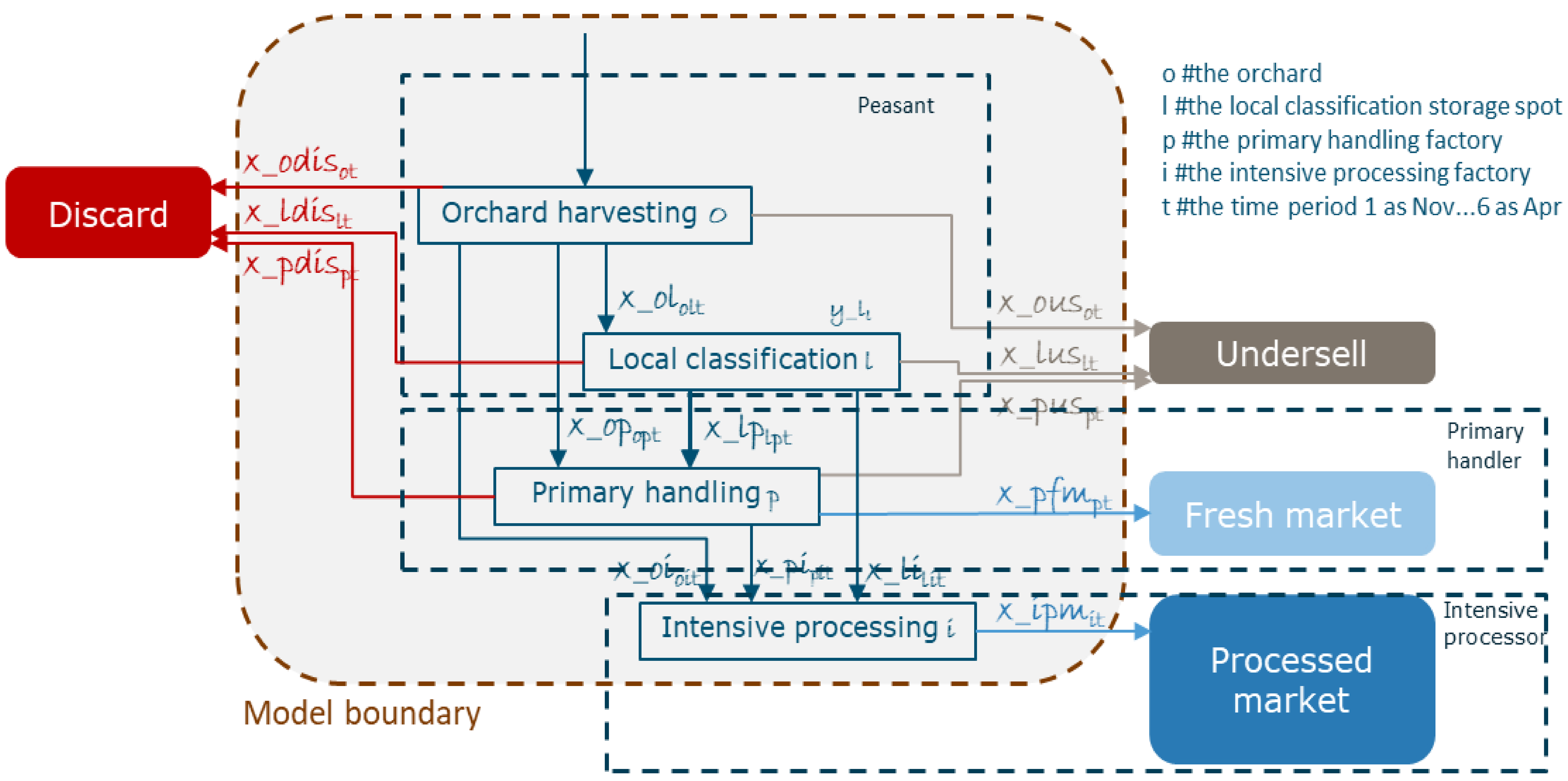
→Classify the oranges earlier (less FLWs, less transportation amounts, less mechanical physical harms to products)

- 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)

Sustainable, Healthy, Affordable, Reliable and Preferable Diets in China

Sustainable Diets: Respecting the Food Cultures

PhD Student: Zhiyao Chang
Supervisors in CAU: Prof. Yuanying Ni; Prof. Xin Wen; Prof. Shenggen Fan; Prof. Fusuo Zhang
Supervisors in WUR: Prof. Pieter van 't Veer; Prof. Elise Talsma; Dr. Sander Biesbroek; Prof. Edith Feskens

Background

In China, overconsumption and unhealthy diets cause a massive burden of malnutrition, which as a result leads to undernourished, overweight and non-communicable diseases, there were more than 300 deaths per 100,000 population in China in 2017 due to dietary risks. Modern diets not only impact health, but also the environment. The share in global GHG emissions of China in 2018 is 26.8%, and almost 30% anthropogenic emissions of which is caused by food systems. And nowadays, there are at least 1.58 billion people cannot afford EAT-Lancet reference diets, which are considered as the most healthy and environmentally sustainable recommended diets around the world.

In 2010, the Food and Agriculture Organization (FAO) proposed that sustainable diets are, according to the definition, diets with low environmental impacts, which contribute to food and nutrition security, and are respectful of biodiversity and ecosystems, cultural acceptability, accessibility, economically fair and affordable.

First, in terms of health, moderate energy intake and nutrients adequacy can keep healthy weight and prevent us from undernourished and non-communicable diseases. Secondly, as to environmental sustainability, which refers to respecting the planetary boundaries. For affordability, the prices of food should be affordable and equally distributed. With regard to reliability, dietary patterns must be consumer-oriented by complying with regional and national food cultures and dietary habits. Finally, for preferability, the majority of food items are accessible to consumers and have not been contaminated, which could guarantee 'food security' and 'food safety'.

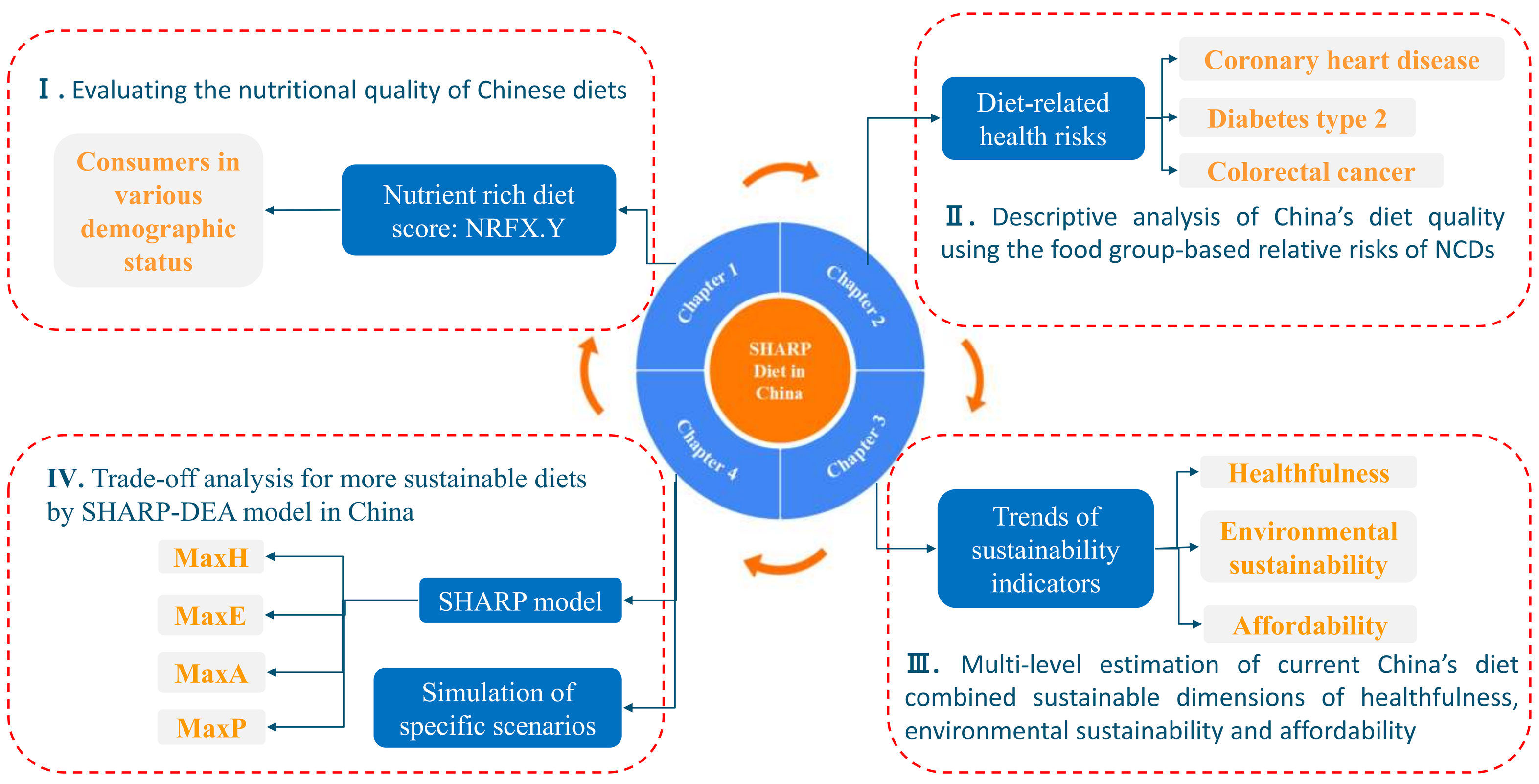
There is thus an urgent need to transform both Chinese food production systems and food consumption patterns. This thesis focusses on the design of sustainable diets for Chinese consumers by trade-offs analysis with these five aspects.

Figure.1 Concept of SHARP diets

Objectives

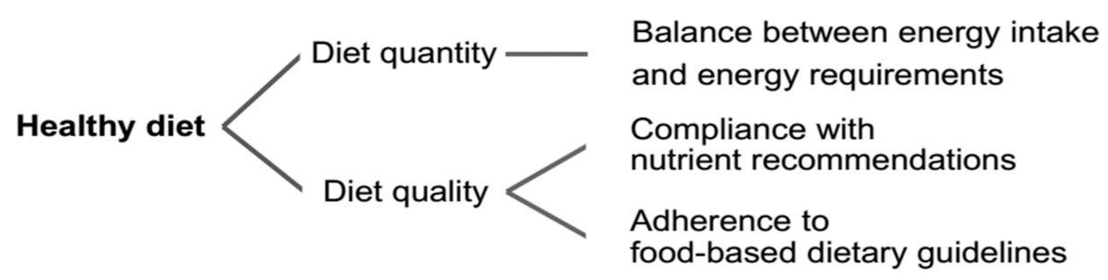
1. Diet quality analysis based on data from the latest CHNS surveys using the Nutrient Density Score, Healthy Diet Indicator or other indices.
2. Descriptive modelling of Chinese diet quality by food items (food groups) and demographic variables.
3. Trade-off analyses of Chinese diets among health, sustainability, affordability, reliability and dietary preferability

Framework



Methods

1) Diet quality analysis:



2) Descriptive modelling of diet quality by food items/food groups, regions and demographic variables:

1. Assessing the diet quality and nutritional quality

2. Healthfulness, environmental impacts, and monetary costs of Chinese diets

3. Optimization of more sustainable diets considering the acceptability

3) SHARP-DEA model:

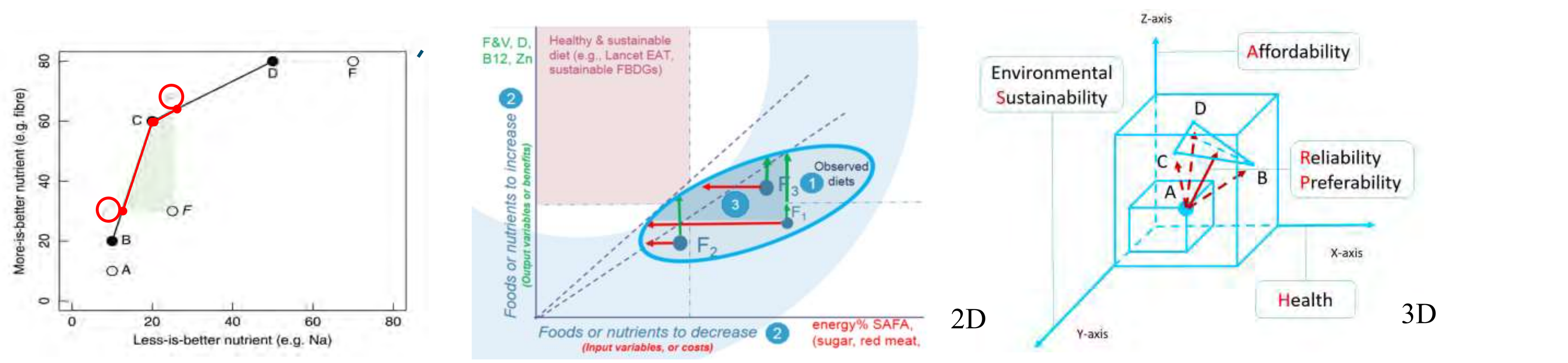


Figure.2 Concept of SHARP-DEA Model

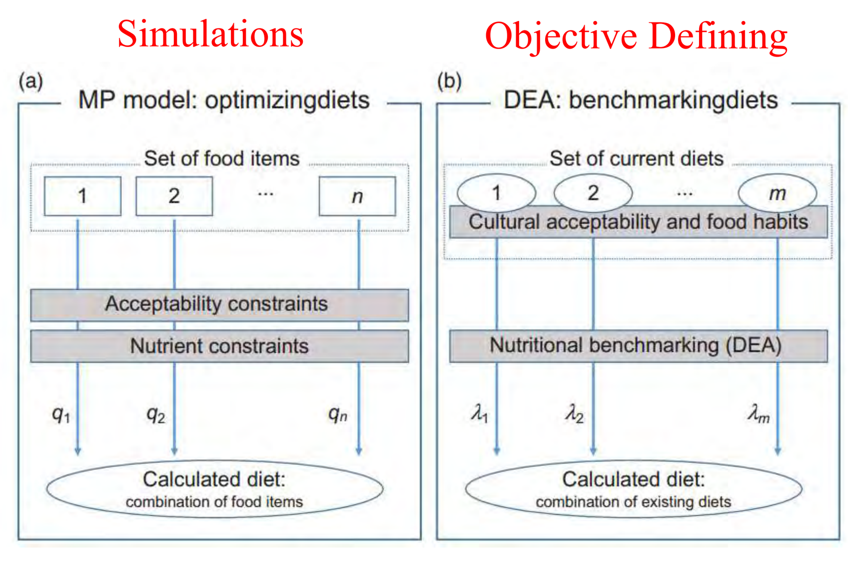


Figure.3 Comparison between model approaches

Results

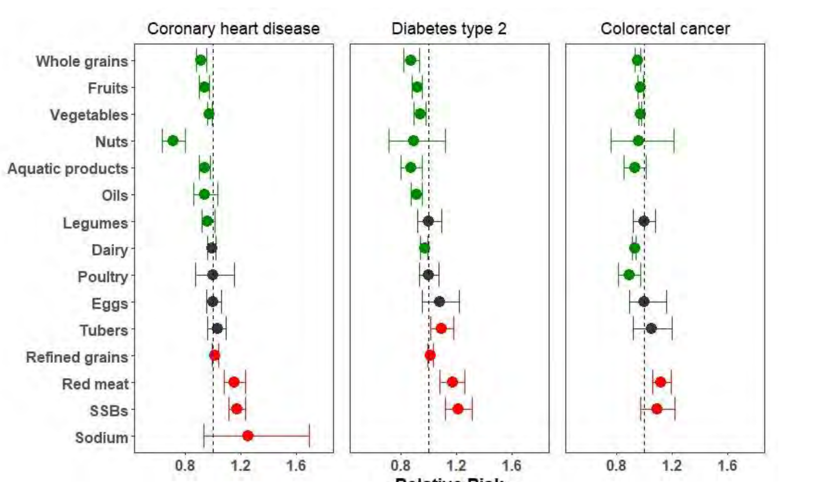


Figure 4 Summary of relative risks of coronary heart disease, diabetes type 2, and colorectal cancer for different food groups per serving size.

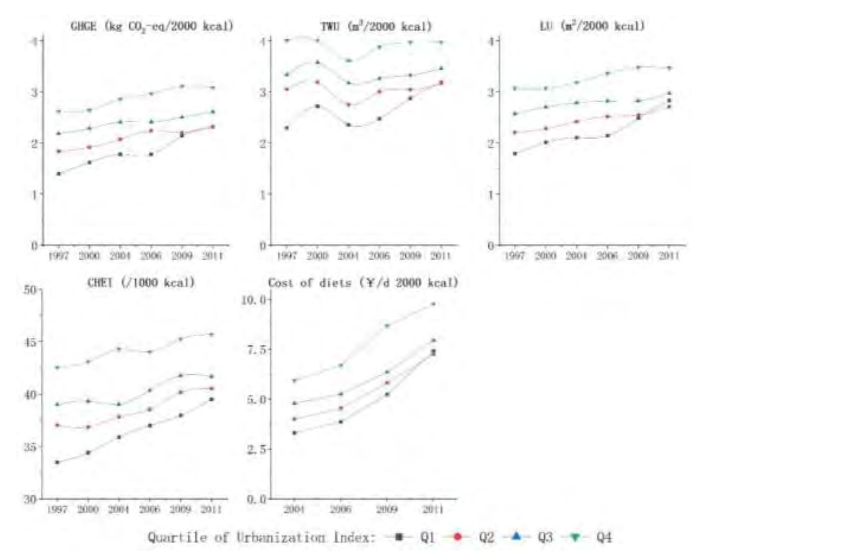


Figure 5. Diet-related GHGE, TWU, LU, CHEI2016, and cost of diet by quartiles of the urbanization index in the CHNS 1997-2011.

Acknowledgements

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

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Optimization and realization of green planting technology system for main crops based on multi-objective coordination

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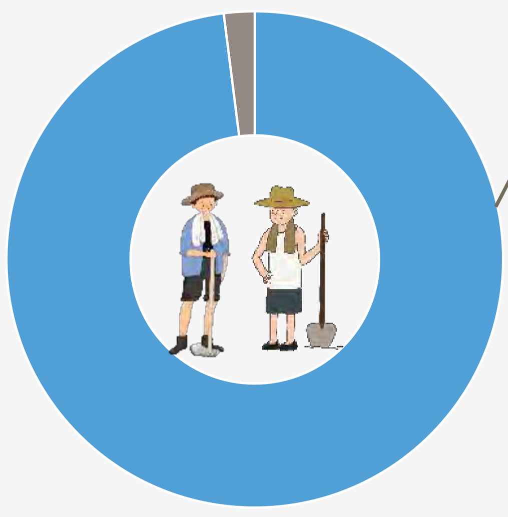
1. National Academy of Agriculture Green Development, CAU
2. Environmental Policy Group (ENP), WUR
3. Environmental Economics and Natural Resources Group (ENR), WUR

1. Background



200–300 million smallholders
98% agricultural operators

Basic national condition of China:
Smallholders dominate the country agriculture

Fertilizer, Pesticide, Water, etc …

Large inputs

Recent decades → Conventional extensive management →

High yield

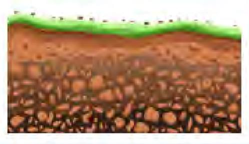
Environmental & resource unsustainability

How to optimize planting practices to achieve multi-objective coordination?

2. Methods

Sustainable practice bundles

Soil management
- Fertilizer
- Tillage
- Straw



Crop cultivation
- Variety
- Sowing date/rate
- Harvest date

Sustainable smallholder farming system

Food security
- Yield

Economy sustainability
- Output/Input
- Labor productivity

Smallholder farmers

Resource sustainability
- Emergy sustainability index
- LCA energy consumption
- LCA water consumption

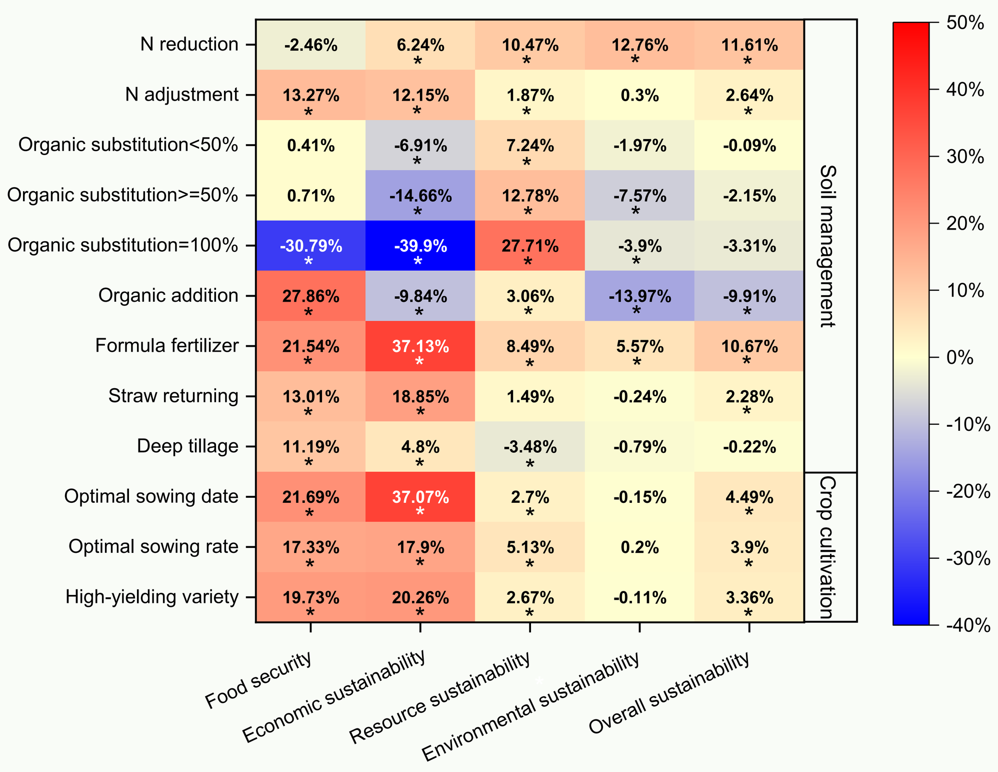
Environment sustainability
- LCA global warming potential
- LCA soil acidification potential
- LCA aquatic eutrophication potential

Construction of realization pathway

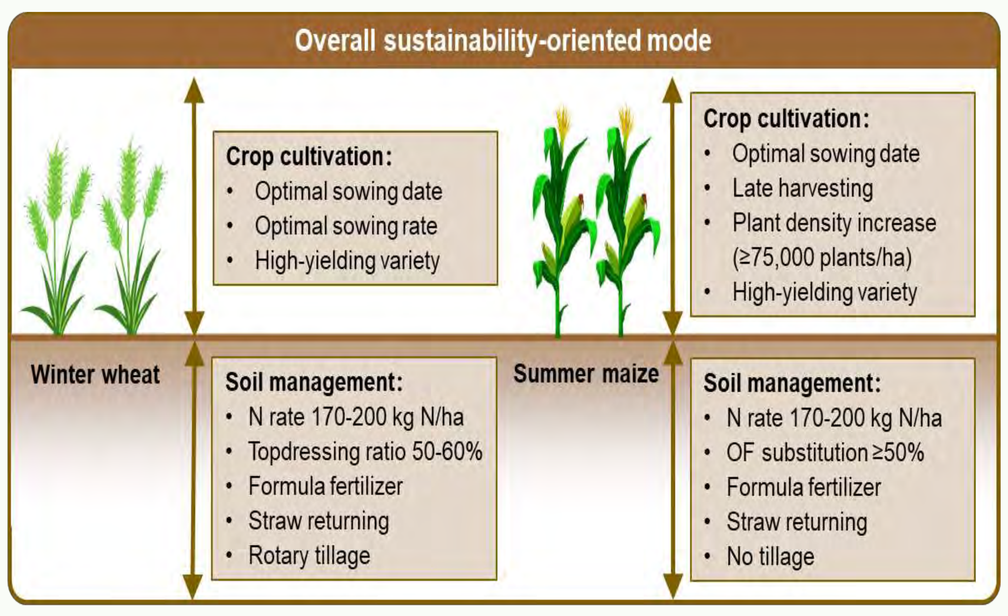
Social practice theory
Competence, Material, Meaning

Sociotechnical system
People, Technology

3. Results



Effect size of the optimized practices



Objective-oriented sustainable prototypes

4. Conclusions

- Sustainability assessment method proposed in this study can significantly distinguish the sustainability degree of different smallholder groups.
- Different oriented-prototypes consist of different crop cultivation and soil managements.
- Agriculture green transformation requires not only optimized practices, but also economy and policy support.
- Realization of green transformation pathway should involve smallholder farmers, and take their competence, materials, and meaning into consideration.

Acknowledgements

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

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Smallholder farmers' sustainability practices in the North China Plain——insights from China's Science and Technology Backyards

Supervisors: Annah Zhu(WUR), Xueqin Zhu(WUR), Simon Bush(WUR), Chong Wang(CAU)
Poster author: Xiaodan Li

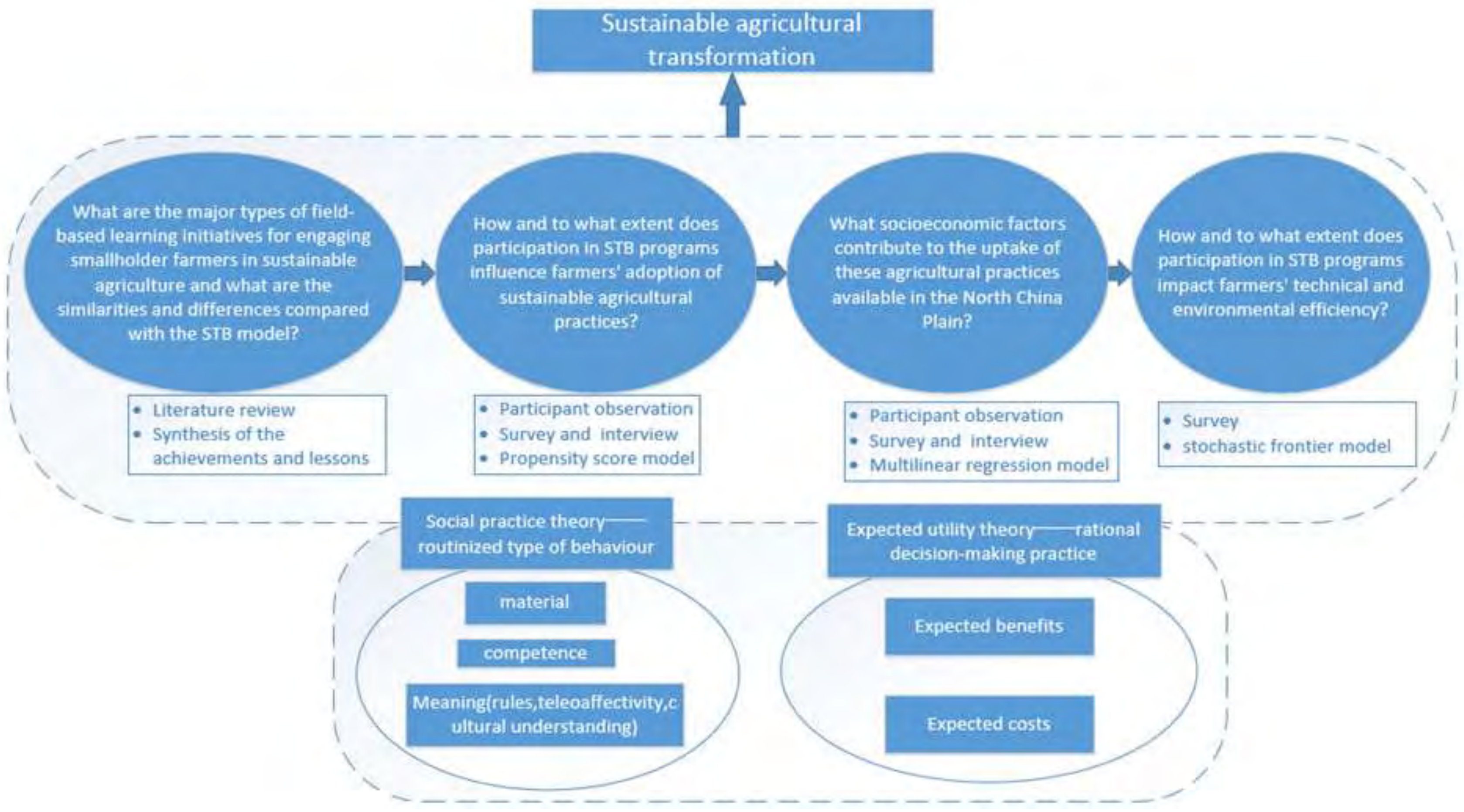
Background

- Science and technology backyard linking researchers in the university and smallholder farmers can foster knowledge co-production and nudge technology transfer, which addresses the pitfalls of traditional farmer field school for not delivering what farmers' needs. It is time to generalize what works well for farmers and what not and how can things be improved for farmers to accept better technology

Objectives

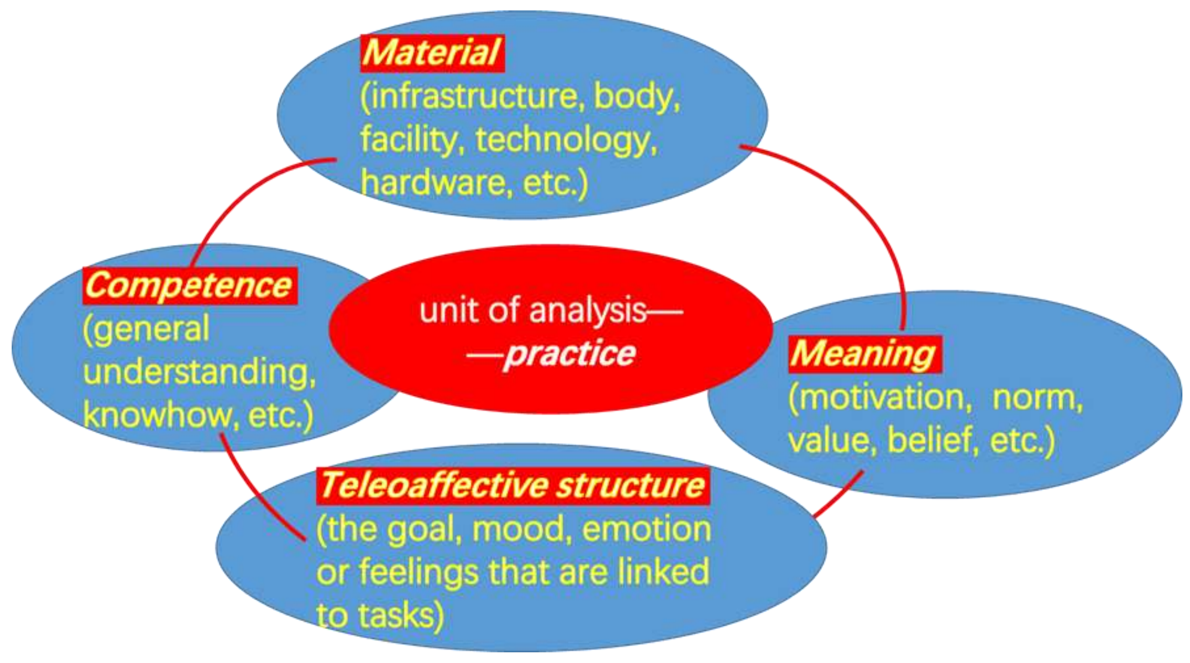
- An understanding of the socio-economic factors and the local-based learning mechanisms that influence farmers' adoption of more sustainable practices may help policymakers design initiatives to accelerate the process of technology diffusion and the uptake of new social practices.

Research framework



Theoretical lens

- ■Rational choice maker
  - ●Lack of unconscious influences on people's behavior
  - ●Lack of observations on people's everyday routines
- ■Different perspective
  - ●Social practice theory



Research progress

- The purpose of this literature review study is to compare different versions of farmer participatory research aiming to improve the diffusion of sustainable practices and afford insights into policy implications, with a focus on the participatory technology extension model. The main research question of the literature review is as follows:
- What are the major types of participatory initiatives for engaging smallholder farmers in diffusing sustainable practices (e.g., farmer participatory research, innovation platforms, etc.), and what are the similarities and differences compared with the STB model?
- Methodology: literature review (1990-2022)
- Five types of participation (Ashby, 1996)
  - Nominal participation
  - Consultative participation (most common type)
  - Action-oriented participation (most common type)
  - Decision making participation
  - Collegial participation

Acknowledgements

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

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Predicting nitrogen use efficiency of individual dairy cows by mid-infrared spectra

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WAGENINGEN UNIVERSITY & RESEARCH

中国农业大学 China Agricultural University

Background

- N surpluses at dairy farms have adverse impact on the environment.
- But milk production will increase in China --> increase of N surplus
- Unless nitrogen use efficiency (NUE) of dairy cows can be improved.
- But how to measure NUE?
- Proxies for NUE and nitrogen loss (NL) based on input (N intake), output (N milk) and the difference (N surplus).
- Dry matter intake (DMI) required for N intake.
- Can mid-infrared (MIR) spectra play a role in these proxies?

Objectives

- Prediction of individual NUE, NL, and DMI.
- From MIR spectra and daily milk yield records.

Materials and Methods

- 56 Chinese Holstein cows in a free-stall design farm (in Beijing).
- Days in milk ranged from 154 to 452 days.
- Same diet during the experimental period.
- Data: daily DMI, milk yield, protein contents, MIR spectra etc.
- N milk = protein output in milk / 6.38
- N intake = protein input in feed / 6.38
- NUE = N milk / N intake NL = N intake − N milk
- After data editing, 600 records were retained for prediction.

Results

Calculating individual NUE, NL and DMI

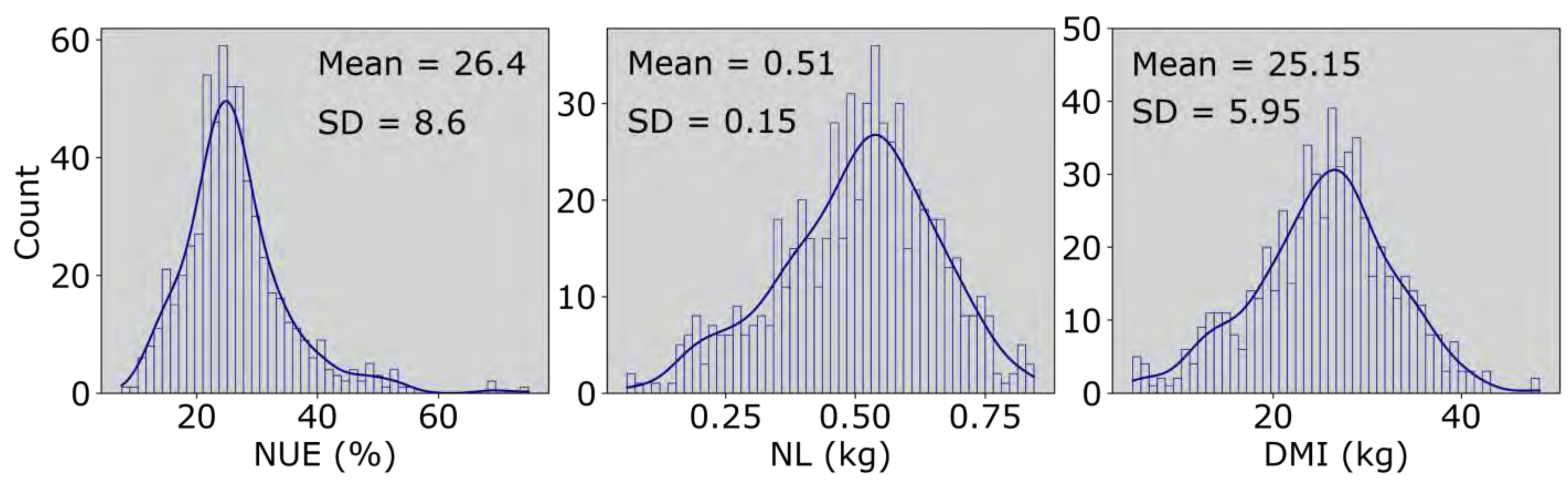

Figure 1. Distribution of individual nitrogen use efficiency, nitrogen loss and dry matter intake.

Best prediction models

- Six prediction models were tested for each trait (Table 1).

Table 1. Prediction models for nitrogen use efficiency, nitrogen loss and dry matter intake.

Model	Predictors	# Variables
1	MIR	215
2	MIR + Milk yield + Parity	217
3	MIR + Milk yield + Parity + Body condition score (BCS)	218
4	MIR + Milk yield + Parity + BCS + DIM group	219
5	MIR + Milk yield + Parity + BCS + DIM group + Days in pregnancy (DIP)	220
6	Milk yield + Parity + BCS + DIM group +DIP + Milk urea nitrogen + Protein + Fat + Lactose	9

- Model 2 was the best model for predicting NUE and DMI, while model 1 was the best for predicting NL (Figure 2).

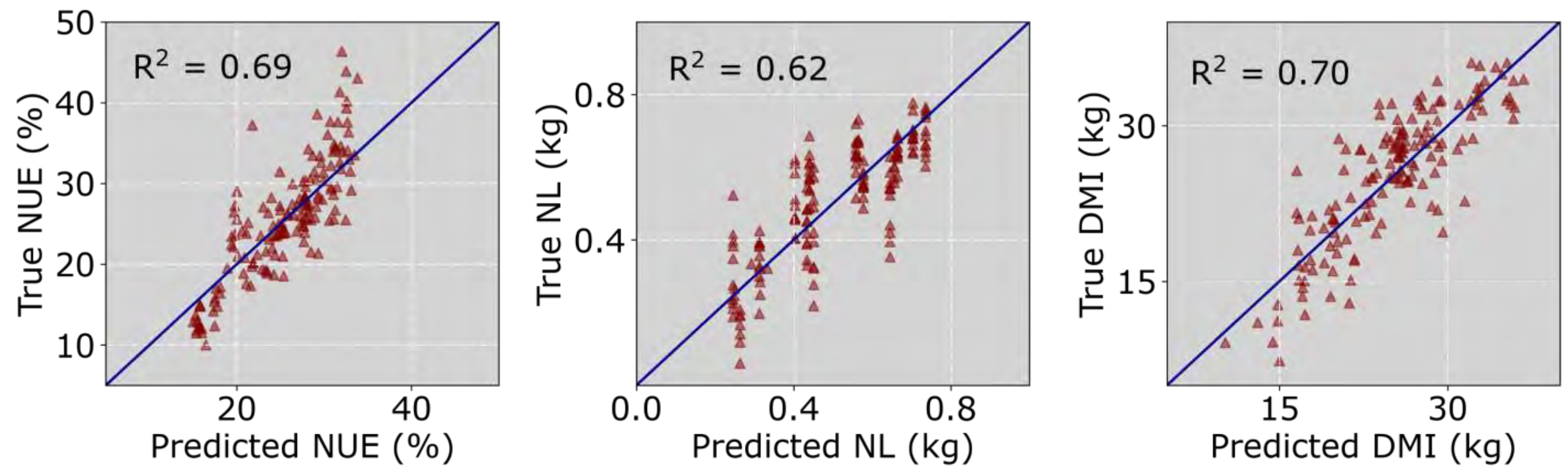

Figure 2. Plot of measured and predicted individual nitrogen use efficiency, nitrogen loss and dry matter intake by the best models.

Important features

- Feature score: the absolute value of the corresponding regression coefficient in prediction models.
- Daily milk yield, MIR wavenumbers around 988.5 cm^{-1}, 1182.4 cm^{-1} and 1354.0 cm^{-1} (Figure 3) were important features.

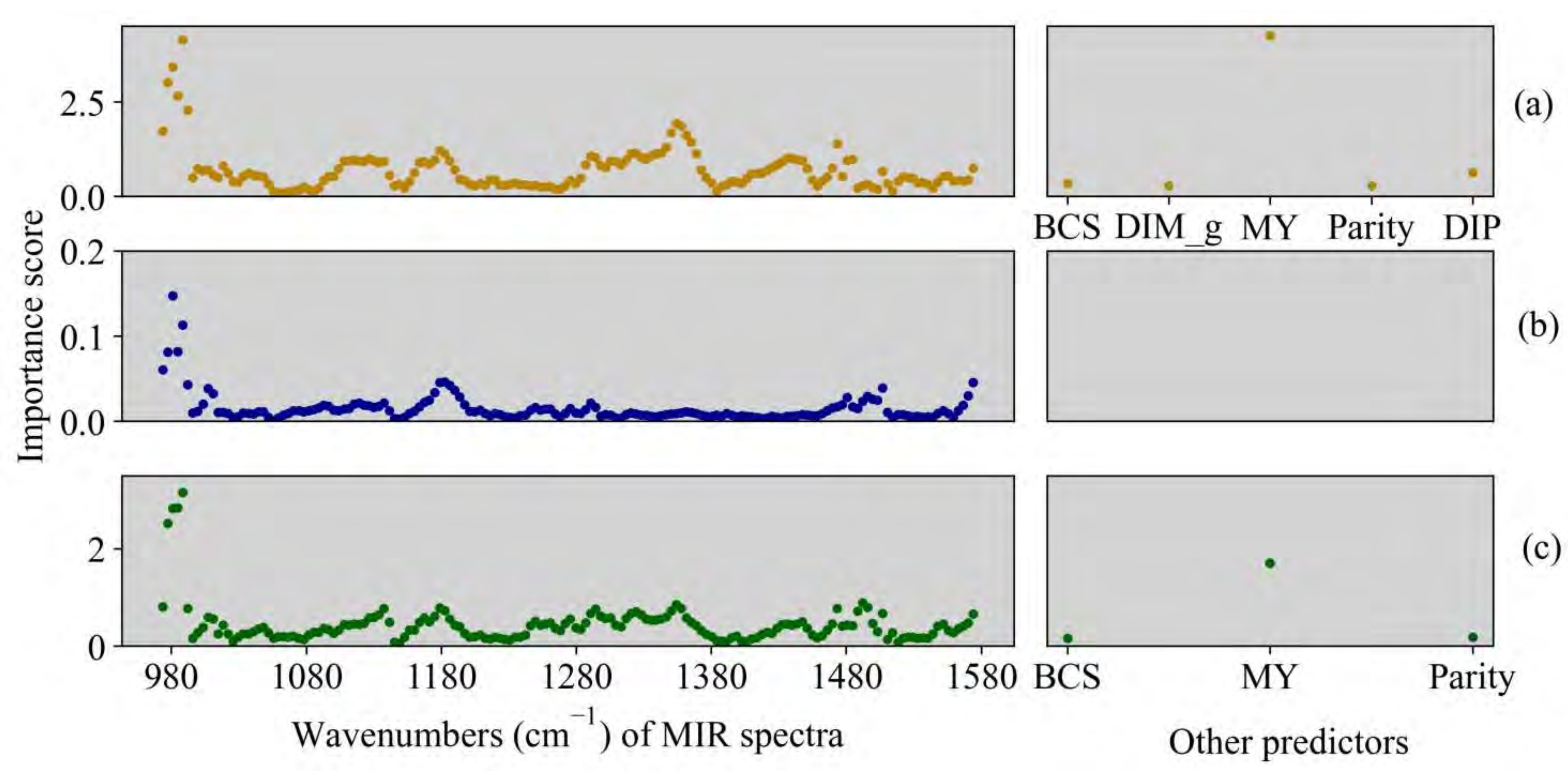

Figure 3. Feature importance score across mid-infrared wavenumbers for predicting individual nitrogen use efficiency, nitrogen loss and dry matter intake.

Discussion

- Best prediction models for NUE, NL and DMI included MIR spectra and few additional predictors (model 1 and model 2).
- Milk yield was an important variable in all models: highly correlated with N milk (pearson correlation = 0.96).
- The specific wave range of MIR comprised C-H, C-N and N-N stretching, which is related to proteins, thus contributed significantly to the prediction of N-related traits.

Conclusions

- Including MIR spectra for predicting NUE, NL and DMI resulted in a substantial increase of R^2.
- The prediction models will be used in genetic evaluation and in management support of dairy herds in China.

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University. The Beijing Dairy Cattle Centre is acknowledged for providing data. This research is supported by China Agriculture Research System of MOF and MARA.

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Legacy effects of legume-grass mixtures leys on phosphorus uptake and yield of maize at different growth stages

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

Background

Crop diversification is considered to be an important way for the sustainable development of cropping systems. Well-managed ley pasture could provide beneficial services including improved soil structure and increased forage and livestock production (Martin *et al.* 2020). However, how soil legacies of different legume-grass mixtures with phosphorus fertilizer application affect the establishment of follow-on crop and nutrient acquisition remains largely unknown.

Objectives

In this study,we hypothesized that:

(i) The legacy effect legume-grass mixture on the performance of a subsequent forage maize crop depends on the legume proportion

(ii) The level of phosphorus fertilization in the previous legume-grass mixture can create different P-legacy effects and affects the P uptake in a subsequent maize crop

Methods

The ley pasture system was established over a period of 5 years (2016–2020) using a split-plot design (Fig. 1). The main plots were treated with different legume and grass seeding ratios (L: G ratio) of 3:7, 4:6, 5:5, 6:4, and 7:3, or one of the four monocultures of each species. The subplots were treated with phosphorus fertilizer (superphosphate) including four levels (0, 40, 80, or 120 kg ha−1 P_2O_5) (hereafter 'P levels'). The pasture was harvested on May 9, 2021 and maize (Zea mays) was sown on June 6, 2021.

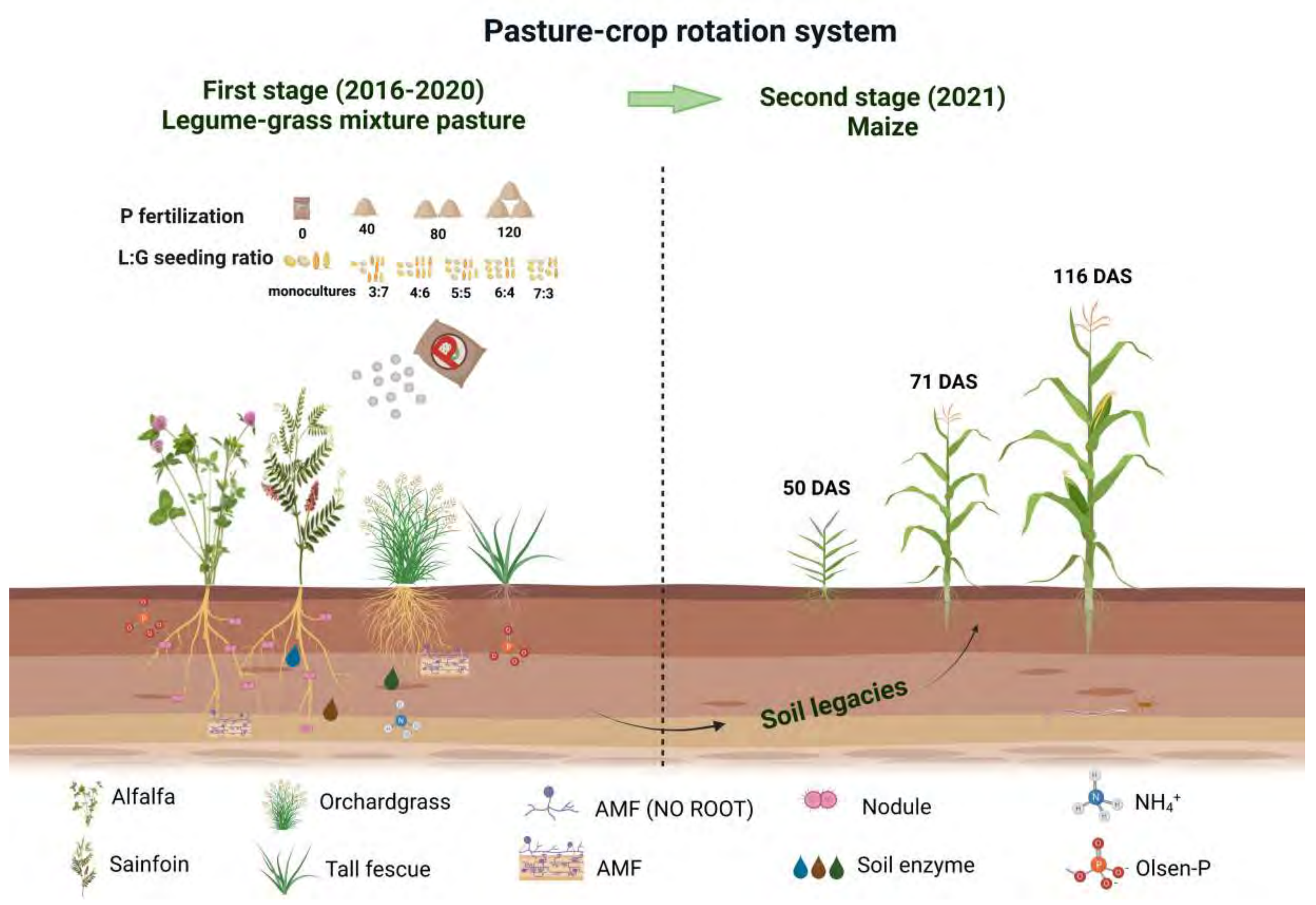


Fig. 1 Scheme of experimental design.

Results

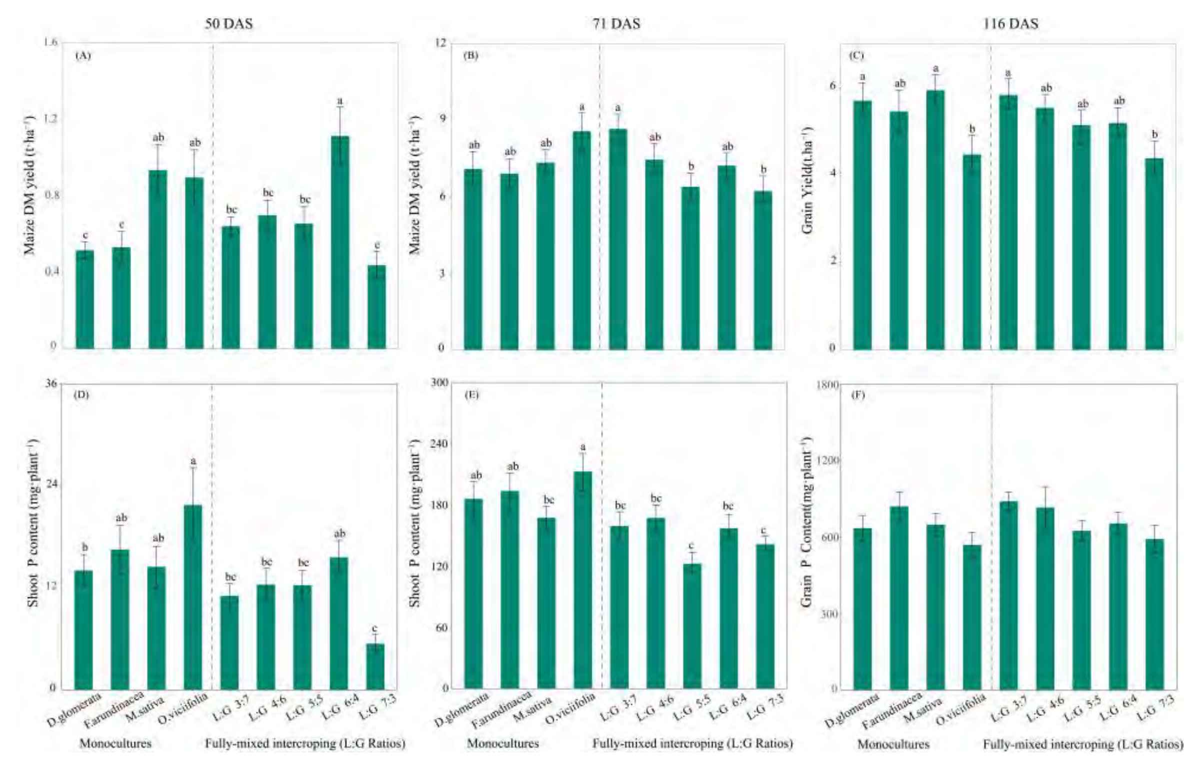


Fig. 2 The aboveground biomass in the jointing stage (V6; A), big trumpet period V12; (B) and grain yield (C), P uptake in the jointing stage (V6; D), big trumpet stage (V12; E) and grain P uptake (F) in different monocultures and fully-mixed legume-grass mixture obtained in a subsequent crop of maize.

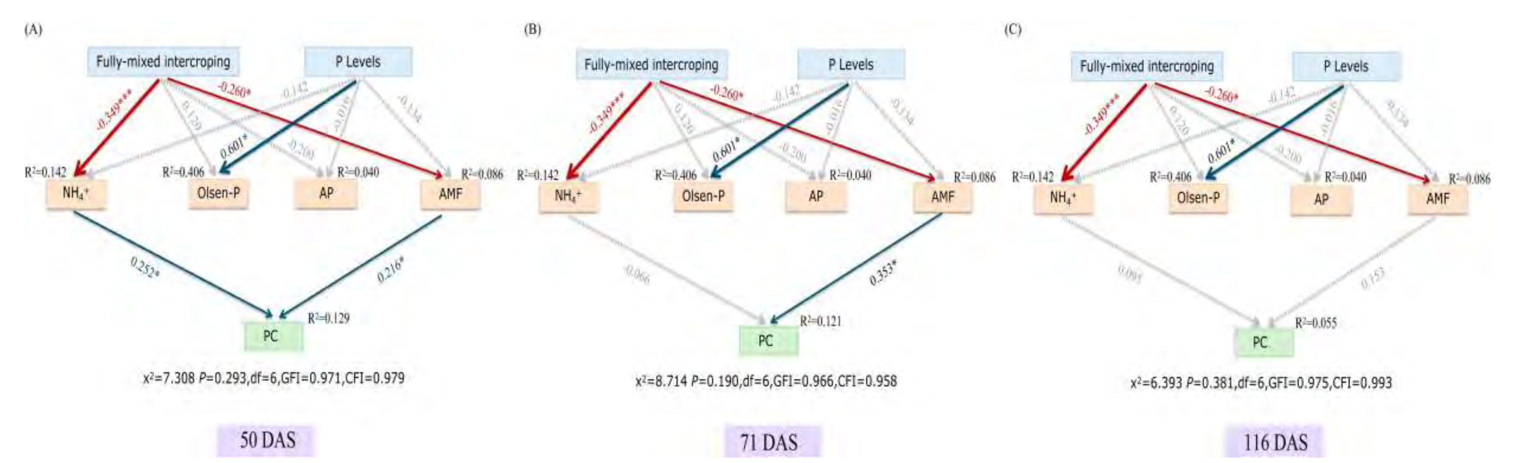
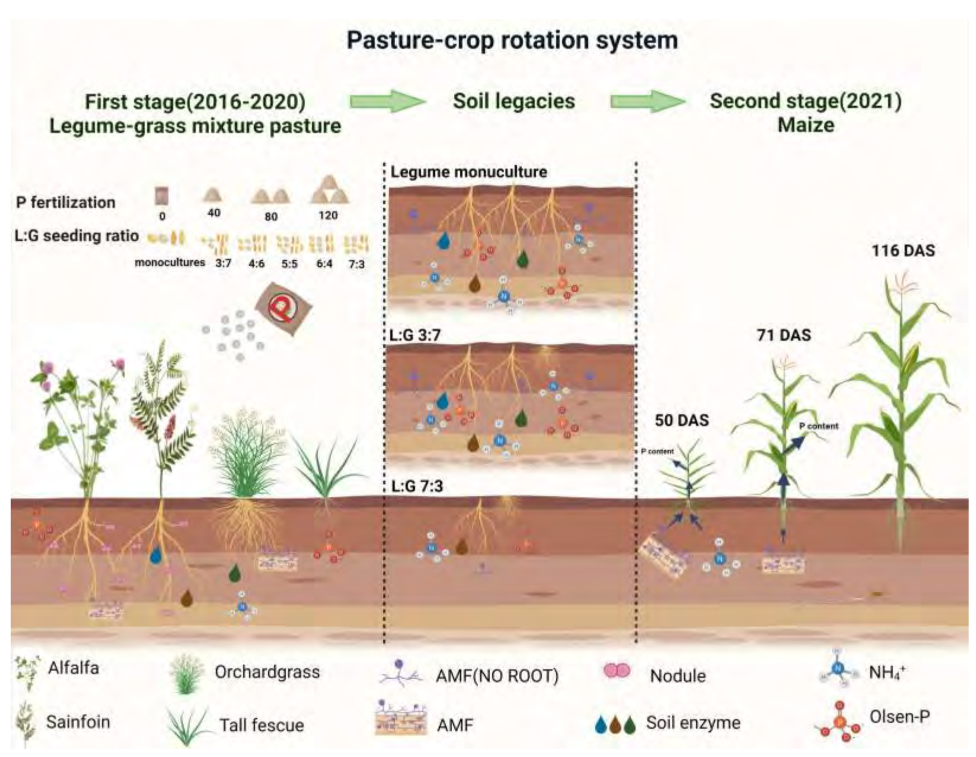


Fig. 3 Plant P contents in the jointing period (V6; A), big trumpet stage (V12; B) and grain P content (C) of maize are differentially affected by soil abiotic and biotic legacies. Path analyses show the relationships between soil NH_4^+, Olsen-P, AP, AMF at the end of sward and P contents in follow on crop of maize.

Conclusions



(i) 30% legume proportions in the previous legume-grass mixture had a comparable positive legacy with legume monoculture.

(ii)The positive legacy effects gradually decrease or even disappear as the follow-on crop grows.

Mediene, S., Moreau, D., Valentin-Morison, M., Novak, S., Parnaudeau, V., Paschalidou, F., Vertès, F.o., Voisin, A.-S., Cellier, P. & Jeuffroy, M.-H.l.n. (2020) Role of ley pastures in tomorrow's cropping systems. A review. *Agronomy for Sustainable Development : A journal of the French National Institute for Agriculture, Food and Environment (INRAE),* 40.
Schipanski, M.E., Barbercheck, M., Douglas, M.R., Finney, D.M., Haider, K., Kaye, J.P., Kemanian, A.R., Mortensen, D.A., Ryan, M.R. & Tooker, J. (2014) A framework for evaluating ecosystem services provided by cover crops in agroecosystems. *Agricultural Systems,* **125,** 12-22

Acknowledgements

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Forage quality in cereal-legume intercropping: A meta-analysis

Hao Liu
Supervisors: Yingjun Zhang, Jingying Jing, Paul 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, such as nitrogen fixation, pest and weed control. 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

Here 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 net effect is defined as the difference between the observed yield in the mixtures and the expected yield of mixtures of fodder from equivalent monocultures at the same mixing ratio. A positive value means that crops intercropped at a certain seeding ratio have a higher yield compared to sole crops mixed in the same ratio.

$$NE=(Y1+Y2)-(EY1+EY2)$$
$$NE1=Y1-EY1$$
$$NE2=Y2-EY2$$

Where Y1 and Y2 represent the actual dry matter yields of species 1 and 2 in intercrop, whereas EY1 and EY2 represent the expected dry matter yields of two species, which were calculated as the products of the yield of each sole crop and its land share. Similarly, the net effects of CP, ADF, NDF and non-CP non-NDF yields can be calculated independently. NE1 and NE2 represent the partial net effect of the two intercrop species.

Results

Cereal legume intercropping results in a significant NDF yield advantage compared with sole crop, while the yield advantage of CP is not obvious. The partial net effects of legume crops of dry matter (-0.22±0.29 Mg/ha), CP (-0.14±0.13 Mg/ha), NDF (-0.34±0.22 Mg/ha), ADF (-0.13±0.15 Mg/ha) and non-CP non-NDF (-0.17±0.13 Mg/ha) yields were not significantly different from zero. Conversely, the partial net effects of cereal crops of dry matter (2.23±0.50 Mg/ha), CP (0.26±0.11 Mg/ha), NDF (1.56±0.71 Mg/ha) and non-CP non-NDF (1.04±0.48 Mg/ha) yields were higher than zero, while that of ADF yield (0.56±0.36 Mg/ha) was not different from zero significantly (Fig. 1b).

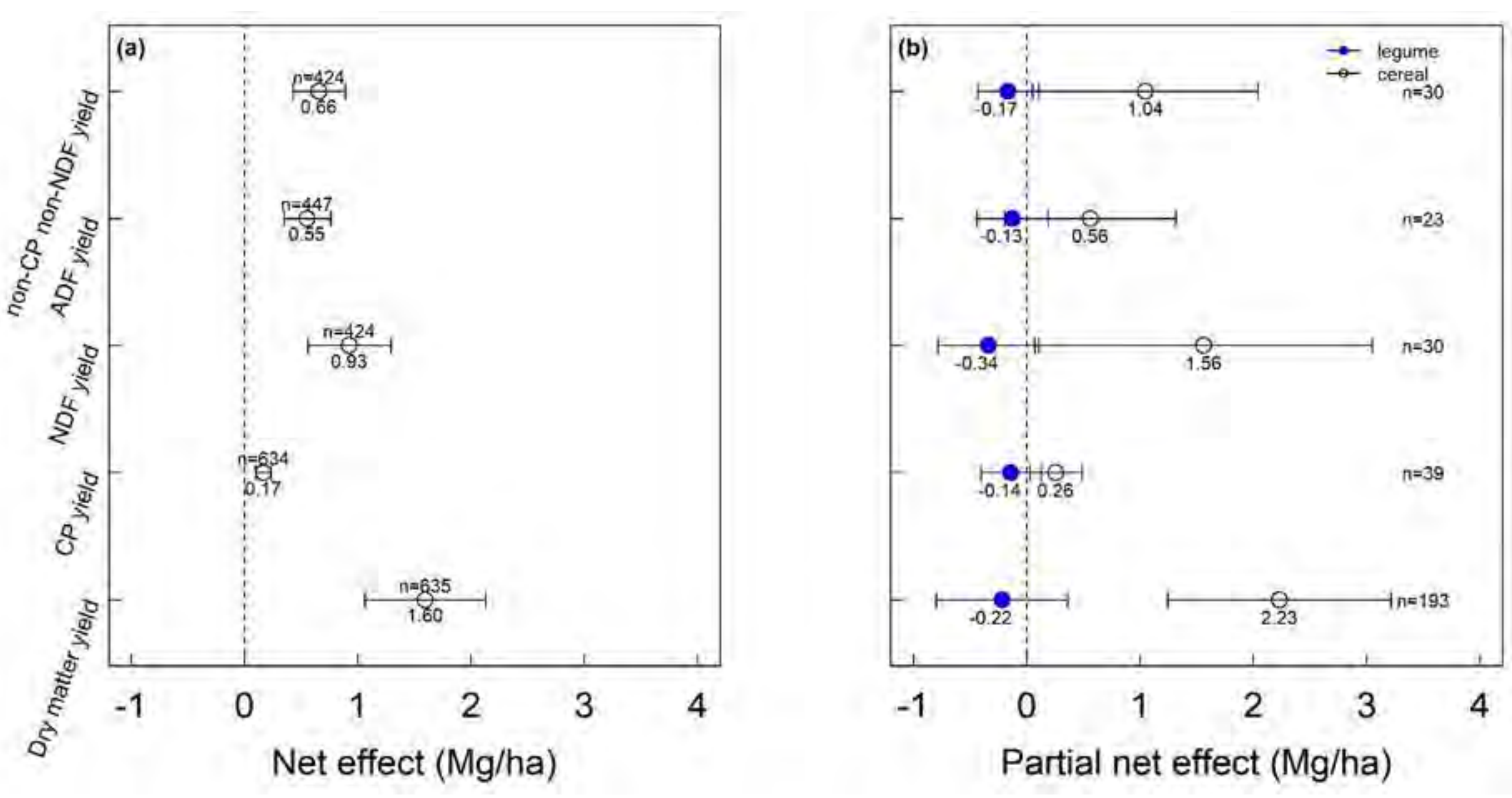

Fig. 1. The net effects (a) and the partial net effects (b) of cereal-legume intercropping calculated with the dry matter, CP, NDF, ADF and non-CP non-NDF yields of intercrops.

Conclusions

In this meta-analysis, we found that intercropping can significantly increase the dry matter, CP, ADF and NDF yields of cereal and legume fodder, however, fodder quality was lower as %CP decreased. A positive relationship was further found between RDT and the net effects of dry matter, NDF and ADF yields, when the mixtures contained annual cereal and perennial legumes, when cereals were harvested in their vegetative stage and legumes were harvested in their reproductive stage, when at higher N fertilization rate.

Acknowledgements

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

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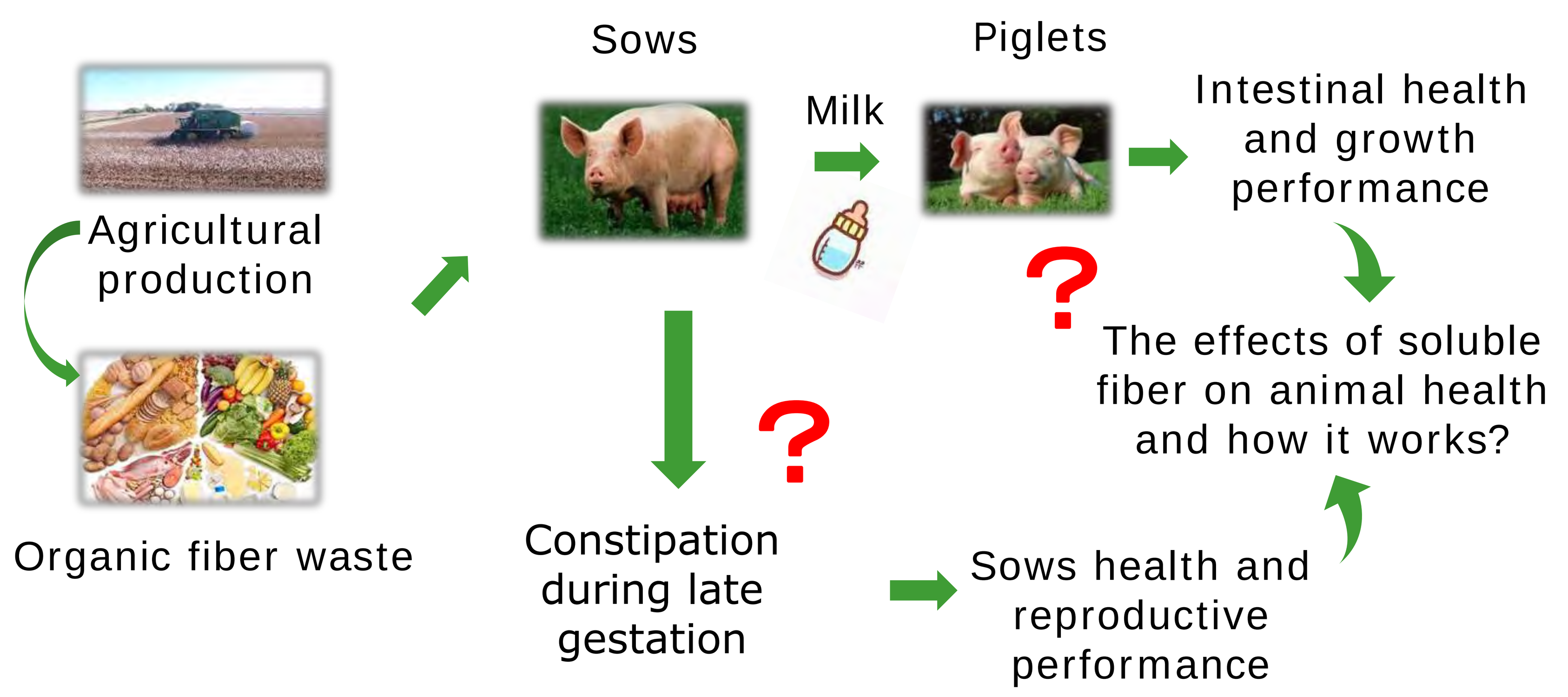
Effects of different fiber source on constipation and offspring health in lactating sows

PhD Candidate: Dongdong Lu
Supervisors: Junjun Wang; Defa Li; Nicoline Soede; Bas Kemp
Major: Animal Nutrition and Feed Science
Institute: State key laboratory of animal nutrition, College of animal science and Technology, China agricultural university, Beijing

Backgrounds



- There are a large amount of waste organic fiber were produced in agricultural production and food processing, including soluble fiber that can be used by animals.
- Dietary fiber is one of the essential raw materials in sow feed nutrition, which can affect the health of the mother and the health of the offspring.

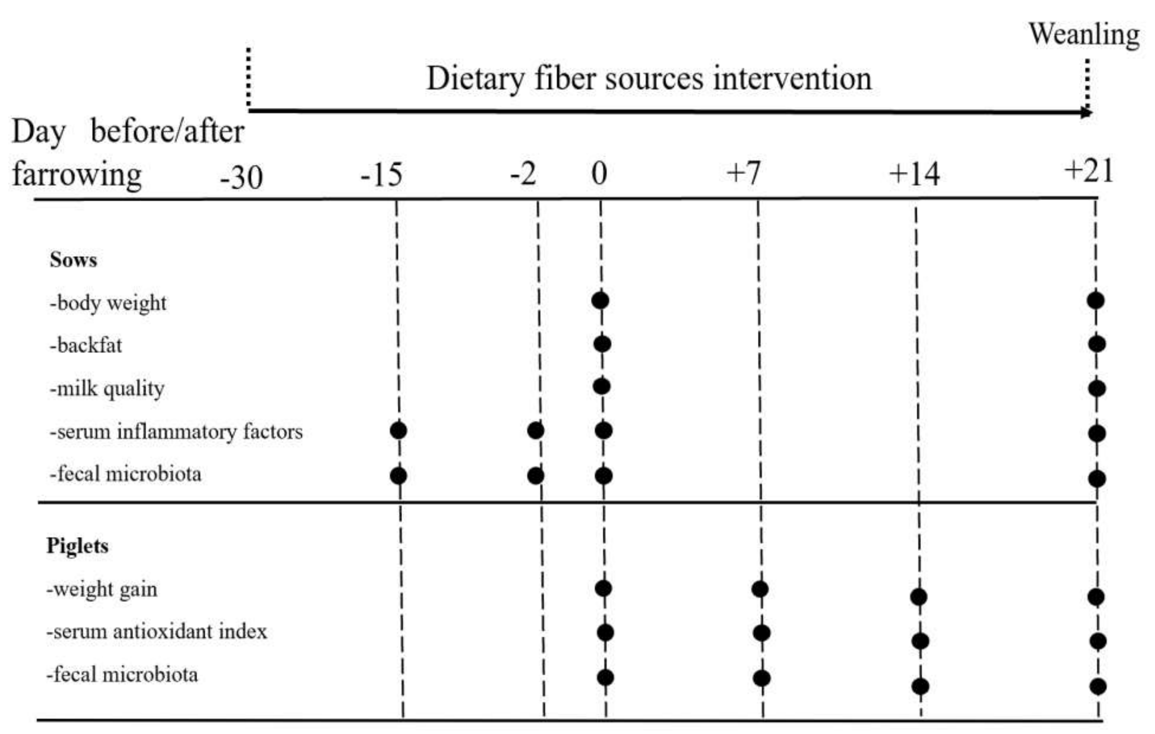
Objectives

- To investigate the effects of different fibers on the reproduction performance and constipation of sows.
- To investigate how different fibers affect piglets health through lactating and its mechanisms.

Progress

Animal designs

- Animals: a total of 80 sows were randomly allocated to 4 groups
- Diets design: Control (CON, basic corn-soybean meal) and one of three dietary fiber treatments with the same total dietary fiber (TDF) from day 85 of gestation to delivery. LIG (replace 1.5% of wheat bran with lignocellulose), PRS (replace 2.0% of wheat bran with resistant starch), and KON (replace 2.0% of wheat bran with konjaku flour.

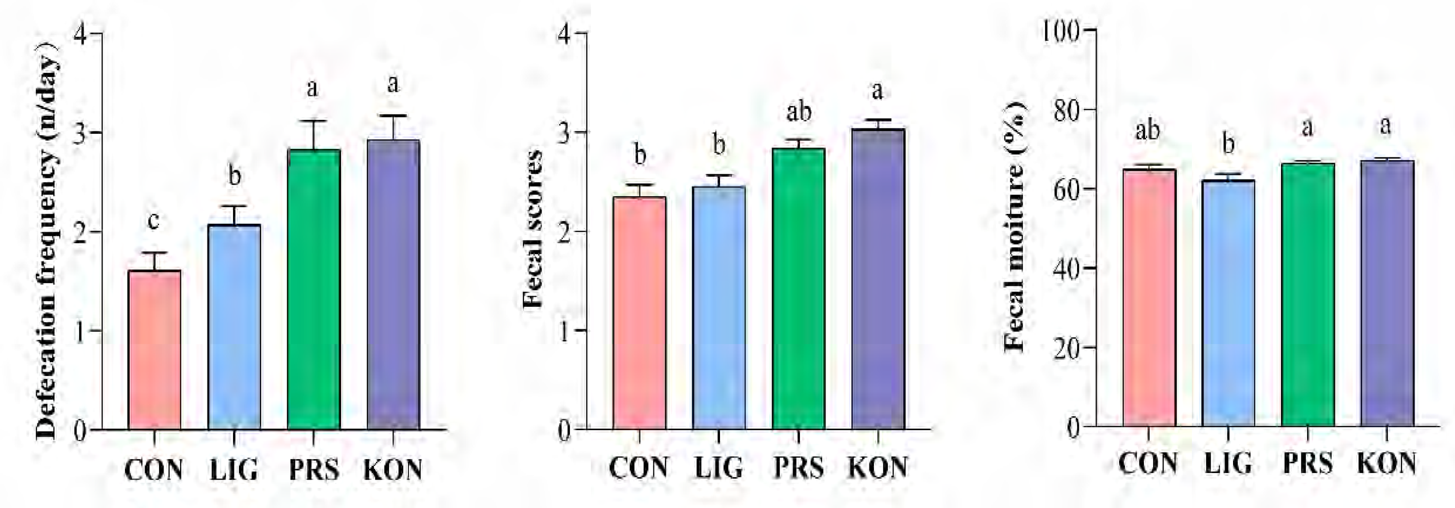


From day 109 to day 114 of gestation

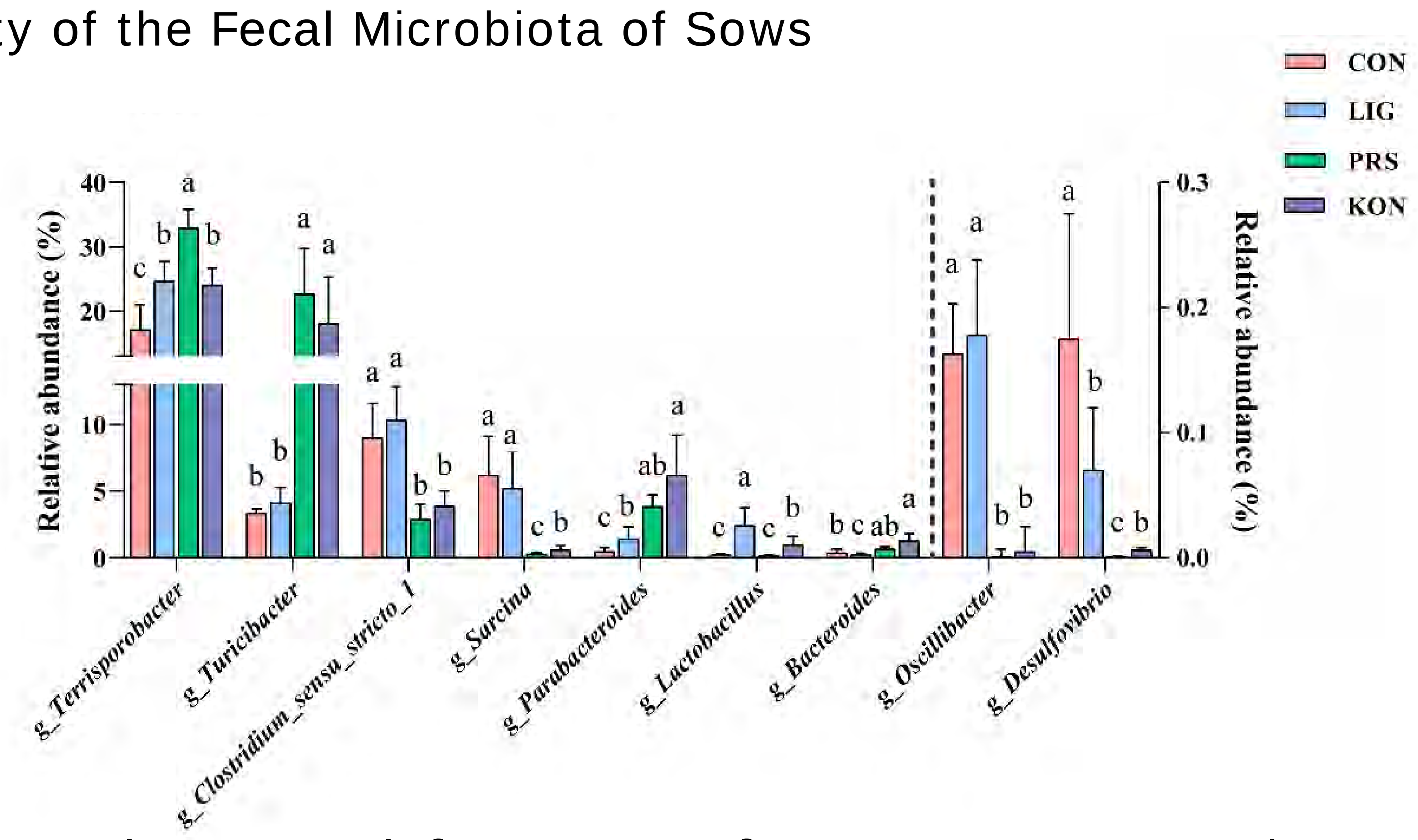
- **Defecation performances:**
  Defecation frequency
  Fecal moisture
  Fecal consistency scores
- **Gut motility regulatory factors:**
  5-hydroxytryptamine (5-HT)
  motilin (MTL),
  endothelin-1 (ET-1)
  acetylcholinesterase (AChE)

Results

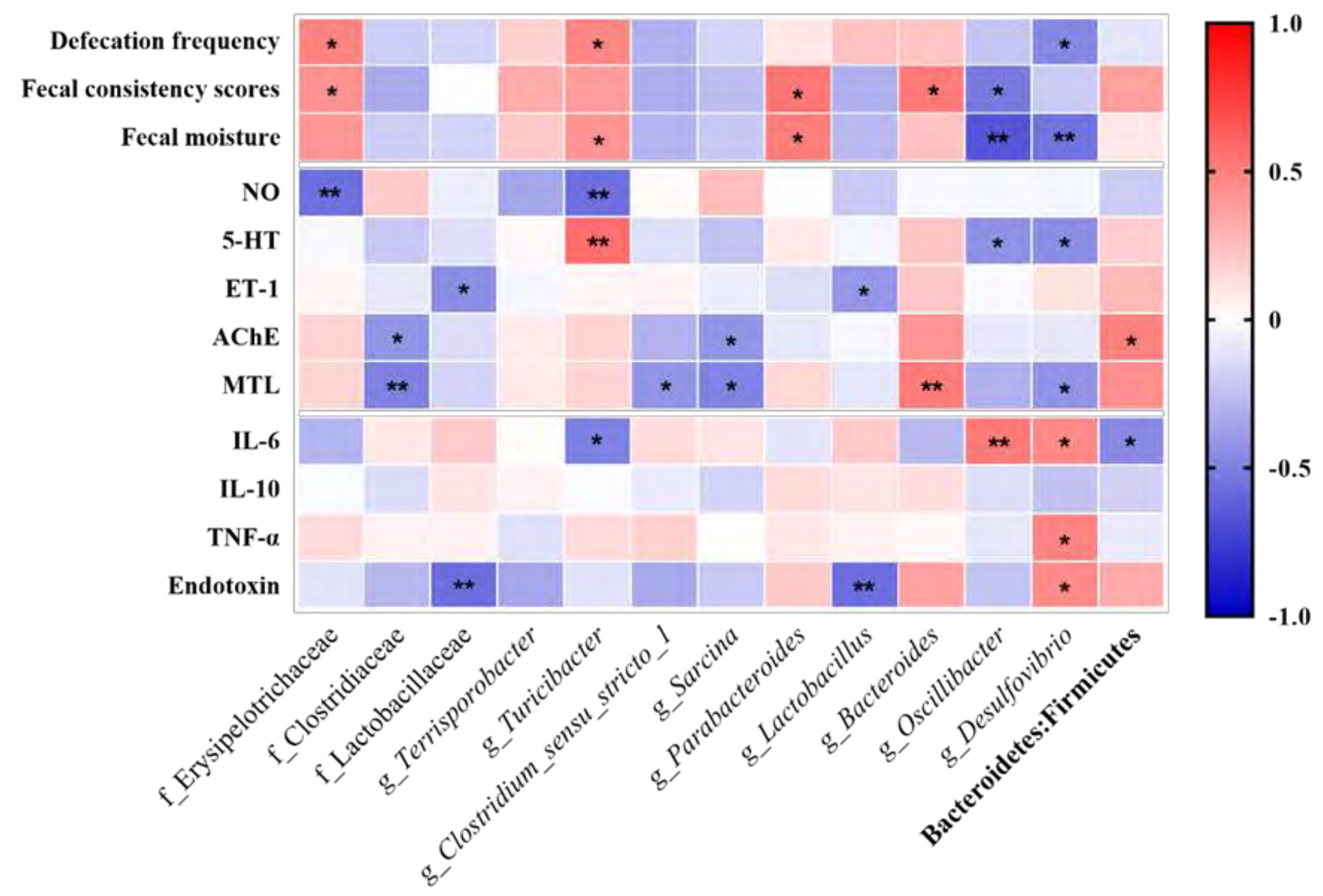
- Effects of Different Fiber Sources on the Defecation Frequency and Fecal Parameters of Sows



- Effects of Different Fiber Sources on the Composition and Diversity of the Fecal Microbiota of Sows



- Correlation between defecation performances, gut regulatory factors, inflammation factors, and differential bacteria



Relationship with AGD program

- Due to rapid development of China swine industry, supply of feed ingredients become insufficient. On the other hand, enormous fiber byproducts from agricultural production and food processing were not well utilized. In our study, we can postulate reasonable strategy for better application of fiber byproducts therefore partially solving supply-demand imbalance conflict.

Acknowledgements

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

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Environmental trade-offs of dietary structure change can be alleviated by cleaner technology and emission restriction

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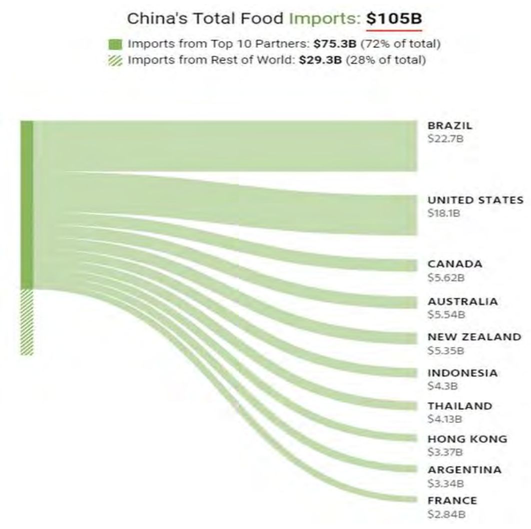
[3]College of Resources and Environmental Sciences, National Academy of Agricultural Green Development, China Agricultural University, Beijing 100193, China.

Background & Questions

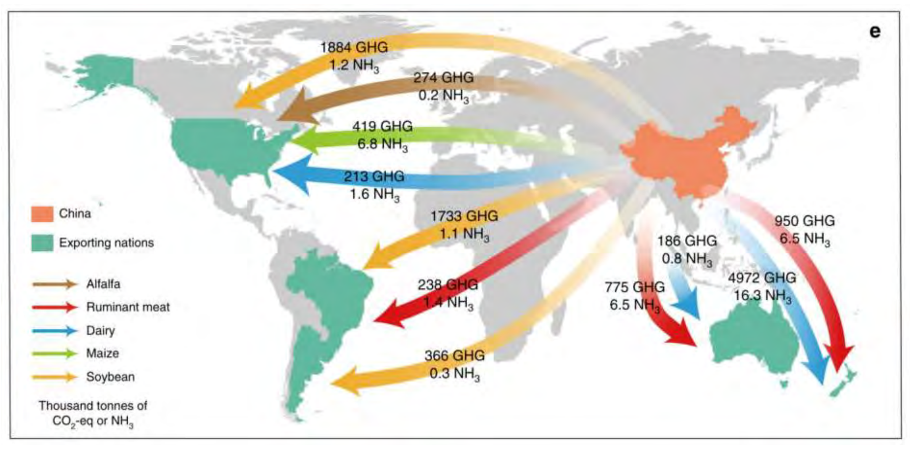
Feeding an increasing population with less pollution is one of the global challenges. China is one of the leading food supply and demand countries in the world. Importing food products transfers the environmental impacts associated with the production of the imported goods to exporting countries, causing the so-called ‘spillover ’.

h ’ d d d importing partners



(O x , 17)

‘ ’ exporting countries



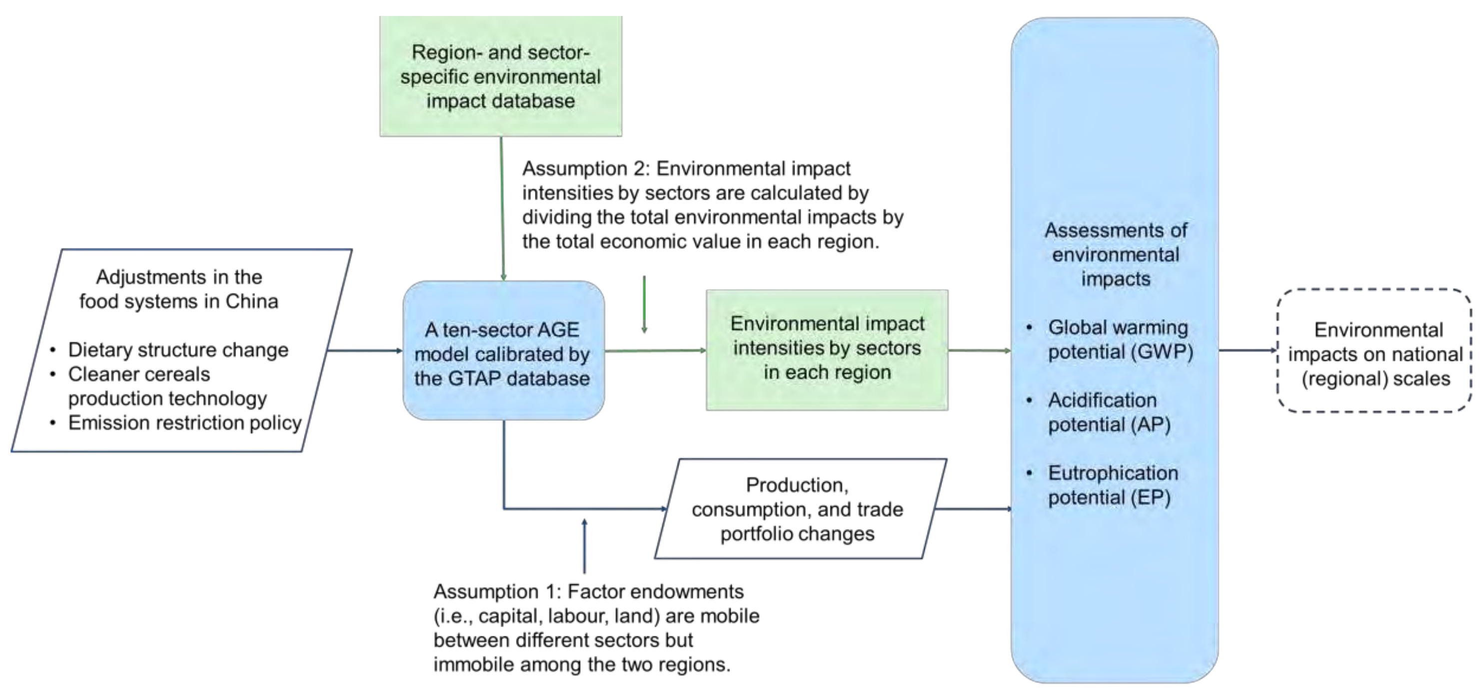
(Du, Y., et al., NC, 2017)

However, there is debate about whether possible measures targeted for a certain sector/region will cause trade-offs among environmental impacts and unwanted changes in other sectors or regions.

- What are the environmental impacts of adjustments in the food systems through changes in dietary structure, production technology, and emission restriction in China?
- What are the ‘spillover ’ on ’ main food and feed importing partners of the adjustments?

Answering these questions requires **an analytical economic-environmental framework** to quantify the *synergies and trade-offs among different environmental impacts* and trace the *interconnections across sectors and countries*.

w k & h d



- **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)

- **Regions:**
- China
- The main food and feed importing partners (MFIP, including Brazil, the United States, and Canada) of China
- **Sectors:**
- 4 crop sectors (cereals, vegetables & fruits, soybean, other crops)
- 3 animal sectors (pig, poultry, other animals)
- 1 feed sector (compound feed)
- 5 other sectors (soy-based food (SBF), other food, nitrogen fertiliser, phosphorous fertiliser, non-food)

Results

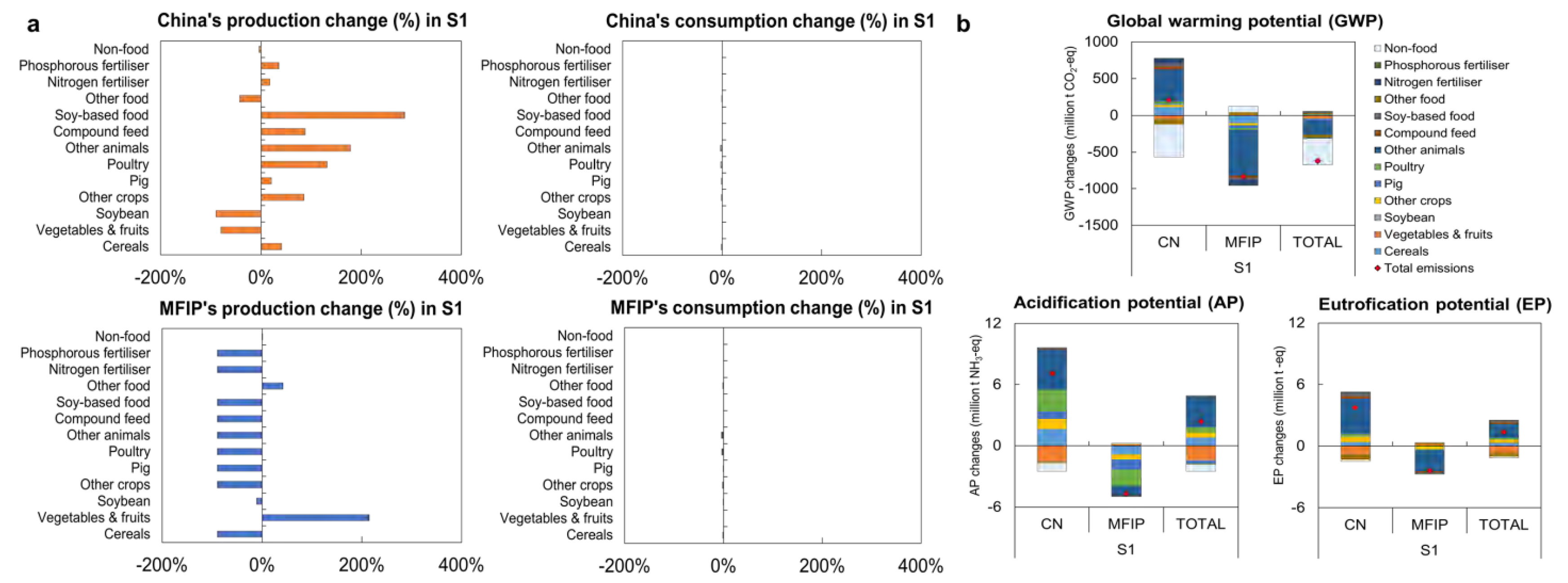
➢ **Environmental quality related to global warming potential (GWP), acidification potential (AP), and eutrophication potential (EP) under the baseline and the different environmental concerns (S1).**

		GWP	AP	EP
S0	CN	100	100	100
	MFIP	100	100	100
S1	CN	98	79	62
	MFIP	110	134	143

(N: ; M I :)

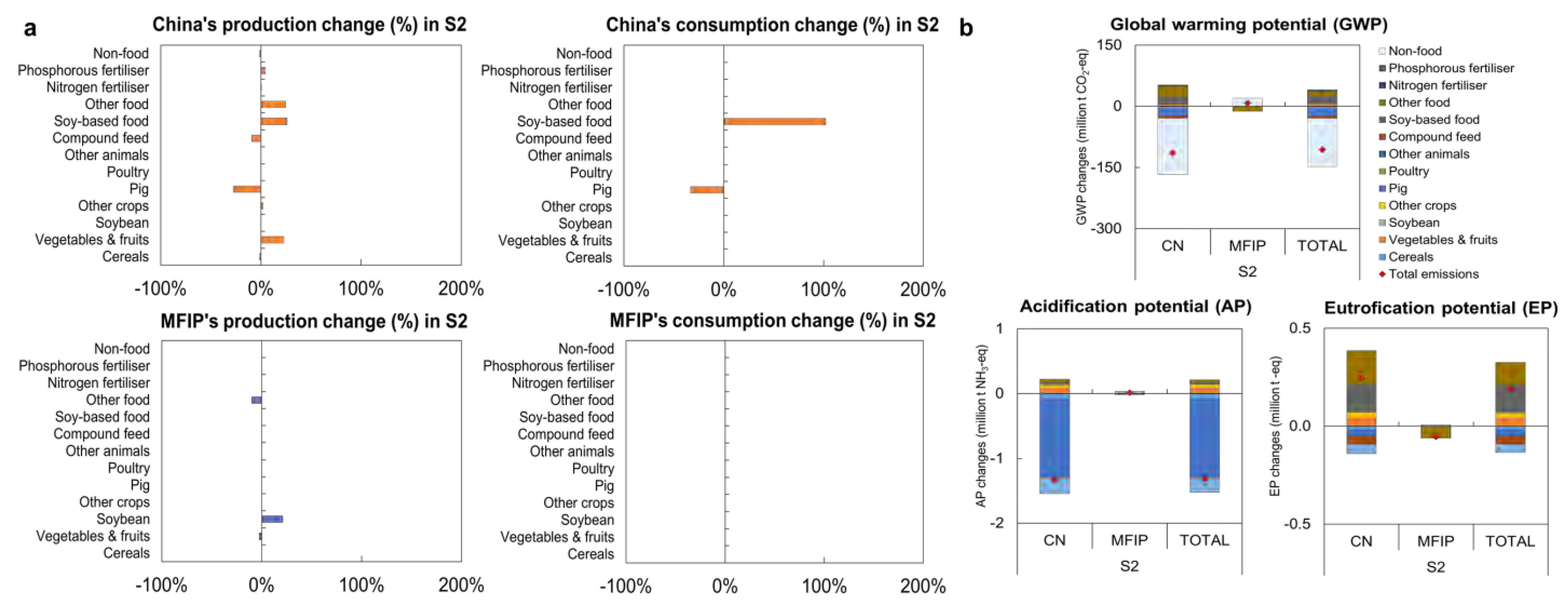
- MFIP with a relatively higher environmental willingness to pay (China: 1%; MFIP: 2%) has higher environmental quality than China.

➢ **Changes in production, consumption, and emissions under S1.**



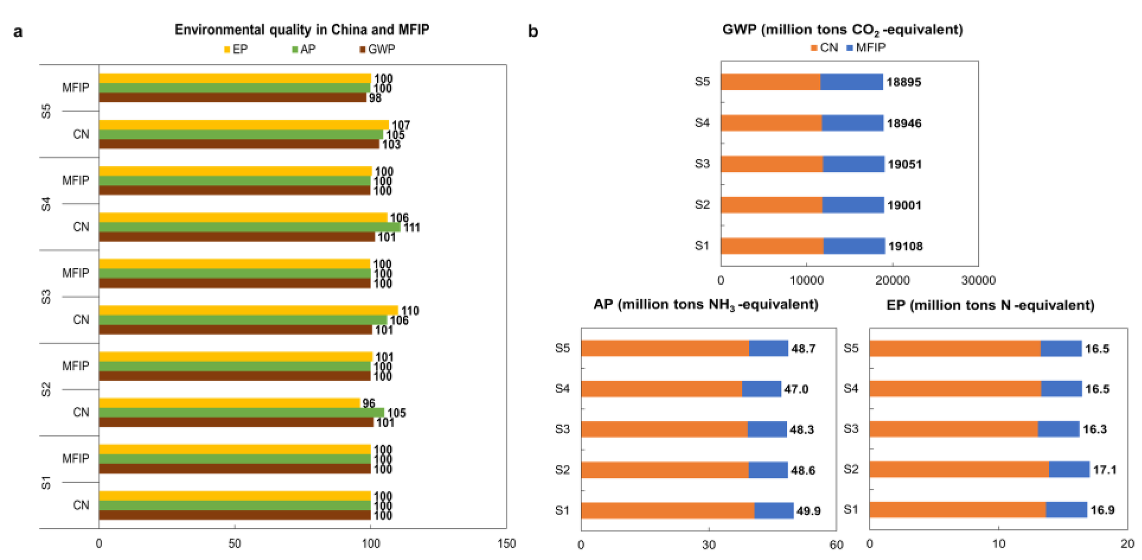
- Given the assumption of environmental willingness to pay, the consumers in MFIP care more about environmental quality than those in China.
- Therefore, to achieve high environmental quality, MFIP would reduce the production of goods with high emission intensities.

➢ **Changes in production, consumption, and emissions under the dietary structure change scenario (S2).**



- A dietary shift from pork to soy-based food in China alone will generate benefits for GWP (-1%) and AP (-5%), but at the expense of EP (+4%) .
- The EP emission increase is caused by the increased production of goods with high EP emission intensities (i.e., SBF and other food) in China.

➢ **National environmental quality and emissions under the different environmental concerns (S1), dietary structure change (S2), cleaner cereals production technology (S3), combining dietary structure change and cleaner cereals production technology (S4), and emission restriction policy (S5).**



- The trade-offs can be alleviated by combing a dietary shift with cleaner technology in cereal production (GWP: -1%; AP: -11%; EP: -6%) and restriction for emissions in China (GWP: -3%; AP: -5%; EP: -7%).

Conclusions

- A dietary shift from pork to soy-based food in China alone will generate benefits for GWP (-1%) and AP (-5%), but at the expense of EP (+4%) when we aim to maximise social welfare consisting of both economic welfare and environmental quality.
- The trade-offs can be alleviated by combing a dietary shift with cleaner technology in cereal production (GWP: -1%; AP: -11%; EP: -6%) and restriction for emissions in China (GWP: -3%; AP: -5%; EP: -7%).
- Food demand and supply-side measures need to be combined to mitigate multiple environmental impacts simultaneously while maximising social welfare.

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Automated training pigs to urinate in open/closed toilet via operant conditioning

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 urinate in the toilet.

Objectives

- Proof of principle: Can we train pigs to urinate in designated area?
- Characterize the learning process of pig toilet training.
- Evaluate the difference between an open and closed toilet design.
- Training pigs with an automated way.

Methods

The experiment is done in an organic farm in Oirschot, NL. There are 4 pens with 6 pig in each pen. The size of the pen is 4.15*2 m^2 in the indoor pen and 3*2 m^2 in the outdoor run (figure 1). Pen 1 and 3 are closed toilet while pen 2 and 4 are closed toilet (figure 2). The toilet (0.5*1.5 m^2) is at the back of the pen near the exit to the outdoor run, there is a one-way gate at the exit of the closed toilet.
The training device has 3 components, sensor , processor, and reactor. The sensor (made by Kamplan B.V., the Netherlands) is a liquid sensor for urination detection. The processor receives and records the signal from the sensor to determine whether to give a reward. The reactor consists of a device to give secondary reinforcer (a light signal) above the reward bowl, an electronic reward bowl. Pigs are rewarded when they urinate in the toilet area. The reward a mixed candy and dextrose powder.
The pigs were trained for 2 weeks during which they were rewarded when urinated in the toilet area. The observation is done in the last week with focus on toilet-related behaviour and excretion behaviour. Video analysis were done via Boris.

Figure 1, Four pen with open and closed toilet.

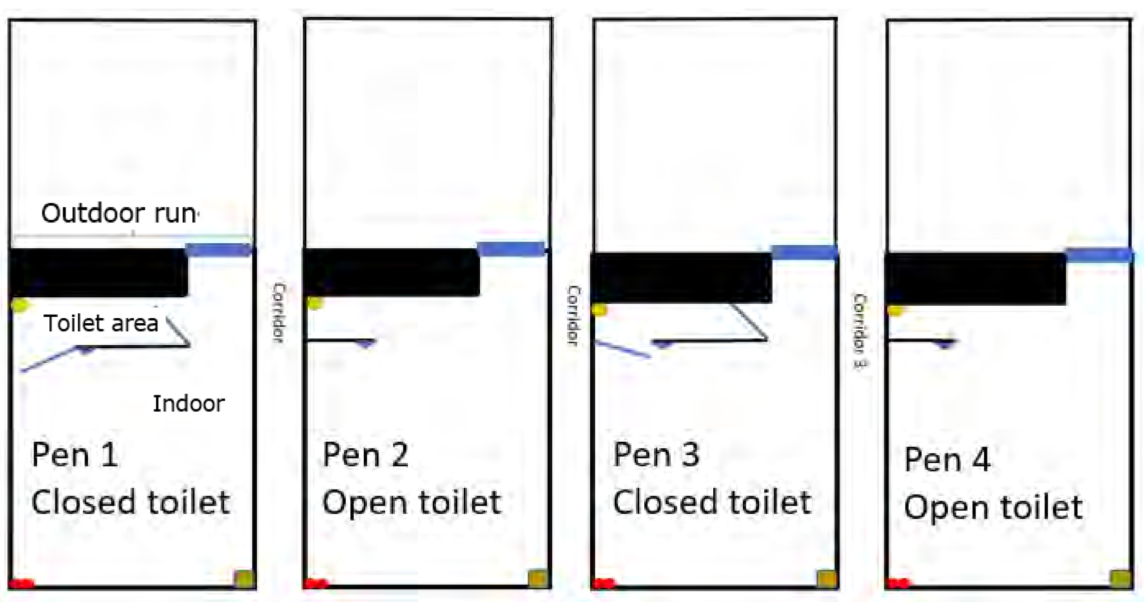
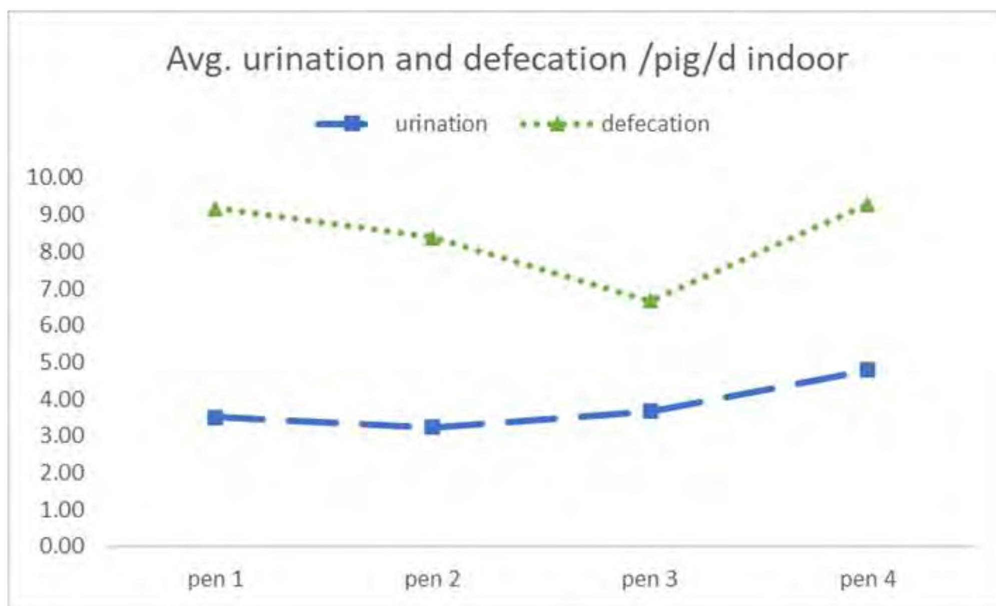


Figure 2, open (left) and closed (right) toilet design

Results

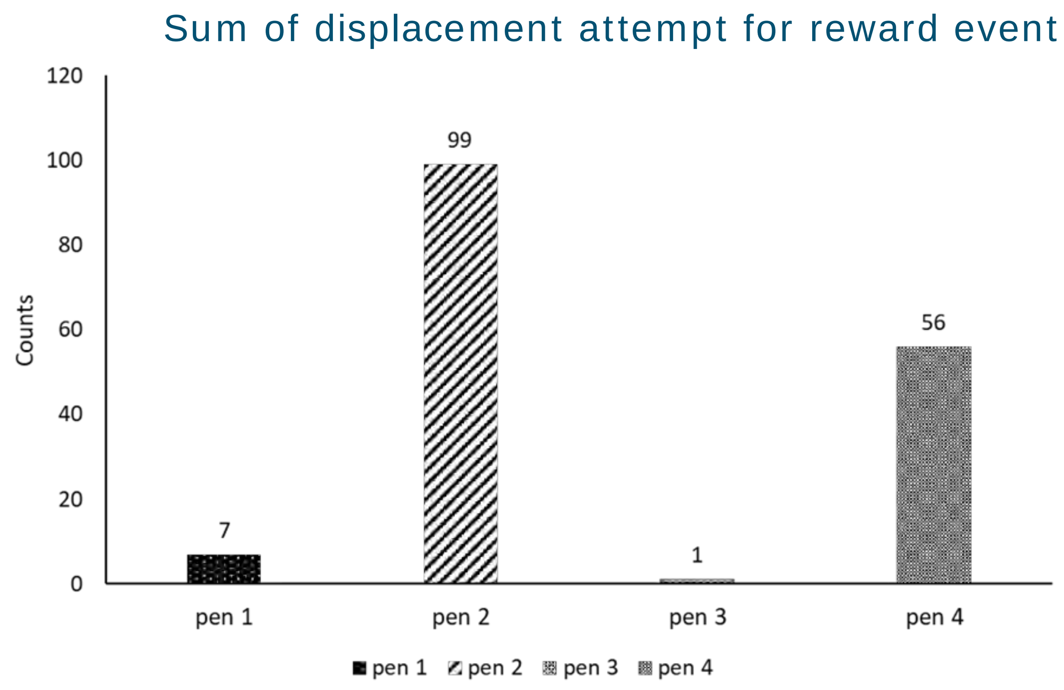
In general, the pigs urinates 3.2-4.7 times per day and defecates 6.7-9.3 times per day (figure 3). The peak hour of excretion is between 8-10 am, 1-2 pm, and 4-5 pm.

Figure 3, Average excretion per pig per day.



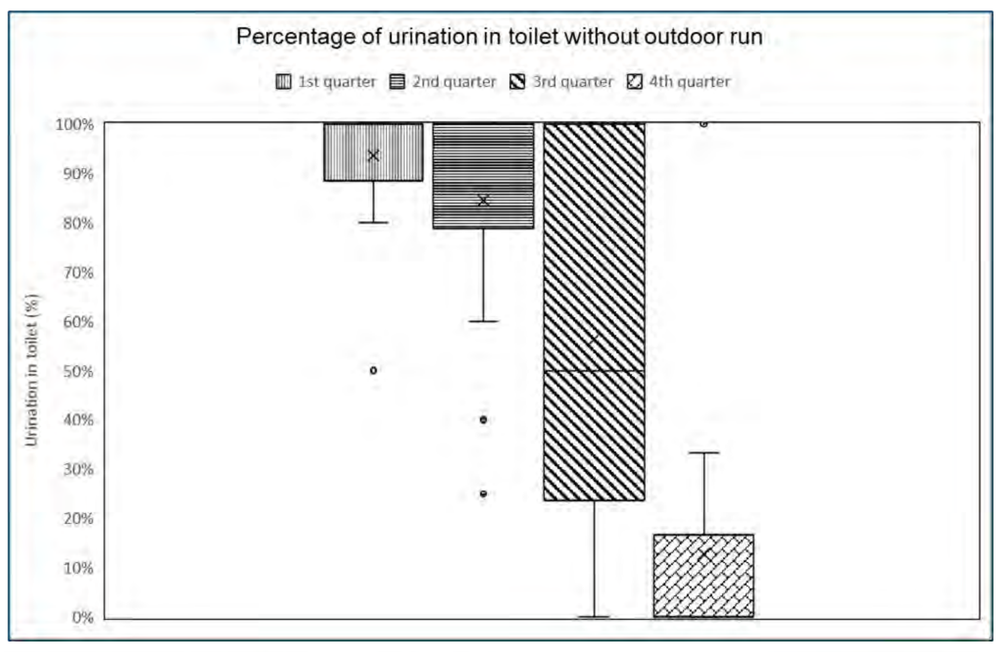
Compared with closed toilet (pen 1 and 3), open toilet design (pen 2 and 4) has more aggression event when the reward is given (figure 4).

Figure 4, Effect of open and closed toilet design on displacement attempt for reward



Pigs were divided into four quarters. From quarter 1 to 4, pigs receives less and less reward (figure 5).
As pigs receives more reward, not only the chance of urination in the toilet increases, but also the variation of pig's behaviour decreases.

Figure 5, Effect of the number of reward received by the pigs on urination behaviour



Example: a pig is being rewarded for urinating in the toilet.

Conclusions

This experiment shows that there is potential for pig toilet training, however, more research is needed focusing on making stable automation device, optimize pen and toilet design, as well as proof on principle under stable experimental environment.

Acknowledgements

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

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Using thermal images to recognize defecation and urination behaviour in pigs

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.

Experimental animals	75 pigs in all 8-9 pigs per pen (35kg)
Experimental period	1ST– 12th August 1.5 hour per day
Thermal camera	Testo 862

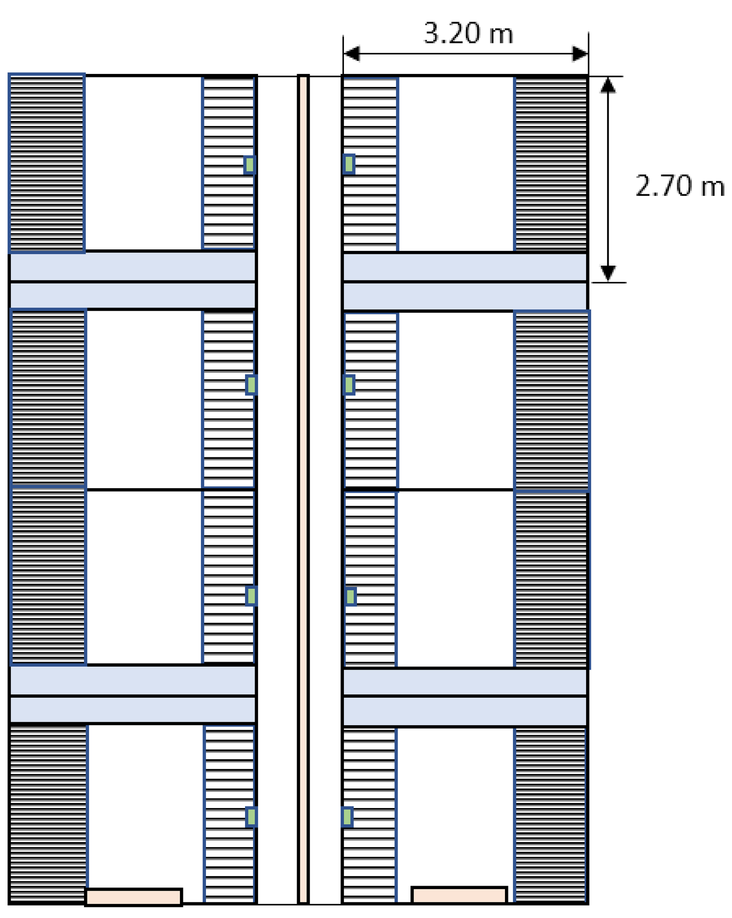

Figure 1. Layout of the experimental unit

Results

1. Pig urination / defecation events in thermal images

The pig excretion events in thermal images are shown in figure 2.

The urination posture of female pigs is different from male pigs.

The defecation posture of pigs in both genders is same.

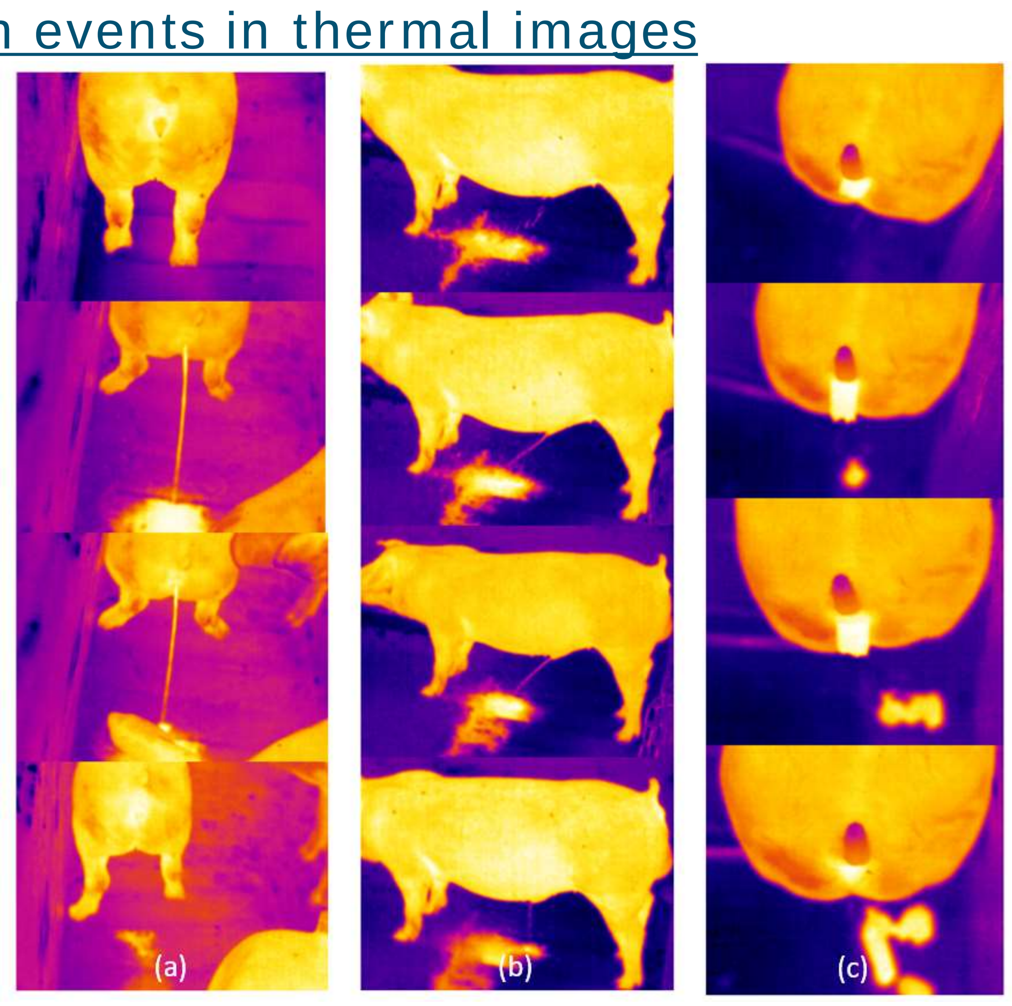

Figure 2. The process of pig excretion events in thermal images
(a) female urination event; (b) male urination event; (c) defecation event

2. Three classes of pig behaviours in the dataset

Figure 3. Pig behaviours in 3 classes:
(a) defecation; (b) urination;(c) non-excretion

Table 1. Data size of 3 behaviour classes

Behaviour Class	Data size
Defecation	637
Urination	626
Non-excretion	1503

All thermal images were labeled in 3 classes: defecation, urination and non-excretion. The uneven data size was augmented by weight enhancement.

3. Train and test three CNN models with dataset

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

Table 2. The accuracy of the 3 models on behaviour classification

Model	Accuracy(%)
Vgg19	85.09
Resnet50	87.64
EffcientnetB0	88.36

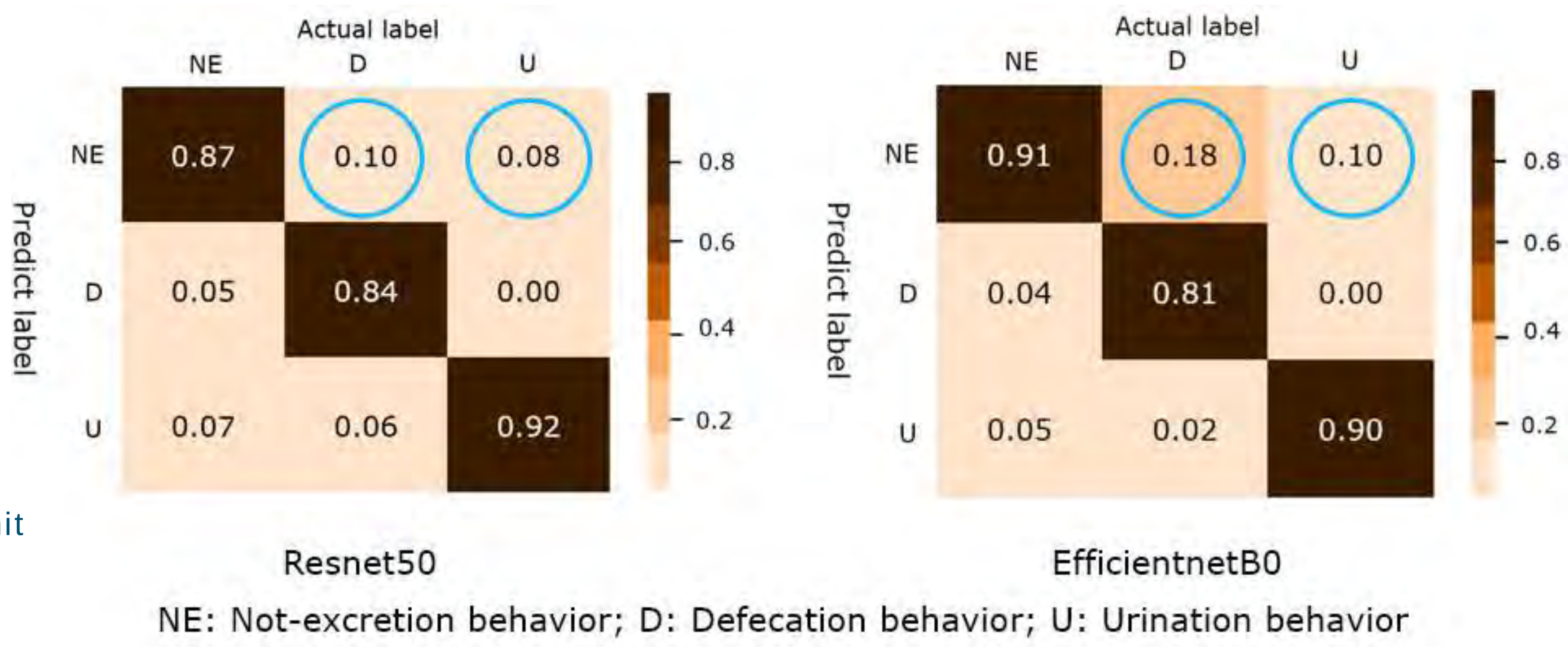

Figure 4. Confusion matrix of Resnet50 and EfficientnetB0

Conclusions

- ❑ It is possible to recognize the female and male urination and defecation postures based on thermal images
- ❑ Resnet50 and efficientnetB0 have a higher accuracy of behaviour classification
- ❑ It is easier for both models to distinguish defecation and urination behaviour compared to distinguishing non-excretion from excretion behavior

Acknowledgements

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

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Can Friendly Labels Reduce Pesticides Use? Empirical Evidence from a Randomized Controlled Trial

Juhui Chen

Supervisors: Junfei Bai, Hans van Trijp, Xi Lu, Ellen Van Loo

Background

Information asymmetry can lead to market failure, but simply providing information to people may not work if the effectiveness of information delivery is not considered. Information transparency through labels is considered a fundamental way to communicate with individual producers and consumers, but some studies have found that traditional labels have relatively little impact on individuals' decisions and behaviors. A common explanation is that the consumers do not care about labels. However, whether this is just because the label design and formatting itself deters the users from relying on the label and its information is rarely asked. Accordingly, there are great merits to examining whether changing the format or design of the pesticide labels can encourage farmers to use the information on them and change their behaviors.

Objectives

- Empirically evaluate whether pesticide labels with friendly design can reduce the overuse of pesticides.
- Identify the marginal effects of different friendly design labels.

Methods

We conducted a randomized controlled trial to collect data. In total, 1,132 households were sampled in thirty villages, including 932 treatment households (T1+T2+T3) and 200 control households (C).

The experiment was designed as follows.

First, the participants were randomly assigned to one of four groups. Participants in the control group received a bottle of pesticide with the original label that is sold on the market. Participants assigned to Treatments 1, 2 and 3 received pesticides with readable, calculable and measurable labels, respectively (Fig. 1). It is worth noting that T2 and T3 received identical labels, the only difference being that participants in T3 received an additional measuring cup for measuring pesticides.

Then, participating farmers were given one minute to read the label. When the minute was over, the surveyors asked the farmers to calculate the pesticides used per sprayer according to the pesticide label and pour it into the specified container. During this time, the surveyors concentrated on recording the farmer's handling behavior, including whether they used measuring cups, read the labels, and used mixing sticks.

Finally, the surveyors saved the liquid that was poured by the farmer and measured it after the whole survey was completed.

(A): The original label in the control group (B): The readable label in T1 (C): The calculable/measurable label in T2 and T3

Fig. 1. Intervention labels for the experiments.

Results

Table 1 reports the main results. The evidence indicates that although farmers who received the user-friendly label intervention still used higher-than-standard amounts of pesticides, the calculable and measurable label significantly reduced their overcalculated amount of pesticide compared to the control group. Specifically, for the farmers in the calculable label or the measurable label treatment group, the amount of calculated pesticide use per sprayer decreased by approximately 7 ml, which represented a decrease of approximately 30% over the calculated amount compared to the control. Unfortunately, the pesticide reduction effect of user-friendly labels did not work in reducing the pesticide amount poured by farmers.

Table 1 Treatment effects

	Overcalculated amount			Overpoured amount		
T1: readable label	-5.238 (5.155)			-0.201 (4.462)		
T2: calculable label		-7.464* (4.301)			-2.411 (3.908)	
T3: measurable label			-6.556* (3.925)			-0.577 (3.593)
Household covariates		Yes			Yes	
Mean dependent variable in control		22.761 (ml)			23.565 (ml)	
Observations	285	381	621	340	438	711
R-squared	0.112	0.102	0.070	0.086	0.057	0.049

However, further heterogeneity analysis found that the user-friendly label could change the pesticide handling practices of farmers who did not trust pesticide retailers (Results not shown due to space constraints). Whether in overcalculating or overpouring, user-friendly labels clearly played a significant role in pesticide reduction. This implies that label information may replace, to some extent, the pesticide retailer's recommendation to farmers, which can reduce pesticide overuse that may result from pesticide retailers recommending excessive amounts

Conclusions

Based on a randomized controlled trial, this study uses pesticide labels as an example to provide evidence that labels are largely useless because their content or design is too unfriendly to use. In the case of pesticides, a user-friendly label has a positive effect on improving the accuracy of farmers' pesticide calculations. The impact is considerable, leading to an average decrease in the overcalculated amount of pesticides by approximately 30%. While there is no evidence that user-friendly labels also reduce the amount of pesticide that farmers actually pour, for farmers who do not trust retailers, the impact of user-friendly labels on actual pesticide reduction is significant.

Acknowledgements

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

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Will cultured meat be served on Chinese tables? A study of consumer attitudes and intentions about cultured meat in 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.

One major challenge to the introduction of CM relates to the consumer acceptance of this novel food. When confronted with new, unfamiliar food products or production processes, consumers are often sensitive to the provision of information, and framing effects play a crucial role in this stage (Bryant & Dillard, 2019; Mancini & Antonioli, 2019). 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.

We explore how and to what extent the acceptance and intentions of Chinese consumers are affected by alternative naming of CM in Mandarin. Ours is the first study to contribute insights from China to the growing body of evidence on the effects of naming on attitudes about CM. Moreover, Our article provides additional evidence on the attitudes and behavioral intentions of Chinese consumers with regard to CM. This research is intended as a stepping stone for relevant stakeholders involved in the promotion and introduction of CM in China, with broader implications at the global level.

Conceptual framework

- Our experimental study explores framing effects according to two factors: name framing and the provision of information on the production process for CM.
- We hypothesized that names would influence consumer attitudes and intentions through the mediators of awareness and knowledge (Fig. 1).
- In the absence of elaborate information, consumers evaluate products automatically, without reasoning, resulting in what is known as implicit attitudes. Evaluations that emerge as more elaborate information is available result in explicit attitudes. We measured differences in implicit and explicit attitudes due to exposure to information, hypothesizing that information influences consumer attitudes.

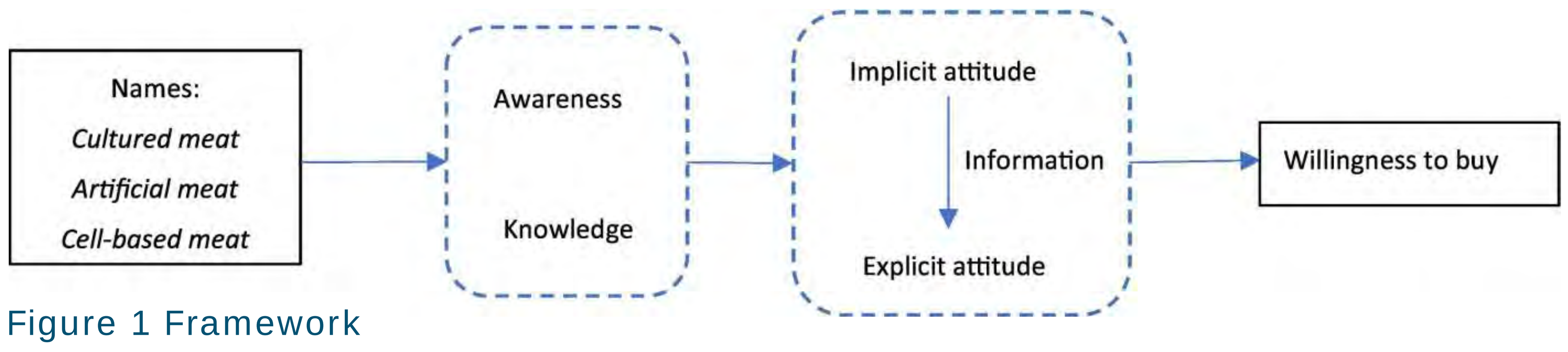


Figure 1 Framework

Method

- We obtained 1532 valid responses through an online questionnaire in China.
- Participants were randomly assigned to one of three treatment groups (based on naming), with these groups constituting a between-subject factor. An information treatment (Fig.2.), in which each participant received a piece of information about CM, was included as a within-subject factor.
- Multiple hierarchical regression was used to explore the empirical effect of the naming treatments and to identify predictors of consumer attitudes and the likelihood of purchasing CM. The dependent variables were implicit attitude, explicit attitude, and willingness to buy.
- Awareness, prior knowledge, behavioral intentions, socio-demographics and meat consumption habits were measured.

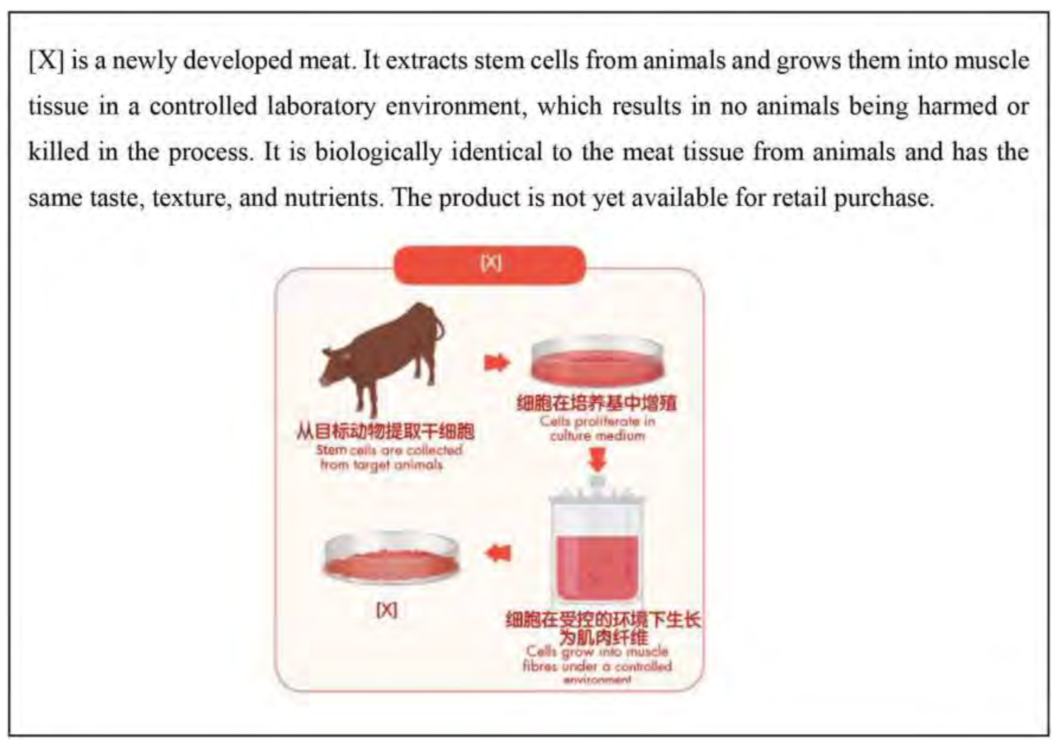


Figure 2 Information about CM.

Results and Conclusions

- The Chinese consumers participating in our study had low awareness and prior knowledge of CM, and most had not heard of either the terms "cultured meat" or "cell-based meat" before. In contrast, 70% reported that they had heard of "artificial meat", but it could be that few of them knew precisely what this meat alternative was.
- Although the term "artificial meat" was the most familiar to consumers, it was also the most unappealing. Familiarity alone is not sufficient to name a novel food. The significance of naming was reflected in the attitudes and intentions of the consumers in our study. Moreover, our participants had no firm ideas about trying and purchasing CM, and more than half were unwilling to pay more for it than for conventional meat.
- Elaborate information could help to increase consumer support for CM, but the effect of neutral information was limited in our study. Even after receiving this information, consumers remained relatively negative about CM. The most promising segment to target is young, well-educated female consumers.
- Prior knowledge and the name treatments were strong predicators of attitudes and willingness to buy.

Implications

- In contrast to consumers in Western countries, Chinese consumers tend to be quite conservative with regard to this novel meat alternative.
- We suggest that the CM industry or stakeholders should be cautious about the strategies employed to communicate with consumers. When bringing this meat alternative to the market, careful attention should be devoted to how it is named and introduced.
- In addition, policymakers should implement relevant regulations to eliminate uncertainty relating to safety issues of CM, thereby enhancing consumer confidence.

[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.meatsci.2022.109081

Agricultural ammonia emission control is essential for reducing N deposition-induced water pollution

PhD candidate: Sijie Feng (Water Systems and Global Change Group)
Supervision team: Fusuo Zhang, Carolien Kroeze, Lin Ma, Maryna Strokal, Wen Xu, Mengru Wang

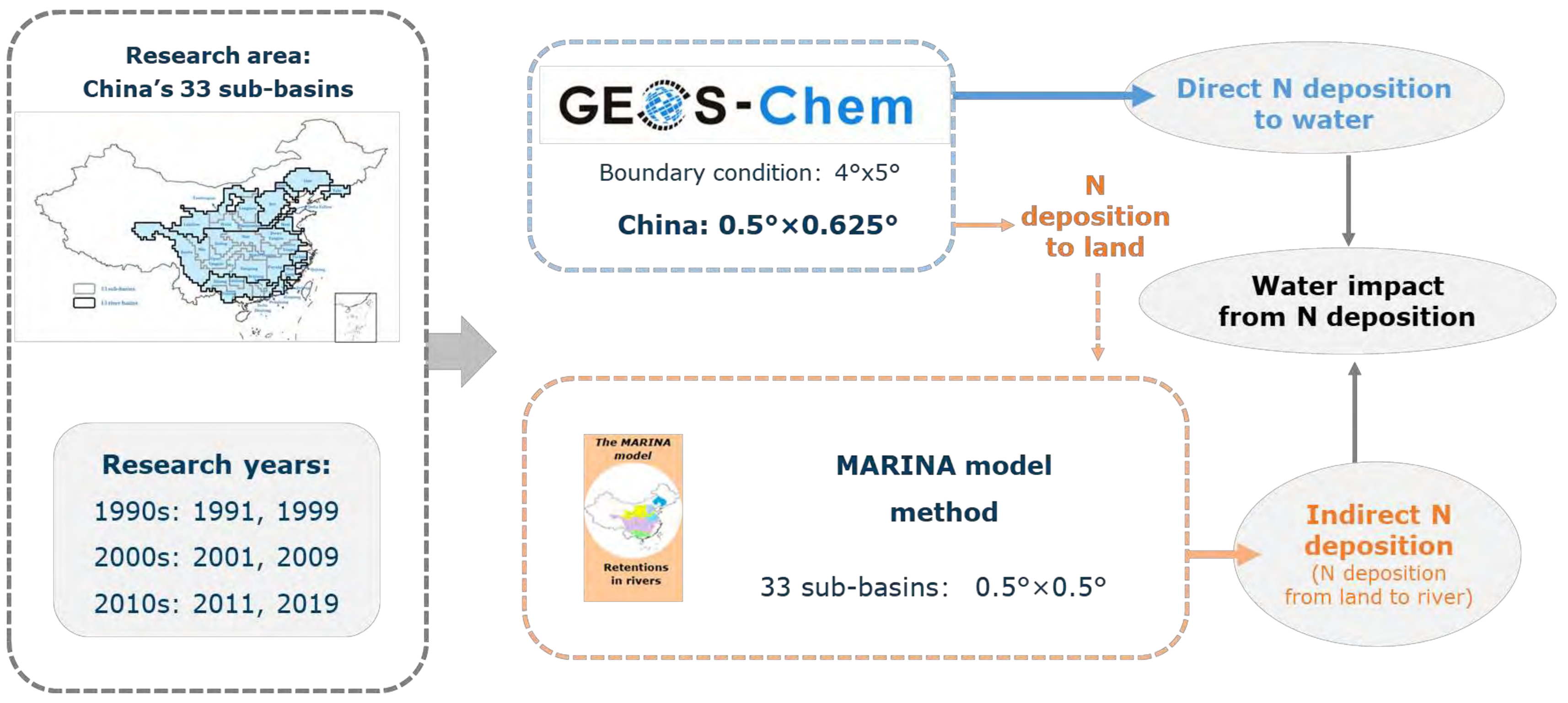
Background

Human activities in energy and food production have substantially increased reactive nitrogen emissions to the atmosphere which 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. China is a hotspot of N deposition and has implemented strict atmospheric policies in the last three decades. Yet, the responses of direct and indirect N deposition on rivers to these policies are not well known.

Objectives

- Examine the trends and spatial distribution of direct N deposition on 33 Chinese sub-basins from 1990s to 2010s.
- Identify the main contributors of N deposition.
- Analyze the effectiveness of atmospheric policies in reducing N deposition to land and on rivers.

Methods



Results ①

- Total Nr deposition on land and direct to water increased by 55% over 33 sub-basins, continued to increase from 1991 to 2019 (Fig.1).

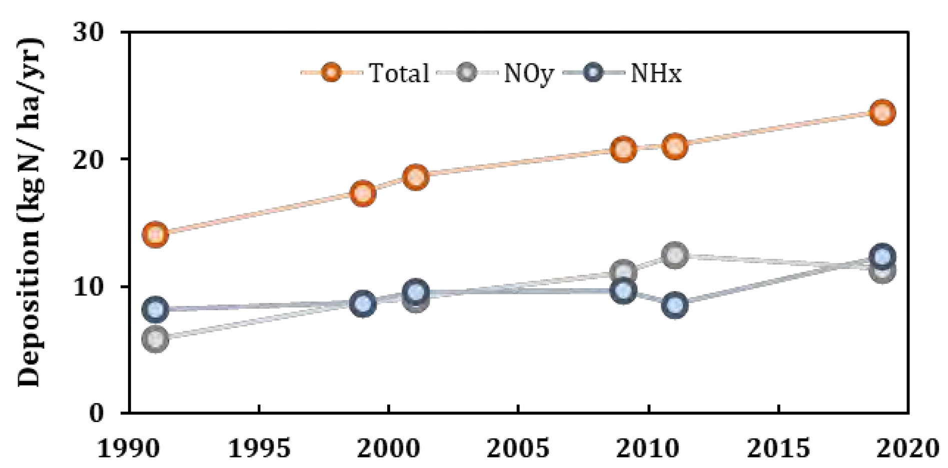


Fig.1 Annual total Nr deposition fluxes over China's 33 sub-basins within three decades

Results ②

- Current polities are effective in control NO_y deposition, but not effective for reducing NH_x deposition, shown by the increases in dry NH_3 and wet NH_4^+ deposition (Fig.1 and Fig.2).
- Agriculture was estimated as the most important source, contributing 30% and 37% to the total N deposition in 2011 and 2019 (Fig.2).

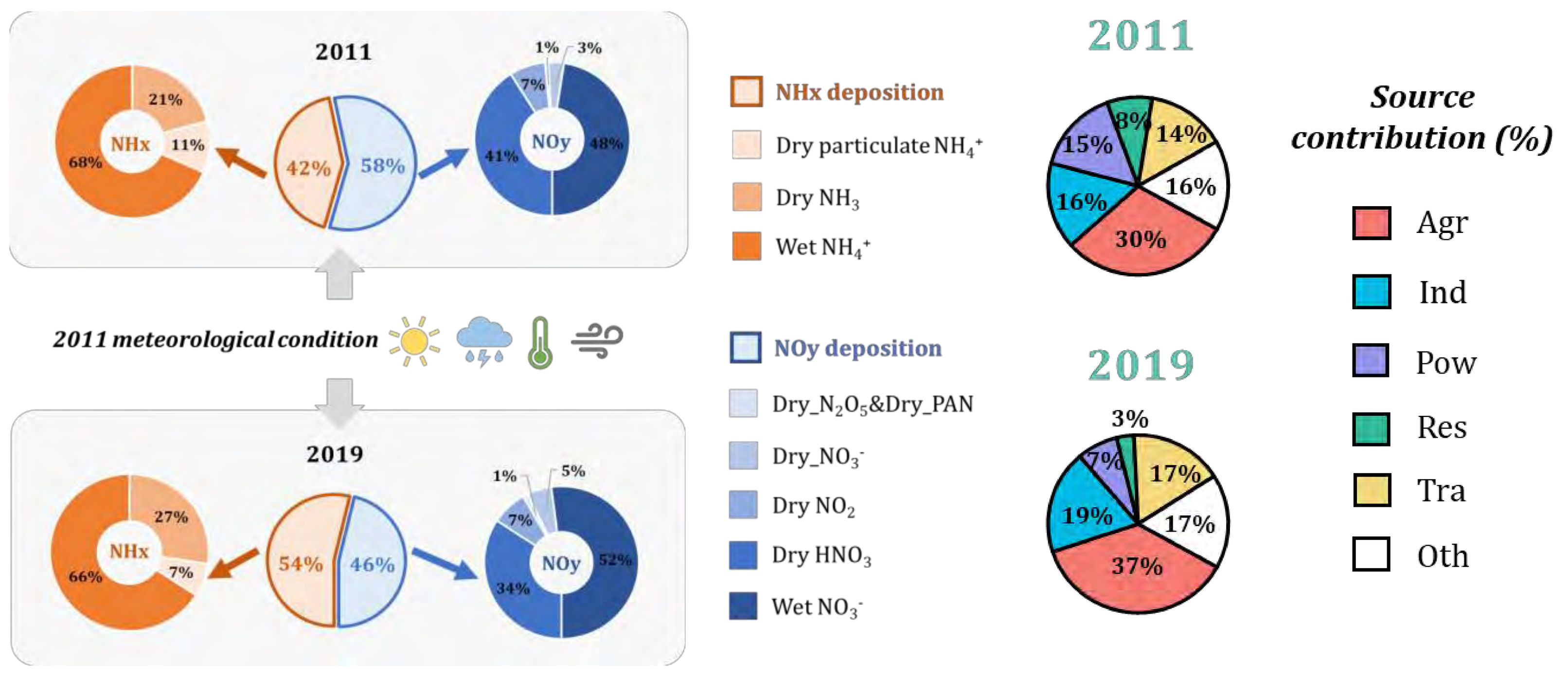


Fig.2 Total N deposition amounts and different species of N deposition changes in under 2011's meteorological conditions (left); Fractional contributions (agriculture, industry, power plant, residential, transportation and others) to total N deposition from emission sectors in 2011 and 2019 (right).

- The amounts of direct and indirect N deposition on water on average declined by 2% across all sub-basins (Fig.3).

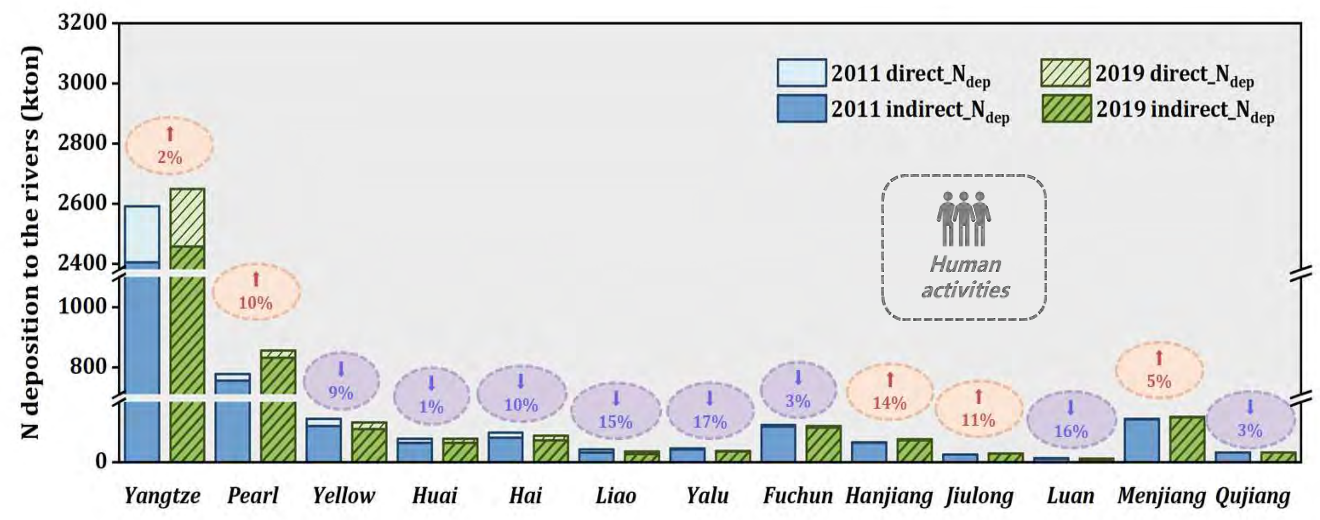


Fig.3 The amounts of N deposition caused by human activities to rivers (kton yr^{-1}) over 33 sub-basins in the 2010s.

Conclusions

- Agricultural ammonia emission control is essential for reducing N deposition-induced water pollution.
- This integrated air-water model can assess the impacts of N deposition on water quality, providing insights to develop the pollution control policy for both air and water in sub-basins.

References

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(4) Zhao, Y. et al. 2017. *Atmospheric Environment.*

Acknowledgements

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Optimizing fertilizer and liming strategies to reduce soil acidification and nutrient losses

Donghao Xu*, Gerard H. Ros, Qichao Zhu, Xuejun Liu, Fusuo Zhang, Wim de Vries

Background

Soil acidification affects food security and agricultural sustainability, and it has been accelerated by improper agricultural management, including overuse of nitrogen (N) fertilizers in China [1,2]. The soil acidification model VSD+ [3] has been proven appropriate for the simulation of soil acidification and liming impacts in intensive agricultural systems [4]. Comprehensive mitigation strategies are urgently needed on Chinese croplands at regional sale. This requires insight into the effects of agricultural management for multiple crops, soils and climatic conditions.

Objectives

This study aim to validate the capacity of the VSD+ model to assess long-term optimal combination of fertilizer, manure and lime to mitigate soil acidification and nutrient losses at field level, thus guiding a sustainable management strategy for soil acidity of croplands at regional scale.

Methods

This study is conducted in Qiyang County, China, where the average topsoil (0-20cm) pH has decreased by 0.6 unit during 1980s-2010s according to a systematic survey (2.7×2.7 km) [5]. The study includes a long-term experimental site since 1990, where the application of mineral N, phosphorus (P) and potassium (K) fertilizers (NPK treatment) sharply decreased the soil pH by 1.5 units after 30 years, compared to the control treatment (CK). To mitigate soil acidification, 70% of the N from mineral fertilizers was replaced by organic manure (NPKM) or lime was applied (NPKL) in two additional experiments.

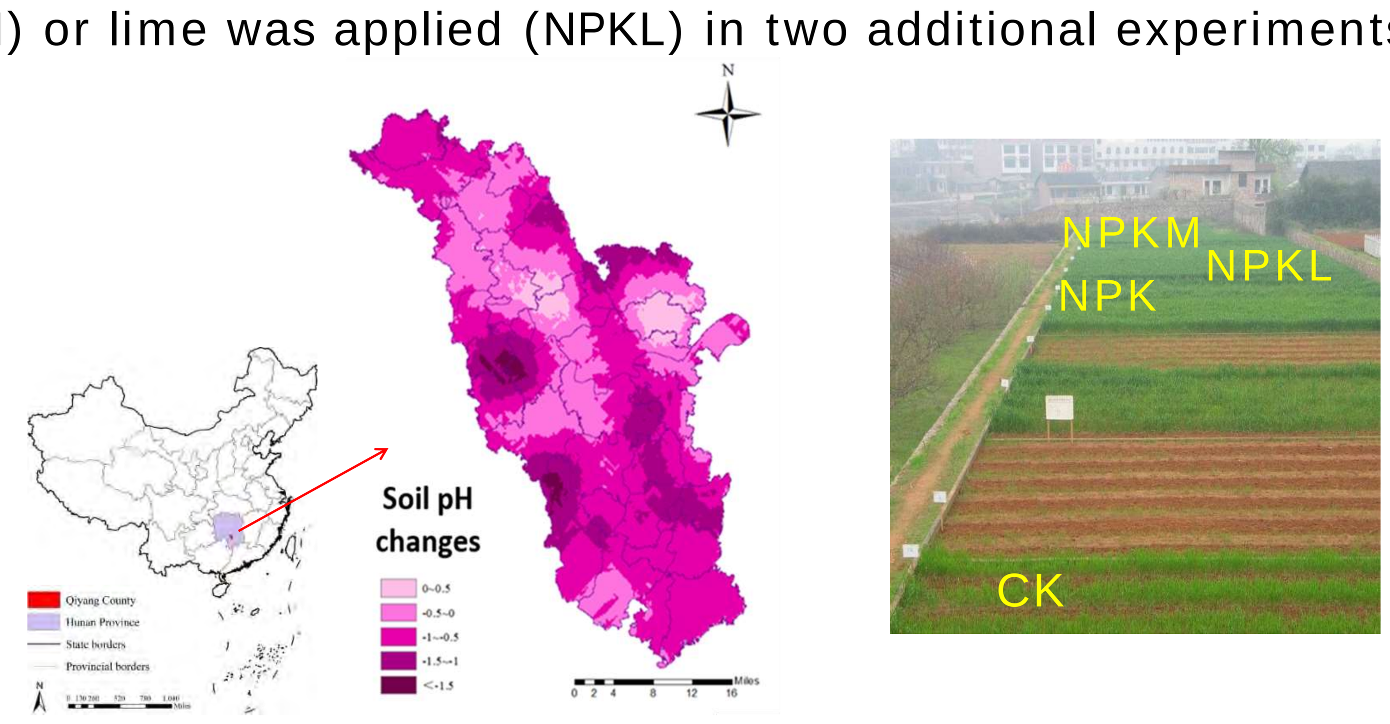

Fig. 1 Location of Qiyang County in China (left), spatial distribution of topsoil pH decrease in Qiyang (1980s-2010s) (middle) and the Qiyang long-term experiment since 1990 (right), where CK is the control, NPK is the input of mineral N, P and K fertilizers; NPKM is the treatment with organic manure addition and NPKL is with lime.

Results

The VSD+ model well simulated historic soil pH changes of different nutrient management practices.

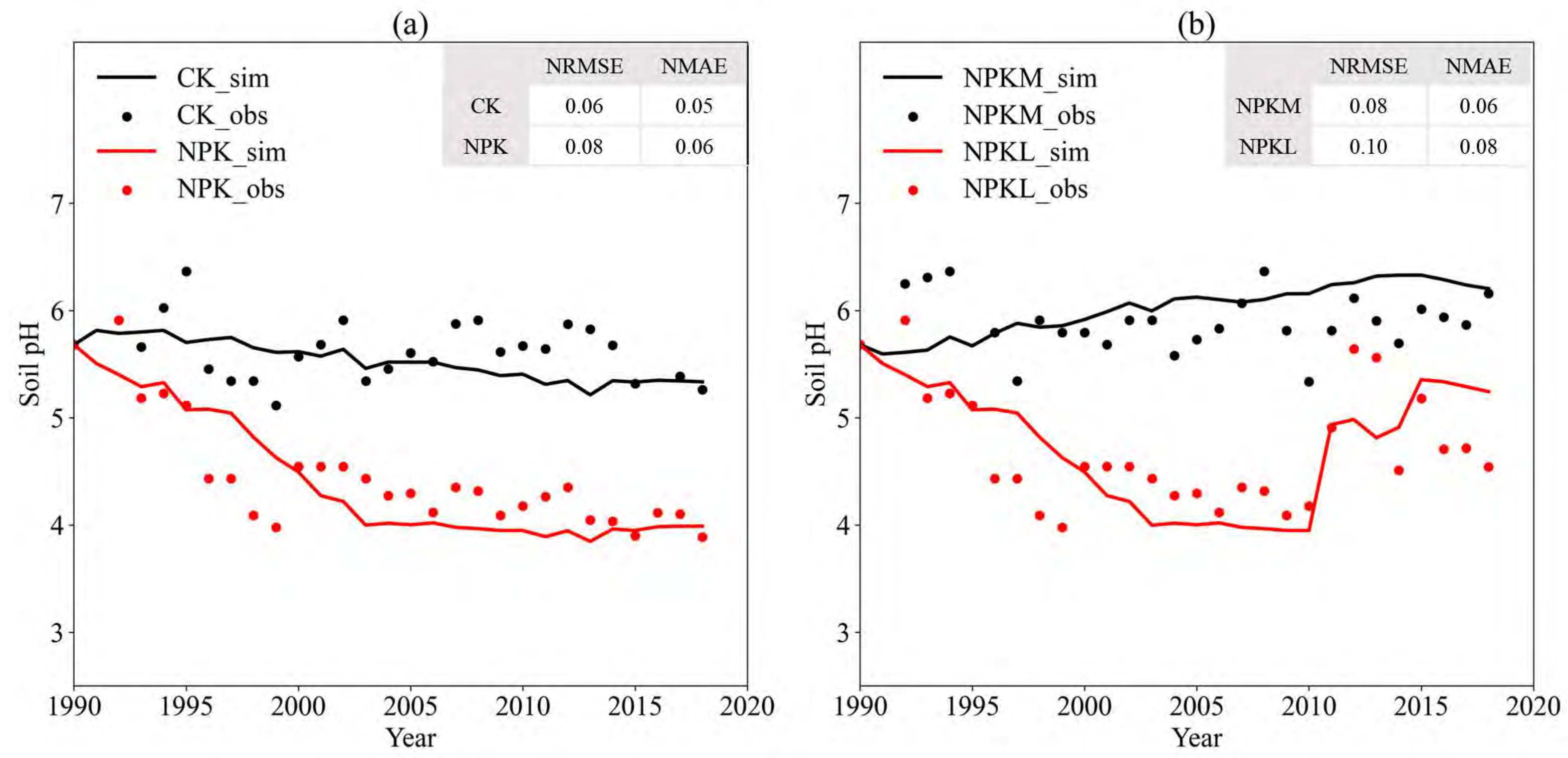

Fig. 2 Observed (●) and simulated (lines) changes in pH of the topsoil (0-20 cm) for the different treatments at Qiyang long-term fertilization experiments by VSD+. Values within the figure are the Normalized Root Mean Square Error (NRMSE) and Normalized Mean Absolute Error (NMAE) of the simulated soil pH to the observations.

An optimized combination of fertilizer, manure and lime (OPT) was identified to minimize acidification and unnecessary N and P surpluses, by balancing crop N, P and base cation (BC) demands and unavoidable N and BC leaching.

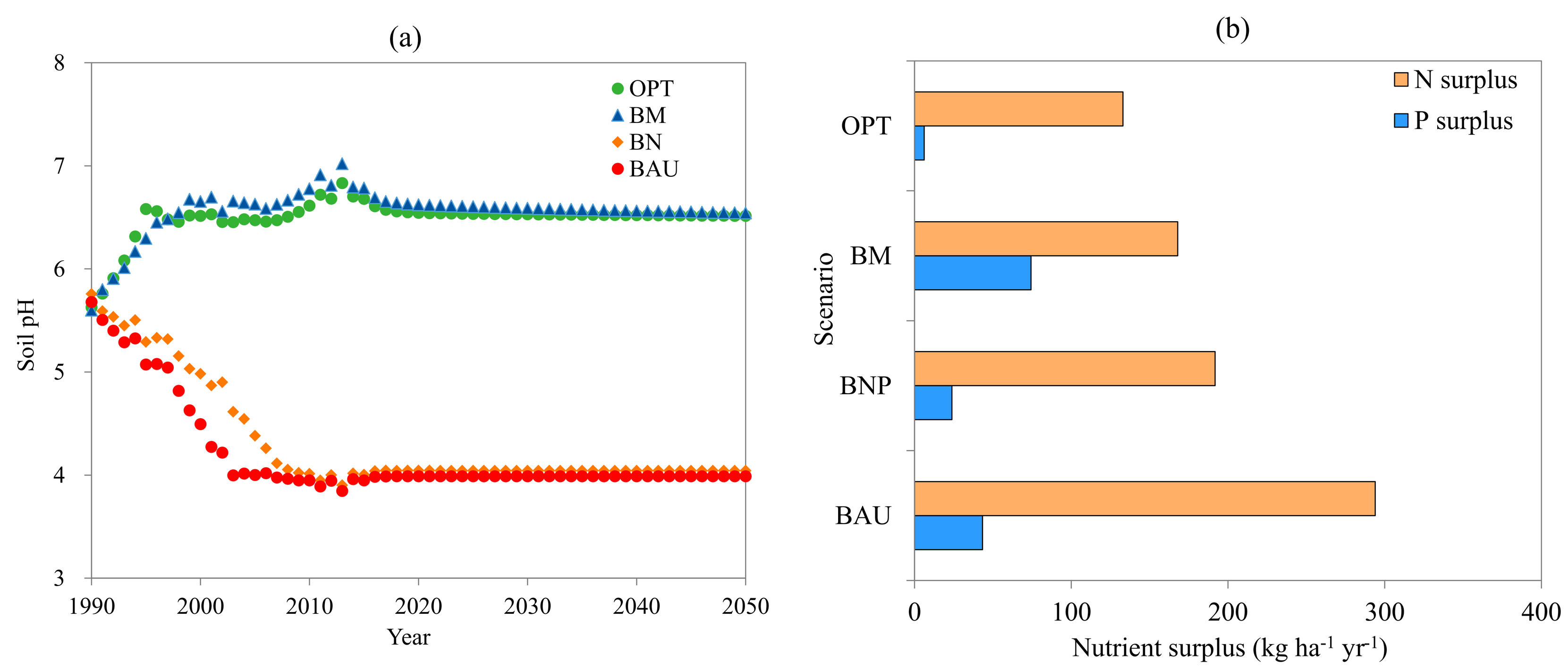

Fig. 3 Scenario analysis for soil pH (a) and nitrogen (N) and phosphorus (P) surplus (b) in response to various agricultural management scenarios, i.e., BAU: business as usual being the current straw removal and fertilization practice of NPK treatment kept constant from 2018-2050; BNP: balanced N and P input in view of crop demand; BM: balanced N fertilizer input with local swine manure only; OPT: the optimal management by achieving N and P balance and keeping soil pH at an optimal situation, with 38% of N and all P inputs from manure, and an average lime input of 13.3 keq ha^{-1} yr^{-1}.

Conclusions

The VSD+ model can be used as a sustainable nutrient and acid management tool to derive optimal application rates of fertilizer, manure and lime in agricultural systems. Its implication at regional level may further guide sustainable acidity management for croplands.

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Acknowledgements

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Application of plant-soil feedback theory in rotation cropping system

Zhaoqi Bin*, Ciska Veen, Guangzhou Wang, Junling Zhang, Wim van der Putten

Background

To promote the transformation of agricultural development from a high-input and high-environmental footprint model to a model based upon sustainable intensification, agricultural green development aims to provide theoretical support for such green transformation. Crop rotations help maintain long-term crop yields without heavily depending on synthetic chemicals such as fertilizers. Given the negative environmental impacts caused by high-input and high-environmental cost conventional agricultural practices, developing systematic methods to manage crop rotations effectively is paramount. Plant-soil feedback (PSF) can be defined as a process that a plant leaves biotic and abiotic soil legacies that in turn affect the performance of the next generation plant. As crop yields vary in rotation combinations, we expect PSF to serve as a tool to determine the most favorable crop rotation combinations in maximized productivity.

Objectives

This research aims to apply PSF theories to determine the optimal crop rotation sequence by evaluating PSFs in twelve common crop species and elucidate how crop performance follows soil legacies of previous crops.

Methods

We conducted a classic PSF experiment with 12 common crop species consisting of condition and feedback phrases (Figure 1). In the training phase, a mix of live and sterilized soil was conditioned by each of the twelve crops for 60 days. In the feedback phase, the conditioned soil were used to serve as the legacy effect provider for the feedback plant. The feedback plants were allowed to grow for 60 days. In total, we had 144 combinations of the twelve crops and five replicate for each combination.

$$PSF = \ln\left(\frac{biomass}{home\ biomass}\right)$$

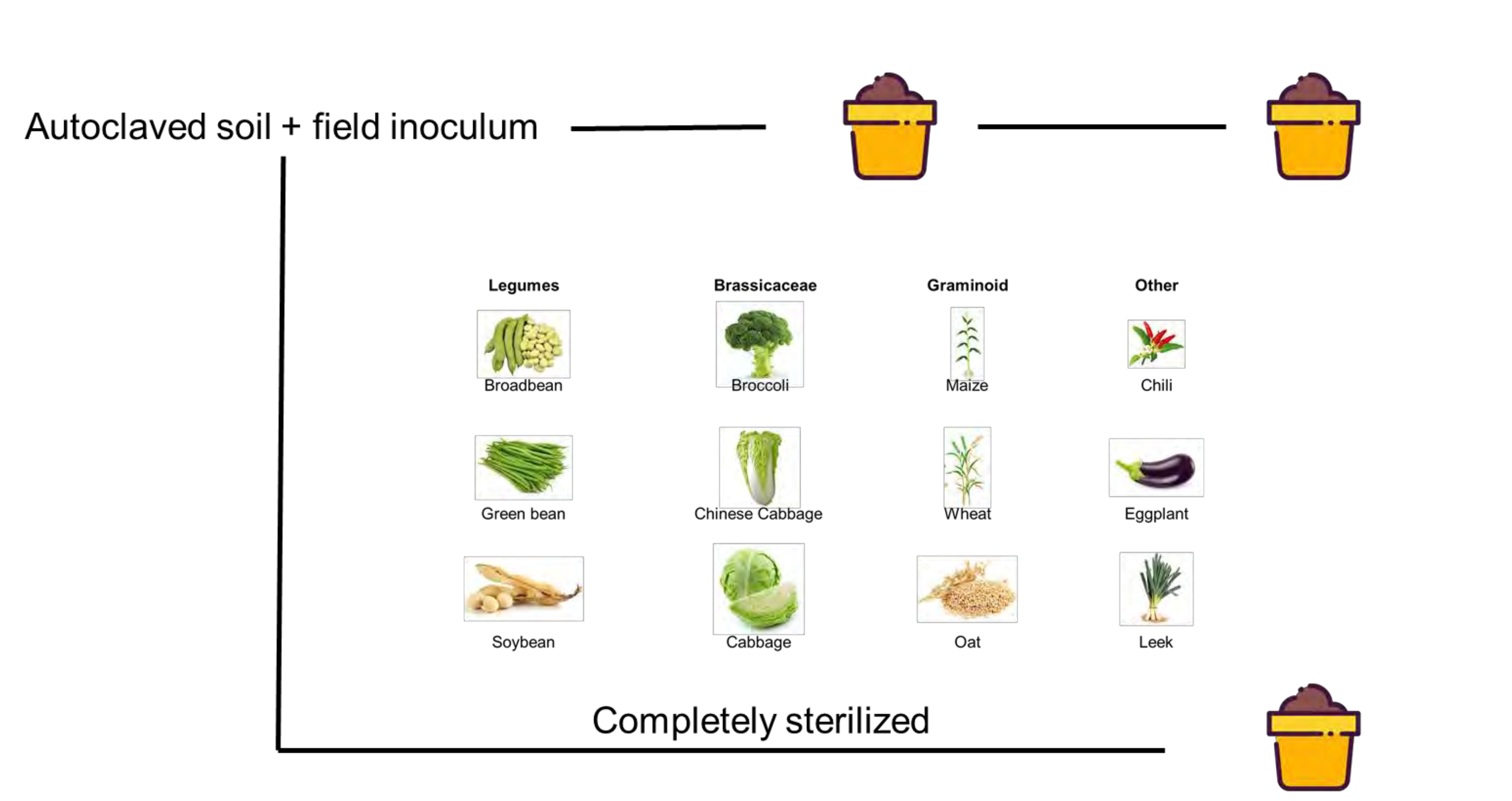

Figure 1 Experimental design of the PSF experiment. A list of twelve species classified into four groups was used in the experiment.

We measured plant biomass at the end of the feedback phase. As we want to imitate the agriculture system, we use shoot biomass to calculate PSFs by comparing the shoot biomass of each crop grown in soils trained by each of the eleven other crops against biomass in self-trained soil (See the equation in Figure 1).

Results

The growth performance of feedback crop varies from different species conditioned soil. Of all the four groups, bean group conditioned soil had the most positive effect for the subsequent plant growth. (Figure 2)

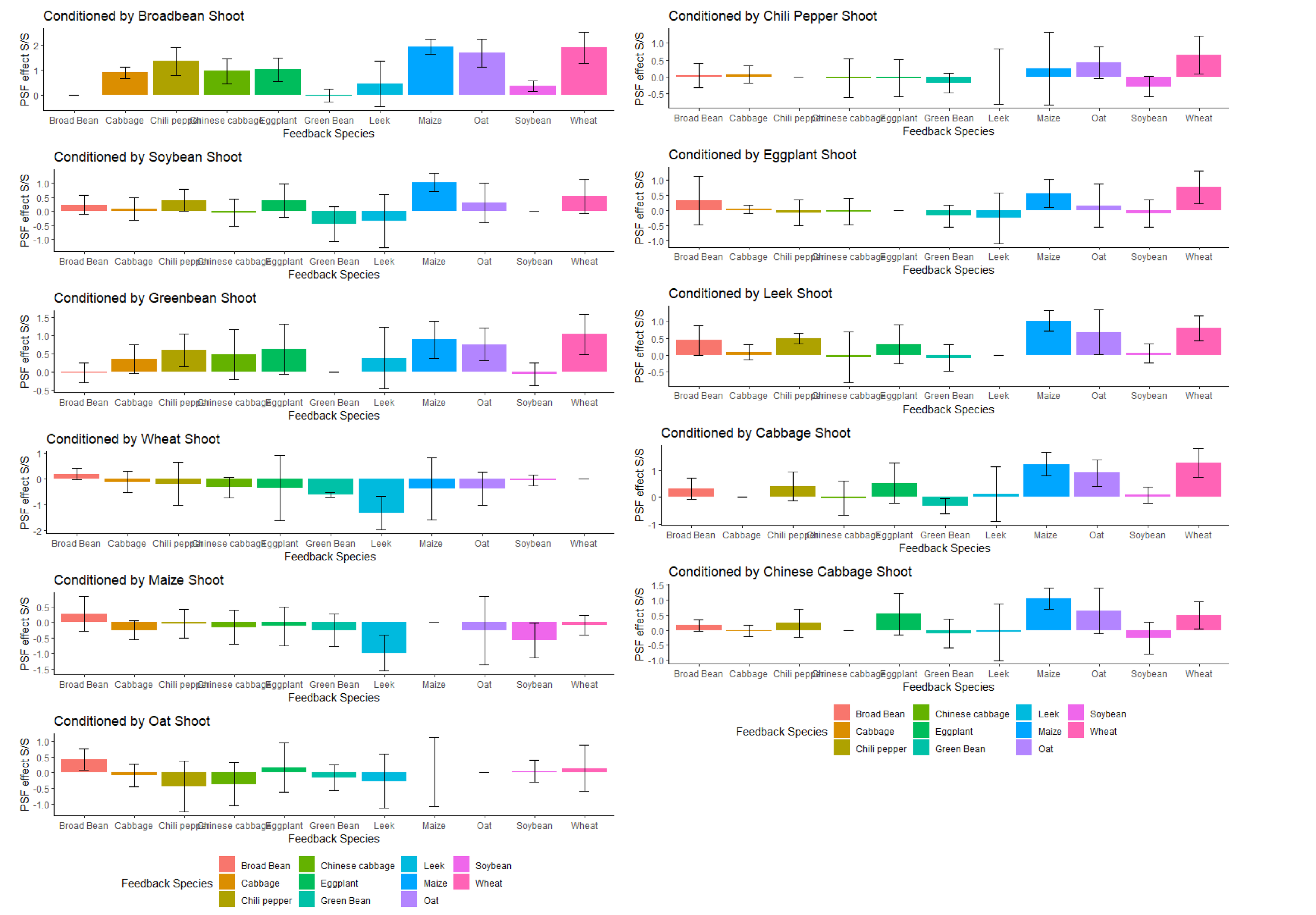

Figure 2 Soil feedback grouped by different species-conditioned soil.

Using the feedback results, hypothetical two-crop and three-crop rotation starting from broad bean and mazie, broadbean, cabbage and maize were constructed to maximize shoot biomass. Leek and wheat, Leak, Chinese cabbage and wheat rotation sequence have the lowest biomass. (Figure 3)

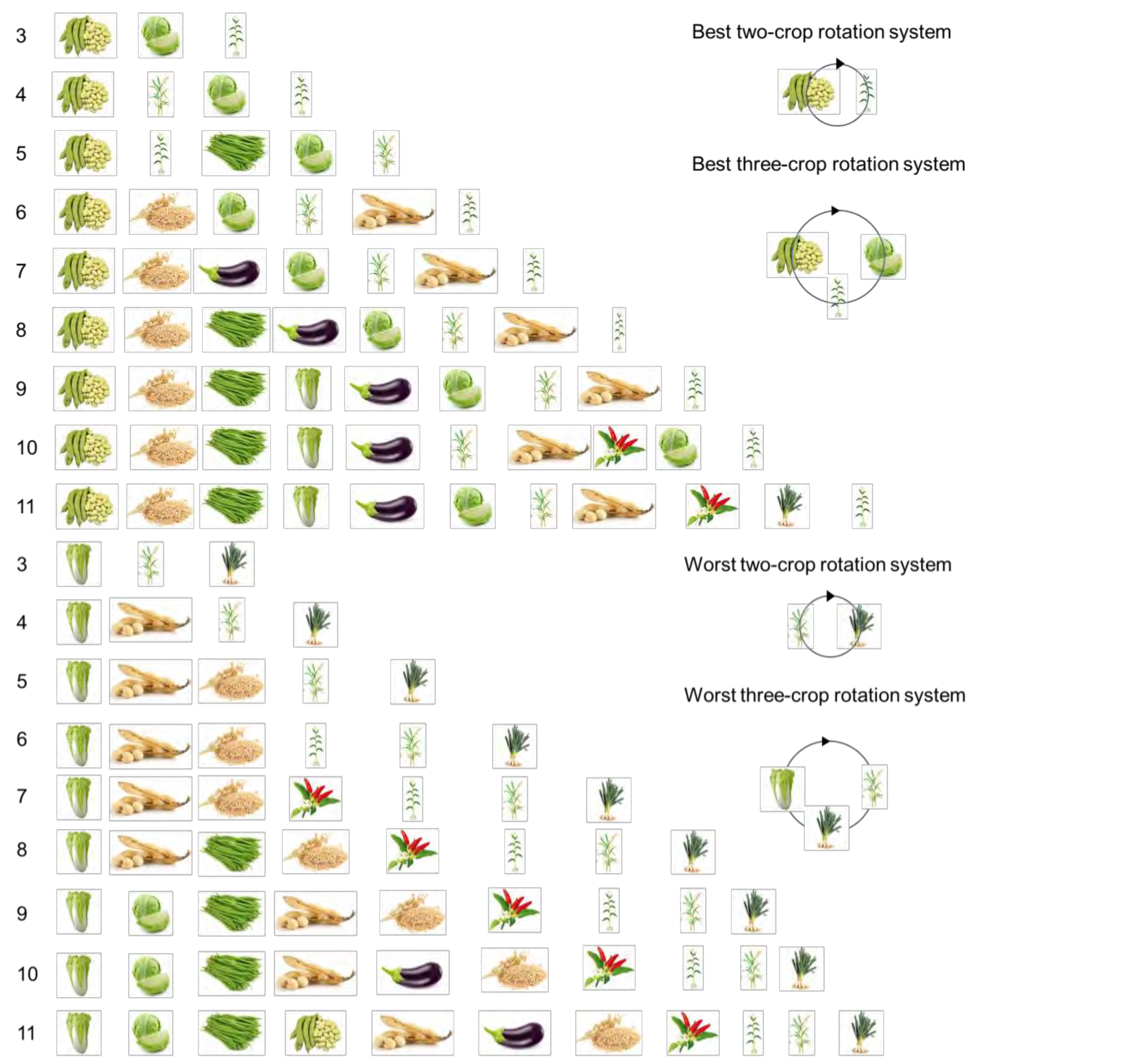

Figure 3 Best and worst crop rotation sequence calculated by feedback values

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.201913043) and Hainan University. Many thanks to Hengjun Zhao, Ivor Keesmaat, Gregor Disveld and other people who had helped for maintaining this PSF experiment.

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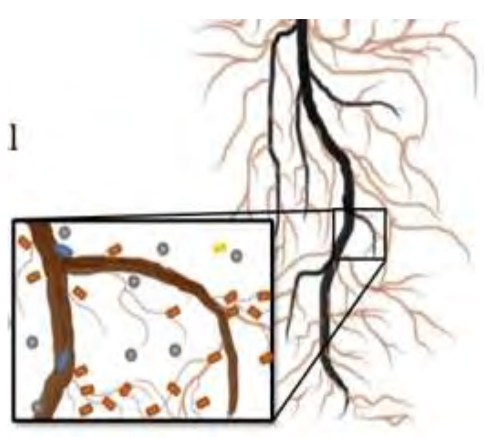
Effect of AMF on N_2O Emission in Crop Stubble Soil and Its Mechanisms

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

Background

Hotspots of N_2O production in agricultural soils are often associated with crop residues. Arbuscular mycorrhizal fungi (AMF) are ubiquitous, its extradical hyphae can penetrate into the organic patches, absorb nitrogen and/or the alteration of the communities of ammonium-oxidizing microbes or denitrifiers. Yet, little is known about the underlying mechanisms how AMF interact with hyphosphere microbiome to influence greenhouse gas emissions from "hot spot" microsites. Given that AMF receive 4-20% of total photosynthetic C from plants and the hyphae form a dynamic network redistributing C into unexplored non-rhizosphere zones, this knowledge gap has important knock-on effects for the development of suitable management practices to increase nutrient use efficiency while mitigating N_2O emissions. This especially important in sustainable agriculture because current intensive agricultural practices result in substantial declining AMF diversity and abundance.



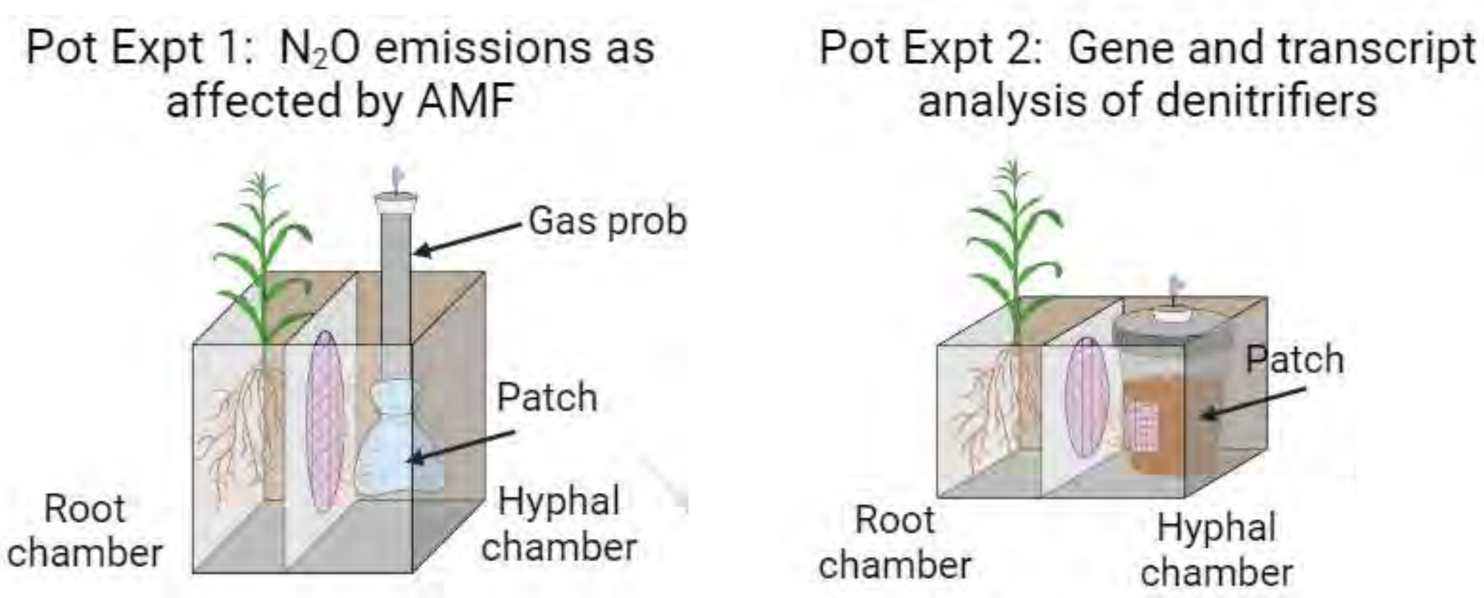
Objectives

To explore plants establish symbioses with mutualistic fungi, such as arbuscular mycorrhizal (AM) fungi, and bacteria, such as denitrifiers, to mitigate N_2O emissions.

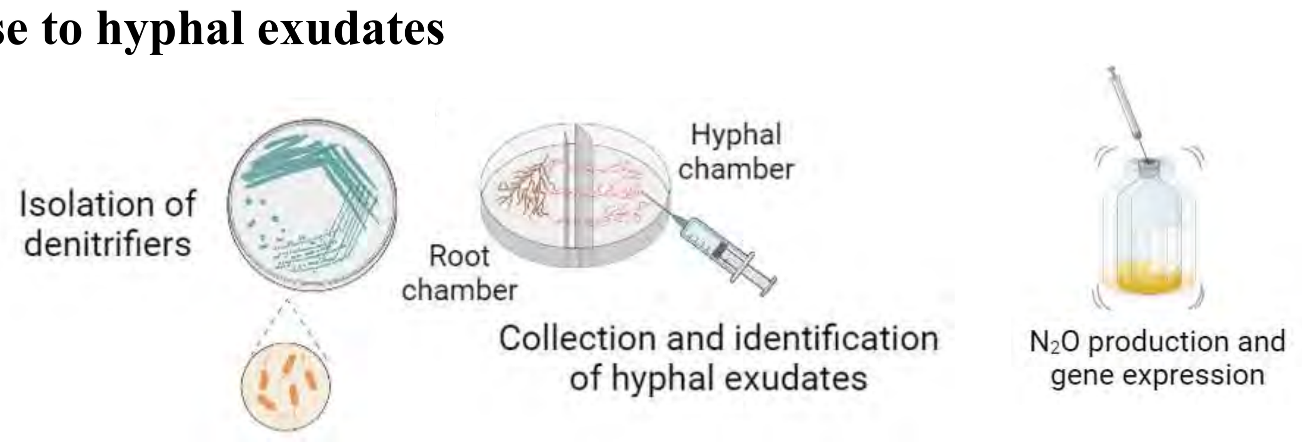
Methods

Part 1 N_2O emissions and denitrifying communities in response to AMF hyphae

Two pot experiments (pot expts 1 and 2) were conducted to examine whether N_2O production in faba bean (*Vicia faba* L.) residue patches declined in the presence of AMF hyphae. We also analysed the abundance and structure of N_2O-producers and N_2O-reducers in all patches with and without AMF hyphae.



Part 2: *In vitro* experiment: N_2O production by isolated denitrifiers in response to hyphal exudates



Results

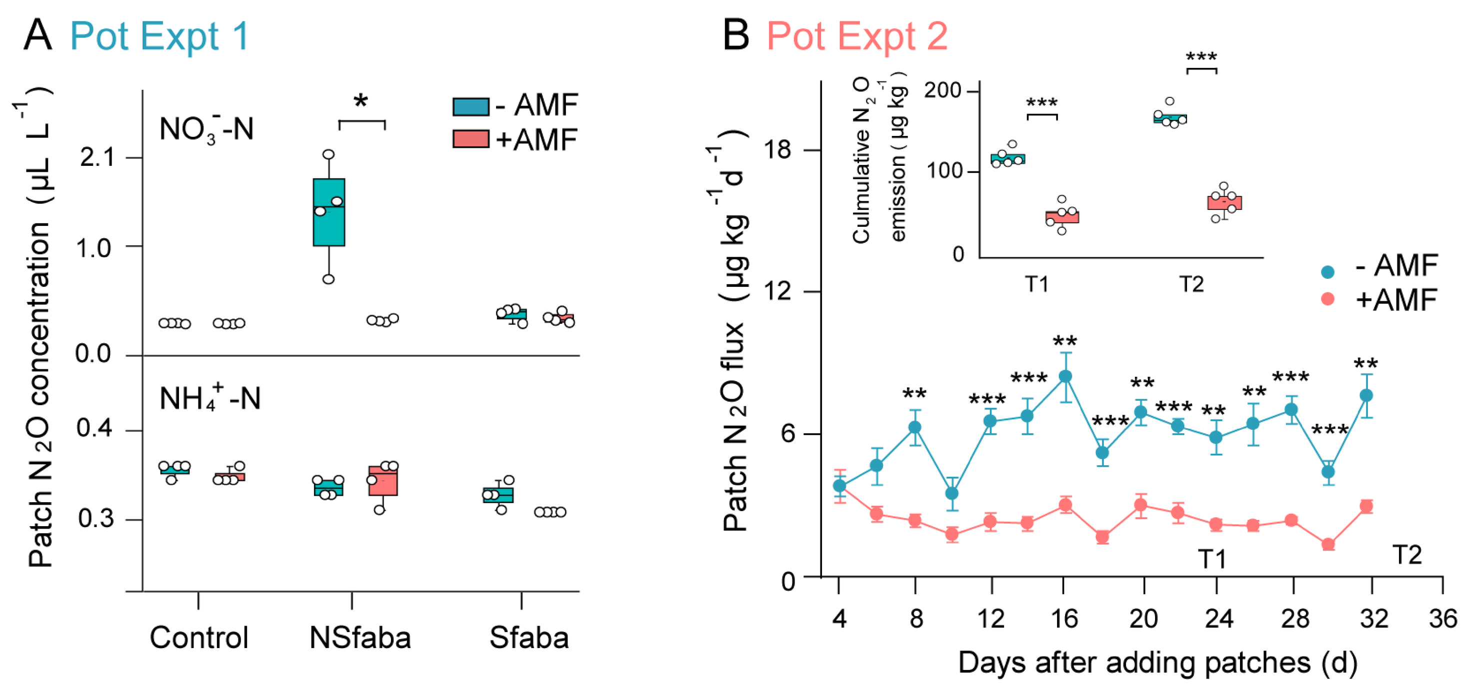


Figure 1. N_2O emissions from patches in the absence (–AMF) or presence (+AMF) of AMF. A, pot expt 1. B, pot expt 2. T1 and T2, first (day 24) and second (day 34) harvests, respectively; asterisks, significant differences between –AMF and +AMF treatments within each gas-sampling time or each harvest 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).

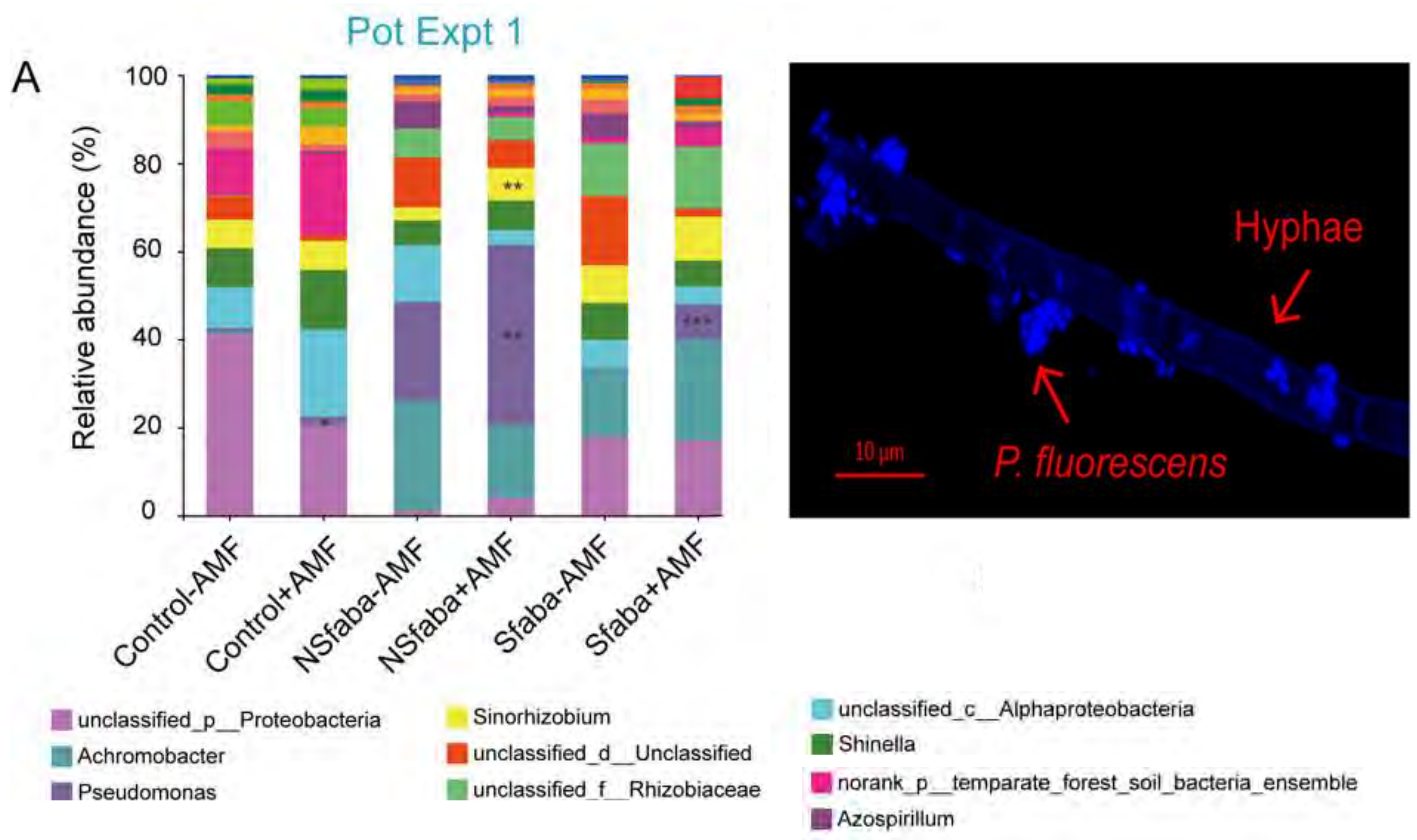
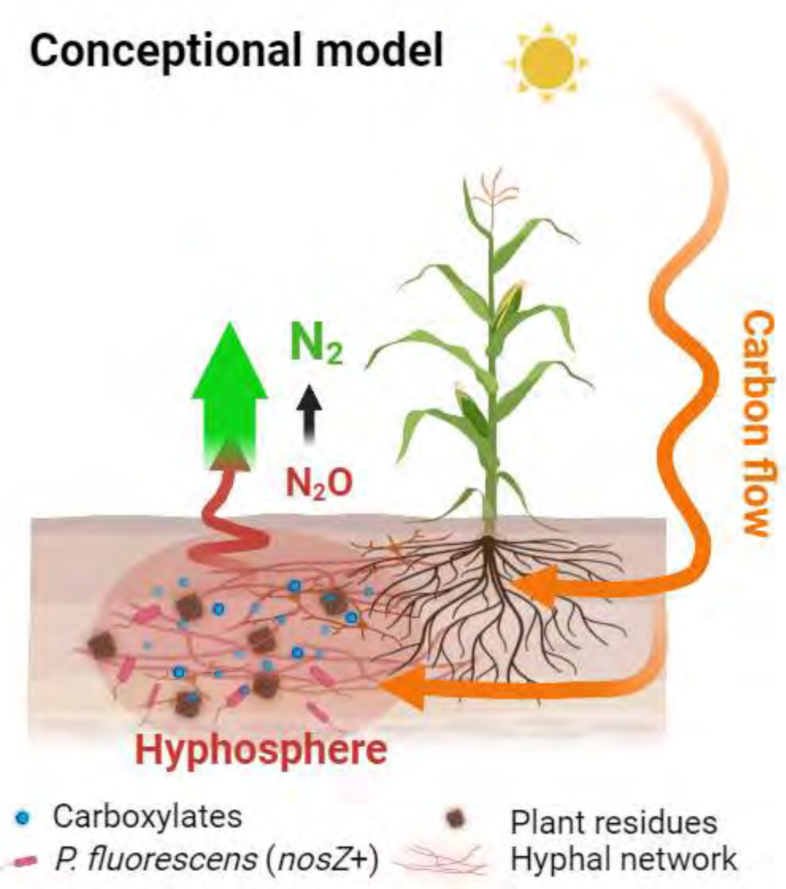


Figure 2. Structure of clade I *nosZ* community in three different patches in pot expt 1 (A) and AMF hyphae with attached *P. fluorescens* stained with 4′,6-diamidino-2-phenylindole (DAPI); scale bar, 10 μm **(B).**

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 with enhanced soil ecosystem services for 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 improve soil ecosystem services.

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 soil ecosystem services in the North China Plain(NCP).

Research framework

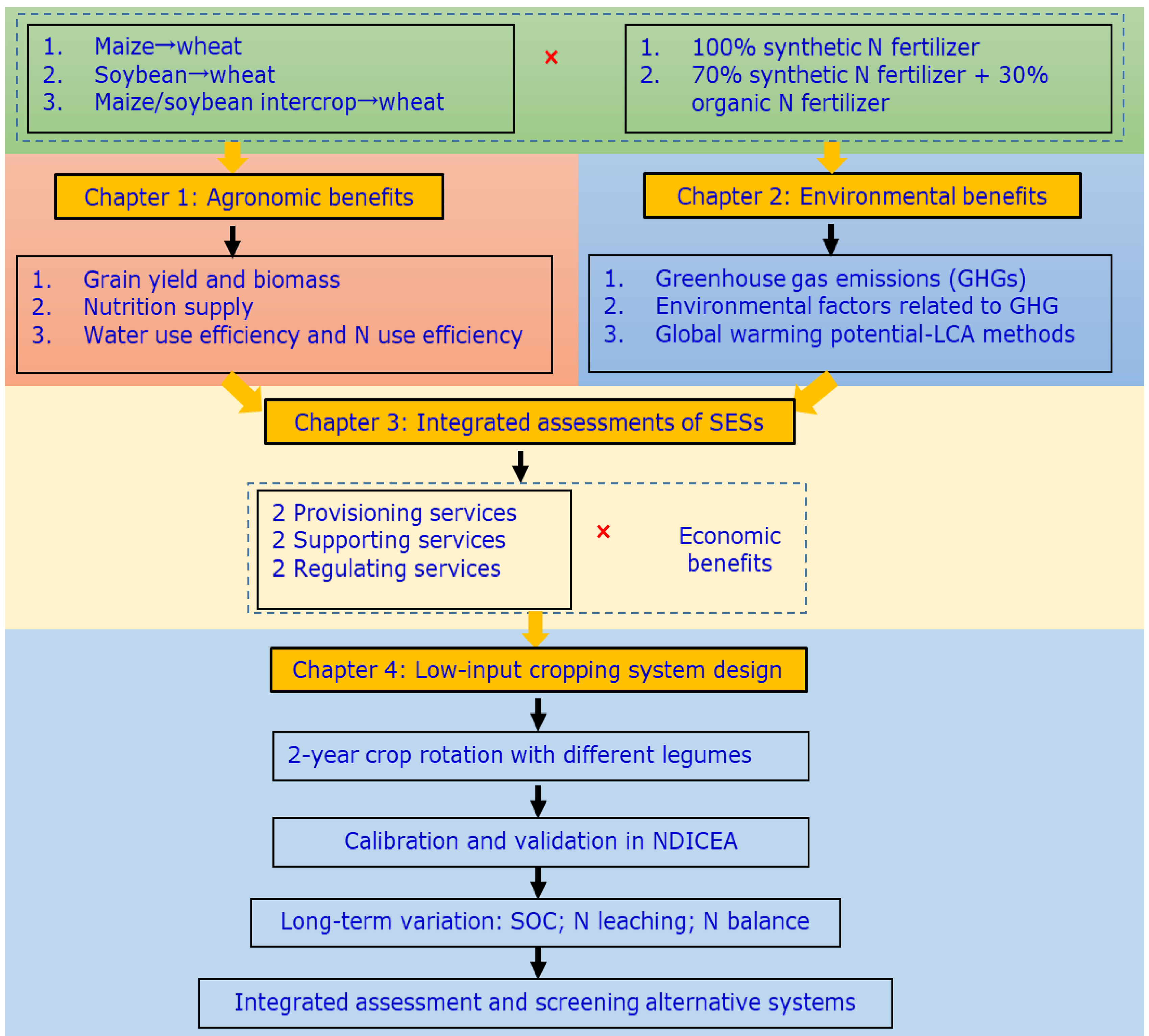

Figure 1. Framework of the project.

Methods

- The field experiment will be established in June 2021 at Quzhou Experimental Station (36.87^{O}N, 115.02^{O}E), 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%.

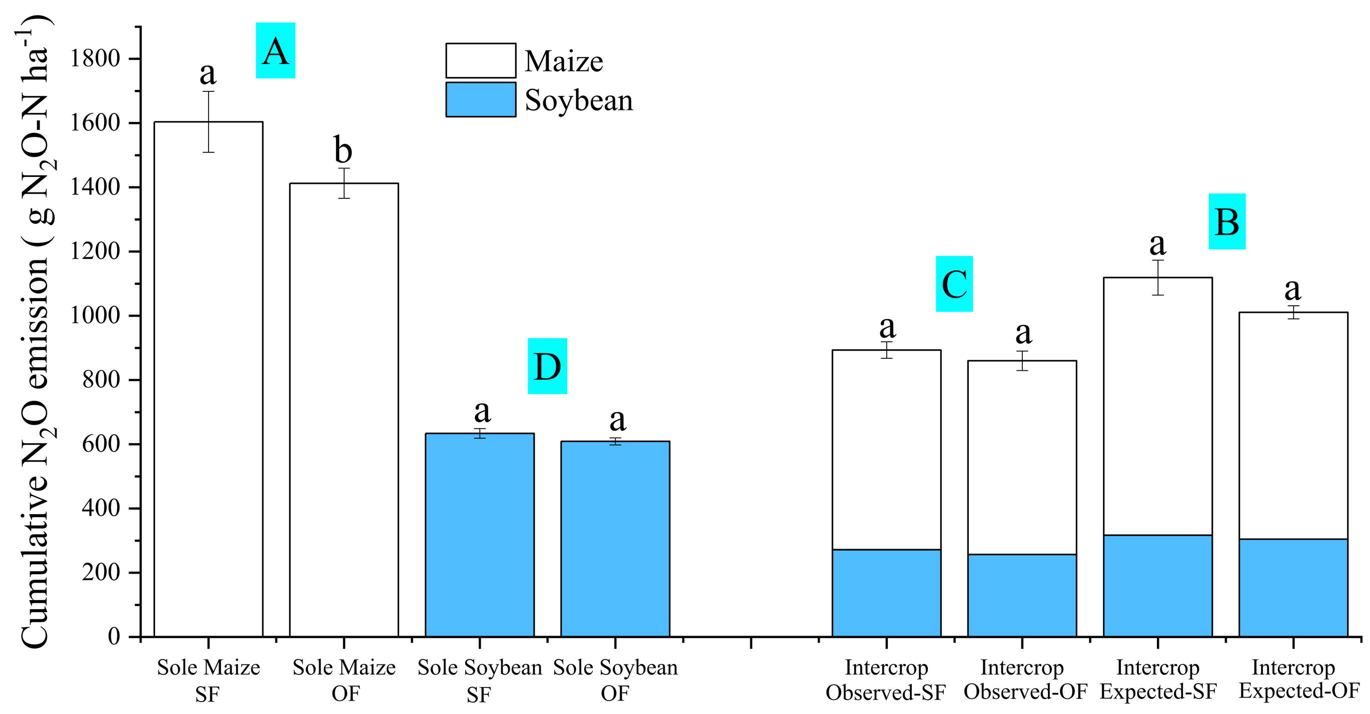

Figure 2. Cumulative N_2O emission of maize, soybean and intercrop under two fertilizer treatment (SF: synthetic fertilizer; OF: 70% Synthetic N fertilizer + 30% Organic N fertilizer). Expected value is calculated as the weighted mean value in the sole crops, with weighing according to the relative density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

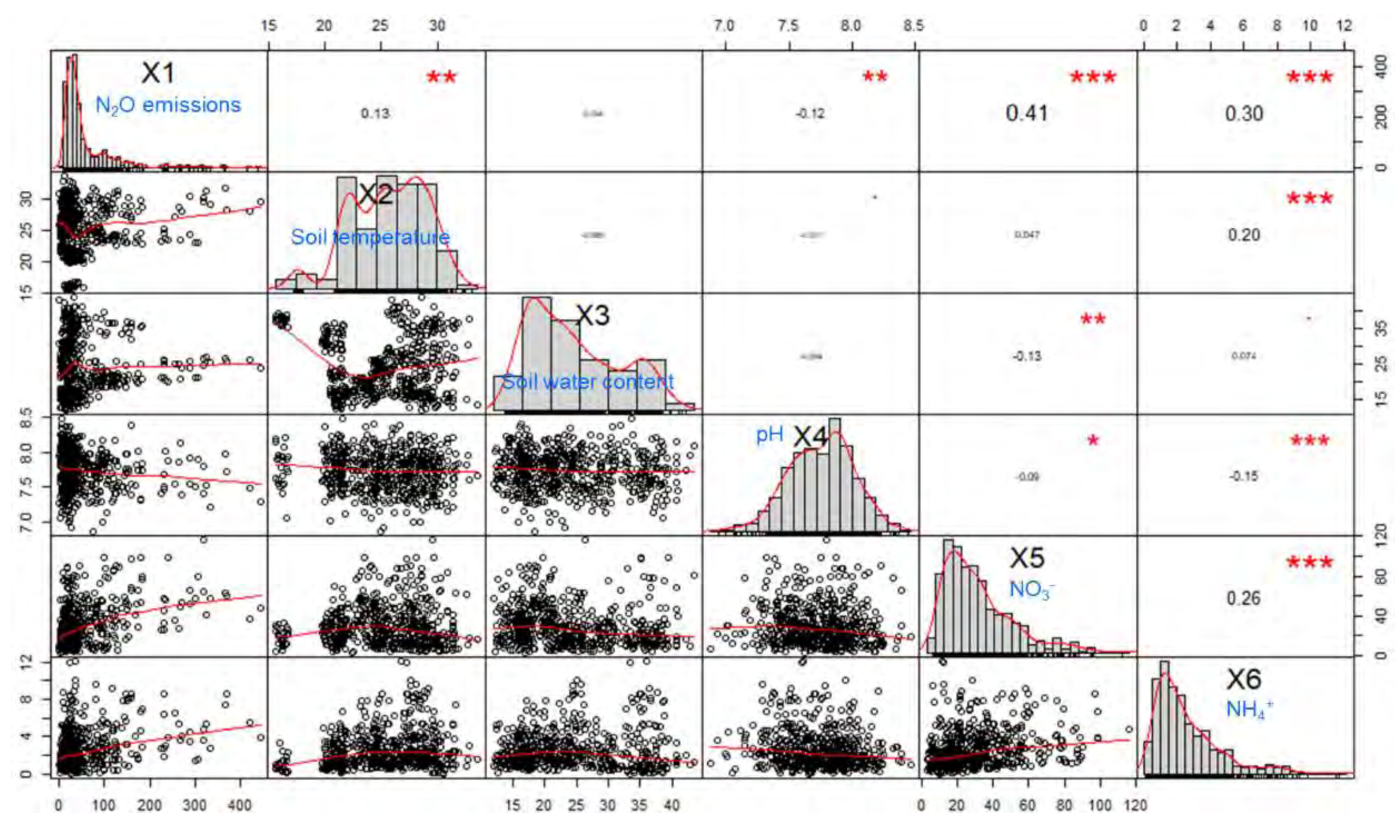

Figure 3. Correlation matrix of associations between N_2O emissions and environmental factors in different cropping systems..

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: EJ van Henten, GW Kootstra, A Leylavi Shoushtari (WUR); Lujia Han, Kailiang Zhang (CAU)
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.

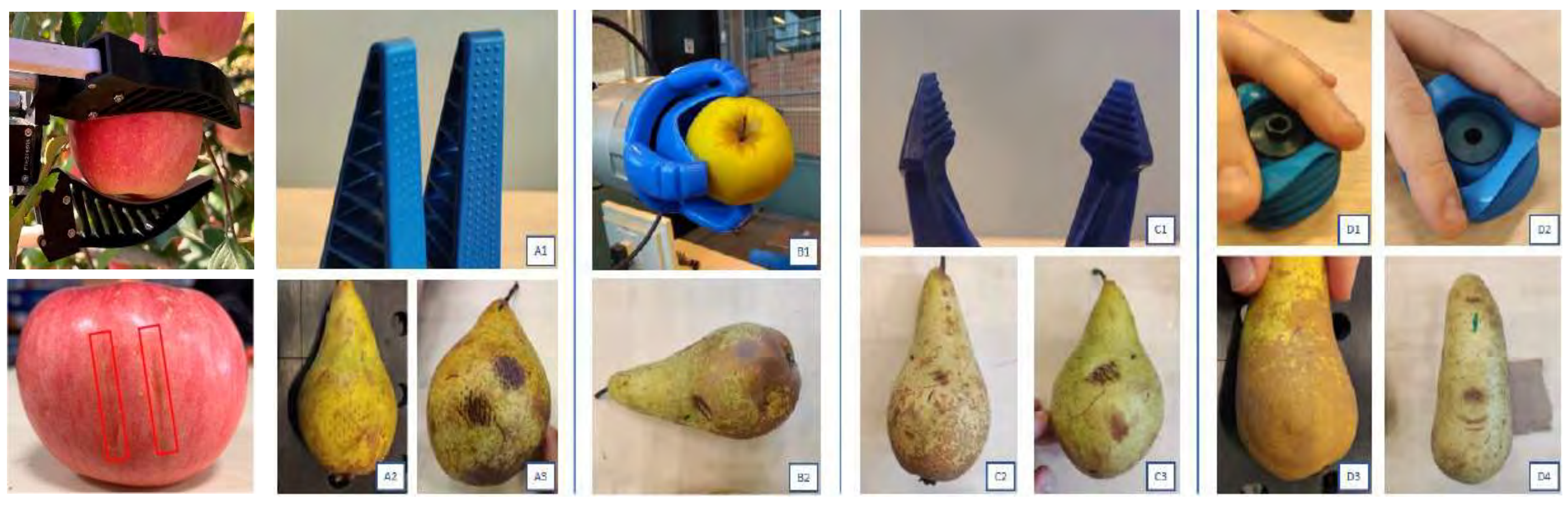

Fig. 1 Examples of grasping damage to the fruit cause by grippers.

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.

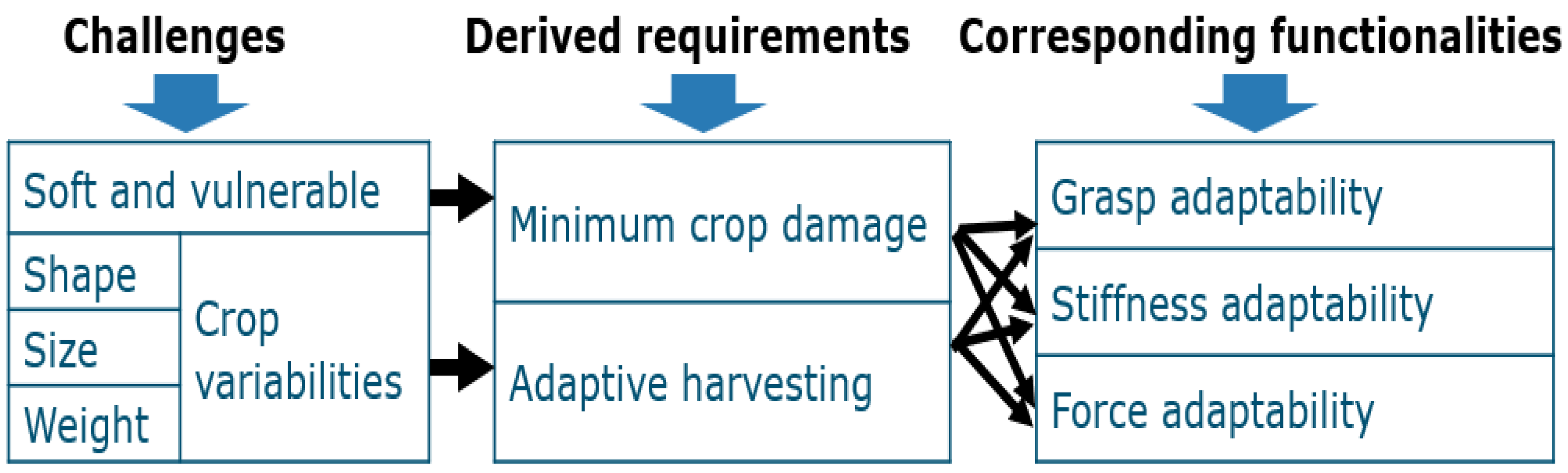

Fig. 2 The challenges, requirements and functionalities for the safe and versatile soft robotic gripper.

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 enlarge their advantages and complement their disadvantages, one mechanism from each category has been selected for the gripper design.

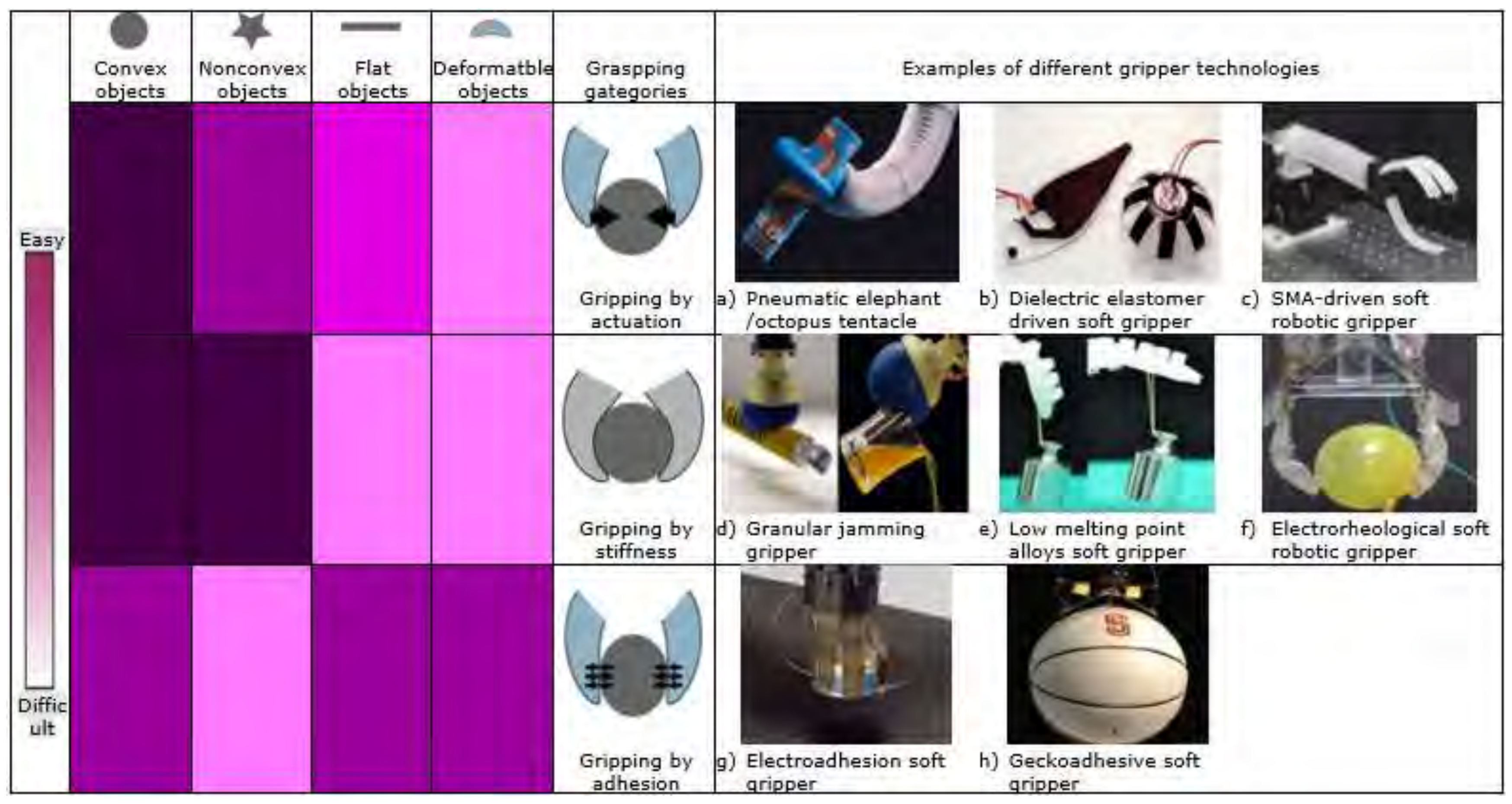

Fig. 3 Examples of soft gripper mechanisms and a qualitative overview of the suitability of different gripper technologies for object shapes.

Results

A hybrid design solution has been proposed through meta-analysis. Tendon driven from grasping by actuation, granular jamming from grasping by stiffness and gecko-adhesion from grasping by adhesion 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	Flat object	Multiple direction approach	Surface condition adaptability
Tendon driven	•Global grasping adaptability •Grasping force	*Low*	*Low*	*High*	*High*
Granular jamming	•Local grasping adaptability •Adaptable stiffness	*High*	*Low*	*Low*	*High*
Gecko adhesion	•Adhesive force	*Low*	*High*	*Low*	*Low*

Tab. 1 The complementary functionalities of candidate mechanisms.

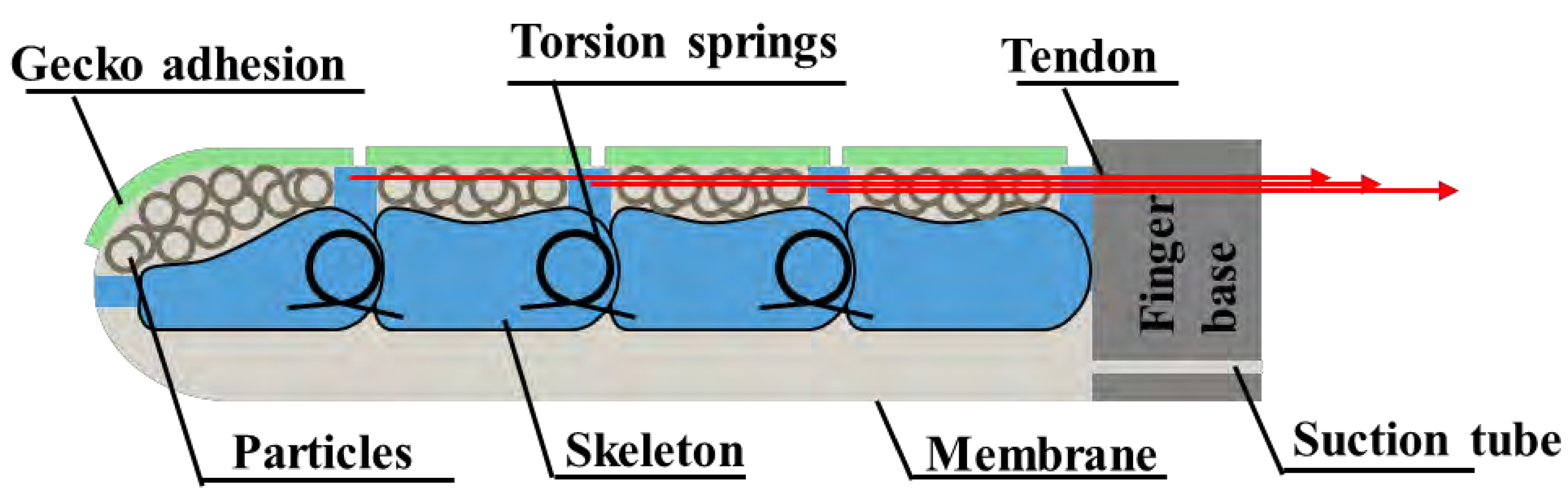

Fig. 4 The schematic view of the finger hybrid design.

Conclusions

A conclusion can be made that the tendon-driven and granular jamming and gecko-adhesion 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.

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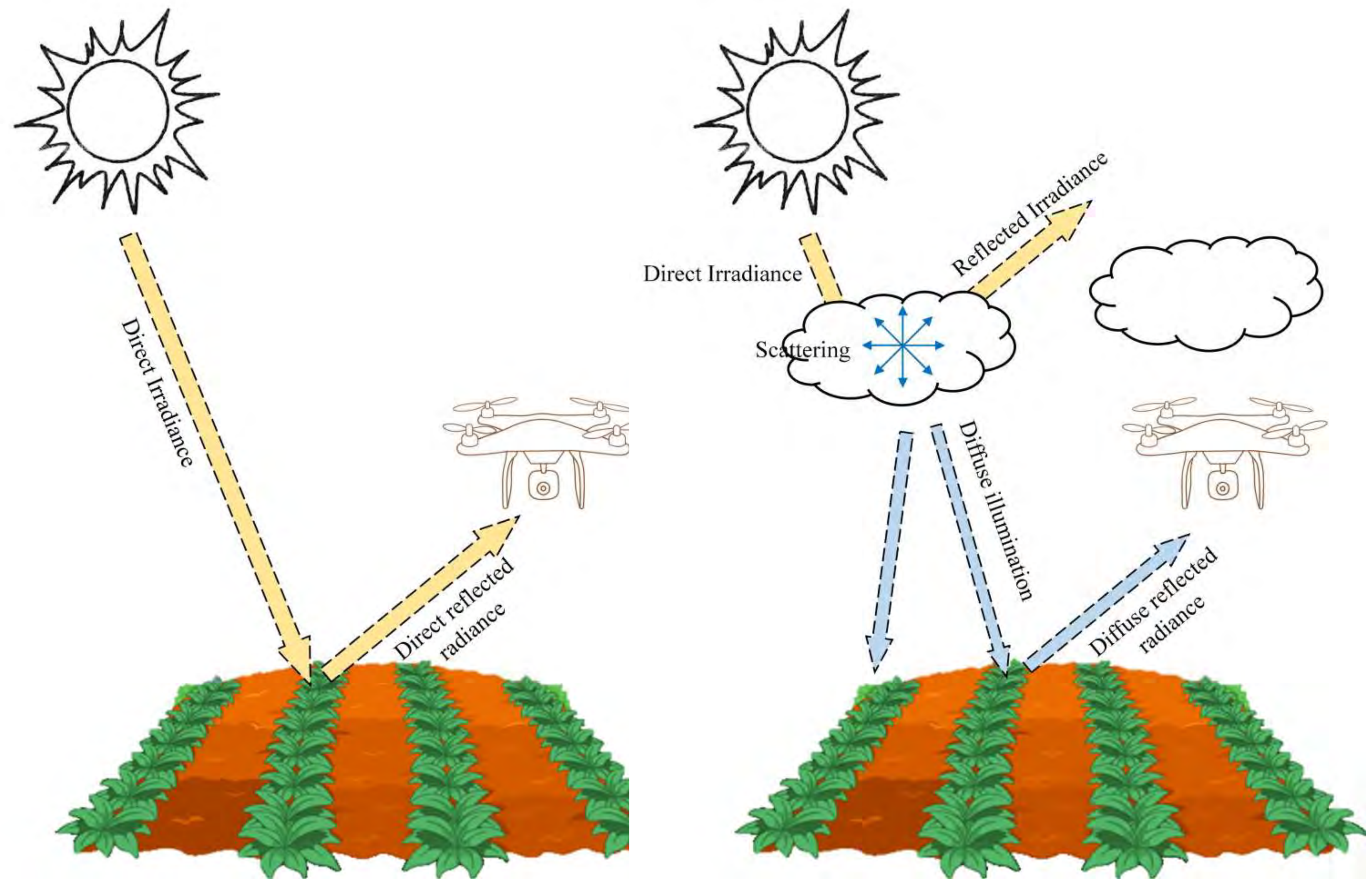
The impact of variable illumination on vegetation indices and evaluation of illumination correction methods on chlorophyll content estimation using UAV imagery

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) Evaluate the performance of Empirical Line Method on illumination correction
b) Evaluate the feasibility of Multi-scale Retinex algorithm for illumination correction
c) Proving the importance of illuminant-invariant VIs for leaf chlorophyll estimation

Methods

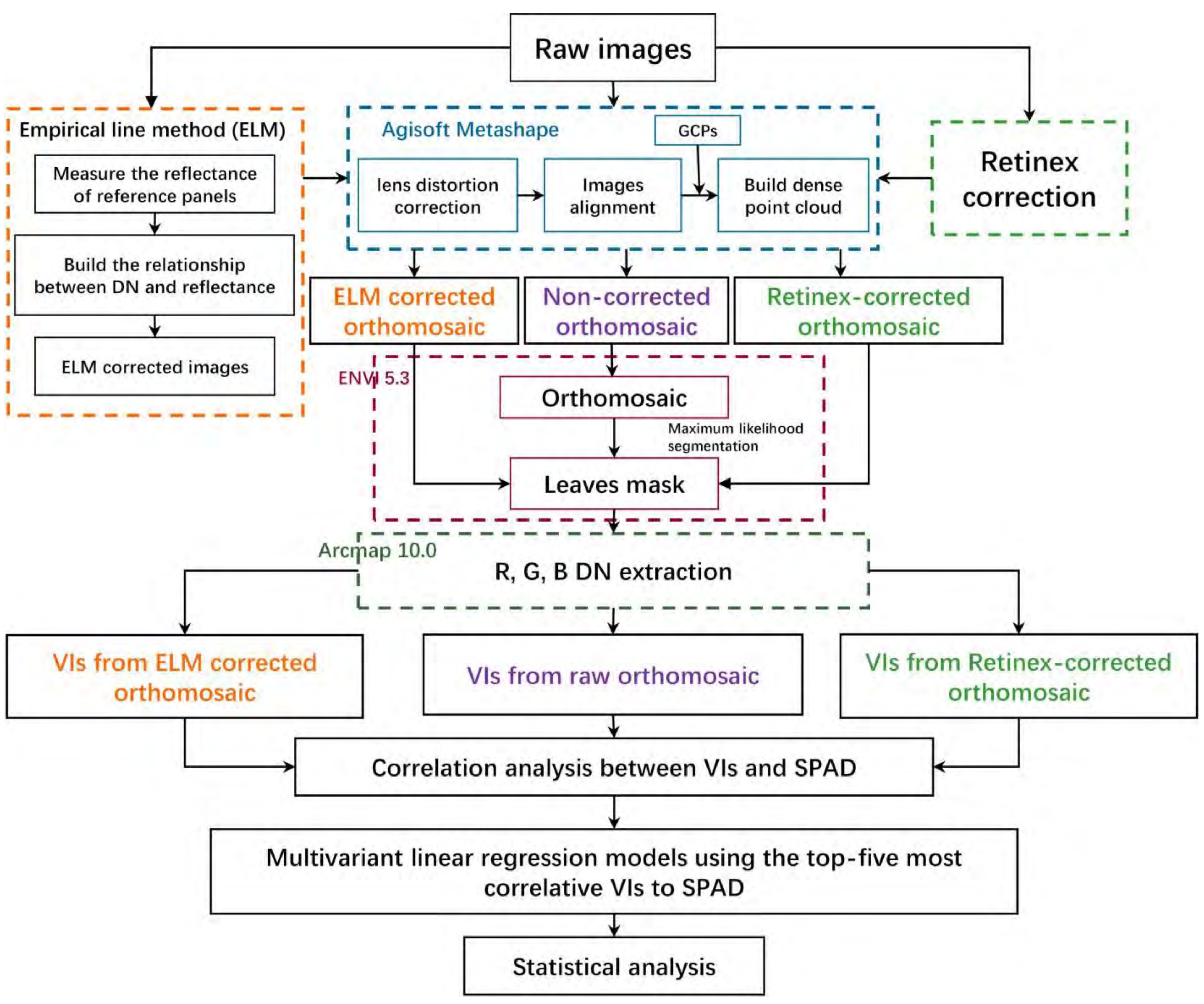


Figure 1. Flowchart for UAV image processing and analysis including illumination correction (ELM and Retinex correction). The workflow is o process aerial images collected under sunny, overcast and cloudy conditions with variable solar irradiance.

Results

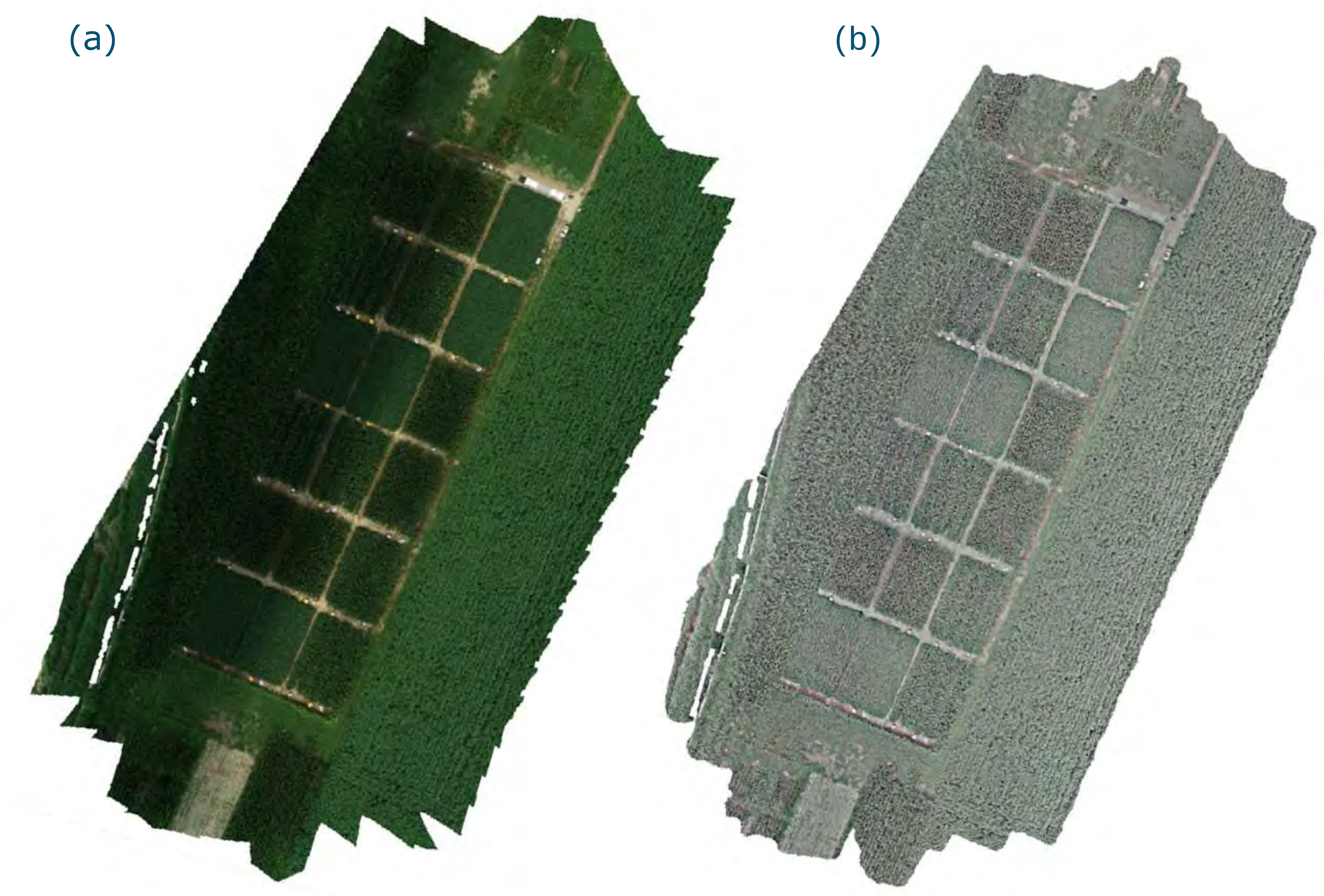


Figure 2. (a) The orthomosaic collected under variable solar irradiance; (b) The illumination corrected orthomosaic using Multi-scale Retinex algorithm

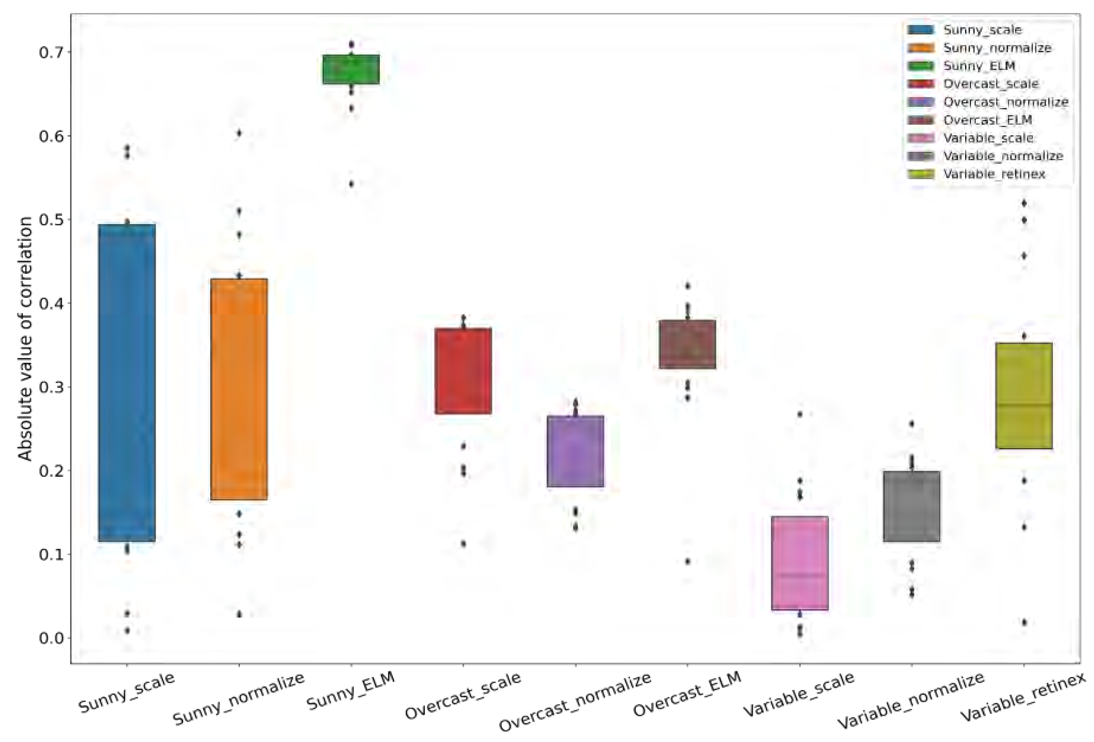


Figure 3. Boxplot of the absolute value of Pearson correlation of each VI and SPAD values.

Illumination	Sunny	Overcast	Variable
Scaling	0.68	0.33	0.3
Normalization	0.53	0.74	0.12
ELM	0.6	0.56	----
Multi-scale Retinex	0.65	0.31	0.61

Table 1. Coefficient of determination (R^2) of the multivariable linear model of soybeans between the top-five most relevant VIs and SPAD under different illumination conditions.

Conclusions

- ELM correction improves the precision and repeatability of the estimation of leaf chlorophyll based on images gathered during a sunny and overcast day.
- Multi-scale Retinex correction mitigate the impact of variable irradiance during a partially cloudy day, improving the performance of leaf chlorophyll content estimation model
- Achieving color or reflectance consistency is important for crop monitoring especially facing changing solar irradiance

Acknowledgements

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

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Land Use Intensity Constrains the Positive Relationship Between Soil Microbial Diversity and Multifunctionality

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

Background

Soil microorganisms play indispensable roles in providing multiple soil functions, namely soil multifunctionality (SMF), such as nutrient cycling, organic matter decomposition, carbon (C) sequestration and pathogens suppression, etc. Many studies have provided evidence that SMF is positively correlated with microbial diversity in both natural and agricultural ecosystems. However, the positive effects of microbial diversity on SMF are mediated jointly or independently by multiple abiotic factors, in particular in agriculture, where agricultural management practices have a profound effect on soil microbial ecosystems by affecting the soil environment in different ways. Improving our understanding of the impact of agricultural managements on soil microbial community and multifunctionality benefits both the cropping system design and ecosystem services.

Objectives

The positive soil biodiversity and multifunctionality relationship has been widely recognized, however in agricultural ecosystems, this relationship is context dependent and could be altered by land use intensity (LUI). Understanding how LUI affects soil microbial community and multifunctionality (SMF) is instructive for optimizing external inputs and managements.

Methods

This study was conducted across Quzhou experimental station of China Agricultural University, located in the central North China. Primary planting patterns in this region were previously investigated, as rotation of winter wheat (Triticum aestivum L.) and summer maize (Zea mays L.), vegetables [cabbage (Brassica oleracea L.), tomato (Lycopersicon esculentum Mill.), eggplant (Solanum melongena L.), etc.] and cotton (Gossypium hirsutum L.). These cropping systems have distinct soil managements which result in different LUI. The cotton cropping system has the lowest LUI (7.73), followed by the wheat-maize rotation system (14.09), and the highest LUI (50.18) occurs in the vegetable system. Soils were sampled from 100 farmlands (55 wheat-maize, 18 vegetable and 27 cotton) in this region (Fig. 1). The soil biological indicators related to C cycling (soil basic respiration, α-1,4 Glucosidase, β- 1,4 Glucosidase, β-1,4 Xylosidase, β-Cellubiosidase), N cycling (leucine-aminopeptidas, β-1,4-Nacetylglucosaminidase, negative value of N2O emission) and P cycling (acid phosphatase activities, alkaline phosphatase) were normalized to a range from 0 to 1 using the maximum method ($f(x) = xi/xmax$). Soil multifunctionality index were determined by averaging all normalized values. All the samples were sequenced on the Illumina MiSeq (300-bp paired-end reads) platform (Illumina).

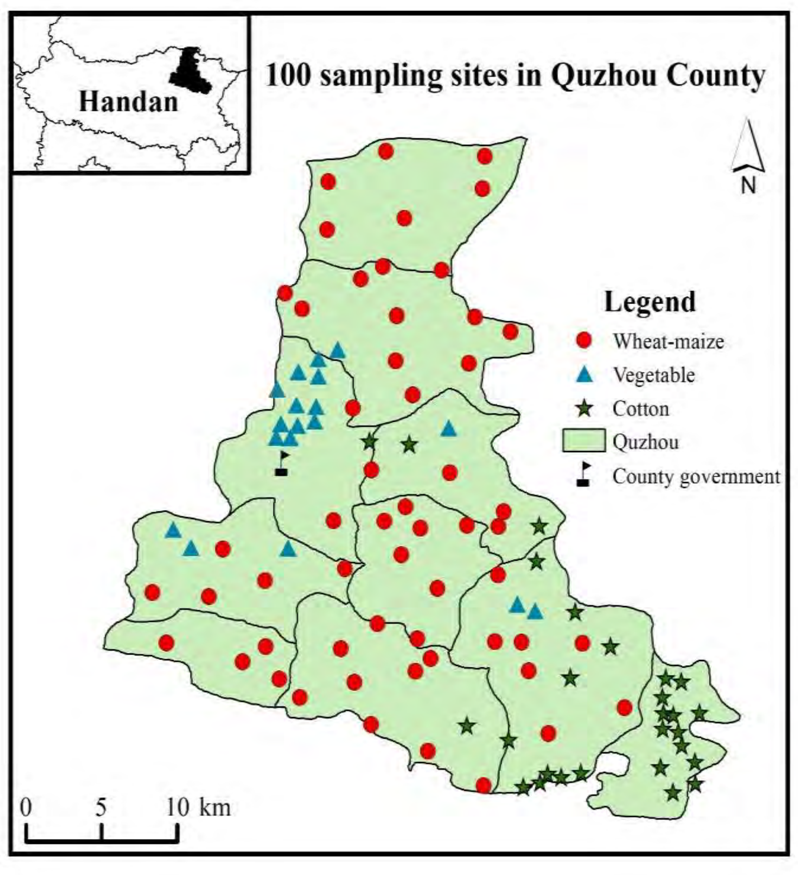

Fig. 1. The distribution of 100 sampling sites across Quzhou experimental station in North China Plain.

Results

Soil microbial diversity and community composition were significantly affected by cropping systems. Microbial α diversity for bacteria and fungi were the highest in the wheat-maize system and lowest in the vegetable system.

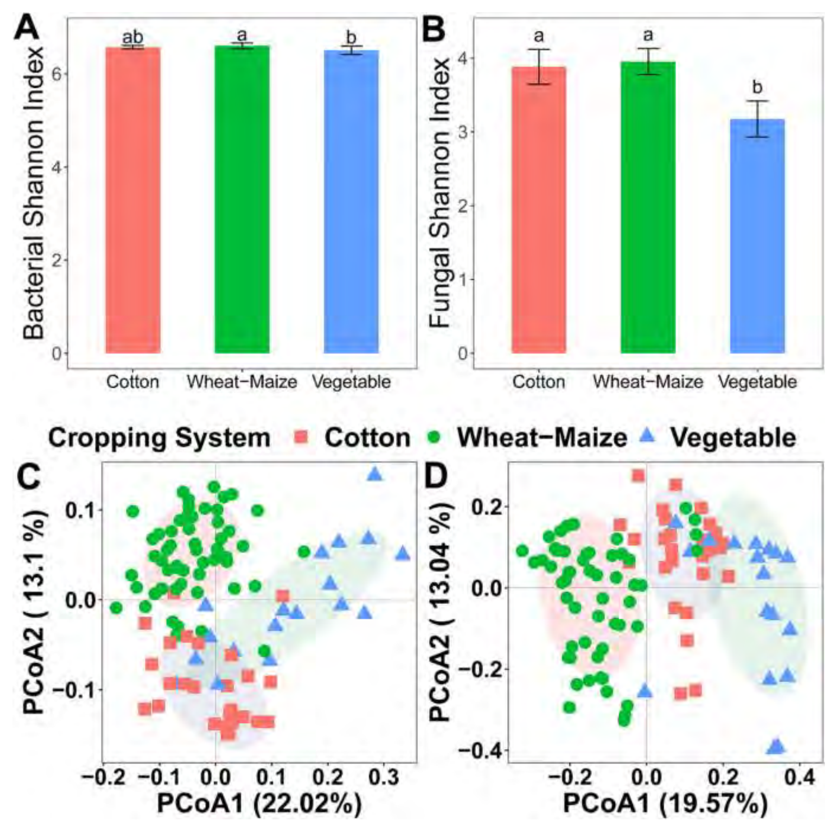

Fig. 2. Levels of soil bacterial (A) and fungal diversity (B) in different cropping systems; Principal co-ordinates analysis (PCoA) of the bacterial (C) and fungal (D) community compositions.

Bacterial not fungal diversity was positively related to SMF. And the realized maximum effect of diversity (Rmde) was 5.77, 4.11 and 3.13 at the threshold of 80%, 69% and 95%, respectively. Therefore, bacterial diversity was most efficient in driving SMF in cotton system compared with wheat-maize and vegetable systems.

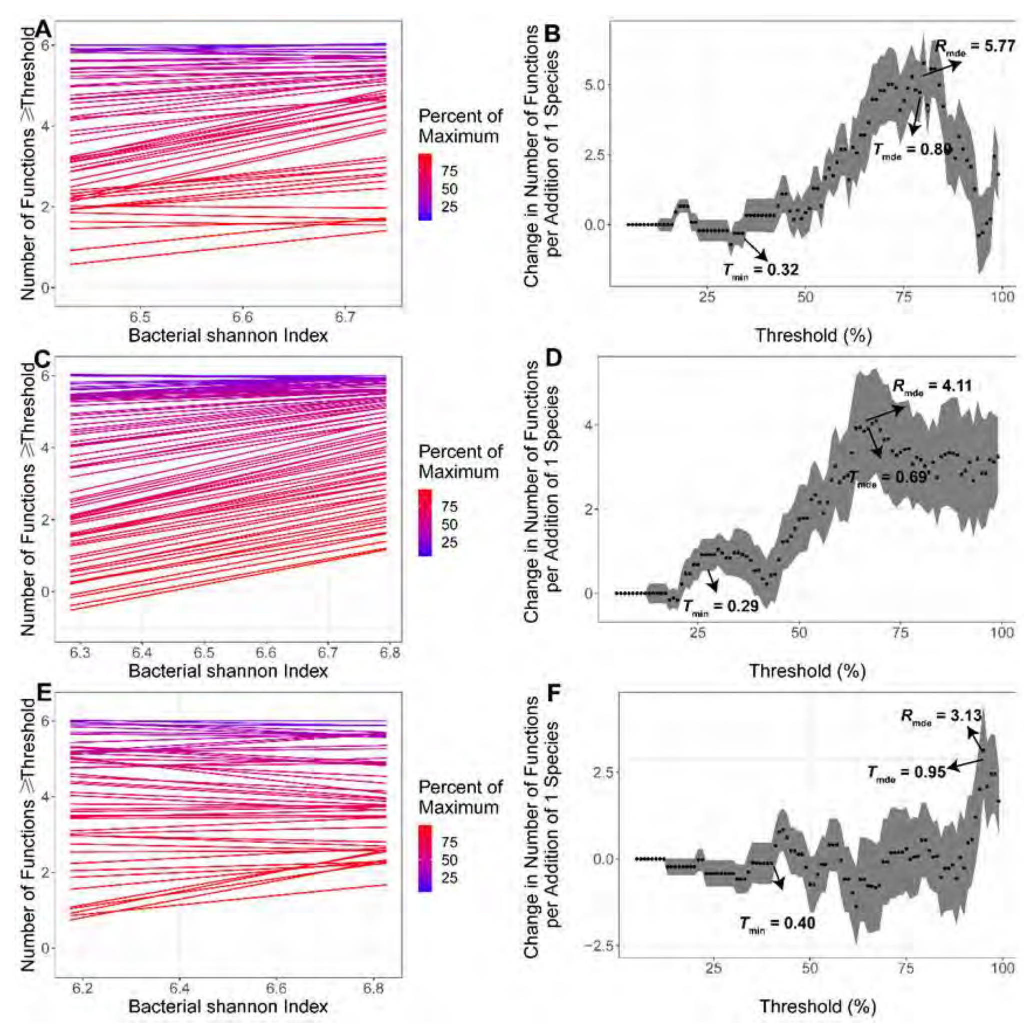

Fig. 3. Relationship between bacterial diversity and soil multifunctionality based on the multi-threshold approach in cotton (A, B), wheat-maize (C, D) and vegetable system (E, F).

Conclusions

Collectively, our results demonstrate that LUI significantly affected the relationships between microbial diversity and SMF. Bacterial but not fungal diversity was positively correlated to SMF. Bacterial diversity in the cotton system had the strongest effect on the ability of the soil system to provide more functions, and the lowest effect in the vegetable system with the highest LUI. Among all the functions, C and P cyclings were two major processes affected by bacterial diversity and composition in generating soil multifunctionality. This study highlights the necessity of reasonable inputs and management for maintenance of soil bacterial diversity and restoration of fungal diversity in order to support higher SMF in agricultural ecosystems.

Acknowledgements

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

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Building a Hospital for Soil Health Diagnosis and Treatment: A Modelling Approach

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

Background

Soil health is crucial for food security worldwide. The North China Plain (NCP) is a main food producing area of China, where although the yield is increasing, inappropriate field practices polluted the soil and dramatically reduced the soil biodiversity. Soil is not just a growing medium for crops, but it should sustainably provide other ecosystem services, which largely depend on soil ecological processes and as such on soil life. Enhancing soil multifunctionality requires evaluation of the soil health status and optimized soil management practices. Existing soil evaluations in China do not fully implement the concept of soil health due to a lack of consideration of dynamic soil properties related to biological characteristics and processes. Optimization of soil health in the NCP requires a holistic system to evaluate the effects of soil management practices.

Figure 1. The five soil functions.

Objectives

To develop multi-criteria decision support models for soil health assessment and optimization tailored to winter wheat-summer maize rotation system in the NCP.

1) To establish a soil database of the wheat-maize rotation system in Quzhou to provide data to support the modelling work in the next steps;
2) To develop knowledge-based cognitive DEXI models to evaluate the capacity of the 5 soil functions (primary productivity, water purification regulation, carbon sequestration & climate regulation, soil biodiversity & habitat provisioning, and nutrient cycling);
3) To validate the DEXI models with the Quzhou soil database;
4) To evaluate trade-offs and synergies between the delivery of 5 soil functions from soil management practices;
5) To develop a soil management optimization model towards desired capacity of 5 soil functions.

Methods

The EU LANDMARK Decision Support System (DSS) is based on decision expert integrative models which describe the relationship between key measurable soil parameters and soil attributes (Figure 2). The convergence of decision trees allows this model to quantify the capacity of a soil to provide five soil functions into three levels: high, medium and low. After the assessment, according to users' desired capacity of each soil function, the model will generate recommendations towards sustainable soil management.

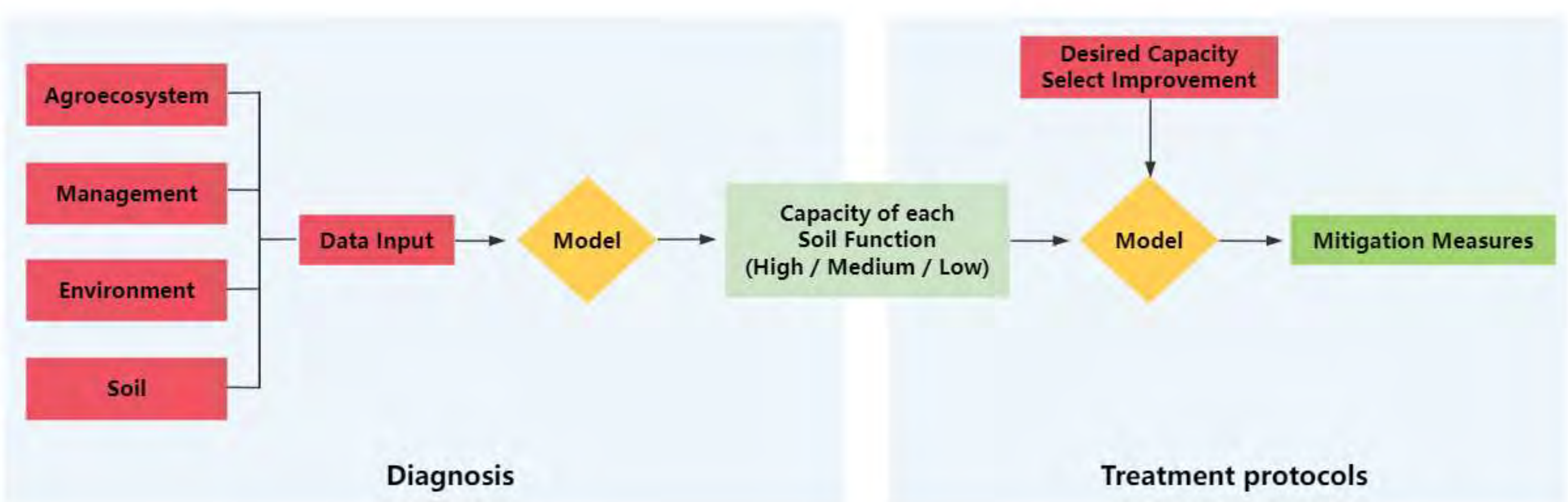


Figure 2. Framework of the DSS model.

A soil database was established to provide data support for the modelling work. The database includes soil properties, management data and meteorological data of Quzhou county. Soil samples from winter wheat-summer maize rotation fields in the Long-Term field Experiments (n=173) and Science and Technology Backyard farms (n=46) in Quzhou were collected before harvesting in the maize season (October in 2020). After soil sampling, a selection of soil physical, chemical and biological indicators were measured in the laboratories of CAU. Field management (including crops yield) data were gathered from questionnaire surveys with local farmers conducted by MSc and PhD students in CAU. Meteorological data were downloaded from the China Meteorological Data Service Centre.

Preliminary results - Primary productivity model

A knowledge-based theoretic DEXI models for soil primary productivity function evaluation tailored to wheat-maize rotation system in the NCP was established. A hierarchical classification tree was designed using the DEXI platform. The 4 main sub-functions were considered as the soil system to provide crops with Water&Air, Nutrient, Heat and Other (to prevent crop failure from pest, weed, salinity and heavy metals). As shown in Figure 4, the input parameters (on the right side) are aggregated at each branch in the decision tree into the overall soil function evaluation score (Low, Medium and High capacity, on the left side).

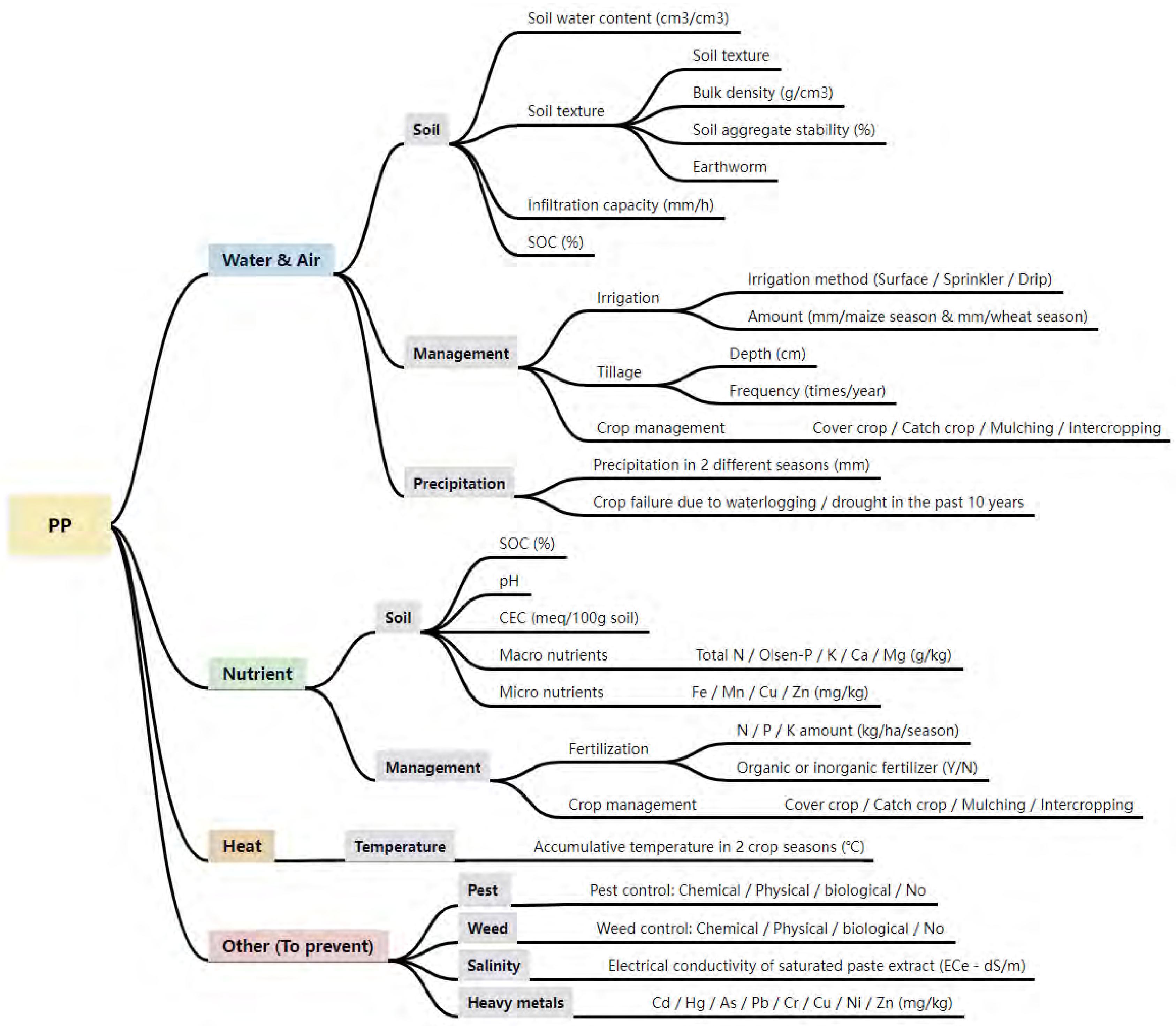
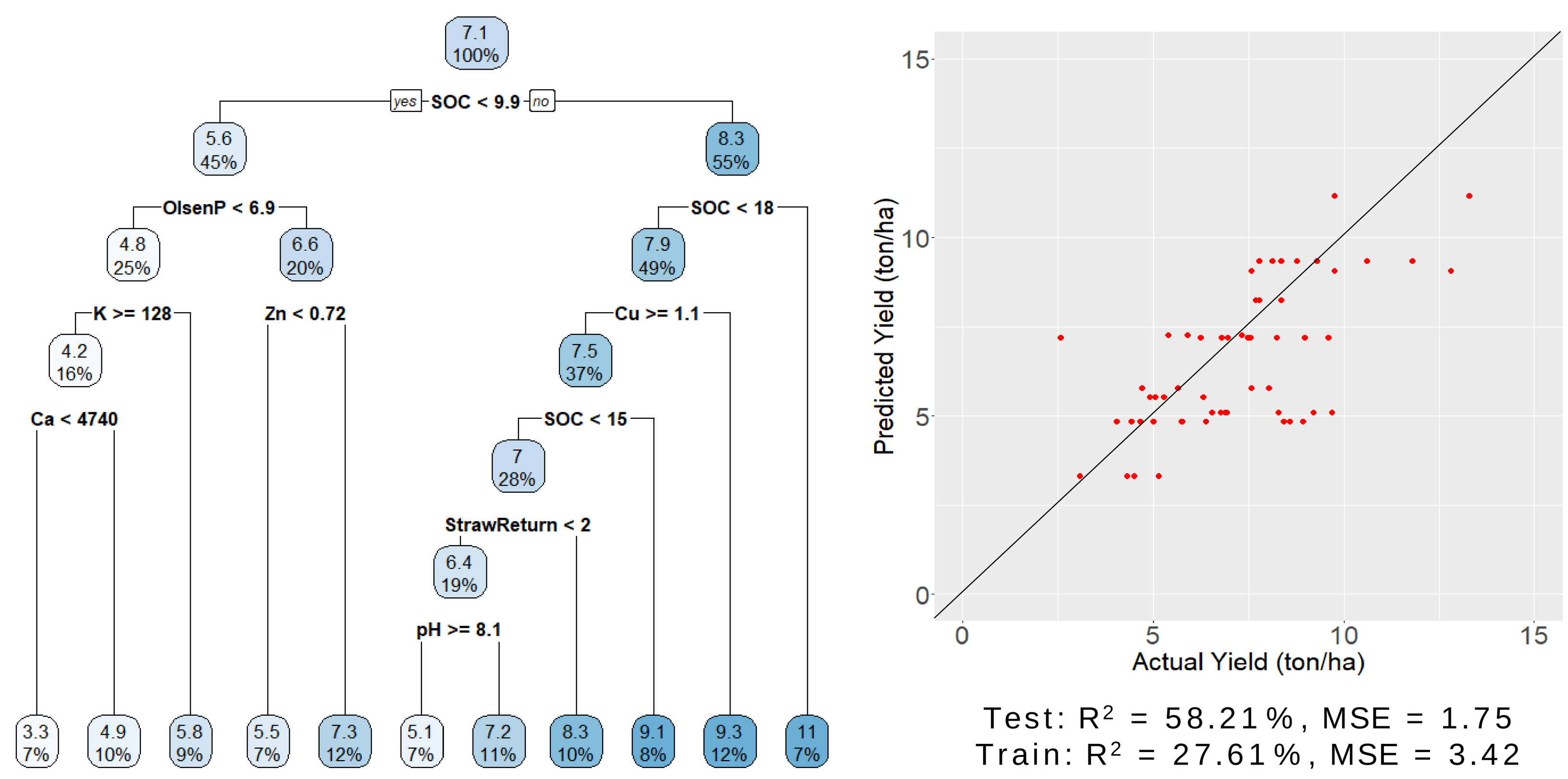


Figure 3. Classification tree of soil primary productivity function.

The cognitive knowledge-based DEXI model was further calibrated and validated with the Quzhou database, through comparing the predicted function capacity versus categories of actual crop yields. Machine learning and data mining of the Quzhou database was employed to explain the importance and cut-offs of indicators from the data perspective (Figure 4). These information will be used to prune the tree and make adjustments to the indicator thresholds and integration rules of initial DEXI model.



Test: R^2 = 58.21%, MSE = 1.75
Train: R^2 = 27.61%, MSE = 3.42

Figure 4. Classification tree generated from data mining (the left figure) and its prediction performance (the right figure).

Acknowledgements

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

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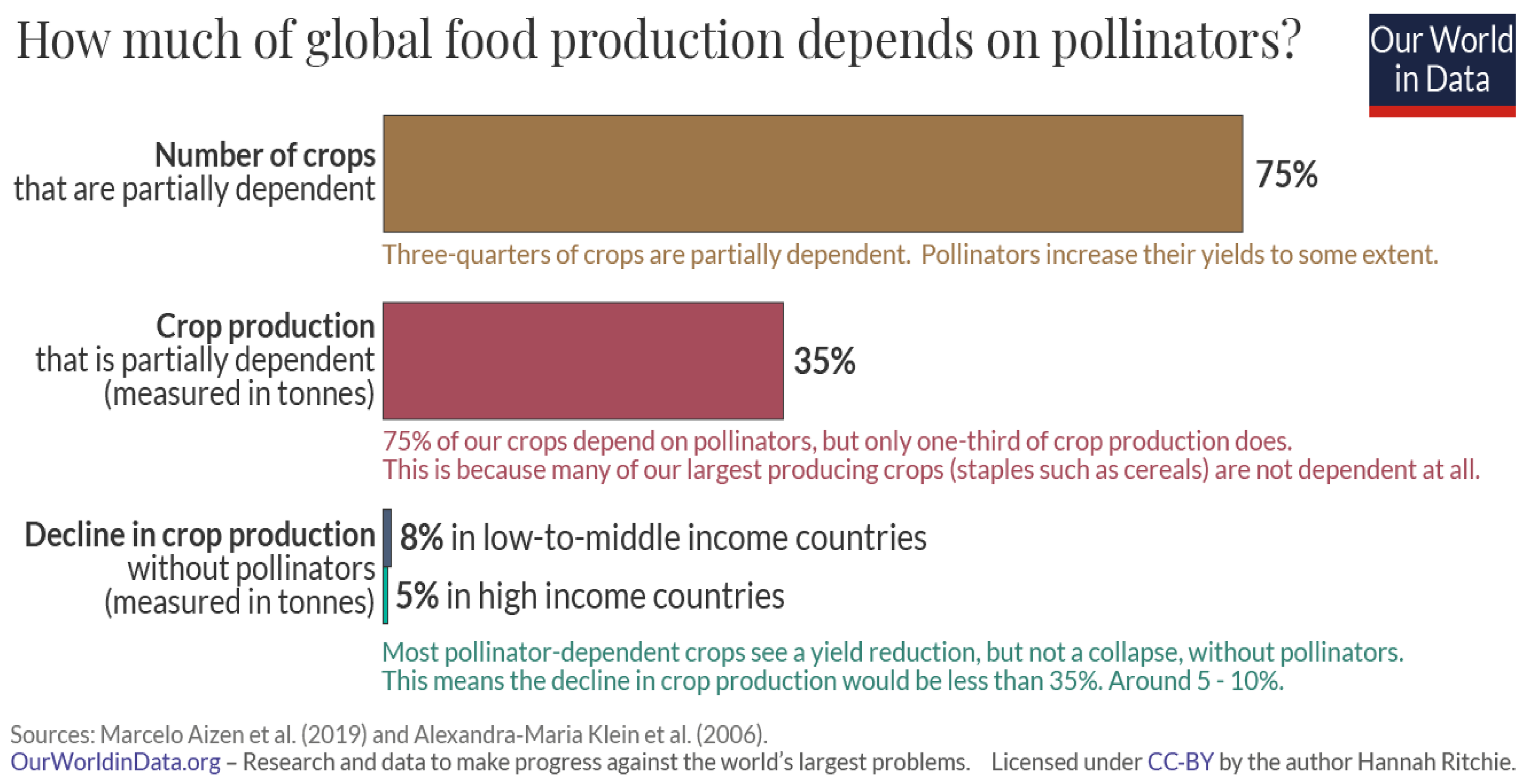
What's the status of pollination services in China's typical intensive farmland?

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

Background



The requirement for pollination services will increase with people's health, nutrition and diverse food demands. However, farmers may underestimate pollination service's contribution to crop yield. Landscape simplification and use of pesticides are detrimental to most pollinators, but there is a lack of information on the abundance and diversity of pollinators in China's intensive farmland and the pollination services provided.

Objectives

a) Estimate the insect pollinators' abundance and diversity, also pollinator visitation rate related to pollination services in China's typical intensive agricultural region;
b) Explore whether there is a pollination limitation in Quzhou, a typical crop producing county in the North China Plain and experimental zone for agriculture green development.

Methods

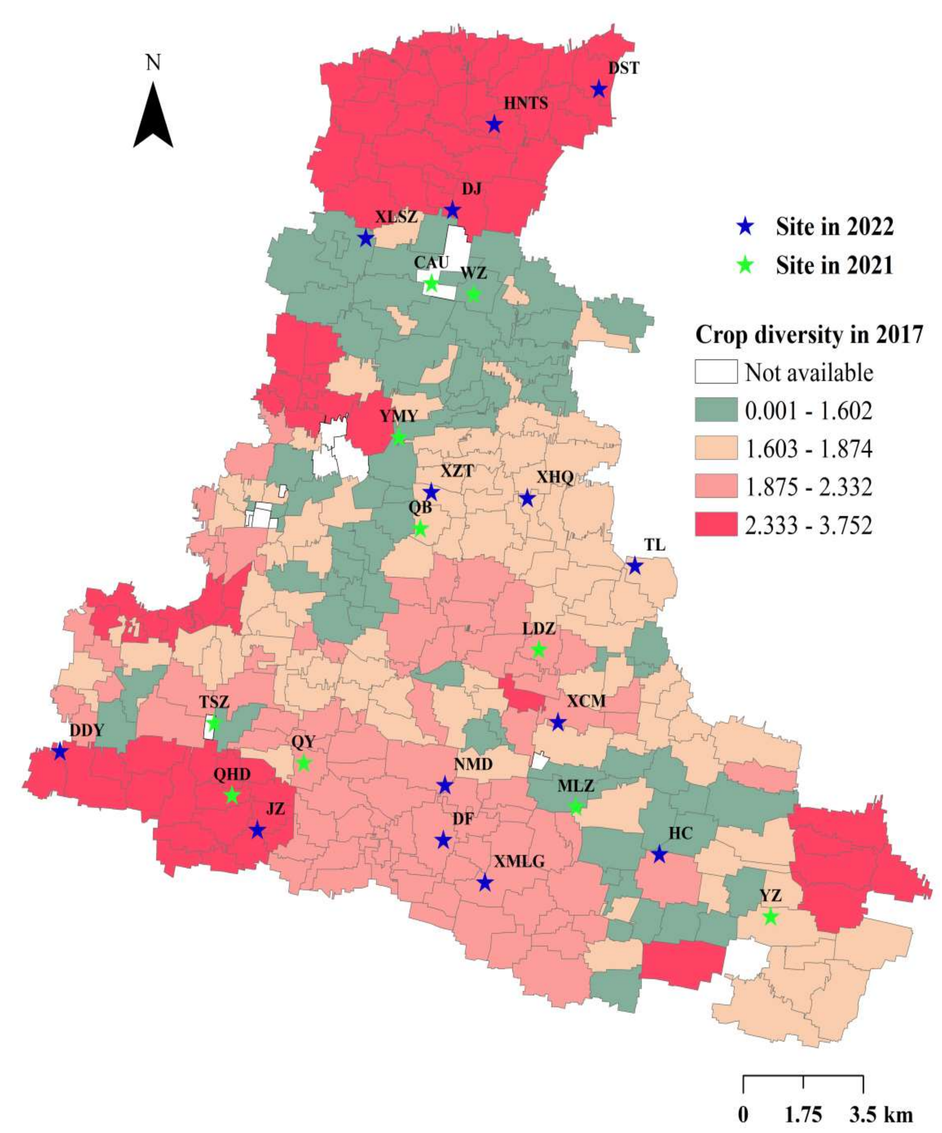


Fig 1. Experimental sites in Quzhou County. The crop diversity baseline referred to the statistical yearbook of Quzhou in 2017

Fig 2. Pan trap stations used to collect pollinator samples

Fig 3. Buckwheat plants were put in the field to measure pollinator visitation rate and pollination

A two-year field experiment was established in Quzhou county to estimate the status of pollination service in intensive farmland. Based on the gradients of crop diversity, we chose 24 sites. At each site, pan trap stations were installed to collect the pollinators in this region. Buckwheat (*Fagopyrum esculentum* M.) depends highly on insect pollination. Plants were put in the field to determine pollinator visitation and pollination success.

Results

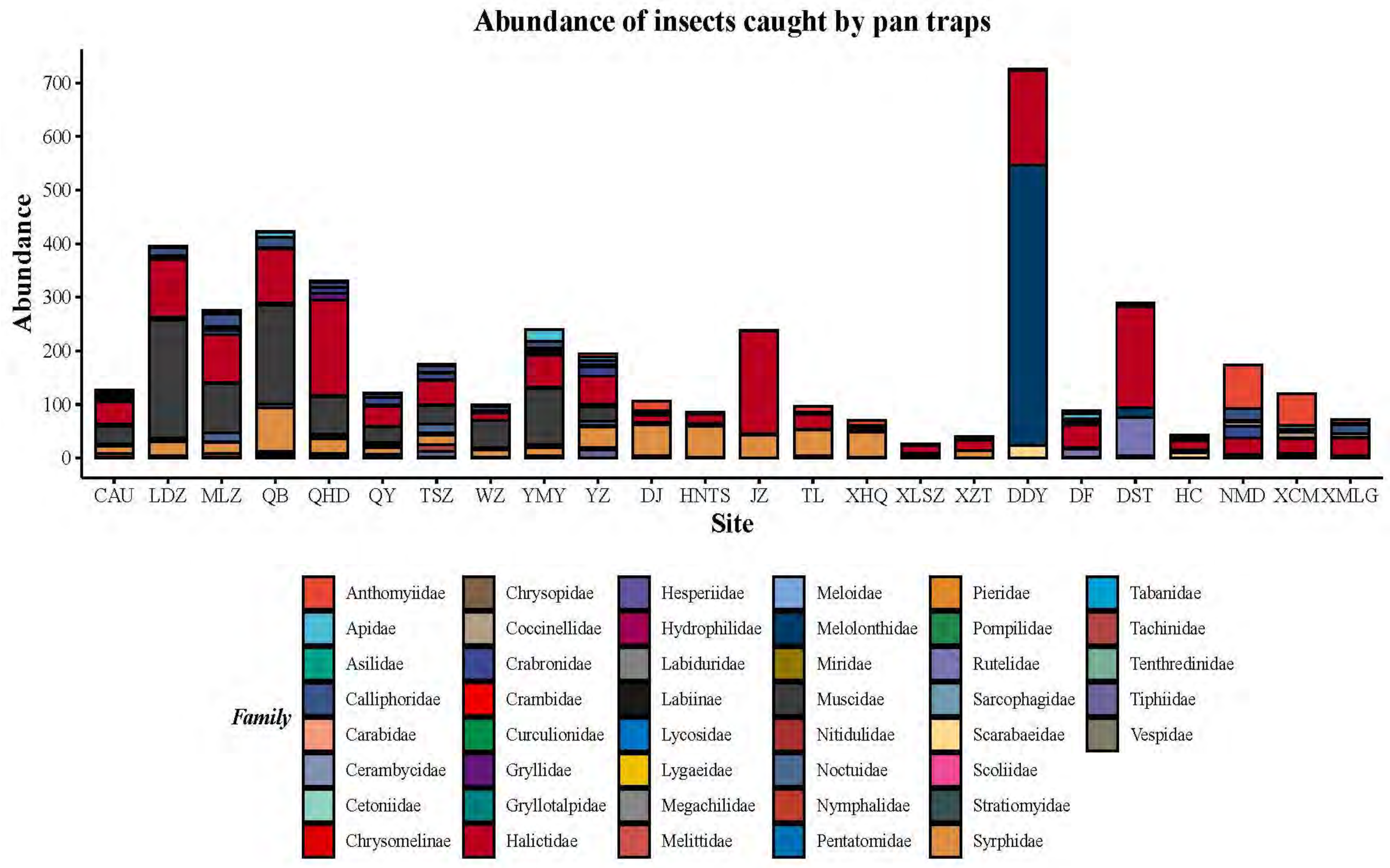


Fig 4. Abundance and composition of insects caught by pan traps

At these 24 sites, the total insect abundance was 4559, and the richness of insects was 45 at the family level. The Shannon diversity (exponentiate Shannon entropy) of insect pollinator groups in this region was 4.89. The dominant pollinators were *Halictidae, Syrphidae, and Muscidae*.

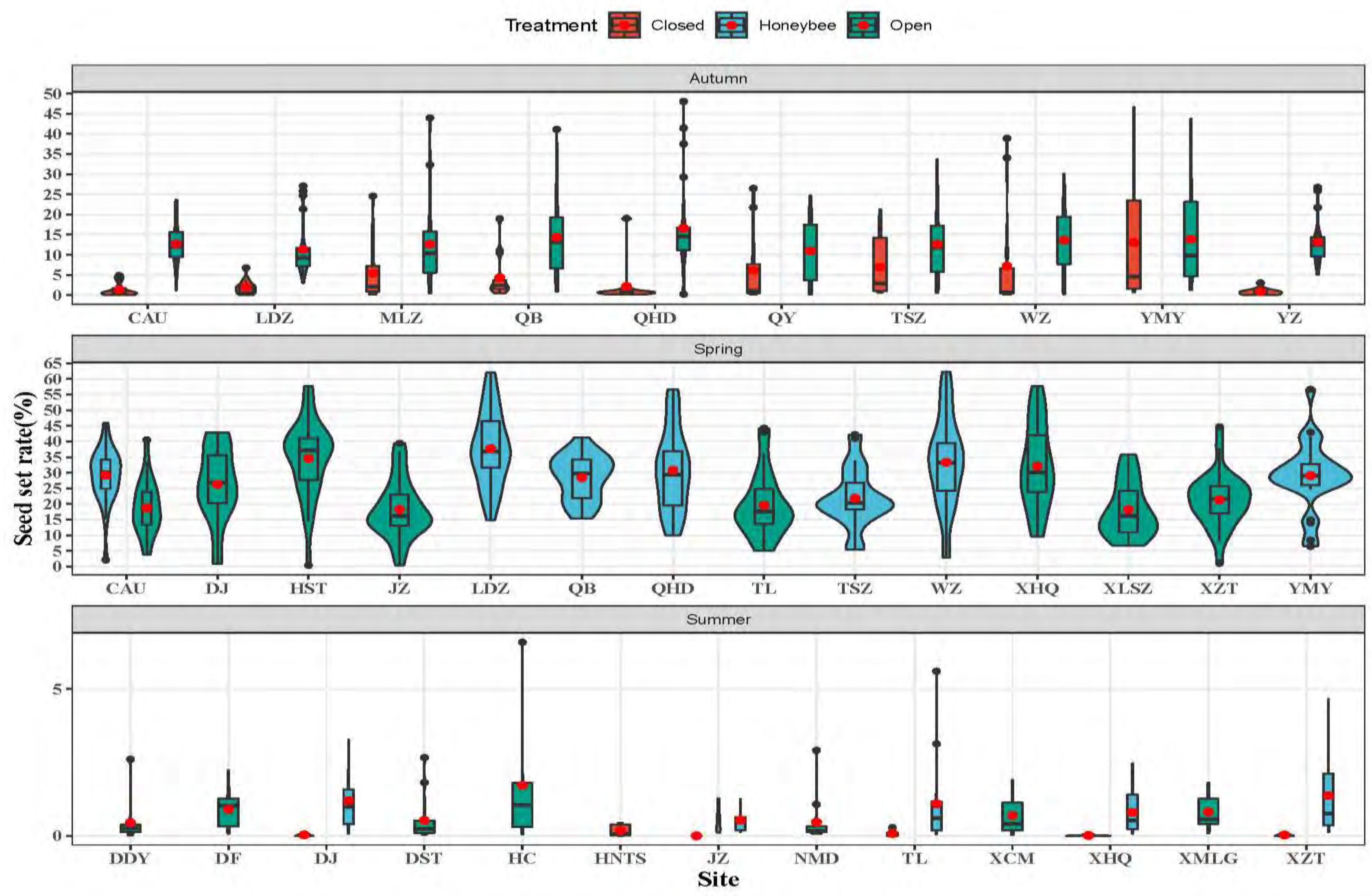


Fig 5. Seed set rate of common buckwheat at different pollination treatments

The seed set rate varied greatly between seasons and was affected by rainfall and temperature. Supplementation of honeybees improved seed set. The effect of honeybee was greater in spring than in summer.

Conclusions

a) *Syrphidae* and wild bees of the family *Halictidae* were the main wild pollinators of common buckwheat in this study.
b) Compared to the open pollination treatment, the honeybee treatment improved the seed set rate in part of the sites, which meant some areas, but not all areas in intensive farmland, had pollination limitations.
c) We will further explore whether landscape factors or crop management (pesticide use) can explain differences in pollinator communities and pollination limitations between sites.

Acknowledgements

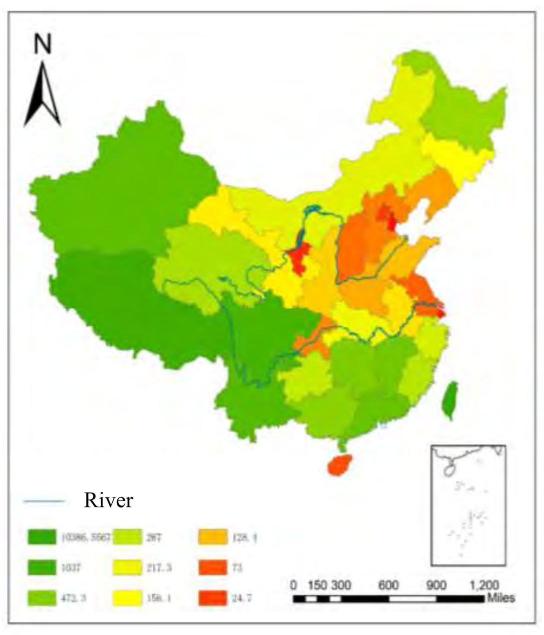
We gratefully acknowledge the sponsors of this research: China Scholarship Council (NO.201913043) and Hainan University.

Contact: yanjie.chen@wur.nl (Centre for Crop System Analysis)

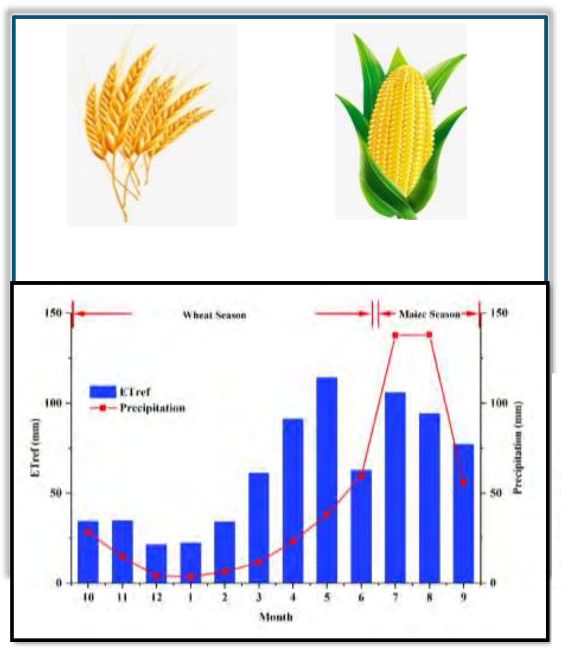
Reduce the water productivity gap by optimizing the irrigation regime for the winter wheat-summer maize system in the North China Plain

Bo Wang
Supervisors: Xiaolin Yang (CAU), Coen Ritsema, Jos van Dam (WUR)

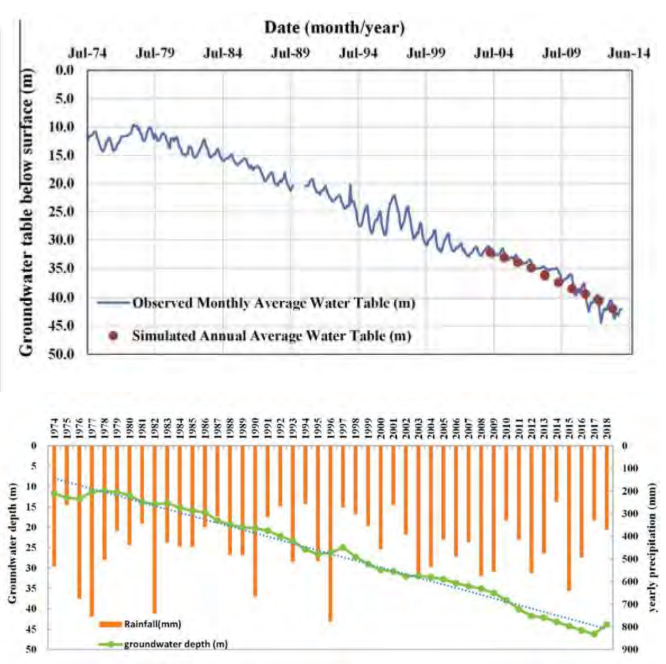
Background



➢ The groundwater resources in the North China Plain are insufficient, and the water resources each person are small



➢ Precipitation time ≠crop water demand during in traditional wheat-maize rotation system



➢ Caused groundwater level decline

Objectives

1.Calibrate the SWAP-WOFOST model to accurately simulate the crop growth, yield and water consumption of the whole wheat-maize rotation in the NCP;

2. Reveal the response and the gap in the annual yield, water consumption, WP and economic output of the whole wheat-maize rotation under different irrigation schedules from different precipitation type years between 1980 and 2017;

3. Recommend the optimized irrigation schedule for wheat-maize rotation under different precipitation type years.

Methods

1.SWAP-WOFOST model calibration and validation:

$$R^2 = \left[\frac{\sum_{i=1}^{n}(O_i-\bar{O})(S_i-\bar{S})}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{O})^2}\sqrt{\sum_{i=1}^{n}(S_i-\bar{S})^2}}\right]^2 \qquad RMSE = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(S_i-O_i)^2} \qquad MAE = \frac{1}{n}\sum_{i=1}^{n}\left|S_i-O_i\right|$$

To evaluate the accuracy of the simulation results for ETa and crop production, we used the determination coefficient (R^2), root mean square error (RMSE), and mean absolute error (MAE) in the following equations. where O_i and S_i are the i th observed and simulated values; $\bar{O}$ and $\bar{S}$ are the average of the observed values and simulated value. n is number of data pairs.

2.Classification on precipitation year-types:

$$DI = (P-M)/\sigma$$

The wet, normal, and dry years, according to the annual precipitation from 1980 to 2017, were determined by the drought index (*DI*) calculated as the following, where P is the annual precipitation (mm), M is the average annual precipitation over the period 1979–2017 (mm), and σ is the standard error. Wet years were when *DI* > 0.70, normal years when -0.70≤*DI*≤0.70 and dry years when *DI* < -0.70.

3.Evaluation calculations

$$WP = \frac{Y}{ET_a}$$

where WP is water productivity for grain yield of one crop or one given cropping system (kg m^{-3}), Y is total annual grain yield (kg ha^{-1}) of one crop or one given cropping system, and ETa is the corresponding actual evapotranspiration over the crop growing season (mm)

$$IWP = \frac{Y_{irr} - Y_{rainfed}}{I}$$

$$\text{Marginal benefit} = \frac{\Delta Y}{\Delta ET_a} = \frac{(Y_{irr} - Y_{rainfed})}{(ET_{irr} - ET_{rainfed})}$$

Y and $Y_{rainfed}$ are total grain yield of crop or one cropping system with and without irrigation (kg ha^{-1}), respectively; I is irrigation amount(mm). The grain yield of T1W0M0 was $Y_{rainfed}$.

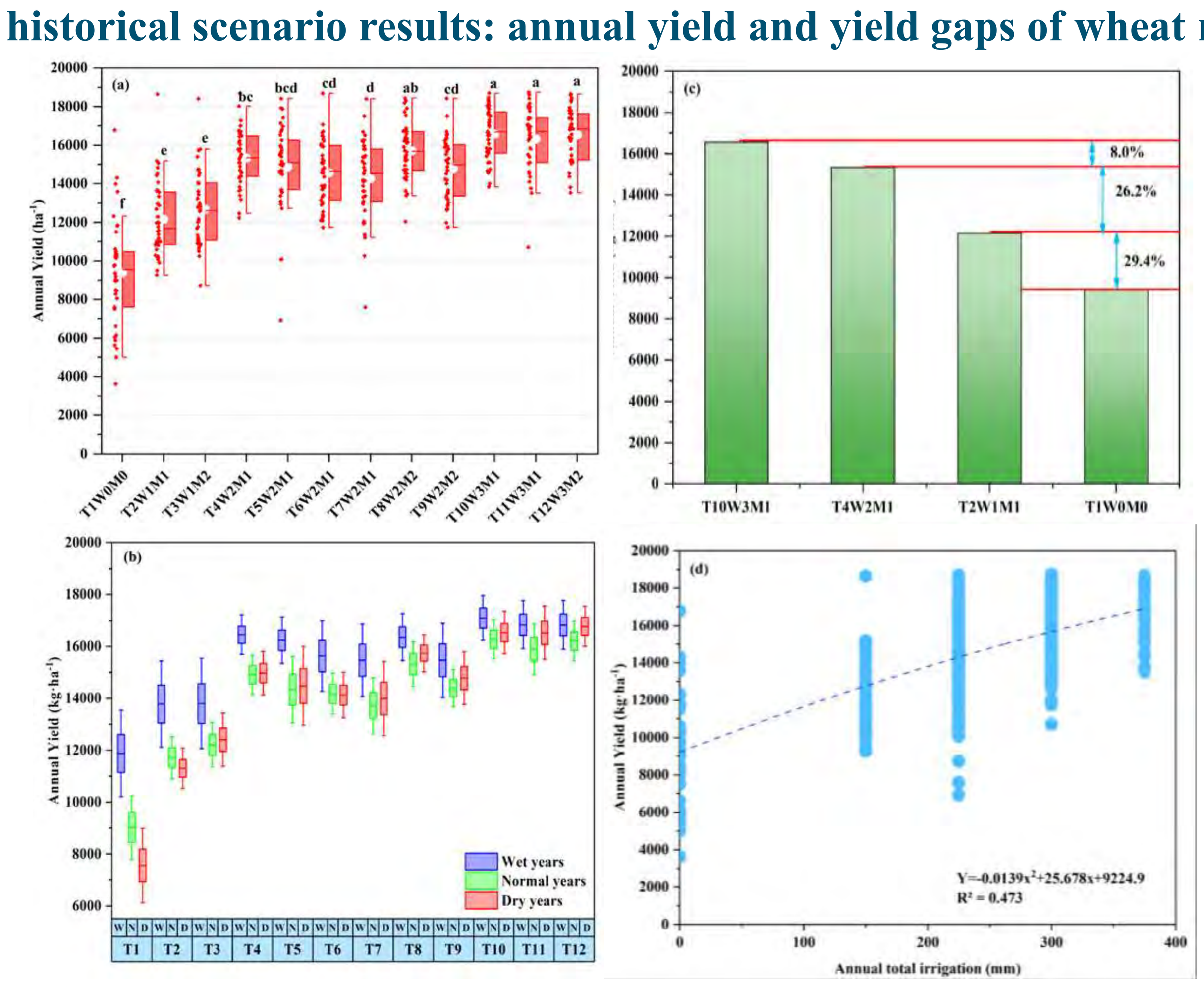
$$Economic\ Output_i = Yield_i \times Price_i \times \frac{CPI_i}{CPI_{1980}}$$

$$EWUE = \frac{\sum_{i}^{n}\text{Economic Output}}{\sum_{i}^{n}ET_a}$$

Where in economic output, *i* is one given year, CPI is the national Consumer Price Index. Since the simulation started from 1980, we assumed the CPI in 1980 as the baseline.

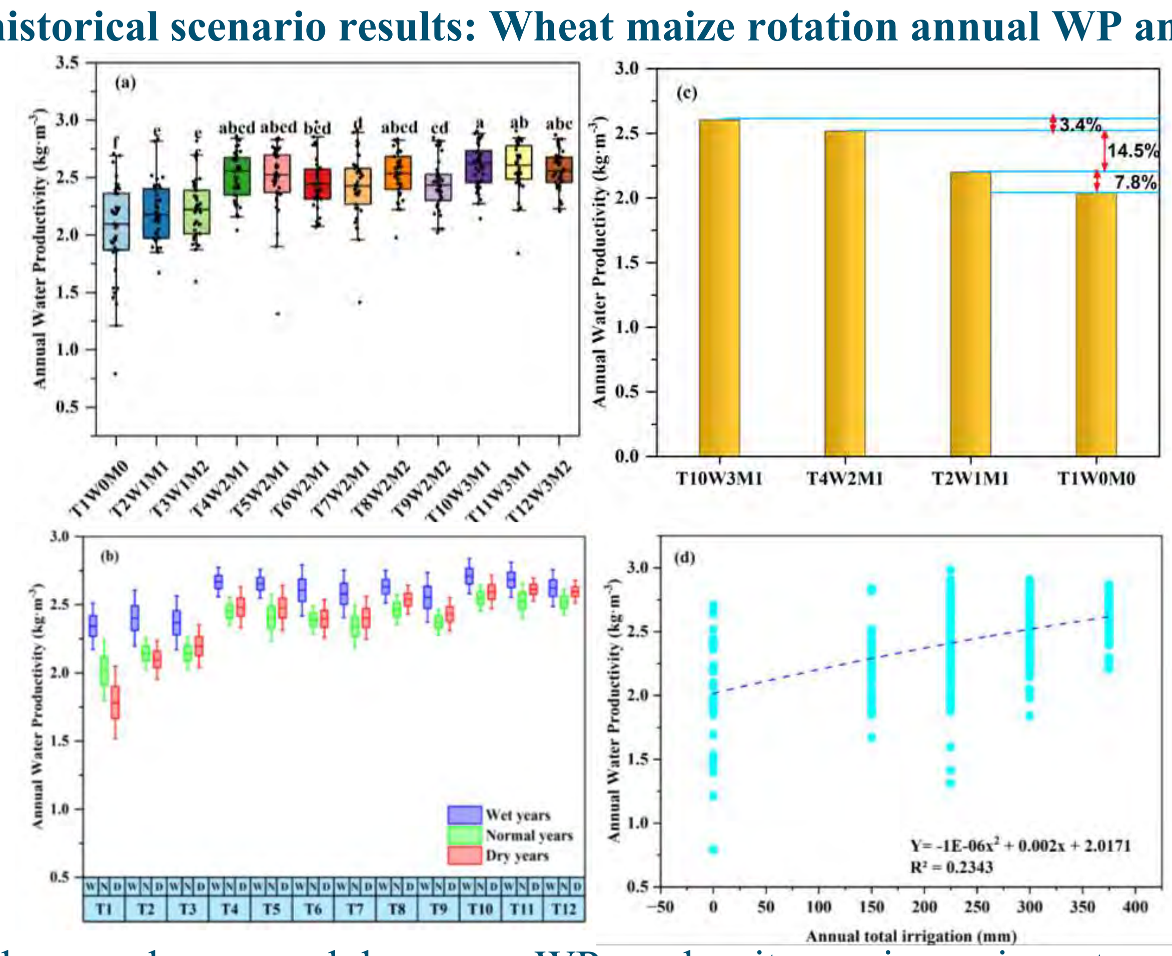
Results

1.Analysis of historical scenario results: annual yield and yield gaps of wheat maize rotation



➢The yield gaps between 4 irrigation maximum yield treatment (T10), 3 irrigation (T4), 2 irrigation (T2), and rainfed treatment (T1) was 8%, 26.2% and 29.4%, respectively. The yield difference between 3 and 4 irrigation treatments is relatively small.

2.Analysis of historical scenario results: Wheat maize rotation annual WP and WP gaps



➢Compared with normal years and dry years, WP reaches its maximum in wet years. The T4 treatment in the flood year was the turning point

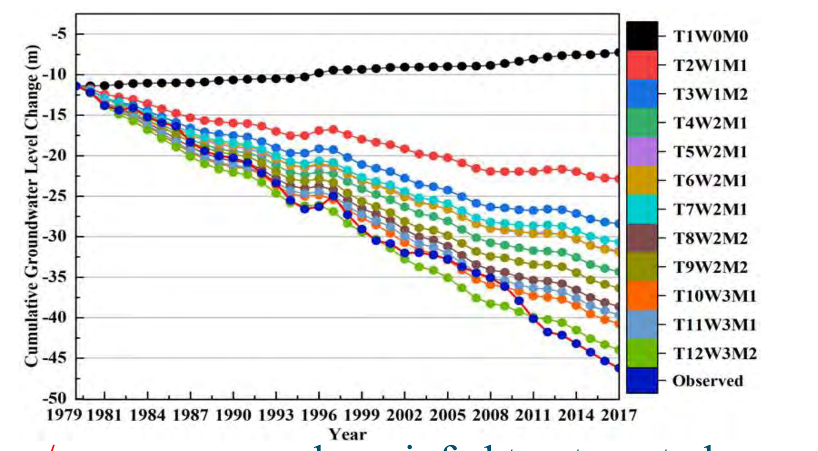
➢The WP ranges from 2.0 kg/m3 - 2.56 kg/m3. The lowest WP for T1, and the highest yield/WP for T10, there was no significant difference in WP between T4 and T10

3.Analysis of historical scenario results: simulation of groundwater level change in wheat and maize rotation

Net groundwater decline（NWD）:
NWD=R-I
R：Deep groundwater recharge I：Irrigation

$$\Delta h = \frac{NWD}{\eta}$$

Δh：Groundwater level change（m/yr）η：drainable porosity



➢ Groundwater levels will rise at a rate of 0.11 m/yr per year under rainfed treatment alone. The average groundwater level decline rate was 0.55 m/yr for 3 irrigation treatments and 0.72 m/yr for 4 irrigations.

Conclusions

➢ T4 treatment was the most efficient irrigation treatment, with a 26% increase in yield compared with T2 and 63% compared with T1, but no significant yield difference between 4-5 irrigation in wet year and normal year.

➢ Rainfed treatment (T1) increase the groundwater table at a rate of 0.11 m/yr, while irrigation definitely decrease the groundwater level.

➢ Combining all productivity and economic output indicators (WP, IWP, Margin benefit, Economic output, EWUE), the T4W2M1 irrigation strategy shows the best results, so it is recommended as the best solution to mitigate the decline of the groundwater table, increase annual yields and reduce the water productivity gap.

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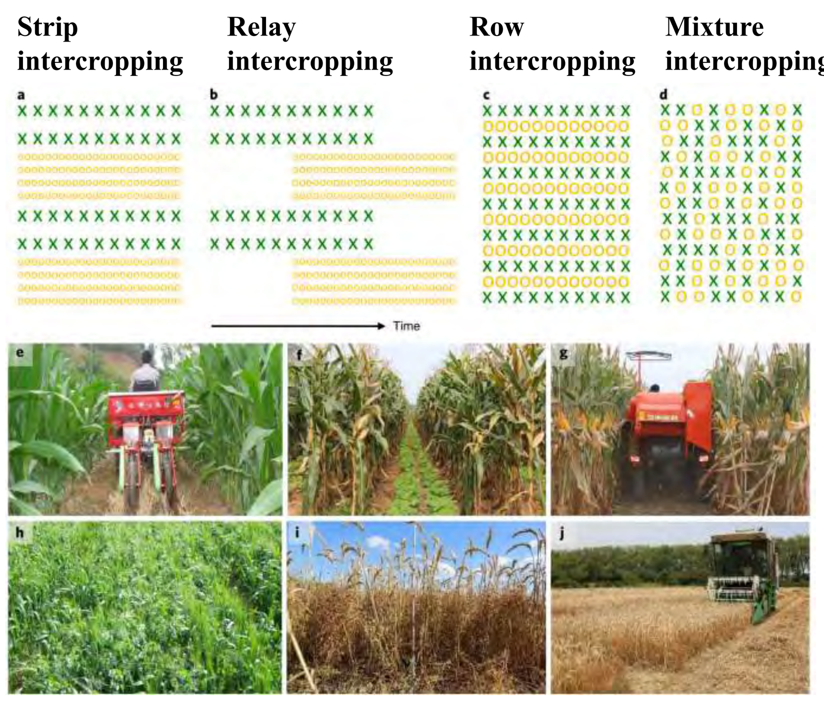
N input strategies affect the N use advantage of intercropping

Yalin Liu*, TjeerdJan Stomph, 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 the N-saving potential of different functional species groupings

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 yield and fertilizer N data was built with 694 data records representing the results of 158 independent experiments, extracted from 95 publications with four different functional species groupings (C3-cereal/legume, maize/legume, maize/C3-cereal, C4-non-maize/legume).

Results

The average FNERs of intercrops with C4-cereals (maize/legume: 1.42 ± 0.05, maize/C3-cereal: 1.44 ± 0.08, C4-non-maize/legume: 1.45 ± 0.07) were significantly greater than that of C3-cereal/legume (1.17 ± 0.06) (Figure 1a). The results indicated that the intercrops with C4-cereals (non-maize or maize) allowed greater potential in N saving than in C3-cereal/legume intercrops to produce the same yield as their sole crops. Similar to FNER, the average LERs of intercrops with C4-cereals (maize/legume:1.32 ± 0.03, maize/C3-cereal: 1.36 ± 0.05 and C4-non-maize/legume: 1.32 ± 0.04) were significantly greater than that of C3-cereal/legume (1.15 ± 0.04) (Figure 1b).

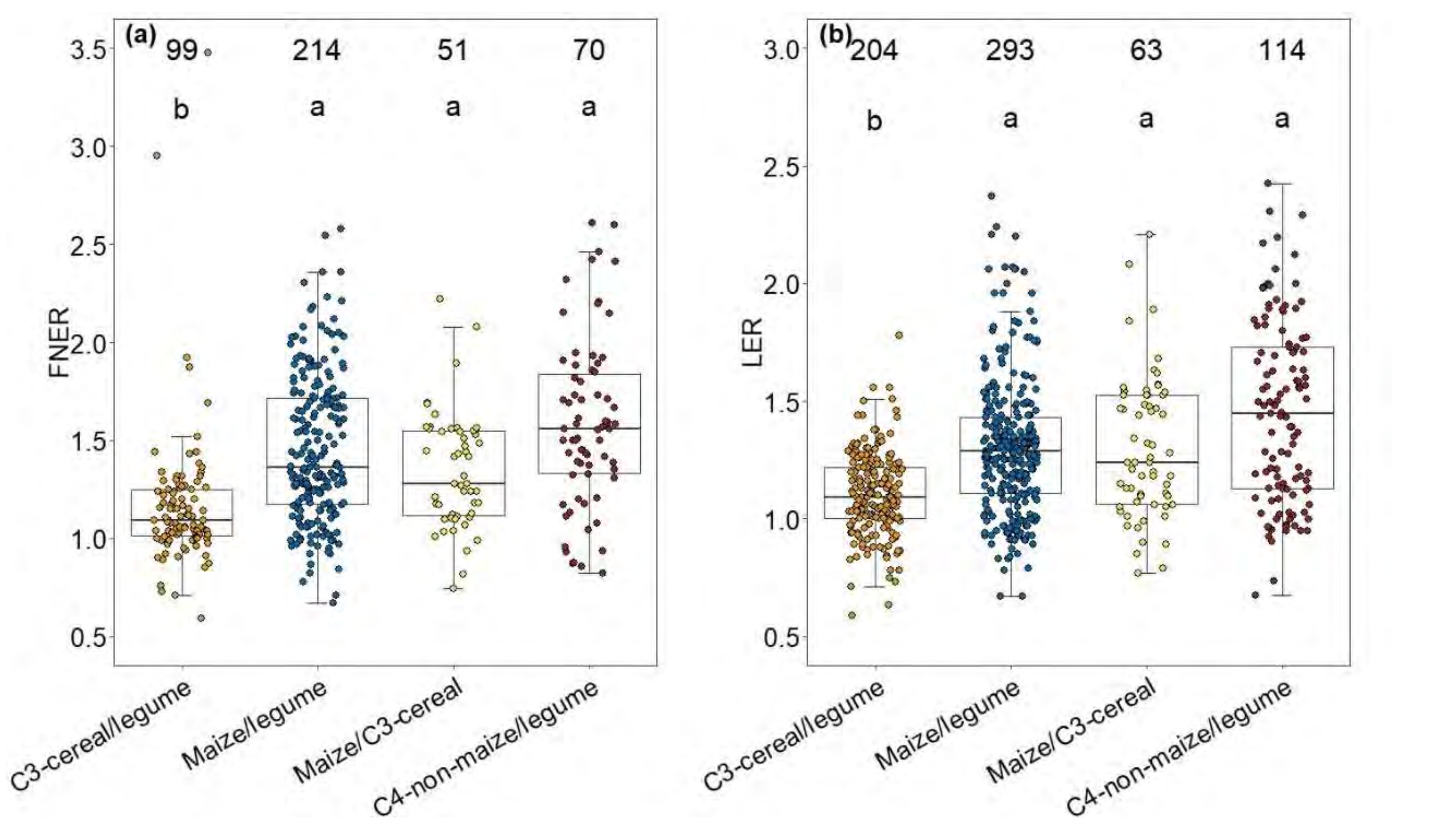


Figure 1 Observed fertilizer N equivalent ratios (FNERs) (a) and land equivalent ratios (LERs) (b) across functional species groupings. The pure orange circles, dark blue circles, bright yellow circles and dark red circles represent C3-cereal/legume, maize/legume, maize/C3-cereal and C4-non-maize/legume, respectively (same below). Different letters indicate significant differences among different functional species groupings (Tukey's HSD test, $P < 0.05$).

The results showed that the FNER increased when less N input in intercrops compared to sole crops while the LER decreased, indicating that although reducing N fertilizer input increased the productivity of per unit N fertilizer, but it reduced the utilization efficiency of per unit land.

Table 1 The N fertilizer input levels effect on FNER and LER in intercrops. N1 (N2): the N input in species 1 (species 2); Nic: N input in intercrops.

Conditions	N input in IC	FNER	LER
Nic > (N1+ N2)/2	Greater than sole crop average	1.25 ± 0.03	1.24 ± 0.03
Nic = (N1+ N2)/2	Equal to sole crop average	1.34 ± 0.02	1.27 ± 0.01
Nic < (N1+ N2)/2	Less than sole crop average	1.71 ± 0.06	1.16 ± 0.03

The FNERs of C3-cereal/legume and maize/C3-cereal intercrops did not respond to N fertilizer input (Figure 2a). However, there was a negative relationship (slope = -0.0005 ± 0.0003) between FNER of maize/legume and N fertilizer input (Figure 2a, P = 0.047), and the FNER of C4-non-maize/legume intercrops decreased 0.009 ± 0.002 (Figure 2a, P = 0.001) per unit of N fertilizer input.

N fertilizer input had no significant effect on the LERs of maize/legume (Figure 2b, P = 0.20), and C4-non-maize/legume (Figure 2b, P = 0.86), while the LERs of C3-cereal/legume (Figure 2b, P = 0.043) decreased 0.0006 ± 0.0002, and maize/C3-cereal intercrops increased 0.0008 ± 0.0003 with per kg of N fertilizer input (Figure 2b, P = 0.002).

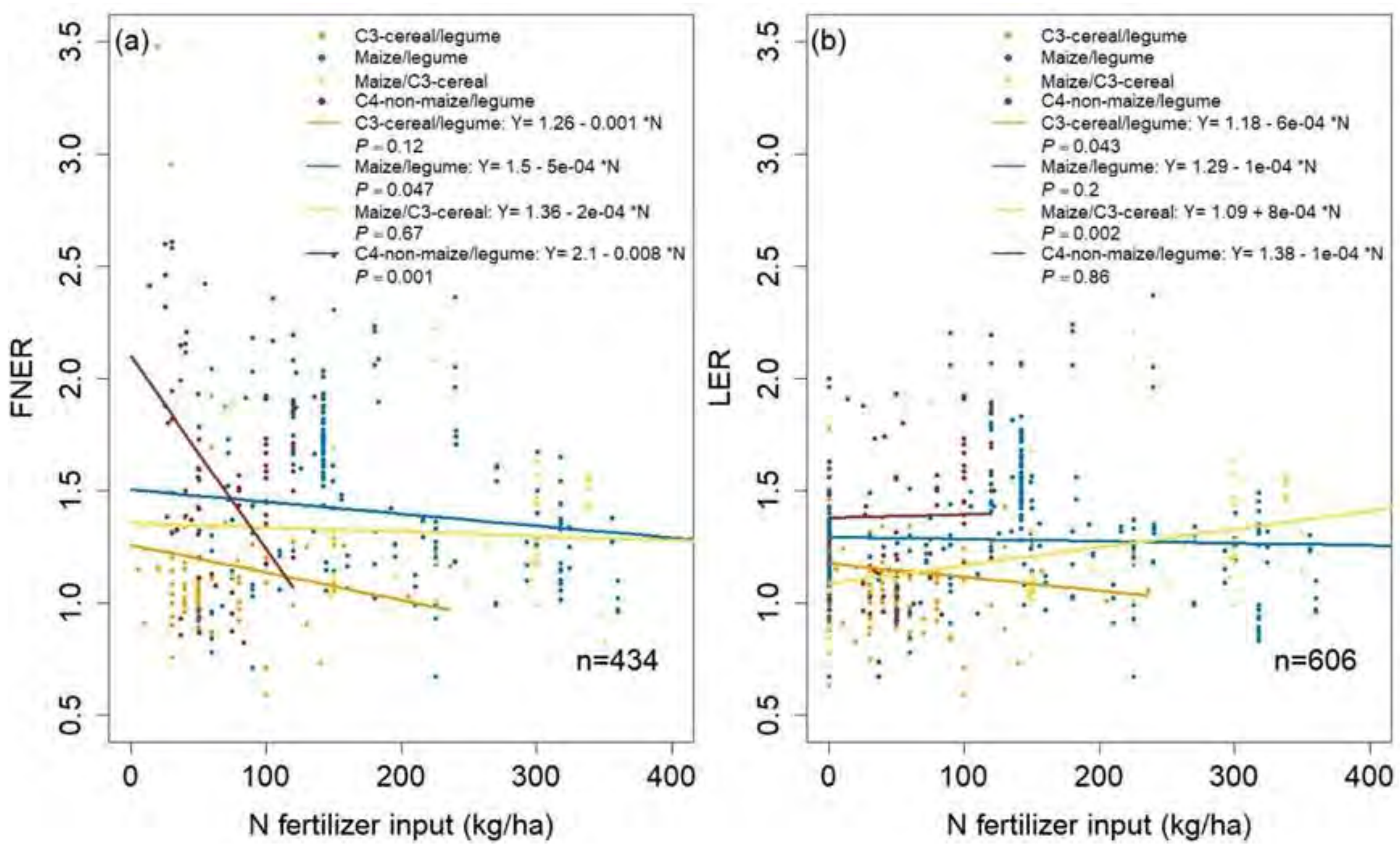


Figure 2 Relationship between fertilizer N equivalent ratio (FNERs) and N fertilizer input in different functional species groupings (a) and land equivalent ratio (LERs) and N fertilizer input (b) in different functional species groupings. P-values relate to the slopes of the regressions.

Conclusions

- Average fertilizer nitrogen equivalent ratio (FNER) of intercrops was 1.36 ± 0.04 and intercrops saved N through a combination of production on less land and with less fertilizer N input.
- N input in C4-cereal/legume intercrops significantly decreased the N fertilizer saving when producing the same yield compared to sole crops.
- Low N input in intercrops enhance fertilizer N saving in intercrops while decreasing the land use efficiency.

Acknowledgements

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Overview PhD projects – starting year 2021

Posters, January 2023

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.

Better Policy, Living Healthy

Improving nutrition in rural China - Effects of agricultural policies and e-commerce on smallholder production and consumption of vegetables

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

Background

Big data and digital platforms influence the way of selling and purchasing goods in the online environment. E-commerce has entered people's life and is changing the structure, process, and activities throughout the whole value chain. This new market channel in China has effectively influenced the poverty alleviation in rural areas. According to Chen et al., (2022), sales in China's rural areas have increased from USD 27.99 billion in 2014 to USD 278.25 billion in 2020 by e-commerce. Comparing to the total national online transactions, the rural sales account for nearly 15.2% with an annual growth rate of 30% more consistently for six years since 2015. Poverty situation, accordingly, in rural areas are alleviating as the engagement of the e-commerce in the food value chain transition(Thom B. et al., 2021).

Conventionally, smallholders would be willing to join the agribusiness of e-commerce as income increasement. However, in fact, rare smallholders participate in the new value chain of e-commerce (Li et al., 2021). Limitations that restrict smallholder engaging behaviours are not clear so far from the smallholders perspective.

Recently, most rural e-commerce research focus on generally elaborating its benefits and limitations on the successful experiences from the southeastern areas (Wang et al., 2021; Xiong and Nie, 2022). Some proposed the improvement about the rural infrastructures and transportation system due to the severe topographic characteristics and relatively small-scaled production of rural areas (Liu et al., 2015; Qi et al., 2019; Liu et al., 2020). How to induce smallholders' awareness and behavior for the agribusiness e-commerce, what policy can promote the rural e-commerce development are still questionable for the policymakers and researchers (Chen, 2022).

Research objective

Based on the above statement, this thesis will focus on on the smallholder's perspective for investigating the restrictions that limited the rural e-commerce development for the poverty alleviation and subsidies adjustments.

4 chapters:

（a）Mechanism behind the working processes and structures of the new food value chain of rural e-commerce on smallholders' perspective

（b) Analytical reviewing the limitations and constrains behind the rural e-commerce development of smallholders

（c) Impact assessment on subsidies of the rural e-commerce development

（d) Transformations on agro-food system in the new food value chain of rural poverty alleviation.

Methodology

Step 1: Archival Records – Documentation reviewing.
Retriving the information from the related publications, reports and literature could be helpful to deduce an initial conceptual framework of the rural e-commerce agribusiness.

Step 2: Survey –Interview and Questionnaire.
Interview aims to collect the information in depth to extend the knowledge of mechanism behind the new food value chain from corporation, cooperatives, and government.

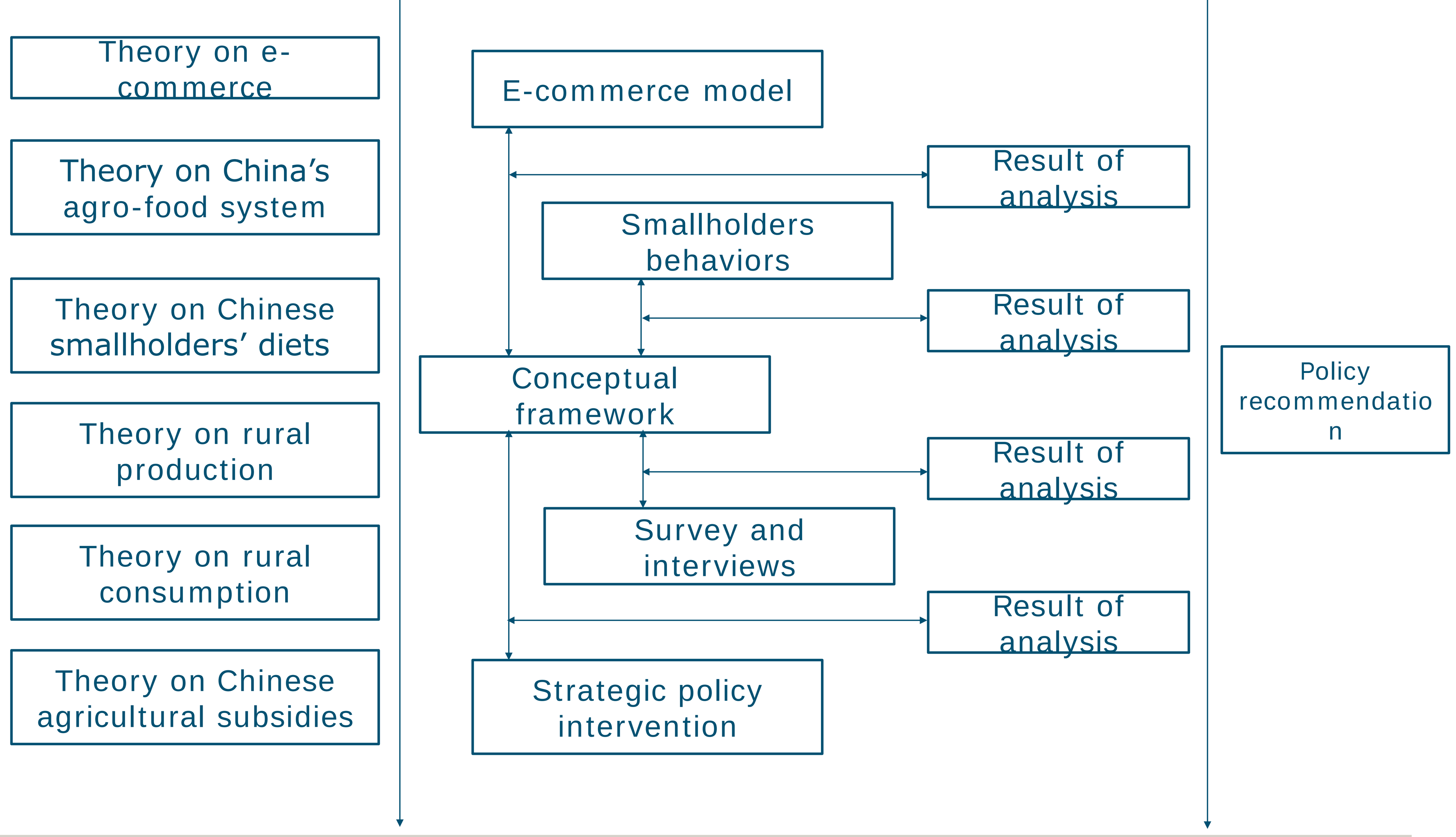
Questionnaire aims to gather the information for a relatively large population sample, smallholders, in a rapid and systematic way (Codó, 2008). The data from questionnaire can be used to develop a generalisable finding of a current fact (Rowley, 2014). It can be used to detect the reasons about smallholders' negative reaction toward e-commerce in this research.

Summary of the interviewees and the main topics for the semi-interviews

Interviewees	Name of the coperation/ copperative/ department	Themes for the interviews (Under the new value chain of agribusiness)
Corporation	1. Rongjiang	▪ Main agricultural productions of the corporation; ▪ Stategic promotion, branding and advertising; ▪ Difficulties and challenges about rural e-commerce; ▪ Relationship between government, cooperatives and smallholders
	2. Nongken	
Cooperative	1. Gufeng	▪ Key contents and measurements of contractual agricultural production; ▪ Current value chain between government, coperations and corporation; ▪ Employment relationship with smallholders; ▪ Difficulties under the current policy; ▪ Future expectations of the new value chain development and policy improvement
	2. Yuanfeng	
Government departments	1. Agribusiness	▪ General agricultural industry and production situations in Dali; ▪ Branding of the local agricultural products; ▪ Development situation and challenge of the rural e-commerce; ▪ Differences between the other rural areas of agricultural production in China; ▪ Discussion about current living, production, and consumption situation about smallholders ▪ Plan of the future agribusiness development ▪ Expectations on agricutural policy adjustments
	2. Agricultural production	

Step 3: Direct Observation – Practical visiting as the field research.
Field notes, pictures, videos, and the voice records both can be combined as the recording methods to find out the answers based on the research objective. Those collected information will be used to diagnose the difficulties of promotion the e-commerce for smallholders, generalize the mechanism behind the current e-commerce agribusiness in China's rural areas, and help to finalized the conceptual framework for knowledge extension.

Research framework



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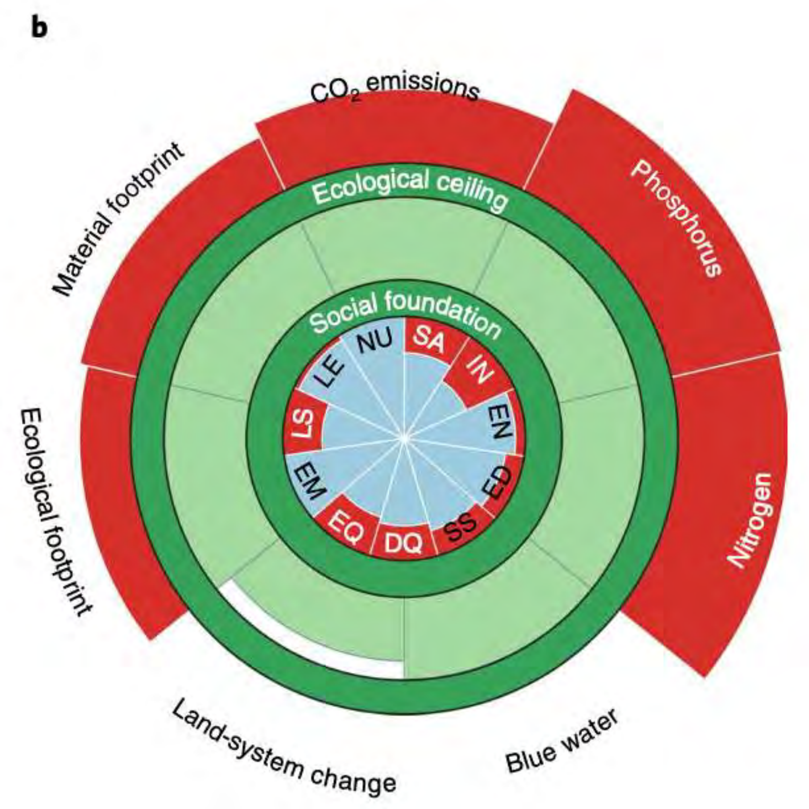
China Agriculture Green Development: conceptual framework and its contribution to global sustainable development

Yuan Feng

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

WUR Supervisors: Hans-Peter Weikard, PhD

Background

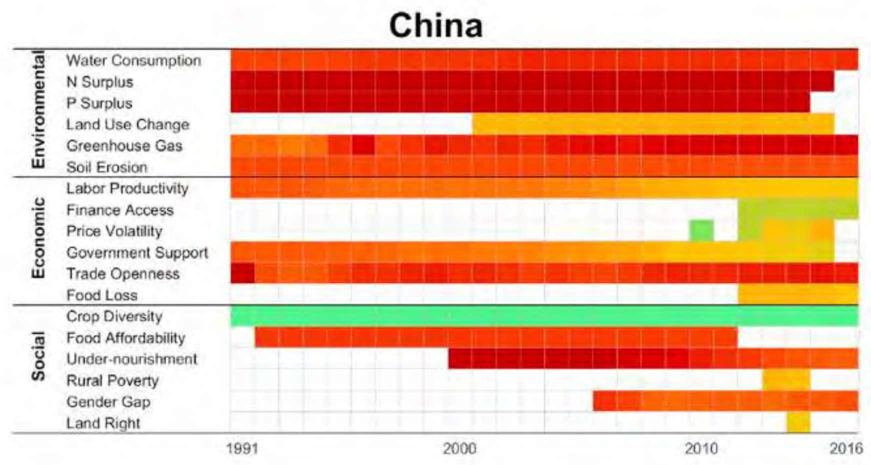


Global performance relative to the biophysical boundaries and social thresholds (2015)

(Fanning et al. Nature sustainability, 2021)

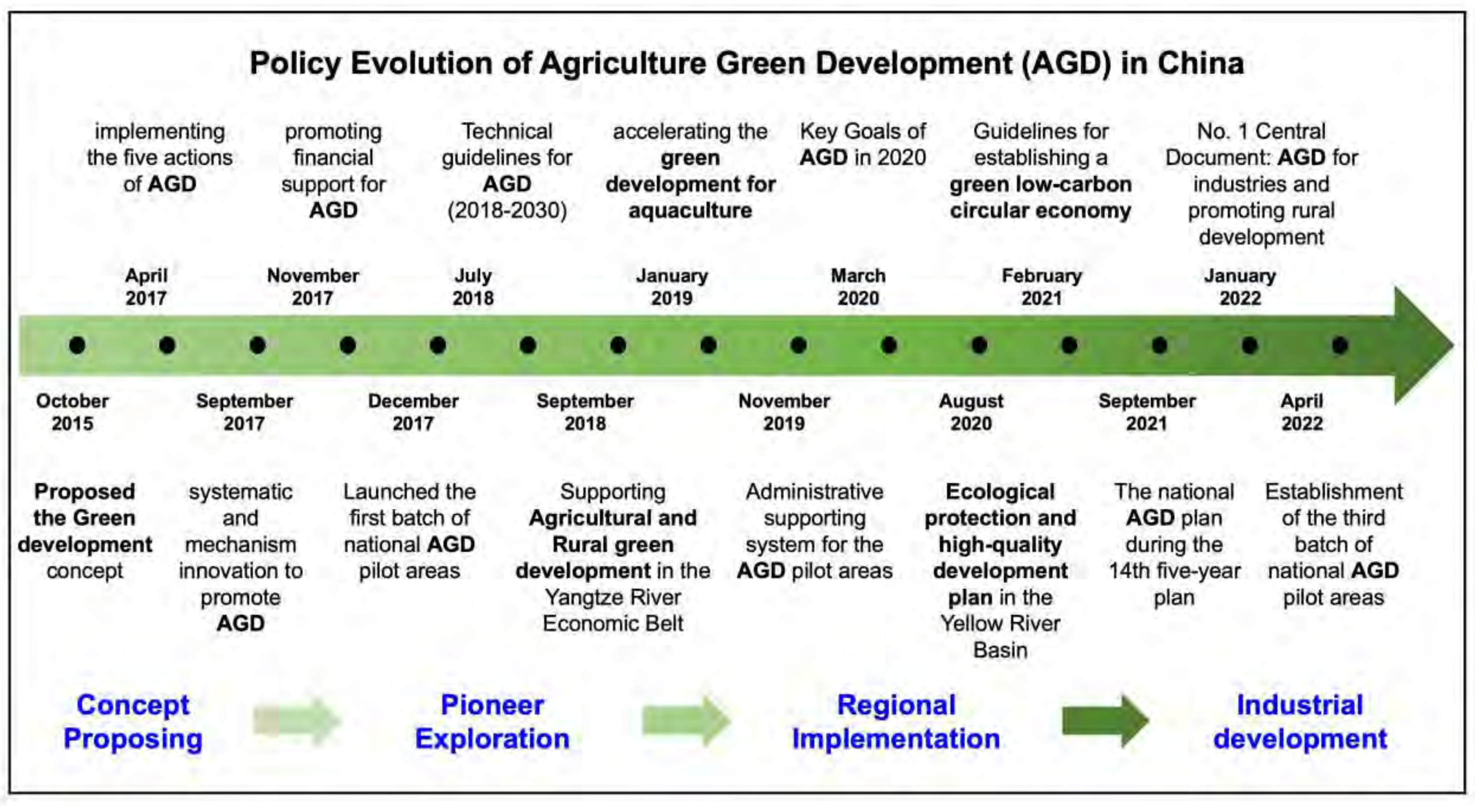
Global sustainability is facing a double burden of social wellness and environmental pollution. Agriculture is essential to many social goals and environmental boundaries such as Nitrogen, Phosphorus, Carbon, and Ecological footprint.

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.



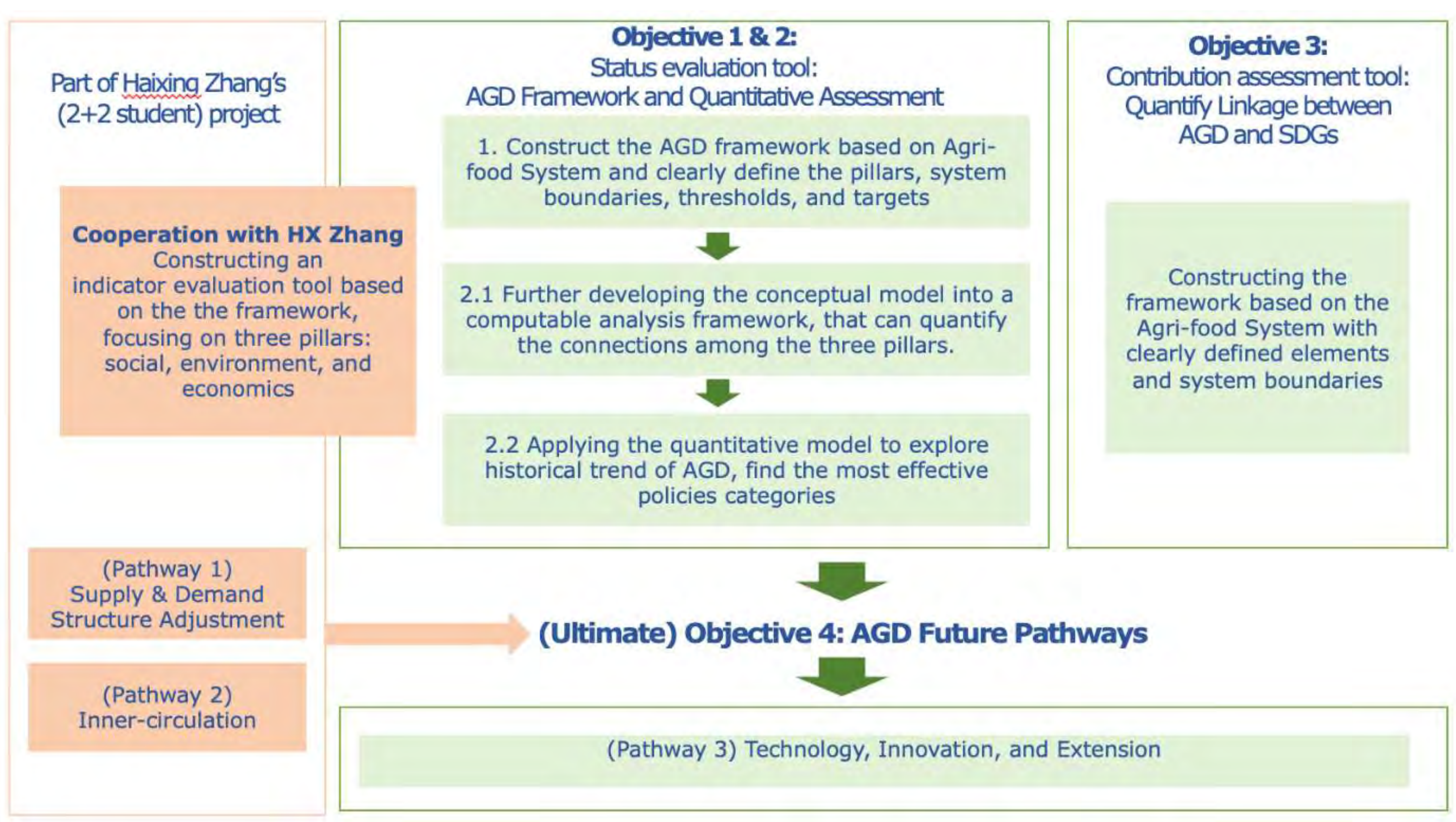
In 2016, the Chinese government promoted Agriculture Green Development (AGD) as a national strategy for agriculture, aiming to increase resource use efficiency, decrease agricultural non-point source pollutants, and encourage rural revitalization.

What are the theoretical foundations for AGD, and how to scientifically evaluate AGD's current status?

What is China AGD's contribution to UN SDGs?

What is the future pathway of change to achieve environmental, economic, and social synergy development?

Research Plan



Chapter 1: Comprehensive literature review of sustainable agriculture development frameworks and conceptualizing the AGD framework.

Chapter 2: Develop the AGD framework, including system boundaries, flow models, and impact assessments. Construct a Cost-Benefit Analysis Method for China's Agricultural Green Development.

Chapter 3: Theoretically and quantitatively evaluate the relationship of AGD with UN SDGs.

Chapter 4: Scenario Analysis: Pathways and Potential of Technological Change at the National Scale

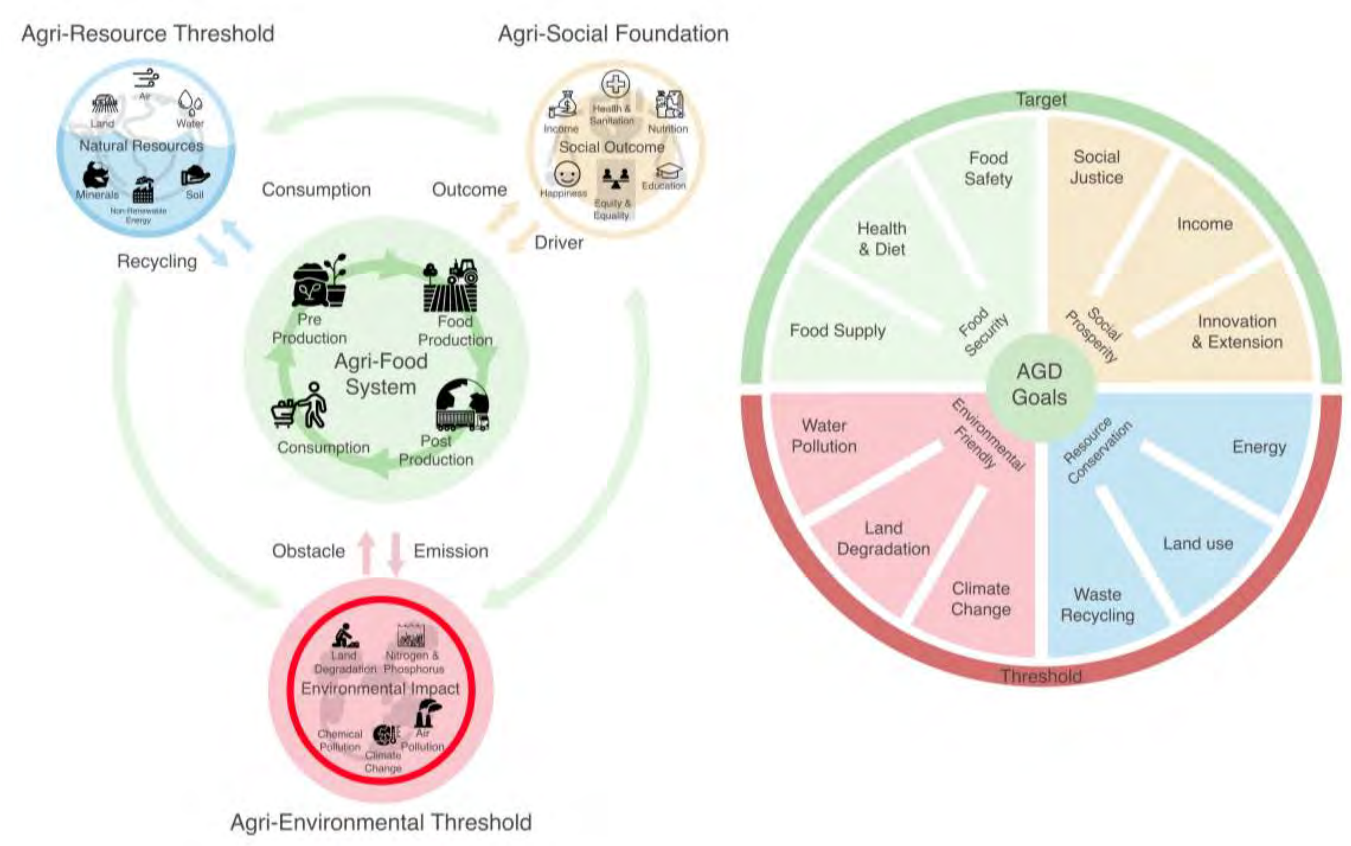
Research Highlights

1. this study focuses on downscaling sustainable development research to the agricultural sector; current sustainable development research is mostly on overall sustainability evaluation, and few previous studies have been downscaled to the agricultural sector dimension

2. Multidisciplinary intersection: through the perspective of economics, such as cost-benefit, opportunity cost, etc., and environmental science, such as carbon, nitrogen and phosphorus footprint. We attempt to analyze the current situation and policies of China's agricultural green development

Research Objectives

Conceptual Agri-Food System and Evaluation Framework



We conceptualized a flow framework that depicts the relationship of our agri-food system with natural resources, social outcome, and environmental impact.

Natural Resource: any production along the agri-food system needs to drain from the resource pool, and the food system can also refill the pool by approaches such as waste recycling.

Social Outcome: agri-food system's impact on human society, such as income, nutrition, health, etc.

Environmental Impact: pollution from the agri-food system, especially water pollution caused by the overuse of nitrogen and phosphorus fertilizer. The polluted environment would also turn back to the agri-food system, such as climate change.

Agri-Food System: the whole industry chain for food production, including pre-production such as seeds, fertilizer, machinery; food production such as agronomy, horticulture, livestock; post-production such as logistics, cold-chain, storage, sales; and consumption.

Evaluation: Based on the measurement of each sector, we conceptualized an indicator evaluation framework, trying to capture the whole image of our agri-food system. The four goals for AGD are
food security,
social prosperity,
environmentally friendly,
and resource conservation.

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Acknowledgements

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China's Agriculture green development: From the construction of evaluation indicators system to the realization pathways

PhD candidate: Haixing Zhang

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

Background

- Agriculture Green Development (AGD) has become a well-known expression in China. The main objective is to align "green" with "development", to realize the transformation of current agriculture with high resource consumption and high environmental costs towards a green agriculture and countryside with high productivity, high resource-use efficiency and low environmental impact.
- Many studies have explored pathways towards a sustainable food system. However, there is limited research that attempts to distinguish the priority of possible measures. A green development framework including comprehensive pathways and evaluation indicators to measure agricultural progress towards sustainable development at national and regional levels needs to be built up.

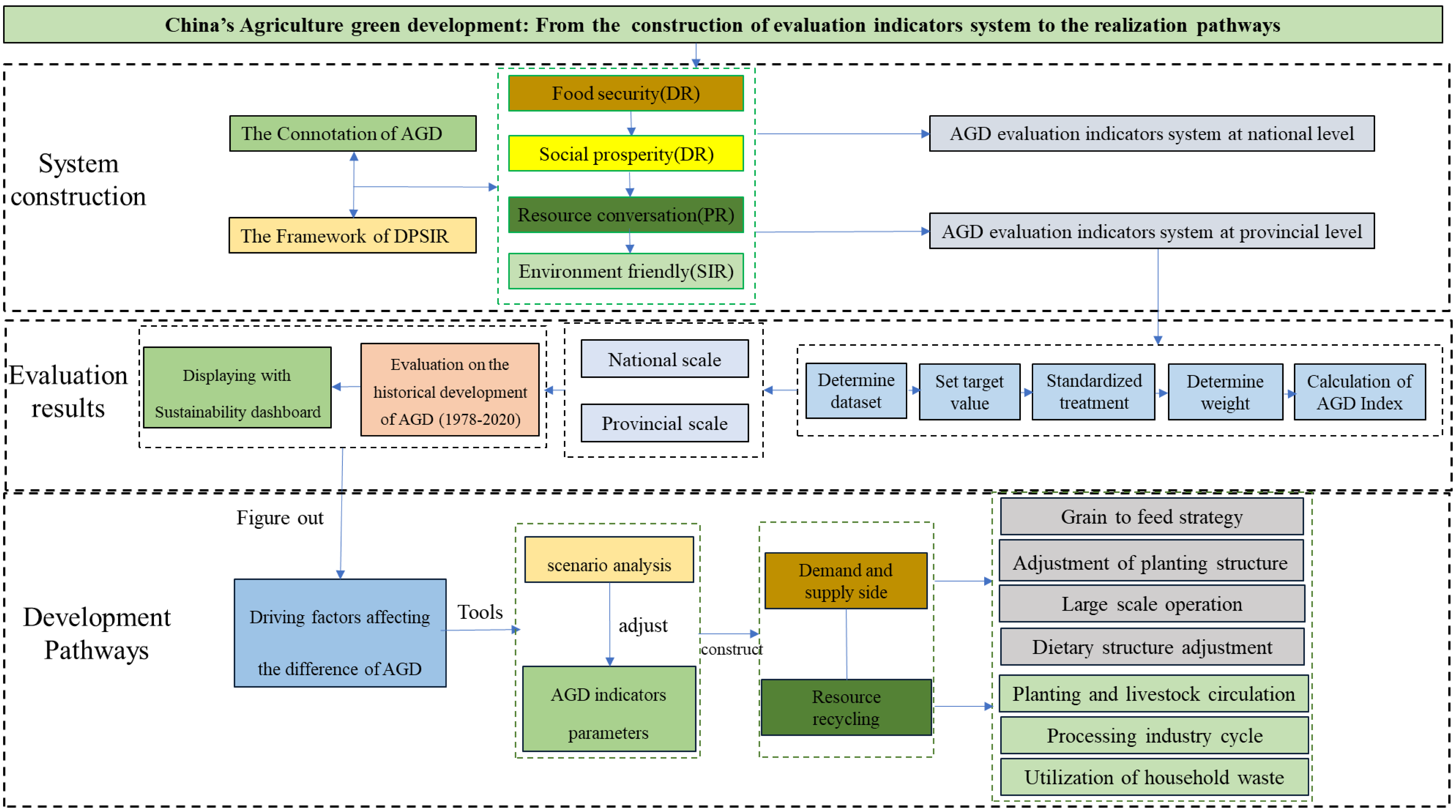
Research question

- How to establish an appropriate indicator system to evaluate the status of China's agriculture green development at regional and national scale?
- What are the feasible pathways of China's agriculture to green development and how did it contribute to AGD?
- What is the linkage among different indicators of AGD (synthesis or trade-offs) and to SDGs?
- How can the goals of AGD be aligned with the demands in the coming decades?

Results (AGD indicators system construction)

The dimensions of AGD indicators system were determined based on the SDGs, including Food security, Social prosperity, Environmental Friendly and Resource conservation. In each dimension, we selected 3 consistent indicators to represent, and the indicators have been proposed in the literature before.

Framework



Acknowledgements

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

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Genetic parameters for rumination time and related resilience indicators in Chinese Holstein heifer

PhD student: Wenqi Lou

Supervisors: B Ducro, A van der Linden, H A Mulder, S J Oosting, Yachun Wang

Background

- With severe **climate problems** and **intensification requirements** of dairy industry, the related negative impacts such as poor animal welfare and lower efficient production become more prominent. It is important to improve the **resilience** of cows.
- Published study shown that breeding on resilient cow could resulted in favorable response on resistance and tolerance to infection, which might be reduce the **abuse of medicine like antibiotic** and its **negative environmental effects**.
- As an internal activity for ruminants, **daily rumination time** (DRT) is expected to be more directly affected by disturbances than milk yield. Therefore, **quantifying the resilience** with DRT in dairy cows is an interesting question.

Objectives

a) Investigate the **genetic feature** for the daily rumination time (DRT) of heifer;

b) Define **potential resilience indicators** based on DRT of heifers and to investigate if they can really be used to genetically improve resilience by estimating their **genetic parameters**;

c) Validation of weather those resilience indicators good or not.

Methods

Objective a):

- The genetic feature of DRT were estimated by random regression test-day models based on Bayesian methods and Gibbs sampling:

$$y_{ijklmno} = TYM_i + CM_j + Feed_k + \beta_1 Age\_c_l + \sum_{n=0}^{3} ITFC_n\, a_{mn} + \sum_{n=0}^{3} ITFC_n\, pe_{mn} + \varepsilon_{ijklmno}$$

$$G=\begin{bmatrix} \sigma_a^2 & \cdots & \sigma_a\sigma_{a\_L3} \\ \vdots & \ddots & \vdots \\ \sigma_a\sigma_{a\_L3} & \cdots & \sigma_{a\_L3}^2 \end{bmatrix}$$

$$Pe=\begin{bmatrix} \sigma_{pe}^2 & \cdots & \sigma_{pe}\sigma_{pe\_L3} \\ \vdots & \ddots & \vdots \\ \sigma_{pe}\sigma_{pe\_L3} & \cdots & \sigma_{pe\_L3}^2 \end{bmatrix}$$

$$T=\begin{bmatrix} 1 & L1(-60) & \cdots & L3(-60) \\ 1 & L1(-59) & \cdots & L3(-59) \\ \vdots & \vdots & \cdots & \vdots \\ 1 & L1(7) & \cdots & L3(7) \end{bmatrix}$$

➡ $\lambda = TGT',\ \xi = TPT'$ ➡

$$\lambda=\begin{bmatrix} \sigma_{a\_-60}^2 & \cdots & \sigma_{a\_-60}\sigma_{a\_7} \\ \vdots & \ddots & \vdots \\ \sigma_{a\_-60}\sigma_{a\_7} & \cdots & \sigma_{a\_7}^2 \end{bmatrix}$$

$$\xi=\begin{bmatrix} \sigma_{pe\_-60}^2 & \cdots & \sigma_{pe\_-60}\sigma_{a\_7} \\ \vdots & \ddots & \vdots \\ \sigma_{pe\_-60}\sigma_{a\_7} & \cdots & \sigma_{pe\_7}^2 \end{bmatrix}$$

Objective b):

- Define the resilience indicators based on the fluctuation (deviation between actual and unperturbed value) of DRT curve, and the unperturbed curve was simulated by quantile polynomial regression model.

$$y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + \beta_4 t^4 + \varepsilon$$

- The indicators included variance and standard deviation of deviation (Var_{dev}, SD_{dev}), natural log-transformed variance ($LnVar_{dev}$), lag-1 autocorrelation (r_{auto_dev}, r_{auto_orig}), mean negative residual, and slopes (Slope_D and Slope_I).
- And the genetics parameters of those resilience indicators were evaluated by the animal mode: $y_{ijklm} = BYM_i + CYM_j + \beta_1 n_k + a_l + \varepsilon_{ijklm}$

Results

Objective a):

✓ The heritability (h_2) and repeatability (rep_2) increased during the heifer period (ITFC: -60 to 7 d; 0 d means the first calving of a cow), which ranging from 0.17 to 0.36 and 0.21 to 0.66, respectively. And high genetic correlations exists adjacent days.

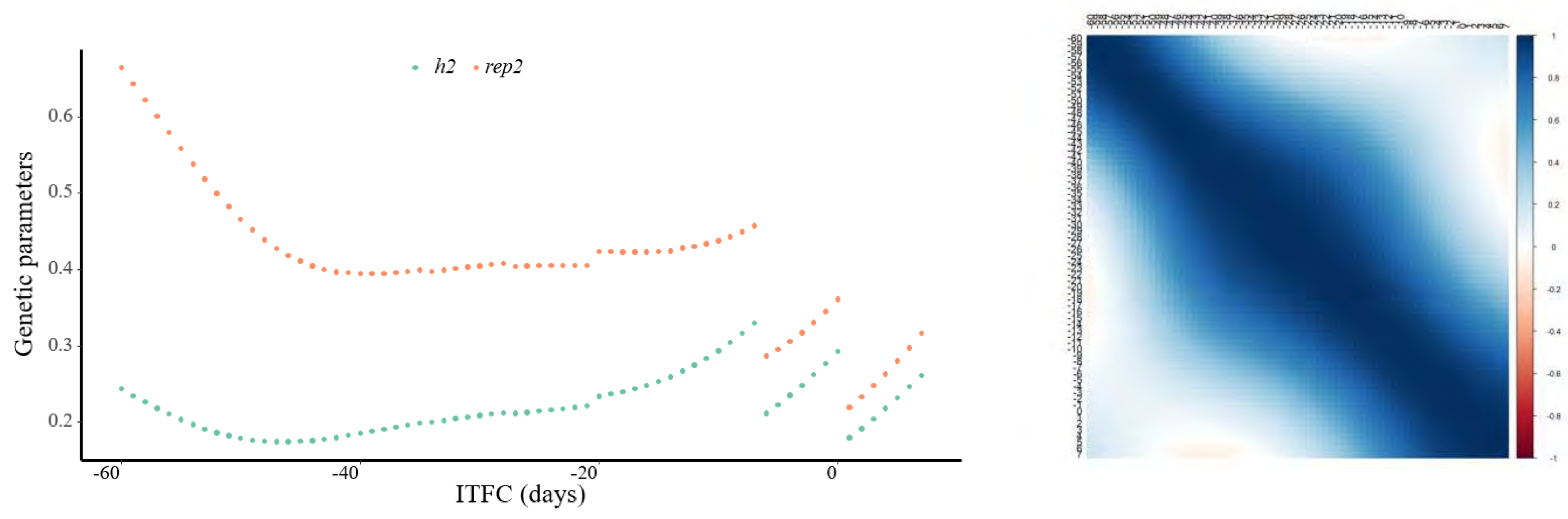

Figure 1. The genetic parameters of daily rumination time across the heifer period (-60 to 7 d).

Objective b):

✓ The heritability of those resilience indicators were from 0.03 to 0.16. The better indicator included Var_{dev} and $r_{auto\_orig\_1}$.

Table 1. Description of phenotype and genetic parameters of resilience indicators.

-60 to -1 d	Mean	SD	σ_a^2	σ_e^2	h^2	SE
Var_{dev}	2,428.30	1,027.2	94347.52	812514.0 0	0.10	0.05
SD_{dev}	48.31	9.69	6.85	73.01	0.09	0.04
$LnVar_{dev}$	7.72	0.39	0.01	0.12	0.08	0.04
$r_{auto\_Orig\_}1$	0.30	0.23	0.007	0.030	0.16	0.05
r_{auto_dev}	-0.007	0.18	0.00095	0.030	0.03	0.02
Mean negative residuals	-45.98	10.80	3.74	93.67	0.04	0.03
-7 to 7 d	Mean	SD	σ_a^2	σ_e^2	h^2	SE
$r_{auto\_Orig\_}2$	0.51	0.24	0.002	0.04	0.05	0.03
Slope_D	-31.96	14.61	13.33	200.06	0.06	0.03
Slope_I	36.29	24.75	17.00	495.13	0.03	0.03

Objective c):

✓ The cows with resilience have higher percentage of normal calving ease (76.54% vs 65.99%), non-disease (73.01% vs 70.04%), one insemination time (60.62% vs 57.49%) compared with that of non-resilient group.

Table 1. A comparison of other cow performance (average daily rumination time, calving ease, number of disease and insemination) between non-resilient and resilient cows.

Traits	Non-resilient cows (247 cows)	Resilient cows (226 cows)	Wilcox.tes t
Average DRT (min/d)	478.43	466.75	0.01
Calving ease (level: 1-4)	1(65.99%); 3+4 (12%)	1(76.54%); 3+4 (7.5%)	0.01
Number of disease (level: 0-2)	0(70.04%); 2 (10.53%)	0(73.01%); 2 (7.96%)	0.42
Number of insemination (level: 1-3)	1 (57.49%)	1 (60.62%)	0.62

Conclusions

✓ Daily rumination time are **heritable**, and it is a good data that used to **capture the resilience information**.

✓ According to part of resilience with higher heritability, the resilient cows perform **more health and good fertility**.

Acknowledgements

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Farm typology and spatial analysis to inform targeted farming systems interventions: A case study in Northern China Plain

Yuhang Sun **Supervisors: M.K. van Ittersum, A.G.T. Schut and Y. Hou**

Background

Smallholder farms play a substantial role in ensuring food security worldwide. Currently, smallholder farms exist across the whole of China, while some large-scale crop farms are present in the northeast and northwest of China. Importantly, more than 70% of croplands are managed by farmers with a farm size of less than 0.6 ha. Small farm size (in China, typically ~0.1 ha for each parcel) is strongly related to overuse of agricultural chemicals. Inherently dynamic decision-making processes of individual small farms result in a great diversity of farming practices, which leads to enormous difficulties and complexity in further sustainability and policy evaluation. Hence, Hence, it is important to explore the key farm types and their farming practices to represent diversity at a scientific and statistic view. While it is rarely practiced, particularly in China's dairy farming.

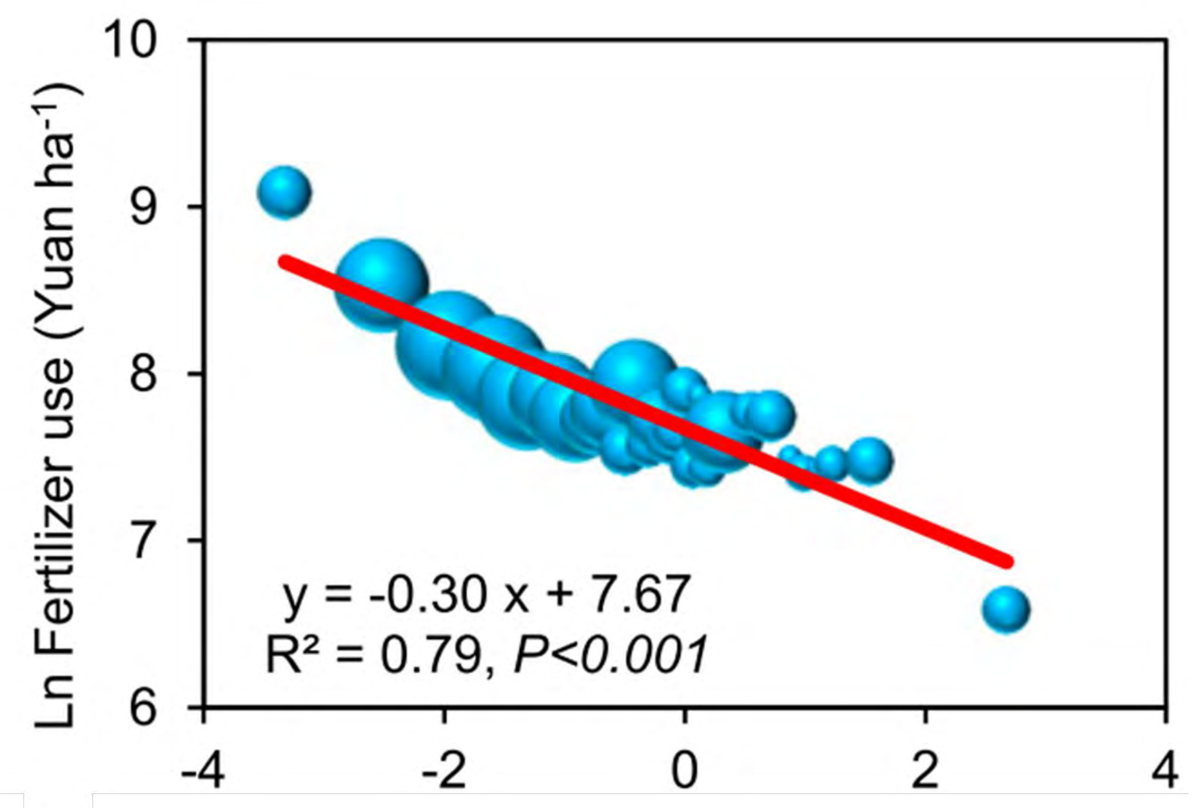


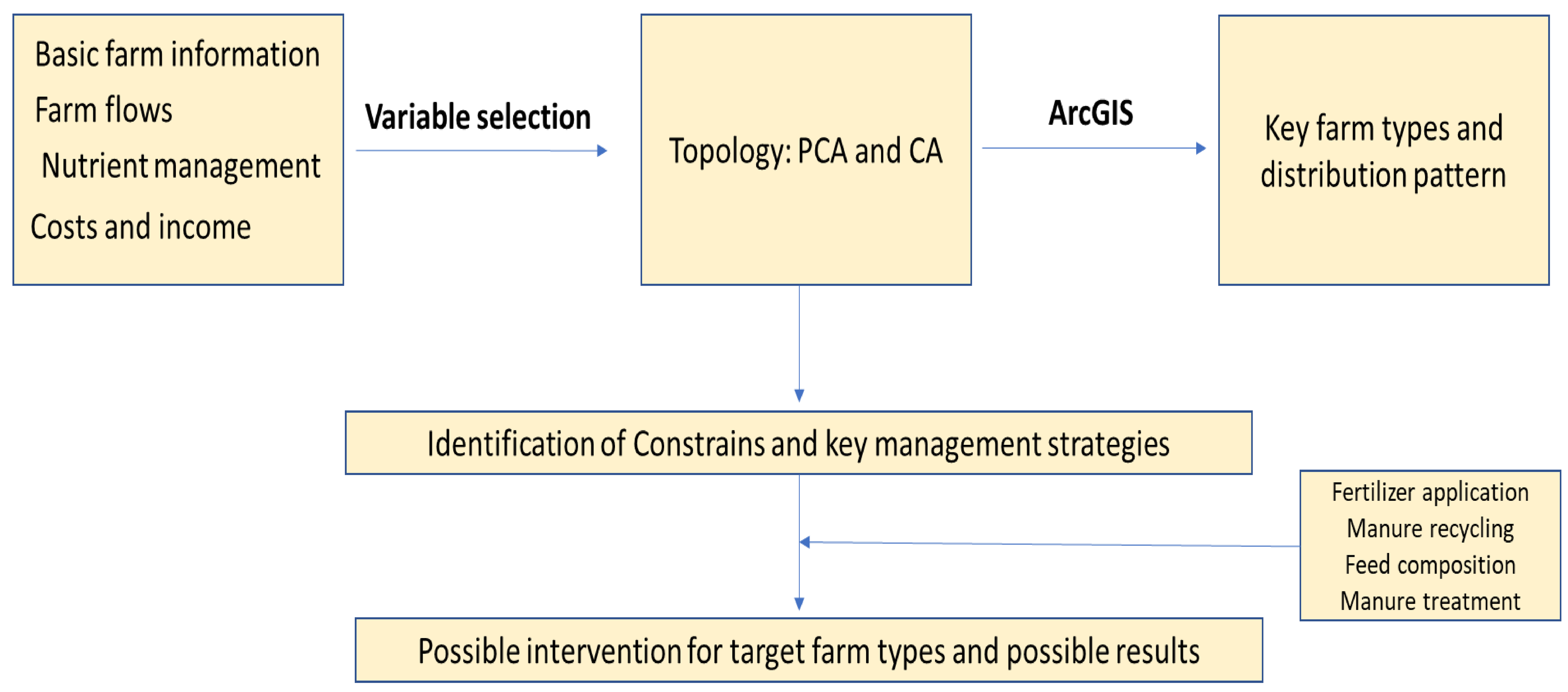
Figure 1. Relationships between farm size and chemical use per area
(Wu et al., 2018 *PNAS*)

Objectives

- To identify the key farm types in Quzhou and Shunyi by a data-driven typology
- To determine the factors of the distribution of farm types
- To capture the diversity of management strategies of smallholder farms, giving insights into key constrains for environmental, social and economic sustainability.

Methods

- Survey: household survey will be conducted. Six key topics will be included: 1)Basic farm information 2) farm in and out flows 3) nutrient management 4) household structure 5) Variable costs and market prices 6) Farmers' perception to their farms
- Farm typologies will be based on this survey. GIS will be used to locate farms. Principle component analysis would be used to determine main variables.



Expected outcomes

- There would be some principles under current farm type distribution, for example farm patterns may be different between peri-urban areas and suburbs. Livestock farms may be closed to urban areas.
- Small Farm households with cereal-based cropping system and subsistence livestock may be predominant in China Northern Plain. Big farm households with mixed farming systems may be rare.
- Several key pathways based on the individual practices may be identified which are associated with the manure storage, and processing and fertilizer usage.

Acknowledgements

We thank WU and CAU supervisors for supporting the field survey. We thank farmers for willingly responding to interviews during the field survey. We gratefully acknowlege the sponsors of this research:China Scholarship Council and Hainan University.

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What are the differences between cities on nitrogen circularity of food systems? Case studies in the North China Plain cities

PhD candidate: Chuanlan Tang
Supervisors: P. J. Gerber, S. J. Oosting and O. van Hal (WUR-APS)
M.K. van Ittersum and A.G.T. Schut (WUR-PPS)
Y. Hou and HL. Wang (CAU)

Background

- Food systems facing high demand pressure and environmental pressure (FAO,2021; Springman et al., 2018). The natural nitrogen (N) is being markedly discupted by anthropogenic acitivies and high amount of reactive N are released into the environment, resulting as a series of environmental problems.
- The 21 cities in the NCP have diversified agricultural production, diet consumption and social-economic development. City classification helps to propose differentiated strategies for circular food systems.
- Aquaculture and fisheries, companion animals and waste management subsystems are non-ignorable in the food systems.
- Circularity reflects how nutrient cycles are closed. Increasing circularity between sub-systems and increasing the internal efficiency of sub-systems contribute to close the nutrient cycles.

Research questions

- What are the current N circularity of the food systems in each city and the overall of the NCP?
- What are the contribution of aquaculture and fisheries, companion animals, and waste management to N use, recycling and loss in the NCP food systems?
- How are cities classified according to N recycling degree for each subsystems and for the overall food systems?
- What are the differentiated strategies for N management in different city categories?

System boundary

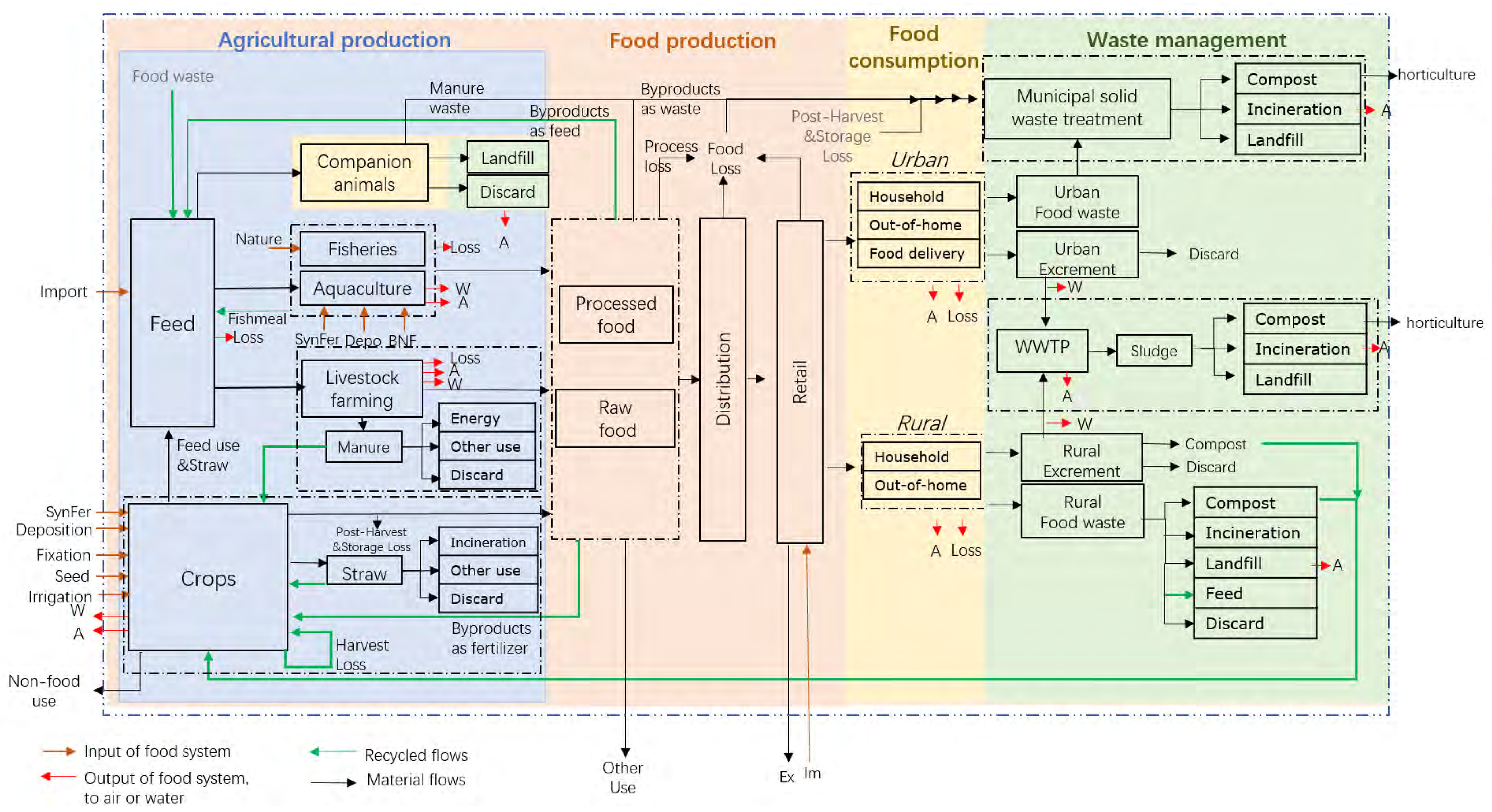

Figure 1. Food system boundary (current situation)

Research framework

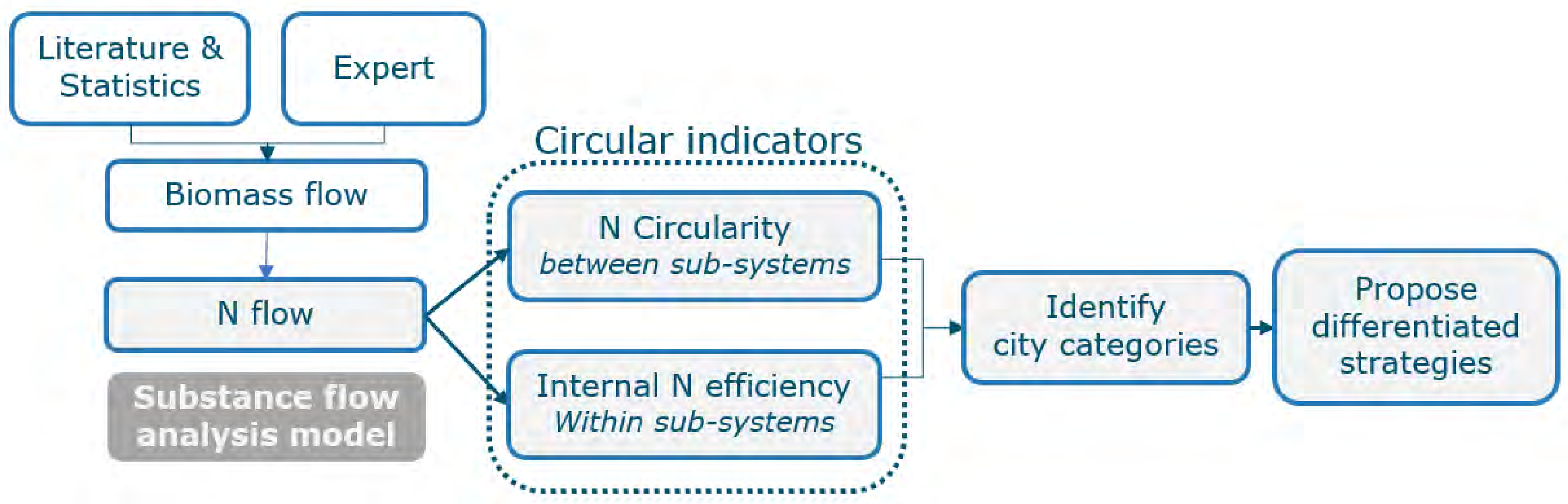

Figure 2. The research map of this study

Expected outputs

- The N use (Gg/cap), recycling(%) and loss (Gg/cap) of the food systems in each city and the overall of the NCP;
- The contribution (%) of aquaculture and fisheries, companion animals, and waste management to N use, recycling and loss of the food systems in the NCP;
- City categories based on N recycling degree for each subsystems and for the overall food systems;
- Differentiated improvement strategies for each city category.

Reference

The State of Food Security and Nutrition in the World 2021. (2021). FAO, IFAD, UNICEF, WFP and WHO.
Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., de Vries, W., Vermeulen, S. J., Herrero, M., Carlson, K. M., Jonell, M., Troell, M., DeClerck, F., Gordon, L. J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., … Willett, W. (2018). Options for keeping the food system within environmental limits. Nature, 562(7728), 519–525.

Acknowledgements

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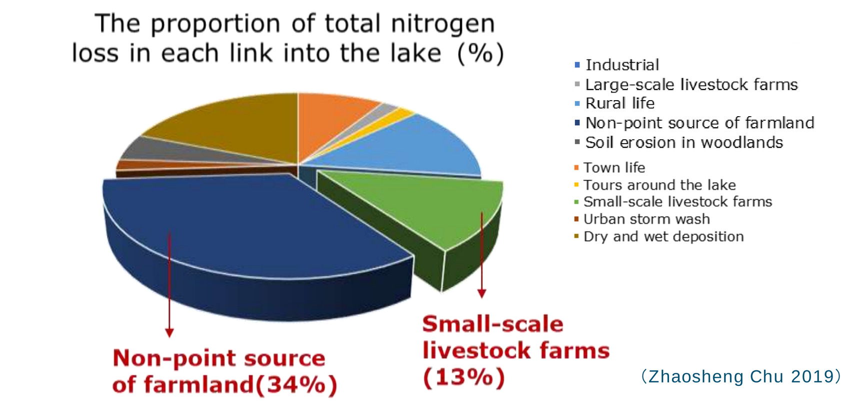
Recycling of regional organic wastes: lessons from Erhai

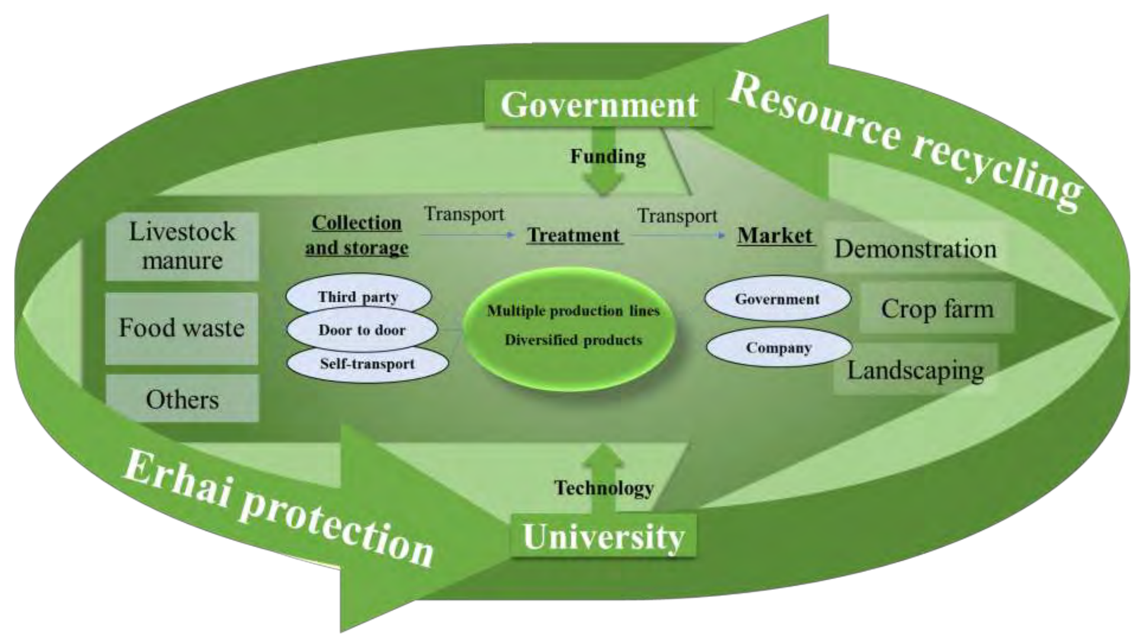
Xiaoying Zhang Supervisors: Y. Hou and HL. Wang (CAU)
M.K. van Ittersum and A.G.T. Schut (WUR-PPS)
P. Gerber and S. Oosting (WUR-APS)

Background

- Animal production in Erhai basin is mainly small-scale farmers, which has a huge pollution risk.
- Policy-oriented---"Three Bans and Four Promote"
—Prohibit the sale of chemical N and P, and promoting the replacement of chemical fertilizers with organic fertilizers ; promoting the utilization of manure: collect and treat more than 140,000 tons of manure every year by organic fertilizer enterprises.
- Yunnan Shunfeng Erhai Environmental Protection Technology Limited liability company will obtain 80 RMB/ton purchased manure from the government subsidies.



	Dairy	Beef cattle	Swine	Poultry
Large-scale	9%	3%	17%	59%
Small-scale	91%	97%	83%	41%



SFErM (ShunFeng Erhai Model)

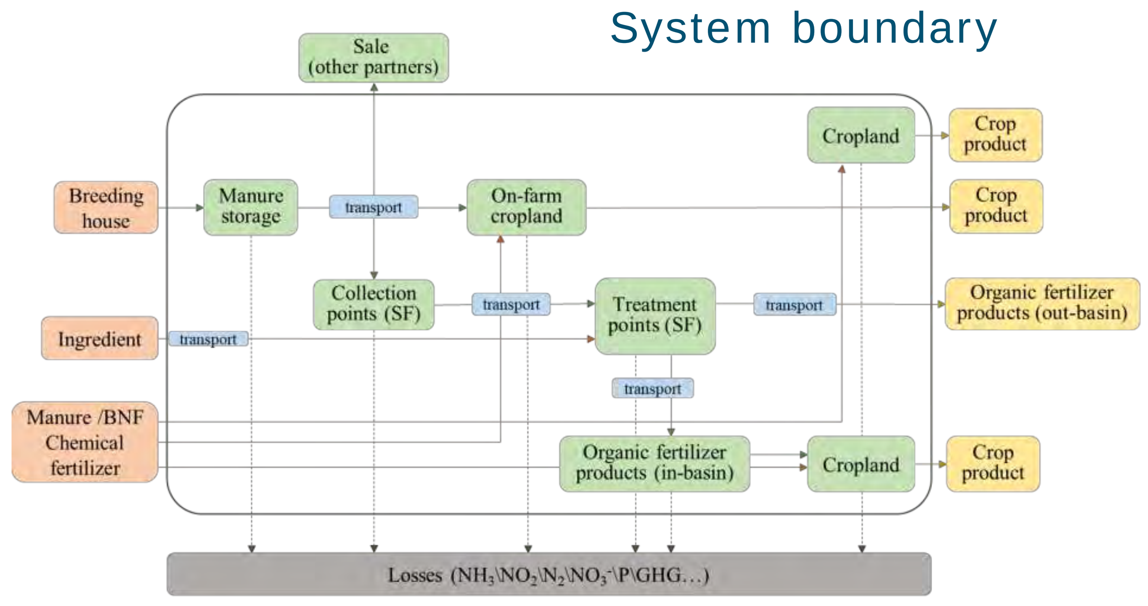
Objectives

The operational mechanism of the SFEhM is firstly clarified by qualitative, and then quantify the contribution of the SFEhM in realizing the combination of crop and livestock, including resource utilization and economic benefits. Finally, we explore the space for its further improvement through optimization.

Methods

- Quantitative evaluation—— MFA & LCC & Scenario analysis

System boundary



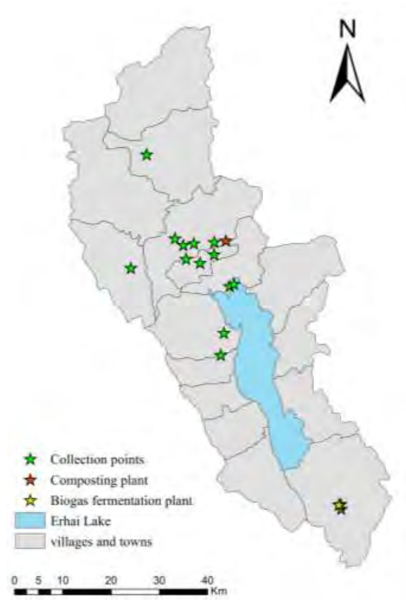
Methods

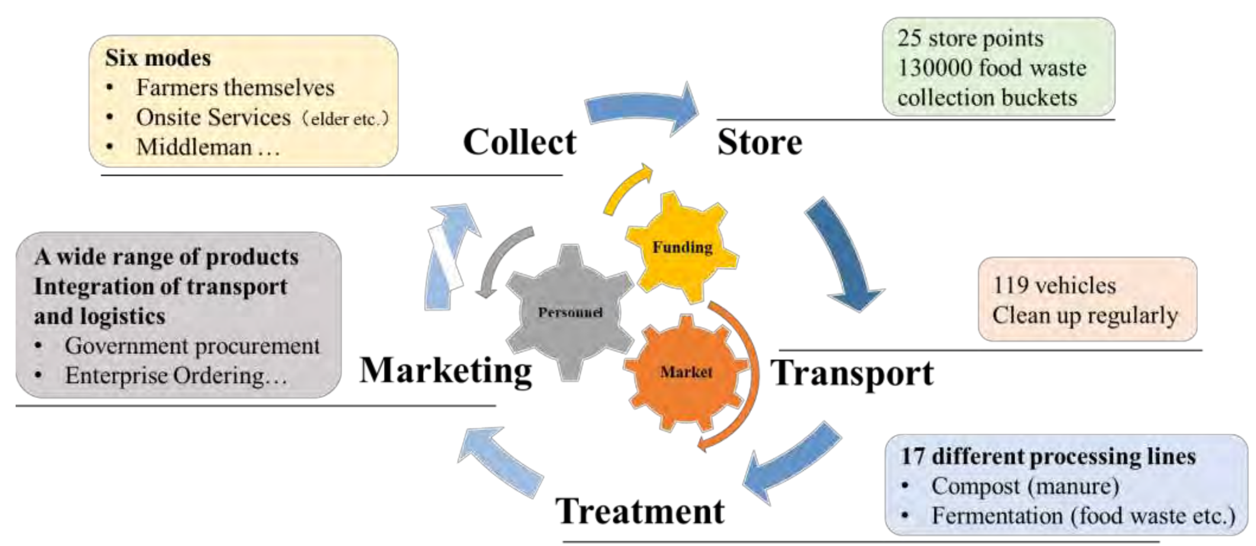
- Qualitative evaluation——Conduit Brokerage: An institutional approach to manure recycling (Bettina Bluemling and Fang Wang, 2018)

"Conduit Brokerage" analysis framework		Evaluation indicators
1.Structural conditions	1.1 Environmental regulation and market demand	Interdependence between farmers
	1.2 Resource exchanged and distance between stakeholders	Dependence on broker
	1.3 Complementarity of actors and resources	Opportunity
	1.4 Heterogenicity of manure produce and crop demand	Brokerage intensity (relative effort)
2.Institutionalization of brokerage	2.1 Service intensity	Impact institutionalization
	2.2 Processing technology	
	2.3 Benefits for all parties	
3.Effectiveness of brokerage	3.1 Selection criteria for clients	Impact effectiveness
	3.2 Planning and rules for scheduling service delivery	

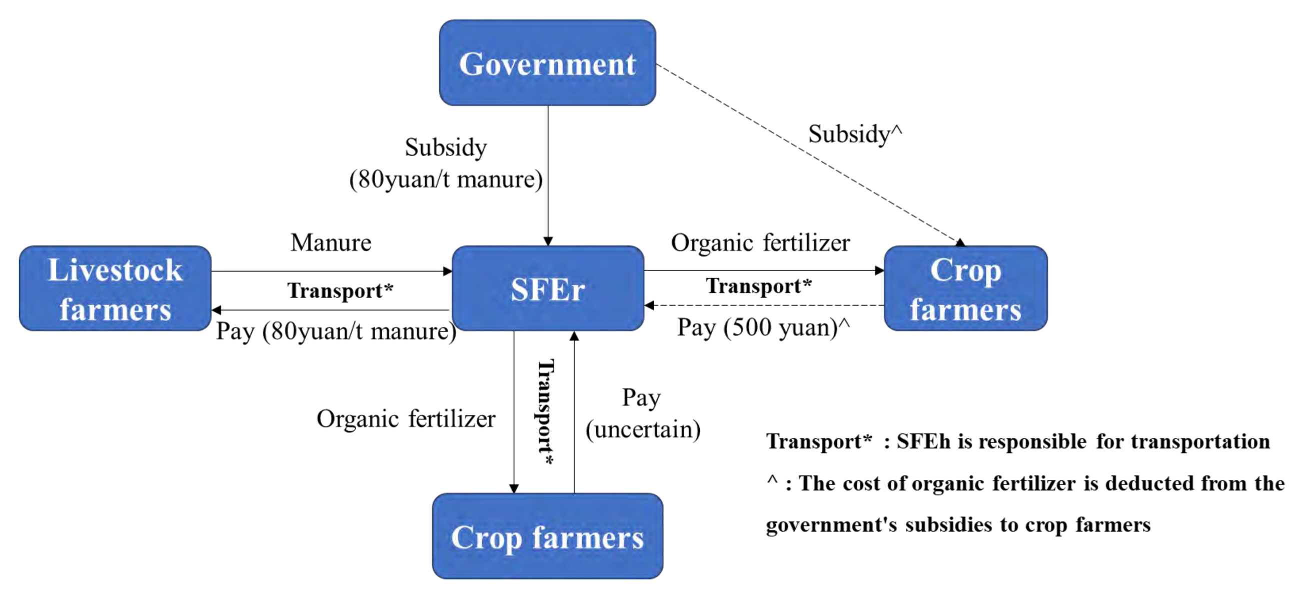
Results

1. Qualitative evaluation



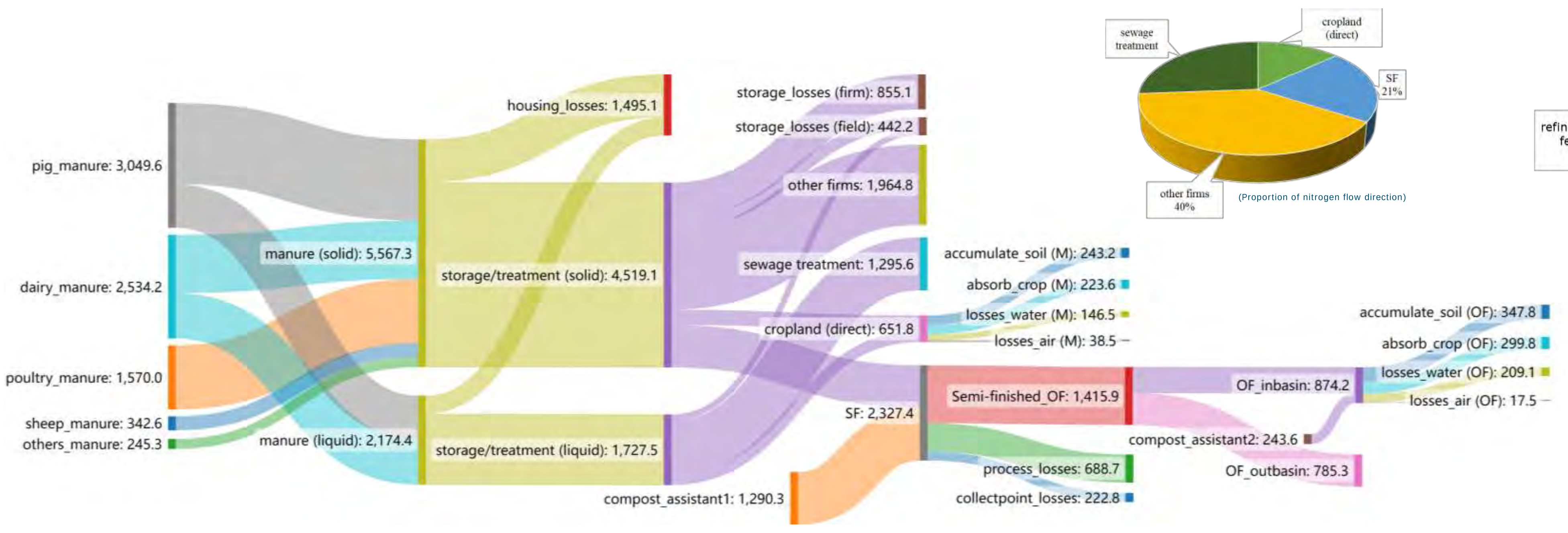


- Cover the entire river basin, extend the entire industry chain

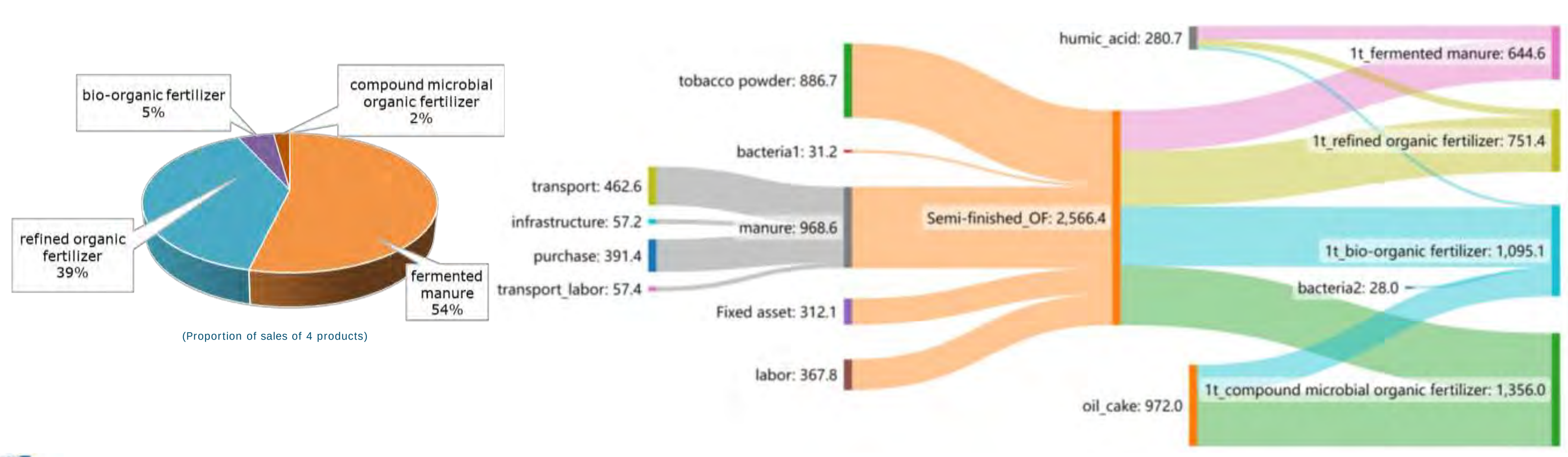


- Multi-stakeholder cooperation

2. Quantitative evaluation



- Nitrogen flow of Erhai's manure (t N)



- Nitrogen flow of SF's products (yuan·t product)

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Recoupling livestock and cropland on a regional scale could reduce manure N loss from 10.5 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).

Optimization of spatial manure recycling strategies in view of economic and environmental impacts in Chinese agriculture

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

Background

During the last few decades, China has strongly decoupled its crop and animal production. Currently, the average manure-recycling ratio is lower than 40% in China indicating that half of the manure nutrients are lost to the environment, leading to great pressure on the environmental quality. Recoupling livestock and cropland on a regional scale could strongly educe manure N and P losses and reduce soil acidification rates Currently, there is a lack of a manure allocation model that optimizes manure recycling based on agronomic, environmental and economic aspects of crop fertilization. This includes requirements with respect to crop demand in view of target crop yields (agronomic), nutrient losses in view of impacts on soil, air and water quality (environmental) and farmers' income, as a function of manure policies and subsidies.

Objectives

Optimization spatial manure recycling strategies in view of economic and environmental impacts, focusing on six counties in Quzhou city by:

- ☐ Quantifying the spatial variability in crop nutrient demands and its match with the attainable nutrients from animal manure for the base year 2020.
- ☐ Quantifying the nutrient availability and losses from manure in response to livestock numbers, farm sizes and manure treatment technologies, focusing on the base year 2020 in perspective to changes in 2011-2020 and trends in 2021-2030.
- ☐ Assessing the cost and benefit of the coupled crop-livestock production and quantify the optimal transport distance for different manure recycling modes

Framework

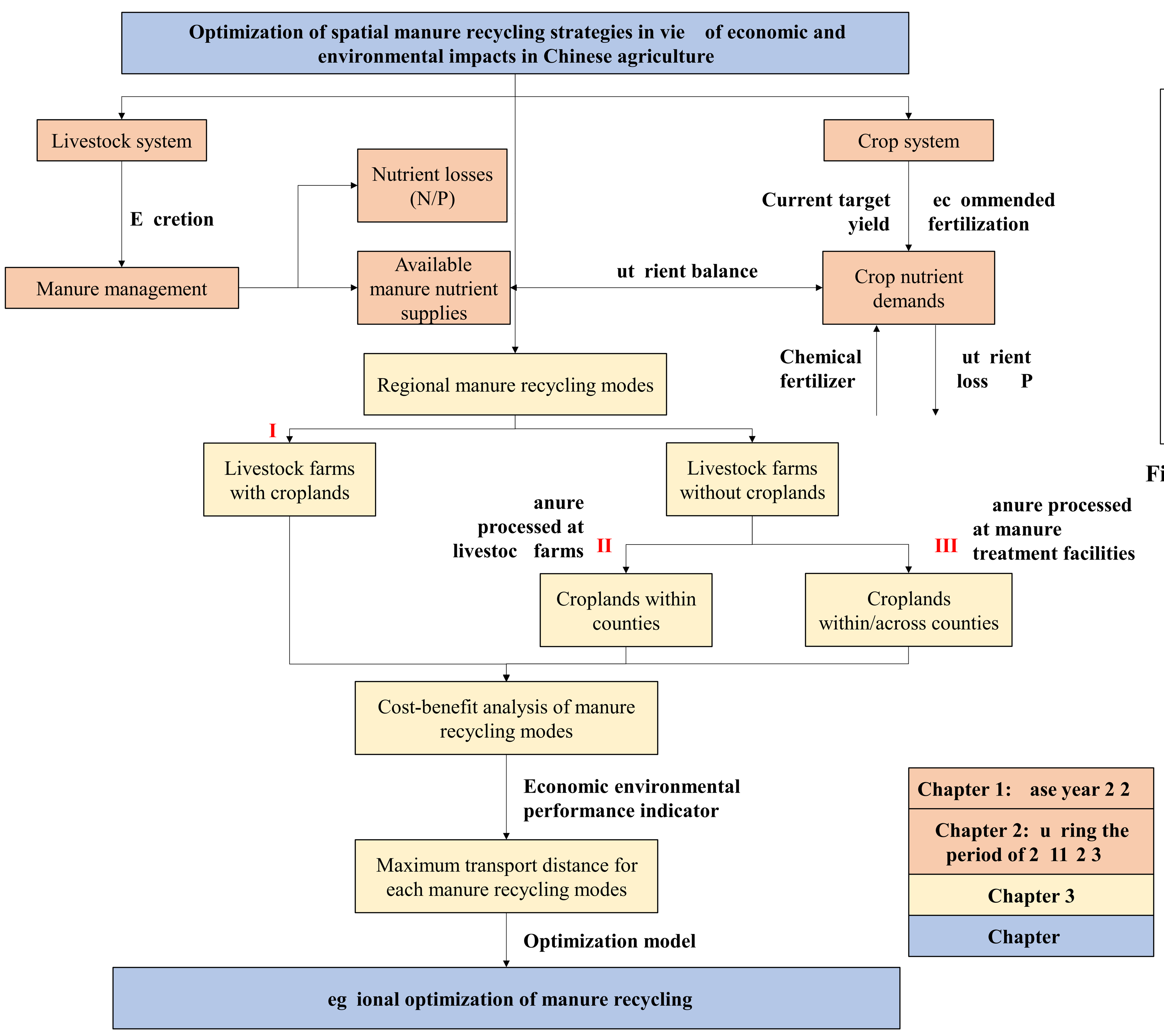

Fig. 1. Overview of the project approach.

Methods

- ✓ Questionnaire surveys of manure management, cost and revenue of manure processing facilities, etc.
- ✓ Material & value flow analysis
- ✓ Cost-benefit analysis
- ✓ Optimal manure allocation model

Preliminary results

A first assessment is made of the spatial variability in crop nutrient demands and its match with the attainable nutrients from animal manure for the base year 2020 in Quzhou using the overall framework given below:

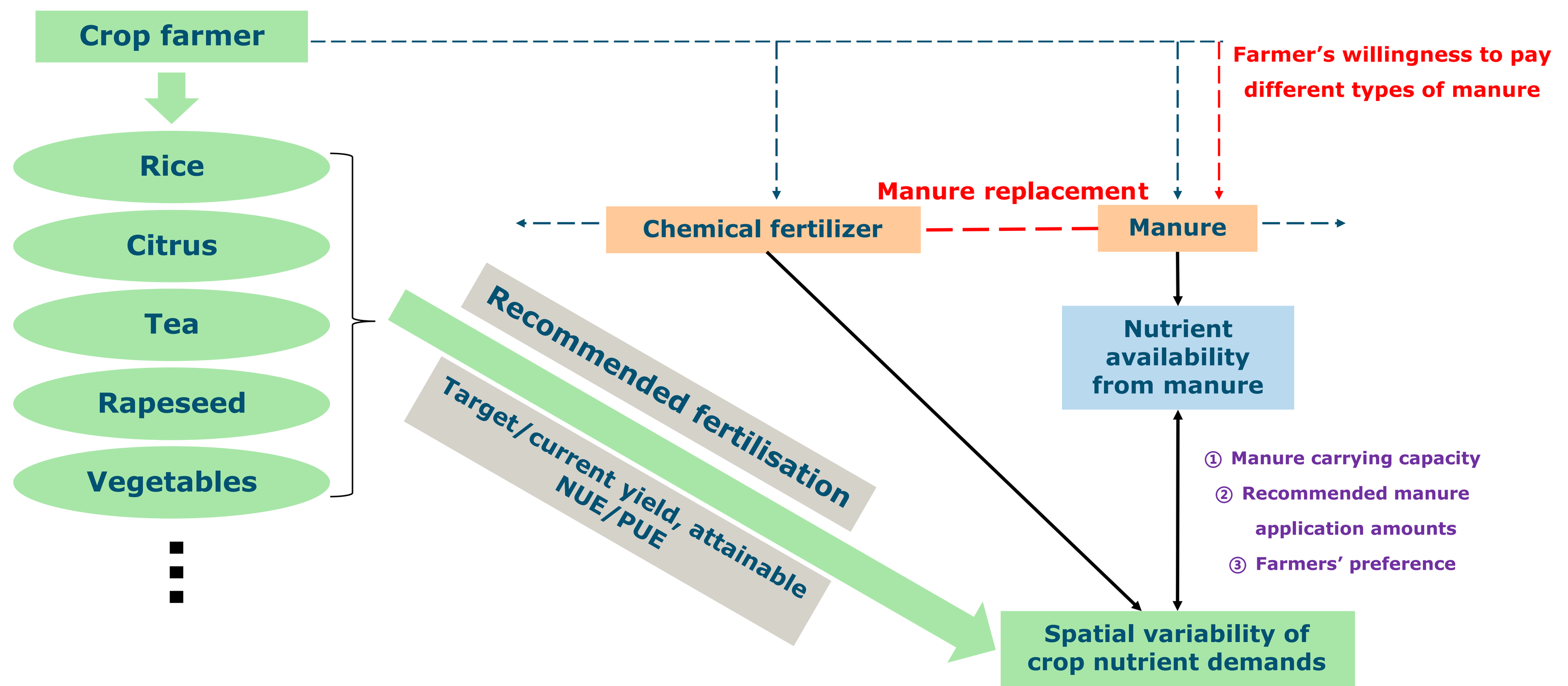

Fig. 2. Framework for the quantification of nutrient balance between nutrient input and crop demands.

Available nutrients in manure under the current manure recycling rate (40%) and its maximum values (100%) are compared with crop nutrient demands for all croplands in Quzhou in Fig. 3. The nutrient demands are calculated using a current crop residue removal rate of 20% (80% recycling) and a minimum value of 0% (100% recycling).

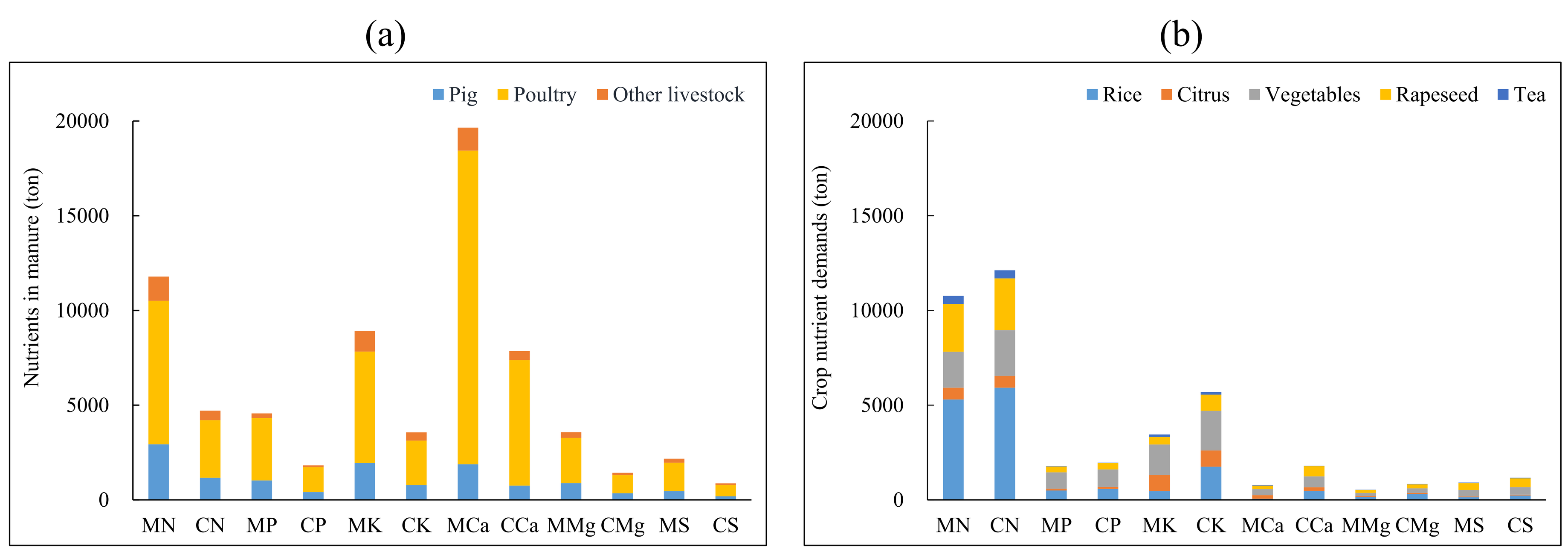

Fig. 3. Nutrients in manure (a) and crop nutrient demands (b) in Quzhou for the base year 2020 under maximum (M) and current (C) recycling rates of manure (a) and straw (b).

Nutrient deficiencies in Quzhou city at the current manure and straw recycling rates occur for N (-7400 ton), P (- 140 ton), K (-2100 ton), and S (- 300 ton). At maximum (100%) manure and straw recycling rates, nutrients from livestock manure can meet up the crop demands for all nutrients (Fig.4).

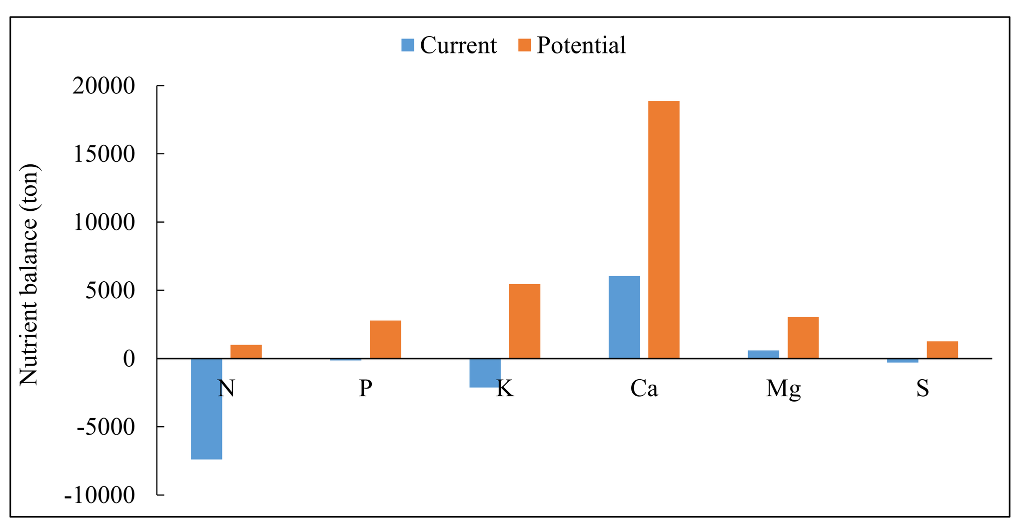

Fig. 4. Nutrient balance between crop nutrient demands and available nutrients from manure under current and maximum recycling rates of manure and straw in Quzhou for the base year 2020.

Acknowledgements

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Sustainable development of China’s agriculture driven by fertilizer policy

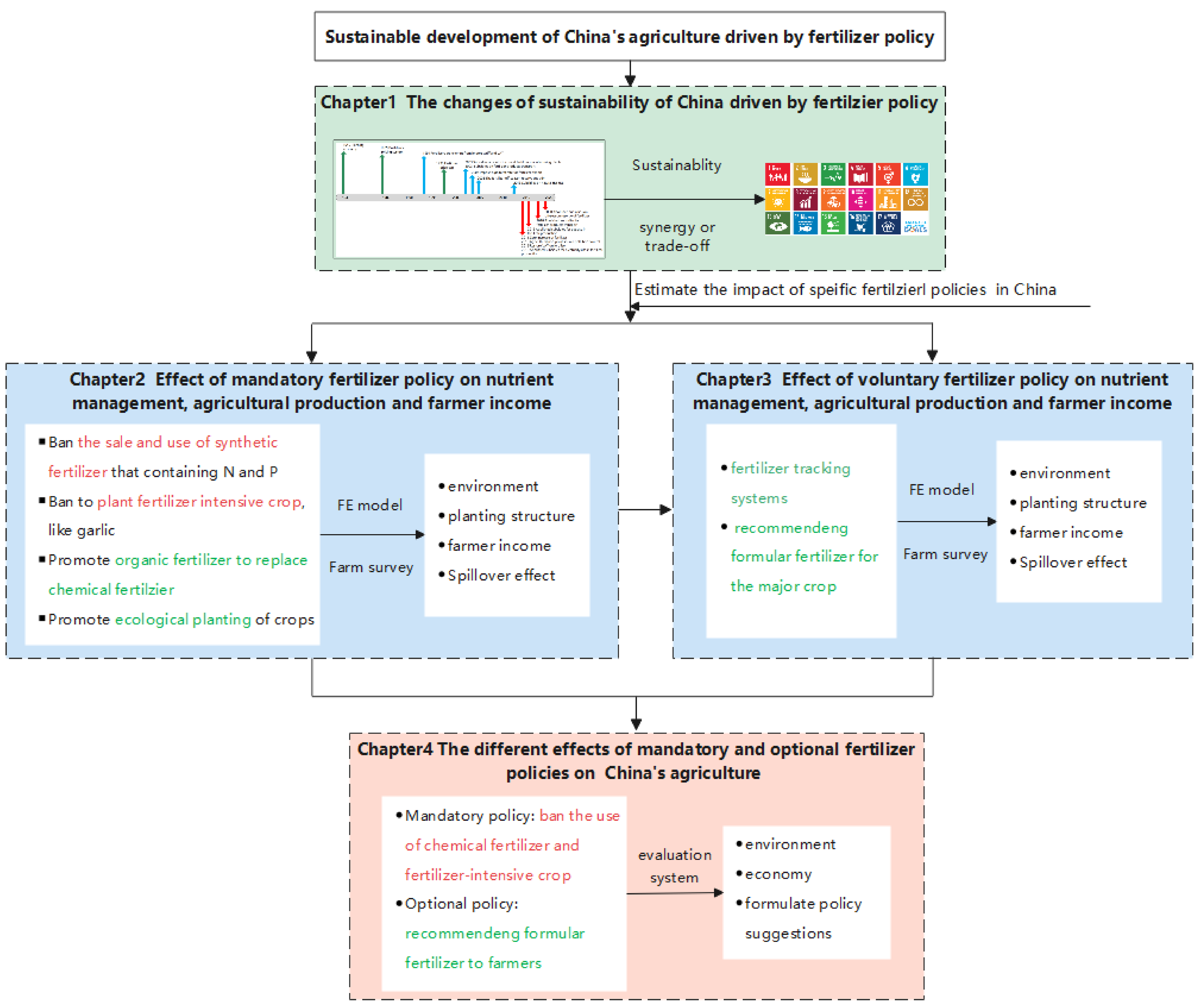
PhD student: Ling Zhang

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



Empirical model

Fixed Effect (FE) model was used to estimate the impacts of fertilizer policy:

$Y_{it}=\beta_1 * X_{it} + \beta_2 * P_{it} + \mu_i + \gamma_t + \varepsilon_{it}$

Where the dependent variable Y_{it} refers to the direct and indirect impacts. The key explanatory variable X_{it} is the payment intensity of the mandatory fertilizer policy. P represents a group of control variables that may affect Y, including operating farm size, number of farmland plots, rental farmland area, number of family work on planting, whether raising livestock, whether agriculture as the major source of income, crop price, and chemical fertilizer price. μ represents household fixed effects. **γ** refers to year-fixed effects. ***ε*** refers to the error term.

Results of Chapter 2

- The implementation of the mandatory fertilizer policy significantly decreased the chemical fertilizer input (1542.6 kg ha^{-1} $year^{-1}$), organic fertilizer become the major nutrient input in crop production.
- For the N and P nutrient, total fertilizer N input (48.6%) and N surplus were significantly reduced, but the total fertilizer P input and P surplus with no significantly change.
- The policy implementation harmed the net benefit per unit of cropland , a reduction of 81125 RMB, about 62.3%.
- Ban the planting garlic (fertilizer-intensive) crop was responsible for the environmental improvement (reducing N and P surplus), but taken a toll on farmers’ incomes. While the ban of use of chemical fertilizer and promote organic fertilizer didn’t reduced N surplus but increasing P surplus.

Dependent variable	(1) Winter season	(2) Summer season	(3) Whole year
Panel A.	-0.1970684***	-0.0151251	-0.0703423***
Log (total fertilizer N input) (kg N ha^{-1})	(0.000)	(0.707)	(0.000)
Number of observations	264	265	267
R^2	0.3494	0.0237	0.3128
Panel B.	-0.1416628***	0.0765499***	-0.0128622
Log (total fertilizer P input) (kg P_2O_5 ha^{-1})	(0.000)	(0.000)	(0.261)
Number of observations	264	265	267
R^2	0.2961	0.1679	0.0613
Panel C.	-0.4919035***	0.0038205	-0.2911125***
Log (N surplus) (kg N ha^{-1})	(0.000)	(0.936)	(0.000)
Number of observations	259	265	267
R^2	0.4164	0.1318	0.2232
Panel D.	-0.2748113***	0.2815583*	-0.0265822
Log (P surplus) (kg P_2O_5 ha^{-1})	(0.000)	(0.000)	(0.609)
Number of observations	259	265	267
R^2	0.2797	0.2496	0.0230
Panel E.	-0.2573383***	-0.0095753	-0.111808***
Log (net benefit) (yuan ha^{-1})	(0.000)	(0.678)	(0.000)
Number of observations	269	269	271
R^2	0.2563	0.0626	0.2078

Conclusions

- The implementation of the mandatory fertilizer policy achieved zero planting of garlic, while chemical fertilizer input per was reduced by 64.9%.
- The policy didn’t achieve the expected goal of improving water quality, because only N surplus reduced, while no effect on P surplus, and both N and P are the main elements causing eutrophication in lakes.
- The policy hinder farmers’ benefit largely, the reduction was 81,125 RMB ha^{-1}, due to the ban planting of garlic.
- The two sub-policies with trade-off effects, the reduction of P surplus derived from ban the planting of garlic was offset by the promotion of manure replacement.

Acknowledgements

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

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Potential of agricultural management strategies to minimize the gap between current and critical ammonia emissions for ecosystems in China

PhD student: Rong Cao

WUR Supervisors: Wim de Vries, Gerard Ros; CAU supervisors: Wen Xu, Xuejun Liu

Background

The Chinese agricultural sector emits large amounts of ammonia as a result of the large-scale application of fertilizer and manure. The consequent high deposition and concentrations of NH_3 (can) cause damage to ecosystems, by eutrophication and acidification, and to human health, by increasing particulate matter exposure. Spatially explicit information on the gap between current and critical ammonia emissions is currently lacking, being crucial to optimize agricultural management strategies minimizing this gap

Objectives

1) Improvement of NH_3 emission totals, spatial and interannual patterns of NH_3 emissions based on bottom-up methods;
2) Assessment of the spatial variation in critical ammonia emission, and the gap with current emissions
3) Assessing optimal spatial reduction strategies to reduce the gap in current and critical NH_3 emissions

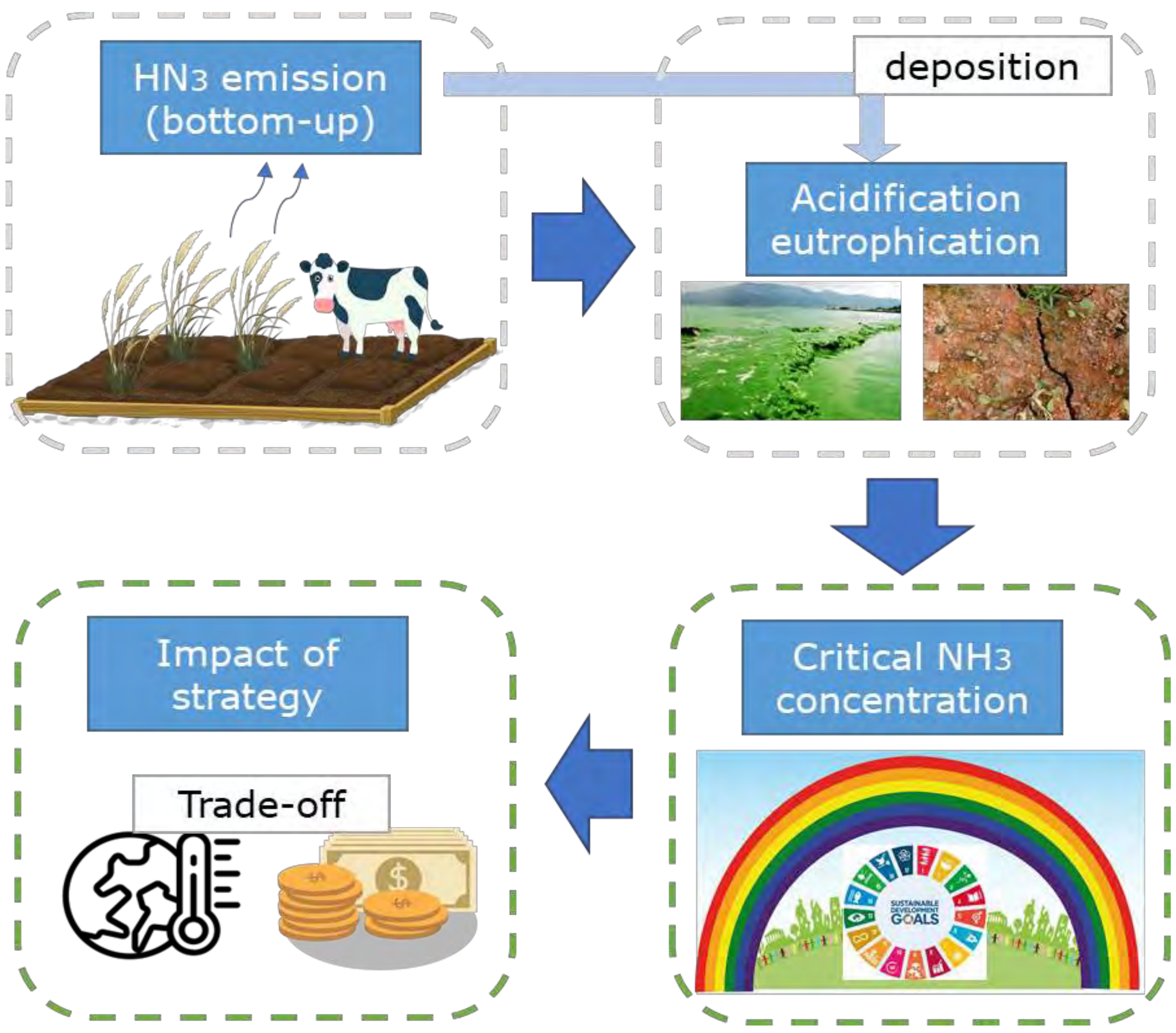

Figure 1. Research roadmap of the project

Research Questions

- How to improve spatial and temporal patterns of NH_3 emissions and the NH_3 emission total in China?
- What is the spatial variation in critical nitrogen loads and critical acid loads for terrestrial ecosystems in China?
- What are impacts of ammonia abatement strategies on spatial patterns of ammonia emission and deposition in China?

Framework

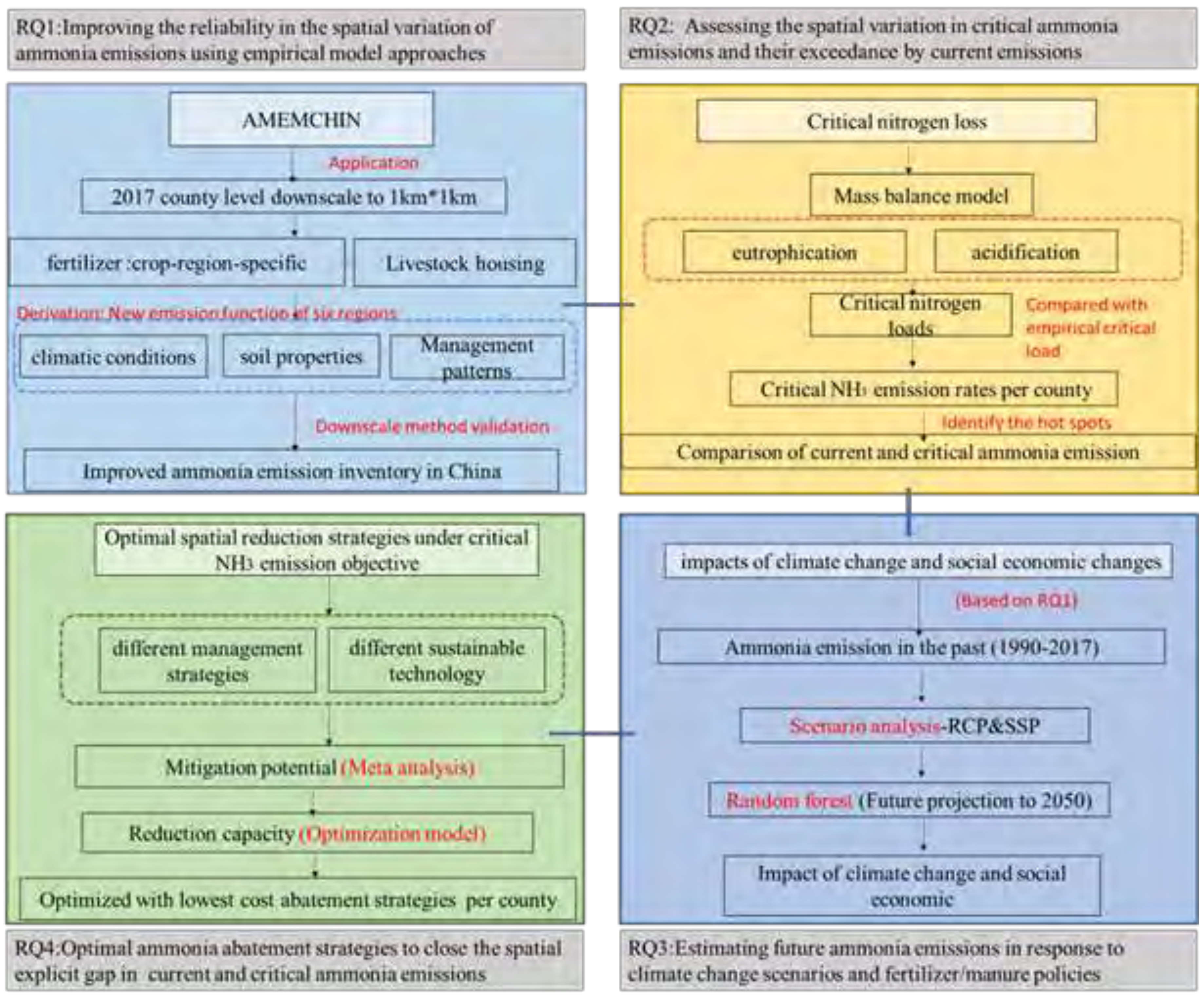

Figure 2. Details of research framework

Expect results:

✓High-resolution NH_3 emission inventory in China of 2017
✓Critical nitrogen loads for acidification and eutrophication
✓Temporal prediction of NH3 emission under climate change
✓Optimal reduction strategies of ecosystems

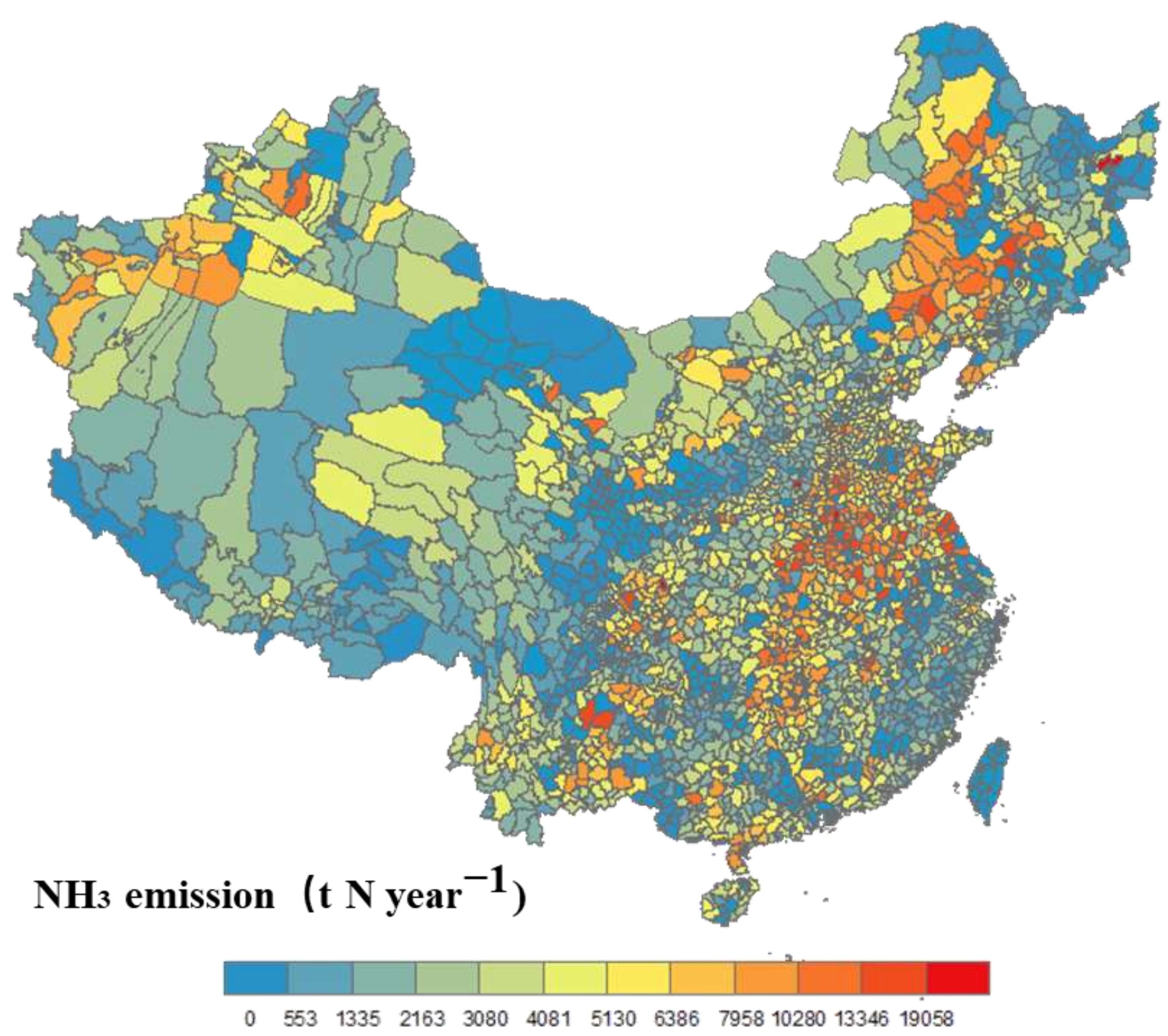

Figure 3. County-level agricultural ammonia emission in 2017 in China

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inverse modeling techniques (4D-Var, Kalman filter, etc.) assimilating these satellite observations have provided unique opportunities to improve NH_3 emission estimates with high spatial and temporal resolution using continuous, near real-time, large-scale measurement (Chen et al., 2021). This method has been applied to derive NH_3 emissions in other countries and at the global scale (Cao et al., 2020; Chen et al., 2021; Luo et al., 2022; van der Graaf et al., 2022), but such inversion studi

Optimizing ammonia emissions in China based on satellite inversion and the reduction targets of multi-pollutant synergy

PhD student: Jianan Chen

Supervisor: Wen Xu, Qichao Zhu, Maarten Krol and Wim de Vries.

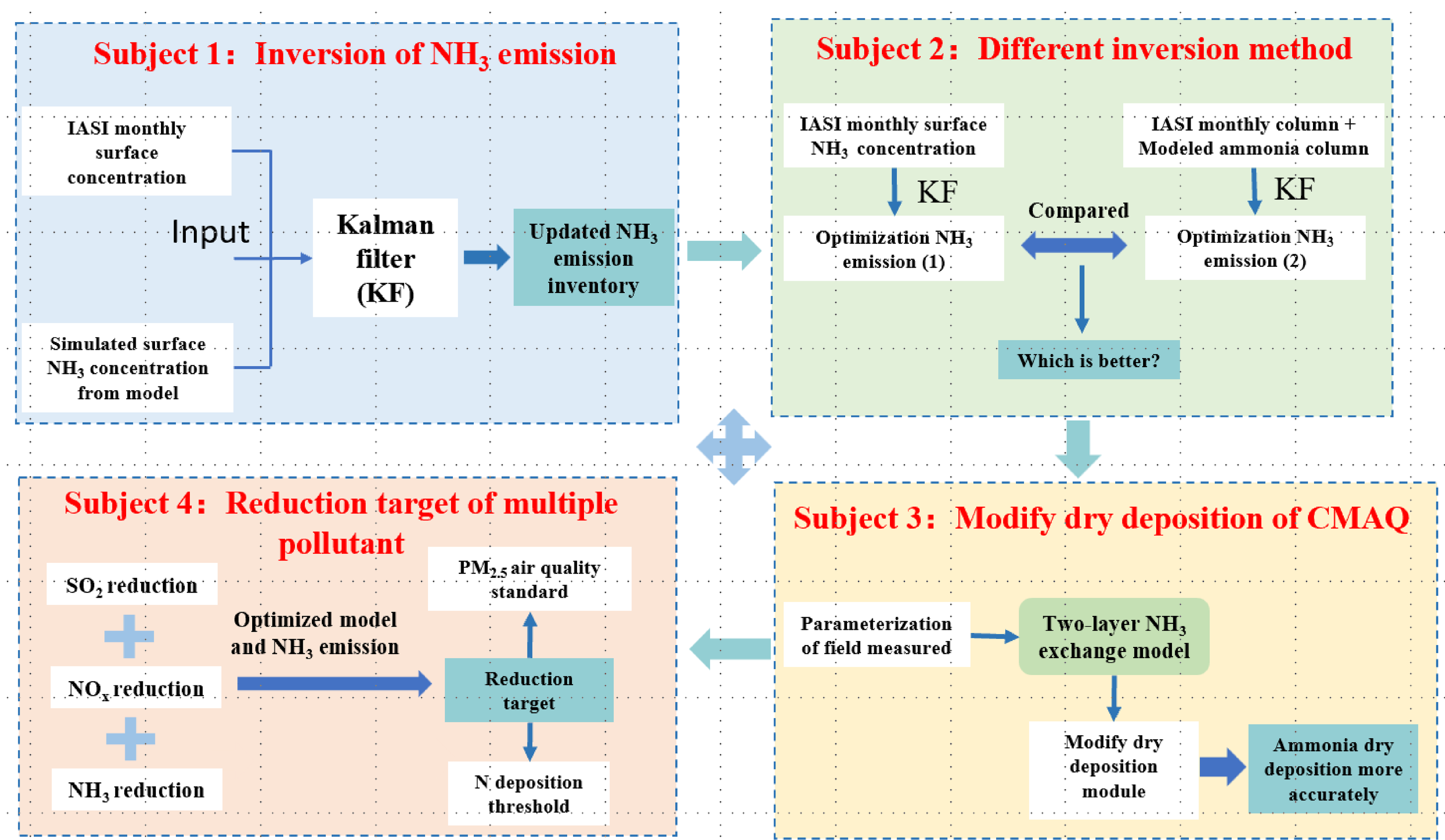
Background

Atmospheric ammonia (NH_3), as an important component of reactive nitrogen (Nr), plays a key role in atmospheric chemistry, and in the nitrogen cycle at global and ecosystem scales. China is recognized as a global hotpot of ammonia emission owing to recent agricultural intensification processes and widespread fertilizer applications (Warner et al., 2016; Zhan et al., 2021). An accurate ammonia emission inventory is important for improving nitrogen management and air quality. Inverse modeling techniques (4D-Var, Kalman filter, etc.) assimilating these satellite observations have provided unique opportunities to improve NH_3 emission estimates with high spatial and temporal resolution using continuous, near real-time, large-scale measurement (Chen et al., 2021).

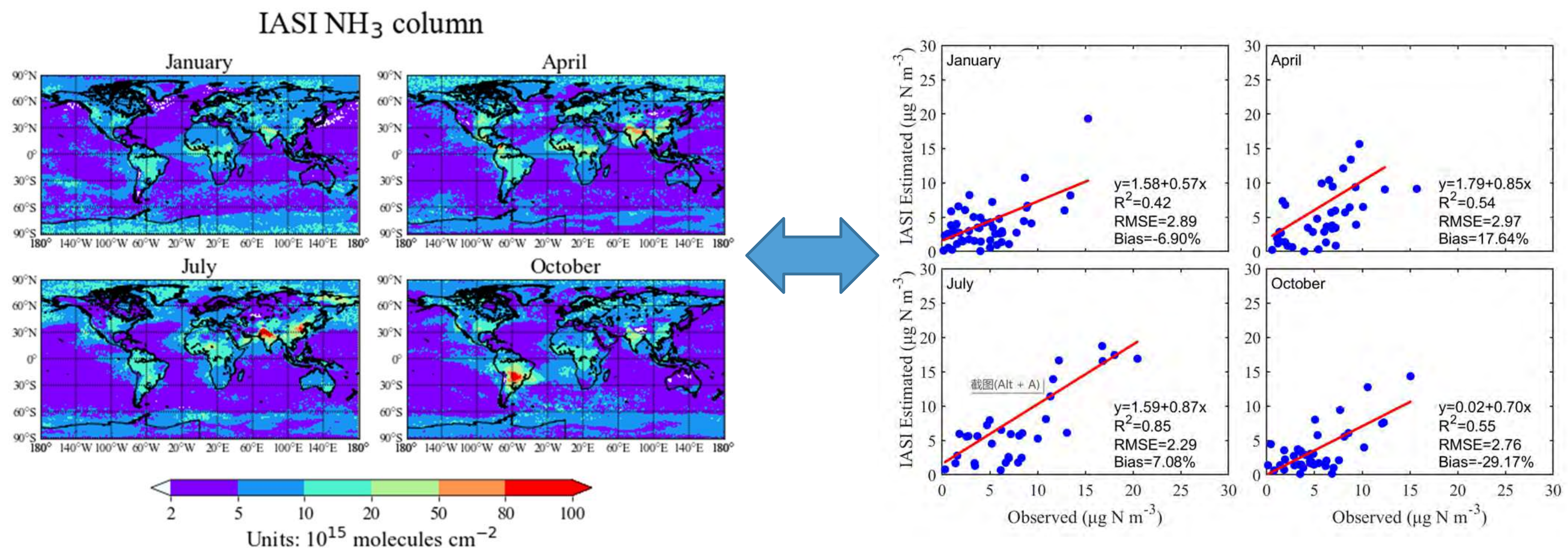
Objectives

- ➢ Constraining high-resolution ammonia emission in China by assimilating satellite observation.
- ➢ Quantify accurately N dry deposition by considering two-layer ammonia exchange.
- ➢ Quantify ammonia and acid gas emission reductions with multi-objective synergy.

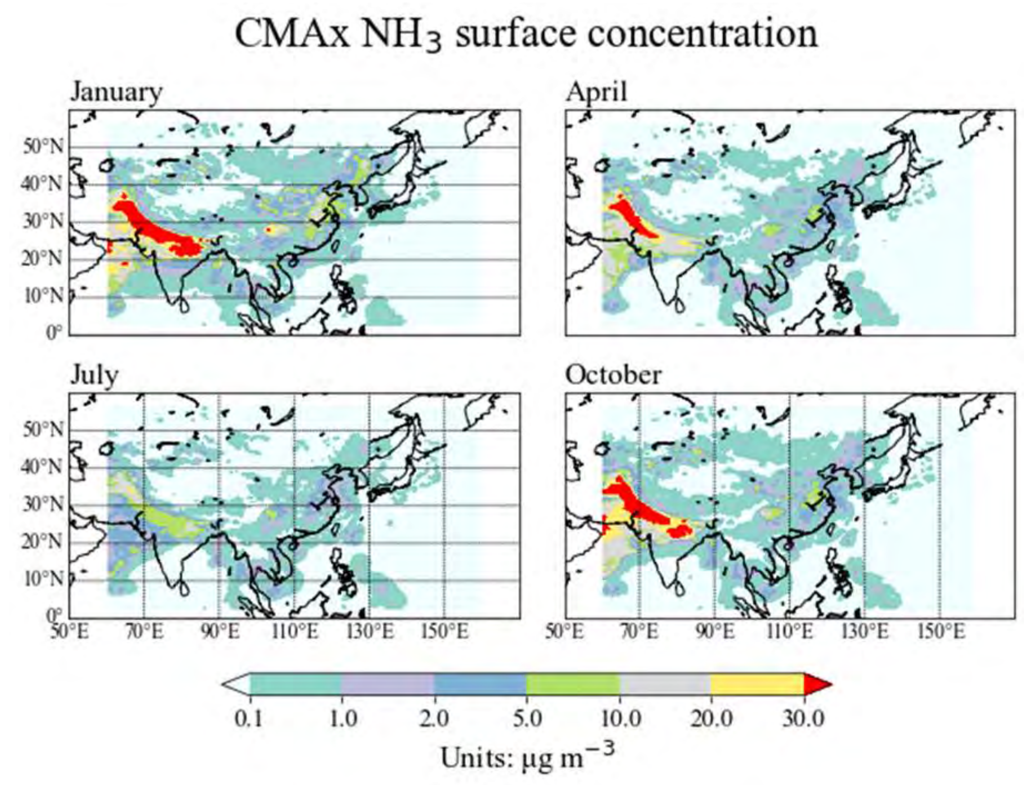
Methods



Results



- ☐ Surface NH_3 concentration inversed from IASI column .
- ☐ Satellite surface concentration is verified by surface network measurement.



- ☐ Monthly surface NH_3 concentration and sensitivity are simulated by atmospheric chemistry model.

Conclusions

- ☐ The NH_3 emission hotpots and high density are concentrated in North China Plain and Sichuan basin in China.
- ☐ IASI satellite surface NH_3 concentration is good fit to surface measurement datasets.
- ☐ The spatial distribution from model is similar to that of IASI satellite observation.

Acknowledgements

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

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Quantifying the impacts of existing and promising soil and water conservation measures on water quantity and quality in the Yangtze River Basin

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

Background

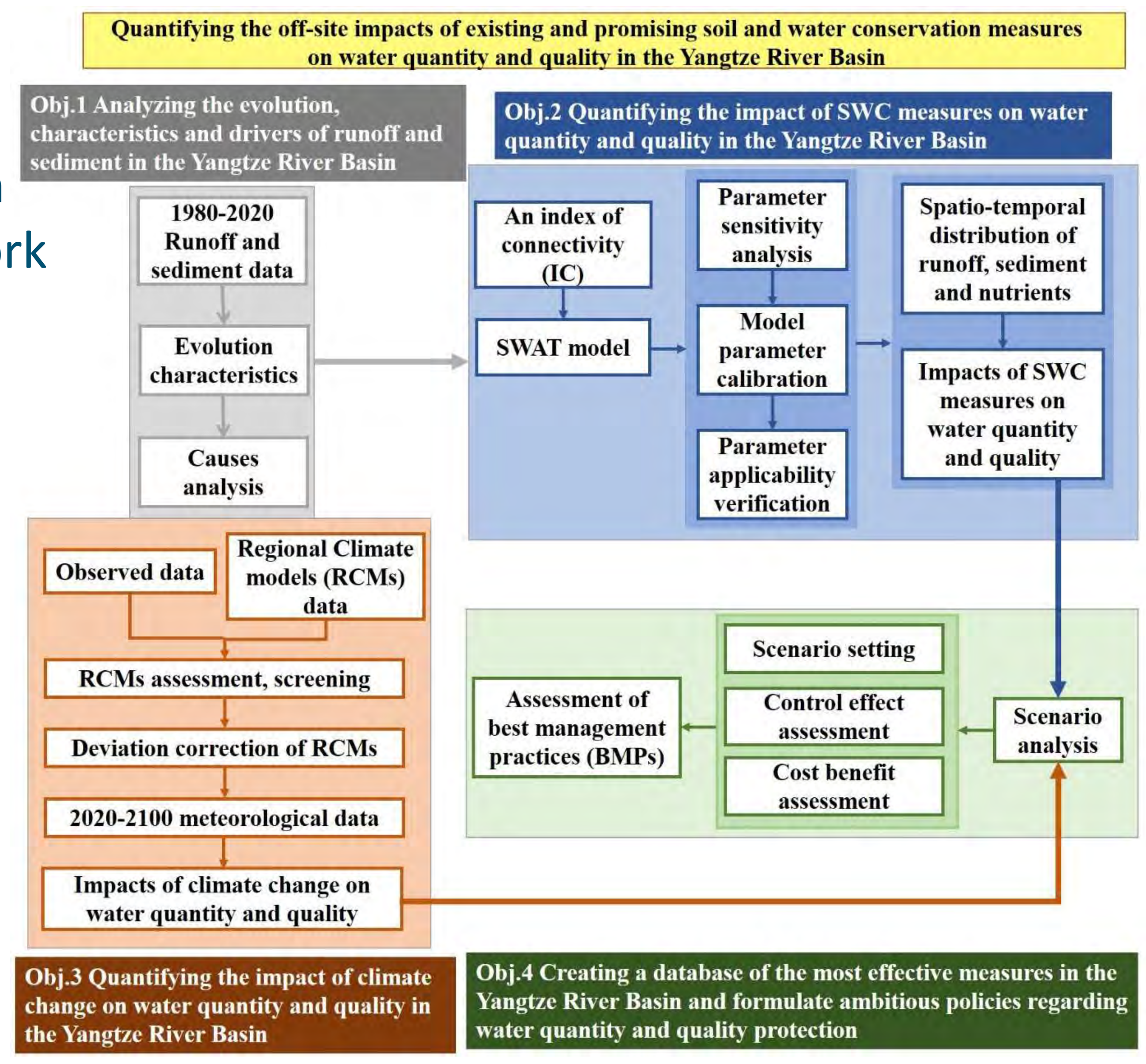
The Yangtze River basin (YRB) uses high amount of chemical fertilizer and suffers serious soil erosion. Since the 1950s, despite a large amount of investment in soil and water conservation (SWC) measures and water quality protection at the national and regional levels, soil erosion and nutrients runoff (with erosion) have not been significantly reduced in all areas. Therefore, quantifying the impact of SWC measures on water quantity and quality is of vital importance to determine the best management measures for the basin. However, the effect of individual SWC measures or their combination on water quantity and quality (nutrients and yield) at the catchment scale has rarely been evaluated.

Objectives

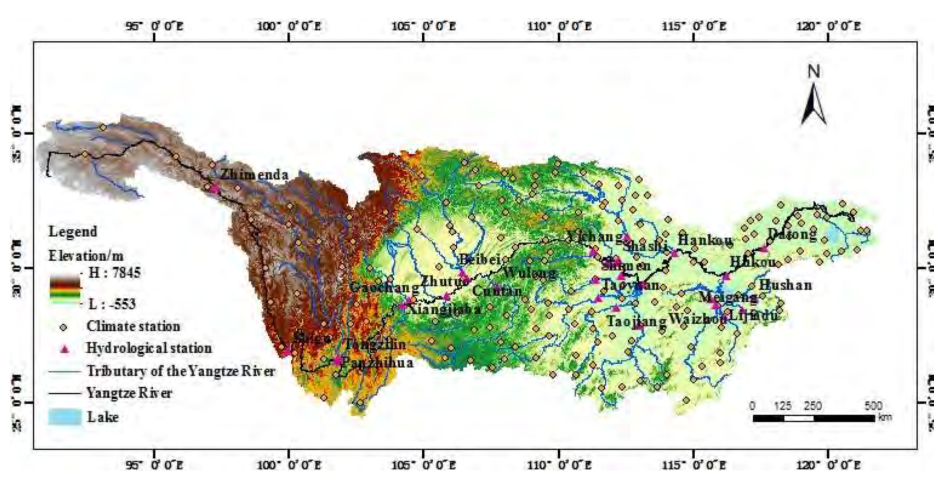
1. Analyzing the evolution, characteristics and drivers of runoff and sediment in the Yangtze River Basin;
2. Quantifying the impact of SWC measures on water quantity and quality in the Yangtze River Basin;
3. Quantifying the impact of climate change on water quantity and quality in the Yangtze River Basin;
4. Creating a database of the most effective measures in the Yangtze River Basin and formulate ambitious policies regarding water quantity and quality protection.

Methods

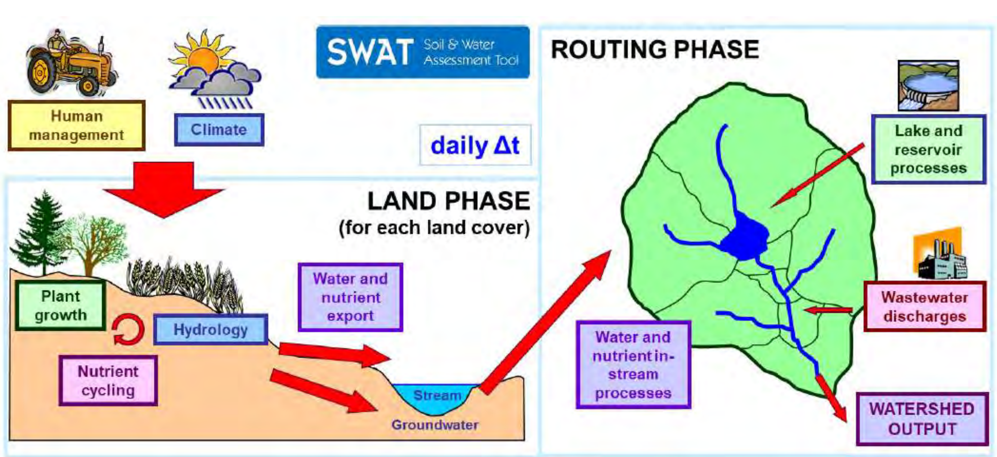
- Research framework



- Study area

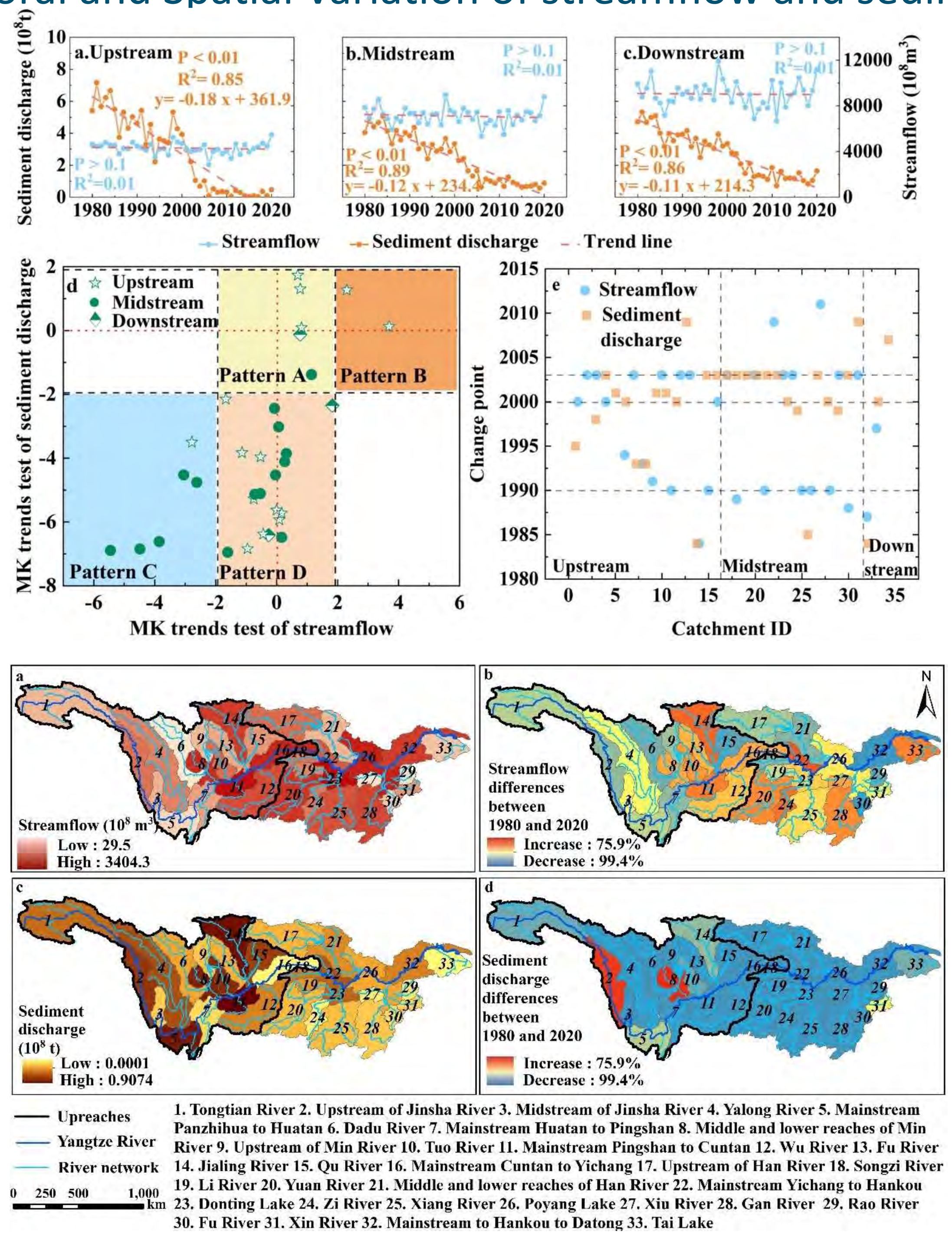


- SWAT model

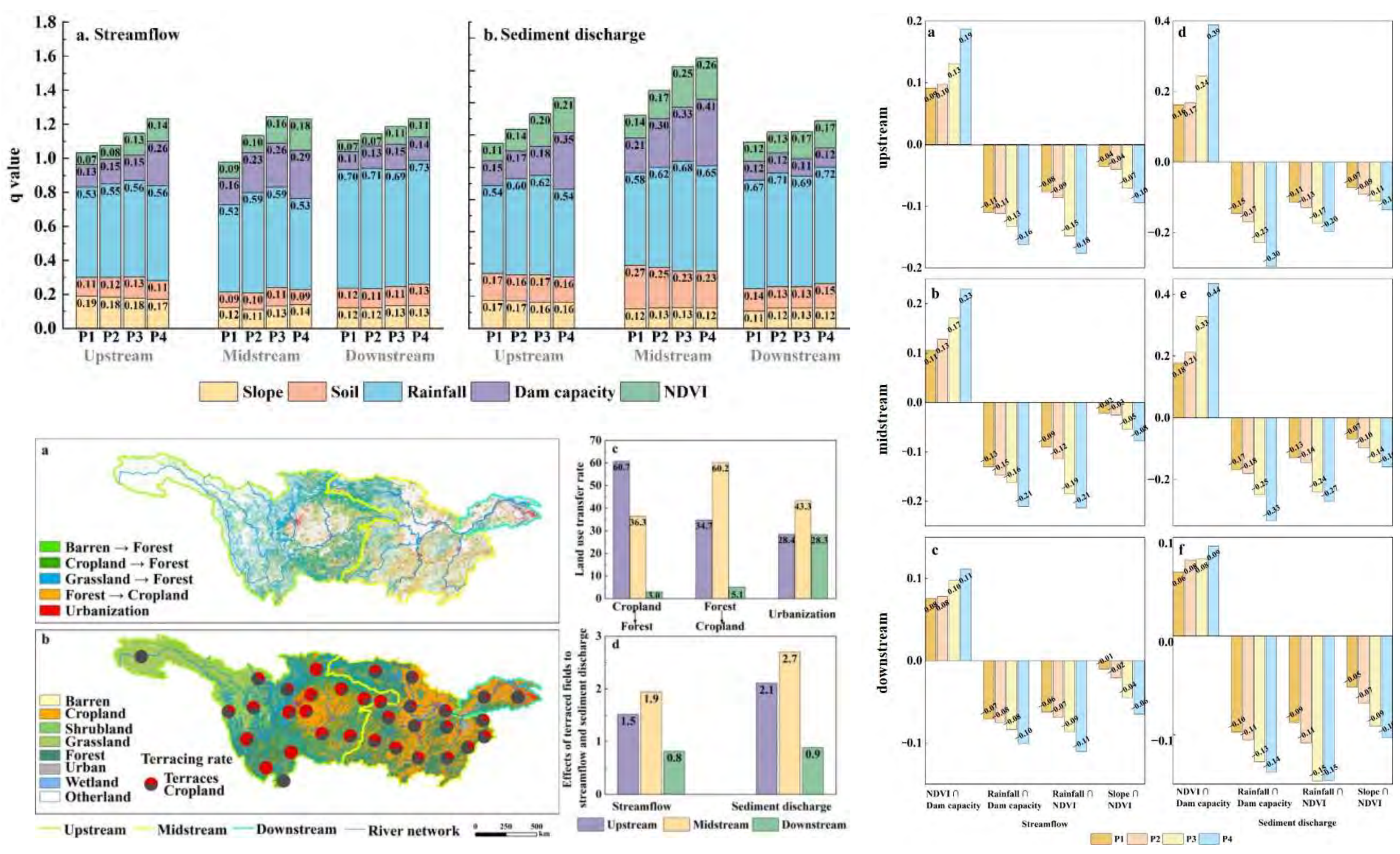


Results

- Temporal and Spatial Variation of streamflow and sediment discharge



- Attribution analysis of runoff and sediment discharge



Conclusions

- In many sub-basins (more than 50%) a significant reduction in sediment discharge was found while streamflow remained stable in the YRB during 1980-2020.
- Different change test methods were used for each sub-basin to determine the most trustworthy change points, which were mostly concentrated in 1990, 2000, and 2003.
- Rainfall had the greatest impact on streamflow and sediment discharge, accounting for 60.1% and 63.6%, respectively. Dam capacity contributed 20.8% more to sediment discharge than to streamflow (13.1%), while NDVI contributed 58.5% more to sediment discharge than to streamflow (7.8%).
- There was an interaction enhancement effect between dam capacity and NDVI on streamflow and sediment discharge, which was approximately 16.5% higher than the single factor effect.
- There were also interactive weakening effects between rainfall and dam capacity, rainfall and NDVI, and NDVI and slope, being respectively 15.6%, 11.1% and 3.7% smaller than the single factor effect.

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Acknowledgements

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Quantify the on-site impacts of existing and promising agricultural measures on land degradation and soil quality

Jichen Zhou

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

Background

Soil erosion is a widely spread environmental problem that not only threatens the sustainability of agriculture by reducing the soil's water holding capacity and its nutrient and soil organic carbon content, but also causes off-site reservoir siltation and water pollution. Especially in the YRB (Yangtze River Basin), water erosion is widely occurring and is acknowledged as a serious problem in many agricultural areas. Based on remote sensing data of the YRB, the index of soil erosion intensity decreased gradually; but an aggravation effect is also obvious. A range of soil conservation technologies is now applied around the world to combat the loss of soil and water. Soil and water conservation measures (SWCMs) can be effectively used to reduce and control soil erosion and sediment mobilization.

Objectives

- 1. Make an inventory and spatial map of existing national and regional policies and (agricultural) SWCMs
- 2. Quantify the impact of SWCMs using the PESERA model
- 3. Create a database of most effective measures and formulate ambitious policies regarding soil remediation

Study site

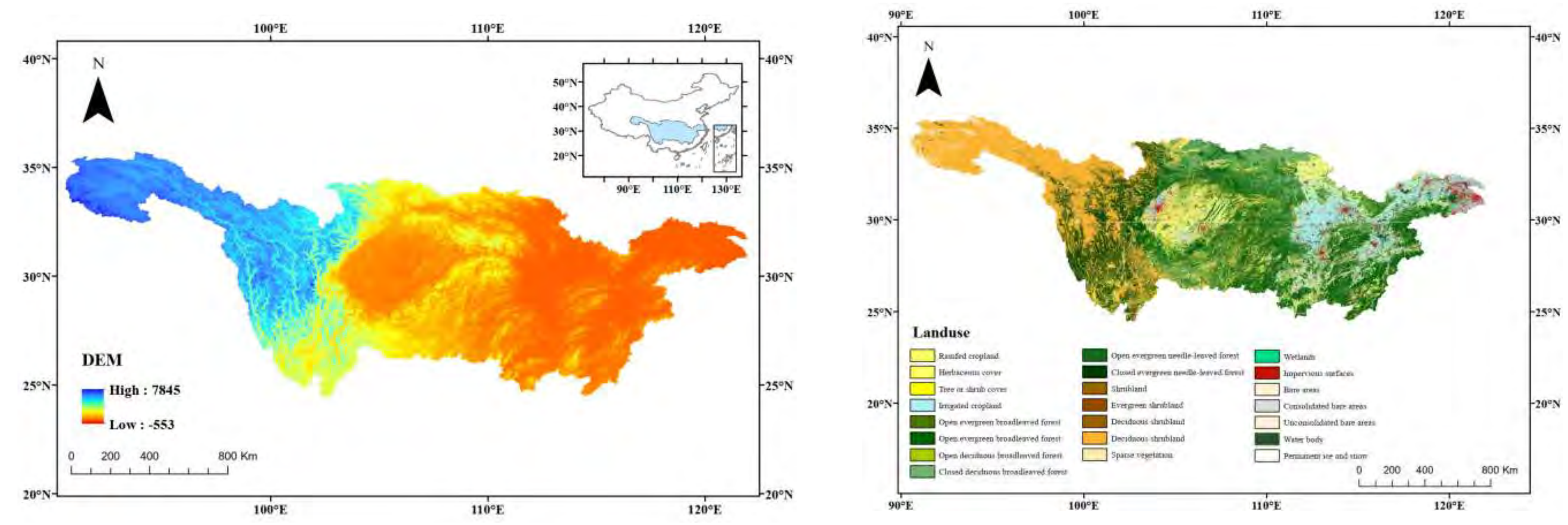

Fig. 1 The DEM and land use map of the Yangtze River Basin.

Methods

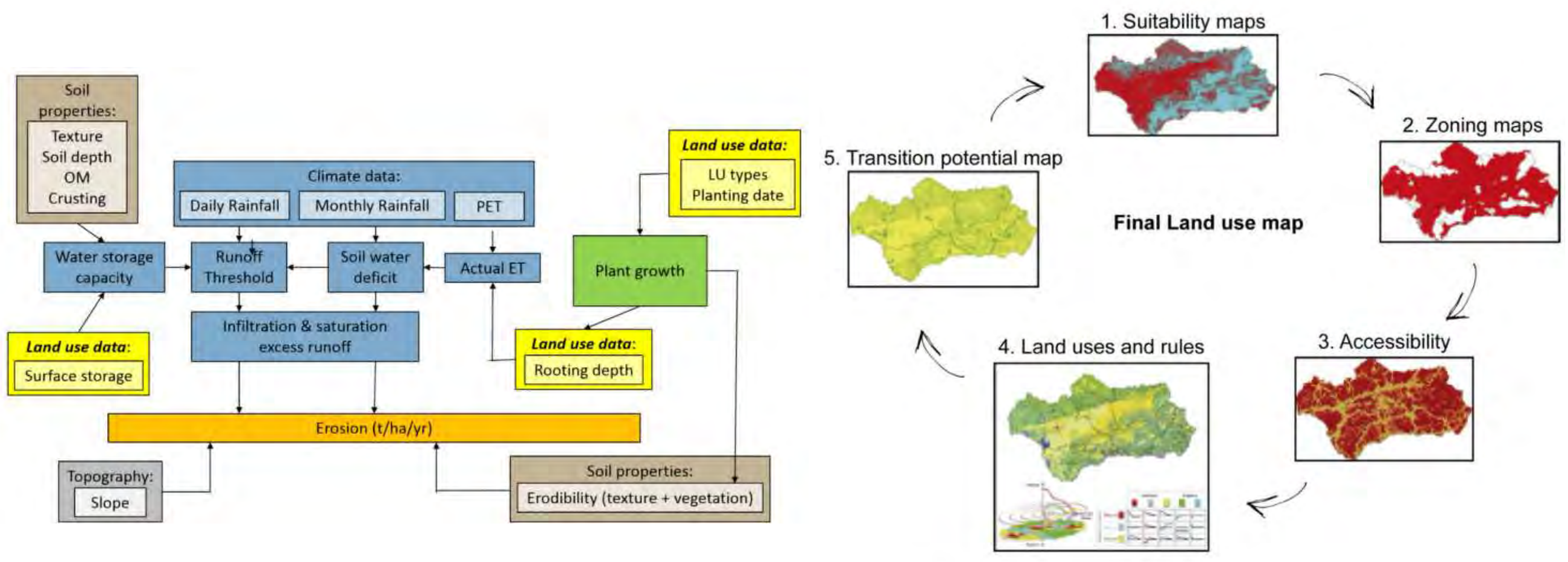

Fig. 2 Schematic overview of processes in the PESERA (left) model and Metronamica model (right)

- The Pan-European Soil Erosion Risk Assessment model (PESERA) is a process-based and spatially distributed model that combines the effect of topography, climate and soil properties.
- Metronamica model is a generic forecasting tool for planners and policy analysts to simulate and assess the integrated effects of policy measures on land use developments.

Preliminary results

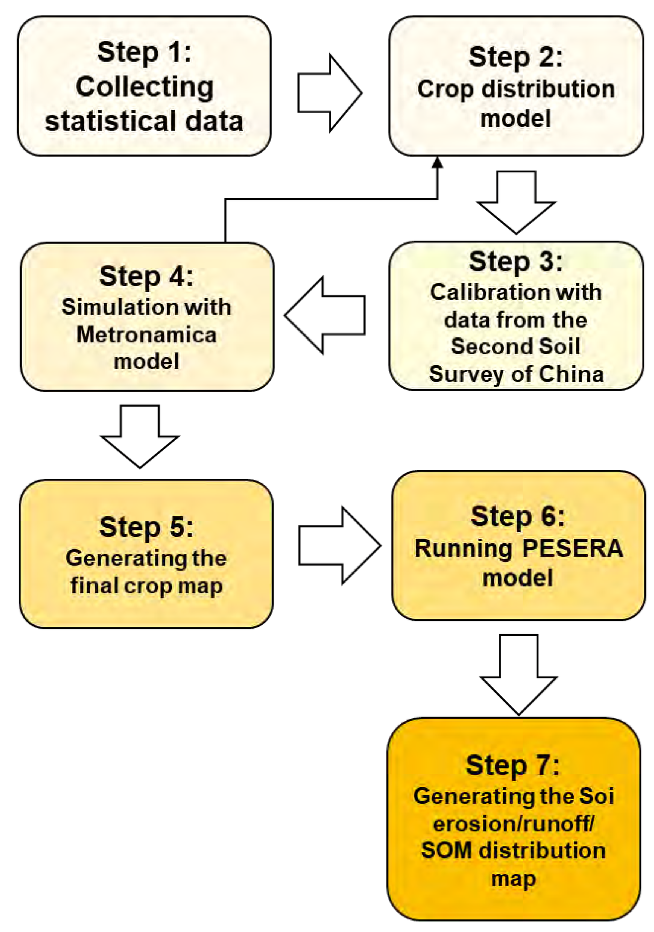

Fig. 3 The workflow of generating crop map.

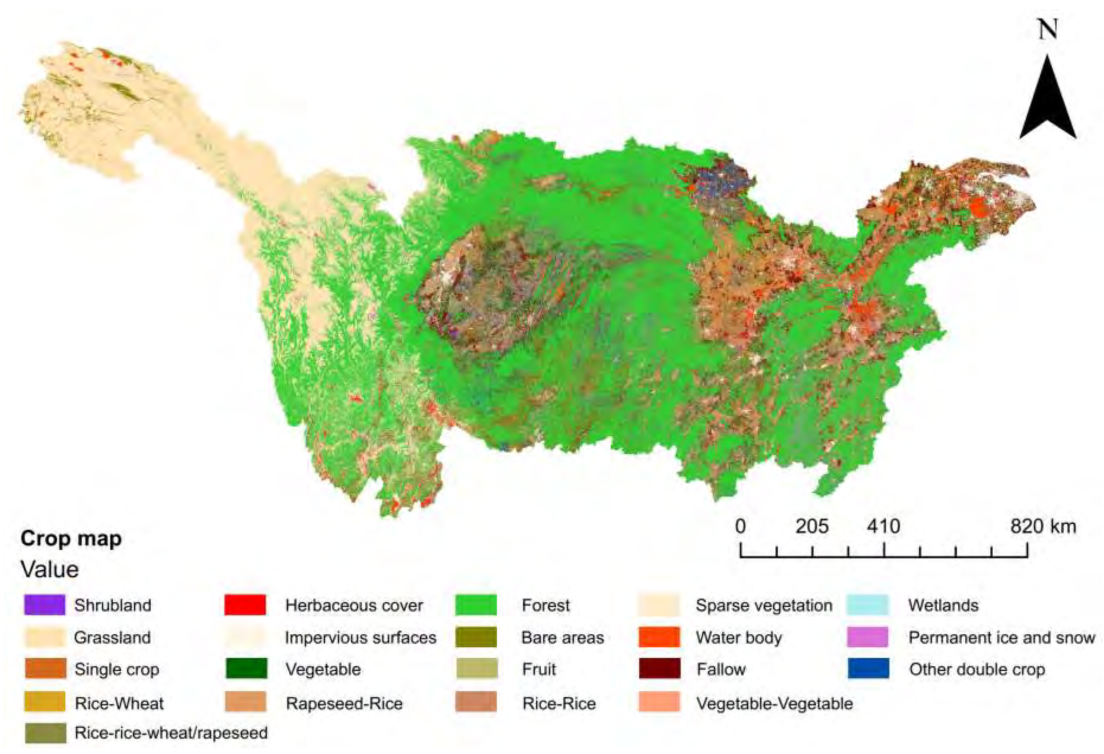

Fig. 4 Map of crop cropping patterns in Yangtze River Basin in 2010s. (Crop distribution map is used as input data into the PESERA model).

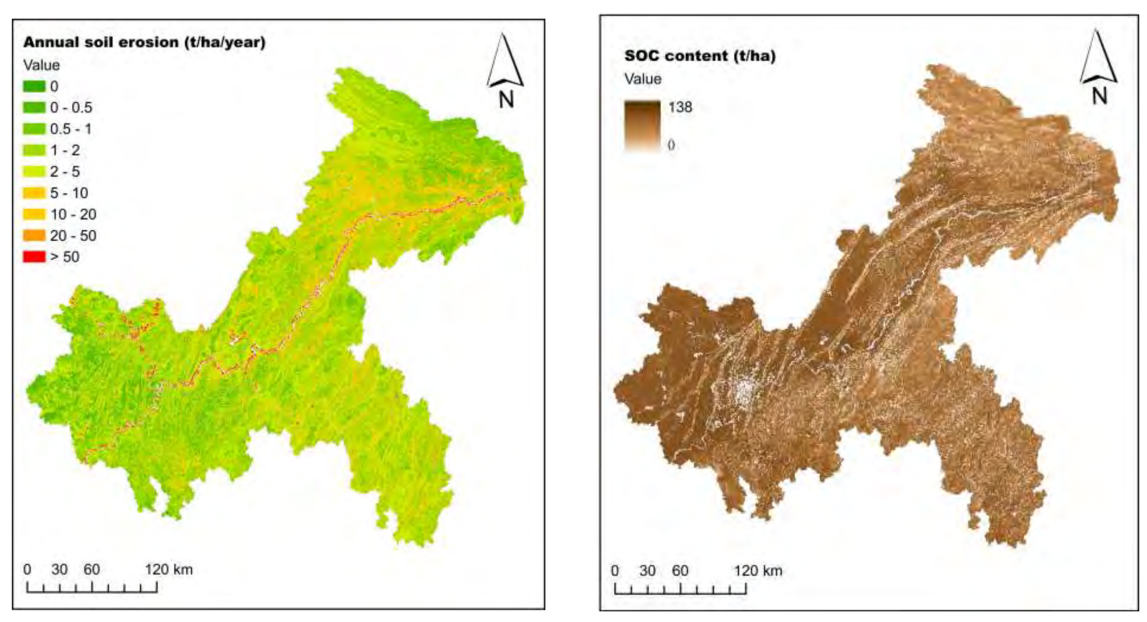

Fig. 5 Map of estimated soil erosion and SOC in Chongqing province in Yangtze River Basin.

Land use	Total (t yr^{-1})	Proportion (%)	Mean (t ha^{-1} yr^{-1})
Artificial	17413	1.20	2.36
Arable Land	1161951	80.29	8.13
Grassland	2235	0.15	4.10
Broadleaf forest	173102	11.96	1.43
Coniferous Forest	68809	4.75	1.38
Scrub	23638	1.63	4.09

Table. 1 The soil erosion characteristics of different land uses in Chongqing province.

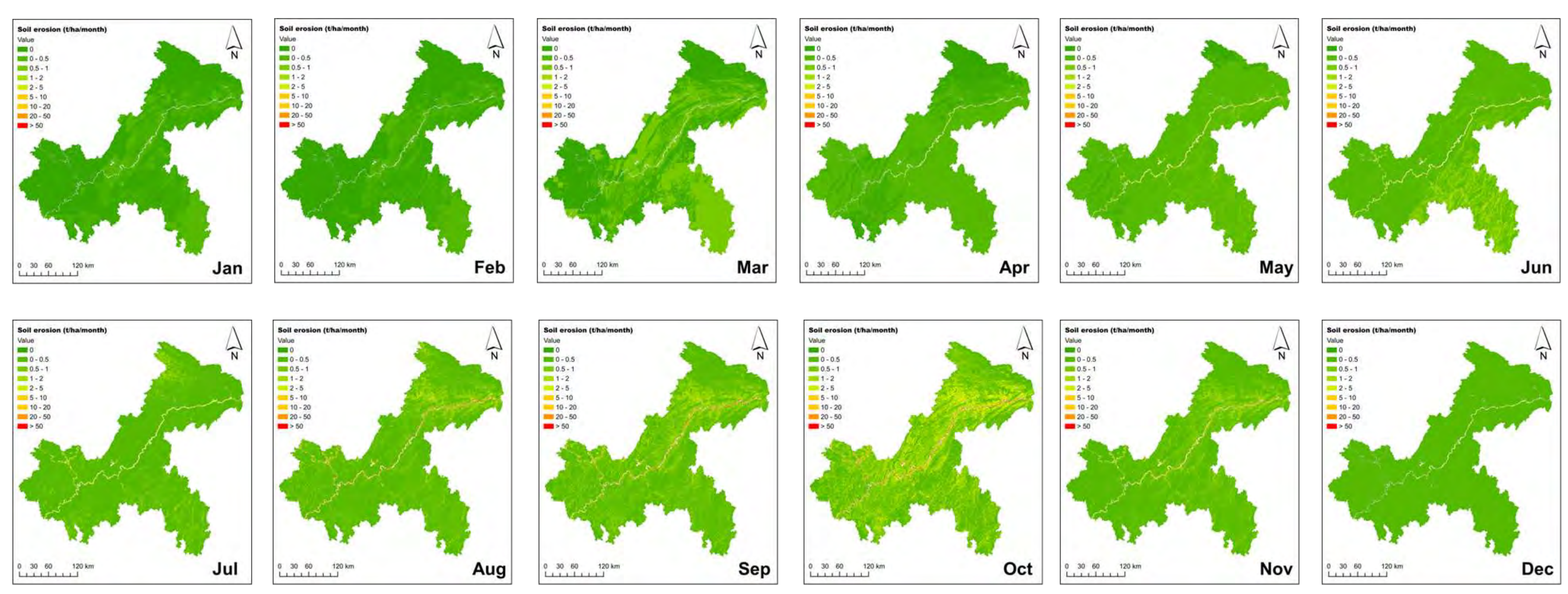

Fig. 6 Map of estimated monthly soil erosion in Chongqing province in Yangtze River Basin.

Conclusions

The average annual soil erosion in Chongqing is 4.4 (t/ha/year).
Soil erosion was the largest in Northeast, followed by Southeast and the smallest in West.
Soil erosion in Chongqing is concentrated between June and October.
Cropland and forests are the main sources of soil erosion in Chongqing, accounting for 80% and 16% of this region respectively.

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Modelling of antibiotics and antimicrobial resistant bacteria in rivers in China

PhD candidate: Songtao Mei
CAU supervisor: Kai Wang
WUR supervisors: Nynke Hofstra, Carolien Kroeze
External supervisor: Heike Schmitt (RIVM)

Background

Antibiotics in the environment pose a potential risk to ecosystems and human health. Under the selection pressure of antibiotics, pathogens can develop antimicrobial resistance (AMR), which makes the treatment of antibiotics ineffective. If AMR is not curbed, there will be 10 million death worldwide because of it in 2050. Due to the difficulty of monitoring, there is a lack of data of antibiotics, pathogen and AMR in rivers in China. For this situation, modelling is a powerful tool to obtain a comprehensive understanding of the sources, environmental fate and transportation of these pollutants in surface waters in China to support a sustainable management.

Research objective

The objective of this research is to contribute to a better understanding of the sources and the behavior of antibiotics, *E. coli* and AMR *E. coli* in rivers in China, and to design intervention policies and technologies for a sustainable management of antibiotics, *E. coli* and AMR *E. coli* in China by modelling.

Research question

RQ1: What are the current concentrations of *Escherichia coli (E. coli)* in rivers in China?

RQ2: What are the current concentrations of antibiotics in rivers in China?

RQ3: How to simulate the current concentrations of antimicrobial resistant *E. coli* in rivers in China by modelling?

RQ4: What potential intervention policies and technologies can be designed to reduce the concentrations of antibiotics, *E. coli* and antimicrobial resistant *E. coli* in rivers in China?

Research framework

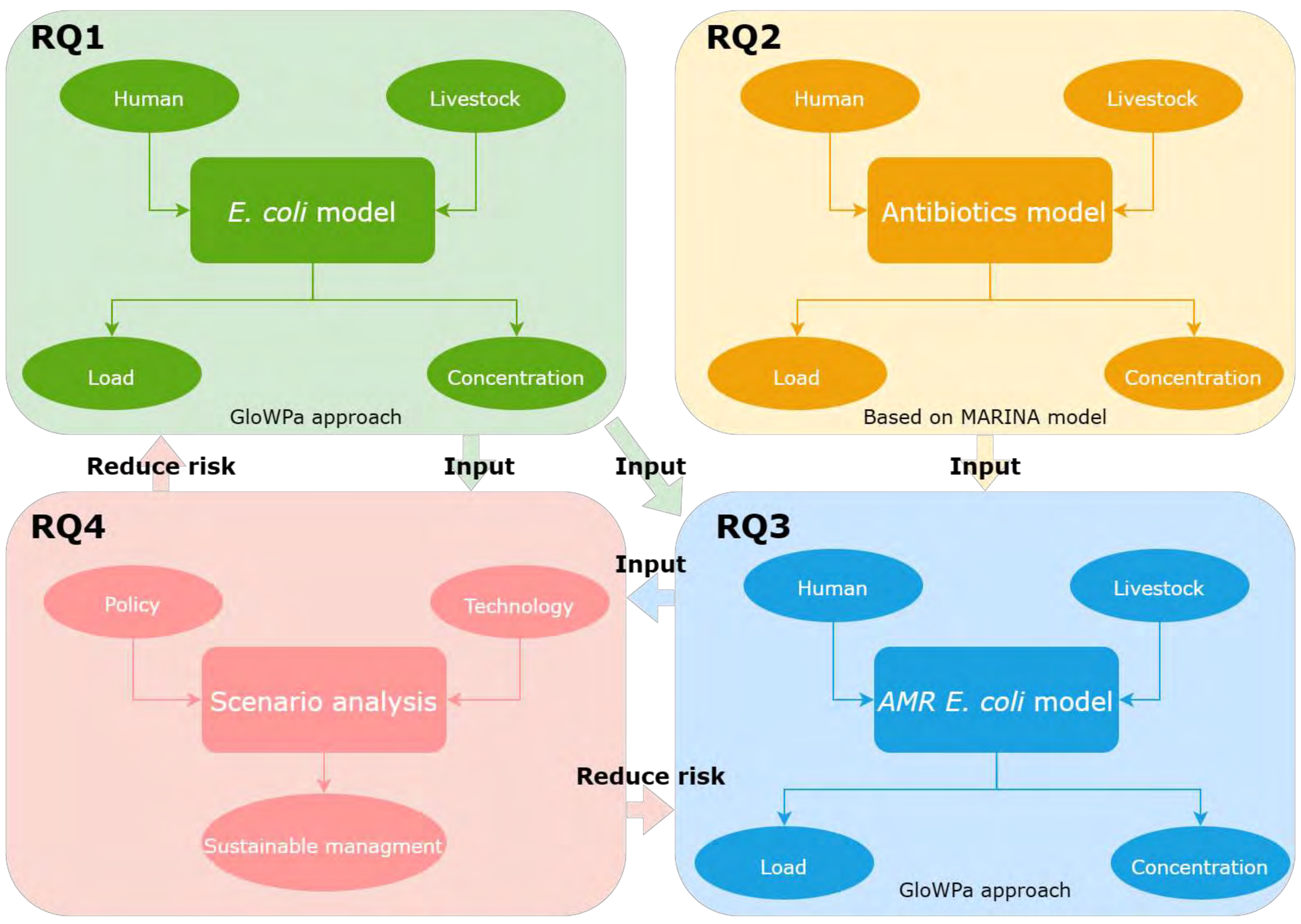

Figure 1 Research framework of the PhD project

Preliminary findings for RQ1: *E. coli* load to land from animal manure in China

- An *E. coli* model is developed based on GloPWa model to calculate *E. coli* load to land from animal manure in China
- *E. coli* load to land from animal manure in China in 2020 is 1.10×20 cells
- The contribution of *E. coli* load from Inner Mongolia, Shandong and Sichuan are the highest

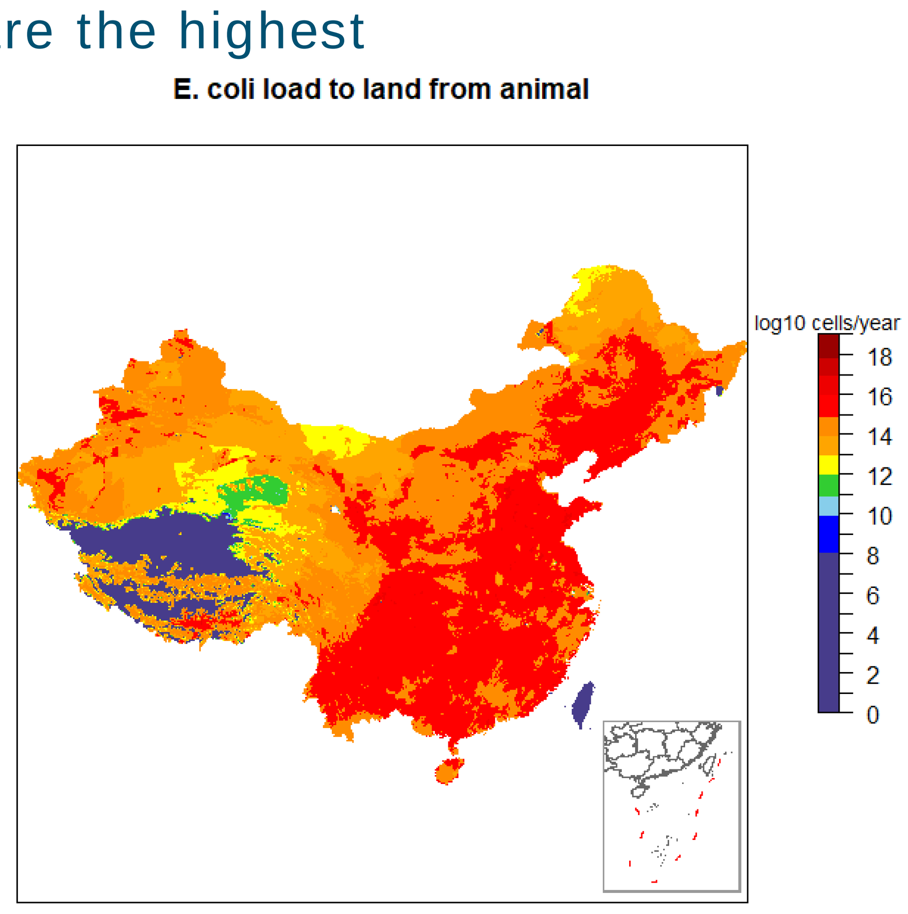

Figure 2 *E. coli* load to land from animal manure in China in 2020

- The contribution of *E. coli* load from pig, cattle and layer are the highest

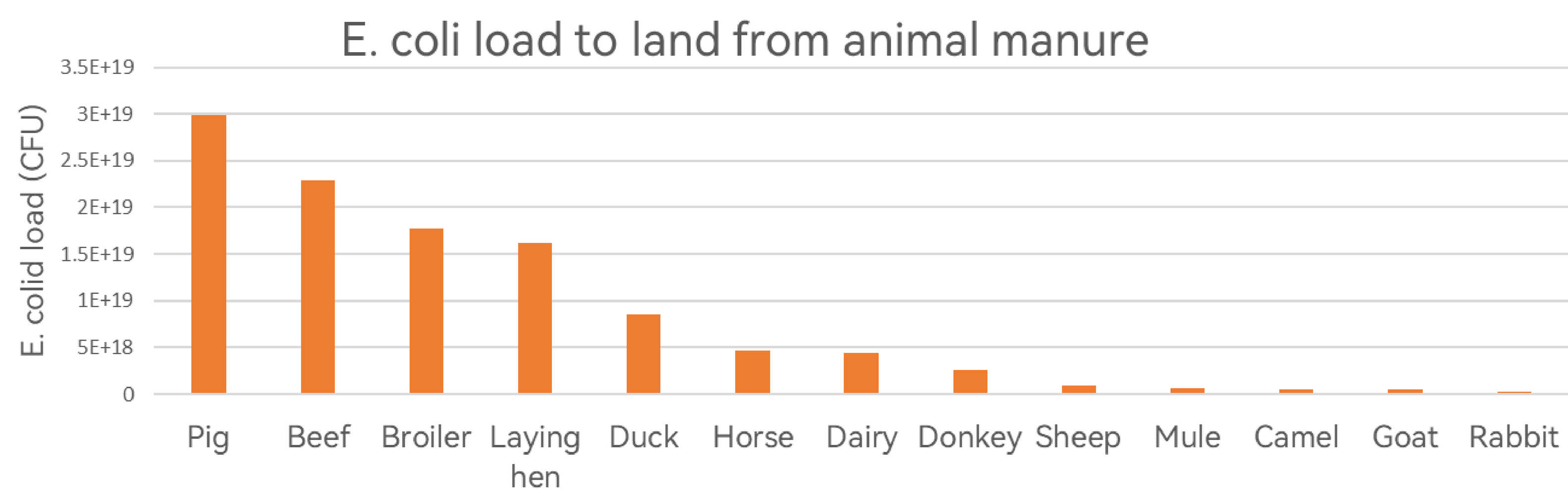

Figure 3 *E. coli* load to land from different animals

- Small farms contribute the most, while *E. coli* load from industrial farms is the lowest

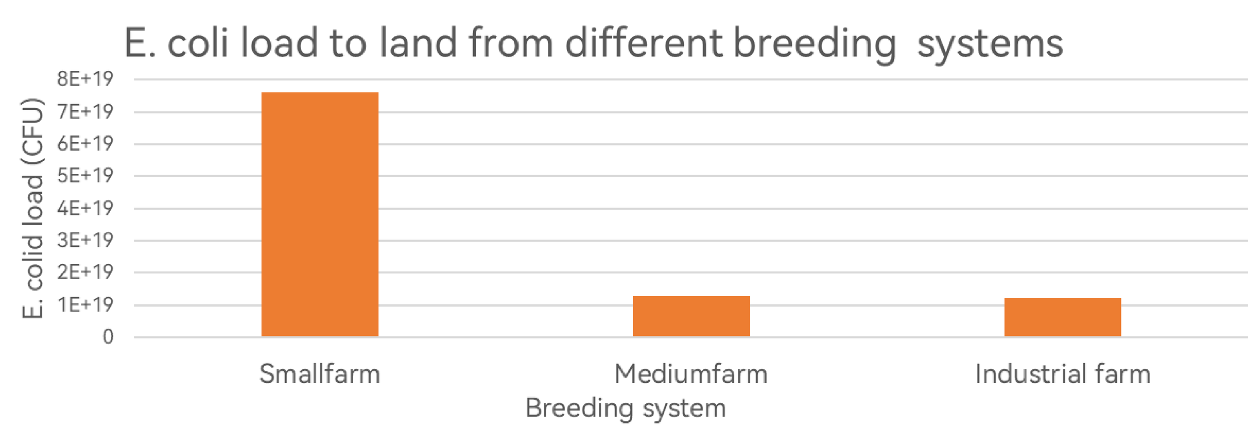

Figure 4 *E. coli* load to land from different breeding systems

Conclusions

- The total *E. coli* load is large (1.10×20 cells) and should be considered in risk studies
- Improvement of animal breeding systems and manure treatment is important to reduce *E. coli* emission from animal

Acknowledgements

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

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Plastic fate, risk and potential control in agricultural soil

Hanyue Zhang, Coen Ritsema, Violette Geissen, Xiaomei Yang, Xuejun Liu, Kai Wang

Background

Agricultural plastic film (APF) improves crop productivity, but plastic residues in soil threats soil quality and surrounding environment. With the weathering and intensive farming practices, plastic residues are prone to be broken and fragmented into small particles, such as microplastics (MPs, <5 mm) that impact soil properties, plant growth and surroundings (on-site/off-site) if transported. However, the knowledge of plastic fragmentation and MPs' transport in soil has not been well-addressed.

Objectives

This research will focus on fragmentation processes of plastic film and MPs' transport both in field observation and laboratory simulation. Based on the findings and scenarios analysis, recommendations will be proposed to deal with (micro) plastic pollution in agricultural soil.

Main Research Question

The main research question is:

How are microplastics generated from plastic film, as well as their environmental fate and transport in agricultural soil?

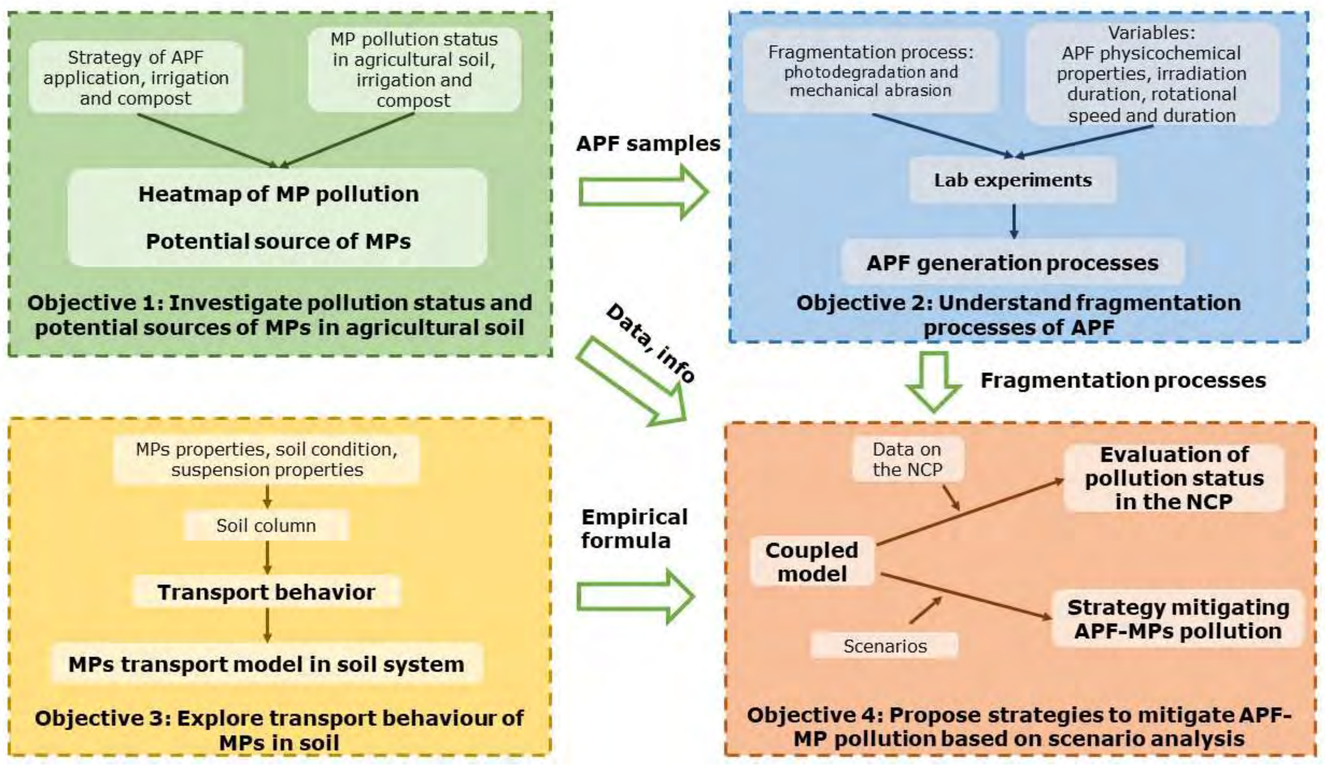

Figure 1. The framework of this project

Methods

Quzhou county, located in the Hebei province, was selected as the study area to explore the MP pollution in agricultural soil. We collected soil samples from different cropping systems, irrigation samples, and compost samples to analyze the abundance, size distribution, shape, and chemical composition of MPs. Macroplastics (> 5 mm) in the farmland were also collected to identify the level of plastic residue pollution in farmland. Meanwhile, a survey was conducted to investigate local APF application strategies.

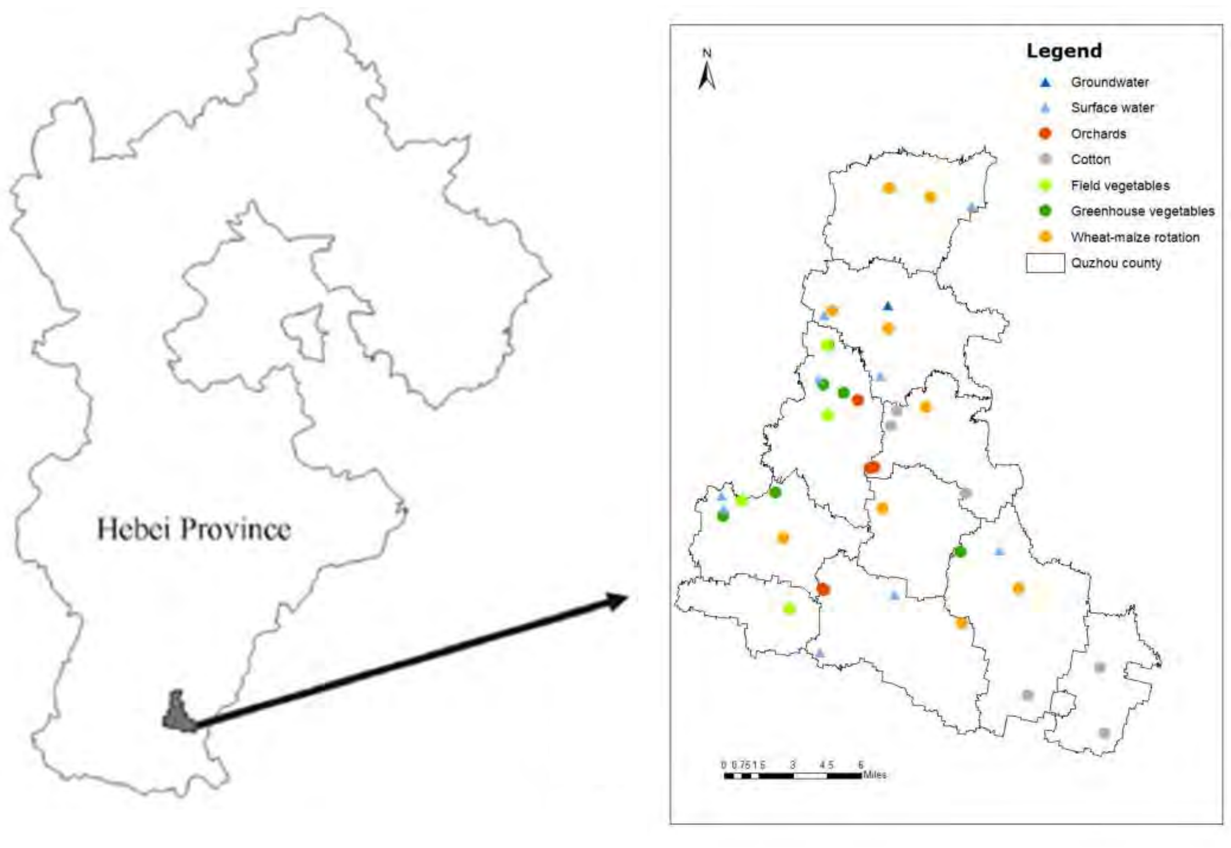

Figure 2. Geographic locations and sampling sites of agricultural soil, surface water, groundwater and compost in Quzhou county.

First results

- The mass of macroplastic debris in 0–30 cm soil varied among different cropping systems. Results indicated that the macroplastic mass in Quzhou County was 0–111,25 kg/ha.

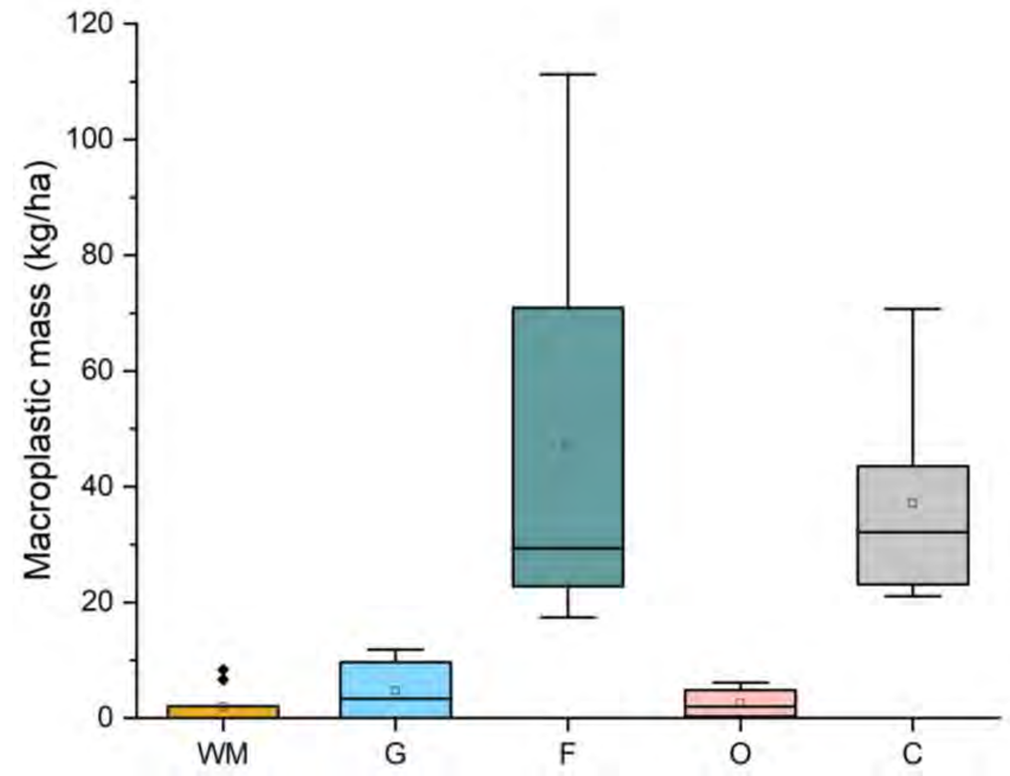

Figure 3. Macroplastic mass in Quzhou county. WM: wheat-maize rotation; G: greenhouse vegetables; F: field vegetables; O: orchards; C: cotton.

- The average number of MPs in compost samples and cotton farmland was 2712,83 ± 1879.51 and 12659,89 ± 9175,64 items/kg, respectively.

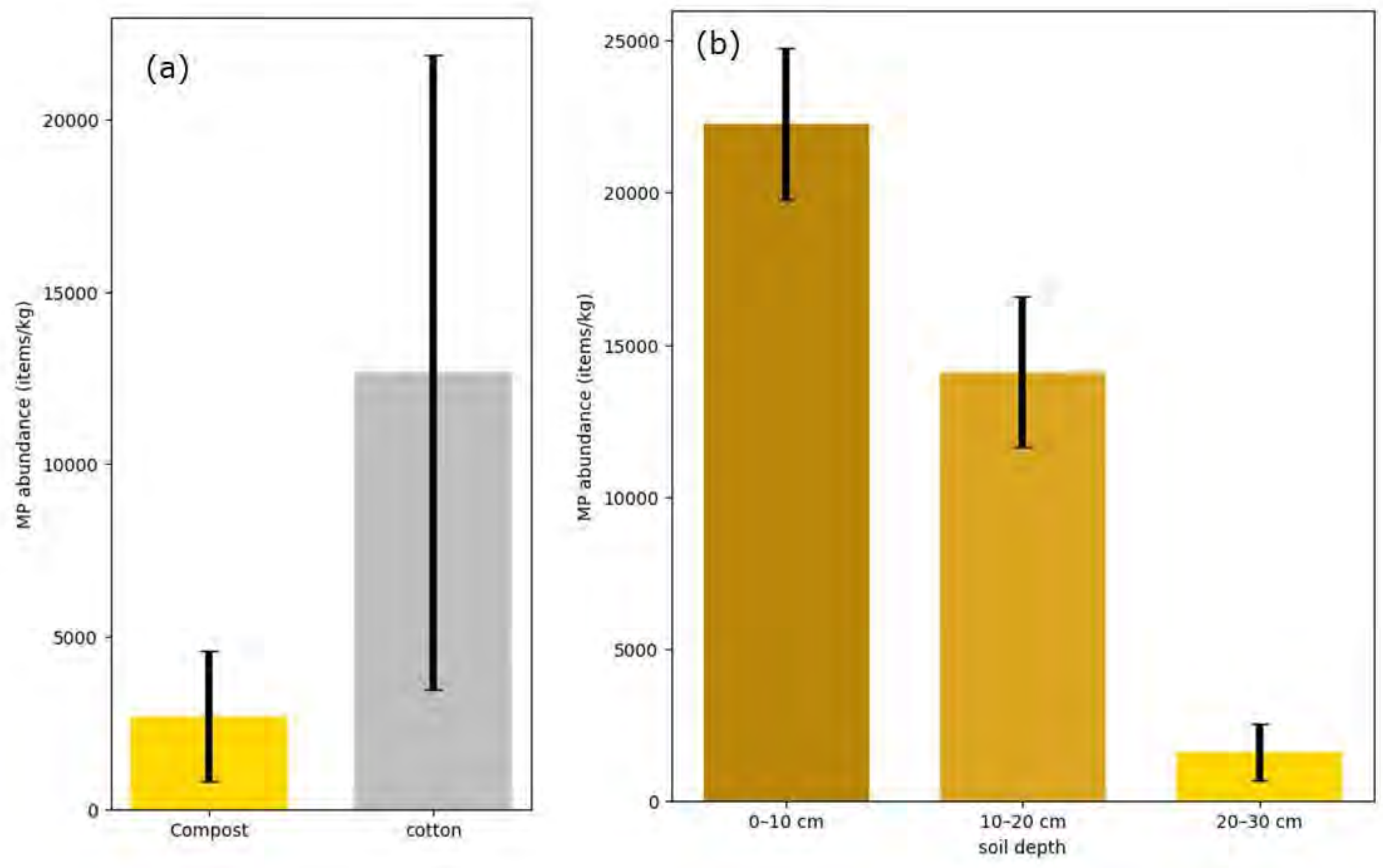

Figure 4. MP abundance in compost and partial soil samples. (a): MP abundance in compost samples and soil samples from cotton farmland. (b): MP abundance of three soil layers in cotton farmland.

Preliminary Findings and Next Steps

- Combined the survey with sampling results, we discovered that Quzhou county's farmlands are strongly suffering from plastic pollution attributing to low recovery rate of plastic after harvesting.
- The number of MPs in cotton farmland decreased with the increasing soil depth.
- We will analyze the MPs' physiochemical characteristics in soil and irrigation samples.
- Based on the amount of APF used, recovery rate, and MP abundance, we will try to figure out the correlations between APF application and MPs' abundance.
- The further work will also include experiments about the rest objectives.

Acknowledgements

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

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Sustainable management of pesticides for green eco-environment: Based on the wind erosion model

Mingyu Zhao, Kai Wang, Daniel Figueiredo, Anke Huss, 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.

Research questions

1. What is the current atmospheric pesticides pollution in Quzhou county, the NCP?
2. How do the pesticides transport from soil to atmosphere in the NCP?
3. How is pesticide exposure related to human health in the NCP?
4. What potential targeted policies can be designed to reduce the input of pesticides into the agricultural system in China?

Current Work

- Passive/active air sampling across Quzhou county

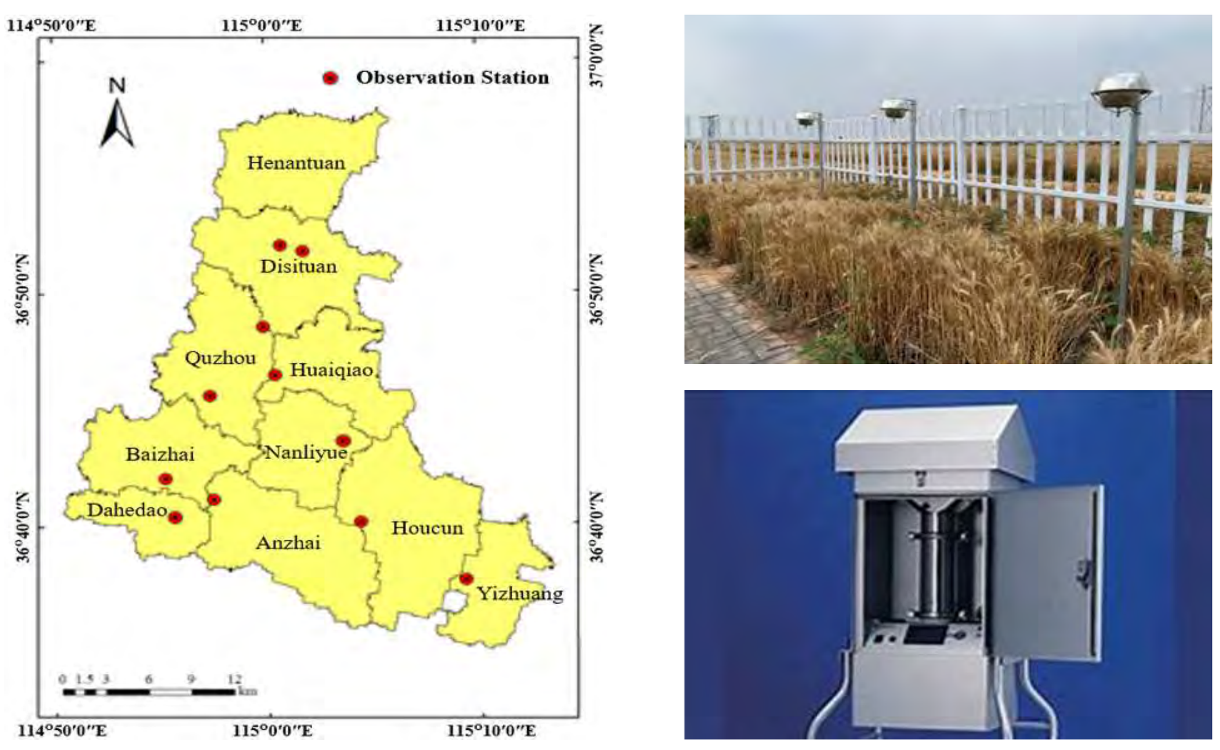

Fig. 1 Locations of sampling sites and the passive/active air sampler

- Modified sample preparation procedure and instrumental analysis method

> Ultrasonic-assisted extraction
> Rotary evaporation
> Solid phase purification

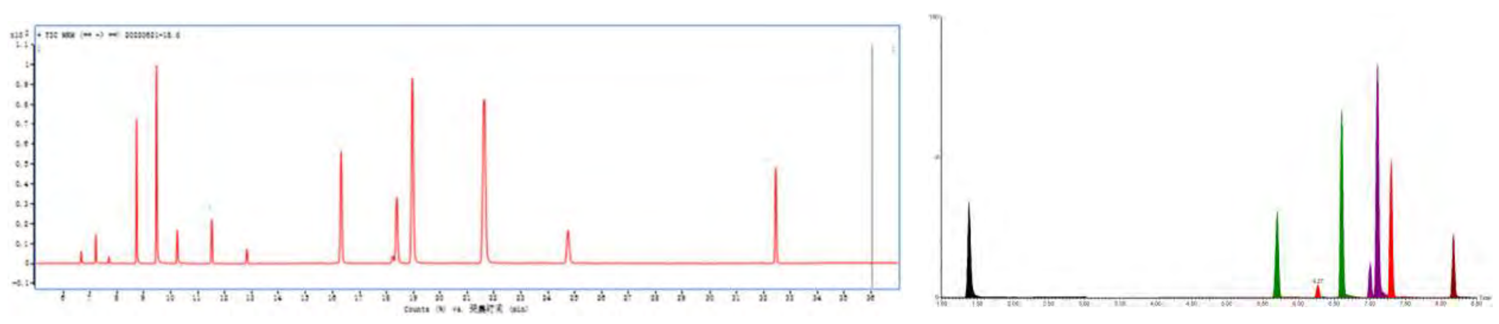

Fig. 2 Profile of the quantitative analysis method

- Development of the wind erosion model

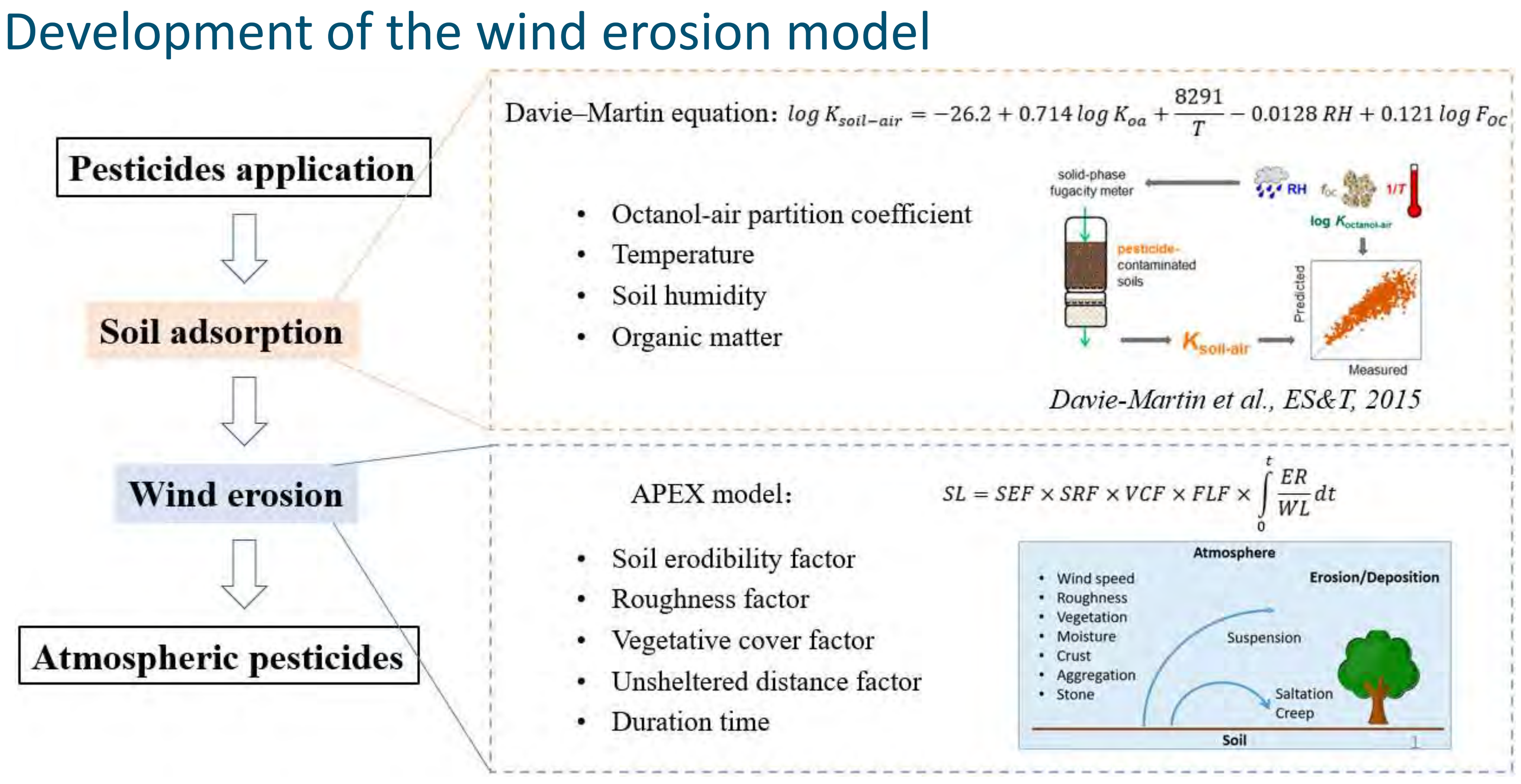

Fig. 3 Framework of wind erosion model for atmospheric pesticides

Results

- Thirty-two pesticides were detected in the ambient air, all air samples contained at least one pesticide residue
- Chlorpyrifos (100%) and carbendazim (97.5%) were the pesticides the most frequently quantified in Quzhou county

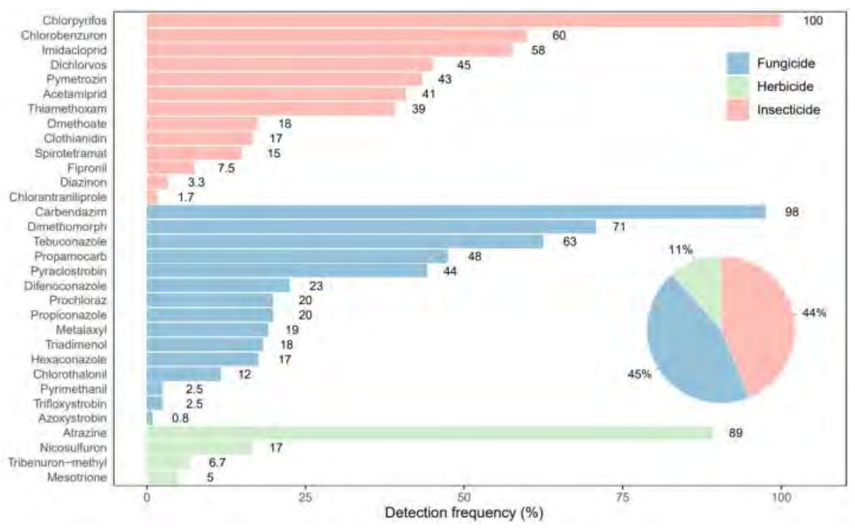

Fig. 4 Detection frequency (%) and proportion (%) of target pesticides

- The concentration of total pesticides in a certain sampling period (months) was in the range of 0.59–25.95 pg m^{-3}
- The pesticide concentrations in the ambient air ranged from 4.96 to 9.56 pg m^{-3} at grain crop sites, from 9.08 to 11.47 pg m^{-3} at economic crop sites, and 3.81 pg m^{-3} at greenhouse site

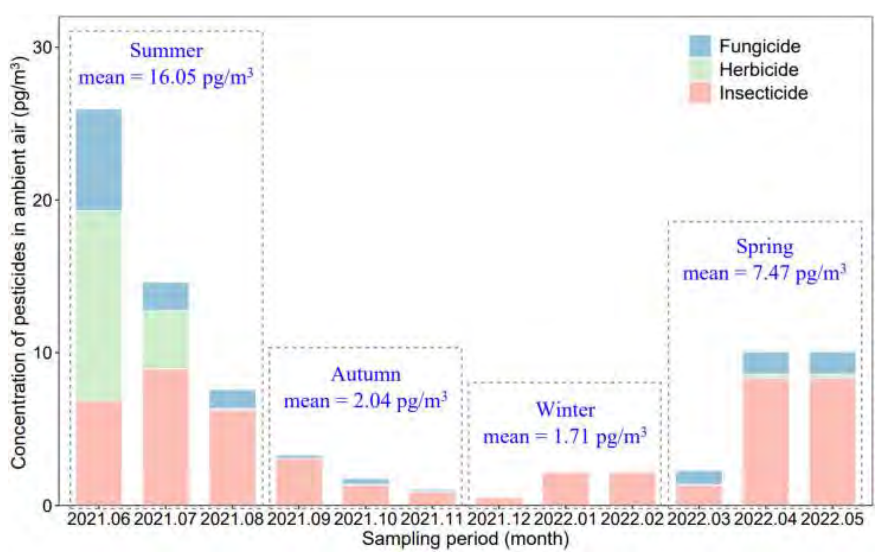

Fig. 5 Total concentration of pesticides in ambient air in different months

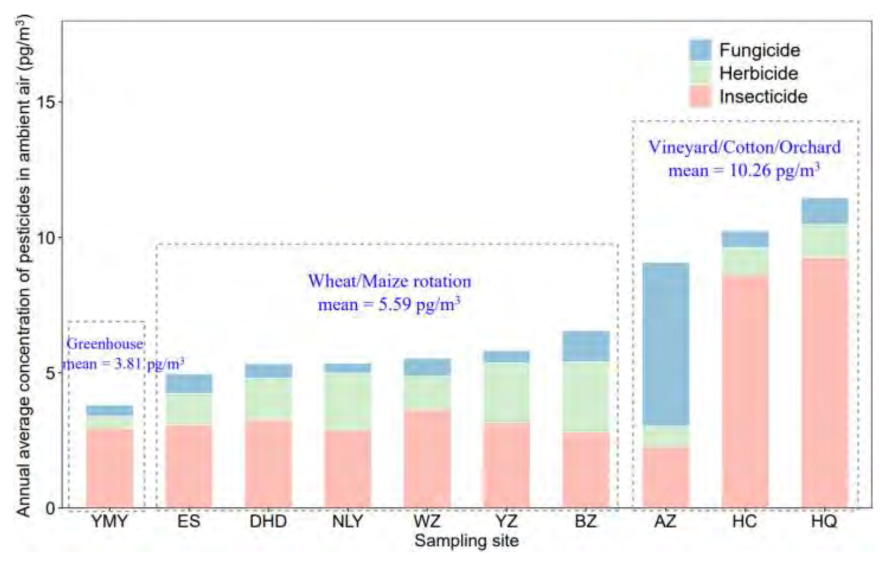

Fig. 6 The average concentration of pesticides in ambient air at different sampling sites

- The hazard index for atmospheric pesticides were less than 1, ranging from 7.23×10^{-4} to 1.50×10^{-2}

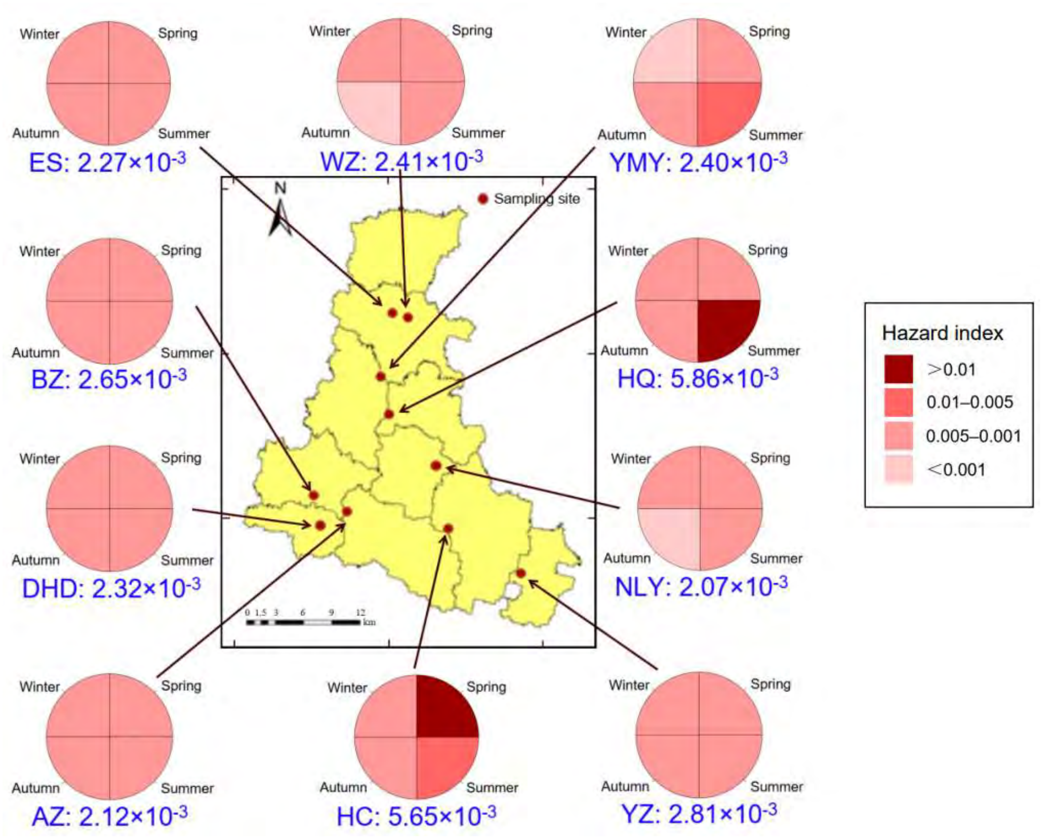

Fig. 7 Hazard index of atmospheric pesticides at different sampling sites

Conclusions

- Higher concentrations were generally observed in summer and reached the bottom in winter
- The highest atmospheric pesticide concentrations were detected at economic crop sites
- Current atmospheric pesticide concentrations would be relatively safe for residents in Quzhou county, the NCP

Acknowledgements

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

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Increasing soil quality in China's cultivated land during the past 40 years

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Supervisors : Dr. Jie Zhang(张杰 副教授), Prof. Fusuo Zhang（张福锁 教授), 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. As the world's most populous country, China is under enormous pressure with food security. Improvement of the agricultural production of cultivated land is a fundamental element in achieving food security and sustainable development. Since the 1980s, China has launched several programs to improve the soil quality of cultivated land, thereby increasing agricultural production, such as the Comprehensive Agricultural Development program, Land Consolidation Program and the Cultivated Land Protection and Quality Improvement Program. Given the great efforts and actions of China to improve the soil quality of cultivated land, it's necessary to investigate the temporal and spatial changes and characters of soil quality in China's cultivated land.

Objectives

- Evaluate the national soil quality of cultivated land;
- Develop a soil quality evaluation model based on environmental variables and machine learning approach;
- Analyze the spatiotemporal changes and characteristics of the soil quality of Chinese cultivated land over the past 40 years.

Framework

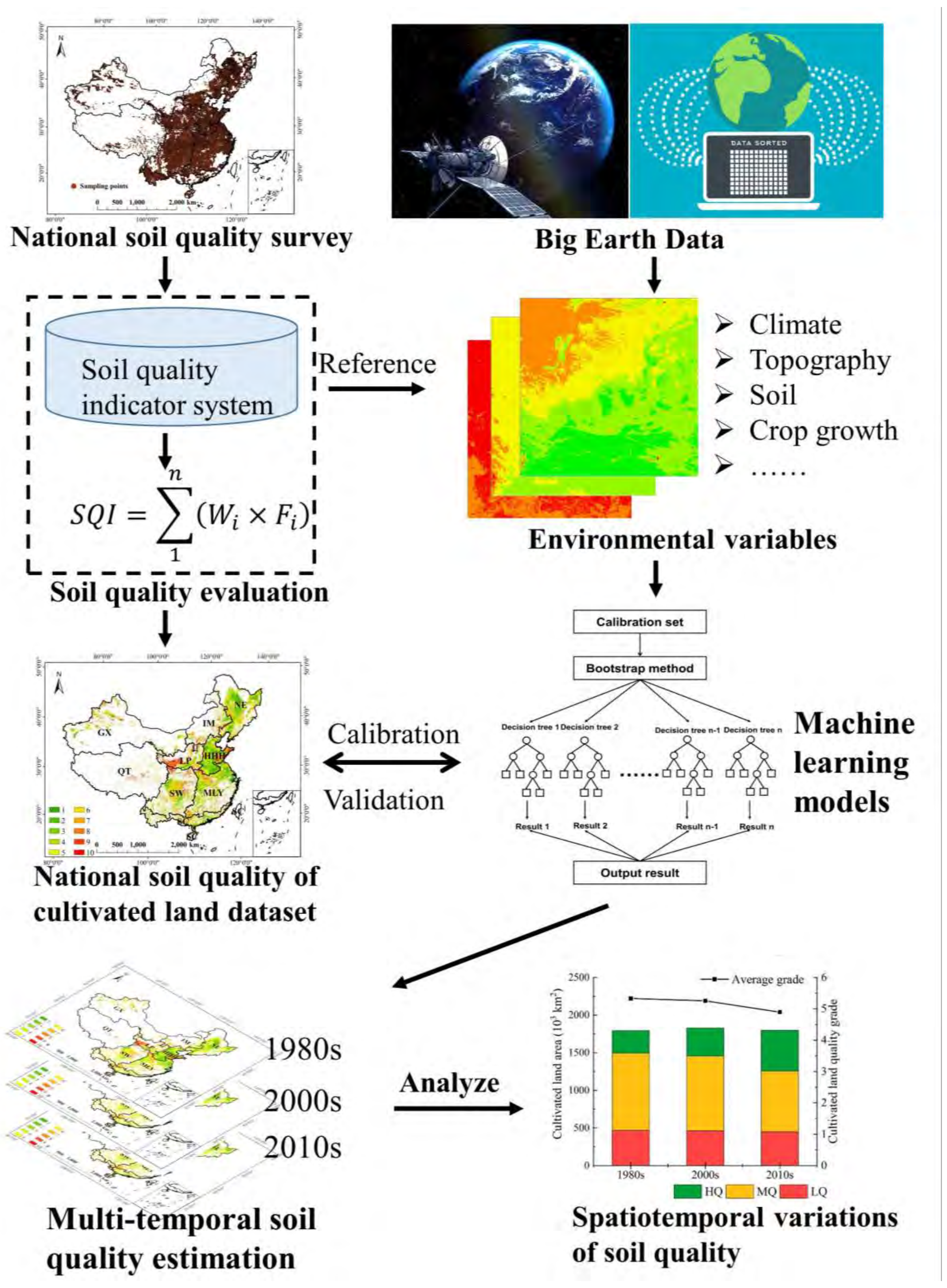

Fig. 1. Methodological framework for analyzing spatiotemporal variations of soil quality.

Result

National soil quality of cultivated land evaluation

The soil quality of cultivated land was evaluated based on China's national standard of *Cultivated land quality grade* (GB/T 33469-2016). The high quality cultivated land mainly distributed in plain agricultural areas, such as Northeast Plain, Huang-Huai-Hai Plain, Middle and Lower Yangtze River Plain.

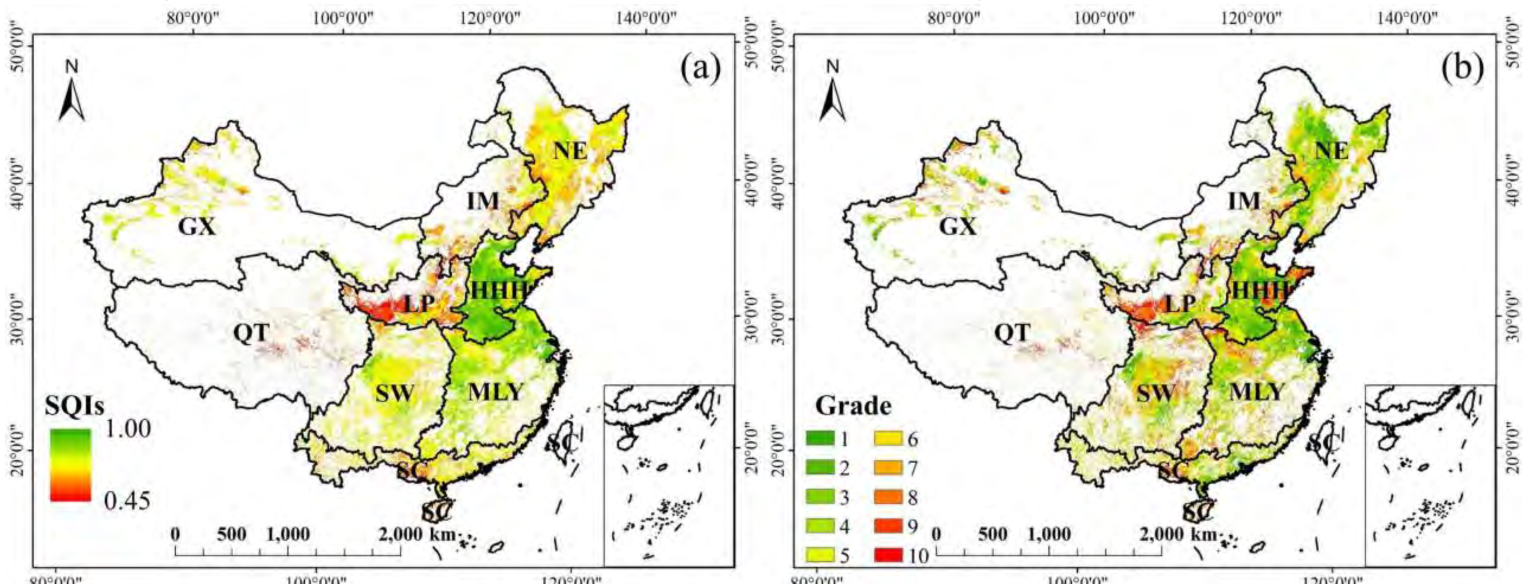

Fig. 2. China's soil quality of cultivated land dataset (a) SQI, (b) Soil quality grade.

Spatiotemporal variations of soil quality of cultivated land

Based on the machine learning model, the soil quality in 1980s, the 2000s, and the 2010s were estimated. In the past 40 years, the average soil quality grade of cultivated land in China has improved by 0.44 grades (8.26%). For spatial difference, the HHH has the biggest increase of high quality cultivated land during the past 40 years.

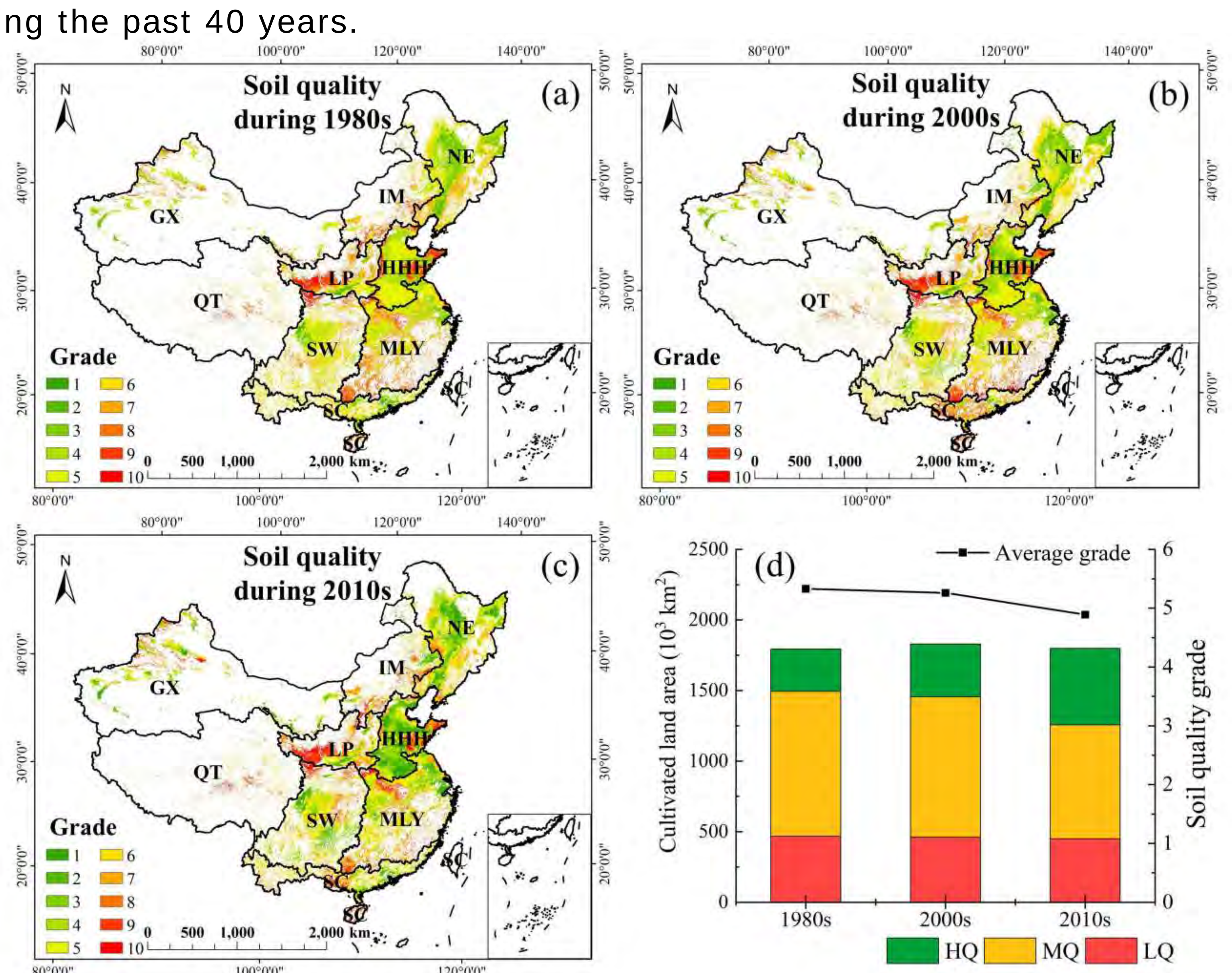

Fig. 3. Spatiotemporal variations of soil quality grade of cultivated land across China: (a) the 1980s, (a) the 2000s, (c) the 2010s, and (d) temporal variations of soil quality grade of cultivated land.

Summary

This study monitored long-term temporal and spatial changes on soil quality of cultivated land, which is valuable to developing national agricultural policies to improve agricultural production productivity and achieve sustainable development.

Publication

白雪源，张杰，崔振岭，王广进，吕玉娇，张福锁．中低产田评价指标与主要方法研究进展[J]. 土壤学报，2022，DOI：10.11766/trxb202204070045.

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

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RhizoSMASH:
a computational tool to detect catabolic gene clusters related to rhizosphere colonization of rhizobacteria

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3. Microbial Ecology Department, NIOO-KNAW, Wageningen, The Netherlands
4. College of Resources and Environmental Sciences, China Agricultural University, Beijing, China

Background

- Application of plant growth-promoting rhizobacteria as sustainable biofertilizer and biocontrol agents requires understanding of rhizosphere colonization of rhizobacteria
- The catabolic capability to utilize root exudate metabolites largely determines the colonization of rhizobacteria
- However, there is no specified computational tool to analyze the catabolism and rhizosphere colonization capability of rhizobacteria.

Here we introduce rhizoSMASH, a designated tool to detect catabolic gene clusters for the degradation of root exudates. We also show a benchmark result for the current development-stage version of rhizoSMASH.

Objectives

- Develop rhizoSMASH and optimize detection rules profile hidden Markov models to detect catabolic gene clusters that degrade root exudate metabolites
- Benchmark rhizoSMASH with published genomes experimentally labeled with rhizosphere colonization capability
- Demonstrate that catabolic gene clusters detected by rhizoSMASH are indicators for rhizosphere colonization

Methods

- Search literatures for known catabolic gene clusters in rhizobacteria that degrades metabolites in root exudates
- Customize profile hidden Markov models (pHMMs) for genes only assigned with broad domain families and optimize detection rules (Fig. 1)
  - Download protein sequences that share a similar genome context from KEGG
  - Make multiple alignment with **muscle** and build pHMMs with **hmmbuild**
  - Assign initial bit-score cutoff with reference to the **hmmsearch** result
  - Detect catabolic gene clusters in a tuning genome dataset with **rhizoSMASH** and collect genome context of cluster regions
  - Align and visualize gene clusters using **clinker**

Fig 1. Optimization workflow of detection rules

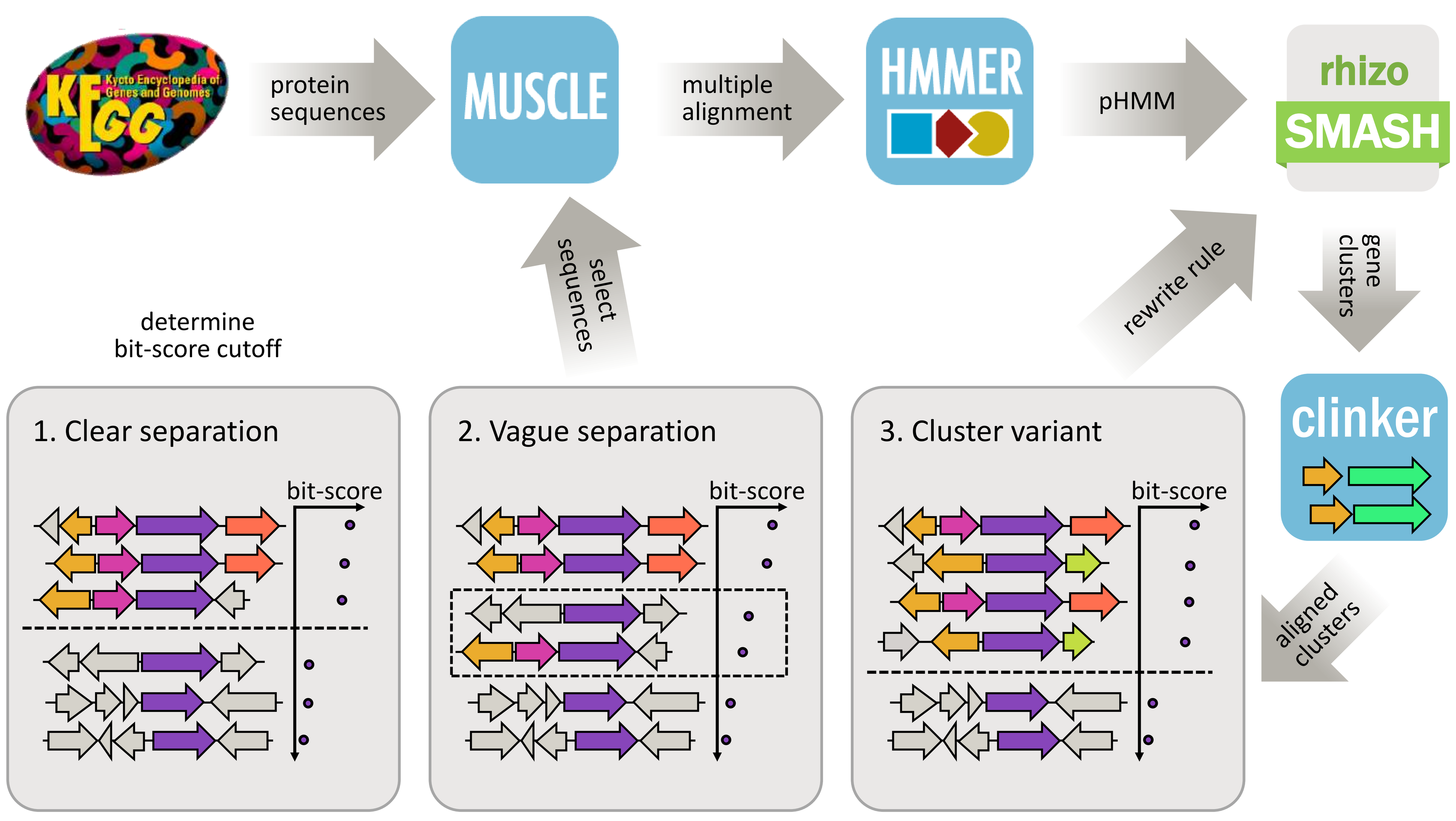
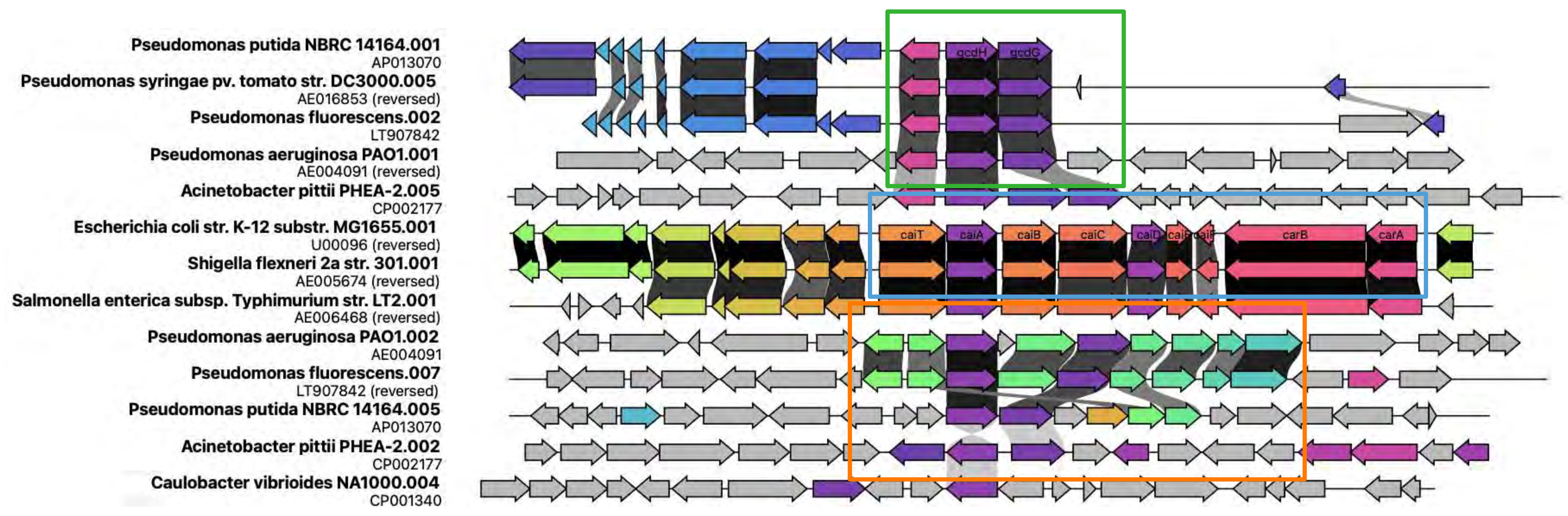


Fig 2. An intermediate clinker output (CoA-dependent glutarate degradation gene cluster)



- Manually revise genome context and determine changes to update
  1. Bit-score separates true hits and false hits: set cutoff to the median
  2. Bit-score cannot separate true and false hits: build pHMM from true hits
  3. Mixture of gene organization in hit clusters: add and redesign detection rules

Fig. 2 shows an intermediate output from clinker for the glutarate_2 cluster. Green box: true hits; blue: unexpected hits of a carnitine cluster; orange: false hits

Results

Our development-stage rhizoSMASH contains 12 detection rules that covers categories of sugar, sugar derivative, organic acid, amino acid and secondary metabolites. Benchmark data containing 37 sequenced soil bacterial genome and their rhizosphere colonization score were obtained from Zhalnina, K. *et al* (2018).

Detected catabolic gene clusters showed a tendency to appear in rhizosphere-colonizers (Fig.3). Some detection rules did not match any result in the benchmark dataset, although they appeared in our tuning dataset.

Fig 3. Benchmark: presence of catabolic gene clusters and rhizosphere colonization capability

Conclusions

The benchmark on our development-stage rhizoSMASH has shown a tendency to separate rhizosphere-colonizers from non-colonizers. Our result also show that salicylic and nicotinic acid degradation gene clusters are more often present in rhizosphere colonizers, in accordance with the conclusions in the original publication. In future development, rhizoSMASH will carry more detection rules and will be calibrated with larger tuning dataset.

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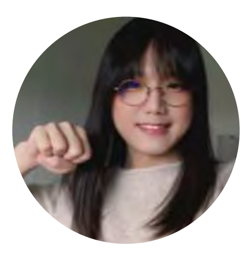
Contact



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Acknowledgment

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Unravel the impact of domestication on foxtail millet microbiome composition and functions under biotic stress

PhD Candidate: Mingxue Sun

Supervisors: Chunxu Song (CAU); Marnix Medema; Liesje Mommer (WUR); Jos Raaijmakers (NIOO-KNAW; Leiden University)

Background

Foxtail millet (*S. italica*) domesticated from the wild species green foxtail (*S. viridis*) more than 16,000 years ago in northern China (Andrew Doust and Diao, 2017). China's foxtail millet production accounts for 80% of the world's production. They are particularly important due to their nutritional value and potential health benefits, such as the prevention of diabetes mellitus and cancer (Saleh et al., 2013). Foliar pathogen *Pyricularia grisea* caused up to 80% or even total loss to the yield of foxtail millet and became un urgent production issue in China. Plant domestication has a significant impact on microbiome composition and functions. The “ ” during domestication are hypothesized contribute to reinstate the beneficial plant-microbe associations to enhance crop productivity. However, little is known for the impact of host domestication and biotic stress on microbiome assembly of *S. viridis* and *S. italica*. Therefore, foxtail millet is used here as the research object to link the changes of root exudations to the rhizosphere microbiome functions upon pathogen invasion, thereby, to serve the green development of agriculture.

References :

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[2] Saleh Mansoor N, Bussel James B, Cheng Gregory, et al., Safety and efficacy of eltrombopag for treatment of chronic immune thrombocytopenia: results of the long-term. Blood. 2013, 121(3):537-45

Objectives

I. Phenotyping different foxtail millet cultivars through domestication upon foliar pathogen *Pyricularia grisea* infection to screen rhizosphere microbiome dependent pathogen resistant cultivars ;

II. Decipher the molecular and chemical cross-talk in foxtail millet-microbiome communication upon pathogen invasion;

III. Unravel the underlying molecular mechanisms of microbiome-dependent protection

Framework

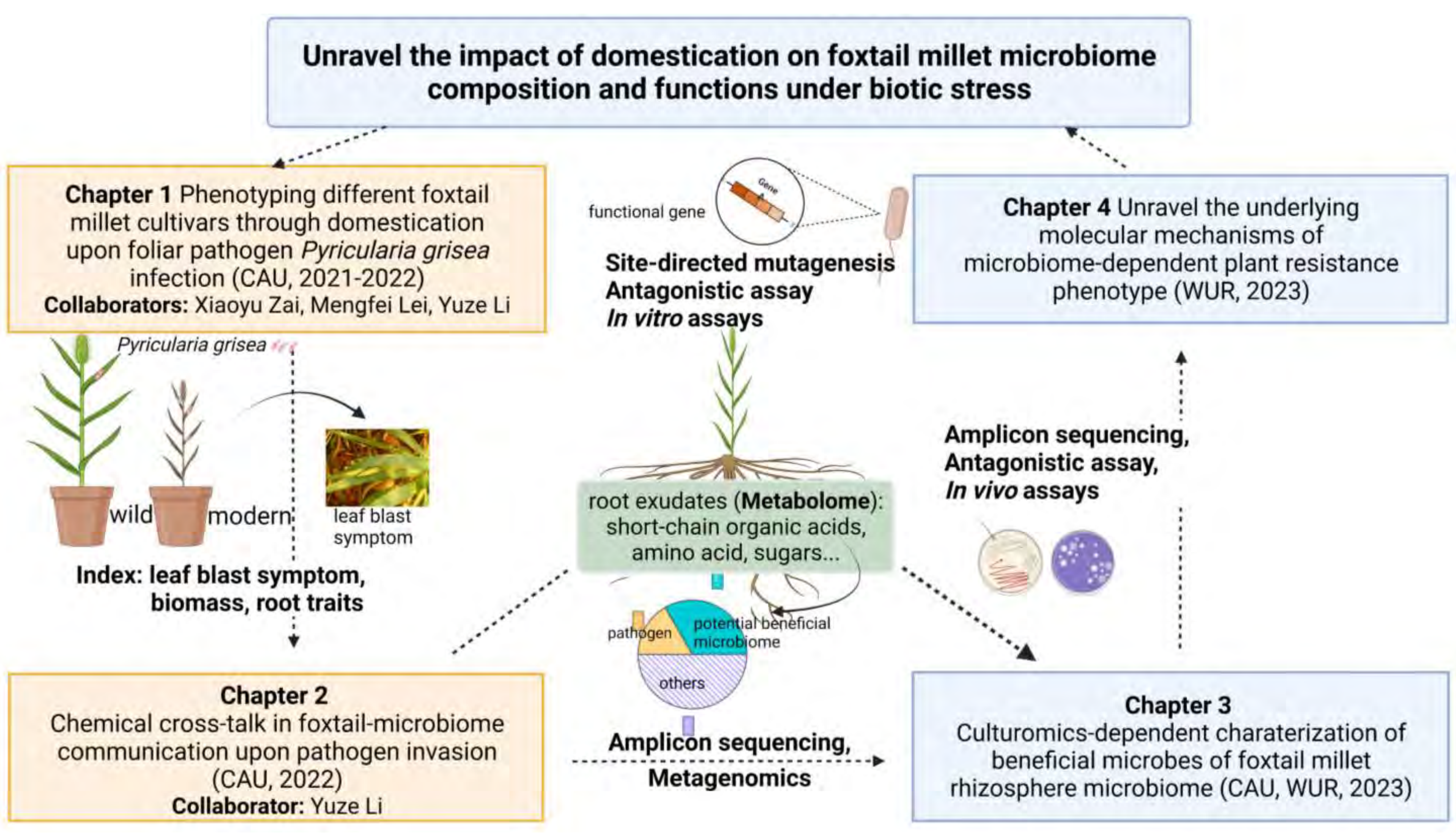

Fig.1 Framework of PhD project unravel the impact of domestication on foxtail millet microbiome composition and functions under biotic stress.

Materials and Methods

(1) Phenotyping experiment: 20 different foxtail millet cultivars will be screened for the resistance levels upon *Pyricularia grisea* invasion according to the severity of their leave spots. qPCR will be used to determine the biomass of the pathogen. Meanwhile, the fresh weight and dry weight of aboveground and underground root of foxtail millet will be measured;

(2) High-throughput sequencing: The rhizosphere microbiome samples will be sent for 16S rRNA gene/ITS high-throughput sequencing to determine microbial diversity and composition;

(3) Metagenomics: Metagenomic analysis will be performed on selected samples to analyze the functional potential of differentially recruited microbes;

(4) Metabolome: Root exudates will be collected and subjected to LC-MS/MS analysis, and to identify specific cues for attraction/activation of the beneficial microbiome;

(5) Culturomics: Beneficial microbes will be isolated from rhizosphere soil and will be characterized. Targeted mutagenesis will be conducted and *in vivo* and *in vitro* assays will be carried out for functional validations.

Experimental design

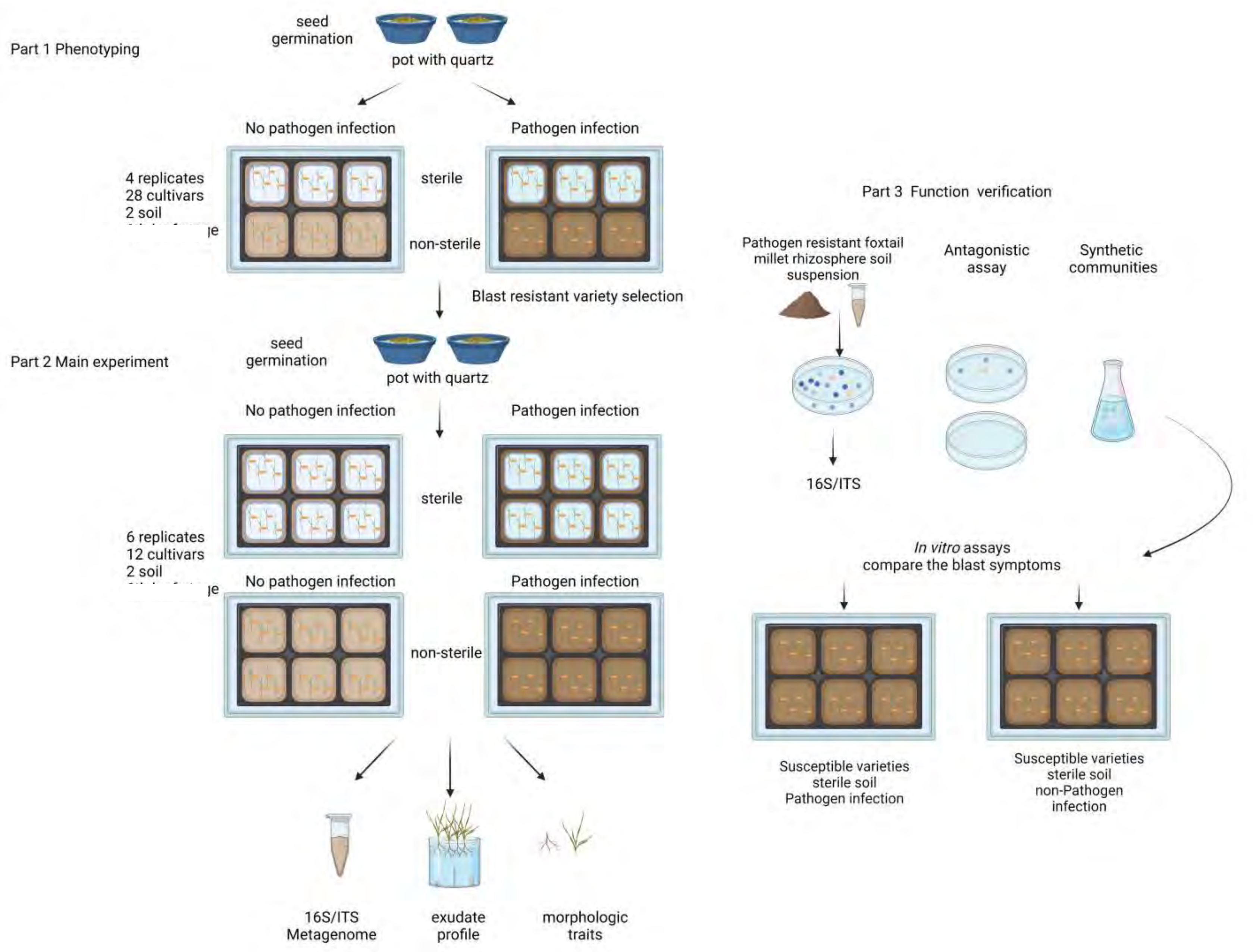

Fig.2 Experimental design of the current PhD project

Results

- 20 wild to modern cultivars were phenotypically screened based on the relative infected area of plants leaves between agricultural soil and sterile soil to determine their rhizosphere microbiome dependency.
- The relative infected area of Q23 (wild), L40 (landrace), C31(modern type) were significantly higher in sterile soil than agricultural soil (Fig.3, Fig.4), which demonstrates the resistance of these three cultivars was dependent on the rhizosphere microbiome.

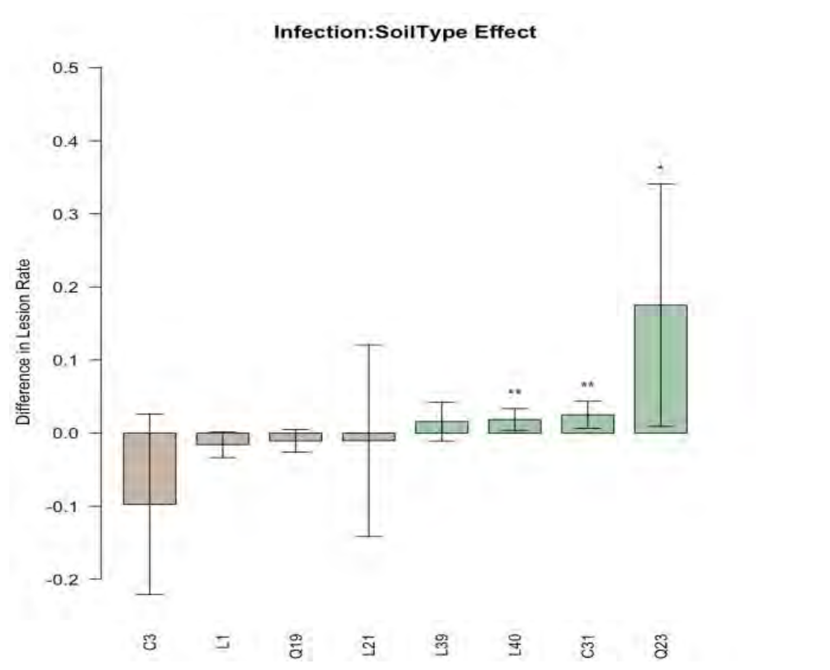

Fig.3 Comparisons of cultivars relative infected area in agricultural soil and sterile soil. Note: These cultivars were chosen from 20 cultivars and their relative infected area were significant higher in pathogen inoculation treatments than control (water) treatments. Asterisks represents the adjusted P-value (FDR), *,**,*** mean adjusted P-value < 0.1, <0.05, <0.01, respectively.

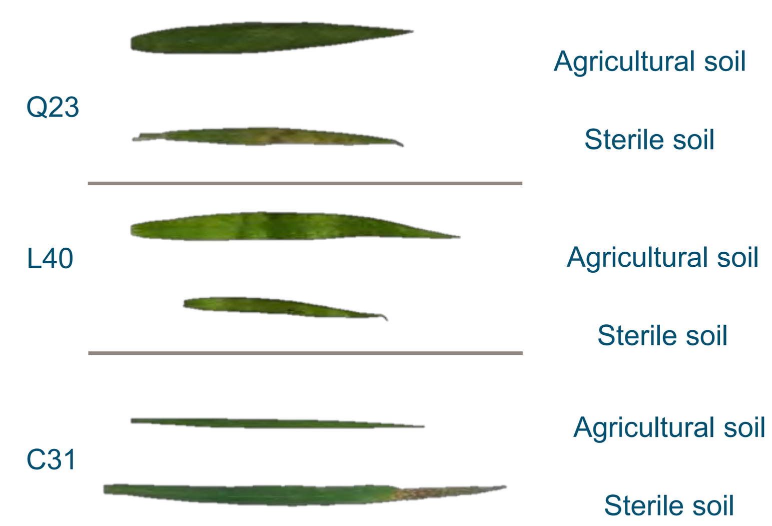

Fig.4. Phenotype of three infected cultivars in agricultural soil and sterile soil

Conclusion

- Our results suggested that domestication might decrease the beneficial association of plant-microbiome interaction, which calls for the need of going back to the wild resources and to unravel the mechanisms will be crucial to improve plant breeding and soil management for microbiome optimization.

Acknowledgements

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

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Designing and optimizing sustainable food supply chains for healthy diets in China

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CAU supervisors: Wenfeng Cong, Shenggen Fan, Mo Li, Fusuo Zhang
WUR supervisors: Joke van Lemmen-Gerdessen, Tjeerdjan Stomph, Wopke van der Werf, Sander de Leeuw,, Anneleen Kuijsten, Edith Feskens

Background

Problems

Public nutritional issues

Consumption side: unbalanced diet, micronutrient deficiencies, and nutrition-related diseases are prevalent (CNS, 2021).

Multiple disturbance and shocks

Food system: confronted with multiple disturbance such as climate change, economic crisis, COVID-19 lockdowns, etc. (Fan et al., 2021).

Environmental externalities

Supply side: overuse of water and nutrients result in important environmental side-effects (Hu et al., 2020). Production efficiency needs to be enhanced.

Possible solutions

Food system needs to be more robust

The food system needs to be as resilient and robust as possible, providing adequate nutrients and recovering quickly when confronted with shocks.

Sustainably supply nutritious foods can be a win-win strategy

Nutritious foods such as whole grains & mixed beans can contribute to increasing the nutrition adequacy and alleviating environmental externalities of the food system.

Objectives

Robustly supplying nutritious foods with lower environmental burdens is the ultimate goal of this project.

- ☐ Quantifying and understanding the vulnerability of local food systems, giving insights into regional and national policy and strategy formulation.
- ☐ Investigating the process of reconstructing a food supply chain network and evaluating the interesting indicators to provide action priorities when implementing production and consumption structure adjustment.
- ☐ Supplying coarse cereals and mixed beans in a more sustainable way to improve the nutrition level of Chinese residents.
- ☐ Integrating coarse cereals and mixed beans into the local agriculture and food system to better achieve sustainable goals.

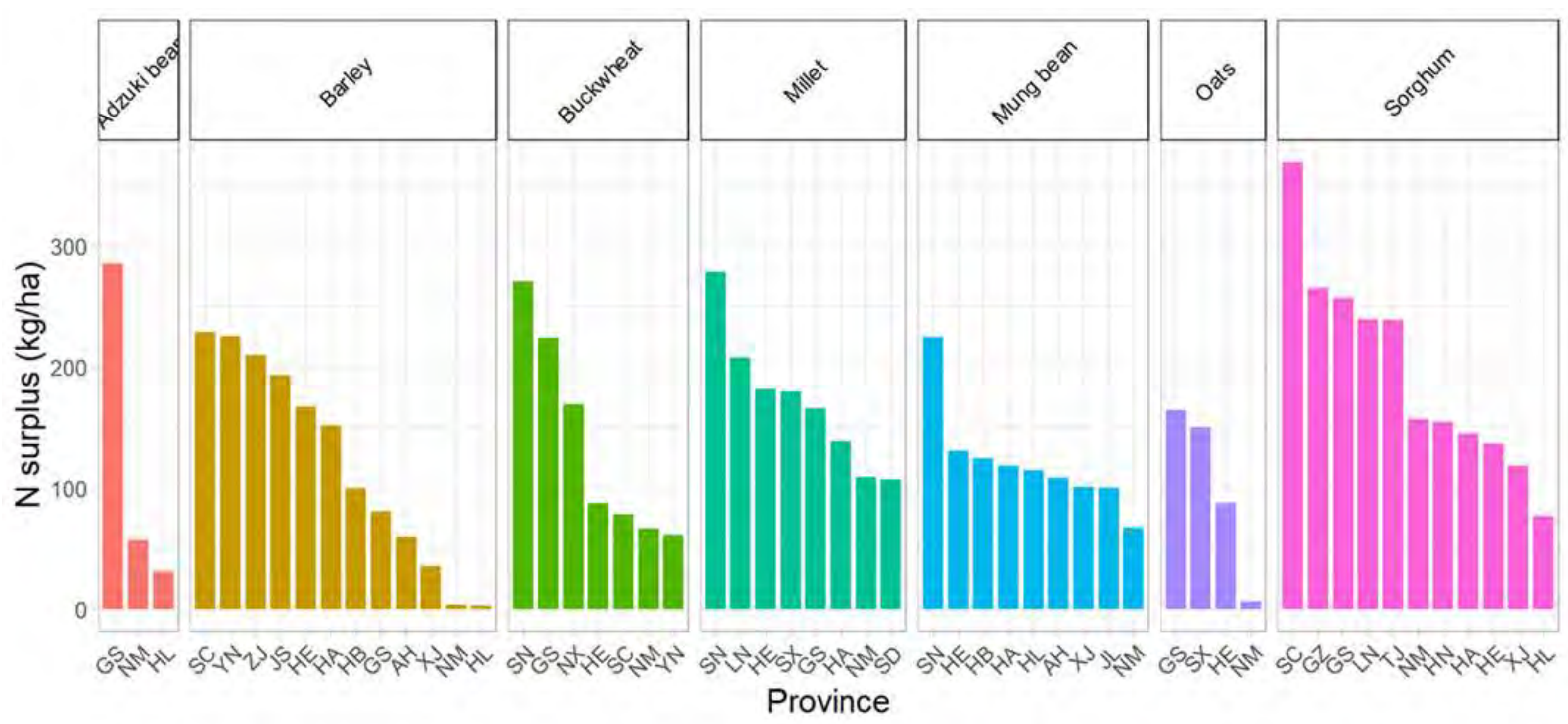

Fig. 3 N surplus for seven coarse cereals and beans in several provinces in China

Methods

- ☐ Network theory: bipartite network
- ☐ Linear programming + multi-objective optimization
- ☐ Methods used to quantify environmental impact, e.g., N surplus, water consumption
- ☐ A simulation-optimization approach

Results

- ✓ Complete the procedures of computing link weights, nutrient coverages and nutrient Shannon diversity for bipartite networks with every combination of province and year (Fig. 2).
- ➤ **Vitamin B and Calcium are bottleneck nutrients with low nutrient coverage.**
- ➤ **Calcium, vitamins A, and C are nutrients with low diversity.**
- ✓ Calculate N surplus (Fig. 3) and water consumption (Fig. 4) for growing coarse cereals and mixed beans at the provincial level.
- ➤ **For the same crop, the nitrogen surplus varies greatly in different provinces, and the difference between the highest and the lowest nitrogen surplus is basically more than 100kg/ha.**
- ➤ **The production structure has a great impact on the potential water consumption in crop production.**
- ✓ Construct the linear programming mathematical model.

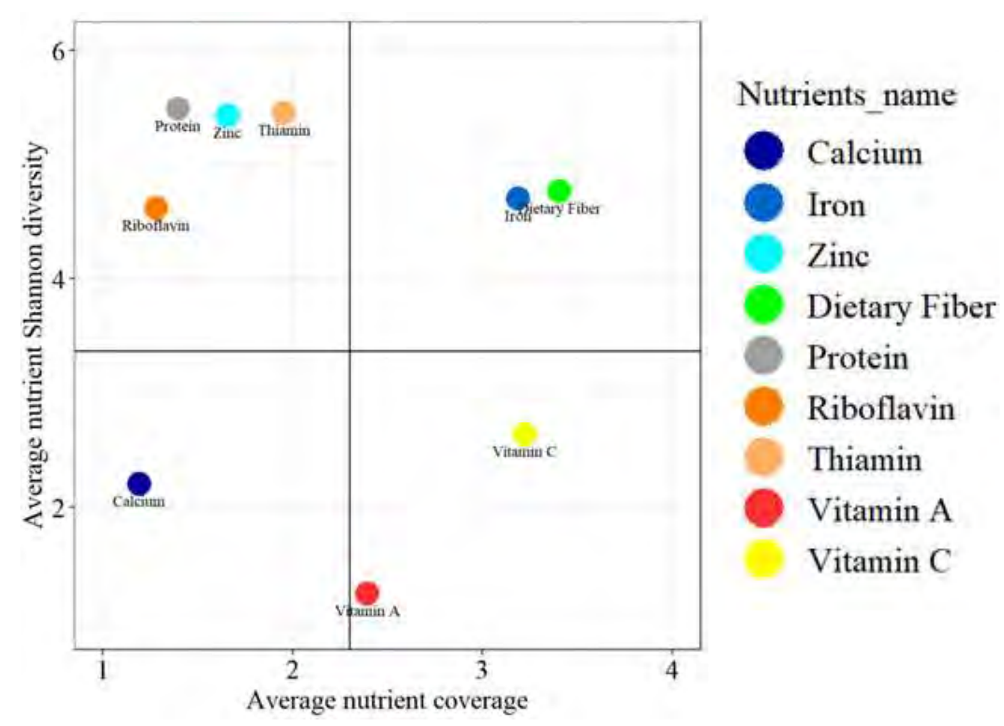

Fig. 2 The average nutrient coverage and diversity of nine nutrients for Shanxi Province

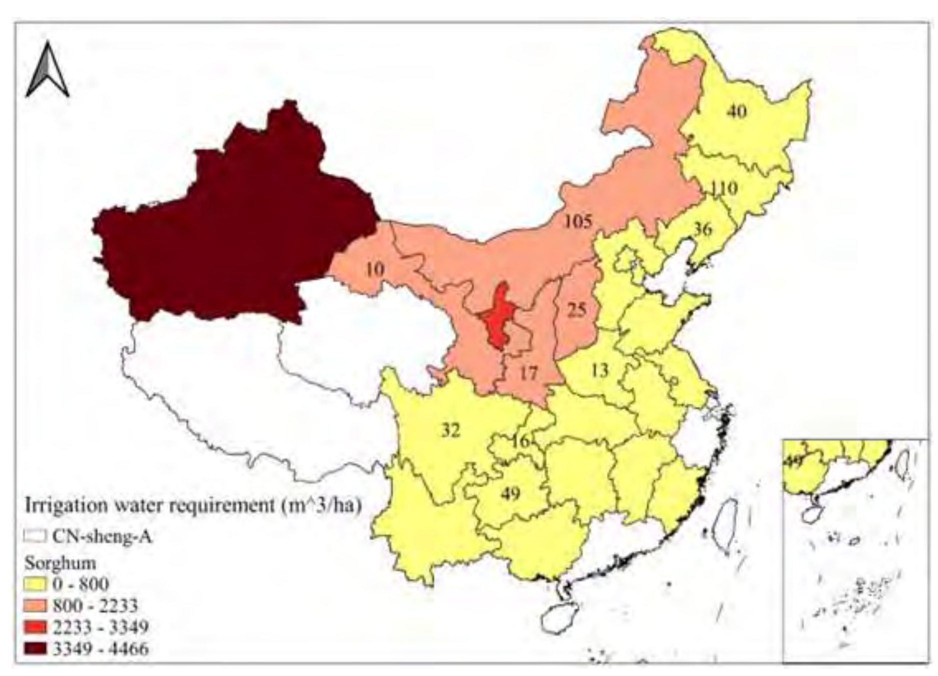

Fig. 4 Irrigation water requirement for sorghum in China (m^3/ha)

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The influence factors and interventions to promote whole grain foods consumption of Chinese

Xin Zhang (2+2 PhD student)
CAU Supervisor: Shenggen Fan; Jinjing Wang; Haixiu Gao;
WUR Supervisor: Inge Brouwer

Background

➢Inadequate intake of whole grains of Chinese
- Over 80% of Chinese **don't** take enough whole grains,that contribute to diet related disease and health care cost, meanwhile produce whoe grians replace refined grains can improve edible rate of grais and reduce carbon emission.

➢Research gap
- Few studies have shed light on consumers behaviors and effective interventions to promote whole grains consumption of Chinese.

Objectives

1.Identify barriers of whole grain industry in China.

2.Analyze the attribute preference and willingness to pay of Chinese consumers to whole grain food.

3.Analyze the gap between intention and behavior in whole grain food consumption and identify the main influencing factors.

4. Identify the effectiveness of different behavioral interventions to increase consumer consumption of whole grain foods.

Methods

Methods of Objective 1.
Literature review.

Methods of Objective 2.
Conduct Choice Expirement to explore consumers preference and willingness to pay of whole grain foods.

Methods of Objective 3.
Conduct survey to explore consumers intention and actual behaviors of whole grain foods. Then conduct emprical analysis.

Methods of Objective 4.
Desigening different interventions to promote whole grain foods intake,and compare the heterogeneity and effectiveness of different interventions.

Results

1.China's whole grain products market is developing slowly.
- The whole grain products is insufficient in quantity and variety.
- And the definition of whole grain food in China is not clear, relevant standards and labels are still developing, the quality of whole grain products in the market is uneven.
- Chinese consumers' cognition level of whole grains is still not high. According to a special survey (2021), 75% of consumers do not know what whole grains are, and 95% of consumers do not have a comprehensive understanding of the nutritional value of whole grains.

2.Main barriers of whole grains industry in China.
- The lack of industry standards and information identification leads to information asymmetry and market failure.
- Government has a few policies to support the development of the whole grain industry.

3.Other research objectives are still in the process of research and no results has been reached.

Conclusions

1.Policies, regulations, healthy diet knowledge, and supply chain research are suggested to promote whole-grain consumption and industrial development in China.

2.Other research objectives are still in the process of research and no conslusion has been reached.

Acknowledgements

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

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Stabilizing food security via sustainable intercropping in arid irrigation areas

Tao Song*, Chunjie Li, Chaochun Zhang, Wopke van der Werf, Stomph Tjeerd Jan,

Background

◆ Achieve the sustainable agriculture in arid irrigation areas is urgently needed.

◆ Intercropping has the potential to use efficiently local resources to achieve sustainable agriculture, which contains food security, diversified supply and low environmental cost.

Objective and Research questions

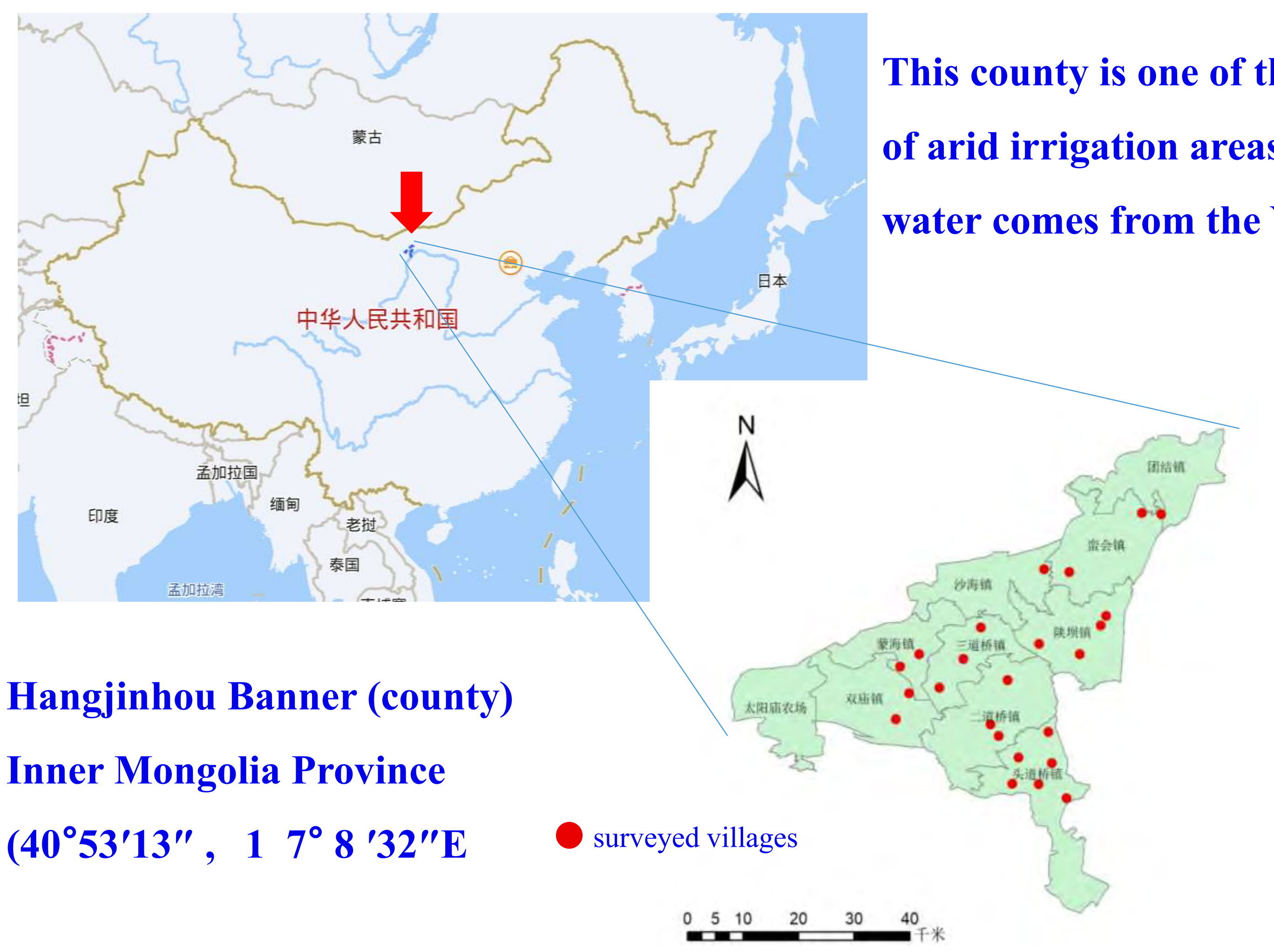
◆ Objective:

Explore the relationship between management and yield gain of intercropping.

◆ Research questions:

1. What are the management and input differences between intercropping and monocultural?
2. How much yield and economic gain would get via intercropping with optimal management?
3. Where the optimal management differs between sole crops and intercrops?

Survey site and sampling principles



This county is one of the representatives of arid irrigation areas, 93% of irrigation water comes from the Yellow River

Hangjinhou Banner (county)
Inner Mongolia Province
(40°53′13″， 1 7° 8 ′32″E

Sampling principles

◆We select 8 towns from 10 towns in Hangjin Banner, because the selected town must include monocultural and intercropping system in 2021 and 2022.

◆The 24 selected villages in total were recommended by the local government based on the following principles:

① At least two intercropping or monocultural systems in selected village.

②The top 24 villages in terms of intercropping and monocultural cultivated area

◆We selected randomly 15-20 farmers in each village:

①For monocultural farmers, we chose farmers who planted maize or wheat or sunflower in 2021 and 2022.

②For intercropping farmers, we chose farmers who planting intercropping system regardless of crop variety in 2021 or 2022.

Results

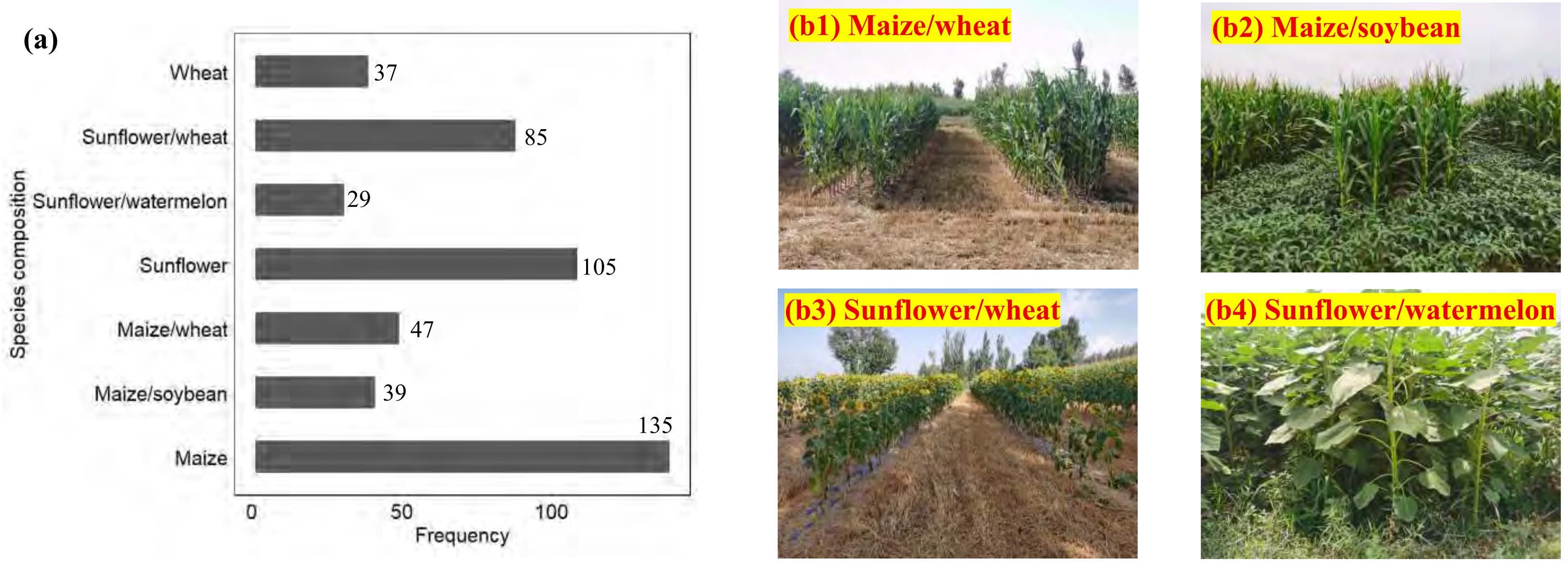


Fig.1 The number of survey questionnaires (a) in different systems, and the photos (b) of the local intercropping system, these photos were taken at the end of July 2022, when the wheat and watermelons have been harvested.

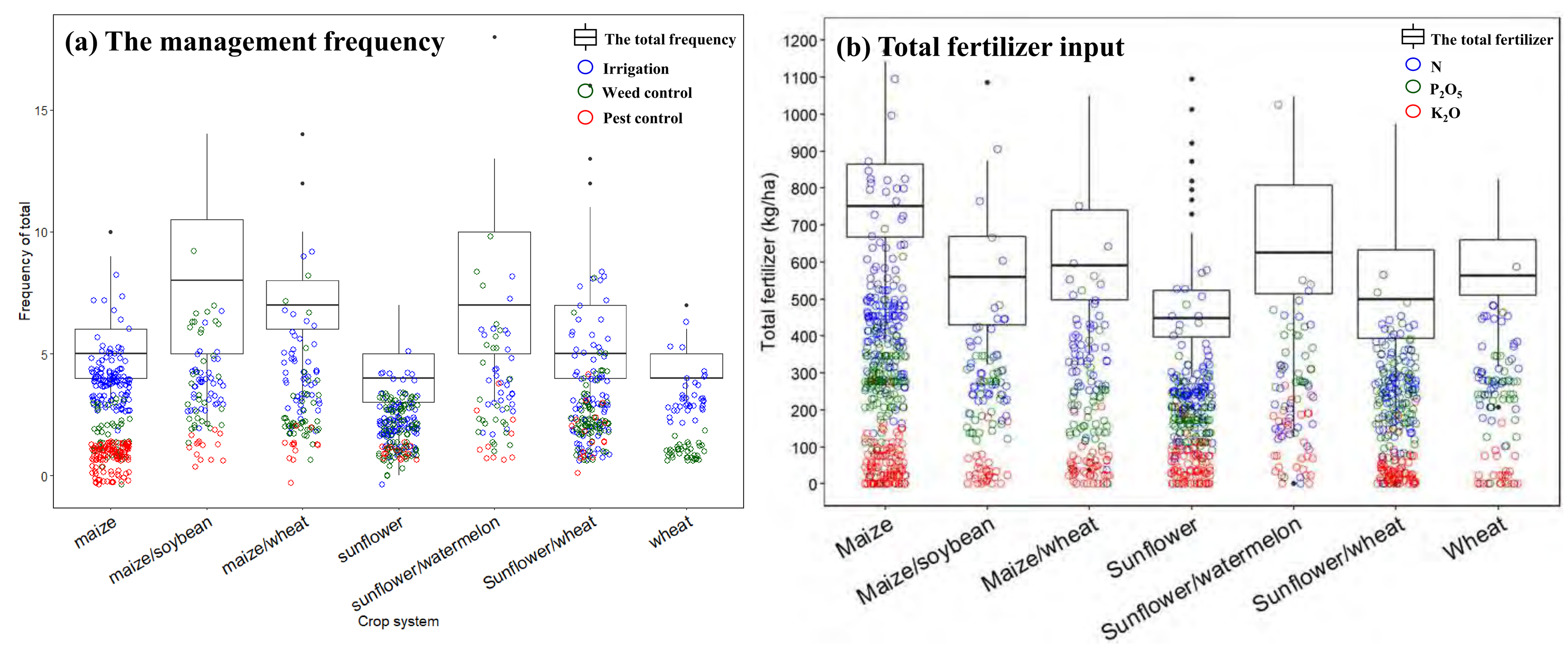


Fig. 2 The management frequency (a) and the total fertilizer input (b) of different crop system. The box in (a) represents the sum of the three management frequencies, Irrigation (blue circle), Weed control (green circle) and pest control (red circle); the box in (b) represents the sum of the pure fertilizer input, N (blue circle), P_2O_5 (green circle) and K_2O (red circle).

	Yield (t/ha)	Yield of top 25% (Yt) (t/ha)	Median yield (Ym) (t/ha)	Yield gap (=Yt-Ym)
Maize	Intercropped (Yic)	8.625	7.5	1.125
(Maize/soybean; Maize/wheat)	Sole crop (Ys)	8.48	6.83	1.65
	Yield gain (=Yic-Ys)	0.145	0.67	
Wheat	Intercropped (Yic)	6.10	5.18	0.92
(Sunflower/wheat; Maize/wheat)	Sole crop (Ys)	5.05	3.77	1.28
	Yield gain (=Yic-Ys)	1.05	1.41	
Sunflower	Intercropped (Yic)	3.75	2.25	1.5
(Sunflower/wheat; Sunflower/watermelon)	Sole crop (Ys)	1.88	1.62	0.26
	Yield gain (=Yic-Ys)	1.87	0.63	

Table 1. The yield gap and yield gain of intercropping compared with monocultural

Conclusions

◆ The management frequency of intercropping is more than monocultural, mainly due to the increase in weed control times and irrigation times with great variations.

◆ Intercropping could save fertilizer than monocultural.

◆ The farmer attainable yield of intercropping were higher than sole crop, Intercropping could reduce the yield gap of wheat and maize.

Acknowledgements

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

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Phosphorus Mobilization by LMWOAs in Calcareous and Red Soils After Receiving Long-Term Fertilizations

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

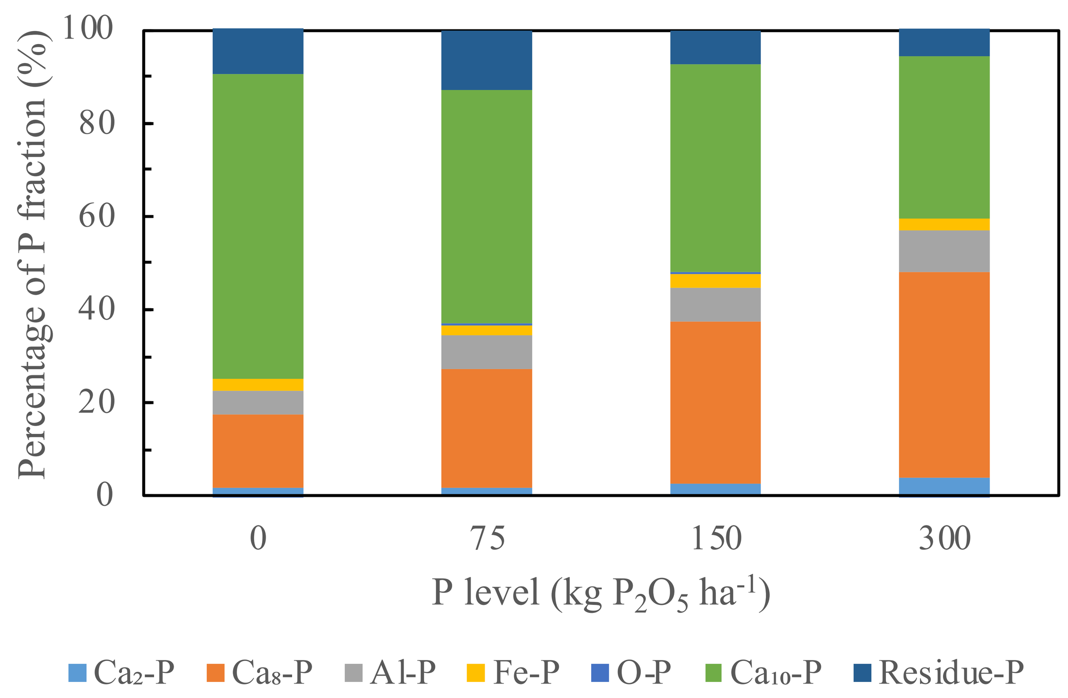

Fig 1. Proportion of phosphorus forms in calcareous soil extracted by Jianggu continuous extraction method.

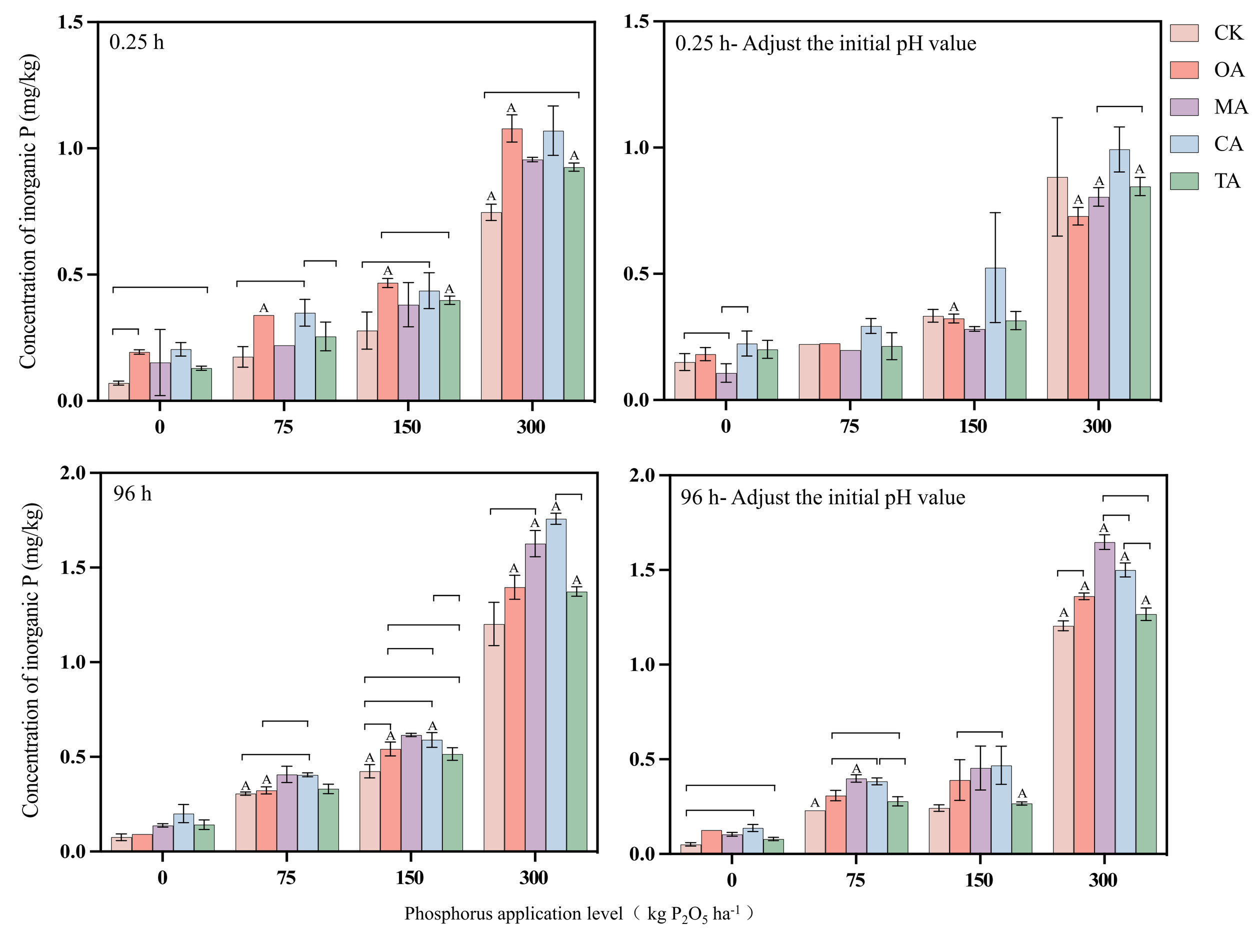

Fig 2. Phosphorus concentration of calcareous soil (phosphorus application level is 0, 75, 150, 300 kg P_2O_5 ha^{-1}) extracted by organic acid at 0.25 and 96 hours with or without adjusting the initial organic acid pH value.

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.

Acknowledgements

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

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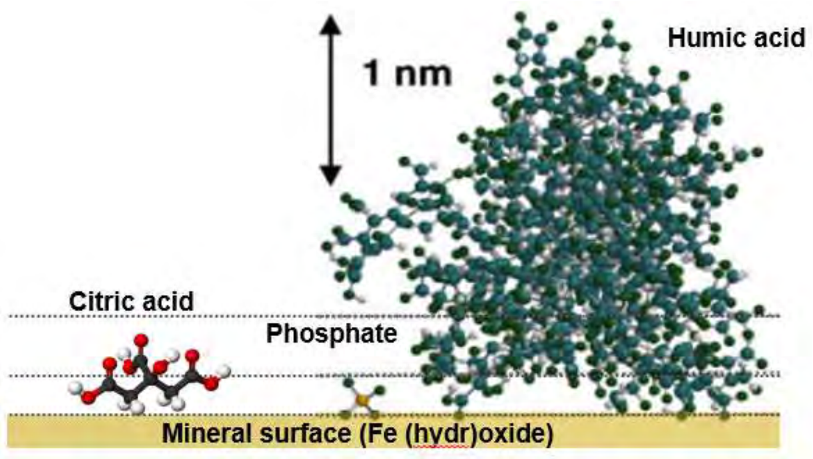
Geochemical mechanisms of enhancing the phosphorus and iron bioavailability by maize root exudates

PhD candidate: Man Pu Supervisors: Walter Schenkeveld, Liping Weng
Chair group: Soil Chemistry and Chemical Soil Quality, Wageningen University and Research

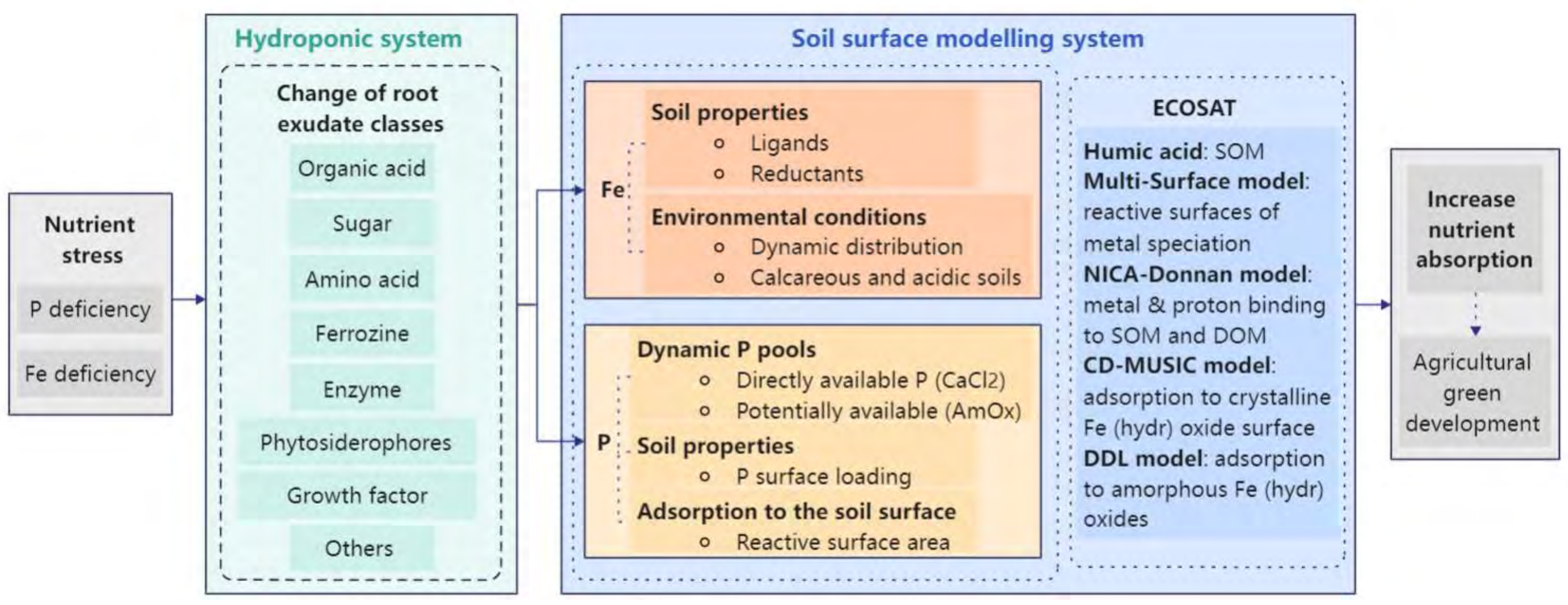
Background



Phosphorus (P) and iron (Fe) are two of the most crucial elements for plants in the agriculture system. However, the availability of P and Fe is extremely low in soils for plants (Li et al., 2008). This is because there are various P interfacial behavior present in the soils. Therefore, interaction between various species in natural systems may affect the adsorption of P and its mobility and bioavailability. In terms of Fe, divalent iron that can be directly absorbed by plants is always oxidized to iron oxides that cannot be absorbed by plants (Weng et al., 2008). It is worth noting that iron oxide can serve as the adsorption site of phosphorus, which causes P and Fe to be highly related.

In this study, we want to increase the Fe and P uptake for the maize by root exudates. Root exudates are a mixture of thousands of complex compounds, including organic acid, sugar, protein, phenolics, amino acid, etc. Root exudates play an important role in the competition and transport of organic substances to metal (hydr)oxides. Previous studies has found that plants will release more root exudates under deficient conditions to helps plants absorb nutrients. However, most of the studies only focus on several types of root exudates, the interactions between root exudates themselves is ignored. Therefore, a full characterize and quantify of root exudates is necessary. In this study, we want to research what are the profile of the root exudates under P and Fe deficiency and their changes over time.

In soils, there are always natural organic matter (NOM) present. NOM strongly influences the behavior of many organic and inorganic elements as well as the behavior of mineral colloids (Gu et al., 1996). For example, NOM will neither directly compete with P for adsorption site in the Stern layer at the mineral surface, or indirectly inhibit iron-oxide crystallization (Weng et al., 2011). The adsorption of phosphate is reduced due to the competition of organic matter for the same sites on the oxide surface. However, the competition adsorption between root exudates, NOM to metal (hydr)oxides is rarely studies. In this study, we want to research the adsorption of root exudates and P on the Fe (hydr)oxide surface with the present of NOM.



Objectives

This project will focus on the interaction between several root exudate components and natural organic matter in soil at the surfaces of soil minerals, to study the underlying mechanisms of the effect of root exudates on phosphorus and iron uptake. The specific objectives are:

1)To understand the exudate profiles of maize varieties grown under phosphorus and iron deficiency as a function of growth stage and daytime;
2)To study the reactivity of root exudate compounds towards iron (hydr)oxides surfaces with the present of humic substances;
3)To reveal and quantify the molecular level interactions between root exudates and phosphate at the surface of iron (hydr)oxides with the present of humic substances;
4)To investigate the synergistic effects of multiple root exudate compounds to mobilize phosphorus and iron in soils.

Methods

1. Hydroponic experiments

In order to find the profile of root exudates and determine the most important compounds in root exudates, root exudate of maize were collected from different growth stage in hydroponics, which will be examined to establish the dynamic of different types in root exudate under phosphorus deficiency (10 μM) and iron deficiency (10 μM).

For the collected root exudates, the following indicators will be analyzed: categories and amount of organic acid, total dissolved sugar, phytosiderophores, reduction capacity, acid phosphatase, total dissolved organic carbon and nitrogen, SUVA, root phenotype.

2. Model interpretation

To determine the interactions between phosphate, iron, root exudates, soils (hydr)oxide partials and NOM, chemical species models will be used. Metal speciation (goethite) will be modeled for humic acid (HA) as the model analogue for natural soil organic matter (SOM) using the computer program ECOSAT (Keizer and van Riemsdijk 1994), and addition of main root exudate compounds to the soil will be simulated.

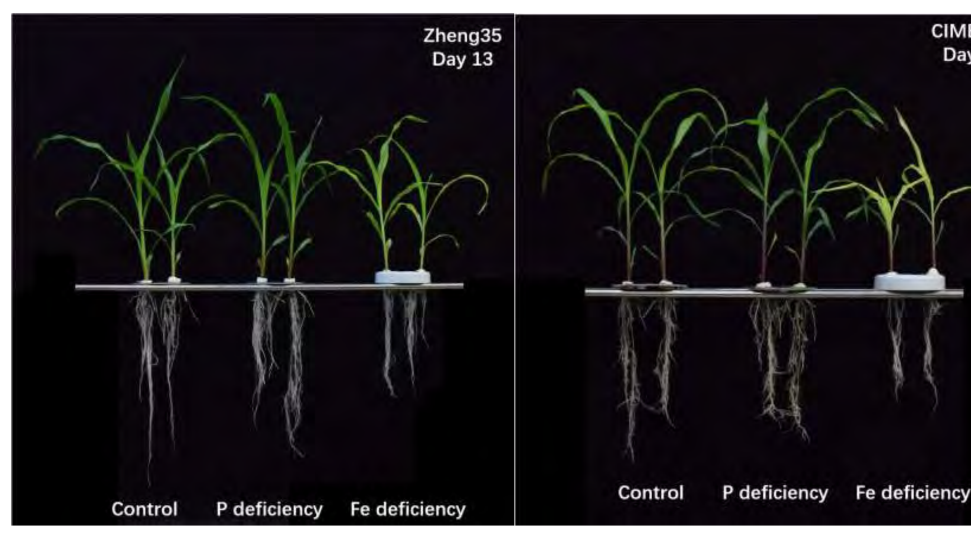
Metal speciation in soils will be modeled using a Multi-Surface approach (Weng et al, 2001). Metal and proton binding to SOM and dissolved organic matter (DOM) will be described with the Non-Ideal consistent Competitive Adsorption (NICA)-Donnan model (Kinniburgh et al, 1999). Adsorption to crystalline Fe (hydr) oxide surfaces will be described with the Charge Distribution Multi Site Complexation (CD-MUSIC) model (Hiemstra and Van Riemsdijk 1996, 1999). Adsorption to amorphous Fe (hydr) oxides will be described with the Diffuse Double Layer (DDL) model (Dzombak and Morel, 1990).

Results

Symptoms of phosphorus and iron deficiency in maize can be a reflection of the secretion of different root exudates.

One of the strategies for maize to cope with phosphorus deficiency is to grow more roots (greater biomass), while iron deficiency leads to a decrease in root biomass. Zheng35 (left figure) was not tolerant to phosphorus deficiency but was tolerant to iron deficiency and CIMBL92 (right figure) was tolerant to phosphorus deficiency but not to iron deficiency. For CIMBL92, more root biomass and more yellow leaves were observed compared to the control. This conclusion also applies for Zheng35. But when we compared the two varieties, Zheng35 had relatively less increased root biomass and yellow color than CIMBL92.

Except for root biomass, what is more important is the changes in root exudates, such as organic acids and sugars. Our results indicate (data not shown) that under the phosphorus deficiency treatment, more oxalic and succinic acids were collected, but less malic acid was collected. Less malic acid was unexpected, as more malic acid was found in other studies. Further explanations are to be discussed. On the other hand, more sugars were collected under iron deficiency conditions, which could be through the effect of microorganisms thereby indirectly enhancing iron absorption, but this hypothesis remains to be tested.



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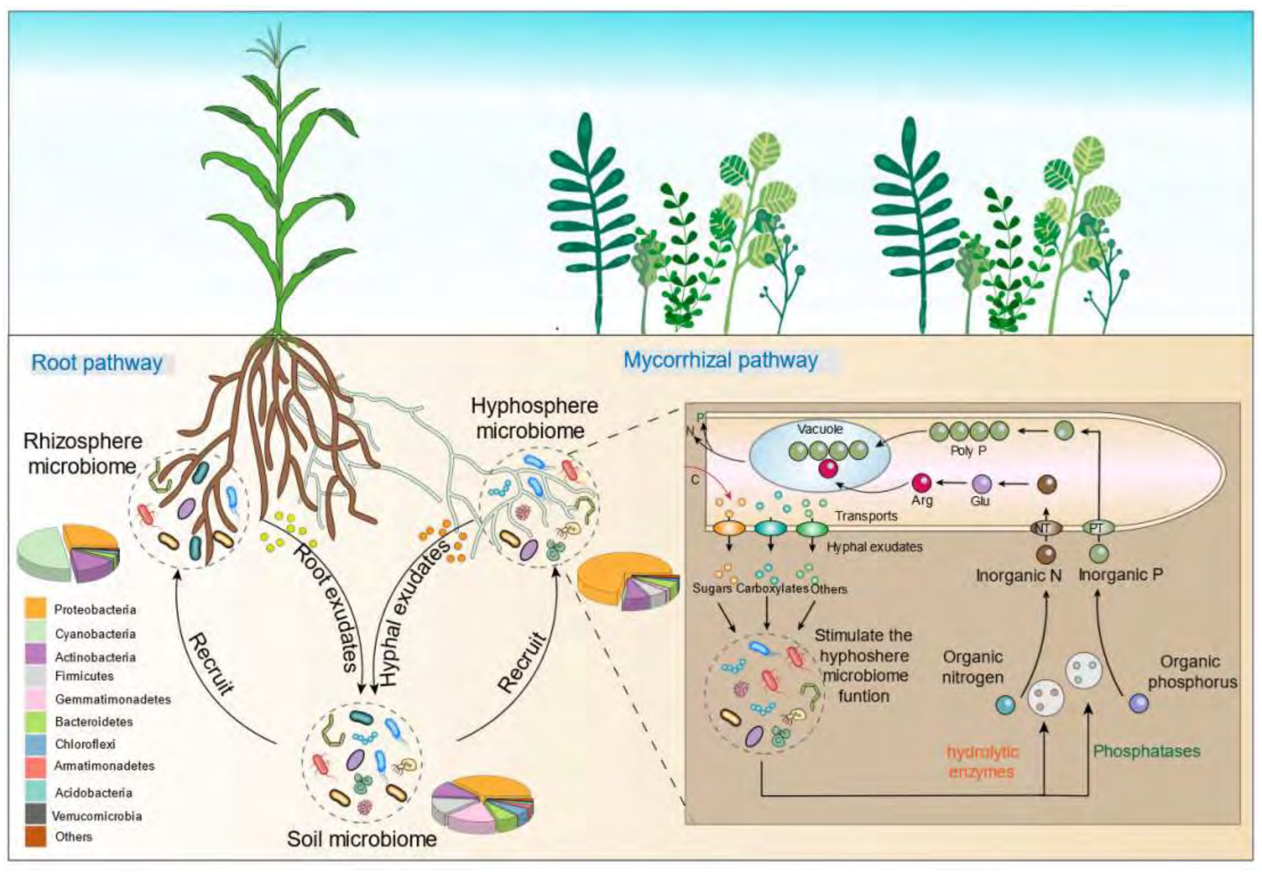
The mechanisms of plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction involved in stimulating AM symbiosis and plant performance

Presenter: Xiaofan Ma

Supervisors: Erik Limpens (WUR), Xu Cheng (WUR), Lin Zhang (CAU), Gu Feng (CAU), Chunxu Song (CAU)

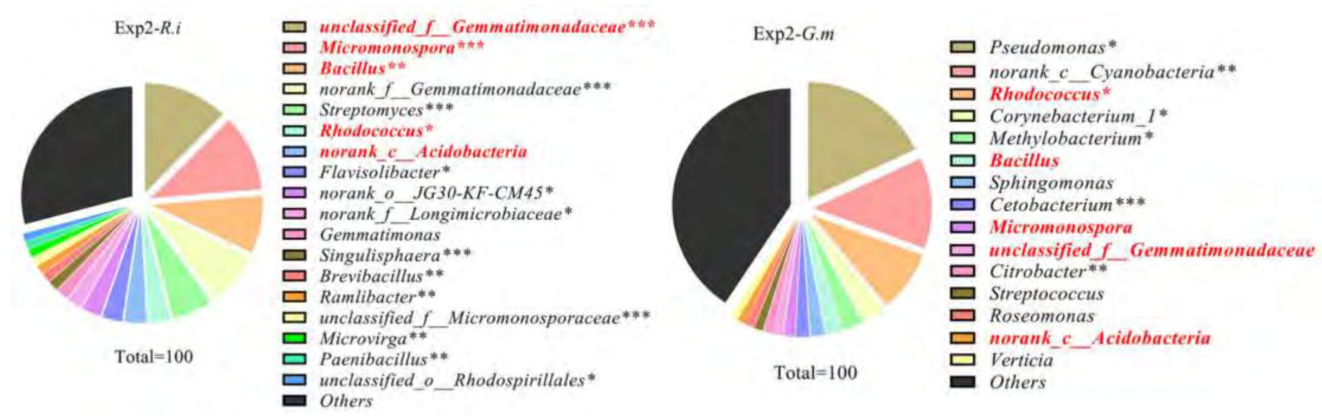
Background



(Zhang et al., 2021)

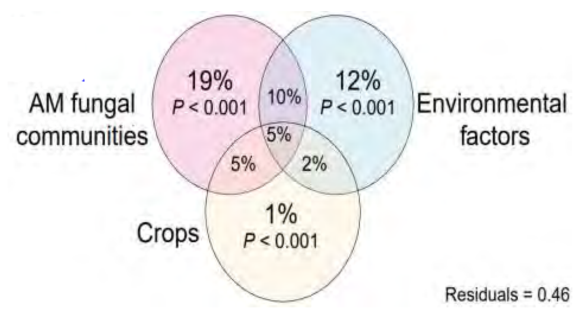
Arbuscular mycorrhizal (AM) fungi can colonize more than 80% of land plants. Similar to the microbiome in the rhizosphere of plants, the microbiome associated with AM fungi will have important functions in biogeochemical processes of various mineral elements and therefore plant/AM fungi nutrition and performance.

Bacteria that colonize the hyphal surface of AM fungi and stimulate the symbiosis development have been termed mycorrhiza helper bacteria (MHB). These bacteria can have multiple functions, however, the molecular mechanism that MHB promotes the establishment of symbionts is still rarely studied.



(Zhou et al., 2020)

On the other hand, different AM fungi co-colonizing on a single plant root recruit distinct microbiomes. And different combinations of plant-AM fungi also habour distinct hyphosphere bacteria, recent study believe AM fungal communities induced variation in hyphosphere bacterial communities. But how plants-AM fungi regulate hyphosphere bacteria, the mechanism underlying is still unclear.



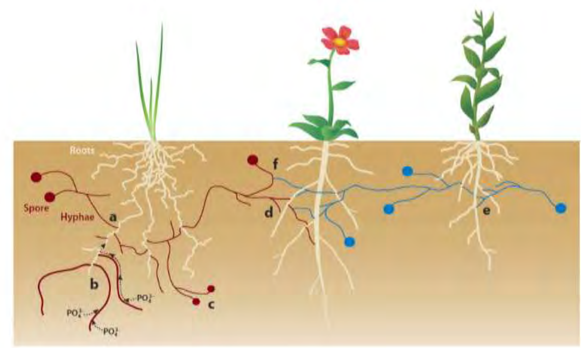
(Wang and Zhang et al., 2022)

Objectives

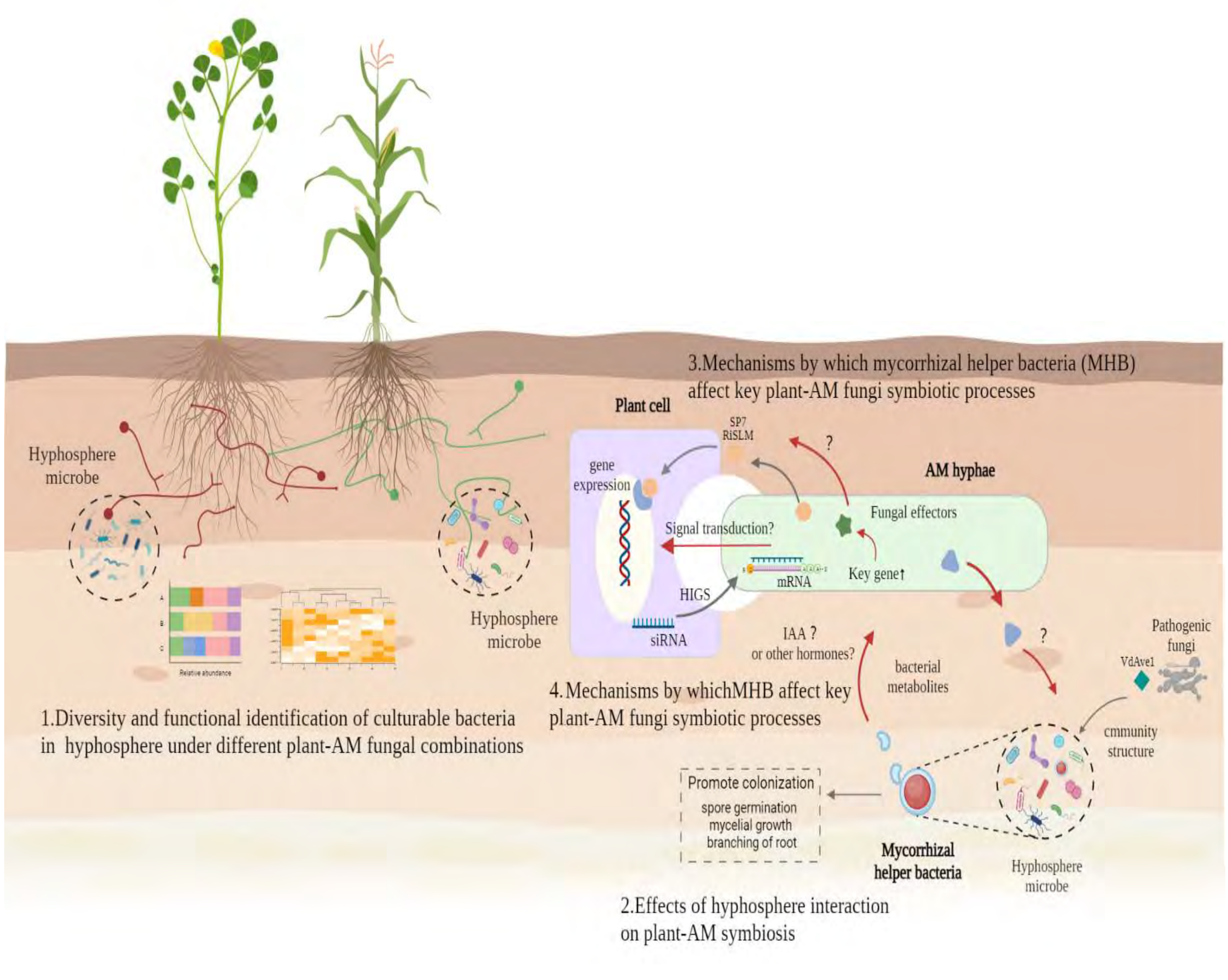
In this project, we aim to fill this knowledge gap to improve soil nutrient-use efficiency and propose novel strategies to take best advantage of the indigenous AM fungi and bacteria in the field, which will help to realize green production designs.

We will use different host and 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.



Framework



Expected results

1. Different plant-AM fungi combinations have distinct hyphosphere bacteria with different functions.
2. AM fungal effector can regulate hyphosphere bacteria.
3. Conserved signaling pathways in plants regulate AM fungal secreted proteins and therefore shape hyphosphere bacteria.
4. Specific bacteria in hyphosphere can promote the establishment of symbiosis and nutrient absorption through bacterial metabolites.

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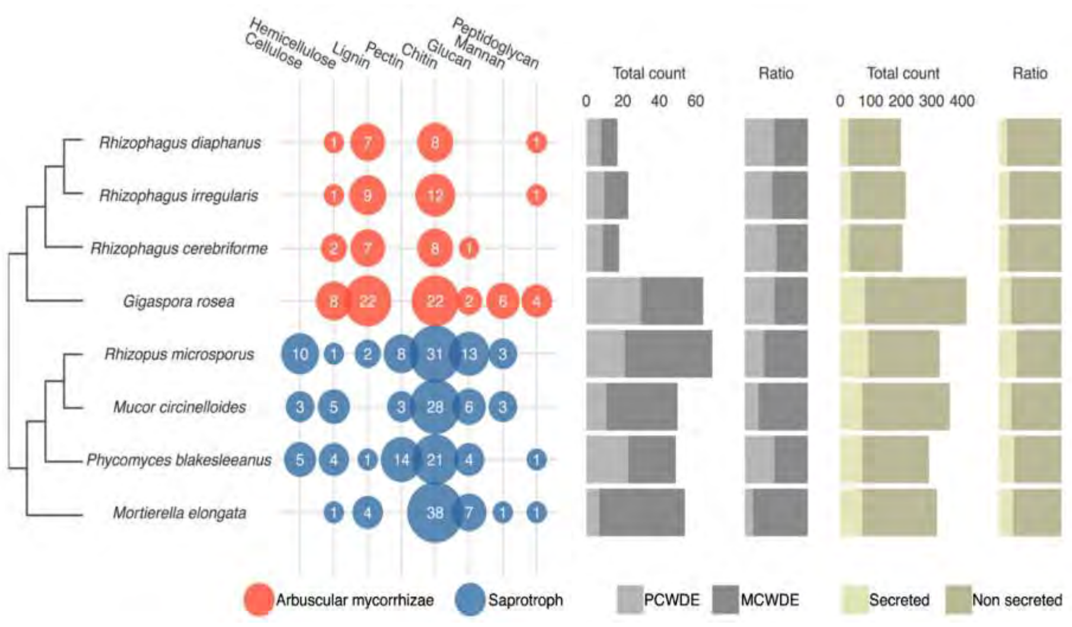
Unraveling mechanisms for arbuscular mycorrhizal fungi recruit and activate hyphosphere bacteria to improve plant phosphorus uptake

PhD student：Zihang Yang

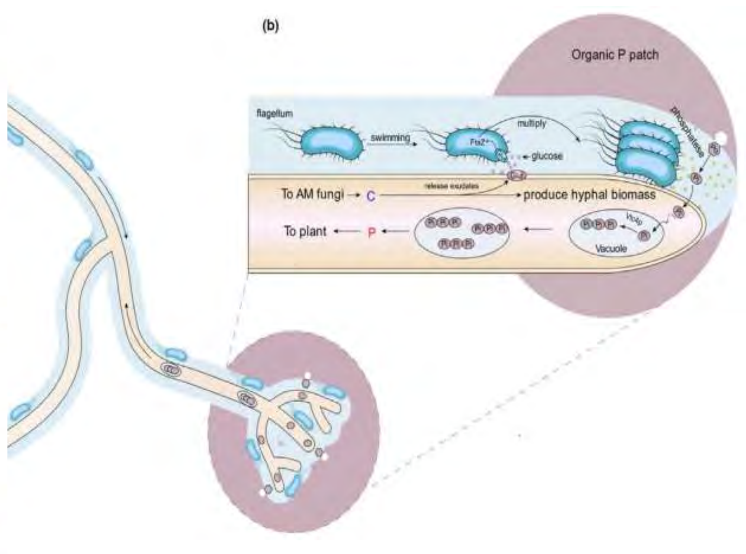
Supervisor：Lin Zhang, Gu Feng, Erik Limpens, Cheng Xu

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.

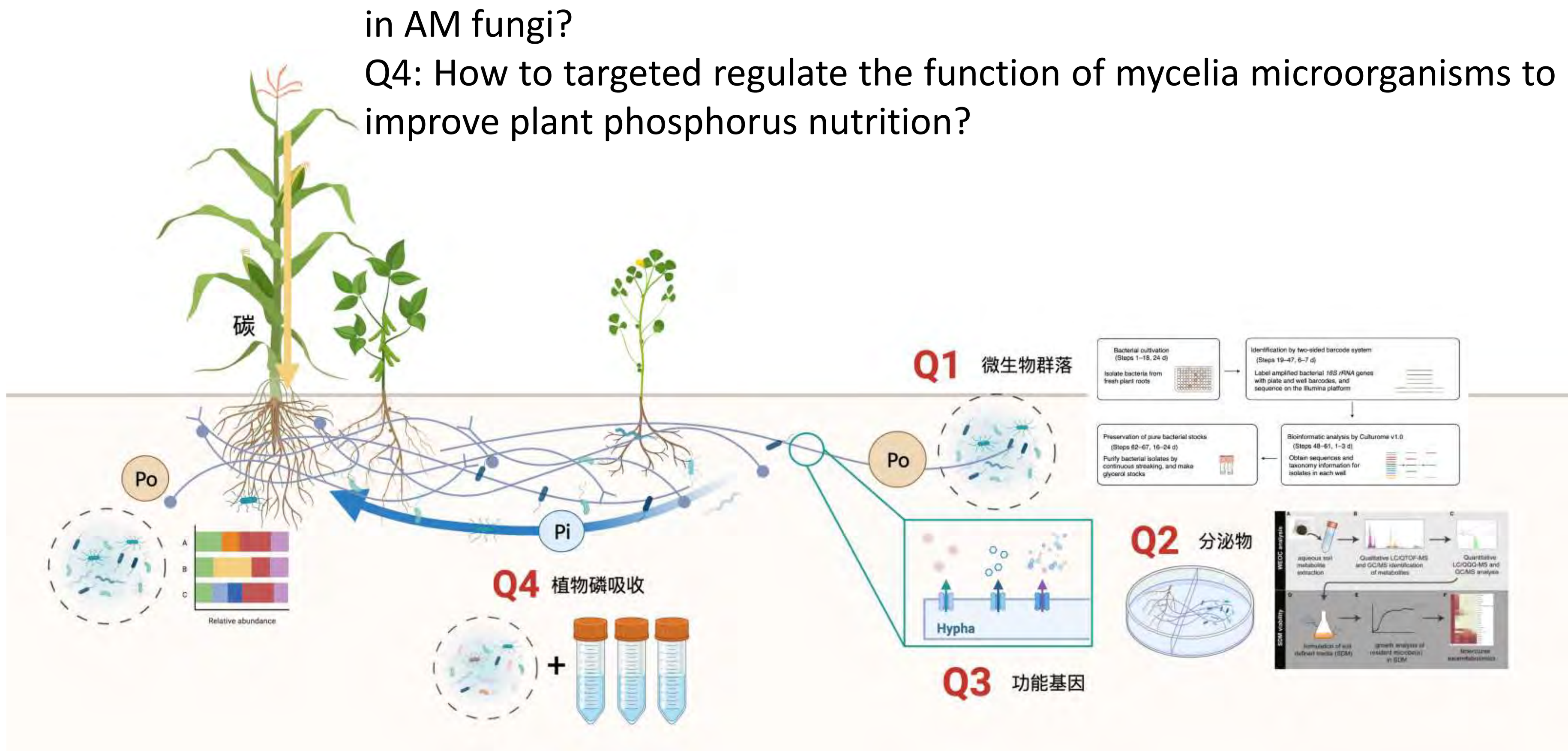
Framework

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?

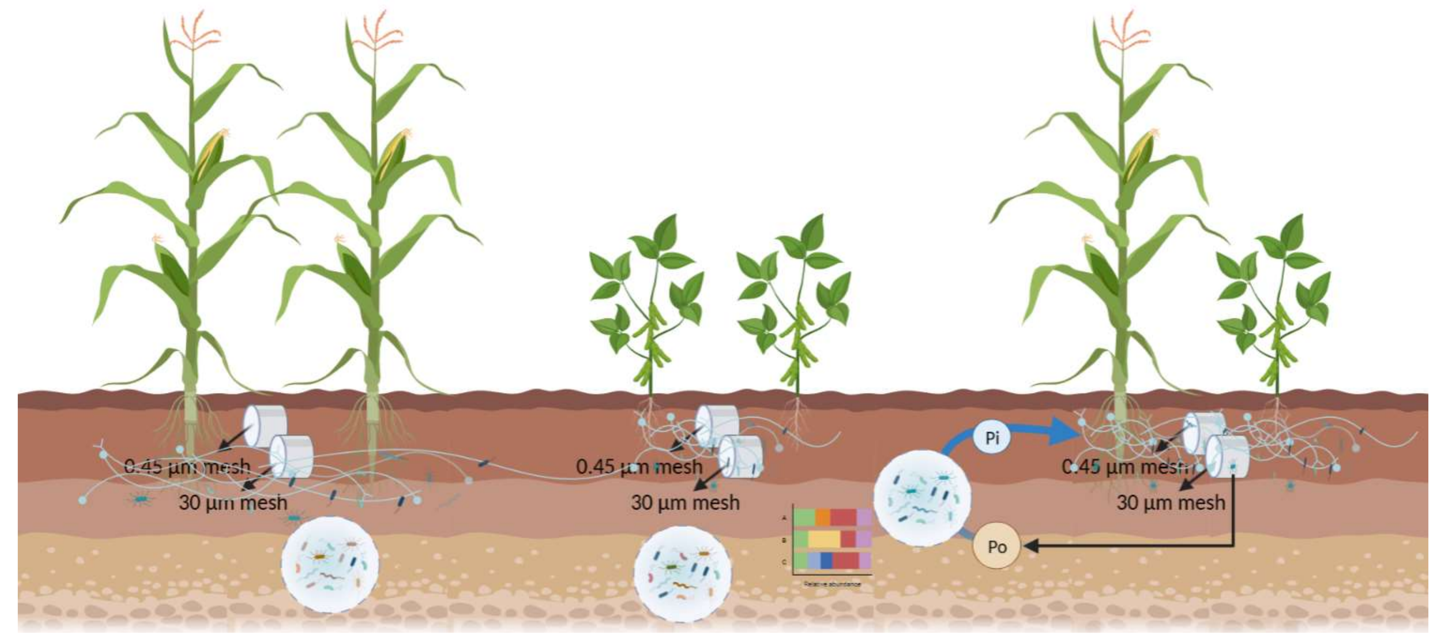
Q4: How to targeted regulate the function of mycelia microorganisms to improve plant phosphorus nutrition?



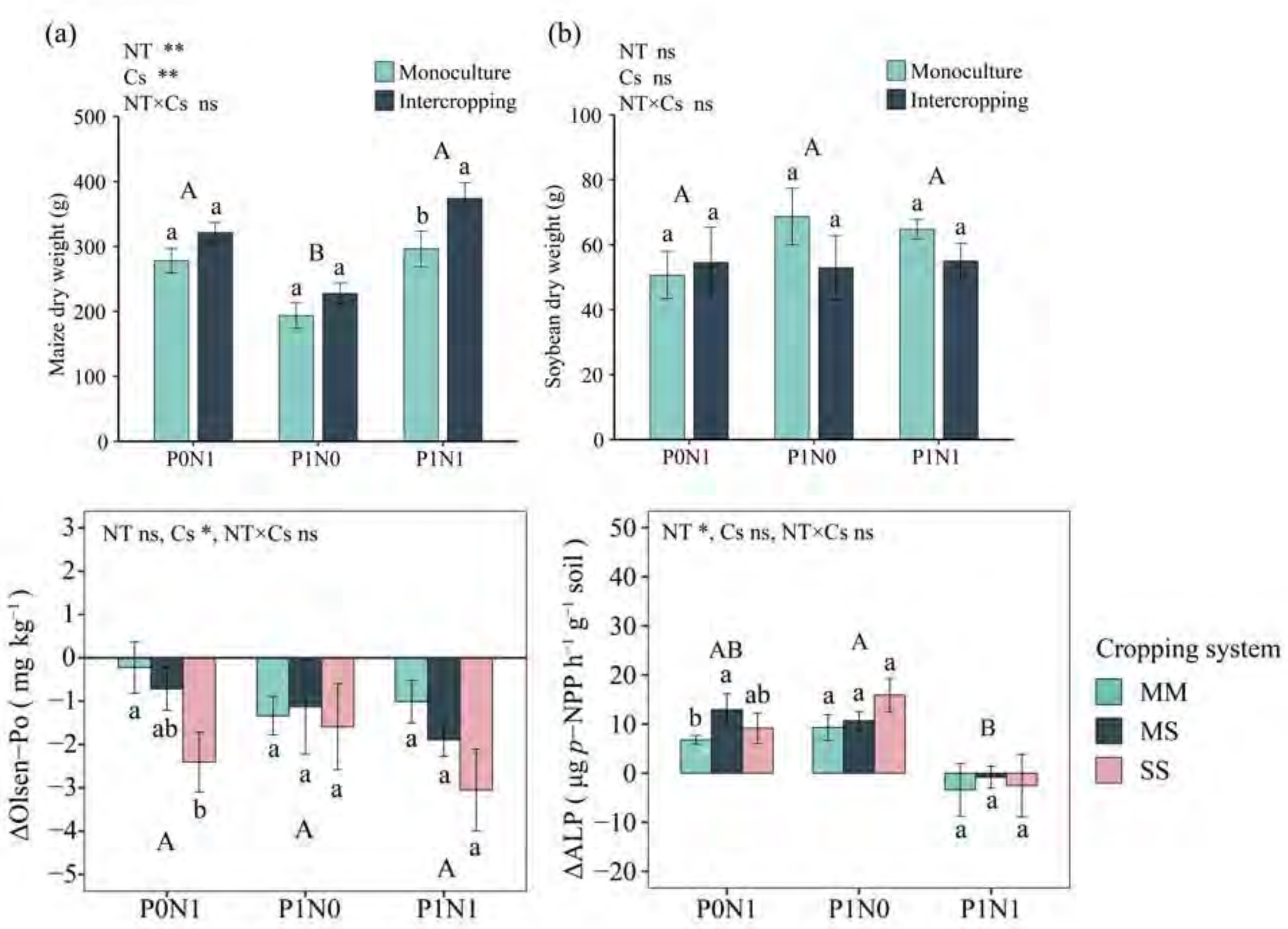
(Zhang et al, 2021)

Chapter 1: Mechanism of organic phosphorus 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). The mechanism is that plants with strong phosphorus activation ability can improve soil phosphorus availability through the rhizosphere process to promote the growth of adjacent plants (Li et al., 2014). 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 phosphorus mineralization in the hypha interface under different cropping systems and nutrient supply conditions.



Result



The cropping system and nutrient supply significantly affected the shoot dry weight of maize; AM fungi significantly increased soil phosphatase activity, promoting the mineralization of organic phosphorus.

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Finding adaptations to an ancient mycorrhizal symbiosis signalling cascade that enables its use in 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].

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 *Pancyclops* mutant phenotype.
- Description of CYCLOPS-responsive elements (CYC-REs) activity in different species.
- Confirmation of CYC-Res by EMSA and/or transactivation assay.
- Identification of the molecular mechanism that determines which genes are activated by the common symbiotic signalling pathway.

Methods

- Phenotyping.
- EMSA and/or transactivation assay.
- Co-immunoprecipitation and/or DNA affinity purification.
- CRISPR-Cas9

Results

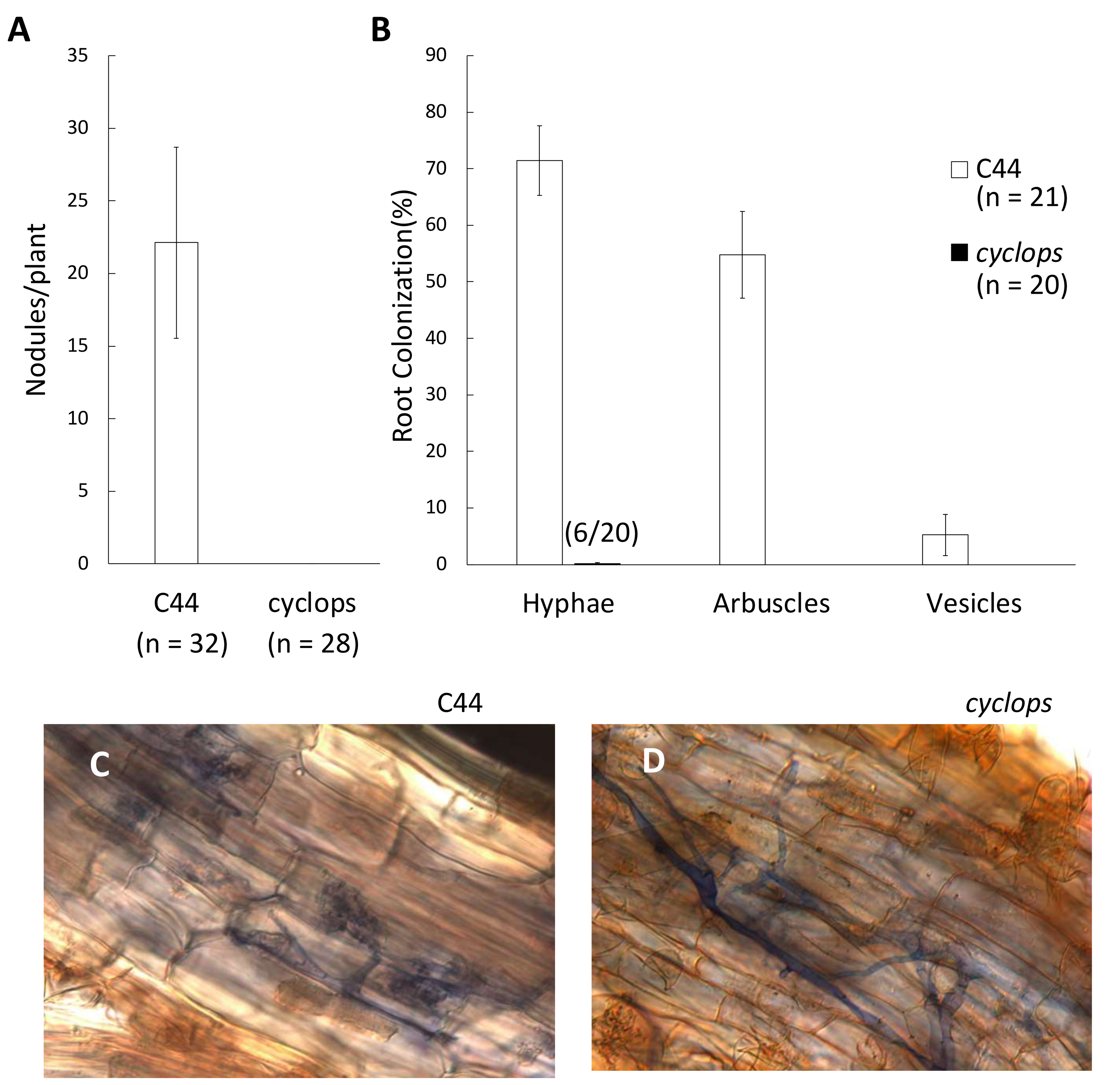

Figure 1. Phenotypes of *Pancyclops* mutant. (A) *Pancyclops* mutant cannot form nodules when inoculated by rhizobia for 4 weeks (4 wpi). C44 is a wild type line transformed with Cas9, but without sgRNA. **(B)** Root colonization rate of C44 and *Pancyclops* mutant when inoculated by AM fungi for 6 weeks (6 wpi). AM hyphae were rarely observed in 6 plants out of 20. Arbuscles or vesicles were not observed in *Pancyclops* mutant. The degree of colonization was determined by gridline intersect method. Mean values are shown, and the error bars indicate standard error. **(C)** The hyphae and arbuscles formed in C44. **(D)** Fungal infection aborted in *Pancyclops* roots.

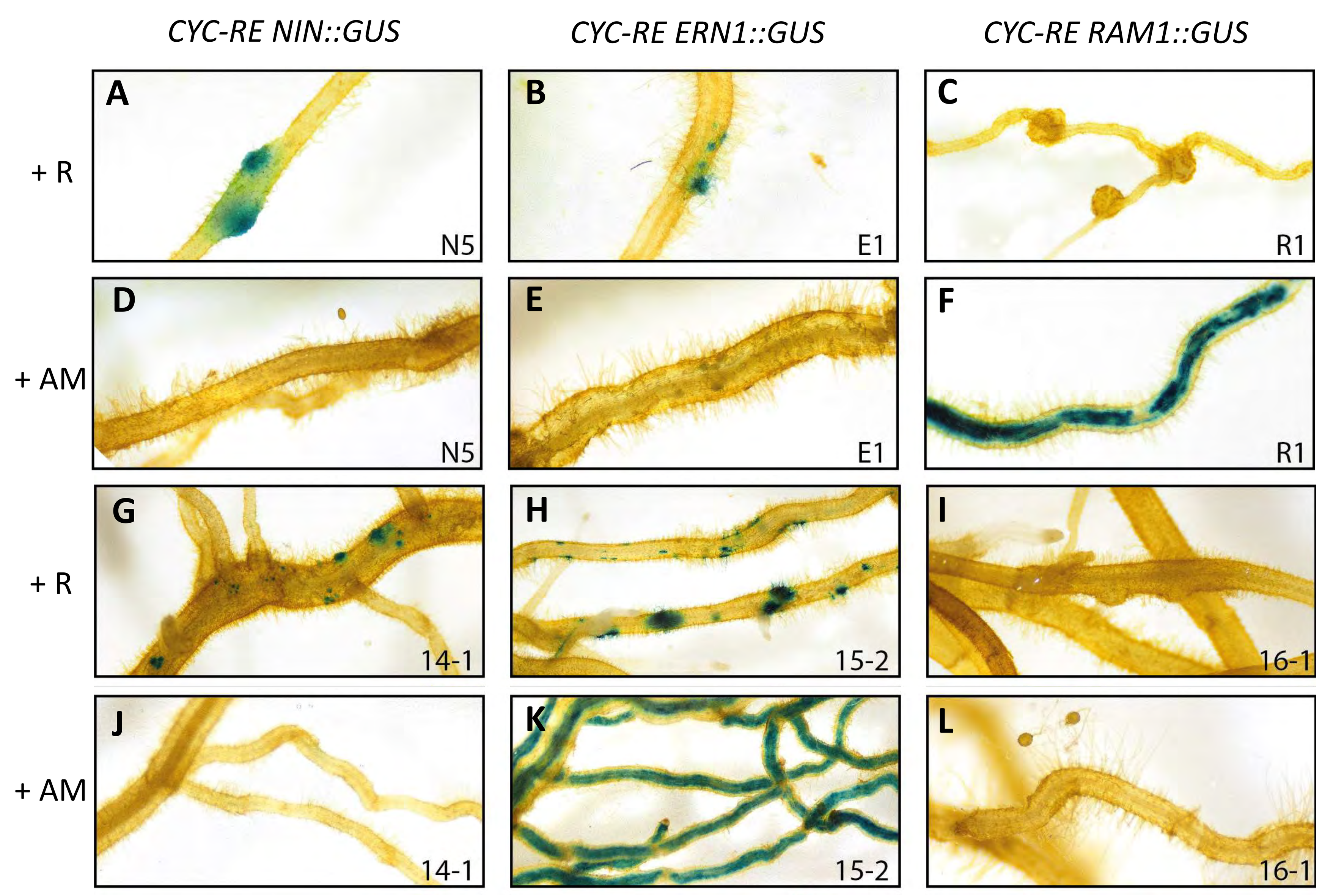

Figure 2. Responses of CYC-REs to rhizobia or AM fungi. Wild-type parosponia were stably transformed with *GUS* gene driven by CYC-REs. R: Rhizobia; AM: AM Fungi. **(A-F)** Responses of long version CYC-REs to rhizobia (2 wpi) or AM Fungi (4 wpi). **(G-L)** Responses of short version CYC-REs to rhizobia (2 wpi) or AM Fungi (4 wpi). The short CYC-REs were cloned by identifying the conserved sequence among different species.

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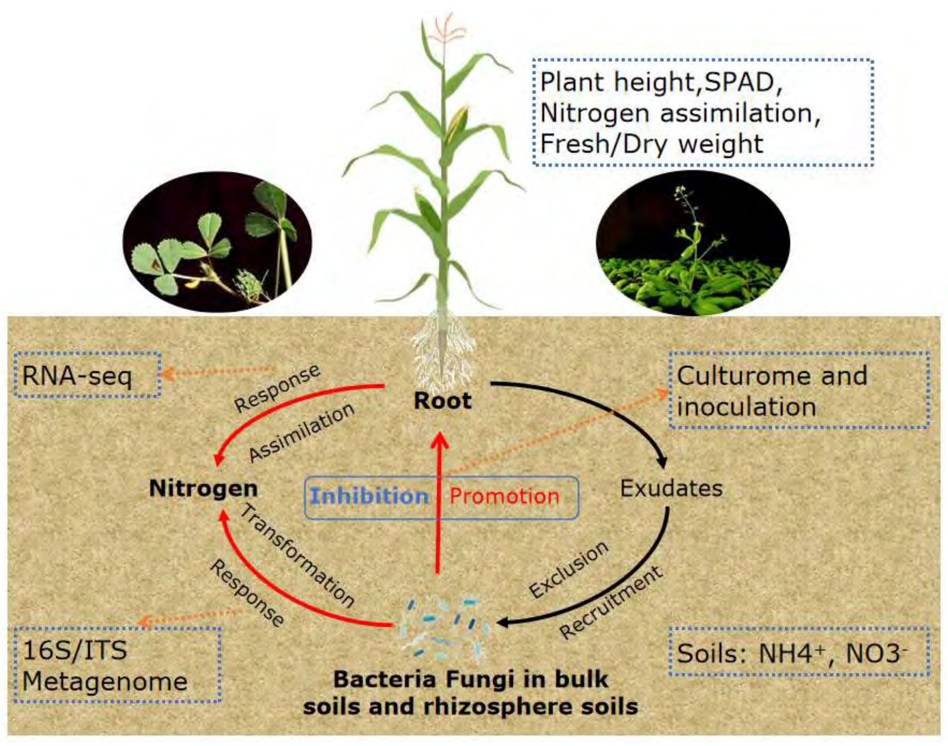
Uncovering the coordination mechanisms between plant and rhizosphere microbiome under different nitrogen levels

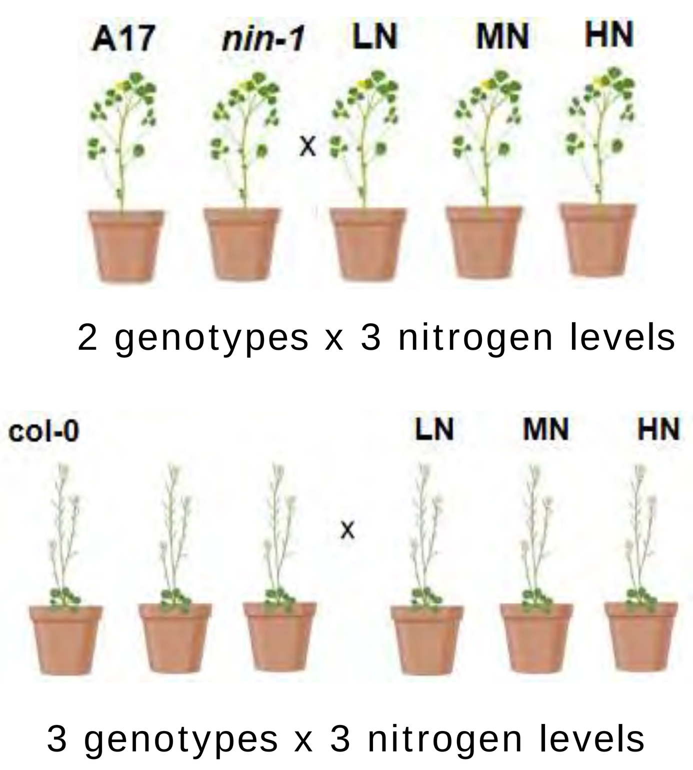
PhD student: Pugang Yu
Supervisors:Prof. Jianbo Shen, Prof. Bin Ni, Dr. Rene Geurts

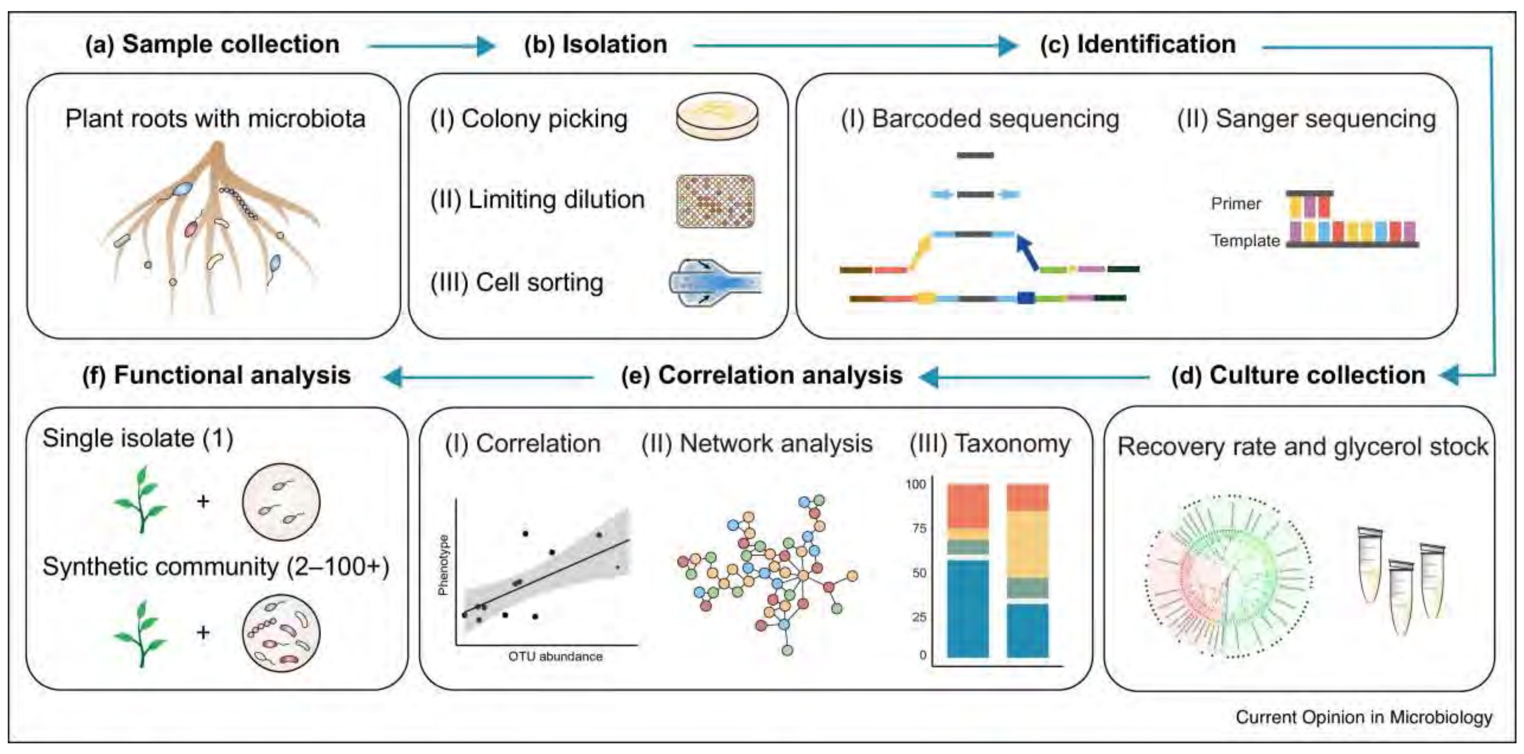
Background

- ✓ Nitrogen is an important element for plants growth and development. In the past decades, the applications of nitrogen fertilizer have greatly improved the yeilds of crops. But too many nitrogen fertilizers caused a lot of environmetal pollutions. Microbial fertilizers are ideal substitutes to partially replace chemical fertilizer.
- ✓ Microorganisms related to plants are defined as plant microbiome, which includes rhizosphere, endosphere, phyllosphere, endophytic and stem microbiome. Plant microbiome plays indispensible roles in plants growth and development, nutrients assimilations and response to abiotic or biotic stress. Rhizosphere is a special niche where soil-microorganism-plant interacts with each other. Our study mainly foucs on rhizosphere microbiome.
- ✓ Microorganisms drive nitrogen cycle including nitrogen fixation, nitrification, denitrification and so on. It was reported that long-term nitrogen input changed the compositions and fuctions of microbiome in bulk soils and rhizosphere soils. For plants, nitrogen is not only a nutrient but also a signal. Plants have complexed gene regulatory networks to response to different nitrogen input levels. Whether there are coordinations between plant and rhziosphere microbiome and how does the mechanism work are mysteries to us. In our study, we want to uncover the coordinations mechanisms between palnt and rhizosphere microbiome under different nitrogen levels.

Research methods







Culturome and Inoculation[1]

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.

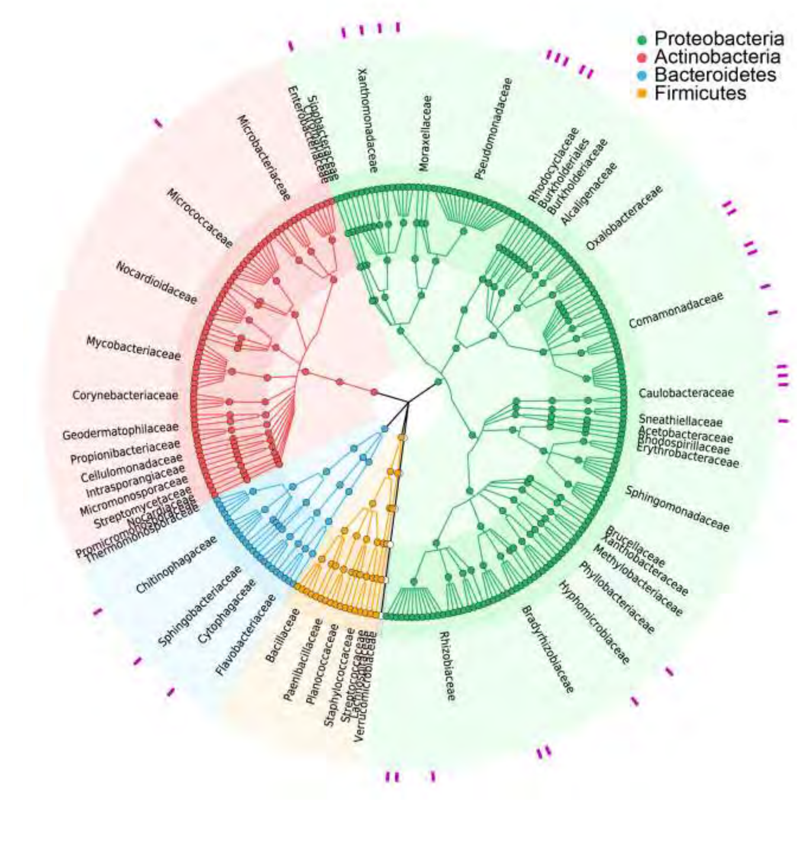
03 To explore the coordinations between rhizosphere microbiome and plant roots.

04 To find common design principles in shaping these plant-rhizosphere microbiome interactions between legumes and non-legumes?

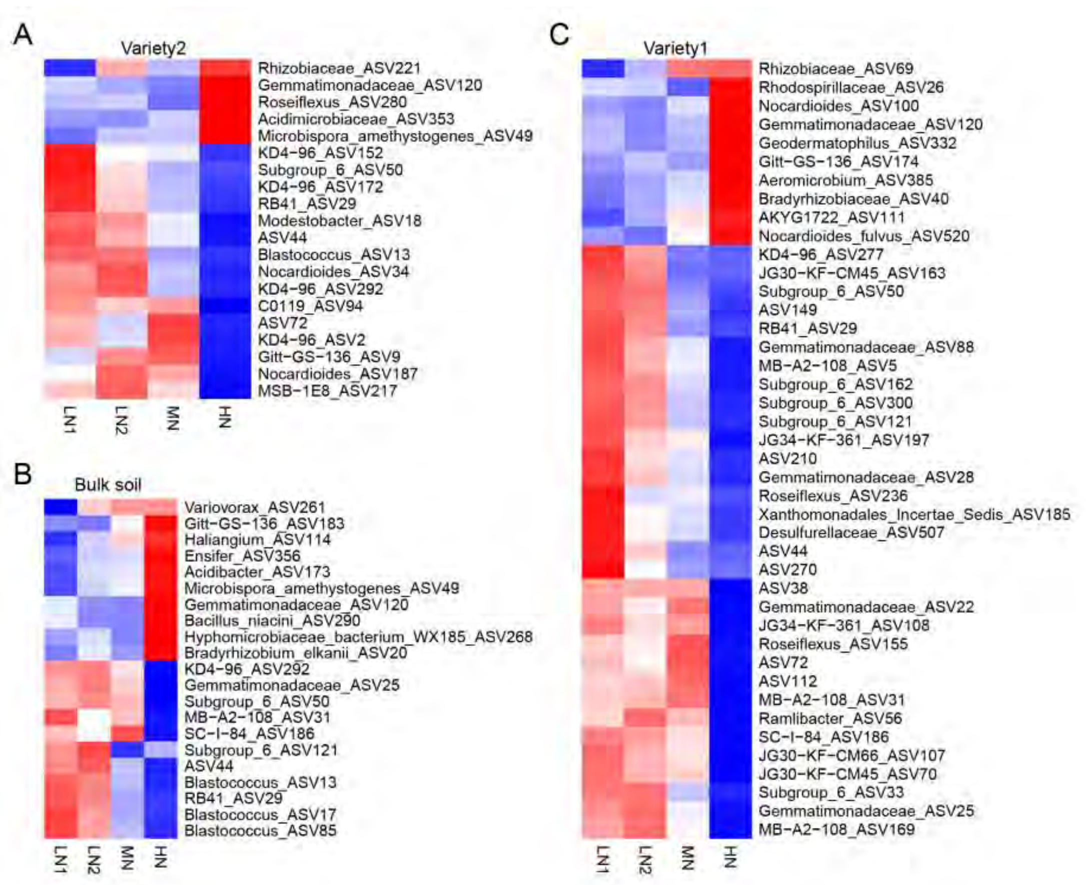
Research prospect

1. Based on the research, the coordinations between rhizosphere microbiome and plant roots under different nitrogen levels will be partly clarified.
2. Based on the theoretical breakthrough, new microbe fertilizer will be developed. Then to partly replace the applications of nitrogen fertilizer.
3. To develop new crops systems: maximize the coordinations between plants and microbiome.

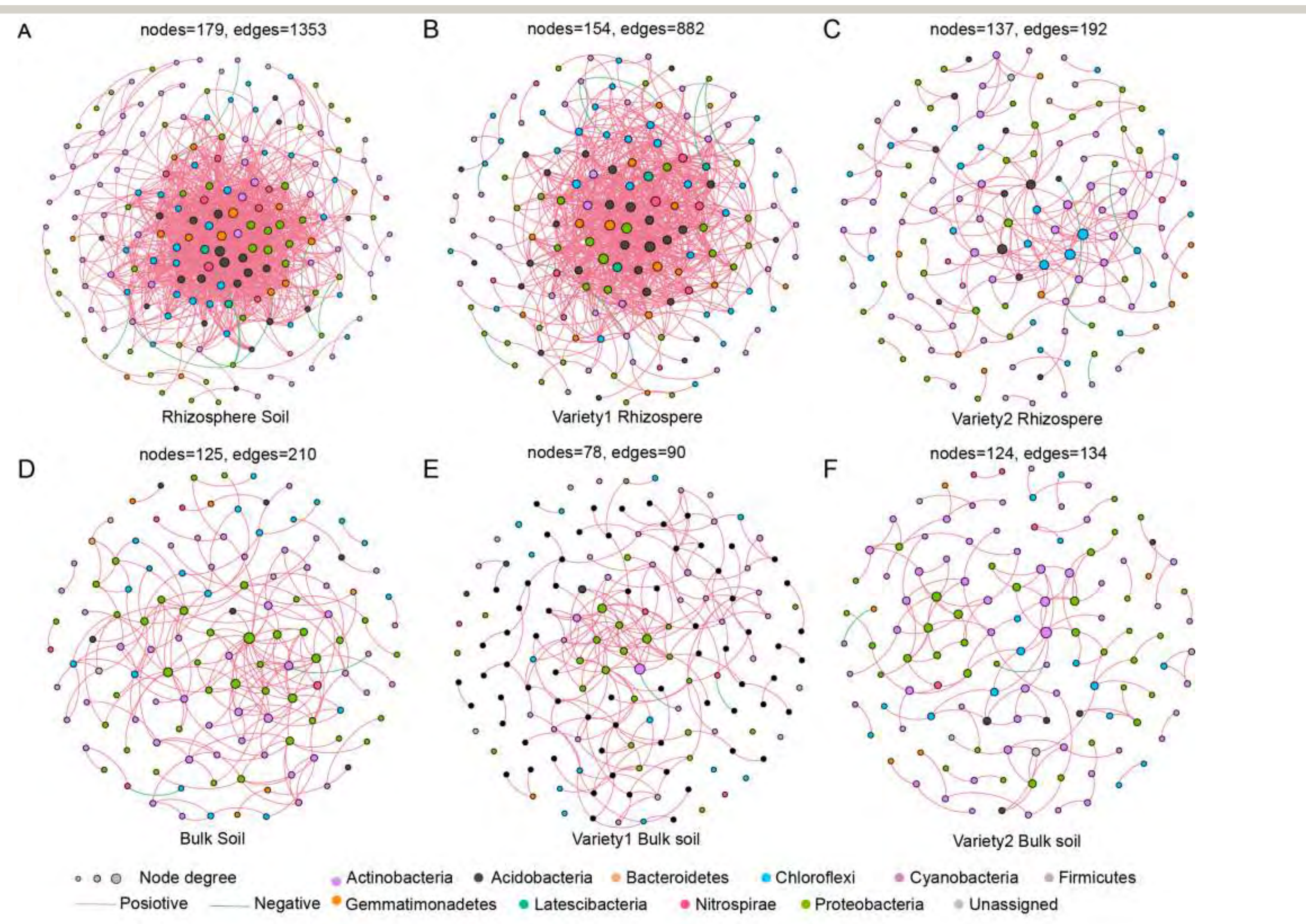
Results



8 weeks maize root bacteria cultrome



Relative abundances of marker ASVs under different nitrogen input levels



Molecular ecology networks in bulk soils and maize rhizosphere soils

Reference

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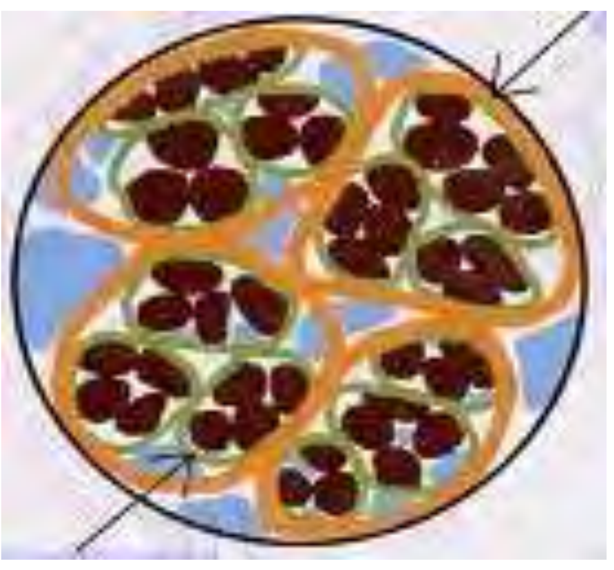
Organic manure alters N transformation and corresponding functional genes at aggregate level

Candidate: Zewen Hei

Supervisors: Yongliang Chen; Stefan Geisen; Jan Kammenga

Background



In terms of that N transformation of soil aggregate was driven by the aggregate fractions and the associated microbial organisms in organic agriculture, it's crucial to elucidate the aggregate N transformation and its associated microbial mechanism for utilizing soil N in agronomic management practices.

Objectives

1.Explore the effect of organic manure and chemical fertilizer on nitrogen transformation process at aggregate level.

2. Explore the differences between large macroaggregate, small macroaggregate and microaggregate in nitrogen transformation process

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.

Index determination

Soil extracellular enzyme activity-fluorimetric assay method

Soil N_2O production-soil microcosms in lab

potential nitrogen transformation-soil microcosms in lab

Microbial residual nitrogen-high-performance liquid chromatographer

Functional gene-Metagenomic sequencing

Results

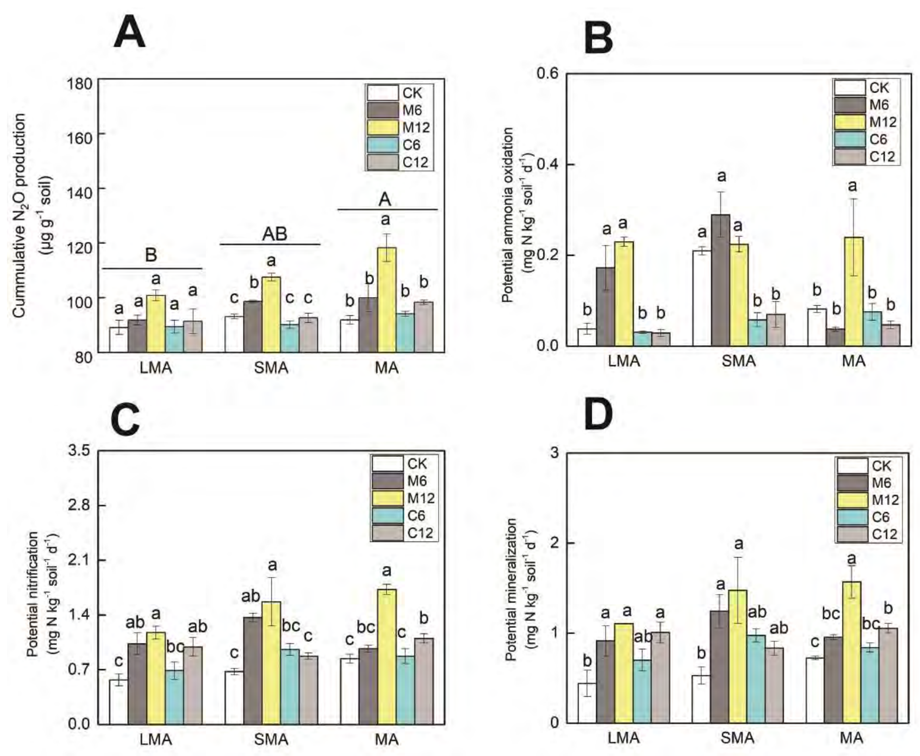


Fig. 1. Soil nitrogen transformation dynamics in organic manure and chemical fertilizer across three aggregate sizes. Potential N_2O production (A), potential ammonia oxidation (B), potential nitrification (C), and potential mineralization (D) in three aggregate size fractions.

Among the three aggregates, microaggregate had the highest cumulative N_2O production, and followed by small and large macroaggregates.

Compared with control and chemical fertilizer, high organic manure significantly increased the cumulative N_2O production, potential ammonia oxidation, nitrification and mineralizationnin small macroaggregate and microaggregate.

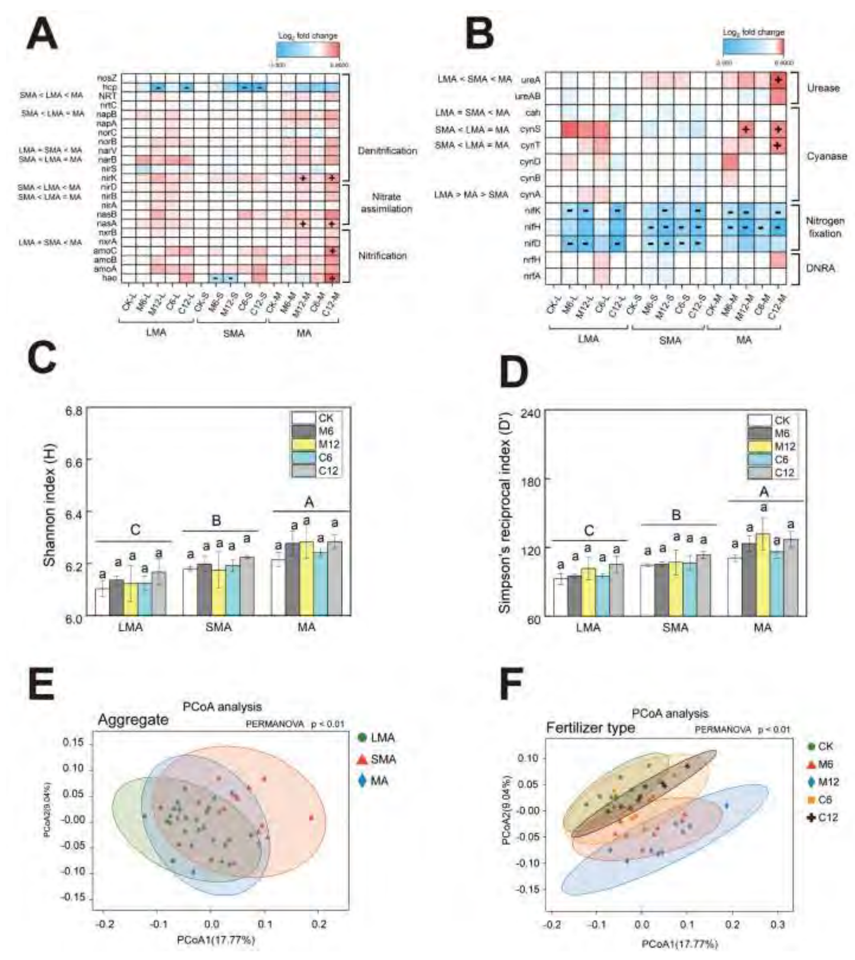
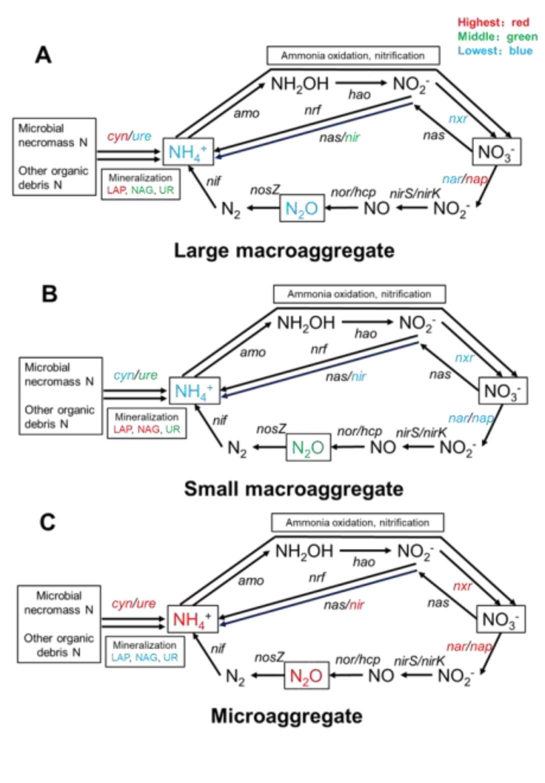


Fig.2 The abundance, alpha diversity and community structures of functional genes involved in nitrogen transformations in organic manure and chemical fertilizer across different aggregate sizes.

Microaggregate had the highest functional nitrogen transformation gene abundances, such as nitrification, denitrification, nitrate assimilation, cyanase and urease compared with other aggregates. Alpha diversity was highest in microaggregate relative to other aggregates. Significant difference was found between aggregates in beta diversity.

High organic manure significantly increased the denitrification, nitrate assimilation, cyanase gene abundances in microaggregate. On the contrary, in three aggregates, nitrogen fixation gene abundances were significantly decreased in organic manure and chemical fertilizer. Fertilizer types had significant effect on functional gene community structure.

Conclusions



Among the three aggregates, microaggregate had the highest nitrogen transformation gene abundance, alpha diversity and N_2O emission, but had the lowest enzyme activity involved in N dynamics.

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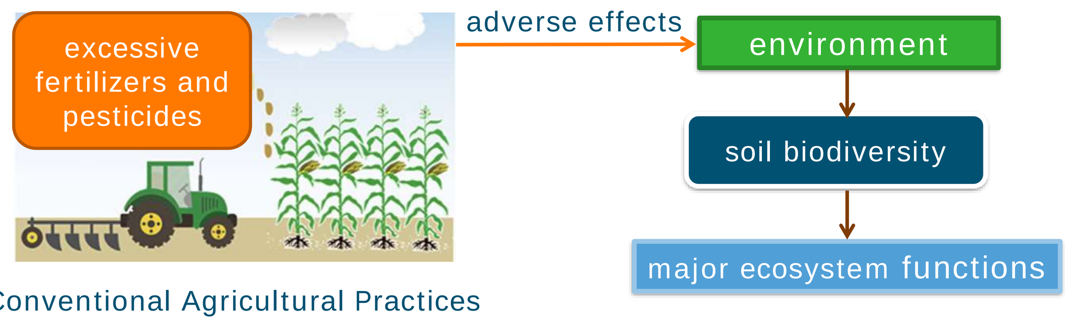
Understanding the dynamics of rhizobiomes to enhance crop productivity

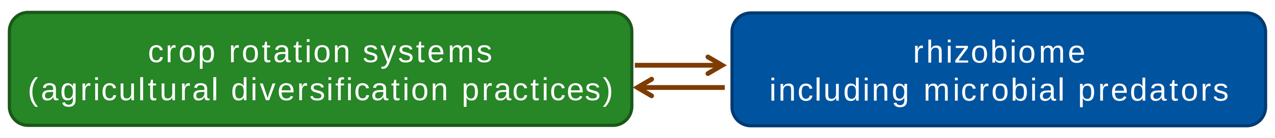
PhD candidate: Shunran Hu

Supervisors: prof.dr.ir. Jan Kammenga, dr. Stefan Geisen, dr. Yongliang Chen

Background



- Tight link between plants and the soil microbiome with both affecting another
- The importance of immensely complex microbiome on plants in crop rotation systems is missing.



- Aim to elucidate the importance of microbiome diversity and multitrophic complexity for ecosystem functioning and crop productivity in rotation systems.

Objectives

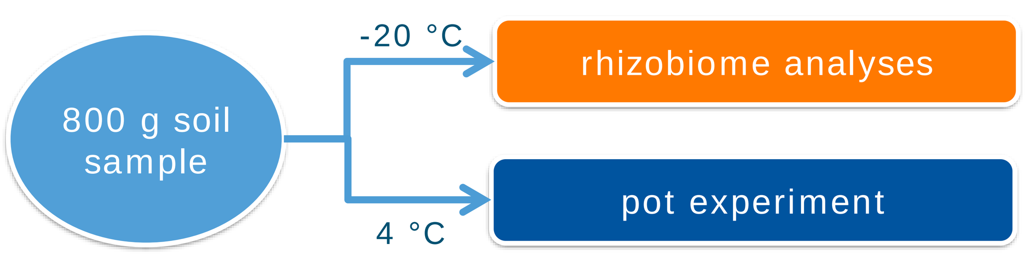
Decipher the rhizobiomes in diversified crop rotation systems and link to their functioning in terms of crop performance.

Methods

(a) Field Study

- Collected soil samples in a long-term field study that had four diversified crop rotation systems.

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)



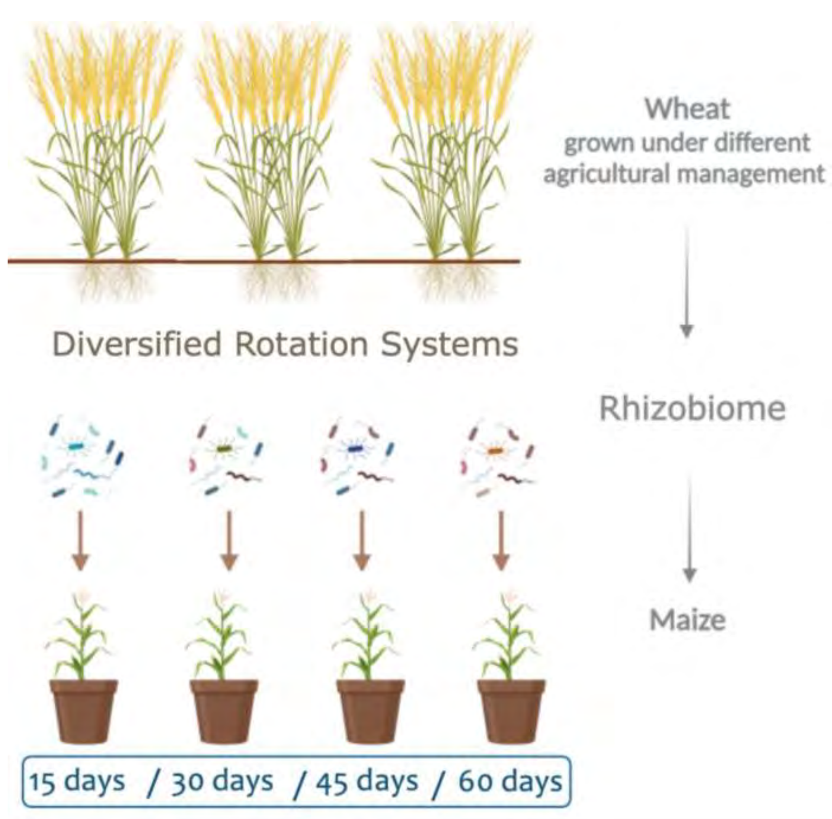
(b) Pot Experiment

- Sieved the rhizosphere soil (200 μm) → reduce interference in soil biodiversity since soil microorganisms (bacteria, fungi, protists, and most of the nematodes) could pass.

(from four diversified rotation systems) (sterilized by γ-irradiation)

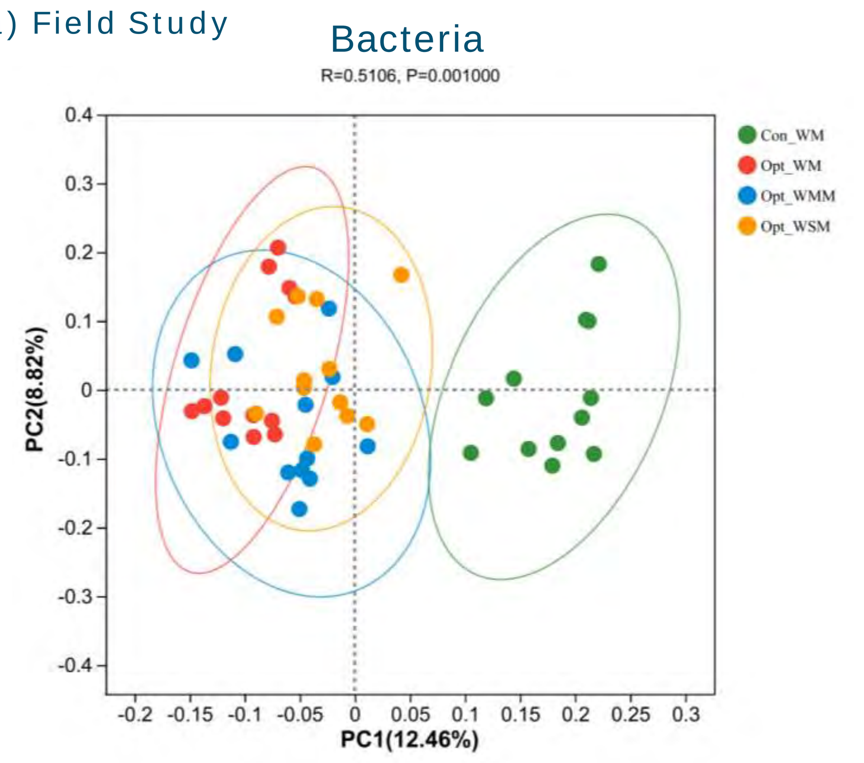
- One maize grew (approximately 30°C for 16 hours in the day and 20°C for 8 hours in the night in greenhouse) in each pot for 60 days.

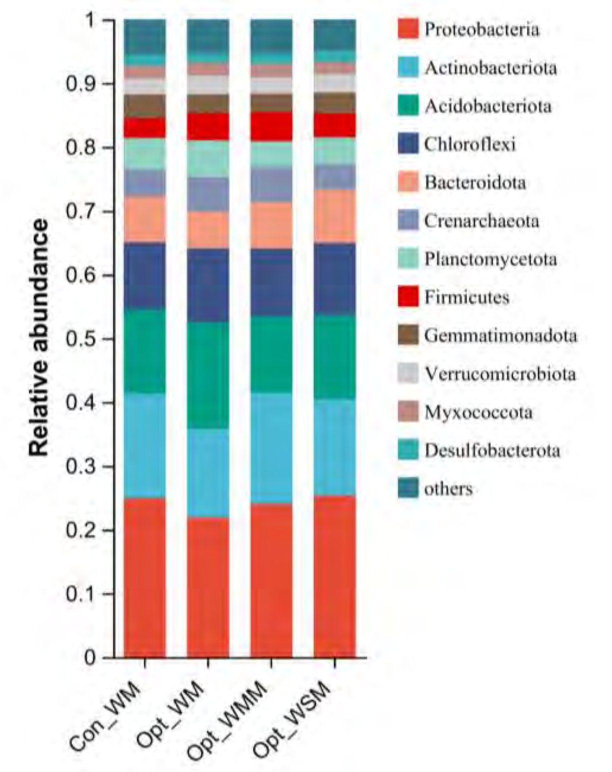
- Harvested maize every 15 days and measured:
  - -plant height
  - -chlorophyll content (SPAD)
  - -leaf area
  - -the biomass of shoot and root
- Monitored greenhouse gas (N_2O and CO_2) emission regularly.
- Normalized all the parameters to relative value on a percentage basis → enable comparison among time and crops.

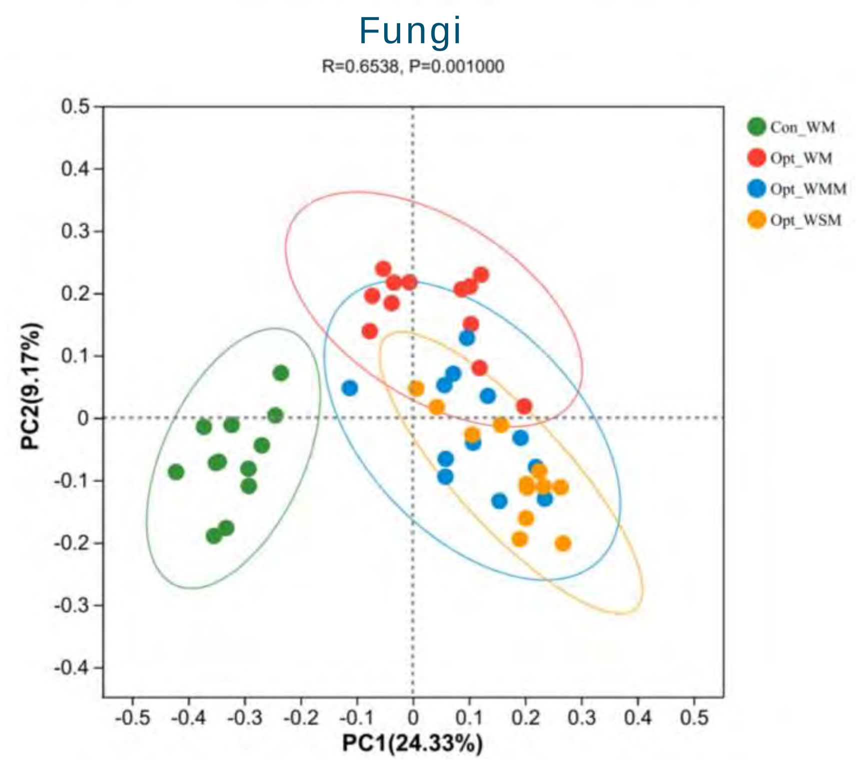


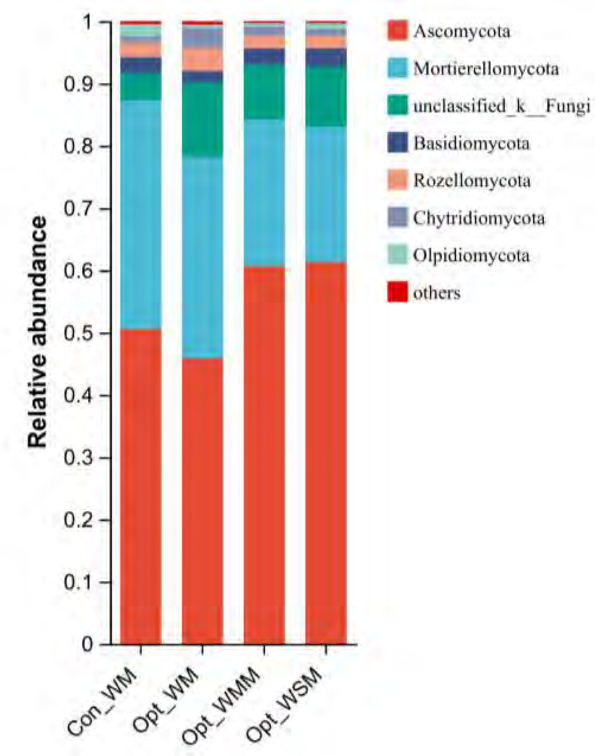
Results

(a) Field Study

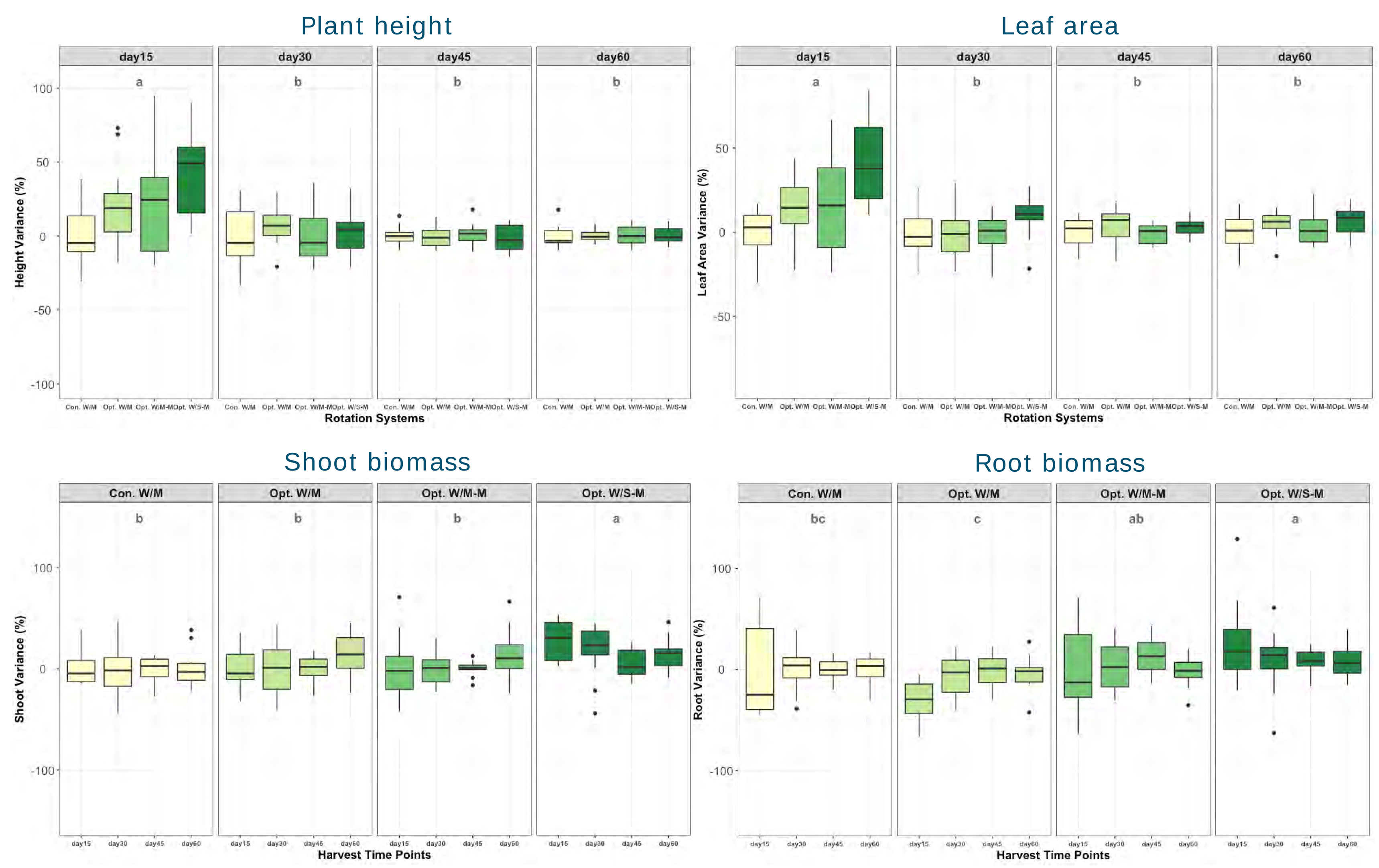








(b) Pot Experiment



Conclusions

1) Compared to less-diversified rotation systems, diversified rotation systems assembled different bacteria and fungi, which could enhance crop growth and increase greenhouse gas emission.

2) Rhizobiomes had stronger influences on crop growth and greenhouse gas emission at early stages of plant growth than at later stages.

Remaining Steps

1) Analyses on microbial predators (protists and nematodes) and microbial interactions;

2) Correlation analyses between soil biodiversity and plant performance.

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Poster overview of all current projects
submitted for the seventh
AGD symposium
1-3 February 2023

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