Current projects

Agriculture Green Development Programme

Current Projects January 2022

Wageningen University & Research

Chinese Agriculture University

WAGENINGEN UNIVERSITY & RESEARCH

中國農業大學 CHINA AGRICULTURAL UNIVERSITY 1905

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Summary reports, December 2021

Theme: Green and nutritious food provision & governance

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1. Hongyi Cai	1+3	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
2. Taian Deng	2+2	Adjusting China's Agricultural Subsidies to Transform its Agro-food Systems for Better Nutrition and Health
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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

Name	*Model**	*Project*
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5. Hao Ye	1+3	Effects of alternative dietary fibre sources and dietary protein levels in lactating sow diets on reproductive performance and litter characteristics
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Theme: Green ecological environment

Name	*Model**	*Project*
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4. Zhilong He	2+2	Agro-pollutants in the soil-water-air nexus: occurrence, transport, risk, and solutions-take pesticide as an example
5. Yanan Li	1+3	Agricultural Green Development in China – Integrated Assessment of green food production, green products and a green environment
6. Fanlei Meng	2+2	Agricultural Green Development in China – Integrated Assessment of green food production, green products and a green environment
7. Hongyu Mu	1+3	Agro-pollutants in the soil-water-air nexus: occurrence, transport, risk, and solutions-take pesticide as an example
8. Zhibiao Wei	1+3	Waste2C: From Waste to Crop – Quzhou as a Living Lab for Sustainable Agro-Food systems
9. Luncheng You	2+2	Towards sustainable nitrogen and acidification management in the Quzhou and Zhaoyuan counties and the North China Plain
10. Qi Zhang	1+3	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach

Theme: Green plant production

Name	*Model**	*Project*
1. Jiali Cheng	1+3	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
2. Zhengyuan Liang	1+3	Developing sustainable diversified crop production systems for the North China Plain
3. Mengshuai Liu	2+2	Crop rotations, intercropping, and negative plant-soil feedback in Quzhou and the North China Plain
4. Zhan Xu	1+3	Crop rotations, intercropping, and negative plant-soil feedback in Quzhou and the North China Plain
5. Lu Liu	2+2	Sustainable, Healthy, Affordable, Reliable, and preferable Diets in China
6. Jie Lu	1+3	Increasing nutrient use efficiency in maize by merging functional structural root modelling and marker assisted breeding
7. 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.

Green and Nutritious food provision & governance - 1

Reporter: Hongyi Cai

Supervisors: Pieter van ‘t Veer, Shenggen Fan, Elise Talsma, Sander Biesbroek

Date: December 20th, 2021

Background information

1. PhD Topic: Achieving healthy, low-cost, and environmentally sustainable diets in China
2. Period of appointment: from 2020.09 to 2024.09
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Over the past four decades, food production in China has grown rapidly to meet the diet requirement of increasingly wealthier population, but it has also contributed to challenges in natural resources and environment such as increased water scarcity, reduced arable land and increased greenhouse gas emissions. Thus, a transition towards sustainable diets must be pursued, focusing on the reduction of the environmental footprint of the diets while ensuring healthiness and affordability. Currently little is known about these sustainability aspects of the Chinese diets. This PhD research aims to assess the environmental footprints and affordability of current and proposed healthy and sustainable diets in China and to investigate what changes in agricultural production systems are needed to support a shift towards healthy and sustainable diets.

Report on a specific research chapter

- Research title of this chapter
- Short background
- Scientific question or research objectives
- Primary/Main results
- Conclusions

Chapter 1: Assess the environmental footprint of Chinese diets, based on the Chinese Nutrition and Health Survey.
Background: There is a lack of data, as most LCA databases are not available in China. In several Chinese publications, the environmental footprints of different food types are based on HIC databases, which are insufficient to reflect the environmental footprints in China. Furthermore, the food LCA system boundaries of most studies are based on cradle to farm gate, leaving out the impact of processing, packaging, distribution, and cooking of foods resulting in an underestimation of the actual environmental footprints.
Research objectives: What are the environmental footprints of foods and drinks in the Chinese diet?

Main results:

Figure 1. Greenhouse Gas Emissions, Water Use, and Land Use of food groups

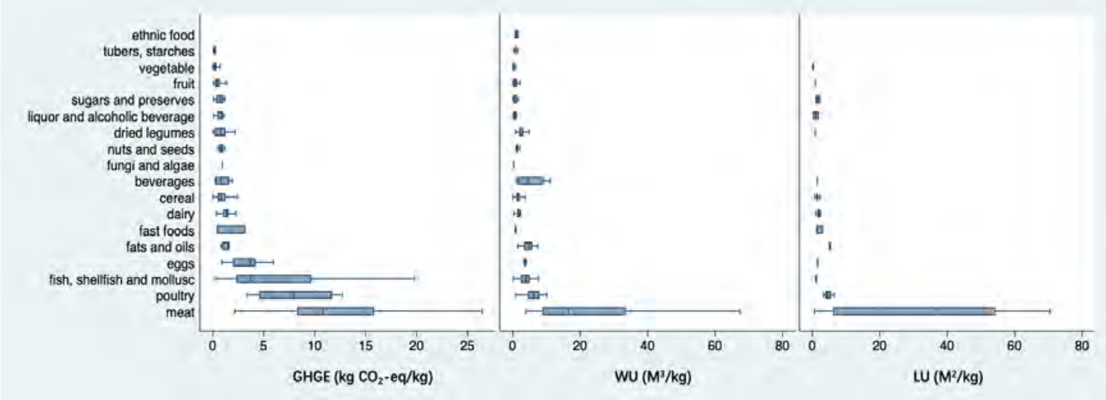
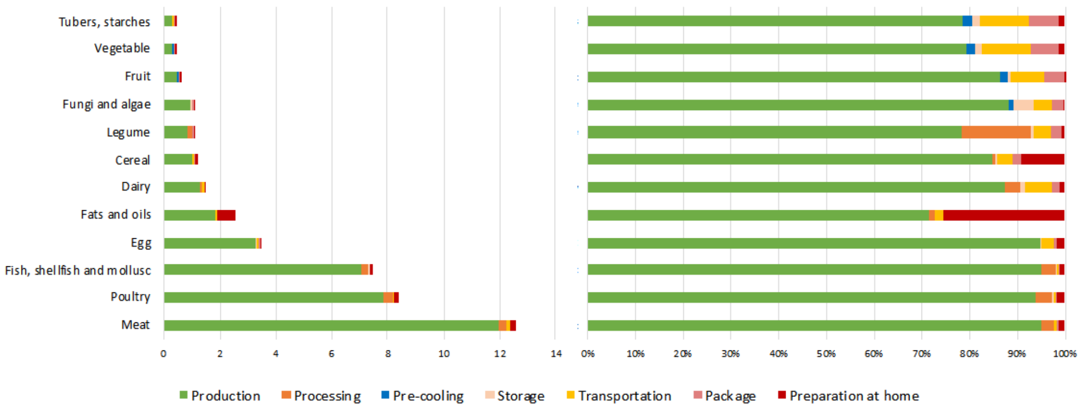


Figure 2. GHGE contribution of post-agriculture activities (kg CO2-eq/ kg) and GHGE contribution in percentage of post-agriculture activities (%)



Conclusions:

To link environmental impacts to the 1,675 food items in CHNS, this study followed these processes.

1. First, this study used data from original research on specific food items in the literature review, as described above. The mean, standard deviation, minimum and maximum values for GHGE were calculated for each specific food, and then matched to the CHNS food database directly. For stage 1 of the linkage process, GHGE matches were made for 67.9% energy and 66.9% weight of the food commodities, and WU matches for 69%, 68.1%, respectively.
2. When no LCA data is available, data from similar food group are used as proxies. For stage 2 of the linkage process, GHGE matches were made for 90.1% energy and 90.3% weight of the food commodities, and WU matches for 87.4%, 88.2%, respectively.

Chapter 2: Demographic analysis of Environmental Footprints of Diets in China

Background: Little is known about the relationship between demographic and socio-economic characteristics with diet-related environmental footprints at the sub-national level. A growing body of literature has evaluated national or regional average per capita diets in terms of environmental footprints such as GHGE, water consumption, ecological footprint and land use. However, these averages miss important socio-economic heterogeneity in dietary patterns characterized by demographic and context factors such as region, income, education level and occupation.

Research objectives: What is the diet-related environmental footprints of populations with different socio-demographic characteristics in China?

Main results: not available yet

Conclusions: not available yet

Chapter 3: Evaluation of Affordability of "Chinese Dietary Guidelines"

Background: Affordability as an important aspect of sustainable diets, has not been taken into account when developing the Chinese dietary guidelines. In contrast to the global situation, few studies evaluate the sustainability of diet from the dimension of diet costs in China. A shift to healthier and sustainable diets requires that these are not only available but also affordable for low-income populations. To date, no studies have calculated the cost of the Chinese dietary guidelines in comparison to affordability.

Research objectives: What is the affordability of dietary guidelines for Chinese residents with different socio-demographic characteristics?

Main results:

Figure 3. Cost of Recommended Diet in China, by Region, 2015-2020

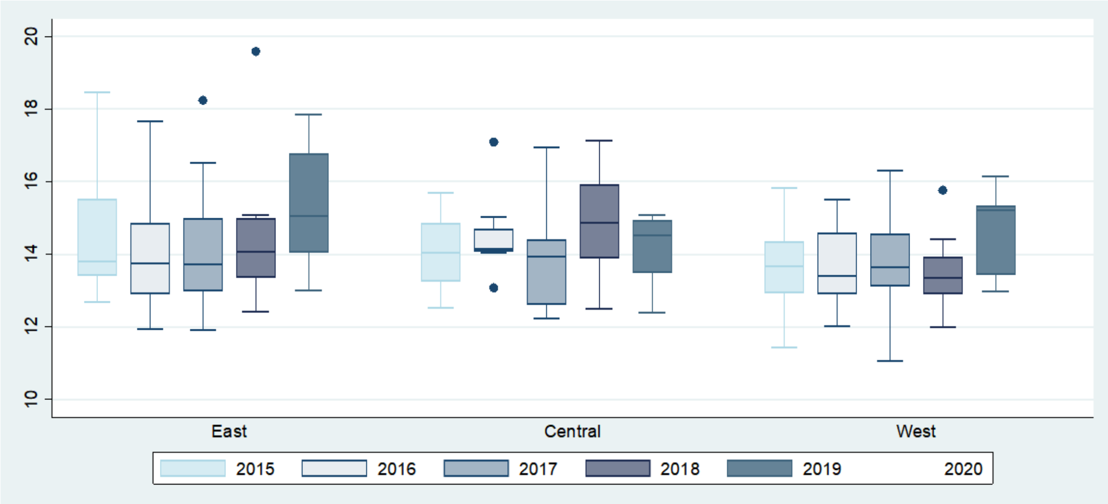


Figure 4. The CoRD of CDG and EAT-Lancet diet in China, 2015-2020

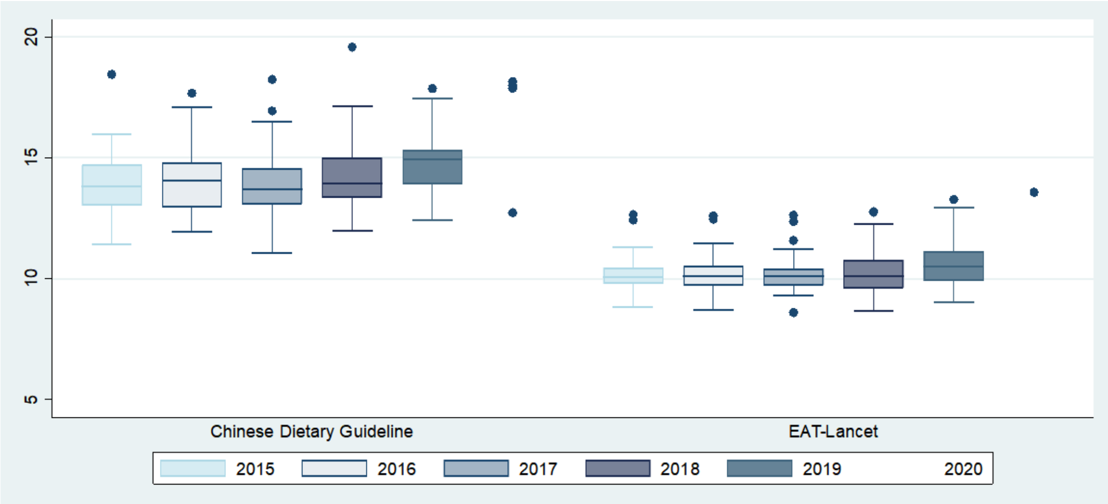
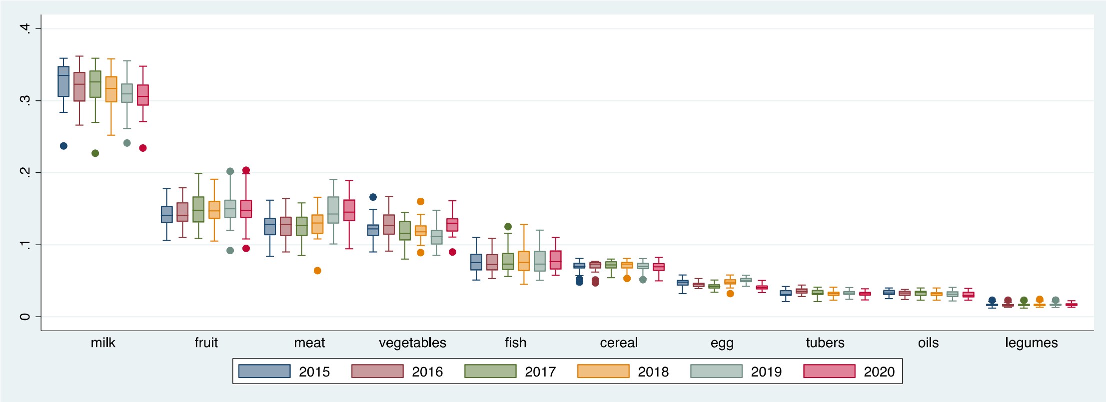


Figure 5. Percentage of food groups in CoRD, 2015-2020



Conclusions:

- The cost of recommended diets in urban is higher than in rural, and both are rising year by year.
- The food groups that account for the larger part of the cost of recommended diet are: fruits, milk, vegetables and meat.
- The proportion of meat in CoRD is decreasing year by year; Vegetables rose slightly, milk remained stable; Fruits have risen sharply after 2011.
- From 2004 to 2015, the unaffordability of CoRD in rural areas were higher than that in urban.
- Henan, Hunan, Guangxi, and Guizhou have the highest Unaffordability rate of CoRD, all exceeding 20% in 2015.

Chapter 4: Multi-dimensional assessment of the sustainability of rapidly changing diets in China

Background: To date, there has been no evaluation of whether the production of food is sufficient to provide a healthy and sustainable diet for the Chinese population. Several studies have proposed how to produce enough food for the growing population in China. As the population continues to increase in China, the food production should be affordable, nutritious and environmentally sustainable. However, few studies discussed how the food supply would need to be adapted when current food consumption shifts to the Chinese dietary guideline.

Research objectives: What changes in the Chinese food supply are required to facilitate the transition towards healthy and sustainable diets?

Main results: not available yet

Conclusions: not available yet

Green and Nutritious food provision & governance - 2

Reporter: Taian Deng

Supervisors: Shenggen Fan, Nico Heerink, Paul Ingenbleek, Fusuo Zhang

Date: December 2021

Background information

1. PhD Topic: Exploring the reasons for insufficient vegetable intake among rural residents in China: based on income, prices, habits formation and nutrition education
2. Period of appointment: from 2019/09/01 to 2023/06/30
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

To formulate science-based recommendations for policies and programs aimed at promoting increased vegetable consumption among rural residents in China, especially for those with inadequate vegetable intake.

Report on a specific research chapter

Chapter 1: Intertemporal Habit Formation of Rural Residents' Vegetables Consumption -- Evidence form the Fixed Observation Points Dataset

Short background: Vegetables play a vital role in the traditional Chinese diet, so vegetable consumption will be influenced by diet habits. Habit formation theory is a branch of consumer demand theory. According to the theory of habit formation, the consumer utility is intertemporal. It is generally assumed that the utility of consumers is inseparable in time, that is, the utility obtained by consumers depends not only on the current consumption level but also depends on the "habit stock" of previous consumption.

Scientific question: How does habit formation influence rural residents' vegetable consumption in different regions in China?

Primary results: Habit formation effect exists for vegetable consumption in rural China; the habit formation effect in the western region is the lowest, around 0.195. The habit formation effect of vegetable consumption is lower for individuals whose vegetables consumption is below the Chinese Food Guidelines (lower than 300g/person/day), around 0.129 ~ 0.298

Conclusion: Ensuring the "vegetable basket" project in the western region and stabilize the vegetables supply and prices, especially in the winter and under extreme weather conditions.

Chapter 2: Home Gardening, Food safety, and Vegetable Consumption

Short background: According to the survey data in Henan, Hebei, and Shandong provinces in 2021, about 75% of rural residents' vegetable sources are the combination of planting in front of their own houses and purchasing in the market, while only 25% of rural residents' vegetables are purchased in the market. The main reasons mentioned by the survey respondents for producing vegetables by themselves are saving money and ensuring food safety.

Scientific question: How does home gardening influence household vegetable consumption and what is the mediating role of food safety?

Primary results: Home gardening promotes vegetables intake in rural households, and food safety plays an intermediary role.

Conclusion: Home gardening for producing vegetables of Chinese rural residents should be considered in the future when the government designing the new countryside, as well as should take action for ensuring food safety.

Chapter 3: Empirical analysis of the impact of income and price changes on vegetable consumption, especially for those people who are insufficient vegetable intake

Short background: From the perspective of vegetable prices, in recent years, Chinese vegetable's prices fluctuate frequently. The national average annual wholesale price in 2020 is 4.66 yuan/kg, an increase of 10.2% from 2019, and an increase of 17.7% from the average level of the past five years.

Scientific question: To what extent do income and vegetable prices affect household vegetable consumption, especially for rural residents with insufficient vegetable intake?

Primary results: People with low income are price sensitive.

Conclusion: To reduce the loss and cost and ensure the supply of vegetables, controlling the stability of vegetable prices.

Chapter 4: How does dietary nutrition education in changing vegetable intake?

Short background: Vegetable consumption is not only affected by prices but also be affected by non-economic factors such as dietary habits, nutritional cognition, regional dietary customs, and differences in individual characteristics.

Scientific question: What is the impact of dietary nutrition education on nutritional cognition, consumption habits, and vegetable intake, especially for rural residents with insufficient vegetable intake?

Primary results: Nutritional intervention can improve residents' vegetable intake to a certain extent, and the effect is more obvious for teenagers and adults than for the elderly, and the effect is more obvious in urban areas than in rural areas.

Conclusion: Advocating the Dietary Guidelines for Chinese Residents to promote consumption of vegetables. Integrate general nutrition education into primary and secondary school curricula to promote lifelong positive nutritional behavior and promote the change of consumers' vegetable consumption behaviour.

Green and Nutritious food provision & governance - 3

Exploring sustainable transformation of plant extract industry

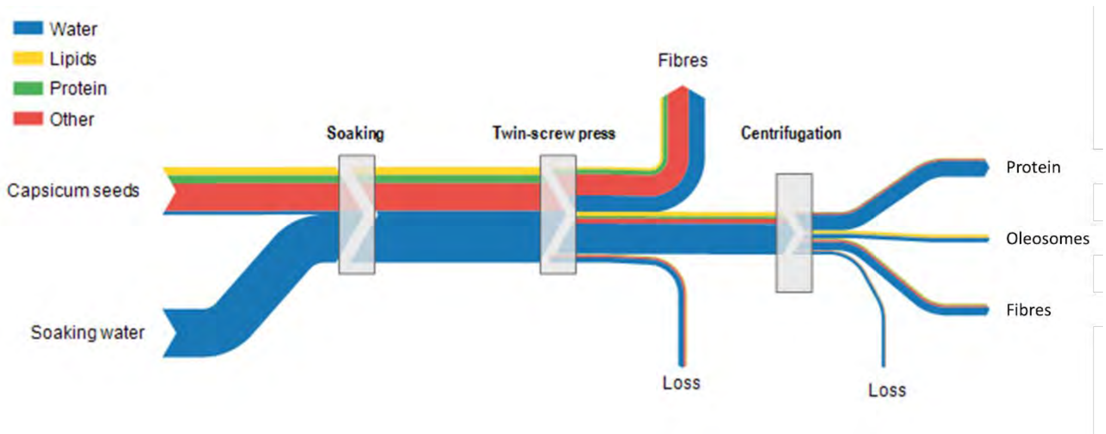
Name PhD/PD: **Mingzhao Han**
Involved staff members: Prof. Yuanying Ni, Dr. Xin Wen, Dr. Costas Nikiforidis (BCT), Prof. dr. Remko Boom (FPE)
Project sponsor: VLAG
Model: 1+3
Start/(expected) end date of project: September 2019-September 2023

Background and goal of project

Capsicum seeds is a main side stream from the production of pigments from capsicum peppers. Chenguang Biotech Group Co., Ltd. (CCGB) is the largest capsicum pigments producer in the world, and produces significant side streams that are currently under-utilised. Capsicum peppers contain around 23% oil and 21% protein. Therefore, research in the recent years focused on explore the properties of oleosomes from capsicum seeds.

Highlight of the past year

- Mass balance of oleosomes extraction from capsicum seeds.
- The basic properties of oleosomes from capsicum seeds.
- Kappa-carrageenan increase the thermal stability of oleosome emulsion

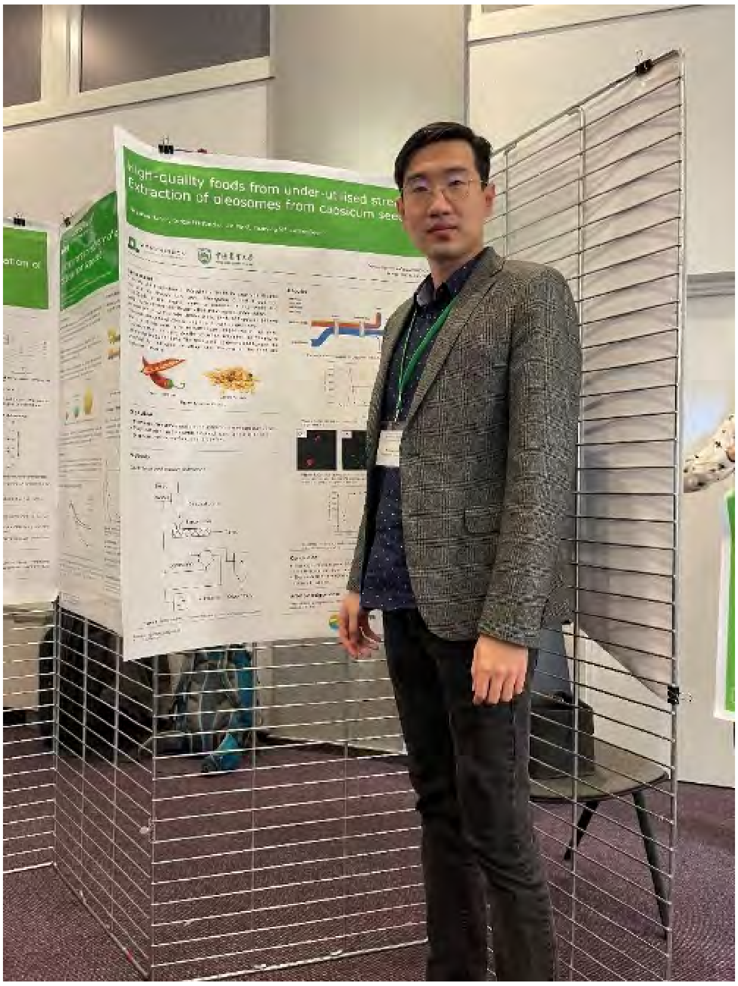


Sankey diagram of oleosomes extraction from capsicum seeds

McClements, David Julian. 2020. “Development of Next-Generation Nutritionally Fortified Plant-Based Milk Substitutes: Structural Design Principles.” *Foods* 9(4):421.

Nikos Alexandratos and JelleBruinsma. 2012. *World Agriculture towards 2030/2050: The 2012 Revision Global Perspective Studies Team FAO Agricultural Development Economics Division*

在第二届lipid droplets & oleosomes国际会议做汇报（2021年12月2日，法国斯特拉斯堡）


在第二届lipid droplets & oleosomes国际会议做海报展示（2021年12月1-3日，法国斯特拉斯堡）

Green and Nutritious food provision & governance - 4

Reporter: Jinghan Li

Supervisors: Cees Leeuwis; Nico Heerink; Weifeng Zhang

Date: December 17th, 2021

Background information

1. PhD Topic: The social impact of Science and Technology Backyards (STBs) in China
2. Period of appointment: from 2019/8/28 to 2023/8/28
3. Model: 1+3
4. Brief of research objectives in PhD thesis

The overall objective of this research is to explore how the STBs solve the complex agricultural problems in the different social contexts and how STBs adapt their activities to the local social context to promote AGD?

Chapter1: what are the interventions to promote sustainable development before the STB's emergency?

Chapter2: the emergency, development of STBs, and its characteristics.

Chapter3: functions of STBs and the difference between different social context.

Chapter4: the orientation of multi-stakeholders in the STBs network.

Chapter5: how to make the STBs more systematic?

Report on a specific research chapter

- Research title of this chapter

Promoting farmers' sustainable production behaviour in China from a historical perspective

- Short background

In the past decades, China has succeeded in producing 25% of the world's grain and feeding 20% of the world's population while using less than 10% of world arable land (FAO,2019). However, cereal grain yield in China has been merely secured by much higher input of resources, including fertilizer, irrigation, plastic film, and other chemicals (Shen et al., 2013). Challenges from substantial resources input in agricultural productions call to transition to a more sustainable production model.

The pursuit of challenge-based innovation missions has become a particular trend in the transformative process in China. For example, when we focus on pursuing green development, a series of recent missions can be found, like achieving zero growth of chemical fertilizer use by 2020 (China, 2015), achieving peak CO2 emissions before 2030, and carbon neutrality before 2060 (Luming, 2020). By formulating clear and ambitious societal goals, policymakers aim to steer the directionality and adoption of innovation (Hekkert et al., 2020).

After setting the goals and priority of development, large-scale interventions become the usual policy responses to promote sustainability in China (Bryan et al., 2018). Actions in this field are led by the central government and implemented by local governments. A complex intervention mix is the foundation of these actions. During the transition process, the intervention mix should adapt to the mission changes. However, few studies clearly understand the dynamic relationship between mission change and adaptation of intervention mixes from a historical perspective in China.

- Scientific question or research objectives

What are the interventions for sustainable development in China from a historical perspective?

Sub-questions1: how the mission changes in the different development stages?

Sub-questions2: what interventions/intervention mixes are applied to fit the different missions?

Sub-questions3: what is the influence pathway of these interventions play functions to stimulating behaviour change?

- Primary/Main results

Table1. The transition of chemical fertilizers related policies and its characteristics in China

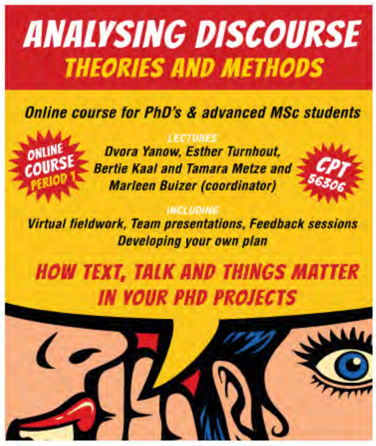
Phase	Stages	CF-related Policy focus	Main Characteristics
I	1981-2000 (6^{th} – 9^{th} FYP period)	CF production and application promotion	-Clear and increasing CF production targets -Promoting the CF industry development and CF use to improve the agriculture productivity
II	2001-2014 (10^{th} – end of 12^{th} FYP period)	CF use efficiency improvement	-Non-point source pollution caused by CF use has been appear in the official government policy repeatedly. -Promoting CF production structure transition and encouraging the products innovation -Dual pressure from keeping agriculture productivity and controlling the non-point source pollution
III	2015-2025 (end of 12^{th} – 14^{th} FYP period)	CF reduction practice	-Clear targets for CF reduction to achieve Agriculture Green Development goals -High priority for the non-point source pollution reduction -CF reduction and non-point source pollution reduction

- Conclusions

Promoting the cognition changes has great potential in improving sustainability of fertilization. However, we spare less attention to promoting cognition change. Alternative method become the main intervention approaches to promote sustainable production, but the effects is doubtful. When we cannot provide a complete support system, we cannot ignore the capacity empower of farmers. Which interventions approaches we should choose depends on what mission we should achieve. We can see an attitude transition of government about chemical fertilizer use, and after the soil testing and fertilizer formula recommendation projects governments used more attention to the communication tools, which aimed at improving farmers' knowledge. However, this types tools ignores the interactive roles of the communication tools, so it is more like up-down instruments.

Other activities

- Publication: preparing
- Meeting etc.: Not yet
- Courses: CPT 56306: Analysing discourse: theories and methods



Green and Nutritious food provision & governance - 5

Reporter: Zhiwei Yu

Supervisors: Prof. Weifeng Zhang; Prof. Wei Si; Nico Heerink

Date: December 10th, 2021

Background information

1. PhD Topic: Building belief in technology adoption
2. Period of appointment: from September 2019 to September 2023
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

The development of agriculture relies on the diffusion of new technology. The difficulty in the initial stage of technology diffusion is the lack of effective demand. Specifically, farmers find it hard to build positive belief in new technology. They cannot trust that new technology will increase their yield or bring other benefits. Therefore, these farmers will not be willing to pay for new technology. The lack of efficient demand gives rise to the lack of efficient supply. The service providers (cooperatives) will also not be willing to invest in their services without payment from farmers, which creates a low level of equilibrium between supply and demand. This kind of low-level equilibrium follows a logic similar to that of the "lemon market". Both of them stem from consumers' distrust of products. Therefore, the research question is that how to guide the low equilibrium to high equilibrium.

Report on a specific research chapter

1. The brief introduction of straw returning

The whole machine investment in straw returning is 70,000 yuan, including strip-tillage cultivators (15,000 yuan, only cultivating seeding rows rather than all field), straw sorting machines (5000 yuan, sorting out straws outside seeding rows), special seeder (50,000 yuan, sowing seeds into the soil mixed with a few straws). A group of these three machines can service 30 hectares of land. It means that smallholders (lower than 10 ha) will lose money if they invest in these machines. The marginal cost of straw returning will not exceed the cost of the traditional way. The most concerned risk of farmers is the decrease in the emergence rate of seeding. The other is that the grass mulched by straws is not easy to control.

The most difficult point of straw returning technology is that the improvement of soil by straw returning is not easy to be observed by farmers. Moreover, whether soil improvement will transfer to the increase in yield is also hard to prove by farmers. Because these two changes may need five years to get feedback. However, it does not take long to get negative feedback, such as the decrease in the emergence rate of seeds.

Table 1. The cost of conservation tillage and traditional tillage

	conservation tillage（保护性耕作）	traditional tillage（传统耕作）
Clean straws (清理秸秆)	100 yuan/ha (sort out straws)	600 yuan/ha (clean straws by hands)
Tillage （旋地）	400 yuan/ha	700 yuan/ha
sow seeds （播种）	500 yuan/ha	300 yuan/ha
all	**1000 yuan/ha**	**1600 yuan/ha**
Machine investment	70,000 yuan	
Potential risk	Decrease in emergence rate The grass mulched by straws is not easy to control	

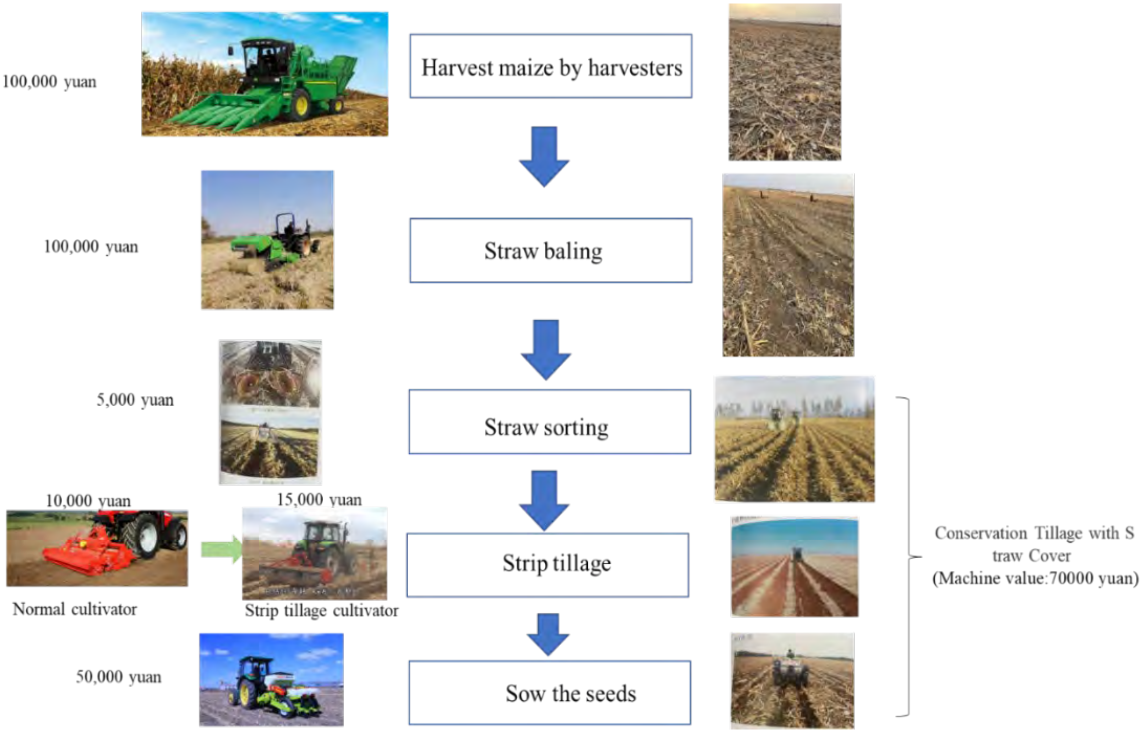


Figure 1. the technology model of straw returning

2. Research objectives

This study aims to explore how to build farmers' belief of straw returning and guide the service market from low-level equilibrium to high-level equilibrium. The service providers play the crucial role to "pry" smallholders to believe the benefit of straw returning. Therefore, the study try to focus on the impacts of service providers on smallholders.

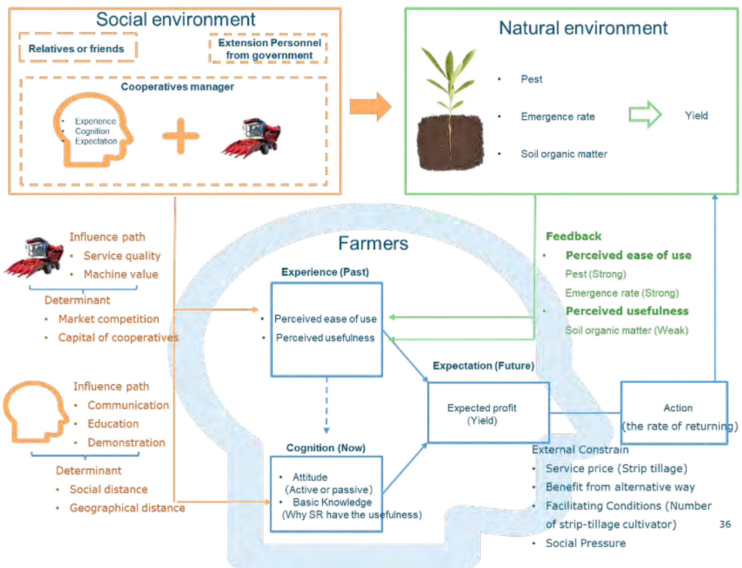


Figure 2. General Concept model of the impacts of service providers on smallholders

2.1 Objectives 1: socio-psychological analysis on straw-returning adoption

The logic of this part follows “Experience (past) – Cognition (now)- Expectation (future)”, which are in the blue brain (Figure 2). First, I intend to test the connection between these concepts and identify the most important socio-psychological factors affecting farmers’ actions.

Moreover, the research focuses on the comparison of cognition of different groups. The service providers are also the straw-returning adopters like smallholders, apart from the suppliers of straw-returning services. Did service providers and smallholders have big gaps in knowledge, norms, attitude? Did service providers perceive the technology easier and useful than smallholders? Is this because service providers sort straws in their lands but not sort for farmers? Or is this because service providers have more knowledge and can distinguish the benefit of straw returning?

Finally, the social and physical distance may determine how service providers influence smallholders’ knowledge, attitude and benefit belief. So, I need to investigate the private relationship between smallholders and service providers. In addition, I will also record the smallholders’ land plot, which is the nearest one from the service providers’ land plot.

2.2 Objective 2: How cost-benefit factors impact the process from belief to action or decision

Farmers’ benefit of adopting straw returning: potential increase in soil and yield; norms

Farmers’ cost of adopting straw returning: service price (most farmers will get service for free), low service quality causing the decrease in emergence rate of seeding, opportunity cost (Price of feed or coals), potential risk (the increase in grass and pests).

Service providers’ benefit for serving farmers: subsidy from government, service price (some providers may charge additional free)

Service providers’ cost for serving farmers: operation cost (especially whether service providers increase the operation of sorting out straws before returning), investment in machines, opportunity cost (Income from straw baling), potential risk (may not get the subsidy due to failing inspection).

Green animal production - 1

Reporter: Guichao Dai

Supervisors: Yong Hou, Fusuo Zhang , Oene Oenema, Hans-Peter Weikard

Date: December 23th, 2021

Background information

1. PhD Topic: Promoting the sustainability of China's cropping and livestock systems from the perspective of feed supply and demand balances
2. Period of appointment: from 2019.09.01 to 2023.06.01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:
   - Chapter 1. Historical trends of feed use in China
   - Chapter 2. How can China increase its domestic feed production for its increasing livestock population?
   - Chapter 3. Improving China's animal product supply and reducing environmental costs by optimizing livestock systems
   - Chapter 4. Securing food security in China through structural modifications in crop and livestock systems

Report on a specific research chapter

- Research title of this chapter

How can China increase its domestic feed production for its increasing livestock population?

- Short background

The increasing feed demand by the increasing livestock population in China leads to food-feed competition for available cropland and to increasing dependence on feed imports. However, the domestic feed production has not been optimized for the increasing feed demand, suggesting that there is potential for increased feed production. This paper addresses the question of how much additional feed can be produced through optimized allocation of crop types to cropping regions, using a linear optimization model and a series of sociolect-economic and environmental constraints. Results indicate that total feed energy production may be increased by 17.57% and total feed protein production by 18.59% through spatially optimized crop-type distributions across the country. At the same time, nitrogen (N) and phosphorus (P) fertilizer inputs may be reduced by 0.16 and 0.18 Mt per year and total greenhouse gas emissions by 3.4 Mt CO_2-equivalent. Our results reveal a marked regional heterogeneity in the potential for optimization, with large potential for increasing feed energy production and decreasing fertilizer inputs in the North-east and for reducing GHG emissions in the South-east. Especially, the area under silage maize will increase. Spatial optimization of the feed crop distribution will diminish the food-feed competition for cropland and strongly decrease the dependence on imported feed , with 3.42 Mt of CO2 equivalences GHG emissions.

- Scientific question or research objectives

Research Objective 1: To investigate the potential to increase the feed supply level in China through feed crop redistribution.

Research Objective 2: To explore how the current cropping structure should be modified when market and environmental indicators are taken into account.

- Primary/Main results

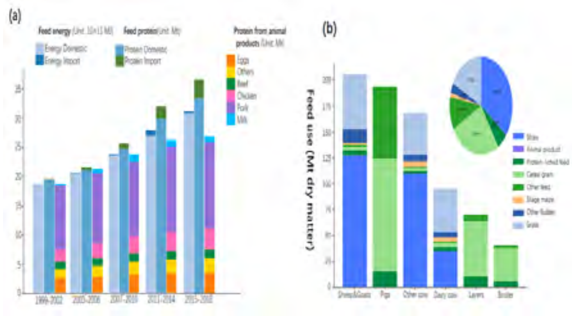


Fig 1. Feed use along with animal products consumption in China.

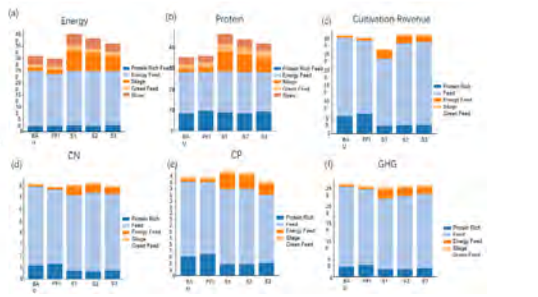


Fig 2. Feed energy, feed protein, farmer income, nitrogen fertilizer and phosphate fertilizer input, and GHG emissions under different scenarios.

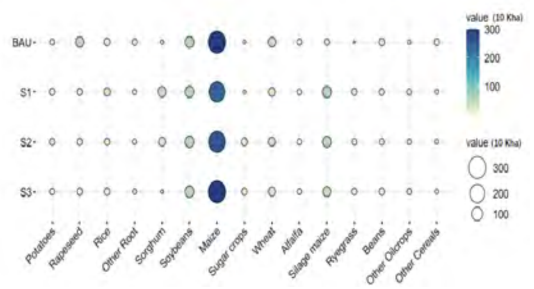


Fig 3. Changes in the planting area of each crop used for feed

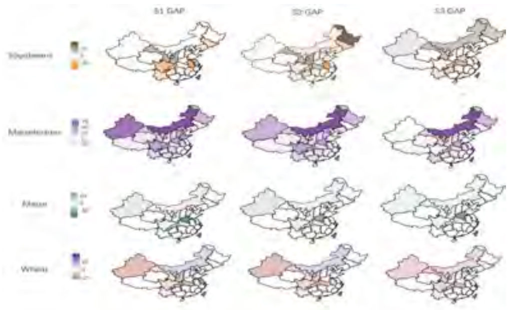


Fig 4. Changes in area under major crops in different scenarios.

- Conclusions

1. From 1999-2018, average annual feed energy use increased from 18.69×10^{11} to 31.11×10^{11}tons .
2. By reallocating feed crops we can increase the cultivation revenue, reduce fertilizer inputs and GHG emissions while increasing the feed energy supply by 17.57% and the feed protein supply by 18.59%.
3. In the future we should increase the area under silage maize and realign the areas under maize and soybeans.

Green animal production - 2

Reporter: Tao Zhang

Supervisors: Yong Hou, Oene Oenema, Hans-Peter Weikard

Date: December 12th, 2021

Background information

1. PhD Topic: The key socio-economic barriers for manure application in different cropping systems and the evaluation of comprehensive environmental effects

2. Period of appointment: from 2019 to 2022

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

1. To explore the key drivers and socio-economic barriers towards manure application.

2. To identify crop farmers' preferences for policy of manure application, and the impact of farmer characteristics on farmers' preferences.

3. Towards greater manure utilization and the reduction of synthetic fertilizers, under the agronomic, economic and environmental constraints.

Report on a specific research chapter

- Research title of this chapter

How to mitigate the risk of nitrogen and phosphorus losses in China's intensive livestock areas?

- Short background

A low recycling of manure nutrients concomitant with a large use of synthetic fertilizer reflects a 'double waste of resources' and a 'double environmental pollution' in China's intensive livestock areas. It is also uncertain for us how to achieve manure utilization and synthetic fertilizers, sustaining food security and mitigating the risks of nitrogen and phosphorus losses?

- Scientific question or research objectives

To promote manure utilization and synthetic fertilizers reduction, enhancing crop yields simultaneously mitigating the risk of nitrogen and phosphorus losses in China's intensive livestock areas.

- Primary/Main results

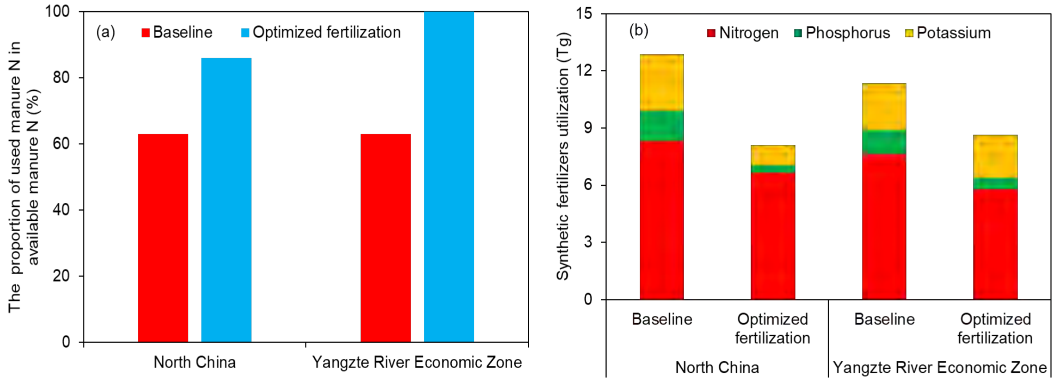


Figure 1. The utilization of manure (a) and synthetic fertilizers (b).

Optimized fertilization with integrating crops nutrients demands, soil fertility and manure nutrients availability, increased the ratio of manure N recycling in available manure N from 63% to 86-100% in North China (NC) and Yangtze River Economic Zone (YREZ). Compared to baseline, the total amount of synthetic fertilizer NPK can be reduced by 37% and 24% in NC and YREZ, and P has the highest potential of reduction with 52-78%.

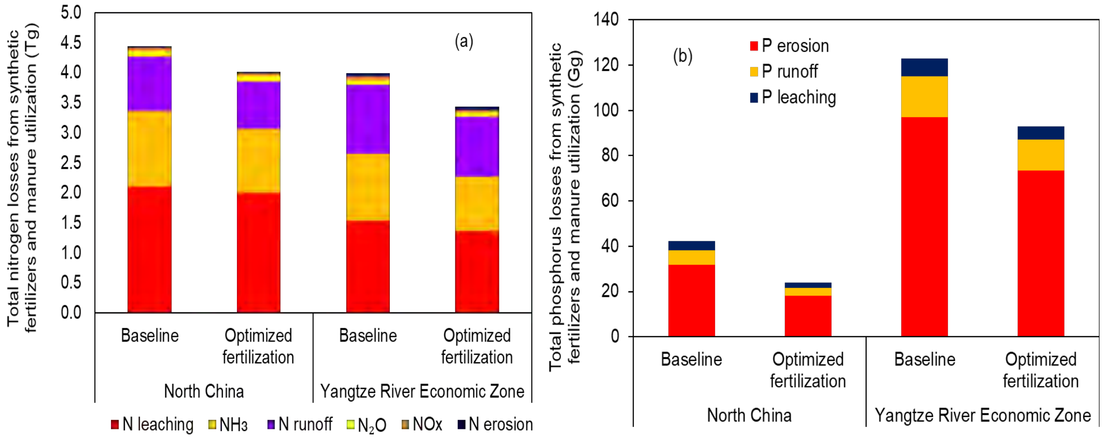


Figure 2. The risk of manure (a) and synthetic fertilizer NP losses (b).

There was great potential of reduction of N&P losses for optimized fertilization. Compared baseline, the P losses can be reduced by 44% and 24% in NC and YREZ, respectively, while N losses can be reduced by 10% and 14% for optimized fertilization.

- Conclusions

There was great potential of manure utilization and synthetic fertilizers reduction, simultaneously mitigated the risks of N&P losses, through integrating crop category-specific nutrients demands, spatial difference of soil fertility and manure type-specific nutrients availability, in China's intensive livestock areas.

Other activities

- Publication

1. T Zhang, Y Hou, T Meng, YF Ma, MX Tan, FS Zhang, O Oenema. Replacing synthetic fertilizer by manure requires adjusted technology and incentives: A farm survey across China. 2021, Resources, Conservation & Recycling, 168: 105301.
2. T Zhang, T Meng, Y Hou, XF Huang, O Oenema. When do crop farmers replace synthetic fertilizers by manure: a choice experiment in China. Resources, Conservation & Recycling (Under revision).

- Meeting: Attend SURE+ International Conferences and make oral presentation in 16 Oct, 2021.

Green animal production - 3

Reporter: Zhenyu Wang

Supervisors: Professor Wang Junjun

Date: December 19th, 2021

Background information

1. PhD Topic: Microbiota-mediated detrimental effect of dietary fiber deprivation in pigs and its implication for pig production and AGD

2. Period of appointment: from 2019/9/1 to 2023/6/30

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

My research focus on understanding the effect of dietary fiber on gut microbiome and gut health status of pigs. The specific chapter arrangement as following:

Chapter 1: Xylan alleviates dietary fiber deprivation-induced dysbiosis by selectively promoting *Bifidobacterium pseudocatenulatum* in pigs

Chapter 2: The detrimental effect of dietary fiber on growth performance and diarrhea of weaned piglets and its association with gut microbiome

Chapter 3: Microbiota-mediated mechanism responsible for detrimental effect of dietary fiber deprivation on pathogen colonization resistance

Chapter 4: Combination strategy of fiber-rich ingredients to achieve optimal performance in pigs

Report on a specific research chapter

Chapter 1 (Finished)

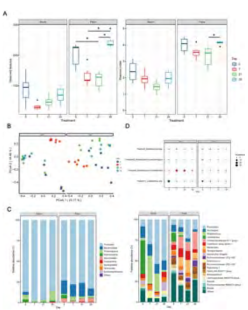
Research title of this chapter

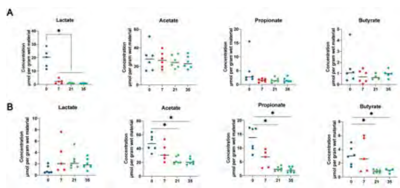
Xylan alleviates dietary fiber deprivation-induced dysbiosis by selectively promoting *Bifidobacterium pseudocatenulatum* in pigs

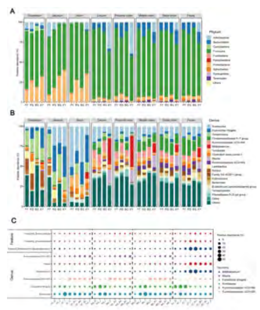
Scientific question or research objectives

Investigating the negative effect of dietary fiber deprivation and whether inclusion of dietary fiber components could alleviate this?

Primary/Main results







Conclusions

Dietary fiber deprivation could induce the probiotic extinction and loss of SCFA production while potential pathogen was promoted. Xylan intervention could precisely restore dietary fiber deprivation-induced gut dysbiosis through selectively promoting B. pseudocatenulatum, and therefore normalizing the gut environment and improving epithelial function.

Chapter 2 (Under analysis)

Research title of this chapter

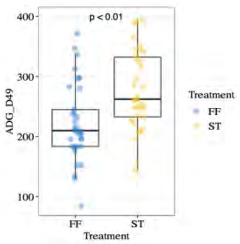
The detrimental effect of dietary fiber on growth performance and diarrhea of weaned piglets and its association with gut microbiome

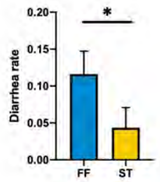
Scientific question or research objectives

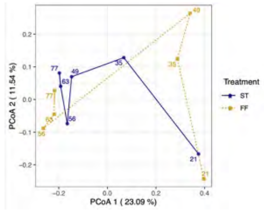
Whether dietary fiber deprivation has detrimental effect on growth performance and diarrhea rate?

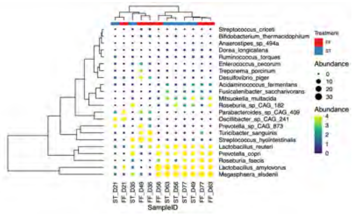
Is this effect associated with gut microbiome?

Primary/Main results









Conclusions

Dietary fiber reduces growth performance and increases diarrhea rate. And this effect may be associated with loss of *Lactobacillus* and *Prevotella*.

Chapter 2 (Under conduction)

Research title of this chapter

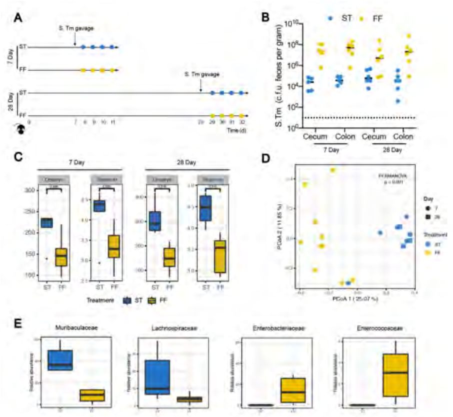
Microbiota-mediated mechanism responsible for detrimental effect of dietary fiber deprivation on pathogen colonization resistance

Scientific question or research objectives

Is alpha diversity or specific bacteria responsible for the colonization resistance against S.Tm?

The specific mechanism?

Primary/Main results



Publication

1. Zhenyu Wang, Yu Bai, Yu Pi, Shiyu Tao, Shiyi Zhang, Dandan Han, Sonja de Vries, Walter J. J. Gerrits, Junjun Wang[#]. Xylan alleviates dietary fiber deprivation-induced dysbiosis by selectively promoting *Bifidobacterium pseudocatenulatum* in pigs. Microbiome.9.227.(2021)

Green animal production - 4

Reporter: Shiyi Zhang

Supervisors: Walter Gerrits, Sonja de Vries, Junjun Wang

Date: December 20th, 2021

Background information

1. PhD Topic: Protein and starch digestion kinetics and effect of fibres on protein digestion in pig
2. Period of appointment: from 2019/9/1 to 2023/8/31
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

To optimize the utilization of 5 feed ingredients, especially protein and starch sources, digestion kinetics chosen feed ingredients and factors explaining variation in digestion kinetics, such as secondary protein structure, AA sequence and fibre type will be identified.

Therefore, the following research questions are raised according to the present project:

1) Evaluate the feeding value and the variation among batches of unconventional feed ingredients (soybean meal, rapeseed meal, peanut meal, cotton seed meal and DDGS) in order to increase the efficiency of by-product utilization for pork production, particularly in China.

2) Develop in vitro methodology to evaluate protein digestion kinetics of the selected protein sources.

3) Estimate the influence of dietary fibres, usually part of these unconventional protein sources, on the protein digestion process, particularly through their effect on physicochemical properties inside the intestinal tract.

Report on a specific research chapter

- Research title of this chapter

  In vitro protein and starch digestion kinetics (in process)

- Short background

  Current pig feed evaluation systems are usually based on the digestibility of different nutrients. The digestibility of nutrients can vary significantly from feed to feed due to differences in structure and composition and measuring digestibility in vivo is time-consuming and expensive. Therefore, there is a need for fast, inexpensive, but reliable in vitro methods to determine the nutrient digestibility of single feeds used in feed formulations.

  Several in vitro methods simulating the digestive processes have been developed to estimate protein digestibility (Boisen and Eggum, 1991; Boisen and Fernandez, 1997). The method of Boisen and Fernandez (1997) was commonly used in measuring digestibility of various feed ingredients by simulating the digestion process in the total gastrointestinal tract (GIT) in pigs. However, since the ileal digestibility cannot show the kinetics and interaction between different macronutrients, a developed method is explored, especially for the low molecular weight nitrogen and sugars, which can be absorbed by the intestinal cells. Moreover, the brush border enzymes was lacking in the previous in vitro method, which may result in an underestimated amino acids digestibility, it is considered in the developed method.

- Scientific question or research objectives
    1. What are the decision parameters of protein breakdown to absorbed molecules. Can BBM break down soluble high molecular weight N to low molecular weight N (starch to glucose)?
    2. Is in vitro protein digestibility comparable with in vivo after adding BBM?
    3. How does molecular size change from insoluble to soluble, and from high molecular to low molecular fraction (for both protein and starch)? What is the kinetics?

- Primary/Main results

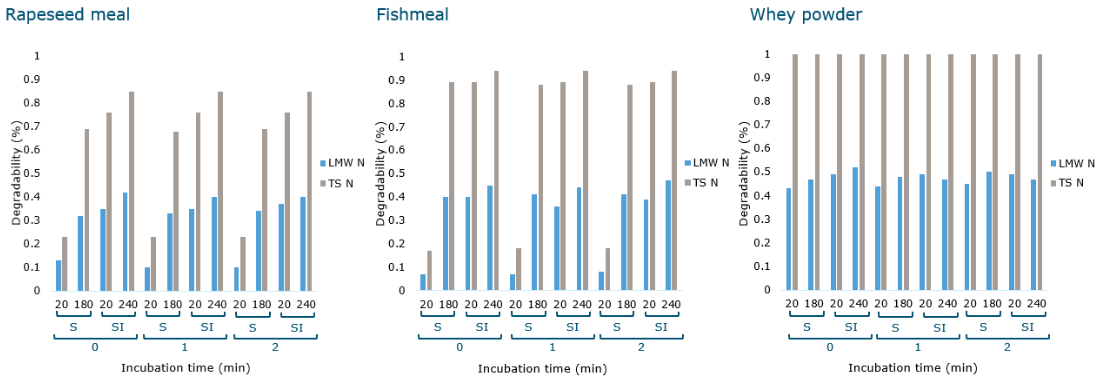


Figure 1 In vitro soluble nitrogen and low molecular nitrogen degradability of rapeseed meal, fishmeal and whey powder during stomach and small intestine incubation. LMW N: low molecular weight N; TS N: total soluble N; S: stomach phase; SI: small intestine phase; 0: no freezing; 1: froze for 1 week; 2: froze for 2 weeks.

Green animal production - 5

Reporter: Hao Ye

Supervisors: Junjun Wang; Defa Li; Nicoline Soede; Bas Kemp

Date: December 16th, 2021

Background information

1. PhD Topic: Effects of protein level and kinetics in lactating sow diet on sow performances, litter characteristics and environments

2. Period of appointment: from 2019.12.8 to 2023.12.8

3. Model: 1+3

4. Brief of research objectives in PhD thesis:

The main objective of this project is to increase our understanding of how dietary protein level and how dietary protein kinetics affect sow and piglet performance and nitrogen losses. Field data on a large number of sows will be acquired to study consequences of sow body condition losses for sow- and piglet performance and the genetic contribution to the variation in these parameters and relations. Two animal experiments will be performed to evaluate effects of dietary protein level and protein degradation kinetics on sow metabolic state (blood parameters), maternal reserve mobilization and nitrogen losses, and on litter performance and post-weaning sow reproductive performances.

Report on a specific research chapter

- Research title of this chapter

  The effects of dietary protein kinetics on sow and litter characteristics at lactation

- Short background

  Different dietary protein sources show different protein breakdown kinetics, as assessed in *in vitro* degradation tests. According to our previous meta-analyses including 21 studies done in the last 20 years, the intake of slowly degradable protein showed positive relationship with litter gain, and negative relationship with maternal protein loss. We expect that as slowly degradable protein is degraded more slowly, the amino acids will be transferred to the blood over a longer period of time, thereby increasing the chance of being used as protein source instead of energy source, and thereby contributing more to the protein requirements of the sow. These assumed effects of protein degradation kinetics are still to be confirmed in experimental conditions.

- Scientific question or research objectives

  This experiment is conducted to investigate the effects of dietary protein kinetics on

  1. sow body weight, loin muscle and backfat losses during lactation;
  2. on milk composition and milk output (=litter growth);

  With the final aim to establish a further understanding of the consequences of dietary protein level on balanced body reserve losses, piglet gain and reproductive output, with a minimum of nitrogen losses to the environment.

- Primary/Main results

Table. Effects of slow protein level in the lactation diet and parity on litter gain between Day 2 to Day 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

Table. Sow plasma urea (mmol/L) levels on day 6, 13 and 20 post farrowing (LSmeans ± SEM).

	Diets in lactation				P-value	
	LSP	MSP	HSP	SEM	D	P
Plasma urea level, mmol/L						
Day 6 post farrowing,	4.9[a]	3.6[b]	3.1[b]	0.3	< 0.01	0.37
Day 13 post farrowing,	5.6[a]	4.1[b]	3.7[b]	0.3	< 0.01	0.49
Day 20 post farrowing,	5.5[a]	4.9[a]	4.0[b]	0.3	< 0.01	0.28

D = Diet (LSP/MSP/HSP, where LSP = Low level of slow protein diet (8%); MSP = Medium level of slow protein diet (12%); HSP = High level of slow protein diet (16%) P = Parity class; LM = Loin muscle thickness; BF = Backfat thickness; [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 $P < 0.1$.

- Conclusions

The body weight loss, loin muscle loss and estimated protein loss between Day 2 and Day 21 of lactation were lowest or tended to be lowest in sows fed with higher fraction of slow protein. The high level of slow protein reduced oxidation of amino acids, as evidenced by lower blood plasma urea level throughout lactation. It was concluded that the amino acid utilization of lactating sow was improved by slow protein ingestion, and therefore leading to lower body loss at lactation.

Other activities

- Courses: Agriculture green development; Systematic analysis and thinking; Scientific writing and presenting. Introduction course on personal effectiveness; Research data management; Searching and Organizing Literature for PhD; Adobe InDesign
- Meeting: Hainan 2020 Online AGD Symposium

Green animal production - 6

Reporter: Hanlu Zhang

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

Date: December 14th, 2021

Background information

1. PhD Topic: Fermentation characteristics of different protein sources and their effects on the large intestine of growing pigs
2. Period of appointment: from 2019/12/09 to 2023/12/09
3. Model: 1+3
4. Brief of research objectives in PhD thesis:
    1) What is the fermentability of conventional and alternative protein sources?
        a) What is the variation in fermentability between different protein sources?
        b) What is the variation in fermentability between different cultivars or batches of one protein source?
        c) Is there a strong correlation between ileal digestibility and fermentability?
    2) Which metabolites are produced during fermentation of different protein sources?
        a) What is the variation in metabolite profile between different protein sources?
        b) What is the variation in metabolite profile between different cultivars or batches of one protein source?
        c) What are the potential drivers of metabolite formation?
        d) What is the effect of dietary fiber on protein fermentation?
    3) What is the effect of protein fermentation on intestinal and overall health of pigs?
        a) What is the variation in typical metabolite levels (in the intestine, blood, faeces, and urine) between different protein sources?
        b) What is the variation in intestinal microbiota, intestinal function, clinical health, and growth performance between different protein sources?

Report on a specific research chapter

- Research title of this chapter:
  In vitro **fermentation of ileal digesta from different protein ingredients**
- Short background
  In monogastric animals, most of the ingested dietary protein will go through to be digested and absorbed in the small intestine (Davila et al. 2012). For common protein sources, standardized ileal digestibility (SID) of crude protein in growing pigs ranges from 75 to 85% (Stein et al. 2001). For uncommon protein sources, SID of crude protein is relatively lower and shows large variation due to variation in composition as well as processing techniques (Li and Piao 2014). Protein fermentation in the hindgut of pigs is regarded to have harmful effects on animal health. Therefore, it is vital to consider the fate of undigested dietary protein of different sources.
- Scientific question or research objectives
  In vitro fermentability of ileal digesta from pigs fed with 11 protein ingredients, using faecal inocula from pigs, was studied. Different protein sources were expected to show different fermentation patterns due to their different availabilities to the microbiota.

- <u>Primary/Main results</u>

  Ileal digesta used was obtained from pigs fed soybean meal (SBM), sunflower meal (SFM), corn germ meal (CGM), cottonseed meal (CSM), peanut meal, rapeseed cake, rapeseed meal, black beans, sorghum, pigeon peas, or roasted peanuts. Cumulative gas productions of digesta (10 mg N added) for 48 hours were fitted to a monophasic model with lag time. Gas production at 24 hours (GP24, ml/10 mg nitrogen) as well as parameters for the asymptotic gas production (A, ml/10 mg nitrogen), the time to reach half of A (B, h) and the lag time (h) were estimated. All the digesta from different protein sources showed similar GP24, A values and lag time as no significant differences were found between groups (Figure 1). However, higher B values were found in CGM and CSM groups compared to PM, RSM, SBM, SFM, roasted peanuts and sorghum groups (Figure 1).

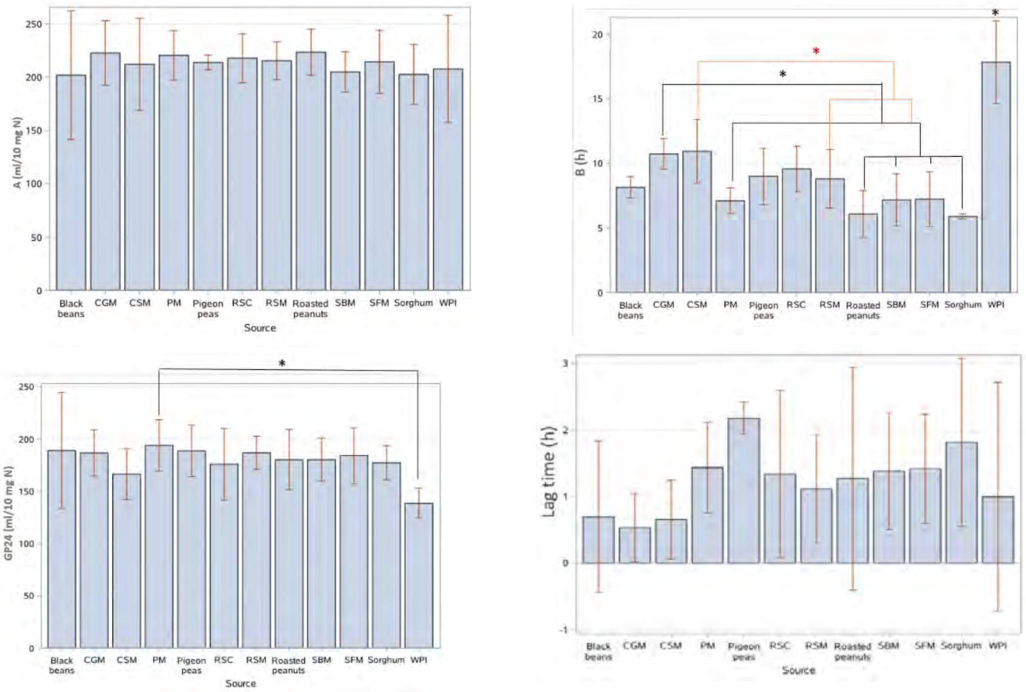


Figure 1. Estimated gas production at 24 hours (GP24, ml/10 mg nitrogen), the asymptotic gas production (A, ml/10 mg nitrogen), the time to reach half of A (B, h) and the lag time (h) of in vitro fermentation of ileal digesta from pigs fed with different protein sources by using monophasic model.

- <u>Conclusions</u>

The source of protein ingredient fed to pigs only influences the in vitro protein fermentation speed of their ileal digesta.

Other activities

- Publication: Impact of Fermentable Protein, by Feeding High Protein Diets, on Microbial Composition, Microbial Catabolic Activity, Gut Health and beyond in Pigs. *Microorganisms*. (IF=4.152)
- Courses: 9 courses taken in 2021.
- Meeting: Project meeting every 2 weeks.

Green animal production - 7

Reporter: Yaowen Zhang

Supervisors: Defa Li, Junjun Wang, Wouter Hendriks, John Cone, Nikkie van der Wielen

Date: December 13th, 2021

Background information

1. PhD Topic: Fermentation kinetics of resistant starch and its interaction with protein in large intestine of growing pigs

2. Period of appointment: from 2019.09.01 to 2023.06.31

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

Using four different corn starch (isolated pure resistant starch 1-4) as resistant starch sources and growing pig as animal model, through *in vitro* and *in vivo* experiments investigate fermentation dynamics of different RS and its effects on gut health of pigs. Meanwhile, analyzing the structure characteristics of RS before and after digestion and fermentation, combining the structure results with microbiota composition and other results, trying to find the relationship of specific structure of RS and specific microbial changes. In addition, using infusion and feeding in the *in vivo* experiment, compare the differences of results and verify each other. The purpose is to use RS as a strategy to adjust microbiota composition and metabolites and provide insights for the development of structure-oriented dietary fiber regulation strategy for the gut health and reducing environmental pressure.

Report on a specific research chapter

- Research title of this chapter
- Short background
- Scientific question or research objectives
- Primary/Main results (including Figures/Tables)
- Conclusions

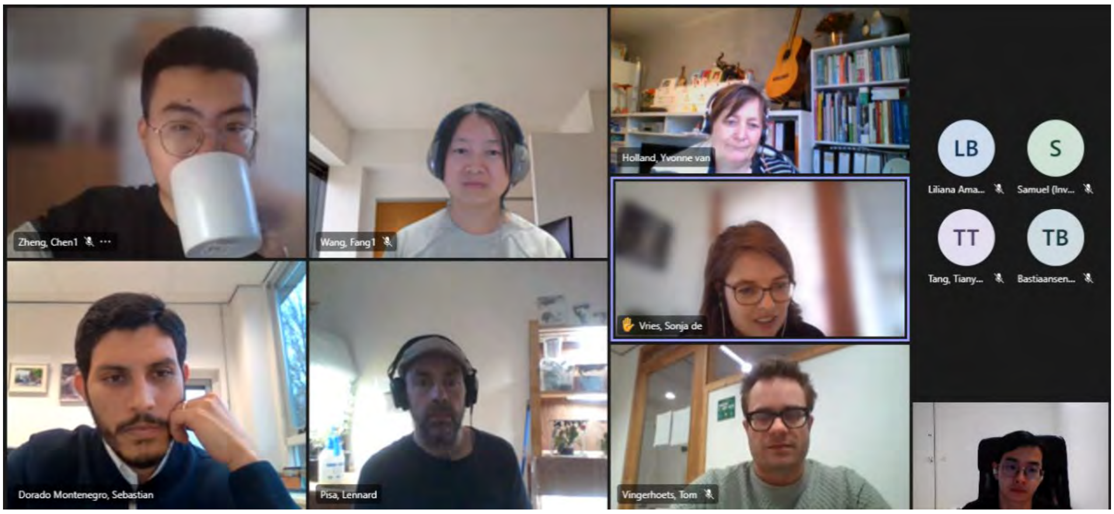
Metabolism of resistant starch in the small intestine and Lactobacillus species-mediated effect during in vivo fermentation

Resistant starch (RS) is a kind of dietary fiber. Like other DF, they mostly be utilized by microbes in the large intestine and produce short-chain fatty acids (SCFA), which contribute to the microbial homeostasis and intestinal tract health. Several studies have shown that different types of RS could cause different changes of microbiota composition in human and pig's gut, but in the in vivo trials, few of research about the association between changes of RS structure and microbiota composition were reported. Research reported that human intaking of different structural RS significantly influenced their feces microbiota composition and SCFA concentration, but it is unclear that physicochemical properties or structural changes play a more important role for health contributing.

Thus, in this study, we use ileum-cannulated growing pigs as animal model, by feeding four types of RS (RS1-RS4) to investigate their digestion and fermentation characteristics, structure changes and the main utilization bacteria in the gut, aimed to (1) identify the digestion characteristics, including the changes of morphological, molecular and crystalline structure, of four types of RS in vivo and compare with the results of in vitro digestion, (2) evaluate the microbes and metabolites, especially the small intestine bacteria, response to the different types of RS substrates in the full digestive tract of growing pigs. Through the in vivo and in vitro experiments to investigate the metabolic changes of different types of RS in the gut, fulfill the research gap about the effects of RS on small intestine bacteria and provide an insight into the guidance for the dietary RS intake to improve human and animal gut health.

Our study investigated the metabolism of RS in the gut from two perspectives, structure changes of RS and their effects on the gut microbiome and metabolites. The long and short-range ordered structure results of four kinds of RS proved that the types were not the main factor to determine their probiotic effects. The analysis of results about RS structure, glucose release and microbiome exhibited that the changes of these results were more obvious in the in vivo experiments than those of in vitro ones. That indicated that the RS structure were more destroyed in the actual small intestine digestion process compared with the pure in vitro enzymatic hydrolysis. These differences were highly likely induced by the small intestine bacteria and Lactobacillus species played main function in the RS degradation in the small intestine, which means the influence of foregut bacteria on nutrients digestion were underestimate. Therefore, we should concentrate more on RS structure instead of RS type and make sure they can arrive and make function at the targeted intestine segment when producing starchy probiotics. Moreover, the differences between in vivo and in vitro experiments should be taken into account when analyzing starch digestibility using in vitro methods, especially for the nutritional evaluation of starch-containing foods.

Other activities



Green ecological environment - 1

Reporter: Muying Duan

Supervisors: prof. Shaozhong Kang, prof. Petra Hellegers, dr. Marijn Poortvliet, dr. Chris Seijger

Date: December 17th, 2021

Background information

1. PhD Topic: Transition towards sustainable agriculture groundwater use in the North China Plain
2. Period of appointment: from 2019/09/01 to 2024/02/06
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

The objective of this project is to appraise the current status of agriculture groundwater use transition and explore why the transition seems to be constrained. By analysing the factors that promote or hinder the transition, the influence of water-saving strategies, the role of different actors and scenario development, I aim to understand the complete process of the entire transition and make contributions to knowledge on the sustainability transition of agriculture groundwater use for food security.

Specifically, four objectives are pursued:

- To evaluate the current stage of agriculture groundwater use in the NCP from the whole transition process and identity the factors facilitate or constrain the transition.
- To explore the impacts of different water-saving strategies on the transition.
- To identity the role of farmers and community network through the agriculture groundwater use transition.
- To explore future transition trajectories and scenario development about the transition pathways and how to facilitate the transition to sustainable agriculture groundwater use.

Report on a specific research chapter

- Research title of this chapter

The sustainability transition of agriculture groundwater use policy in China

- Short background

There has been a considerable interest in the way of achieving sustainability transitions in water management. For example, the historical narrative of Dutch water management transition in has been reconstructed to get in-depth knowledge about this transition (Van Der Brugge et al., 2005; Van der Brugge and Rotmans, 2007). The European NeWater project is developed an innovation method to characterize water management regimes and the dynamics of transition processes (Pahl-Wostl, 2007). Garcia 2019 identify common factors associated with transitions toward sustainability in urban water systems across three cases in American (Garcia et al., 2019). Similar studies have been done in the Colorado River Basin (Sullivan et al., 2017). Water-related transition studies in developing countries are also gradually brought forward. Sixt et al. explored the systemic problems and opportunities in the water harvesting transition in rainfed agricultural production systems of Jordan (Sixt et al., 2018). Water management transition issues also are summed up in Vietnam (Gabi, 2010). However, these studies most focused on water management and governance. There is a lack of knowledge about water use transition process, especially in agriculture system. Understanding the transition process of agriculture groundwater use is of vital importance because the conventional technologies towards the groundwater use is unsustainable. Besides, there is a link between groundwater use and food security. In order to understand the dynamics and chances and explore the barriers of this transition, a longitudinal research of agriculture groundwater use over the past decades needed to be done.

- Scientific question or research objectives

How does the agriculture groundwater use policy transition develop in the North China Plain?

(1) How the transition of agriculture groundwater use policy happens in the North China Plain?

(2) What are the factors hindering or promoting the transition to sustainable groundwater use?

(3) What strategies can we develop to improve or accelerate this shift?

The specific objectives of this paper are: (1) to discuss details on how agriculture groundwater policy change to fit the official goals of social and economic development; (2) to explain the reasons behind different transition phase of agriculture groundwater use for its possible further use in other contexts; and (3) to evaluate the transition process, focusing on outputs and impacts of water-saving effects. In addition, as backdrop for these more general knowledge interests, the paper outlines the transition process of the agriculture groundwater use policy in China context and adds to the understanding of the key expectations that change makers have of the sustainable agriculture groundwater use transition.

- Results

Policy transition summary of agriculture groundwater use

We begin with a brief historical trajectory policies analysis about the transition of the agriculture targets and government attitude towards groundwater use. A complete history is obviously beyond the scope of this paper, this study spans a time period of about 40 years, from the massive use in agricultural production to gradual conversion to sustainable groundwater use. First, we summarize the characteristics and targets in define four phases of agriculture groundwater use development, then we conclude the national government’s attitude towards the agriculture groundwater use (Table 1).

Table 1. Agriculture groundwater use policy transition

Phase	Timeframe	Charateristics and targets	Government attitude
I	1980-1990	• Ensure grain production security and agricultural products increased steadily	• No agricultural water-saving orientation
II	1991-2000	• Agricultural products increased steadily • Increase the irrigated area of farmland	• Initiative phase (pre-development phase) • Increase irrigation area and propose water saving at farmland scale
III	2001-2010	• Propose and develop water-saving agriculture • Different strategyies been made to ensure agriculture groundwater use	• Practice phase (take-off phase) • Positive attitude toward water-saving agriculture: plenty of policies proposed
IV	2011-2021	• Start groundwater resources monitoring • Agriculture green development and sustainable agriculture water use • Put forward targeted policies for groundwater use and the North China Plain	• Practice phase (accelerate phase) • Increased attention to the sustainability of groundwater

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Green ecological environment - 2

Reporter: Yu Gu

Supervisors: Wim de Vries, Jianbo Shen, Gerard Ros, Qichao Zhu

Date: December 18th, 2021

Background information

1. PhD Topic: Combined field and model-based approaches for large scale sustainable phosphorous management
2. Period of appointment: from 2019/09/01 to 2024/03/30
3. Model: 1+3
4. Brief of research objectives in PhD thesis (*titles of each chapter in thesis*)
   A. Assessing impacts of soil properties on soil response to P inputs and related crop P uptake
   B. Long-term impacts of fertilizer P inputs on reactive soil P contents and P uptake by maize.
   C. A novel P index based on relationship between P buffer capacity as a function of soil properties.
   D. Modelling the long-term fate of soil P in response to fertilizer application on crop P uptake, soil P accumulation, P losses to water.
   E. Identifying sustainable P management practices in view of crop production and environment for Quzhou and Qiyang counties in China.

Report on a specific research chapter

- Research title of this chapter : Deriving soil phosphorus indicators related to crop yield and runoff risks to assess long-term sustainable fertilizer phosphorus inputs

- Short background: Exploiting and utilizing soil legacy P has great potential to decrease P fertilizer demand. This legacy P can be described in terms of variable P pools that accumulate in soil due adsorption on aluminum and iron oxides, occlusion to soil minerals and organic matter, and diffusion/precipitation in less available forms. Reducing P fertilizer input is relevant when the soil P status exceeds a level above which crop yield does not respond anymore and/or where the risk for P runoff to surface water is enhanced. . We assessed the impact of long-term P addition, with varying P fertilizer and manure types, on changes in different P pools in soil, and evaluated how crop yield and environmental risk respond to legacy P in wheat-maize rotation systems in China.

- Scientific question or research objectives: This study is set up to: (i) investigate the changes of different soil P indicators, related to directly available (P-$CaCl_2$) and long-term available (PSI) pools to long-term P fertilization in a wheat maize rotation system in South China, and then (ii) deriving critical limits for these soil P indicators related to crop yield and leaching risks, with the aim to assess long-term sustainable fertilizer P inputs

- Primary/Main results: Figure 1 and 2 showing impacts of long term P fertilization on P indicators and figures 3 and 4 showing links to risks for crop yield and leaching

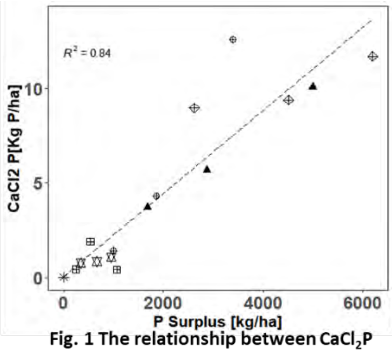


Fig. 1 The relationship between $CaCl_2P$ and P surplus

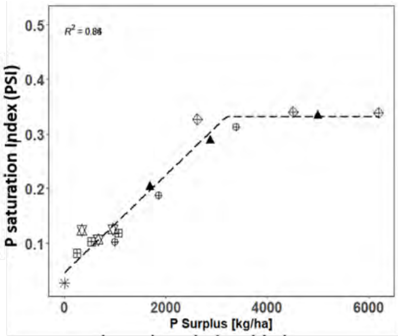


Fig. 2 The relationship between P saturation index and Psurplus

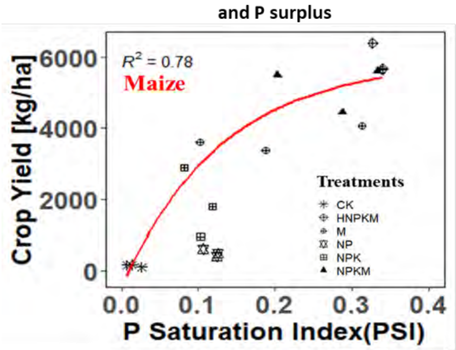


Fig. 3 The relationship between crop yield and P Saturation Index

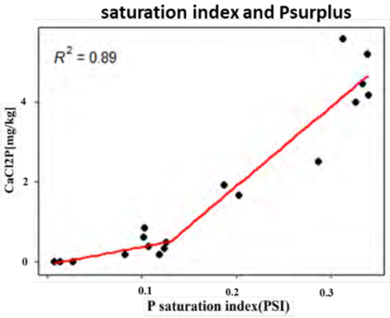


Fig. 4 The relationship between $CaCl_2P$ and P saturation index

- Conclusions

  Crop yield was not (hardly) limited anymore at a P-CaCl2 level near 2 mg/kg (Figure 3). A tipping point of enhanced P-CaCl2 levels was observed near a PSI of 0.15, with a P-CaCl2 level near 0.5-1 mg/kg (Figure 4), being below the agronomic target P-CaCl2 level near 2 mg/kg. Whether this implies that it exceeds a critical value for P leaching in view of environmental impacts will depend on the hydrological circumstances and still needs further investigation.

Other activities

- Two conference abstracts are submitted:
  1. (poster) "Deriving soil P indicators related to crop yield and runoff risks to assess long-term sustainable fertilizer P inputs." Sept. 2022, 22nd world congress of soil science, Glasgow, UK
  2. (presentation) "Potential of soil phosphorus saturation index for evaluating crop yield and runoff risks", February 2022, Webinar "Perspective for reducing "legacy phosphorus" in agricultural soils", ESPP

- Courses:
  - Basic statistics
  - The art of modelling
  - Data management
  - Scientific writing
  - Presentation with impact

Green ecological environment - 3

Reporter: Dongfang Zheng

Supervisors: Jianbo Shen, Wim de Vries, Yang Lv, Gerard Ros

Date: December 20th, 2021

Background information

1. PhD Topic: Optimizing P management strategies based on soil P sorption-desorption and rhizosphere processes
2. Period of appointment: from 2021/06 to 2021/12
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Part 1: Summary of the characteristics and parameters of phosphorus sorption and desorption in different soils: a meta-analysis.

Part 2: Assess relationship between P adsorption-desorption parameters and soil factors.

Part 3: Effect of rhizosphere on the P fractions and sorption / desorption process: a pot experiment.

Part 4: Research on P management strategies based on soil P and rhizosphere processes

Report on a specific research chapter

Part 1: Assess relationship between P adsorption-desorption parameters and soil factors.

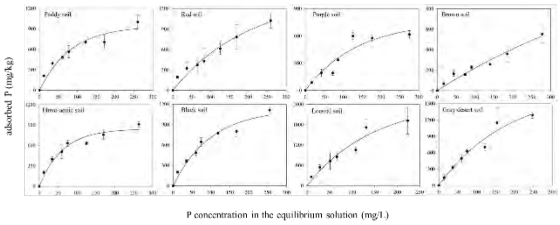
The *objectives* of this study is to assess adsorption constants in Freundlich (K_F values) or Langmuir equations (K_L values) for different soil with a large range in soil properties, such as soil contents of metal oxides, clay and organic matter and pH, controlling P sorption and desorption. And to assess the changes in soil P fractions in response to different P rates with varying soil properties.

Primary results:

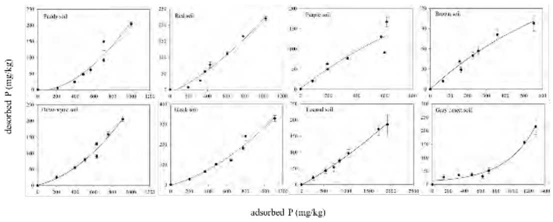
Soil properties:

ID	soil type	sampling site	pH	Olsen-P mg/kg	Total P g/kg	OxalateP mg/kg	Fe-ox mg/kg	Al-ox mg/kg	Ca-ox mg/kg	$CaCO_3$ g/kg	CEC cmol/kg (+)	SOC %
soil 1	Paddy soil	Anhui province	5.41	13.61	0.61	419.65	5430.66	1022.08	25.27	2.91	12.49	1.42
soil 2	Red soil	Hubei province	5.61	2.44	0.49	132.60	2861.19	1173.15	17.03	0.87	12.96	0.96
soil 3	Purple soil	Chongqing City	6.06	3.92	0.5	169.61	654.79	672.88	12.24	7.72	24.57	0.66
soil 4	Brown soil	Shandong province	6.42	3.27	0.11	34.49	773.59	593.81	18.33	0.21	4.46	0.42
soil 5	Fluvo-aquic soil	Beijing City	6.77	3.05	0.49	176.48	595.19	802.61	7.88	27.31	92.89	0.42
soil 6	Black soil	Jilin province	6.9	22.09	0.63	182.28	4519.99	1613.41	31.85	7.66	15.14	0.65
soil 7	Loessal soil	Shaanxi province	7.2	6.75	0.66	286.34	611.33	556.35	3.61	55.12	89.10	0.55
soil 8	Gray desert soil	Xinjiang	7.36	9.32	0.66	592.72	748.66	518.75	9.19	18.00	85.54	0.96

Soil adsorbed P increased with increasing P added in all soils, but the increasing tendency was different in different soils. The highest adsorption capacity appeared on loessal soil. Soil desorbed P increased with increasing P adsorbed in all soils, but the increasing tendency was different in different soils.



P adsorption isotherm

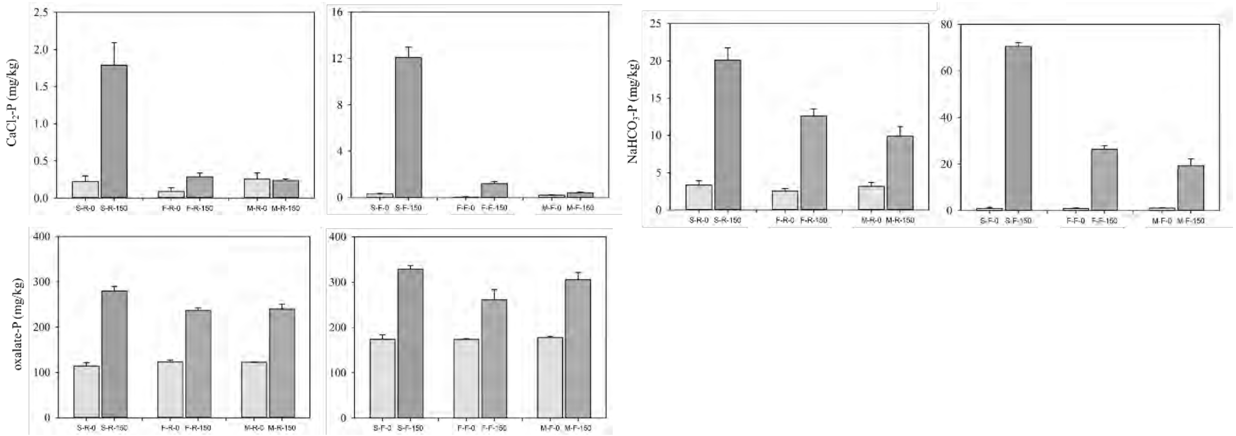


P desorption isotherm

Part 2: Effect of rhizosphere on the P fractions and sorption / desorption process: a pot experiment.

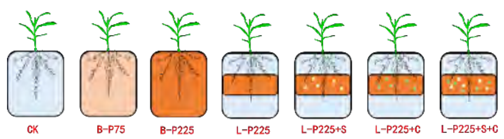
Objective: to find out how soil P pool and P adsorption and desorption change after growing maize and fababean.

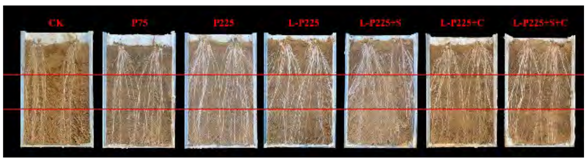
Primary results:

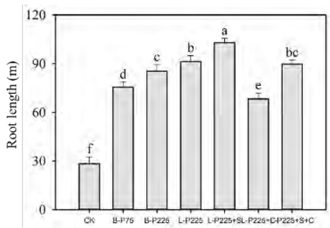


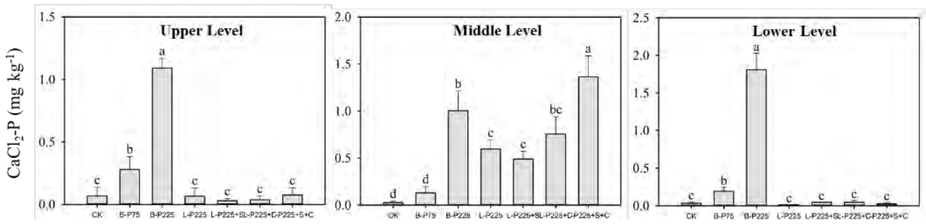
Part 3: Integrated response of maize rhizosphere processes to soil heterogeneous phosphorus, sulfur and carbon nutrients.

Objective: (1) Local application of phosphorus improves phosphorus utilisation by altering the intensity and spatial location of phosphorus supply to induce root growth and physiological responses. (2) Sulphur oxidation produces sulphuric acid, which lowers soil pH, increases phosphorus effectiveness and activates soil insoluble phosphorus. (3) Glucose stimulates microbial growth and activity, promotes sulphur oxidation and synergistically enhances acidification.









Green ecological environment - 4

Reporter: Zhilong He

Supervisors: CAU: Ying Zhang, Xuejun Liu, Wen Xu, Yong Hou: WUR: Wim de Vries, Gerard Ros

Date: December 13th, 2021

Background information

1. PhD Topic: Mitigation of NH_3 Emission and Synergy Effects of Nr losses and GHG emission in the North China Plain - a case study of cropping-layer system in Quzhou county

2. Period of appointment: from 2019-9-1 to 2023-6-1

3. Model: 2 + 2

4. Brief of research objectives in PhD thesis:

Chapter 1: The effect of dietary manipulation (crude protein levels) on NH_3 volatilization from barn

Chapter 2: The response of NH_3 emissions to the additives addition during composting period

Chapter 3: The NH_3 volatilization mitigation potential of replacing chemical nitrogen fertilizer with manure combined with optimized fertilization

Chapter 4: Comprehensive assessment of the effect of the mitigation actions for the cropping-laying hens system on NH_3 emission mitigation

Chapter 5: Synergy effects of reactive nitrogen losses and greenhouse gases emission from linear to circular cropping-layers system in Quzhou county

Report on a specific research chapter

- Research title of this chapter

Substantial ammonia (NH_3) mitigation potential in the circular crop-layer poultry production system -a case study in North China Plain

- Short background

As the main precursor of secondary inorganic aerosols, the NH_3 emission has met rapid increasing and is expected to 132 Tg globally by 2100 (Sutton et al., 2013), and has received extensive attention all over the world, due to its huge effects on human being health such as stroke (Huang et al., 2019) and cardiovascular disease (Tian et al., 2019) and also on visibility (Han et al., 2020). The redeposited NH_3 also can cause serious environmental issues such as soil and ecosystem acidification, water pollution, algal blooms (Bergström et al., 2006; Guo et al., 2010; Le et al., 2010) as well as climate change (Barsanti et al., 2009; IPCC, 2006). A host of evidence indicates that agricultural sources, such as volatilization from manure and synthetic fertilizer application, is the most contributor among anthropogenic emission, with around 80–90% of NH_3 emissions coming from this sector (Kang et al., 2016), and is the priority target when we take NH_3 emission mitigation strategies. Few studies, however, have examined the system NH_3 emission and mitigation potential by considering both crop system and layer poultry system based on situ-measurement results.

- Scientific question or research objectives

The aims of this study was hence: to analyse crop-layer poultry production system NH_3 emissions and mitigation potential by integrating situ-measurement results.

- Primary/Main results

Manure outdoor processing responsible for the majority of NH_3-N volatilization, in both the traditional and the optimized system, with 41–55% of total NH_3 emission derived from this stage, followed by land application and housing stage, accounting for 27–41% and 17–26% of total NH_3 emission, respectively. The results indicate that the combined mitigation strategies, referring to low crude protein feed in housing stage, manure composted with additives during outdoor processing stage and manure substitution based on optimized fertilization during land application, could reduce maximum of 31% NH_3 emission for local eggs production.

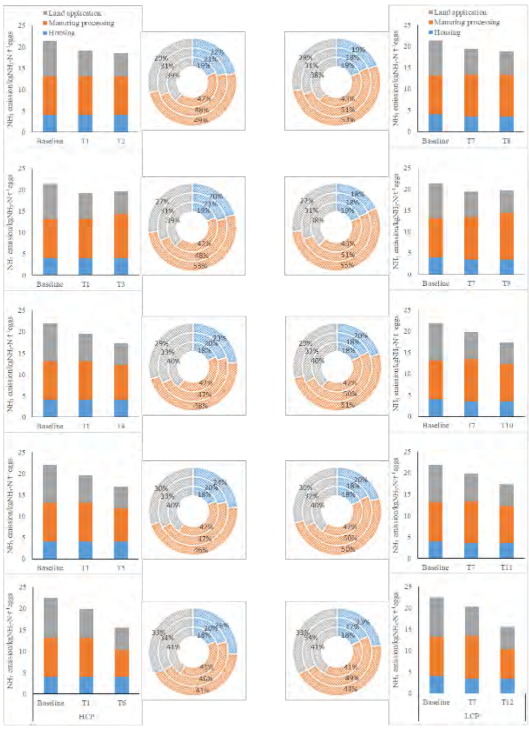


Fig. Systematic NH_3 emission for per unit eggs production ($kgN \cdot t^{-1}$eggs) from baseline and optimized system. Here, baseline represents traditional situation; T1 and T7 refer to optimized fertilization in field; T2-T6 and T8-T12 refer to manure substitution based on optimized fertilization (T1/T7). Note: each subset have equal cropping area determined by the amount of manure N input into field and field nitrogen application rate in order to compare mitigation potential.

- Conclusions

In the whole crop-layer poultry production system, the combination of measures that most reduced NH_3 losses was: LCP feeding, manure derived from LCP composted with additives, the substitution of chemical fertilizer with composted manure amended with additives based on optimized fertilizer regime. These combination strategies reduced NH_3 losses between 21% and 31% compared to HCP feeding, manure natural storage and traditional chemical fertilizer application.

Green ecological environment - 5

Reporter: Yanan Li

Supervisors: Fusuo Zhang, Carolien Kroeze, Lin Ma, Maryna Strokal, Wen Xu

Date: December 10th, 2021

Background information

1. PhD Topic: Multi-pollutant assessment of water quality and food production for agricultural green development in China: an integrated, multi-scale modelling approach
2. Period of appointment: from 2019/09/1 to 2021/12/10
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

This research aims to assess future AGD in China, in terms of sustainable food production and multiple pollutants in water systems at different scales.

Report on a specific research chapter

- Research title of this chapter: Modelling pesticides and mulching pollution from agricultural activities.

- Short background

  Pesticides and mulching are important agricultural production materials to ensure food production. China is the major pesticide and mulching consumer globally. To satisfy the food demand, large amounts of pesticides and mulching are applied in cropland which threatens the environment and human health. Existing studies indicate microplastics (from mulching) and pesticides are related to metabolites that have been detected in soil and waters in China. This situation brings much attention to the impact of pesticides and microplastics pollution to agricultural production and the environment. However, currently, experimental approaches are popularly applied to assess regional pesticides or microplastics pollution. The modelling approach on pesticide and microplastics from mulching losses into surface waters in China is not well studied. Therefore, a large-scale modeling approach is needed for assessing pesticide and microplastics pollution to support policymaking.

- Scientific question or research objectives

  The objective of this research is to develop a new modelling approach to quantify pesticides and microplastic (from mulching) pollution from agricultural production in a spatially explicit way.

- Primary/Main results

  A large amount of mulching is applied in the west part, middle part, and northeast part of China. After collection, the large amount of mulching residual in soil, this situation is especially serious in the west part of China (Figure 1). We calculate microplastics and macroplastics from mulching can through surface runoff enter to rivers (Figure 2). Our results indicate that downstream sub-basins of yellow and Yangtze river, Huai and Hai river sub-basins receive large amount of microplastics and macroplastics.

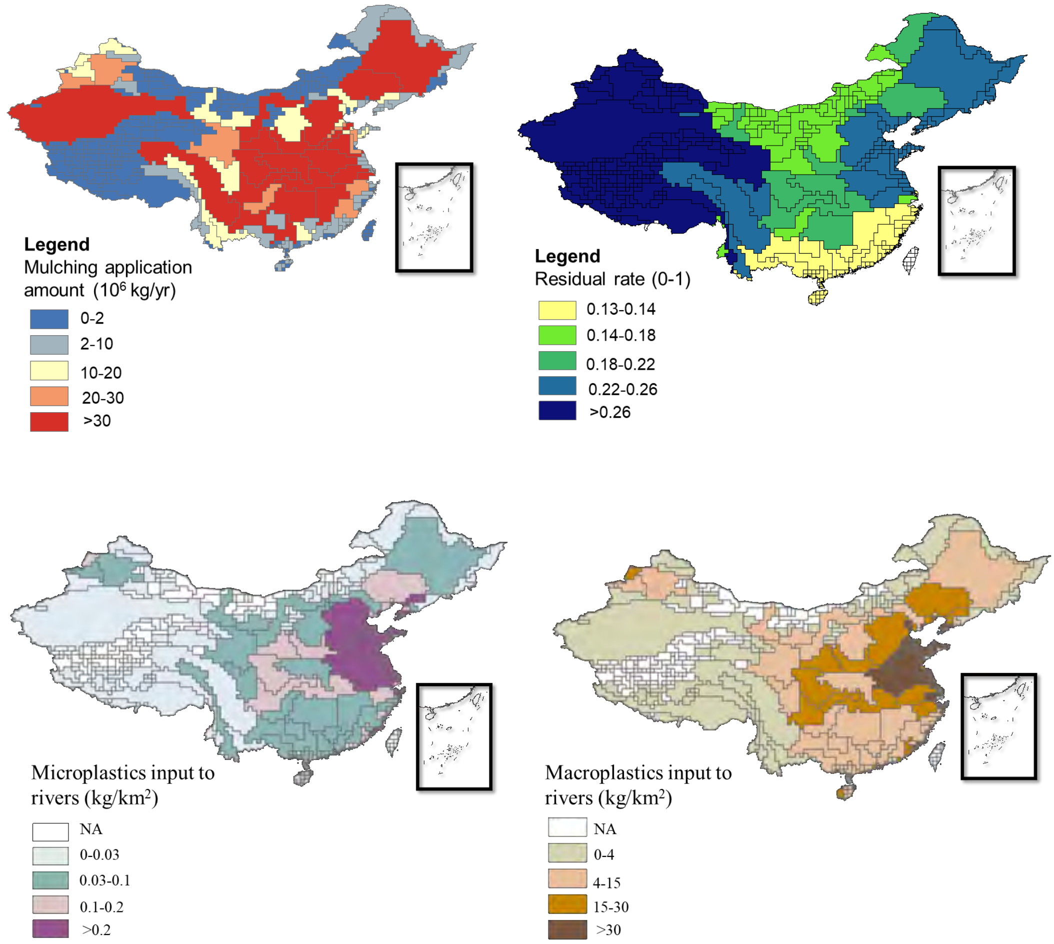


Figure 2. Inputs of micro and macroplastics to Chinese rivers sub-basins from agricultural plastic mulching for the year 2010 .

- Conclusions

According to existing studies, we developed a new modelling approach to quantify inputs of micro and macroplastics to rivers from agricultural mulching. The spatial distribution of our preliminary results is comparable with existing studies. Mulching application amount the residual rate of mulching in soil are two major components that can influence the transportation of micro and macroplastics to rivers.

Other activities

- Publication

Li, Y., Wang, M., Chen, X., Cui, S., Hofstra, N., Kroeze, C., ... & Strokal, M. (2021). Multi-pollutant assessment of river pollution from livestock production worldwide. Water Research, 209, 117906.

Zhang, Q., Li, Y., Wang, M., Wang, K., Meng, F., Liu, L., ... & Zhang, F. (2021). Atmospheric nitrogen deposition: A review of quantification methods and its spatial pattern derived from the global monitoring networks. Ecotoxicology and Environmental Safety, 216, 112180.

Meng, F., Wang, M., Strokal, M., Kroeze, C., Ma, L., Li, Y., ... & Zhang, F. (2021). Nitrogen losses from food production in the North China Plain: A case study for Quzhou. Science of The Total Environment, 151557.

- Courses:

Wageningen in'to Languages

Certificate

Wageningen in'to Languages of Wageningen University & Research Centre certifies that

Y. Li

has successfully completed the course

Scientific Writing

The course took place from **17-09-2021** until **05-11-2021**, consisting of **15** contact hours and **36** hours of self-study.

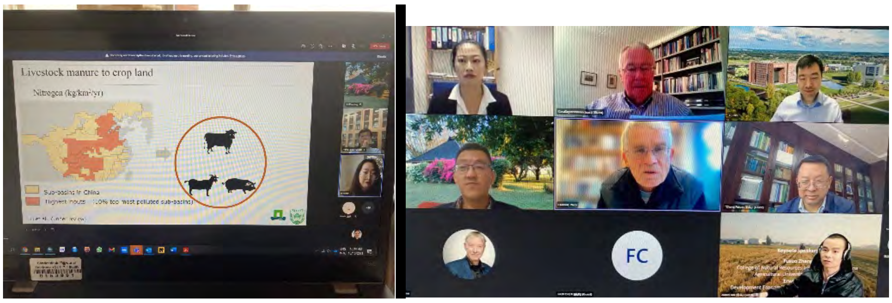
The student has fulfilled the course requirement of attendance.

Wageningen, 05-11-2021

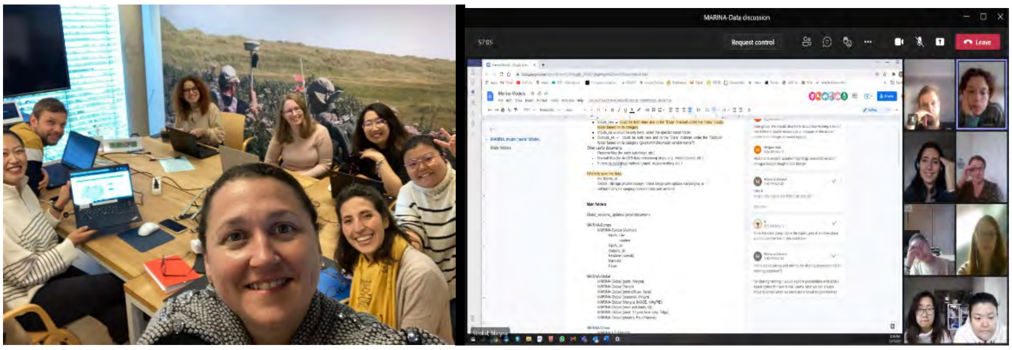
Irene Houkes-Jansen MA
Head of Wageningen in'to Languages

- Meeting etc.:

Webinar of plastic mulching pollution and management



SURE+ International Conference



MARINA model and data meeting

MARINA model training

Strategy day (PhD meeting)

Lessons learned

I already finished my first research question and conducted my second research question during this period. From my first research question, I learned how to write a scientific paper. I need to improve my writing skill. I learned how to better deal with the raw data and appropriately apply these data in my study. Anytime, pay attention to the numbers. I also learned it is important to talk to other PhD in our group, we can share the useful courses and some tips related to research. Communicating and joining the group activities make my study more interesting and not feel alone. Having regular meetings with supervisors to share my opinion about my research topic and asking for feedback from supervisors can help me to always be on the right way.

Green ecological environment - 6

Reporter: Fanlei Meng

Supervisors: Fusuo Zhang, Carolien Kroeze, Lin Ma, Maryna Strokal, Wen Xu, Mengru Wang

Date: 19th December 2021

Background information

1. PhD Topic: Integrated nitrogen management for the green agriculture-environment system in the North China Plain

2. Period of appointment: from 2019 to 2023

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

The main objective of this study are assess nitrogen (N) flows in the water-soil-air interactions with the food chain and to identify agriculture green development (AGD) options for reducing further N emissions in Quzhou and North China Plain. I take Quzhou and North China Plain (NCP) as illustrative case studies. Quzhou is a representative county of NCP with typical crop rotation systems. To reach the main objectives, four key questions will be addressed:

1. What are the current N flows in the water-soil-air interactions with food chain in Quzhou?

2. How to quantify environmental targets for current NH_3 emission to air and NO_3^--N leaching to groundwater in Quzhou

3. What AGD options meet environmental targets for NH_3 emissions to air and NO_3^--N leaching to groundwater in Quzhou?

4. How to upscale AGD options for NCP to meet environmental targets for NH_3 emissions to air and NO_3^--N leaching to groundwater?

Report on a specific research chapter

- Research title of this chapter

  Environment target for food production: Opportunities for nitrogen emission reduction

- Short background

  Agriculture development presents a great challenge to ensure food security while safeguarding environment sustainability. Reactive N losses in food production have exceeds sustainable N levels in North China Plain. NO_3^--N leaching is considered as primary cause of increasing N concentrations in groundwater, and it is directly responsible for water quality degradation.

- Scientific question or research objectives

  In this study, we aim to quantify the environment target for NO_3^--N leaching to groundwater, by taking the Quzhou county as a typical example in the North China Plain.

- Primary results

  NO_3^--N leaching from eight crops were 2.1 kton in Quzhou in 2017. The model calculated the contributions of different crops to the total N losses to the environment. These contributions were 33%, 27%, 21%, 10%, and 9% for maize, wheat, vegetable, fruit, and cotton, respectively. Maize, wheat, and vegetable production was responsible for 81% of the NO_3^--N leaching from crop production.

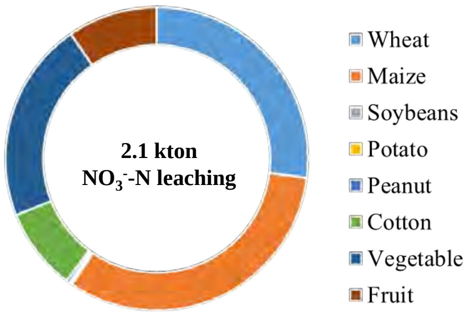


Fig. 1 The NO_3^--N leaching from food production in Quzhou in 2017 (kton).

The environment targets for NO_3^--N leaching to groundwater is 1.3 kton. The NO_3^--N leaching should be reduced 0.8 kton to meet environment targets in Quzhou in 2017.

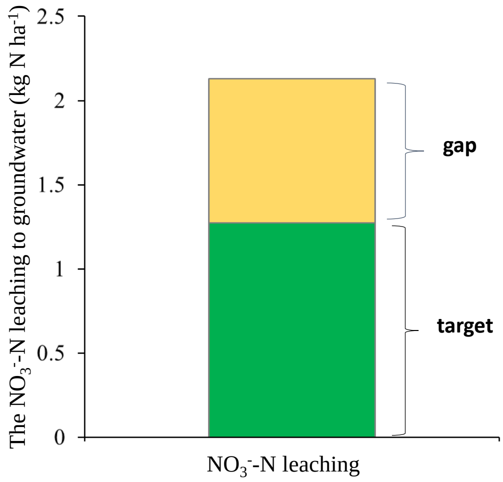


Fig. 2 The NO_3^--N leaching gap between the current emissions and environment target in Quzhou.

- Conclusions

  Maize, wheat, and vegetable production contributed by 81% to NO_3^--N leaching.

  The environment targets for NO_3^--N leaching to groundwater is 1.3 kton.

  Better nutrient management in food production is needed to reduce NO_3^--N leaching.

Other activities

- Publication

  Meng F, Wang M, Strokal M, Kroeze C, Ma L, Li Y, Zhang Q, Wei Z, Hou Y, Liu X, Xu W, Zhang F. Nitrogen losses from food production in the North China Plain: A case study for Quzhou. Sci Total Environ. 2021 8:151557. https://dor.org/10.1016/j.scitotenv.2021.151557.

  Meng F, Zhang Y, Kang J, Heal M R, Reis S, Wang M, Liu L, Wang K, Yu S, Li P, Wei J, Hou Y, Zhang Y, Liu X, Cui Z, Xu W, Zhang F. Trends in secondary inorganic aerosol pollution in China and its responses to emission controls of precursors in wintertime, Atmos Chem Phys (in review)

  Zhang Q, Li Y, Wang M, Wang K, **Meng F**, Liu L, Zhao Y, Ma L, Zhu Q, Xu W, Zhang F. Atmospheric nitrogen deposition: A review of quantification methods and its spatial pattern derived from the global monitoring

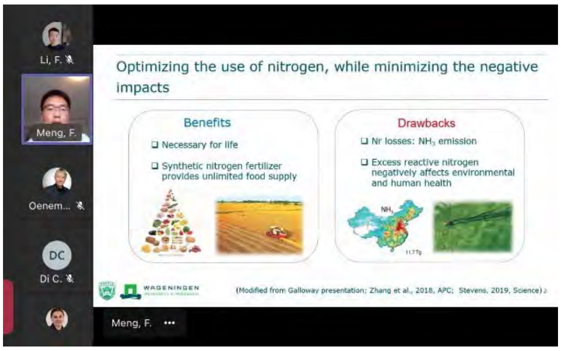
networks. Ecotoxicol Environ Saf. 2021 14; 216:112180. https://dor.org/10.1016/j.ecoenv.2021.112180 .
Gong H, **Meng F**, Wang G, Hartmann T E, Feng G, Wu J, Jiao X, Zhang F. Toward the sustainable use of mineral phosphorus fertilizers for crop production in China: From primary resource demand to final agricultural use. Sci Total Environ. 2022 15; 804:150183. https://dor.org/10.1016/j.scitotenv.2021.150183

- Courses:

Training how to use the MARINA model, 7th July and 11th-12th November 2021

- Meeting:

International Conference: Sustainable Resource Management for Adequate, Safe and Nutritious Food Provision, 16th October 202



Workshop AGD students: Modelling flows in China/Quzhou, 3rd November 2021

Lessons learned

- Learned WRF-CMAQ model to simulate the $PM_{2.5}$ formation
- Learned Python to analysis and visualize data.

Green ecological environment - 7

Reporter: Hongyu Mu

Supervisors: Violette Geissen, Coen Ritsema, Kai Wang, Xiaomei Yang, Xuejun Liu

Date: December 20th, 2021

Background information

1. PhD Topic: Human exposure by pesticide residues in the soil-atmosphere nexus: A case study in the North China Plain

2. Period of appointment: from 2019/6/1 to 2023/6/1

3. Model: 1+3

4. Brief of research objectives in PhD thesis:

Chapter 1: Pesticide usage practices, resulting exposure risks and the risk remediation strategies

Chapter 2: Occurrence, distribution and the ecological risks of pesticides in agricultural soils: A cross-sectional study in the NCP

Chapter 3: Occurrence and distribution of pesticide residues in the atmospheric particles in different sizes

Chapter 4: An systematic study of pesticide exposure in the residential area from multiple exposure routes

Report on a specific research chapter

- Research title of this chapter:

  Occurrence, distribution and the health risks of pesticides in the residential dust: A case study in the North China Plain

- Short background:

  Pesticides have been ubiquitous in the environmental domains and can be easily transported to the residential area via the off-site particulate transport, causing an exposure risk to the local residents. As a major crop producing area in China, North China Plain (NCP) is at relatively high rate of pesticide usage but researches related to the pesticide contamination and exposure risks in the residential area of the NCP is lacking.

- Scientific question or research objectives:

  Scientific question: How pesticides were accumulated and distributed in the residential dust (both indoor and outdoor) from surrounding soil? If the accumulation level of pesticides in dust affect the physical health of residences?

  Research objectives: 1) to investigate the occurrence and distribution of pesticides in residential dust, 2) to assess the health risks pose by detected pesticide mixtures and 3) identify the potential determinants of the pesticide exposure level

- Primary/Main results (including Figures/Tables)

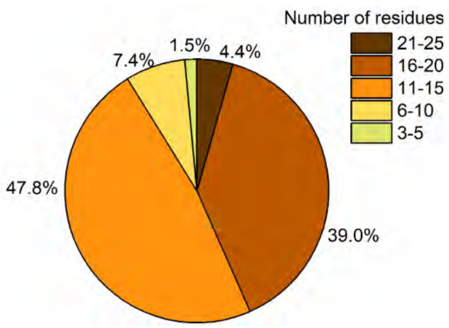


Fig. 1 Distribution of the number of detected residues

Multiple residues were detected in the residential area. Compared to the pesticide concentrations in surrounding soil, most of these residues were concentrated in dust.

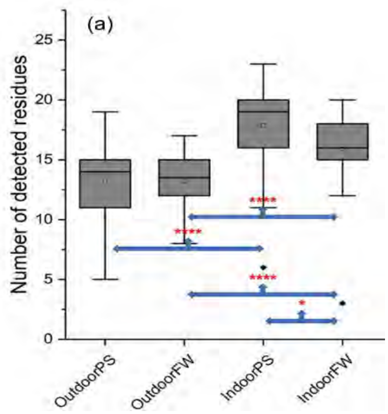


Fig. 2 Box chart of the number of detected residues in indoor and outdoor dust

Note:

OutdoorPS, outdoor dust samples taken from pesticide sprayers' houses; OutdoorFW, outdoor dust samples taken from farm workers' houses; InPS, indoor dust taken from pesticide sprayers' houses; InFW, indoor dust samples taken from farm workers' houses

- Conclusions: More residues and higher concentrations were found from indoor dust. No considerable health risks were posed by pesticides in dust. Floor cleaning frequency and the mixing / loading of pesticide solvents were found significantly correlated with farmers' pesticide exposure level.

Other activities

- Publication
  1. Under review:
     Pesticide usage practices and the exposure risk to pollinators: A case study in the North China Plain *(Ecotoxicology and Environmental Safety)*
  2. In preparation:
     * Occurrence, distribution and the health risks of pesticides in the residential dust: A case study in the North China Plain.
     * Occurrence, profile distribution and the ecological risks of pesticides in the agricultural soils: A cross sectional study in the North China Plain

Lessons learned: Statistics is the key from results to conclusions.

Green ecological environment - 8

Reporter: Zhibiao Wei

Supervisors: Ellis Hoffland, Petra Hellegers, Zhenling Cui, Zhenling Cui

Date: December 20th, 2021

Background information

1. PhD Topic:
2. Period of appointment (year/month/day): from 09/2019 to 04/2024
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

To study options for circularity of N, C and water of the agro-food system of a county. Sub-objectives are to (1) Quantify the current N, C and water flows within Quzhou; (2) Review technologies to promote N, C and water cyclic utilization; (3) Develop options to close N, C and water cycles separately and (4) simultaneously.

Report on a specific research chapter

- Research title of this chapter

Organic inputs to reduce nitrogen export via leaching and runoff: A global meta-analysis

- Short background

Organic inputs as a substitution for, or addition to, chemical fertilizers can potentially mitigate N losses. However, it is not well known how their effects on N leaching and runoff depend on application approaches and the types of organic amendment. There could be trade-offs or synergies between N leaching/runoff and crop production

- Scientific question or research objectives

This study aims to: 1) quantify the effects of different organic application approaches on N export via leaching and runoff depending on the type of organic fertilizer; 2) compare the leaching and runoff LRs between chemical and organic fertilizers, and 3) demonstrate the potential trade-offs and synergies between N losses and crop production

- Primary/Main results

Application approach had a significant impact on leaching and runoff: Equal N_{total} approach reduced both leaching and runoff by more than 30%, but Equal N_{min} approach increased N leaching by 21%, while it had no effect on runoff based on the few available observations (n = 6). Additional N_{org} approach had no effect on leaching and runoff. Organic fertilizer application overall showed only minor effects on crop yield. Crop yield varied with organic application approaches. Equal N_{total} did not significantly change crop yield, while Equal N_{min} and Additional N_{org} increased crop yield by 6% and 5%, respectively.

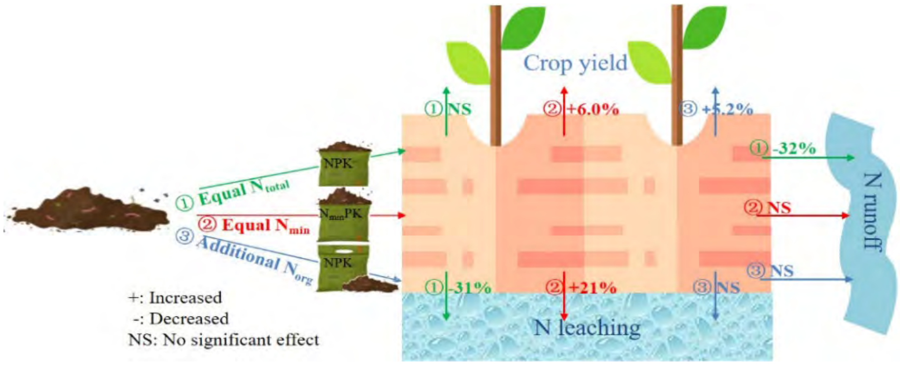


Fig. 1. The effects of organic application approaches on N leaching, runoff and crop yield. The clipart in the figure was downloaded from https://www.flaticon.com.

- Conclusions

This global meta-analysis looked at the effects of different organic fertilizer application approaches on N export via leaching and runoff. Partial substitution of chemical fertilizers by organic fertilizers with the same amount of total N generally reduces leaching and runoff without compromising crop yield. This work emphasizes the importance of loss ratio calibration for leaching and runoff for different types of fertilizers.

Other activities

- Publication:

Wei ZB, Hoffland E, Zhuang MH, Hellegers P, Cui ZL (2021) Organic inputs to reduce nitrogen export via leaching and runoff: A global meta-analysis. Environmental Pollution

- Courses:

How to supervise a MSc student[redacted]
EASETECH: The advanced tool to integrate MFA and LCA
Scientific writing

- Meeting: None

Lessons learned

Being independent is critical to do scientific work, but personal capacity is generally limited, so teamwork can achieve more with less. I would like to hone my critical thinking, expand my scientific network, be more independent and cooperative.

Green ecological environment - 9

Reporter: Luncheng You

Supervisors: Yongliang Chen, Xuejun Liu, Zhenling Cui, Rongfeng Jiang, Fusuo Zhang, Gerard H. Ros, Wim de Vries

Date: December 19th, 2021

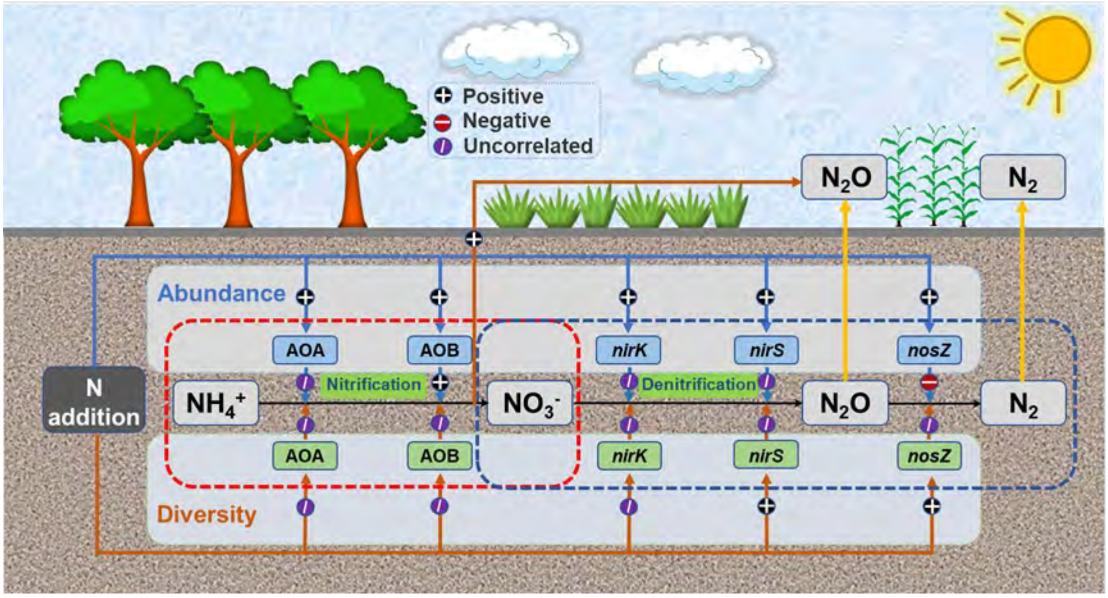
Background information

1. PhD Topic: Large scale impacts of improved management approaches on nitrogen cycling and nitrogen losses from Chinese croplands
2. Period of appointment: from 2019/09/01 to 2023/06/01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:
    1. Assess impacts of impacts of N fertilizer rates and types on the abundance and diversity of nitrogen cycle genes affecting nitrous oxide emissions.
    2. Assessment of impacts of nutrient management, crop management and soil management on nitrogen use efficiency as a function of site conditions.
    3. Assess and map the spatial variation in current and sustainable N inputs, N use efficiencies and N losses in Quzhou and Qiyang counties.

Report on research chapter 1

- **Research title:** Global meta-analysis of terrestrial nitrous oxide emissions and associated functional genes under nitrogen addition
- **Short background:** Functional genes involved in nitrogen (N) cycling regulate soil nitrification, denitrification and N_2O emissions. However, the general patterns and variability of N functional genes in response to N addition, and their association with N_2O emission have not been synthesized for terrestrial ecosystems. More specifically, we lack insight in the relative contribution of N functional genes to N_2O emission by encoding enzymes involved in the transformation of NH_4^+ to NO_2^- (AOA, AOB), NO_2^- to N_2O (*nirS* and *nirK*) and N_2O to N_2 (*nosZ*).
- **Research objectives:** (1) to identify the response of N functional gene abundance and diversity, and the associated N_2O emissions, N-cycling processes and soil properties to N addition; (2) to relate the variation in the response between studies to N addition rate, form and different biomes; and (3) to explore the abiotic (climatic and edaphic factors) and biotic (N functional gene) factors driving the changes in N_2O emissions under N addition.
- **Primary/Main results:** In croplands, N addition increased N_2O emissions (109%), the abundance of ammonia-oxidizing archaea (AOA) (19%), ammonia-oxidizing bacteria (AOB) (95%), *nirK* (52%), *nirS* (40%) and *nosZ* (41%), and the diversity of AOB (15%), *nirS* (12%) and *nosZ* (11%). In grassland, N addition increased AOB abundance (130%) and decreased the abundance of *nirS* (-99%) and *nosZ* (-58%) genes, but in forests, significant effects were only found for the abundance of AOA (35%) and AOB (121%). N_2O emission was negatively correlated with the abundance of *nosZ*, but positively correlated with the abundance of AOA and AOB. Apart from the abundance of functional AOA, AOB and *nosZ* genes, climate variables (precipitation and temperature), and available N concentrations were the main factors explaining the variation in N_2O emission with N addition, as shown by random forest analysis. These findings indicate that impacts on N

functional genes that encode enzymes involved in nitrification (AOA, AOB) and in the transformation of N_2O to N_2 (*nos*Z) are the main mechanisms behind the effect on N fertilizer-induced N_2O emissions.



- **Conclusions:** Our meta-analysis provides three important insights into the role of N functional genes in regulating N_2O emission. Firstly, impact of N addition on N-cycling genes clearly differs among croplands, grasslands and forests. Where N addition increased the abundance of all N functional genes as well as the diversity of AOB, *nirS* and *nosZ* in croplands, effects varied in grasslands and forests. In grassland, N addition significantly affected the abundance of AOB, *nirS* and *nosZ*, but in forests, significant the effects were only found for AOA and AOB abundance. Secondly, our synthesis reveals that N_2O emission was negatively correlated with the abundance of *nosZ,* but positively correlated with the *amoA* abundance, indicating that soil microorganisms consuming N_2O and producing N_2O are both important regulators of N_2O emission under N addition. Thirdly, we found that, unlike our hypothesis of equal N cycling gene contributions, both functional *nosZ* and *amoA* abundance, are the main factors regulating N_2O emission under N addition, together with climate variables (temperature and precipitation) and available N concentrations.

- **Publication: You, L.**, Ros, G. H., Chen, Y., Yang, X., Cui, Z., Liu, X., Jiang, R., Zhang, F., & de Vries, W. (2021). Global meta-analysis of terrestrial nitrous oxide emissions and associated functional genes under nitrogen addition. *Soil Biology and Biochemistry*, 108523.

Green ecological environment - 10

Reporter: Qi Zhang

Supervisors: Fusuo Zhang, Carolien Kroeze, Lin Ma, Maryna Strokal, Wen Xu

Date: December 16th, 2021

Background information

1. PhD Topic: Agricultural Green Development Pathways for Food and Clean Water in China
2. Period of appointment: from 2019/09/1 to 2021/12/10
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

The objective of this research is to explore the future Agricultural Green Development (AGD) pathways for food and clean water in the North China Plain and China in 21st century. First, to analyse the current flows of multi-pollutants from food production to surface and ground water. Then, AGD pathways are conducted for future food production and water requirements in the North China Plain. Third, future clean water availability in the North China Plain based on the AGD pathways are explored. Final, to identify the optimistic options under AGD pathways for clean water availability in China.

Report on a specific research chapter

- Research title of this chapter: Modelling antibiotics inputs to water from livestock production
- Short background

  Antibiotics are important for ensuring food production and security. China is the major antibiotics consumer globally. To satisfy the food demand, large amounts of antibiotics are taken in the livestock production which not only influence the environment, but also threaten to human health. Existing studies indicate antibiotics harmful to human health have been detected in water and soil in China. This situation brings much attention to the impact of antibiotics pollution from livestock production. However, the modelling approach to assess antibiotics from livestock production into surface and ground waters in China is not well studied. Most studies Therefore, a large-scale modeling approach is needed for assessing antibiotics pollution in surface and ground water to support policymaking.
- Scientific question or research objectives

  The objective of this research is to identify antibiotics pollution from livestock production to surface and ground water in a spatially explicit way.
- Primary/Main results

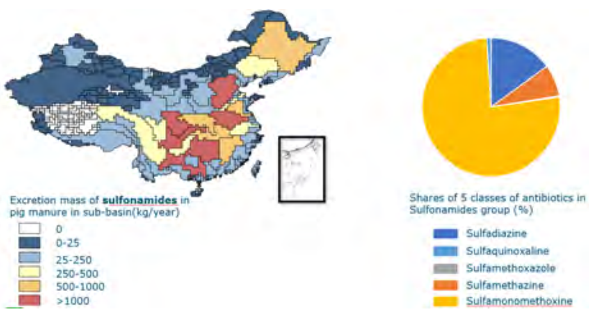


Figure 1. Excretion mass of sulfonamides in pig manure in sub-basin (kg/year)

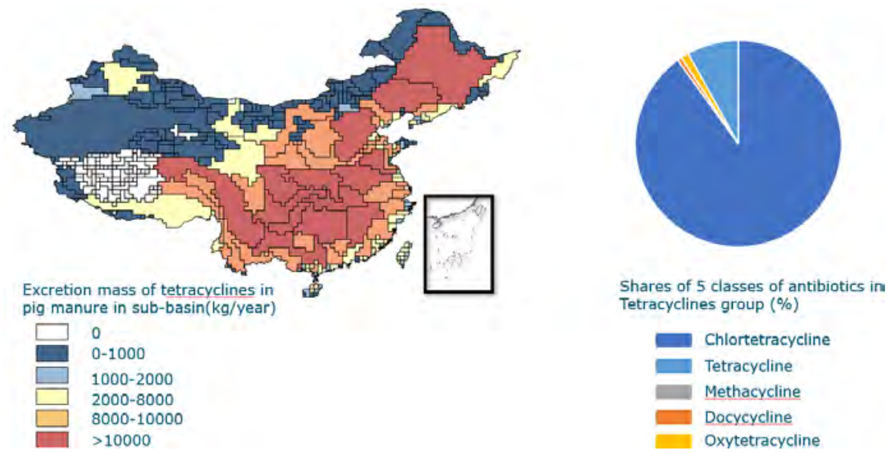


Figure 2. Excretion mass of tetracyclines in pig manure in sub-basin (kg/year)

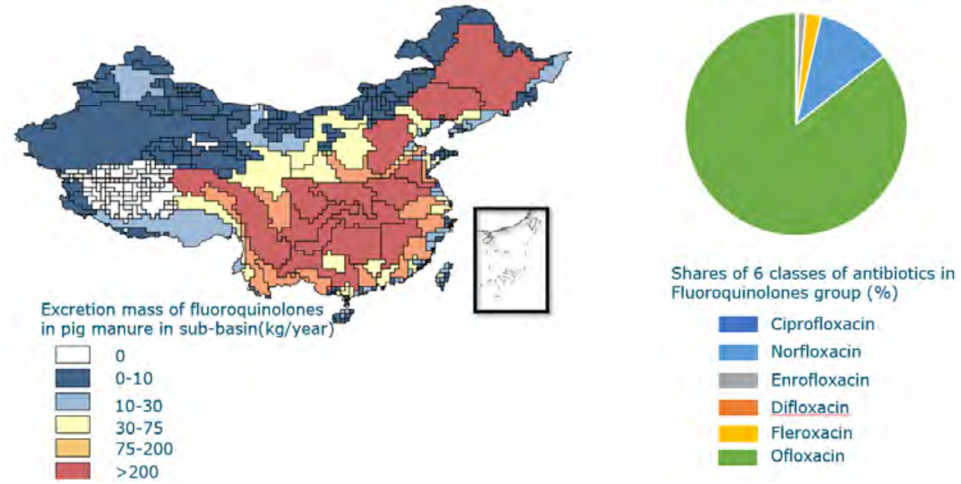


Figure 3. Excretion mass of fluoroquinolones in pig manure in sub-basin(kg/year)

- Conclusions

Tetracycline is the dominant group contribute to the antibiotics excreted in pig manure. For these categories, High excretion mass of antibiotics are concentrated in middle of Yangtze and Yellow river, and also the Heilongjiang river basin. More details will come when I finish all calculations and result analysis.

Other activities

- Publication
  - Zhang, Q., Li, Y., Wang, M., Wang, K., Meng, F., Liu, L., ... & Zhang, F. (2021). Atmospheric nitrogen deposition: A review of quantification methods and its spatial pattern derived from the global monitoring networks. Ecotoxicology and Environmental Safety, 216, 112180.
  - Li, Y., Wang, M., Chen, X., Cui, S., Hofstra, N., Kroeze, C., ... & Strokal, M. (2021). Multi-pollutant assessment of river pollution from livestock production worldwide. Water Research, 209, 117906.
  - Meng, F., Wang, M., Strokal, M., Kroeze, C., Ma, L., Li, Y., ... & Zhang, F. (2021). Nitrogen losses from food production in the North China Plain: A case study for Quzhou. Science of The Total Environment, 151557.
  - Qi Zhang, Carolien Kroeze, Shilei Cui, Yanan Li, Lin Ma, Vita Strokal, Paul Vriend, Mengru Wang, Jikke van Wijnen, Wen Xu, Fusuo Zhang, Maryna Strokal, COVID-19 increases river pollution in more than half of the rivers of the world, resubmission.

- Courses:

  I have finished the Scientific writing course and got the certification of this course.

Wageningen in'to Languages

Certificate

centre of expertise for language and communication

Wageningen in'to Languages of Wageningen University & Research Centre certifies that

Q. Zhang

has successfully completed the course

Scientific Writing

The course took place from **17-09-2021** until **05-11-2021**, consisting of **15** contact hours and **36** hours of self-study.

The student has fulfilled the course requirement of attendance.

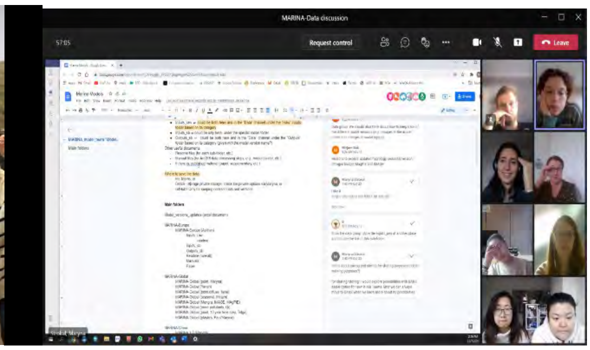
Wageningen, 05-11-2021

Irene Houkes-Jansen MA
Head of Wageningen in'to Languages

- Meeting:

  - **SURE+ International Conference**

  - **MARINA model and data meeting**



- **MARINA model training**

- **Strategy day (PhD meeting)**

- **AGD QuZhou Workshop**

- **Weekly meeting with Supervisors in WUR**
- **Biweekly meeting with the Supervision team in WUR and CAU**

Lessons learned

During the last months, I have learnt how to write a paper logically, how to show the results, and how to construct a modelling approach. Now, I have finished my first research question in my whole PhD. And, I am working on my second research question which is on modelling the antibiotics from livestock production to rivers and groundwater. My supervisor has helped me a lot during this time. I learnt from them how to be critical thinking on research and how to process our research. Thanks a lot.

Green plant production - 1

Reporter: Jiali Cheng

Supervisors: Wopke van der Werf, Jeroen Groot, Andries Richter, Wenfeng Cong, Chaochun Zhang

Date: December 19th, 2021

Background information

1. PhD Topic: Designing diversified agricultural landscape to enhance ecosystem services in Quzhou, North China Plain

2. Period of appointment: FROM 15/10/2019 TO 14/10/2023

3. Model: 1+3

4. Brief of research objectives in PhD thesis:

The main aim of this thesis project is to evaluate ecosystem services provisioning in Quzhou, North China Plain, and to explore how land use diversification at landscape level could meet the demands of stakeholders and contribute to policy objectives of agricultural green development.

To achieve this aim, the following research questions are formulated:

- What is the current state of ESs provisioning in Quzhou?
- What are stakeholder preferences for ESs?
- How does diversification of agricultural landscapes, including cropping systems, contribute to multiple ESs, what are the relations among ESs?
- What are private and public benefits of landscape diversification and which policies are suitable to reach a desirable future scenario of agriculture green development?

Report on a specific research chapter 2

- Research title of this chapter: evaluation of the agroecosystem services preference from stakeholders' perspectives.
- Short background: The different stakeholders with different social-economic background may prioritize ecosystem services for different reasons in their own stakes. In order to better manage the ecosystem services, it's necessary the prioritization of ecosystem services from different stakeholders' perspective and then the trade-offs and synergies among the stakeholders.
- Scientific question or research objectives: What are the stakeholders' preferences for agroecosystem services in Quzhou?
- Primary/Main results

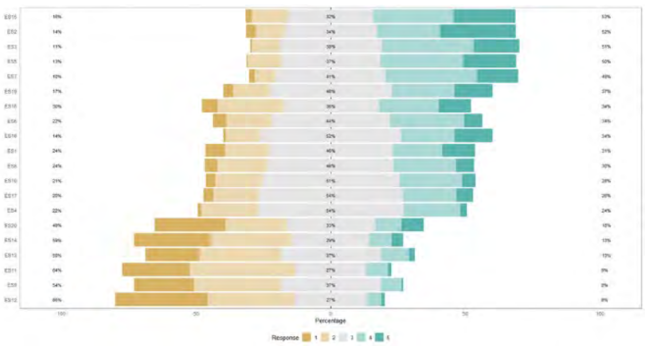
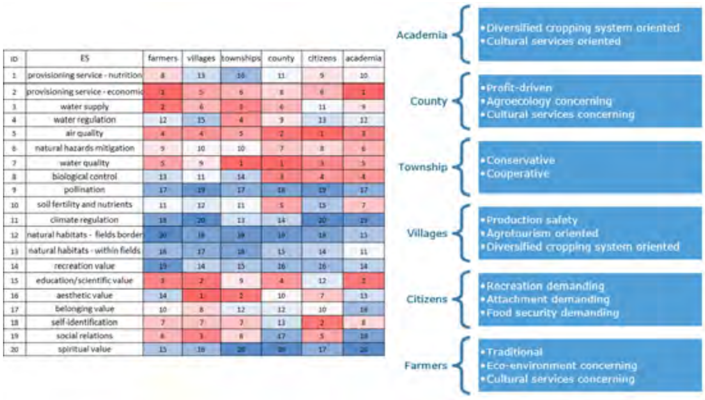


Figure 1 Agroecosystem services preference of all participants.



ID	ES	farmers	villages	townships	county	citizens	academia
1	provisioning service - nutrition	8	13	16	11	9	10
2	provisioning service - economic	1	5	6	8	6	1
3	water supply	2	6	3	6	11	9
4	water regulation	12	15	4	9	13	12
5	air quality	4	4	5	2	1	3
6	natural hazards mitigation	9	10	10	7	8	6
7	water quality	5	9	1	1	3	5
8	biological control	13	11	14	3	4	4
9	pollination	17	19	17	18	19	17
10	soil fertility and nutrients	11	12	11	5	15	7
11	climate regulation	18	20	13	14	20	19
12	natural habitats - fields border	20	18	19	19	18	15
13	natural habitats - within fields	16	17	18	15	14	11
14	recreation value	19	14	15	16	16	14
15	education/scientific value	3	2	9	4	12	2
16	aesthetic value	14	1	2	10	7	13
17	belonging value	10	8	12	12	10	16
18	self-identification	7	7	7	13	2	8
19	social relations	6	3	8	17	5	18
20	spiritual value	15	16	20	20	17	20

Figure 2 different perspectives regarding the importance of ecosystem services

- Conclusions
  - Economic income, water supply and educational/scientific values are the most important ecosystem services.
  - Habitat maintenance services, whether land sharing or land sparing, are of little interest.
  - Different stakeholder groups show very divergent preference of ES importance. Within each stakeholder group, the preference is divergent as well.

Other activities

- Publication: the contents of WP2 is in preparation
- Courses
  - Designing sustainable landscapes within regional food systems; August
  - Multivariate analysis; June
  - Critical thinking; June

- Meeting
  - Landscape 2021 (online participants)

Lessons learned

Take the step.

Green plant production - 2

Reporter: Zhengyuan Liang

Supervisors: Jeroen Groot, Wopke van der Werf, Wenfeng Cong, Chaochun Zhang, Fusuo Zhang

Date: June 2nd, 2021

Background information

1. PhD Topic: Model-aided exploration of sustainable and diversified crop production systems for the North China Plain

2. Period of appointment: from 2020.5.1 to 2024.5.1

3. Model: 1+3

4. Brief of research objectives in PhD thesis

Chapter 1: Pursuing multi-dimensional sustainability of crop production by learning from positive deviants: A case study in the North China Plain.

Chapter 2: Developing sustainable and diversified crop rotations for the North China Plain with a systematic modelling approach.

Chapter 3: Systematic redesign of spatio-temporally diversified crop production systems for contrasting types of arable farms on the North China Plain.

Chapter 4: Multi-objective improvement of the county-scale cropping structure: A case study on the North China Plain.

Report on a specific research chapter

- Research title of this chapter

  Pursuing multi-dimensional sustainability of crop production by learning from positive deviants: A case study in the North China Plain (NCP).

- Short background

  Wheat-maize double cropping (WM) systems, the dominant cropping system in the NCP, are facing multiple challenges and demands simultaneously. In reality, some farmers in local community have reached outstanding overall performances, also called positive deviants (PD). In this sense, if other WMs with undesirable performances could follow those PDs, we could make contribution to agricultural sustainability development.

- Scientific question or research objectives

  1. How do the wheat-maize (WM) perform in terms of sustainability metrics in the NCP? What are the characteristics of positive deviants (PDs) in terms of sustainability performances?
  2. To what extent the sustainability gaps could be closed for worse-performing farmers by learning from PDs? What actions need to be taken?

- Primary/Main results

  Based on the sustainability performances of WM in Quzhou, we identified 49 out of all 344 observations as PDs using Pareto ranking. However, the characteristics of those PDs were different. Then we used hierarchical clustering method to partition all PDs into different clusters (Fig.1). Then we found that PD3 reached the compromise between all metrics, which was regarded as target system (TS) in this study.

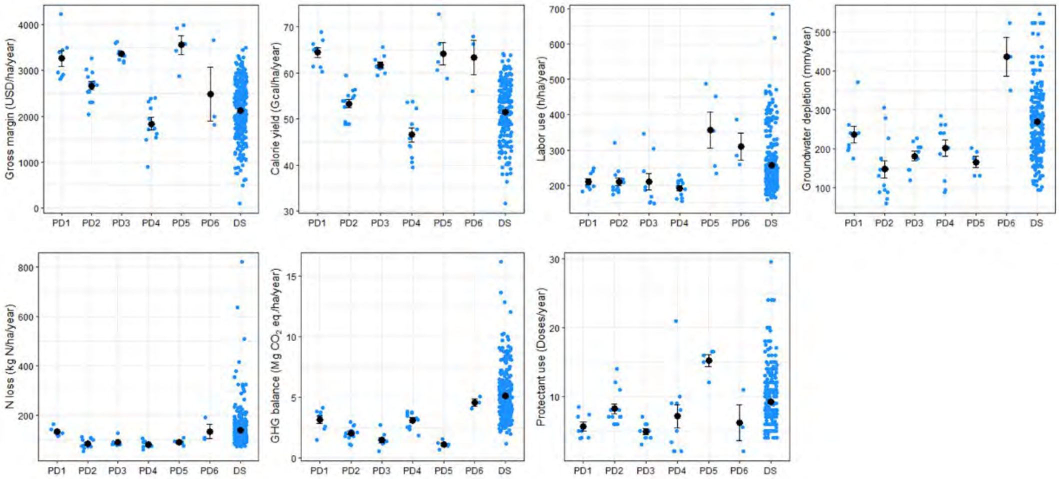


Fig. 1. Sustainability performances of positive deviant clusters (PD1-PD6) and dominated systems (DS).

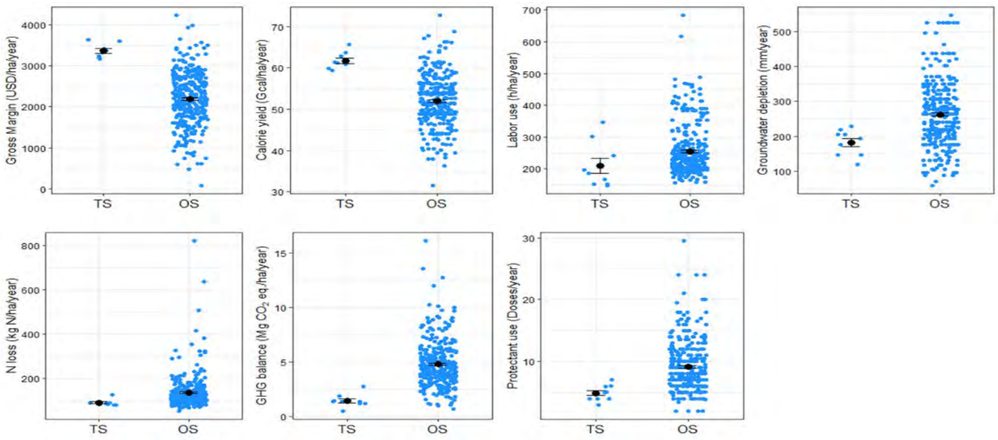


Fig. 2. Sustainability performances of target (TS, n=9) and other systems (OS, n=335).

Compared with other systems (OS), TS could significantly increase gross margin and calorie yield by 57% and 19% respectively while reducing groundwater depletion, N loss, GHG emission and protectant use by 31%, 34%, 69% and 46% respectively, which indicates that learning from the TS could help to achieve multi-objective improvement. Besides, by comparing variables describing crop management behind TS and OS, we found that TS were characterized by the increased sowing density of maize, moderate N input for wheat, reduced irrigation events, and lowered insecticide & herbicide application.

- Conclusions

1. WMs showed a great variability over sustainability metrics, 14% of which are PDs.
2. There were different types of positive deviant WMs representing contrasting directions and intensities of trade-offs among metrics, and some of PDs achieve compromise.
3. Multi-dimensional sustainability gaps have opportunities to be simultaneously and markedly closed, if other systems following PDs.
4. The key practices to improve overall performances included increasing maize sowing density, moderating N input, further reducing irrigation and pesticide use.

Green plant production - 3

Reporter: Mengshuai Liu

Supervisors: Dr. Chunxu Song, Prof. Liesje Mommer, Dr. Jasper van Ruijven, Dr. Jose G. Macia-Vicente

Date: December 16th, 2021

Background information

1. PhD Topic: Filling gaps in the roles of soil-borne pathogens for the negative feedbacks
2. Period of appointment: from 2019/09/01 to2023/07/01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

The objectives of this project are to 1) explore the extent of the potential soil-borne pathogens in current cropping systems in Quzhou area 2) understand the extent of negative plant-soil feedbacks in the wheat and maize cropping systems in this area and 3) reveal the interactions of soil-borne pathogens with nutrient applications.

Report on a specific research chapter

- Research title of this chapter

An inventory of soil-borne diseases in the North China Plain

- Short background

Soil-borne pathogens have been a limited factor in the wheat production in the North China Plain (Xu et al. 2018). Some previous studies of root pathogen such as *Fusarium* spp. causing root or crown rot diseases has been claimed in the North China Plain for wheat (Li et al. 2010, Li et al. 2012, Zhang et al. 2015, Xu et al. 2018). However, we still do not know what the main soil-borne pathogens are in Quzhou and the North China Plain for the continuous cropping of wheat and maize system. Hence, the identification and quantification of soil-borne pathogens are needed in this aera for potential improvements. Furthermore, via crop rotations or increasing crop diversity help to suppress soil-borne diseases. (Termorshuizen 2016).

- Scientific question or research objectives

1) to identify the main soil-borne pathogens of wheat/maize/soybean in the NCP, and 2) explore the ecological factors modifying the variation of specific pathogens.

- Primary/Main results

The most serious soil-borne diseases and pathogens record of wheat, maize and soybean pathogens in NCP according to the literature (Fig.1). Wheat as an example, we tried to find which one is more abundant in the NCP. The results showed that *Bipolaris sorokiniana* was more abundant in the NCP, the reason of which is being analysed (Fig.2). and *Fusarium graminearum* was serious worldwide and in whole China (Fig.3). Why specific pathogen(s) is/are accumulated in NCP? Then it is on the analysis.

Fig.1 the most serious diseases and pathogens in the NCP

Hosts	Diseases	Pathogens	References (ISI, CNKI)
Wheat	Fusarium crown rot	*Fusarium pseudograminearum, Fusarium graminearum, Fusarium equiseti, Fusarium culmorum, Fusarium tricinctum*	Zhou 2014, He 2016, Zhou et al. 2019, Fan et al. 2021
	Fusarium head blight	*Fusarium graminearum, Fusarium asiaticum*	Zhang et al. 2012, Zhang et al. 2015, Liu et al. 2017
	Common root rot	*Biopolaris sorokiniana*	Xu et al. 2018, Kang et al. 2020
	Wheat sharp eyespot	*Rhizoctonia cerealis*	Li et al. 2017
	Take-all disease	*Gaeumannomyces graminis*	Zhang et al. 2019
Maize	Corn stalk rot	*Fusarium moniliforme (F. verticillioides), Fusarium graminearum, Fusarium proliferatum*	Zhang 2010, Sun et al. 2014, Meng 2019
	Corn sheath blight	*Rhizoctonia solani*	Yang et al. 2005, Zhou et al. 2016, Yao et al. 2020
	Maize ear rot	*Fusarium verticillioides, Fusarium graminearum, Fusarium proliferatum*	Duan et al. 2016, Xi 2018
Soybean	Root rot	*Phomopsis longicolla, Fusarium equiseti, Fusarium Fujiko, Phytophthora sojae Fusarium proliferatum, Fusarium solani, Rhizoctonia solani*	Wang 2019, Yang 2012, Ye et al. 2020

Fig.2 the distribution of *Bipolaris sorokiniana* around the World and China.

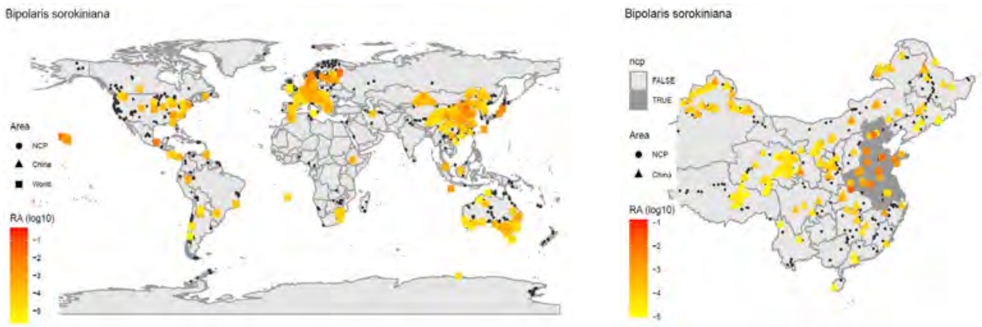
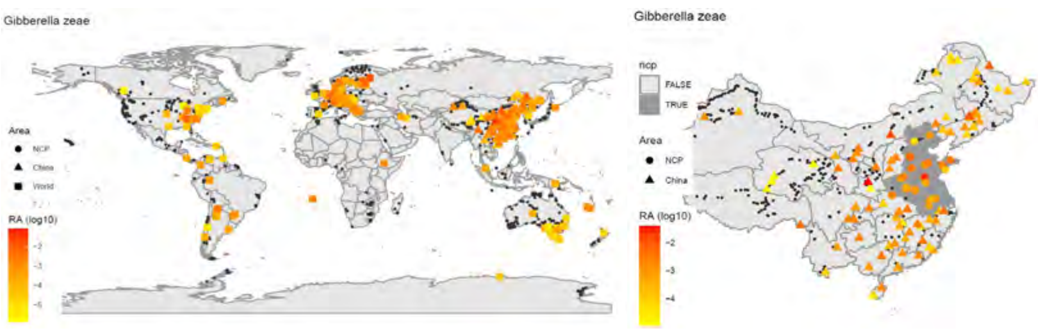


Fig.2 the distribution of *Fusarium graminearum* around the World and China.



- Conclusions

1). Fungal community as a black box needs to be explored more.

2). Pathogens in the underground are crucial factors affecting the plant productivity.

3). Certain pathogens occurred frequently in the NCP, the reason of which need to be addressed

References

Li, H. B., G. Q. Xie, J. Ma, G. R. Liu, S. M. Wen, T. Ban, S. Chakraborty, and C. J. Liu. 2010. Genetic relationships between resistances to Fusarium head blight and crown rot in bread wheat (Triticum aestivum L.). Theor Appl Genet **121**:941-950.

Li, H. L., H. X. Yuan, B. Fu, X. P. Xing, and W. H. Tang. 2012. First Report of Fusarium pseudograminearum Causing Crown Rot of Wheat in Henan, China. Plant Disease **96**:1065-1065.

Termorshuizen, A. J. 2016. Ecology of fungal plant pathogens. Microbiology Spectrum **4**:FUNK-0013-2016.

Xu, F., G. Yang, J. Wang, Y. Song, L. Liu, K. Zhao, Y. Li, and Z. Han. 2018. Spatial Distribution of Root and Crown Rot Fungi Associated With Winter Wheat in the North China Plain and Its Relationship With Climate Variables. Front Microbiol **9**:1054.

Zhang, X. X., H. Y. Sun, C. M. Shen, W. Li, H. S. Yu, and H. G. Chen. 2015. Survey of Fusarium spp. Causing Wheat Crown Rot in Major Winter Wheat Growing Regions of China. Plant Dis **99**:1610-1615.

Green plant production - 4

Reporter: Zhan Xu

Supervisors: Dr. Wopke van der Werf, Dr. Jeroen Groot, Dr. Jasper van Ruijven, Dr. Chaochun Zhang and Dr. Wenfeng Cong

Date: December 17th, 2021

Background information

1. PhD Topic: The role of planned crop diversity in productive and eco-resilient cropping systems in the North China Plain
2. Period of appointment: from 2019/9/1 to 2023/9/1
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Diversification of crop production can be a promising option in developing a more sustainable agriculture where production is simultaneously environmentally friendly, stability and economically beneficial. Although some of these benefits have been synthesized in several meta-analysis, there are still some performances that are less or rarely tested, e.g., water use efficiency, yield stability and nitrogen surplus. And performance of diversified cropping system could be influenced by different nitrogen fertilizer input levels, some trade-offs and synergies exist among these benefits while a comprehensive and quantitative assessment is lacking. And a comparison among these diversified cropping systems should also be considered. There is lack of understanding how sustainability of farm household who adopt different cropping system performance. And test the future of diversified cropping system under different constrains in a case study area is also needed. Here I want to combine meta-analysis and multi-variate analysis to explore the potentials of diversified cropping system and then use linear programming model to test the future of diversified cropping system.

Report on a specific research chapter

- Research title of this chapter: The impact of business farm on crop production activities and sustainability at multiple scales

- Short background:
  - There is no doubt that crop should be produced in a sustainable way, evaluating the consequences of current crop production activities and diagnosing the key sustainability challenges is the first step to improve sustainability.
  - With rapid structural transformation and growing urbanization in China, the conventional small farm production model is being broken gradually and the number of business farm is increasingly but the impact of business farm on crop production sustainability remains in the dark.
  - North China plain is one of the main food sources in China, 50.6% and 27.3% of the national total wheat and maize are planted in the North China Plain in 2018, respectively (China rural statistical yearbook, 2019). Meanwhile, production of high value crops has increased in the North China Plain so a comprehensive evaluation of sustainability performance of all crops at multiple scales should be done, which is planted in the North China Plain.

- Scientific question or research objectives
  - What are the key current crop production activities in Quzhou?
  - What are the current sustainability challenges in Quzhou?
  - How different between business farm and normal farm?
  - How business farm affects the crop production sustainability?

- Primary/Main results

  Compared to normal farm, business farm has a younger, better educated decision maker as a consequence of a larger farm size, more diversified crop choice and less cropping intensity but less farming experience is a weakness. Business farm has a better performance on nitrogen input, irrigation water use, gross margin and nitrogen surplus, and gross margin has increased about threefold but the improvement on environmental aspects are not much, only less 65 kg N ha^{-1} of nitrogen input, only less 67 mm ha^{-1} of irrigation water input and only less 18 kg N ha^{-1} of nitrogen surplus. The reason of sustainability performance improvement is different for different indicators, management, crop species choice, cropping system type choice and cropping intensity both contribute.

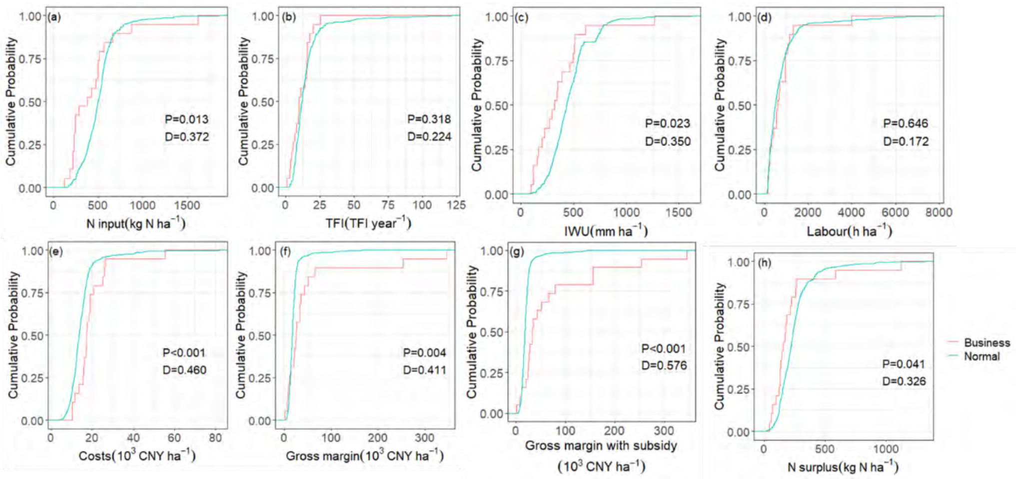


Figure 3 Sustainability indicators comparison between business farm and normal farm.

- Conclusions
  - The diversity of Quzhou is low in two aspects, including few crop species and simplified cropping system type.
  - The key sustainability challenge in Quzhou is nitrogen loss.
  - Business farm can improve crop production sustainability in some aspects, but the improvements are not much.

Other activities

- Publication: The impact of business farm on crop production activities and sustainability at multiple scales. Preparing.
- Courses: Multivariate analysis (June), Ethics in Plant and Environmental Science (November)

Green plant production - 5

Reporter: Lu Liu

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

Date: December 17th, 2021

Background information

1. PhD Topic: Closing nutrition gap through optimizing crop production and nutrients management in North China Plain.

2. Period of appointment: from 2019/9 to 2023/6.

3. Model: 2+2.

4. Brief of research objectives in PhD thesis:

(1) To conduct gap analysis of current Zn and Fe intake for Chinese residents based on latest data from Chinese Nutrition and Health survey.

(2) With quantified biofortification technologies by meta-analysis on rice and wheat, the potential of the technologies to improve crop and human nutrition could be evaluate based on current crop structure.

(3) To set up the relationship between plant nutrition and human nutrition and health through micro-nutrients. Also, optimize the nutrient management and cropping system by the need of human health at last.

Report on a specific research chapter: chapter 1

- Research title of this chapter: Dietary Zn intake among Chinese populations and different diet patterns over regions: data from China Health and Nutrition Survey 2011.
- Short background: Zn inadequacy remains a nutritional problem in Chinese people. The associations between dietary Zn intake and sociodemographic factors and dietary patterns have not been extensively studied.
- Scientific question or research objectives: The aim of our study was to investigate high risk regions of dietary Zn intake inadequacy as influenced by diet patterns across China based on the China Health and Nutrition Survey 2011. Using the EAR cut-point method, we evaluated the dietary Zn intake of individuals in each province to find sub-populations with a high risk.
- Primary/Main results:

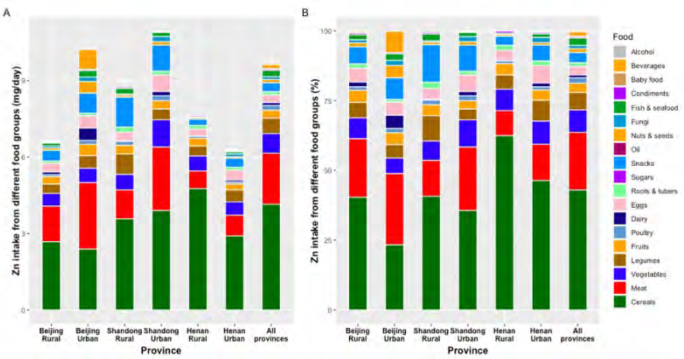


Fig. 1. Daily Zn intake pattern of adults from different food groups for three provinces (Beijing, Shandong and Henan, grouped by rural and urban area) and the average of all provinces surveyed in CHNS 2011, by amount (A, mg day^{-1}) and proportion of total daily intake (B, %).

Daily Zn dietary intake pattern of adults between 18 and 50 years of age from three days intake where food was placed into a total of 19 food groups for a selection of provinces (Beijing, Shandong, Henan and all provinces) surveyed in CHNS 2011 were showed in Fig. 1. For all provinces, 43.0% of dietary Zn intake was from cereals food and 20.6% was from meat. However, their Zn contributions to rural and urban population were different.

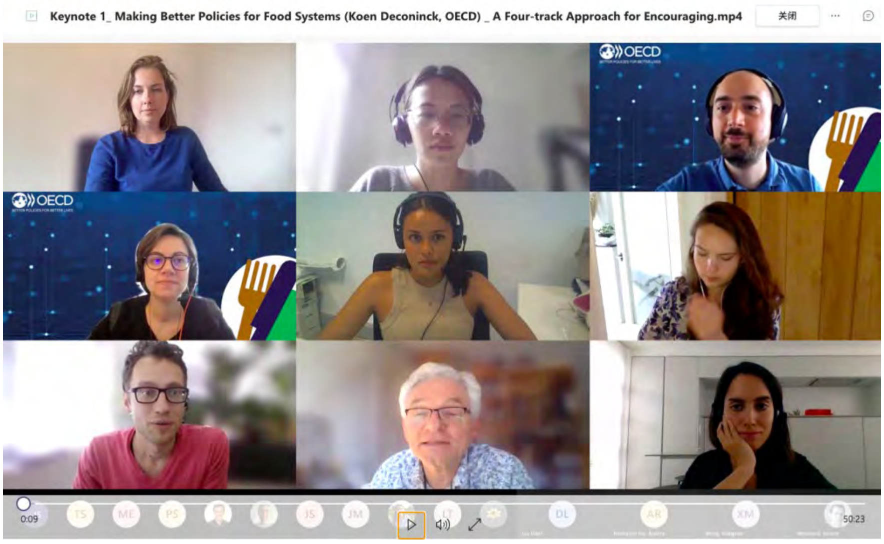
- Conclusions: North China plain was found as high-risk region of Zn dietary inadequacy because too much low Zn-dense foods were consumed. This study highlights the important role of living area and income in determining diet and Zn nutrition of people. For different provinces, there showed larges differences of diet patterns between rural and urban people which was potentially shaped by the regional food system.

Other activities

- Courses

2021.5.10-5.18: Basic Statistics

2021.7.5-7.8: Healthy and sustainable diets: synergies and trade-offs



2021.8.7-8.22: World food system center summer school

Green plant production - 6

Reporter: Jie Lu

Supervisors: Tjeerd Jan Stomph; Jochem Evers; Lixing Yuan

Date: December 14th, 2021

Background information

1. PhD Topic: Integrate FSPM and GWAS to improve NUE in maize
2. Period of appointment: from 2019/8/28 to 2023/8/28
3. Model: 1+3
4. Brief of research objectives in PhD thesis:
   - Develop a whole plant FSP model with C-N sink source relationship of organs and link aboveground with belowground 3D structures to explore plant traits related to NUE driven by light, temperature and soil nitrogen.
   - Linked GWAS with identified model parameters to identify new candidate genes related to NUE.
   - Identify ideal QTL combinations with optimal NUE under certain light, temperature and soil nitrogen environments to assist future plant breeding.

Report on a specific research chapter

Background

The Agricultural Green Development program in China aims at changing current agricultural practices in China to become more sustainable. Nitrogen is one of the essential nutrients for plant growth, required for many physiological processes in plants. NUE can be defined as the yield per unit of soil nitrogen available during the growing season and can be separated into nitrogen uptake efficiency (NUpE) and nitrogen utilization efficiency (NUtE). Since NUE and yield are complex traits, identification of a limited number of regulatory components is not enough to understand their variation (Hirel et al. 2001). Systematic approaches using tools such as crop growth models can provide opportunities to reveal how physiological processes are related in their effect on NUE and yield. However, in traditional crop models many relevant plant architectural traits are not explicitly included. Here a modelling approach is adopted, called functional-structural plant (FSP) modelling that simulates individual plants, their growth, physiological functioning and 3D architecture, growing in a crop stand and competing for resources (Vos et al. 2010).

Research question

What are the plant morphological and physiological traits which possibly have variations among maize genotypes contribute to NUE under different soil nitrogen conditions by using FSP model?

Results

<u>Model evaluation</u>

Model can produce relatively accurate visualization on maize growth with both shoot and root architecture through simulated growth season. Besides, model can also visualize soil nitrogen dynamic during the growth season (Fig. 1). Field experiments were used to evaluate the model (Fig.1).

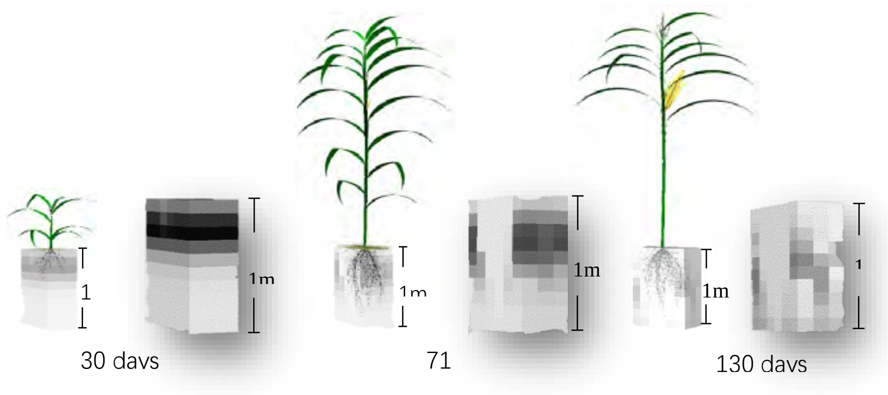


Fig.1 Visualized maize structures and soil N movements from model simulations. The figure presents three important maize growth stages, jointing, silking and maturity with comparable simulation steps. Soil can visualize nitrogen movement. Darker color represents higher amount of nitrogen in the soil cell.

Model sensitivity analysis

Sensitivity analysis was used to identify possible important phenotypes of whole plant under certain light, temperature and soil nitrogen environments. Results shows photosynthesis related characters (such as leaf number and Amax) and root morphological characters (such as root diameters) can have significant effect on NUE relevant characteristics.

Conclusion

This newly developed FSP model can well simulate plant growth driven by light, temperature and soil nitrogen. Also, there is an importance to alter certain genotypes in order to adjust for optimizing growth based on local light, temperature and soil nitrogen.

Other activities

- Courses:
  - Scientific writing
  - Integrating modelling and optimization

- Meeting etc.
  - Supervise MS student

Green plant production - 7

Reporter: Yujie Yang

Supervisors: CAU: Qingchun Pan. Lixing Yuan; WUR: Jochem Evers, Tjeerd Jan Stomph

Date: December 20th, 2021

Background information

1. PhD Topic: Optimizing genotype-environment-management interactions for maize cultivars to adapt to climate change in different zones in China

2. Period of appointment: from 2019/09/01 to 2021/06/02

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

   i) To disentangle the impacts of individual climatic variables on maize yield;

   ii) To quantify the contributions of cultivar, sowing date, planting density and N application to the variation of yield;

   iii) To explore the proper maize traits in different conditions;

   iv) To optimize G × E × M interactions in a target environment.

Report on a specific research chapter

- Research title of this chapter

  An integrated assessment of contribution and associated impacts of hybrid maize production in China - a meta-analysis

- Short background

  The maize cultivars of "zhengdan958" and "xianyu335" have continuously maintained high yield and high stability across time (1990-2019) and regions. However, yields and associated external inputs such as water, nitrogen and pesticide greatly varied among regions, due to variations in soil, climate and management measures (i.e., G x M x E). High-yielding maize cultivars have been adopted in various places in the world since the early 1990s. However, the contribution and adaptability of these high-yielding maize cultivars in terms of agricultural productivity and environmental sustainability have not been systematically and quantitatively analyzed. Here, we reported on the results of a meta-analysis using a dataset consists of 2000 observations from 1000 studies conducted in 20 provinces in China.

- Scientific question or research objectives

  This study illustrated the patterns of environment and management in different zones, and demonstrated an effective approach to develop sustainable intensification options and improve yield and stability with fewer economic-environmental costs by optimizing G × E × M interactions in the future. The results of this study may as well reflect the situation of other cropping systems in China.

- Primary/Main results

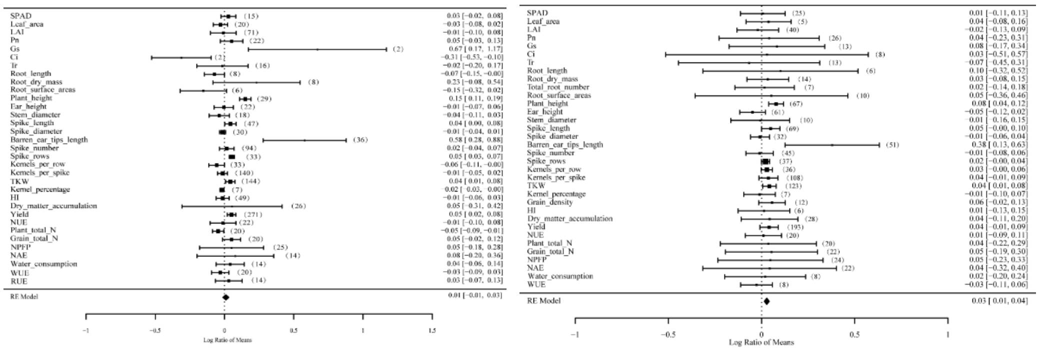


Fig 1. Meta-analysis comparison of xianyu335 versus zhengdan958 varieties of maize in agronomic and morphological traits.

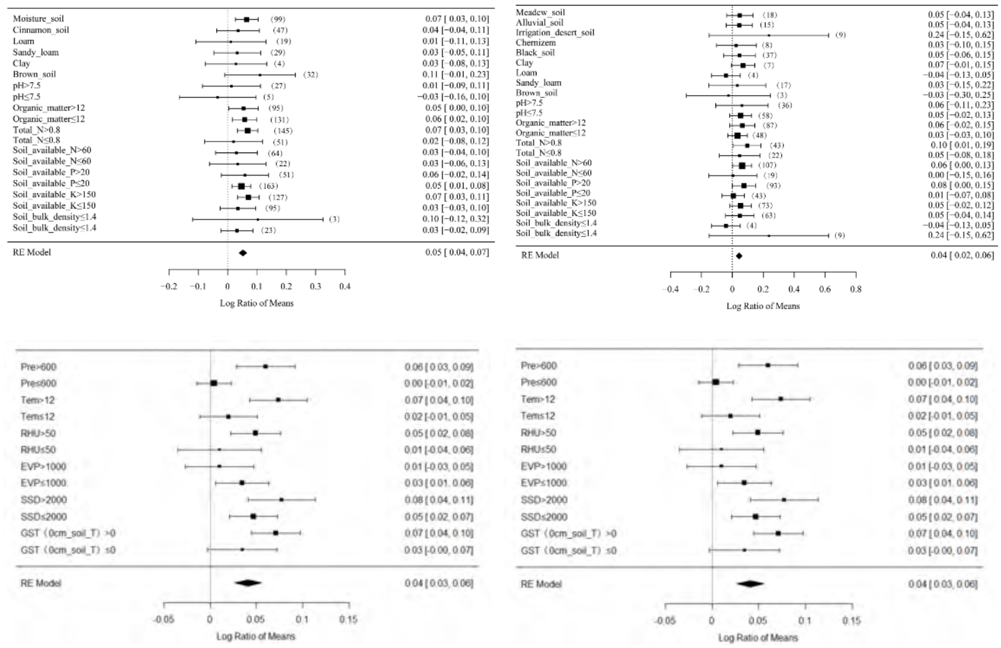


Fig 2. Meta-analysis comparison of xianyu335 versus zhengdan958 varieties in yield under both weather and soil condition.

- Conclusions

1) There was a significant difference in these traits (Plant height, Spike length, TKW), which was speculated to be the reason for the yield difference between the two cultivars.
2) The main factors influencing the yield difference between XY335 and ZD958 in different regions are Pre(rainfall), tem(accumulated temperature)) and SSD (radiation amount).
3) XY335 had higher potential yield than ZD958 in different areas under high N condition.

Overview PhD projects – starting year 2020

Summary reports, December 2021

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

Theme: Green ecological environment

Name	*Model**	*Project*
1. Juhui Chen	2+2	Labelling for sustainable development: perspective from both production and marketing
2. Haorang Li	1+3	Labelling for sustainable development: perspective from both production and marketing
3. Sijie Feng	2+2	Sustainable pathways for green agricultural development-a multi-scale integrative modelling approach
4. 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*
1. Zhaoqi Bin	1+3	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
2. Ruotong Zhao	2+2	Creating a multifunctioning soil by synergizing aboveground and belowground interactions
3. Bowen Ma	2+2	Developing sustainable diversified crop production systems for the North China Plain
4. Laiquan Luo	1+3	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
5. Yuxiang Wang	2+2	Intelligent monitoring and universal robotic harvester for Autonomous intercropping system
6. 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
7. 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
8. Yanjie Chen	2+2	Quantifying and enhancing ecosystem services for sustainable high value and healthy food production in the North China Plain
9. Bo Wang	2+2	Towards more sustainable groundwater use for food security in Quzhou
10. 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.

Green and Nutritious food provision & governance - 1

Reporter: Yujun Wei

Supervisors: Dr.ir. Weishan-Chen, Prof.dr. Xuexian Li, Prof.dr.ir. Huub Rijnaarts

Date: 06/12/2021

Background information

1. PhD Topic: GreenFoodUp: Upcycling fruit and vegetable surpluses and side-streams in China - priorities, emerging technologies and operationalization
2. Period of appointment: from Sep.2020 to Aug.2024
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Section 1: Characterise and prioritise the fruits and vegetables surpluses and side-streams (FVSS) in China's agri-food system

Section 2: Assess the techno-environmental-economic performance of upcycling technologies VS downcycling technology for the prioritised vegetables and fruits

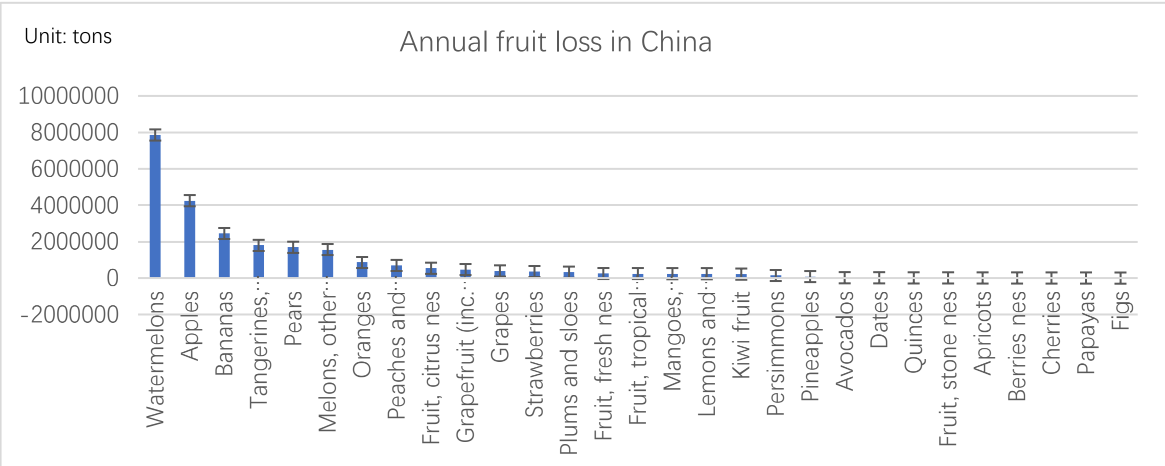
Section 3: Matchmaking the Fruit and vegetable surplus and side-streams (FVSS) with proper valorisation strategies

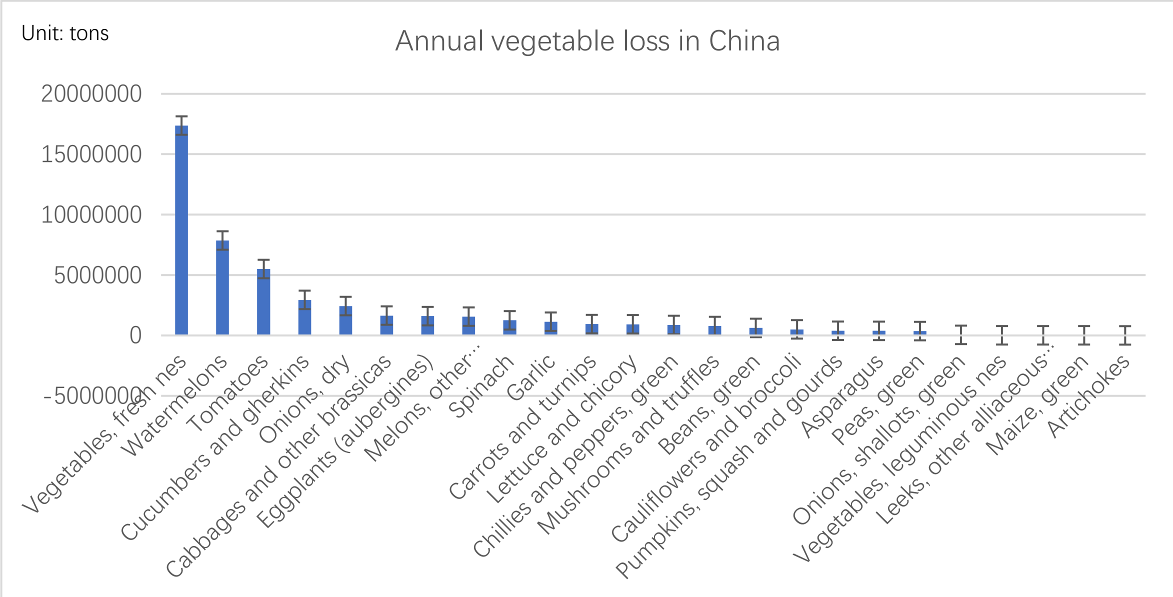
Section 4. Multi-stage valorisation design – a case study

Report on a specific research chapter

- Research title of this chapter: Characterise and prioritise the fruit and vegetable loss in China's agri-food system
- Short background: The first section aims at identifying the top fruit and vegetable loss in China agri-food system according to their environmental and economic impacts. The data of fruit and vegetable loss will be retrieved from FAO website. Currently, the data from 2014 to 2018 is available, the average value will be taken to do further assessment. In FAO database, 29 species/classes of primary fruits and 24 species/classes of primary vegetables are included the classification and definition can be found in FAO website. An Environmental and Economic Assessment Model will be developed to evaluate the fruit and vegetable loss. The fruit and vegetable loss will be prioritized by looking at their environmental and economic impacts.
- Scientific question or research objectives:

  Identify the most significant fruit and vegetable losses in China, based on the quantitative, environmental, economic analysis.
- Primary/Main results:





Note: Watermelon is categorized as vegetable by FAO because it is a temporary crop like other vegetables.

The indicators that will be used to assess the environmental and economic impact:

Environmental indicators:

- Climate change: Global warming potential
- Resource: Land occupation, Water footprint, Cumulative energy demand, Mineral extraction/Abiotic resource depletion
- Pollution: Aquatic and Terrestrial Eutrophication Potential, Acidification Potential

Economic indicators:

- Production cost (seed, fertilizer, water, on farm energy, labour...), Disposal cost
- Value of fruit and vegetable loss

- Conclusions

From FAO data, Top 5 fruit loss in China: watermelons, apples, bananas, tangerines, pears; Top 5 vegetable loss in China: Tomatoes, cucumber & gherkins, onions, cabbages, eggplant; The thing we cannot neglect is that 'vegetable, fresh nes' has the highest loss in China. The vegetable in this item refers to 'other vegetables that are not identified separately because of their minor relevance at the international level', however, some vegetables such as bamboo shoots, radish, though their impact at international level is low, the impact in China could be high, that also could be a reason for highest loss amount of 'vegetable, fresh nes'. The challenge is to estimate the loss of these fruits and vegetables.

Other activities

- Courses: Programming in Python, Circular Economy
- Meeting: Industrial Ecology (Leiden) meets Urban system engineering (WUR); Organic waste valorisation workshop

Green and Nutritious food provision & governance - 2

Reporter: Yi Zhang

Supervisors: Xuexian Li, Wei-Shan Chen, Huub Rijnaarts

Date: 13/1/2022

Background information

1. PhD Topic: Research on China's Green Food Carbon Emission Reduction Potential and Carbon Sink Effect
2. Period of appointment: from 2020/9/1 to 2024/7/1
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Agriculture has become the world's second largest source of carbon emissions, accounting for approximately 23% of anthropogenic greenhouse gas (GHG) emissions (FAO, 2003). As a major agricultural country and the largest carbon emitter, China's agricultural carbon emissions have accounted for 16% to 17% of total carbon emissions. The Chinese government has pledged in the Paris Agreement to peak carbon emission by 2030.

However, unlike industry, agriculture has the dual characteristics of carbon emissions and carbon sinks. Carbon emissions have negative externalities, while carbon sinks have positive externalities, that is, carbon sinks have the effect of reducing emissions. Net carbon emissions are the removal of carbon sinks from total carbon emissions, which has real negative externalities. In this case, scientific and accurate estimation of agricultural carbon emissions that depend on net carbon emissions is an important prerequisite for the targeted formulation of carbon emission reduction policies.

Report on a specific research chapter

- Research title of this chapter: Comparison of carbon emissions between green food cultivation and traditional cultivation in China

- Short background

Green food in China refers to uncontaminated, safe, high quality and nutritious food produced by protecting agroecosystems as well as improving the quality of agricultural products and processed food to support sustainable development of the national economy and society. According to the principle of sustainable development, the Green food standard operational protocols apply to the full industry chain, including the production, processing, packing, storage, and transportation of green foods for farm-to-fork quality control and the efficient utilization of resources, as designed by the China Green Food Development Center (CGFDC). In order to protect the environment on a sustainable basis and improve rural economic conditions, CGFDC has restricted the categories and total amount of chemicals used in the food production process. Compared with traditional intensive agricultural production, it reduces the application environment of chemical fertilizers and pesticides, and increases the use of organic fertilizers and biological agents.

China has a vast territory, and there are obvious differences in natural environment, population quality, economic development level, agricultural development structure and other regions, which may lead to regional differences in agricultural carbon emissions. At the same time, there may also be obvious phased features in the process of agricultural modernization. Therefore, it is necessary to explore the temporal and spatial dynamic evolution trends of agricultural carbon emissions in different regions and dimensions, and to explore whether restrictions on chemical inputs in green food production can reduce carbon emissions by comparing green food and traditional intensive agricultural production Make contributions and provide a valuable reference for policymakers to formulate differentiated carbon emission reduction policies.

- Research objectives

In this chapter, in order to explore whether China's agriculture will consume soil organic matter and cause the loss of organic carbon while increasing production with the development of the years. As well as whether the green food production model can form a soil carbon sink, we will start from the perspectives of geographical conditions in different regions of China, climate, crop varieties, soil types, and soil status (organic carbon content), and analyze the temporal and spatial dynamics of agricultural carbon emissions in different dimensions. Through the collection of 20 years of green food and traditional intensive agricultural production of soil organic matter content for comparison and analysis, in order to study the carbon emission reduction ability of China's green food. And to provide policymakers and agricultural workers with corresponding carbon emission reduction measures that are more suitable for local production conditions and crop varieties under sustainable conditions without affecting yield.

Green and Nutritious food provision & governance - 3

Reporter: Chenqiang Qin

Supervisors: Yuanying Ni; Xin Wen; Remko Boom; Xueqin Zhu; Costas Nikiforidis

Date: January 12th, 2022

Background information

1. PhD Topic: Exploring green transformation of plant extract industry: a case study on CCGB (Chenguang bio-tech company)

2. Period of appointment: from 2020, September, 1st to 2024 June, 1st

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

- Establishing mild extraction methods to fractionate tomato seeds into oleosome-, protein-, and fiber-rich fractions.
- Characterization of the functional and nutritional properties of three fractions extracted under different parameters.
- Exploring the potential application of three fractions in different kinds of food.
- Environmental assessment and economic modelling of different processing scenarios to facilitate decision-making for the cooperated company on sustainable utilization of the byproduct, tomato seeds.

Report on a specific research chapter

- Research title of this chapter: The extraction of tomato seed oleosomes
- Short background: According to FAOSTAT, 18.2 million tons of tomatoes were produced in 2018 all around the world, and accordingly about 1.08 million tons of tomato seeds were also produced. Tomato seeds contain 21.8% of oil, 24.6% protein, and 22.5% dietary fiber, respectively, and are rich in vitamin E. Tomato peels are used to produce lycopene in CCGB, while tomato seeds are used as animal feed or to produce tomato seed oil. Concerning the environment problem and the consumption of using energy, we would like to extract oleosome, which has a phospholipid-protein monolayer surrounding the triglyceride core, being more stable and multifunctional. The innovative twin-screw press technology will be employed to separate oleosomes, using water as the solvent, which could avoid the use of organic solvents and high energy consumption.
- Scientific question or research objectives: The effects of different extraction methods on the properties, yield, energy, environment difference of the oleosomes
- Primary/Main results

1. The composition of tomato seeds

Moisture: 8.36%±0.26%   oil(dry basis): 24.53%±2.35% protein(dry basis): 31.96%±1.96%

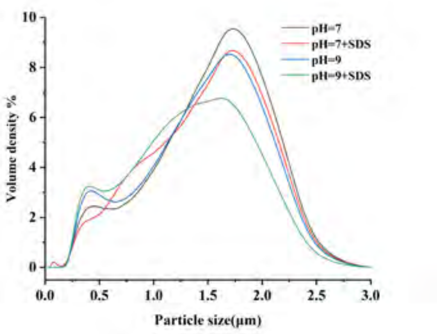
2. The yield and composition of tomato seed oleosomes

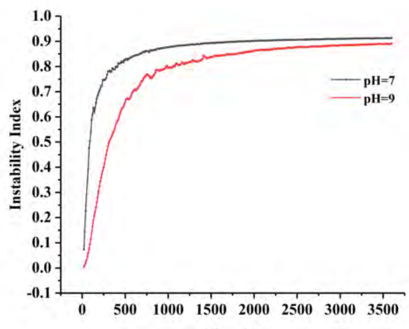
Recovery yield: pH=7: 41.32%±1.59%   pH=9: 34.89%±1.21%

Composition(pH=7): oil: 87.07%±0.33%   Protein: 6.50%±0.27%   Moisture: 46.05%±2.42%

Composition(pH=9): oil: 89.68%±2.51%   Protein: 4.02%±0.24%   Moisture: 54.77%±3.56%

3. The particle size, ζ-potential and physical stability of tomato seed oleosomes



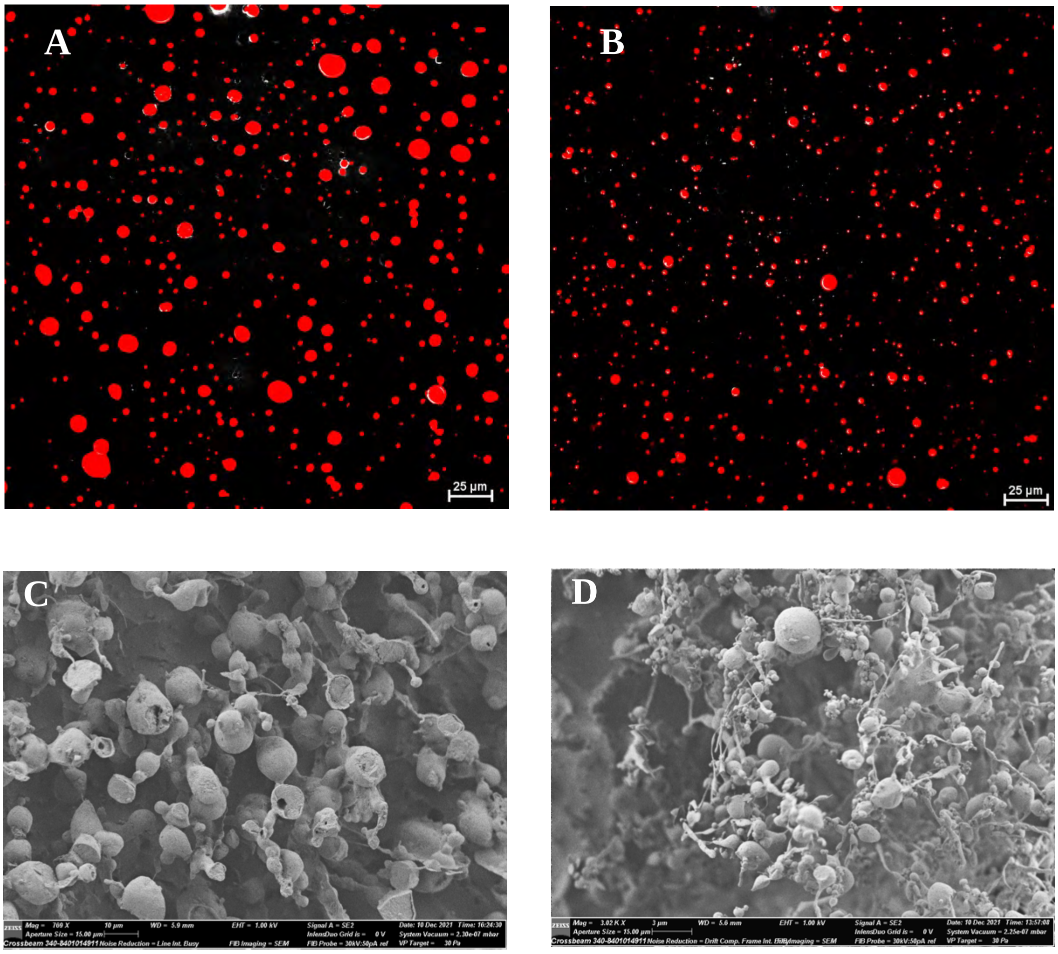


Size: pH 7:1.31±0.00^{a} pH 7+SDS:1.26±0.02^{a} pH 9:1.23±0.01^{b} pH 7+SDS:1.10±0.02^{b}

ζ -potential: pH=7: -21.83±0.31^{a} pH=9: -23.20±0.17^{b}

Physical stability: pH 9 was more stability

4. The micro-structure of tomato seed oleosomes



Note: A: ClSM, pH=7 B: ClSM, pH=9 C: cryo-SEM, pH=7 C: cryo-SEM, pH=9

- Conclusions

1.We can recover more oleosomes at pH 7.

2.The particle size of oleosomes at pH 7 are bigger than that of pH 9 and the absolute ζ-potential is contrast, so the oleosome at pH 9 are more stable.

3.The structure of oleosomes are globular and the protein yield is higher at pH7.

Other activities

- Meeting: Lipid droplets & Oleosomes: Young Scientists online event

Green and Nutritious food provision & governance - 4

Reporter: Ruijn Luo

Supervisors: Xuexian Li, Ting Meng (CAU); Sander de Leeuw, Frits Claassen (WUR)

Date: December 20th, 2021

Background information

1. PhD Topic: Environmental Impact, Economic Benefits and Optimization Strategy of the Green Navel Orange Supply Chain

2. Period of appointment: from 2020/09/01 to 2024/06/30

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

Green food refers to safe and high-quality food, but the development of it has been stable for recent years. Green labeled navel orange is a good example for green food industry because of its concentrated producing area and significant brand effect. This research aims to explore the environmental impact and economic benefits of the green navel orange supply chain (GNSC) networks which is still ambiguous, and to identify agricultural green development (AGD) options for the decision makers. For this objective, life cycle assessment (LCA) and value chain analysis (VCA) will be used to evaluate the environmental and economic performance of the GNSC networks. Results will be combined with benchmarking analysis and multiple criteria decision analysis to redesign and transform the existing structures towards a circular and market driven one.

Report on a specific research chapter

- Research title of this chapter

Environment performance of the green navel orange supply chains (GNSCs) in southern Jiangxi

- Short background

Green food refers to safe, high-quality agricultural raw materials, processed products and condiments that are produced under excellent producing conditions and full-chain quality control and certificated to use the “Green Food” label. Over the past three decades, Green Food has developed exponentially. In 2019, there were 15,984 Green food companies providing 36,345 (127 in 1990s) products. The harvested area also expanded from 0.82 million ha in the 1990s to 11.1 million ha in 2019 (Xu et al., 2020). However, the number of certificated companies and products of green food has become relatively stable in recent years (Bekele et al., 2017).

Citrus ranks the first among the four major fruits due to its planting area and production, while the annual trade volume ranks the third in the world's agricultural trade. Orange is the most popular variety of all kinds of citrus in the world accounting for 49.82% of the total production of citrus (FAOSTAT, 2020). The harvested area and annual production of citrus in China is the largest in the world. In 2019, the harvested area of citrus in China was 2.9 million ha (28.8% of the world) producing 43.5 million tons of citrus (27.6% of the world) (FAOSTAT, 2020). Meanwhile in China citrus is the largest fruit in cultivation area, production and consumption as the supply of it is initially realized throughout the year. In recent years the amount of imported citrus increased gradually but the export fluctuated. The Chinese citrus industry is large but not competitive. Therefore, China needs to improve its citrus industry urgently. Green navel orange is a typical example of Chinese citrus industry because the main producing area of it is concentrated while its brand effect is significant. There are 246 green navel orange companies valued over 4.56 billion yuan, located in Jiangxi, Chongqing, Hubei and the like in 2019 (CGFDC, 2020).

- Scientific question or research objectives

What is the environmental impacts of the GNSCs in southern Jiangxi Province?

- Primary/Main results

1. The business mode for green navel orange companies is divided into seven parts, including seedling, production, purchase, sorting, processing, storage and marketing. However, transportation is not included.

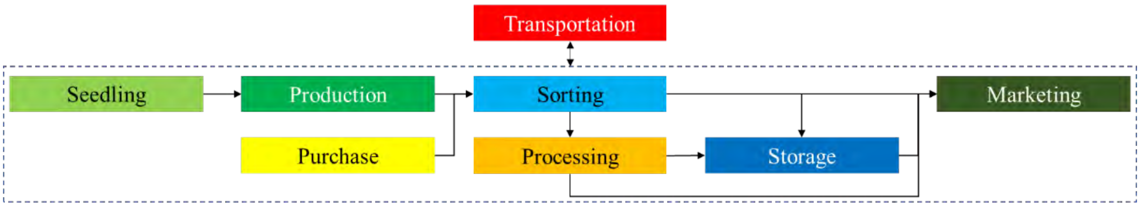


Fig. 1 Overview of the green navel orange supply chain networks in southern Jiangxi

2. Most companies prefer purchasing navel oranges from other cooperatives no matter they run orchards or not. And most fruits are harvested and sold in about 4 months.
3. In a navel orange value chain, some activities are regarded as “value-adding”, like grading, sorting and packaging, while other activities regarded as “necessary but non value-adding” and “waste”.

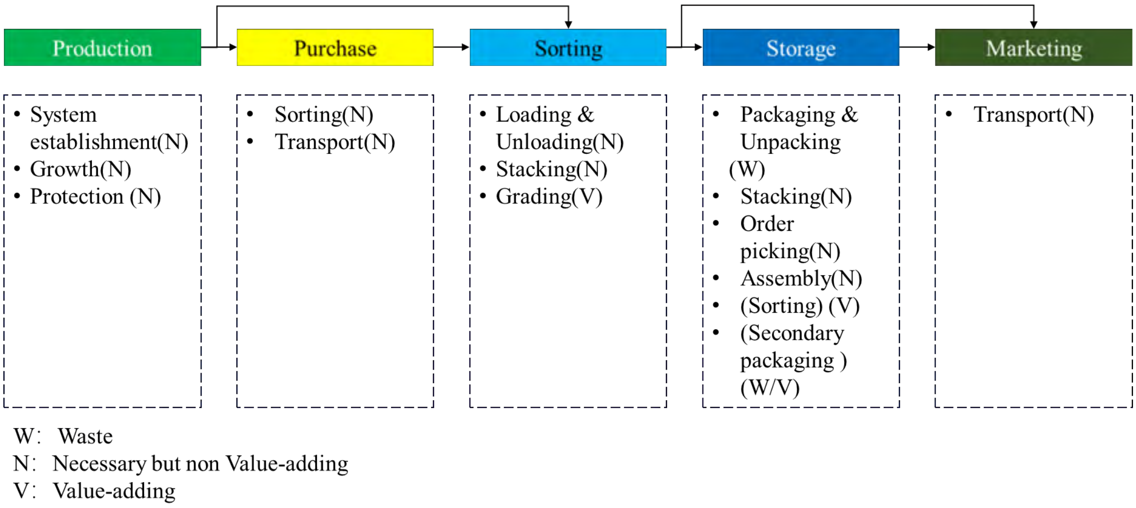


Fig. 2 Material flow in a navel orange value chain

- Conclusions

Companies neglects the storage and transport of fresh navel oranges causing a huge environment impact.

Green and Nutritious food provision & governance - 5

Reporter: Junhan Zhang

Supervisors: CAU Prof.dr. Xuexian Li, Dr. Ting Meng; WUR Prof.dr.ir. S.L.J.M. de Leeuw, Dr.ir. G.D.H. Claassen, Dr. P. Kirst

Date: 2021.12.19

Background information

1. PhD Topic: Greenprint: Multi-model Decision Support for Market-driven Circular Green Food Supply Chain Networks

2. Period of appointment: from 2020/09/01 to 2024/09/01

3. Model: 1+3

4. Brief of research objectives in PhD thesis:

The overall research objective of this PhD project is to support decision-making for the re-design of sustainable GF supply chains by providing strategic (compromising) market-driven alternatives, using advanced models (MCDM) to quantify the valorization of (by-)products and improve resource utilization. Regarding the AFSC characteristics, this will be achieved by 4 studies as shown in Figure 1.

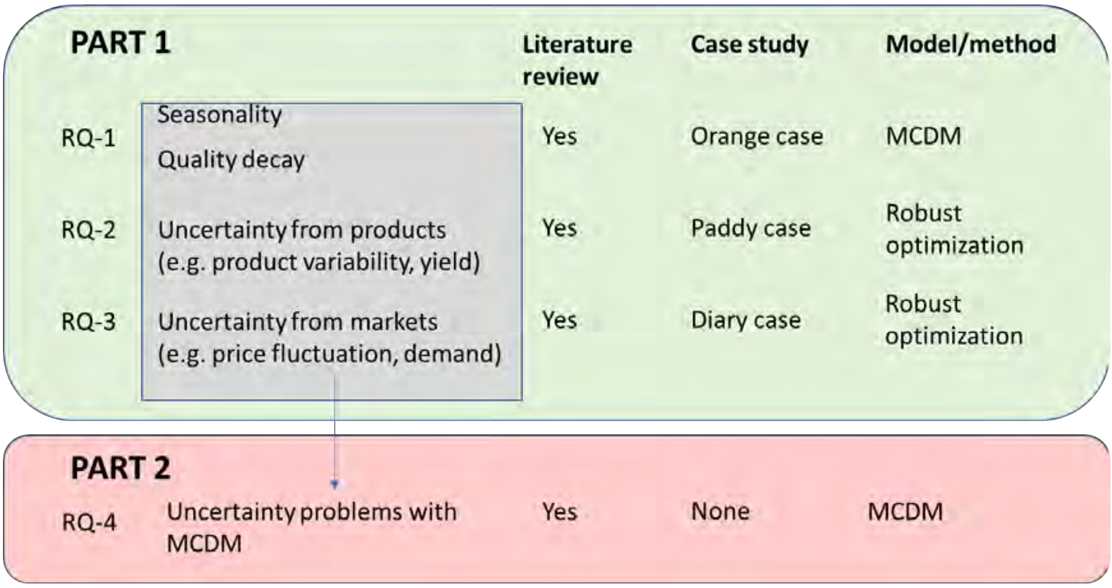


Figure 1. Research framework

Report on a specific research chapter

Chinese agriculture consists largely of planting and husbandry (National Bureau of Statistics of China, 2020). In planting industry, the majorities are grains and vegetables & fruits. Considering perishability, It is reasonable to choose the umbrella case of RQ1 from fruits (Jabarzadeh et al., 2020). Regarding the production scale of Chinese major fruits (Figure 1) and their AFSC characteristics (e.g. processing intensities), orange is chosen as a representative case to study the impact of seasonality and quality decay.

Several stakeholders among the Gannan navel orange AFSC have been visited, ranging from peasants to primary handlers and intensive processors. An important practical problem is about seasonality: the supply peak during harvest season (Figure 2), where the supply of fresh oranges grows rapidly beyond the demand. Another problem refers to quality decay, leading to reduced valorisation and utilization.

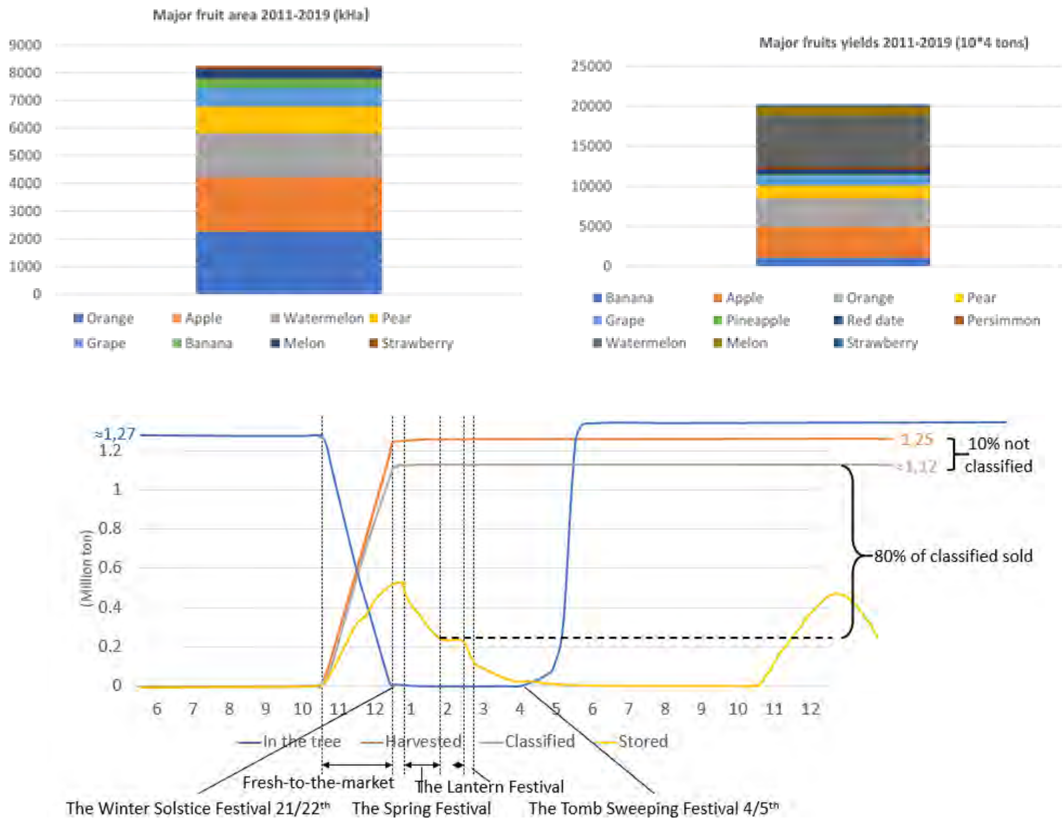
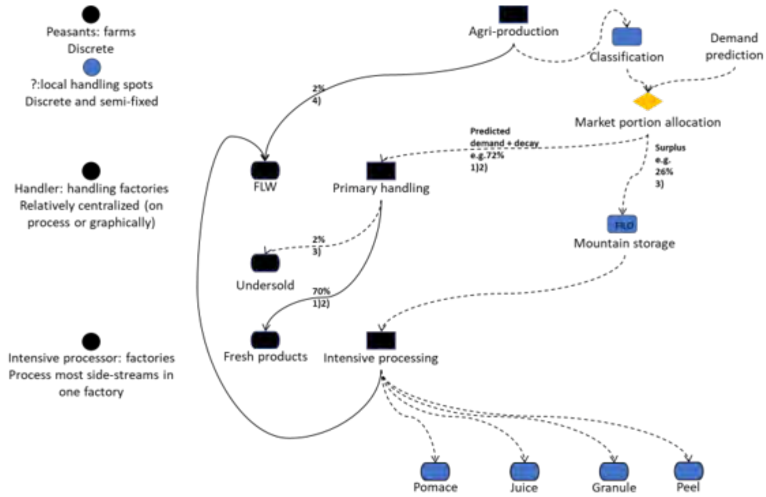


Figure 2. The annual mass distribution of navel orange SC

To remain competitive, the navel orange AFSC is challenged to adopt new technologies including an alternative chain design to lift the valorisation of primary production and reduce FLW (following figure 3, the left part in colours are modified chain stages).



With this basic sustainable AFSC MSDM model, the second step refers to the time aspect and accordingly, take seasonality and quality deterioration into account. Finally, for the case study, aim is to design a feasible alternative network and quantify its performance.

Other activities:

Courses for Python/Scientific reading, writing, and publishing; teaching assistant for Decision Science 1; Supervision of a master student; Attendance of Beta symposium.

Green and Nutritious food provision & governance - 6

Reporter: Zhiyao Chang

Supervisors: CAU Yuanying Ni, Shenggen Fan, Fusuo Zhang, Xin Wen; WUR Pieter van 't Veer, Edith Feskens, Elise Talsma, Sander Biesbroek

Date: December 10th, 2021

Background information

1. PhD Topic: Designing healthy and sustainable diets in China be respecting the regional food culture
2. Period of appointment: from 6/2020 to 6/2024
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Objectives

1) Diet quality analysis of data from the CHNS surveys using the Nutrient Density Score, Healthy Diet Indicator or other indices.
2) Descriptive modelling of nutritional quality, environmental sustainability and affordability for Chinese diet by both different location and demographic variables.
3) Trade-off analyses for China diet between health, environmental sustainability, affordability, reliability and dietary preference using the SHARP-DEA model approach.

Report on a specific research chapter

- Research title of this chapter

  Identification of the relationship between dietary scenarios and diet-related health risk factors

- Short background

  The diet-related health impacts of foods are important but have not been well integrated, previous studies were mainly focusing on the association between single food item and specific healthy risk. Aggregating each health risk from foods to link to the entire dietary patterns will be the solution of complex dietary health outcome for individuals, which **is able to give a composite health profile for the consumers**[1-4].

- Scientific question or research objectives

  Research questions:

  How can we link health impacts to different dietary scenarios? What benefits or damage would be generated when the dietary patterns have changed?

  Objectives:

  Integrate healthy risks of each food item into an entire diet, compare health endpoint of each dietary pattern.

- Main methods

Step 1. Risks (NCDs) identified

Mortality and NCDs (Ischaemic heart disease, Diabetes mellitus type 2, Stroke, Colon and rectum cancer), which risk-outcome evidence is existed.

Step 2. Supplement other Dietary Risk Factors and then identify their theoretical minimum risk-exposure level (TMREL)

Eggs, oils, refined grains and sodium should be consistent with food intake data we used. In particualr, for sodium, the gold standard applied in GBD studies is 24-hours urinary sodium, we meed transfer it to dietary intake by transformation factor (US is 0.86 from dietary sodium intake to 24-h urinary sodium)

Step 3. Entire dietary diseases (NCDs) endpoints

Combine each risk-outcome pair for single food into the entire diets, compare aggregated risk outcomes among varied dietary scenarios.

Step 4. Applying the Health Nutritional Index (HENI) to estimate the total attributable burden of diets

Estimation of healthy life gained or lost of different dietary scenarios based on HENI.

Other activities

- Courses:
  Scientific writing
  Agricultural green development
  Doctoral career planning
  Tailor-made Writing training
  Food Environmental for Healthy Sustainable Diets
- Meeting etc.:
  AGD symposium 2021
  WUR Summer/Winter School Lecturer

References

[1] Clark MA, Springmann M, Hill J, Tilman D. Multiple health and environmental impacts of foods. Proc Natl Acad Sci U S A. 2019 Nov 12;116(46):23357-23362.

[2] GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018 Nov 10;392(10159):1923-1994.

[3] Katerina S. Stylianou, Victor L. Fulgoni and Olivier Jolliet. Small targeted dietary changes can yield substantial gains for human health and the environment[J]. Nature Food.

[4] GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2019 May 11;393(10184):1958-1972

Green and Nutritious food provision & governance - 7

Reporter: Xiaoxia Guo

Supervisors: CAU Fusuo Zhang, Chong Wang, Minghao Zhuang; WUR Annah Zhu, Xueqin Zhu

Date: 2022 January 12

Background information

1. PhD Topic: Optimization and realization of green planting technology system for main crops based on multi-objective coordination

2. Period of appointment: from 2020 September 1 to 2024 May 31

3. Model: 2+2

4. Brief of research objectives in PhD thesis:

The objective of my PhD thesis is to develop a comprehensive quantitative method for agricultural sustainability assessment, analysis the sustainability of widely-used technologies in staple crop production, and construct the application ways in smallholder farmer systems. Specifically, the first goal is to screen and select indicators involving environment, economy, efficiency, and food security dimensions (focusing on widely planted staple crops, i.e., wheat and maize). Define the calculation methods and relevant factors, and test the methodology to prove the effectiveness of this evaluation method. The second goal is to evaluate the sustainable degree of widely used technologies (i.e., seeding rate and date, N topdressing, straw returning, conventional tillage) and score them. Analyzing their economic and environmental performance and explain the reasons. The third goal is to design the sustainable technology combinations based on robust models (i.e.,DSSAT, DNDC, machine learning). The last goal is to construct the application ways to spread sustainable technologies among smallholder farmers.

Report on a specific research chapter

- Research title of this chapter

  Construction of sustainable evaluation method for wheat and maize cropping systems

- Short background

  Agriculture is the key to global sustainable development, because it relates to nourishment essential for human existence. However, the pursuit of high productivity has been accompanied by mounting resource inputs and pollutants. Previous researches generally concentrated on single aspect of agricultural sustainability, such as GHG emissions, nutrient leaching, and profits. Comprehensive evaluation method from systematic perspective is still lacking.

- Scientific question or research objectives

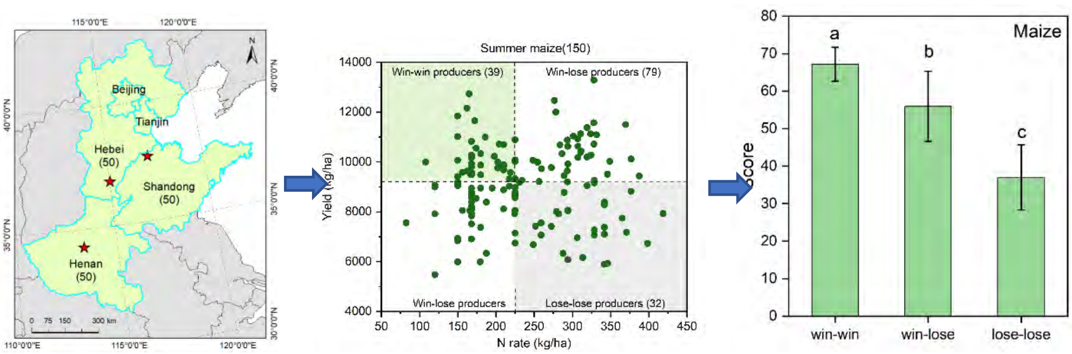
  1. Select indicators for agricultural sustainable assessment and determine their calculation method.
  2. Determine the weights of indicators based on coefficient of variation method.
  3. Test the effectiveness of methodology.

- Primary/Main results

1. Constructing sustainable evaluation index system and determining their weights based on coefficient of variation (CV) method.

Index	Nationwide			
	Weight (wheat)	Rank (wheat)	Weight (maize)	Rank (maize)
Yield	0.0699	9	0.0676	8
Input/Output	0.1297	5	0.0671	9
Labor productivity	0.1312	3	0.1223	3
UEV	0.1474	1	0.0782	7
LCA energy consumption	0.0863	7	0.1059	4
LCA water consumption	0.1314	2	0.2121	1
LCA global warming	0.0743	8	0.0890	6
LCA acidification	0.0988	6	0.1001	5
LCA eutrophication	0.1309	4	0.1577	2

2. Testing the evaluation method.



Study area Smallholder categorization Sustainability score

- Conclusions

Here, we propose a new method for sustainable assessment of agricultural systems based on analytic hierarchy process and coefficient of variation method. After testing, this method is effective and sensitive for sustainable assessment of different smallholder managements.

Other activities

- Publication

Guo, X.X., Zhao, D., Zhuang, M.H., Wang, C., Zhang, F.S., 2021. Fertilizer and pesticide reduction in cherry tomato production to achieve multiple environmental benefits in Guangxi, China. Sci Total Environ, 793, 148527.

- Courses

Systems Thinking and Analysis, Scientific Writing and Presenting, Agricultural Green Development

- Meeting etc.

The Third International Symposium on Agricultural Green Development (December 2020, Haikou, China)

Lessons learned

The determination of weight is the key to the construction of index systems. Compared with expert scoring method, the CV method is more objective and convincing.

Green and Nutritious food provision & governance - 8

Reporter: Xiaodan Li

Supervisors: Annah Zhu, Xueqin Zhu, Simon Bush, Chong Wang, Fusuo Zhang

Date: 2021-1-12

Background information

1. PhD Topic: Smallholder farmers' engagement in participatory programs and sustainability practices——insights from China's Science and Technology Backyards
2. Period of appointment: from 2020 to 2024
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Research question1. What are the major types of participatory initiatives for engaging smallholder farmers in sustainable agriculture in the developing world (e.g., farmer participatory research, innovation platforms, etc.) and what has been their impact thus far?

1. to explore and create a typology of the different forms of participatory initiatives that aim to improve sustainability in smallholder farming.

Research question2. Which socio-economic factors influence farmers' adoption of sustainable agricultural practices?

1. to explore the factors influencing farmers' adoption of sustainable agricultural practices

Research question3. How and to what extent does participation in STB programs influence farmers' adoption of sustainable agricultural practices?

1. to explore the relationship between different levels of participation in STB programs with farmers adoption of sustainable agricultural practices

Research question4. How and to what extent does participation in STB programs impact farmers' technical and environmental efficiency?

1. to evaluate whether and to what extent those farmers who participate in STBs have greater technical and environmental efficiency in terms of higher nutrient-use efficiency, lowered water usage, and reduced greenhouse gas emissions.

Report on a specific research chapter

- Research title of this chapter
- Short background
- Scientific question or research objectives
- Primary/Main results (including Figures/Tables)
- Conclusions

Participatory initiatives for engaging smallholder farmers towards sustainable agriculture——a scoping review

Multi-stakeholder partnerships and other participatory approaches provide ways of disseminating knowledge about and encouraging uptake of more sustainable agriculture practices (Hounkonnou D et al. 2012; Zhang W et al. 2016; Nyikahadzoi K et al. 2012; Holden S TJoseph L O 1991; Reijntjes C et al. 1992; Manyong V M et al. 2001; Struik P C et al. 2014; Kilelu C W et al. 2013; Cronkleton P et al. 2021; Humphries S et al. 2015). Whatever these approaches are labelled, their primary feature is to create public alliances or learning spaces for mutual engagement and negotiation and collective action for sustainable agriculture instead of passively putting farmers in the shoes developed by scientists. Much scholarship has demonstrated this possibility of linking researchers and lay-experts through community-based approaches (Aare et al., 2021; Dolinska, Oates, Ludi, Habtu, Rougier, & Sanchez Reparaz et al., 2020; Dolinska, Oates, Ludi, Habtu, Rougier, & Sanchez-Reparaz et al., 2020; Vetter, 2020), innovation platforms (Brown et al., 2021; Kilelu et al., 2013; Mahiya, 2020; Osorio-García et al., 2020), and farmer participatory research (Chambers & Ghildyal, 1985; Hauser et al., 2016; Humphries et al., 2015) in agriculture. The first chapter answers the question of What are the major types of participatory initiatives for engaging smallholder farmers in sustainable agriculture in the developing world (e.g., farmer participatory research, innovation platforms, etc.) and what has been their impact thus far? The objectives of the research question are: 1) to explore and create a typology of the different forms of participatory initiatives that aim to improve sustainability in smallholder farming. 2) to explore the achievements and lessons learned from these participatory approaches.3) to explore the similarities and differences between China's STB model and other participatory initiatives.

Other activities

- Courses

Completed WASS courses：

Research methodology, From Topic to Proposal (4 credits)

PhD Methodology Course (2 credits)

Advanced Econometrics (6 credits)

Green animal production - 1

Reporter: Rui Shi

Supervisors: Aart van der Linden, Bart Ducro, Herman Mulder, Simon Oosting, Yachun Wang

Date: 2021.12.14

Background information

1. PhD Topic: Developing sustainable breeding strategies of dairy cattle in China with emphasis on improved resilience
2. Period of appointment: from 2020/10/01 to 2024/09/30
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

From a breeding point of view, balanced breeding is the best way to simultaneously improve production efficiency and health and resilience. The objective of this research is to develop sustainable breeding strategies increasing efficiency and resilience and reducing environmental impact of dairy production. Three aspects will be the cornerstones to make the dairy cattle industry in China more sustainable: (1) formulation of a breeding goal with weights for each trait, (2) collection of phenotypic information on these breeding goal traits and estimation of breeding values and (3) designing a breeding strategy to optimally achieve genetic improvement in the balanced breeding goal.

Report on a specific research chapter

- **Chapter 2**: Evaluating the environmental consequences of genetic improvement

- Background of **Chapter 2**

  The primary objective of current breeding strategies is mainly earning income, but breeding could also contribute to minimizing the environmental impacts of dairy industry. The effect of breeding strategies on environment can be evaluated at animal, farm, and chain level, mainly including greenhouse gas emissions and nutrients use efficiency.

  At animal level, new traits can be defined or predicted, and regular genetic evaluation procedures can be applied to these environment-related traits to assess, and to reduce the adverse environmental impacts. At farm or chain level, life cycle assessment (LCA) can be used to estimate the environmental impacts for a group of animals in the farm, or during the whole lifetime of an animal product.

- The objective of this research chapter is to quantify and reduce the environmental impacts of Chinese Holstein cows.

- Main results

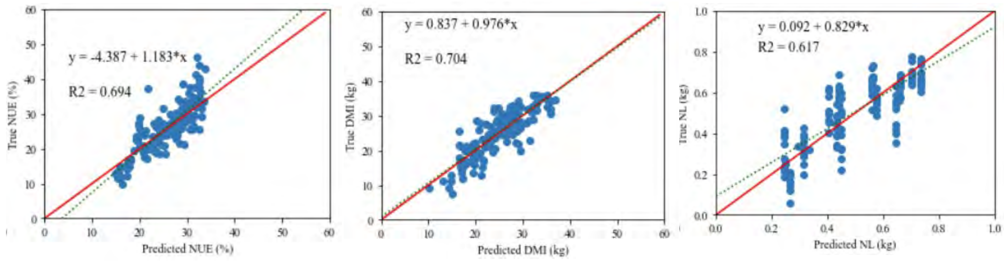
  (1) In the first sub-section, herd parameters, feed formular as well as the economic parameters were collected from a representative demo farm in Beijing, China. The LCA at cradle-to-farmgate level was applied to this farm to quantify the carbon footprint in this production system. Basically, enteric emission of animal accounts for over 53% of all greenhouse gas emission within the farm, and every kilogram of fat and protein corrected milk will produce 1.406 kg CO_2-eq (**Table**). This value is in consistent with previews publications.

Table. Methane emission at farm level

Item	Emission (tons CO2-eq/year)				
	Lactating cows	Heifers	Female calves	Sum	%
Enteric emission	7830.27	620.75	205.1	8656.12	53.27
Farm facilities		882.46		882.46	5.43
Manure management	5816.21	720.79	175.31	6712.31	41.3
FPCM (kg/ year)	11559.35			16250.89	
Allocated emission (kg CO2-eq / kg FPCM)			1.406		

(2) In the second sub-section, individual nitrogen use efficiency (NUE) of dairy cow was predicted. NUE was firstly defined as ratio of grams of N in milk to grams of N intake. True DMI data (from feeding trails) were used to validate the prediction accuracy of NUE. The prediction model included MIR, milk yield and parity, which are frequently recorded in the dataset. After data editing, 600 records from 56 cows were retained for prediction and validation. Results (**Figure**) showed that R^2 of prediction model reaches 0.69, 0.70 and 0.62 for NUE, DMI and NL, respectively.

Figure. Prediction accuracy for each trait



- Conclusions

(1) LCA generates comparable methane emission value at farm level.

(2) By utilizing MIR data, powerful prediction models can be developed for individual N related traits.

Other activities

- Publication
  - Shi, Rui et al. Genetic parameters of hair cortisol as an indicator of chronic stress under different environments in Holstein cows. Journal of Dairy Science. doi:10.3168/jds.2019-17856.
  - Shi, Rui et al. Genotype-by-environment interaction in Holstein heifer fertility traits using single-step genomic reaction norm models. BMC Genomics 22:193. doi:10.1186/s12864-021-07496-3.

Green animal production - 2

Reporter: Yujuan He

Supervisors: Yingjun Zhang, Jingying Jing, Paul Struik

Date: 2021/12/20

Background information

1. PhD Topic: Legacy effects of mixed grassland on subsequent crops under various levels of phosphorus fertilization
2. Period of appointment: from 2020/9/6 to 2024/6/6
3. Model: 2+2
4. Brief of research objectives in PhD thesis

- Abiotic and biotic soil Legacy effects of plant diversity and phosphorus on plant performance
- Influence of mixed ratio and phosphorus on the Legacy effect of mixed grassland and its biological mechanism

Report on a specific research chapter

Influence of mixed sowing ratio and phosphorus on the Legacy effect of mixed grassland and its biological mechanism

- Short background

Several options exist to diversify cropping systems, such as mixing varieties, inter-cropping species, introducing cover crops, and increasing the diversity of crops in the crop sequences. These options have received frequent attention from the scientific community, but another option has received much less: introducing ley pastures into cropping systems. It's really important to elucidate legacy effects of plant-soil interactions from above and below the ground and will provide a deeper insight into a better understanding of the importance of plant trait and soil characteristic-mediated indirect interactions in shaping community assembly, biodiversity and ecosystem function.

- Scientific question or research objectives

1. Are there any positive legacy effects of a previous ley'lhs grass-legume mixed ratio on biomass yield, plant quality of a subsequent crop?
2. Are these legacy effects affected by previous P level?
3. Which mixed ratio and P levels are required in a previous mixture to obtain maximum benefits?

- Primary results

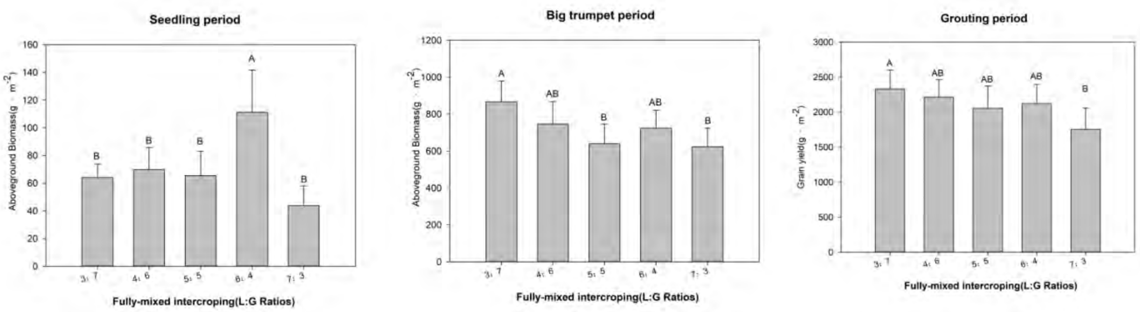


Fig.1 The Effect of different sowing ratio of legume and grass on the above-ground biomass of maize in different growth periods

	No Legume (t DM ha-1)	30% (t DM ha-1)		100% (t DM ha-1)
Seedling period	0.52±0.13	0.64±0.10	NS	0.92±0.28
Big trumpet period	7.00±1.22	8.67±1.13	NS	7.96±1.20
Grain Yield	22.31±3.37	23.33±2.69	NS	23.77±2.83
Legume legacy effect		(t DM ha-1)		(t DM ha-1)
Seedling period		0.12		0.4
Big trumpet period		1.67		0.96
Grain Yield		1.02		1.46

Table 1 Effect of three stand types of the previous ley and the legume legacy effect on the biomass yield of a following crop of Maize

- Conclusions

The results demonstrate a sustained soil transferred performance-enhancing legacy effect on a following crop in a rotation, with previous legume proportions of 30% having a comparable effect compared with that of a previous legume monoculture.

Other activities

- Courses

✓ Scientific Writing and Presenting Course

✓ Agricultural green development

✓ System analysis theory and method

Fig.2 Some pictures in courses

- Meeting etc.

✓ The 3rd Agriculture Green Development Symposium Sino-Dutch AGD project annual meeting

Fig.3 Some pictures in meeting

Green animal production - 3

Reporter: Hao Liu

Supervisors: Paul Struik, Yingjun Zhang, Jingying Jing.

Date: 2021/12/20

Background information

1. PhD Topic: Forage quality in intercropping
2. Period of appointment: from 2020/06/01 to 2021/12/20
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Intercropping has been found to significantly increase the yield, resource use efficiency, and agriculture ecosystem services. However, there are also many intercropping systems that are not aiming to harvest grains but to produce forage. Thus, the forage quality of intercropping should be determined. A meta-analysis and two years of perennials (red clover, whiter clover and lucerne) maize intercropping field trials will be conducted in Wageningen, the Netherlands.

This study aims to investigate the forage yield, forage quality and greenhouse gases emission in maize perennial legume intercropping system. This study improves our understanding of the forage quality of intercropping system aims for forage production.

Report on a specific research chapter

1.

- Research title of this chapter:

  Does intercropping improve forage quality of intercrops? A Meta-analysis

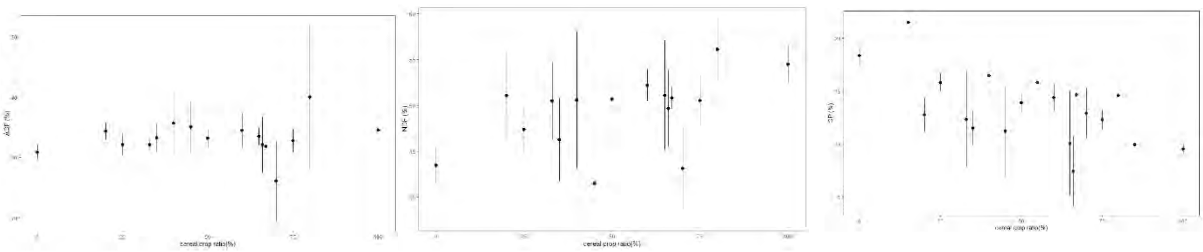
- Short background:

  Intercropping is an ancient practice that has been marginalized by modern intensive agriculture. However, intercropping may be a means to solve some of the major problems associated with modern agriculture, thereby contributing to the realization of productive, effective, and sustainable agriculture. There are many intercropping systems that are not aiming to harvest grains but to produce forage. A lot of field experiments have measured the forage quality in intercropping, but their results are sometimes conflicting. Currently, some meta-analysis have compared intercropping with monoculture, primarily concentrate on yield, resource use efficiency, and agriculture ecosystem services etc. However, no quantitative synthesis has been conducted on forage quality in intercropping.

- Scientific question or research objectives:

  Thus, the aim of this study is to analyze and synthesize experimental evidence on the effect of intercropping on forage quality compared with that of the respective sole crops, through a meta-analysis of published papers.

- Primary/Main results (including Figures/Tables)



The crude protein, acid detergent fiber (ADF) and neutral detergent fiber (NDF) content of different cereal crop seeding ratio in mixed cropping with replacement design are presented in the figures. The crude protein content decreased with the increasing of cereal crop seeding ratio. The NDF content increased with the increasing of cereal crop seeding ratio. However, the ANF content is not influenced by the seeding ratio of cereal crop in mixed cropping with replacement design.

2.

- Research title of this chapter:
  On forage yield, forage quality and greenhouse gases emission in intercropping of maize with perennial legumes.
- Short background:
  Perennial intercropping systems have generated positive results in which soil fertility, crop productivity, nutrient use efficiency, and microbial activity were promoted. Nevertheless, a large proportion of perennial forage legumes intercrop with cereal as a living mulch and cover crop, merely utilized as forages. Increasing attention should be paid to cereal/perennial legume intercropping systems with the aim of enhancing forage productivity without hampering the environment.
- Scientific question or research objectives:
  Thus, the aim of this study is to investigate the forage yield, forage quality and greenhouse gases emission in maize/perennial legume intercropping system.
  Research questions:
  Can perennial crops be intercropped with maize for increasing forage yield, forage quality and mitigating greenhouse gases emission?
  Is there a yield advantage in perennial crops-maize intercropping under various climatic conditions?

Other activities

- Courses: grassland science, data management


- Meeting:
  My supervisor Paul and I meet at a regular base of once per week. Sometimes we have Tjeerd Jan and Alejandro if we discuss database or R studio.

Green animal production - 4

Reporter: Dongdong Lu

Supervisors: Junjun wang, Defa Li, Nicoline Soede, Bas Kemp

Date: 2021/12/09

Background information

1. PhD Topic: **The effects of different fiber sources on constipation and offspring health of sows during late gestation**
2. Period of appointment: from 2020/09/01 to 2024/09/01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Previous studies have shown that fiber-rich diets during both late gestation and lactation can decrease the weight loss of lactating sows and concurrent piglet mortality. The different fiber sources are fermented in the hindgut of the sow, resulting in volatile fatty acid production which contributes to the energy requirements of the sow. Different fiber sources result in different fatty acid profiles which have different effects on sow metabolism and offspring health. Therefore, this study aimed to find the best source of fiber and the best ratio of short-chain fatty acids for the health of sows and piglets.

Report on a specific research chapter

- **Research title of this chapter:** Effects of dietary fibers with different physicochemical properties on constipation in sows during late pregnancy
- **Short background**

  Constipation is a common problem in sows during late pregnancy. Dietary fiber supplementation could effectively change intestinal microbiota, thereby increasing intestinal motility and reducing constipation in many animal models. However, the effects and mechanisms of fibers with different physicochemical properties on intestinal microbe and constipation during late pregnancy have not been fully explored. In this study, a total of 80 sows were randomly allocated to 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, PRS, and KON.
- **Scientific question or research objectives**

  In this study, three fiber sources were selected based on their different physicochemical property and microbial regulation functions to investigate the effects of different fibers on the constipation of sows (defecation frequency, fecal consistency, and fecal moisture) during late gestation.
- **Primary/Main results**

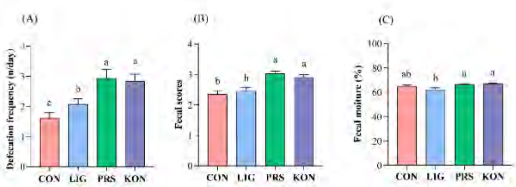


Fig. 1 Effects of different sources of fiber on defecation frequency (A), fecal consistency score (B), and fecal moisture of sows (C).

The defecation frequency within a 24-h period was significantly higher in PRS and KON compared to CON ($P < 0.01$), while there was no difference between LIG and KON. The fecal consistency score was also affected by treatment (**Figure 1**).

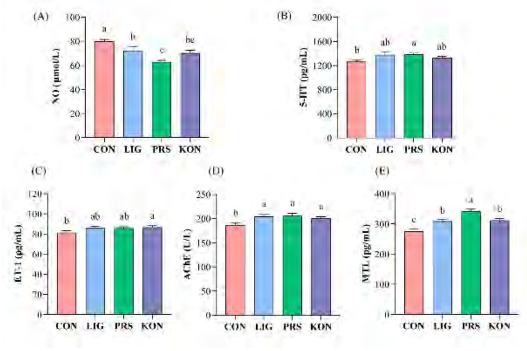


Fig. 2 Effects of different sources of fiber on levels of 5-HT (A), NO (B), ET-1 (C), AChE (D), and MTL (E) in serum of sows.

The sows of CON had the highest serum level of NO and the lowest level of 5-HT among the four groups. Conversely, PRS sows had the lowest level of NO and the highest level of 5-HT compared to other groups (**Figure 2**).

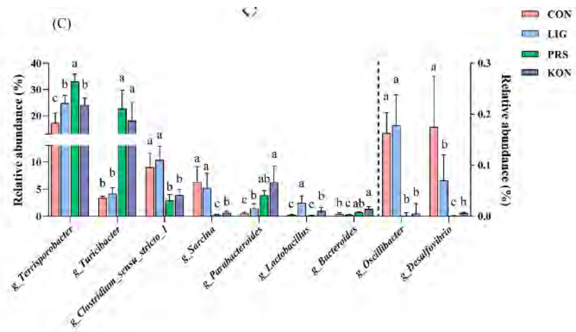


Fig. 3 Effects of different sources of fiber on the microbial structure of the late pregnant sows.

As shown in **Figure 3**, the PRS and KON had a higher abundance of *Terrisporobacter, Parabacteroides*, *Bacteroides* compared with CON. Moreover, the abundance of *Lactobacillus* also tended to be increased in KON and LIG compared to CON.

- **Conclusions**

Dietary fibers sources differently affect the constipation of sows during late gestation. PRS and KON are better than LIG, and CON in alleviating the constipation of sows. PRS and KON supplementations significantly increased the relative abundance of Bacteroides, Parabacteroides, and Turicibacter, and decreased endotoxin-producing bacteria Desulfovibrio and Oscillibacter

Green animal production - 5

Reporter: Weitong Long

Supervisors: Dr. Xueqin Zhu, Dr. Hans-Peter Weikard, Prof. Dr. Oene Oenema, Dr. Yong Hou

Date: December 8th, 2021

Background information

1. PhD Topic: Integrating crop and livestock systems in China: A social welfare analysis
2. Period of appointment: from September 2020 to September 2024
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

China's livestock production has undergone dramatic changes due to population growth, economic growth and urbanization, causing huge impacts on domestic and global food supply and on the environment. With growing livestock production, there is also an increase in manure production. Manure can provide valuable nutrients to amend soil fertility and fertilize cropland, but the current livestock farms are geographically and organizationally decoupled from cropland. Thus, manure is often wasted, causing severe air and water pollution. Little attention has been paid to the potential social welfare gains of integrating crop-livestock systems, which provides valuable plant nutrients and avoids pollution damage. This study aims to explore social welfare effects and sustainable pathways of integrating crop and livestock production systems at different spatial scales in China.

Report on a specific research chapter

- Research title of this chapter

  An environmental-economic framework for integrating crop and livestock systems at different spatial scales: A social welfare analysis

- Short background

  With rising population and per capita income in developing countries, the demand for animal-based food is increasing quickly, placing tremendous pressure on the environment. Integrating crop and livestock systems (ICLS) at the farm and territorial scales is identified as a good solution to improve nutrient cycling and reduce environmental externalities without sacrificing profit or yield. However, with the expansion of livestock production, it is difficult to recouple crop and livestock systems at farm scales due to the limited farm labour force and lack of relevant skills and knowledge for the integration. Crop-livestock integration beyond the farm level is a good alternative to solve such issues. It has been proved that different measures, including technological, structural, and policy measures, in the agricultural production systems can reduce GHG emissions (including carbon dioxide (CO2), methane (CH4), and N2O) and NH3 emissions to the atmosphere and nutrient (nitrogen (N), phosphorus (P)) loadings of soil and water bodies. However, most studies only focus on environmental mitigation measures and pay little attention to the improved environmental service and its consequences for production costs and consumer burdens (i.e., food prices). And few studies focus on the integrated environmental-economic models in food production, which can be applied to different scales, and previous models only consider the feedback of the environment quality either on the consumers or producers.

- Scientific question or research objectives
  - What are the economic and environmental benefits of integrating crop and livestock production systems in China at different spatial scales based on social welfare maximization?

- Our study aims to propose a social welfare maximisation framework for integrating crop and livestock production, which considers the value of the food system in China, including environmental values, and could be applied to different spatial scales.

- Primary/Main results

First, we present the conceptual framework: social welfare analysis, including environmental impacts. Next, we illustrate a specified model to explore sustainable agricultural development at different spatial scales based on social welfare maximisation in the integrated modelling framework. Then we present the data and model calibration followed by model application to scenarios and results.

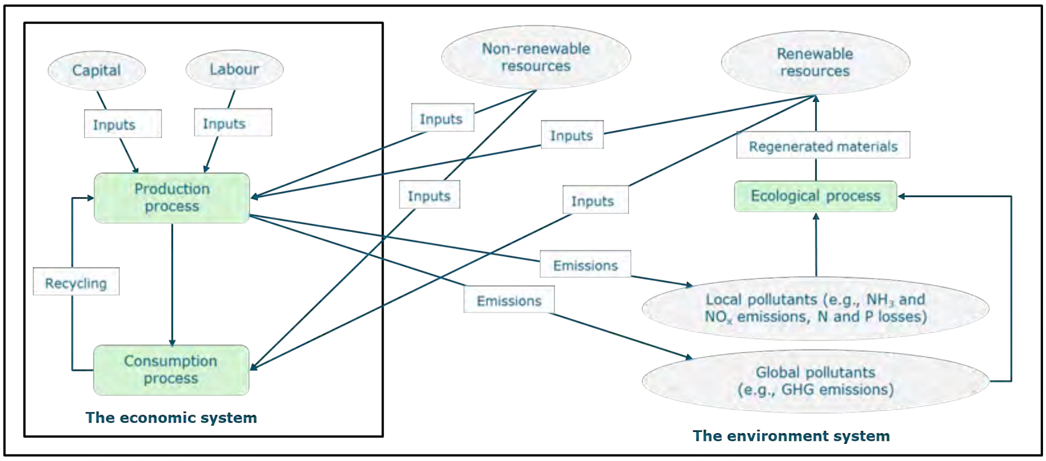


Figure 1. Interactions between the economic system and the environmental system. The processes are indicated as squares, the stocks as circles and the flows as arrows. Source: Based on (Zhu, 2004, Van Ierland, 1993) (NH3 = ammonia. N = nitrogen. P = phosphorus. GHG = greenhouse gas.)

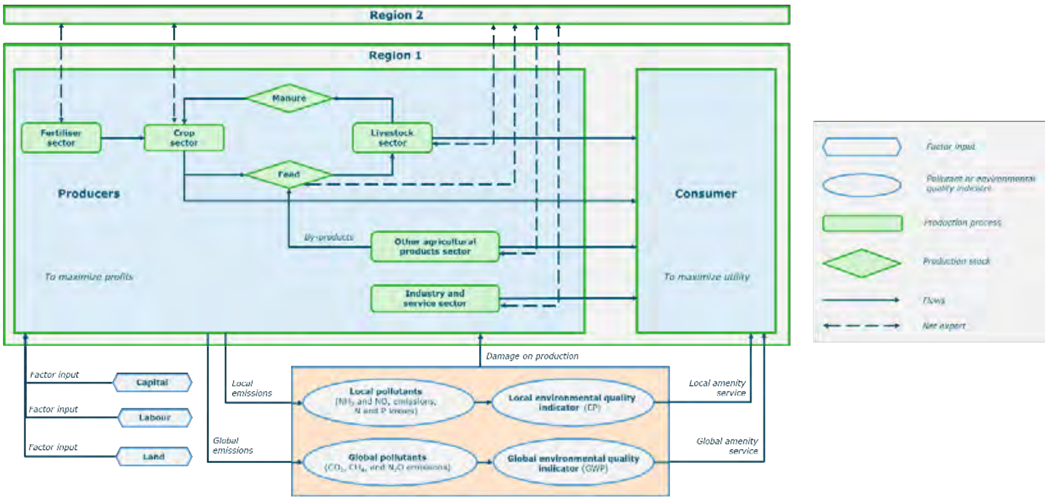


Figure 2. The flows of a two-region framework setting for food production in China. The lines with arrows indicate the flows of substances or the usages of goods. In particular, the dashed lines are the net export (exports minus imports) of goods. (NH3 = ammonia. N = nitrogen. P = phosphorus. CO2 = carbon dioxide. CH4 = methane. N2O = nitrous oxide. EP = eutrophication potential. GWP = global warming potential.)

- Conclusions

This paper concludes with policy implications for integrating crop and livestock systems to simultaneously achieve balanced economic and environmental benefits.

Other activities

- Publication

Long, W., Wang, H., Hou, Y., Chadwick, D., Ma, Y., Cui, Z., and Zhang, F. (2021). Mitigation of Multiple Environmental Footprints for China's Pig Production Using Different Land Use Strategies. Environmental Science & Technology, 55(8), 4440-4451.

Wang, H., **Long, W.,** Chadwick, D., Velthof, G. L., Oenema, O., Ma, W., . . . Zhang, F. (2020). Can dietary manipulations improve the productivity of pigs with lower environmental and economic cost? A global meta-analysis. Agriculture, Ecosystems & Environment, 289, 106748.

Tan, M., Hou, Y., Zhang, L., Shi, S., **Long, W.,** Ma, Y., . . . Oenema, O. (2020). Operational costs and neglect of end-users are the main barriers to improving manure treatment in intensive livestock farms. Journal of Cleaner Production, 125149.

Ma, Y., Hou, Y., Dong, P., Velthof, G. L., **Long, W.,** Ma, L., ... & Oenema, O. (2021). Cooperation between specialized livestock and crop farms can reduce environmental footprints and increase net profits in livestock production. Journal of Environmental Management, 302, 113960.

- Courses

- Agriculture Green Development (WUR & CAU)
- Systems Analysis and Systems Thinking (WUR & CAU)
- Scientific Writing and Presenting (WUR & CAU)
- WASS PhD Introduction (WASS, WUR)
- Advanced Macroeconomics (DEC,WUR)
- Advanced Microeconomics (UEC, WUR)
- PhD Workshop Carousel Online (WGS, WUR)
- Communication with the Media and the General Public (WGS, WUR)
- Dynamic General Equilibrium Modeling Course (UIBE & VU)

- Meeting etc.

  Regular meeting with supervisors biweekly

Lessons learned

I have learned a lot of economic-related and modelling knowledge from courses. And my supervisors have provided useful suggestions to my research.

Green animal production - 6

Reporter: Hu Zhenpeng

Supervisors: Wang Chaoyuan, Peter Groot Koerkamp, Andre Aarnink, Marc Bracke

Date: 2021-12-20

Background information

1. PhD Topic: The pig toilet as solution for welfare and environmental friendly pig production: a behavioural perspective

2. Period of appointment: from 2020-9-1 to 2024-9-1

3. Model: 1+3

4. Brief of research objectives in PhD thesis:

The aim of this PhD project is to develop knowledge and tools to be used in designing a practically applicable pig toilet as a solution to reduce emissions, pen fouling and improve indoor climate in pig houses. This will result in improved health and welfare of the animals and an improved working environment and reduced labour costs for the farmers. This study intends to train pigs, in a time efficient way, to use a small, designated area to defecate and urinate. Besides letting piglets learn toilet behaviour from the sow and designing the toilet in accordance with the natural inclinations of the pigs, operant conditioning is used to let pigs associate the elimination behaviour with a reward. This is expected to highly promote the motivation of pigs to eliminate in the desired toilet area. Different training and housing (design) conditions will be tested, including automated training and open/closed toilet designs. The effects of different types of rewarding method and other design features and potential environmental disturbances on pigs' motivation to use the toilet will be evaluated.

Report on a specific research

- Research title of this chapter

The effect of reward provision in open and closed pig toilets on pen soiling

- Short background

Pigs are naturally motivated to separate the dunging area from areas used for other activities such as lying and feeding. Pigs first select a comfortable lying area when introduced in the pen, while using the rest of the areas potentially as dunging area. Yet, using the smell of the faeces (Yu et al. 2016), and the wetting of the floor (Banhazi et al. 2002; Ocepek et al. 2018), lighting (Opderbeck et al. 2020) etc, could function as extra motivation to attract pigs to eliminate in a certain area.

In the "Toilet-barn" research project, Plomp et al. (2015) trained pigs manually for 5 weeks to eliminate in a tunnel-shaped area in the pen by giving pigs a reward. Pigs were first habituated to the trainer. Then pigs were trained to associate a light signal (given by the trainer) with a food reward presented in the toilet via classical conditioning. Lastly, pigs were rewarded when they eliminated in the toilet. The toilet usage could reach above 90%. Similarly, Scheepens (2015) used a "Urination Box" and trained pigs to urinate and defecate in a separated area by only rewarding urination in the urination area with lemon candy, while providing (the smell of) faeces in the defecation area as inductive material. Pigs seem to use the defecation area for defecation naturally, while learning to urinate in a separate urination area in about 2 weeks with 40% usage, other urination events mostly occur in the defecation area (personal communication with Dr. Scheepens). However, these are not peer-reviewed articles on how to toilet train pigs. Toilet training in other species (horse, cow, pets etc.) normally use techniques related to associative learning (operant and classical conditioning) while training with operant conditioning seem most promising

(Whistance et al. 2009; Gerl 2011; Vaughan et al. 2014; Dirksen et al. 2020b). Associative learning in toilet training was also combined with other techniques, e.g., with a prompted (either by words or signals) scheduled toilet hour, and with an intervention (e.g., stop elimination and bring to the toilet) to approximate the correct behavioural sequence (Van Wagenen et al. 1969; Azrin & Foxx 1971; Cicero & Pfadt 2002). Similar techniques have been applied in calling individual sows to feed in a scheduled hour, and in intervening cattle not to urinate outside the latrine area (Manteuffel et al. 2011; Dirksen et al. 2020b). Acquiring an operant response is to some extent dependent on the correct behaviour that occasionally occurs (e.g., pressing the lever by accident, or eliminating in the toilet by chance), and the site and pattern of elimination. It is important to combine different methods (e.g., inductive material to facilitate initial toilet use, reward type & schedule and intervention in case of pen soiling), into the toilet training, in order to "inform" the pigs what is the right thing to do and facilitate an effective and efficient learning.

- Scientific question or research objectives
  - Can a group pigs learn to use a toilet using automated operant conditioning of urination behaviour?
  - How would they response to toilet training? What is the pig-toilet performance curve (during acquisition, maintenance, and extinction of the operant response) of growing pig?
  - To evaluate the effect of two different toilet designs: an open or a closed toilet.

Hypothesis:

- We expect that most pigs can learn to use a toilet via conditioning, but a proper training method is needed.
- The performance curve is expected to have a steep increase at the beginning, a plateau phase after acquisition, and a slow decrease during extinction.
- The closed toilet may require more time to habituate to but is likely to reduce aggression and thereby improve the trainability of individual pigs and improve performance.

- Primary/Main results

Green animal production - 7

Reporter: Fei Xie

Supervisors: Chaoyuan Wang, Baoming Li, Peter Groot Koerkamp, Andre Aarnink, Marc Brake

Date: December 19th, 2021

Background information

1. PhD Topic:

Self-training pig toilet system based on automatic recognition of defecation behavior.

2. Period of appointment : from 2020-09-10 to 2024-06-30
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

   (1) Recognition of defecation behavior based on deep learning

   (2) Key factors influenced on pig elimination behavior rhythm

   (3) Model usage of pig toilet in farm with different production environment

Report on a specific research chapter

- Research title of this chapter

Recognition of defecation behavior based on deep learning

- Short background

Trained toilets are used to train pigs to defecate in a defined area through operant conditioning, with food rewards to reinforce spatial memory when pigs defecate in the correct location. van Wagenberg proposed the concept of trained toilets and named them 'taught defecation areas', a concept in which pig toilets can identify individual pigs and can be automatically weighed and sorted. This concept is designed to identify individual pigs and allows for automatic weighing and sorting. In 2015, Plomp officially built a manually trained pig toilet. The toilet is an access type with exits and entrances at both ends, located at one end of the pen, and is 2.04 m long and 0.5 m wide overall for eight nursery pigs. Three lights provide light in the toilet and the reward food bowl is placed in the middle. Due to the pigs' high memory capacity and to prevent the trainer becoming a redundant distraction, the trainer rewards the pigs for correct defecation behaviour through a long transparent straw. When the pigs are unable to spot the reward in the food bowl, sound is used as a secondary stimulus to guide the pigs to the reward. The system was not ideal for training urination behaviour, with only 55%-79% of urination behaviour taking place in the toilet at the end of training.

Studies have shown that some pigs, after learning to use the toilet, will deliberately reduce the amount of single bowel movements they defecate, by defecating multiple times in order to gain more rewards. Scheepens invented the automatic training urinal toilet, which distinguishes between a defecation area for pigs and a urination area, with a leaky floor for natural defecation and a urination area with an automatic training device to train pigs to urinate. The automatic training system is based on a humidity sensor sensing urination, which transmits the signal to a reward signal valve that senses and then provides the pigs with lemon sugar. The facility has been commercially used in his personal organic pig farm, but in practice it is not very effective, with only 60% of the urination area being used and the rest of the urination behaviour occurring in the defecation area. This phenomenon is also in line with the physiology of defecation in pigs, where the anal sphincter relaxes during defecation and the urinary channel opens, allowing the urine in the bladder to pass automatically, a similar physiological mechanism of defecation in humans and other animals. This suggests that a design that separates urination from defecation behaviour is not consistent with the physiological mechanism of defecation in pigs and should be avoided in subsequent designs of trained pig toilets.

Previous studies of trained pig toilets have shown that existing trained pig toilets are less automated, responsive and efficiently utilised. There is a lack of scientific and systematic training systems for automatic induction of defecation behaviour, investigation of defecation behaviour patterns of pigs under trained pig toilets and evaluation methods and criteria for the application of trained pig toilets.

- Primary/Main results

With the maturity of machine vision technology and infrared thermography, they have become one of the most important technical tools for detecting pig physiological conditions and evaluating pig welfare, and now are widely used for pig posture and behaviour detection. Machine vision approach is used for fattening pigs, with a motion target detection algorithm and an image recognition algorithm based on symmetrical features of pixel blocks to locate abnormal pigs that exceeded the total daily defecation count, with a correct recognition rate of 78.38%. Compared with fattening pigs, weaned piglets are more likely to play in clusters due to their young age, and sometimes stand and play in the excretory area without excreting, so it is easy to determine abnormal pigs only by the total number of times they appear in the excretory area, which increases the false alarm rate of sick pigs. A classification model was built for diarrhoea detection based on deep convolutional neural networks (CNN) to achieve integrated recognition of piglet identity, posture and abnormal faeces, compared the effect of different iterations on the model effect, and proposed the method of fusion of spatio-temporal information to determine, in terms of both time series succession and spatial distance, the average accuracy mean and recall rate of posture and stool recognition were 95.75% and 89.13% respectively. Based on this model, pig defecation videos are recorded in the toilet and will be further analyzed as shown in figure.

Figure. Pig defecation picture

Other activities

- Teaching assistant in biosystem engineering design
- Course in image and video analysis

Green ecological environment - 1

Reporter: Juhui Chen

Supervisors: Junfei Bai; Hans van Trijp; Xi Lu; Ellen van Loo

Date: 2020/12/10

Background information

1. PhD Topic: The impact of user-friendly labels on pesticide reduction
2. Period of appointment: from 2020/09/01 to 2024/06/31
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

The overall objective of this research is to find effective measures to promote pesticide labels to play a role in reducing pesticide using from the perspective of reactivation of label information.

The specific objectives include:

(1) Clarify the role of pesticide retailers in the current overuse of pesticides

(2) Redesign the user-friendly pesticide labels and identify their impact on the amount of pesticides used by farmers

(3) Explore how retailers' pesticide recommendation strategies change, if pesticide labels work.

Report on a specific research chapter

- Research title of this chapter: Can user-friendly labels reduce the amount of pesticides used by farmers?
- Short background

  These yield-oriented agricultural production systems, along with the non-professionally trained farmers, caused severe damage to agricultural ecosystem degradation and huge chemical losses in the system, threatening food safety as well as sustainable production of China's agriculture. Let us take pesticide use as an example. Although Chinese government introduced some policies to reduce pesticides use since 2015, the average amount of pesticide used in China has reached 8.39, which is 3.86 times that of the U.S. Therefore, how to find a less cost and effective measure in reducing pesticide using is an urgent and important problem. Information will play a key role in guiding farmers to apply pesticides scientifically, but pesticide labels, as the most reliable and scientific method, are unfortunately ignored by most farmers.
- Scientific question or research objectives

  Can redesigning pesticide labels change the current situation that farmers are neglecting labels?

  Does the effect of labeling intervention differ depending on the individual characteristics of farmers (e. g.: different education levels, different levels of trust in retailers)?
- Primary/Main results

  According to the outcomes of descriptive analysis (Figure 1), labelling intervention has positive impact on the reduction of farmers' calculated amount regards to pesticides use, but do not has the same effect in actual amount. Besides, it seems that farmers tend to use more pesticides than the standard amount. The same results are got from the empirical analysis (Table1 and Table 2).

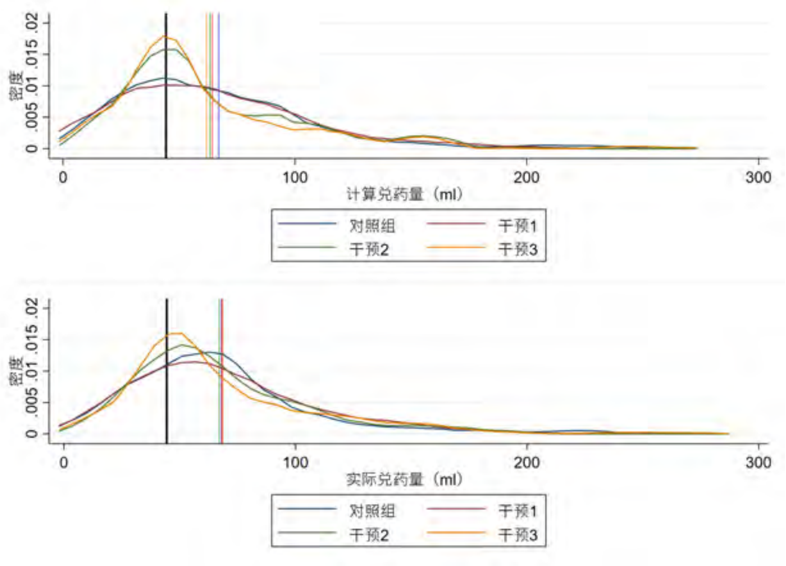


Figure 1. The descriptive analysis of labelling intervention

Table 1 The empirical results of labelling intervention

	计算量			实际量		
	(1)	(2)	（3）	(4)	(5)	（6）
干预 1：易阅读标签	-5.238			-0.201		
	(5.155)			(4.462)		
干预 2：易计算标签		-7.464*			-2.411	
		(4.301)			(3.908)	
干预 3：易测量标签			-6.556*			-0.577
			(3.925)			(3.593)
粮食作物种类	7.212**	2.712	1.995	7.503**	4.634*	3.848
	(3.346)	(2.782)	(2.677)	(3.125)	(2.699)	(2.439)
粮食作物面积	-0.706	-0.784***	-0.155***	-0.746**	-0.704***	-0.203***
	(0.432)	(0.274)	(0.054)	(0.291)	(0.252)	(0.073)
粮食作物农药支出	0.003	0.006*	0.002	0.002	0.003	0.003*
	(0.008)	(0.003)	(0.001)	(0.006)	(0.003)	(0.002)
经济作物种类	4.748	5.333	-0.790	-1.909	-1.655	-2.830
	(5.120)	(5.535)	(3.697)	(4.625)	(5.231)	(3.696)
经济作物面积	-0.116	-0.127*	-0.081	0.211***	0.225***	0.242***
	(0.082)	(0.074)	(0.066)	(0.063)	(0.082)	(0.066)
经济作物农药支出	-0.001*	-0.001*	-0.001	-0.001	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
个人及家庭特征变量		控制			控制	
地区		控制			控制	
观测值	285	381	621	340	438	340

- Conclusions

  The reason why farmers ignore the labels because they do not understand them. User-friendly label design can improve farmers' correct understanding of pesticide application, but it cannot be transformed into real action.

Other activities

- Publication

Chen, J., Zhang, M. and Bai, J.: How information affects consumers' attitude toward and willingness to pay for cultured meat: Evidence from Chinese urban consumers (Under review).

- Meeting etc.

Participated in the "5th Forum for Theoretical Frontiers of Chinese Agricultural Economy" and delivered a conference report.

Green ecological environment - 2

Reporter: Haoran Li

Supervisors: Prof. Hans van Trijp, Dr. Ellen van Loo, Prof. Junfei Bai, Dr. Xi Lu

Date: 2021.12.09

Background information

1. PhD Topic: Labelling for sustainability: consumer choice and inner mechanisms
2. Period of appointment: from 2020 to 2024
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Overall, the objective of this Ph.D. project is to improve the understanding of sustainability labels and the transfer of consumers' intention into behavior by 1) integrating the main streams of research on sustainability in consumer behavior into a more holistic picture, 2) examining the underlying mechanisms of the trade-off procedure, and 3) assessing the impact of peer effects on consumer perception and decision-making. Therefore, the research questions are:

I. What is the role of sustainability in consumers' food choices? How do consumers perceive sustainability labels?
II. How can we redesign the format of sustainability labels (e.g., information load) to improve consumers' understanding?
III. What are consumers' trade-off mechanisms within sustainable dimensions and off sustainability against other attributes?
IV. How would peer effects influence consumers' attitudes of sustainability and decision-making?

Report on a specific research chapter

- Research title of this chapter

Consumer perception of sustainability, sustainable food, and labels: a perspective from generation gap and individual experience.

- Short background

Although prior studies have provided insights on why consumers are reluctant to make a sustainable choice, previous research has several limitations. We are not clear about consumers' perception of sustainability in developing countries like China. To the best of our knowledge, over 148 food ecolabels are available worldwide (Ecolabelindex catalog, 2021), but China only has two kinds of sustainability labels for food and agricultural products: green food labels and organic food label. Though these two labels show clarity to some degree, they cannot meet the growing demand for developing sustainable consumption. Since detailed research about consumer responses to sustainable food in China's context is currently lacking, one of this project's major contributions would be to understand how Chinese citizens perceive sustainability and sustainability labels and use this understanding as a basis of more appropriate design of food labels in the Chinese market.

- Scientific question or research objectives

I. Give a comprehensive overview of Chinese consumers' perceptions of sustainability and food. As sustainable food is fairly a new concept in developing countries compared to their developed counterparts, it would be interesting to study the various aspects of sustainable food consumption in developing nations like China. This will fill the gap of literature related to sustainable food choices in middle- and low-income countries.

II. Explore consumers' perception from several dimensions: concept, food product, and labels which can help us see the connection among these three layers.

III. Explain the distinction of consumer perception and acceptance from the perspective of generational differences. Previous research mainly focuses on young consumers or adolescents but rarely compare young generation and older generation’s choice and explain why they behave differently. We can strengthen the education of young people and affect their parents' food choices through the young generation. This paper could also help segment the market of sustainable food, and practitioners can design packages and labels according to young people's preferences.

IV. Investigate the drivers and barriers for the consumer to choose sustainable food and see consumers' reaction and acceptance to new labels (labels have not been issued in China). Knowing their preference and perception can help policymakers or practitioners to publish or promote new sustainability labels in the future.

- Primary/Main results

a) From their choices, we can see both organic food and green food are frequently chosen by younger consumers, while older consumers usually miss the message of labels in rice, apple, beef, and biscuit category. It is inferred that sustainability labels (the organic label and the green food label) have a better influence on younger consumers to recognize sustainable food.

b) We also set sustainability cues of package materials, such as paper, glass, iron, plastics etc. But it only manifests itself in rice and yogurt category. This shows consumers do not pay much attention to the sustainability of package material.

c) From word clouds, we can infer that children and parents have a big difference in their perception of sustainability. Young consumers link sustainability with green, environment protection, and health, while development, safety, and environment protection are most frequent in the elder group.

d) Young consumers' sustainable choices are mainly influenced by others' recommendations. Some parents mentioned that their children would affect them or that family members asked them to do so. In addition, professional knowledge also has an impact on the behavior of the two groups.

- Conclusions

a) The average score which indicates younger consumers can recognize sustainable products much better than their parents and they perceive sustainability in a more multiple way.

b) The young group's answers to the concept of sustainability are more specific and have a deeper and better understanding. For example, they mentioned energy-saving, pollution-free, recycle, resources, waste sorting, and synergy. They also refer to price as the economic dimension.

c) The influence of the social circle of family and friends dramatically affects spreading the concept of sustainability and food choices (sharing knowledge, recommending each other, changing behaviors and habits, etc.). This impact has probably been underestimated in the past, and it gives us a new direction to further investigate how to promote sustainable food and change individuals' behavior.

Other activities

- Publication: None so far
- Courses: Introduction to R, Sensory perception, Social Science ethics etc.

Green ecological environment - 3

Reporter: Sijie Feng

Supervisors: Fusuo Zhang, Carolien Kroeze, Lin Ma, Maryna Strokal, Wen Xu, Mengru Wang

Date: 2021/12/20

Background information

1. PhD Topic: Solutions for Air and Water Pollution for Agriculture Green Development in China
2. Period of appointment: from 2020/09/01 to 2024/07/01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

The main objectives of this study are to better understand the impact of nitrogen deposition on water quality and explore synergetic options of air and water pollution to reduce this impact in the future. To reach this objective, four research questions will be answered:

- RQ1: What is the impact of air pollution control policy on nitrogen input from the atmosphere to the major river basins in China?
- RQ2: What is the impact of nitrogen deposition on terrestrial ecosystems and coastal waters in China?
- RQ3: What are the effects of water and air control policies and technologies on surface water quality in China's agricultural green development?
- RQ4: What is the feasibility of synergetic options to reduce future air and water pollution in China's agricultural green development?

Report on a specific research chapter

- Research title of this chapter

  Quantify the temporal and spatial distribution of atmospheric nitrogen deposition to China's 33 sub-basins.
- Short background

  Human activities associated with energy and food production have increased the availability of reactive nitrogen (Nr) in the earth ecosystems. Approximately 78% of the anthropogenic Nr returns to the Earth's surface through atmospheric dry and wet N deposition. Excess N deposition can cause adverse ecological effects in terrestrial and aquatic environments. China became a hotspot of N deposition in the world.
- Scientific question or research objectives

  Up to now there is lack of quantifying the impact of nitrogen deposition to China's 33 sub-basins.
- Primary/Main results

  Annual total deposition to China in 2011 was 11.7 Tg N, with 5.4 Tg N (46%) from reduced nitrogen (NH_x) and 6.3 Tg N (54%) from oxidized nitrogen (NO_y).

  The Yangtze basin had the highest dry and wet nitrogen deposition over China's 33 sub-basins in 2011, reaching 0.9 Tg N (21.3%) and 1.3 Tg N (21.1%), respectively.

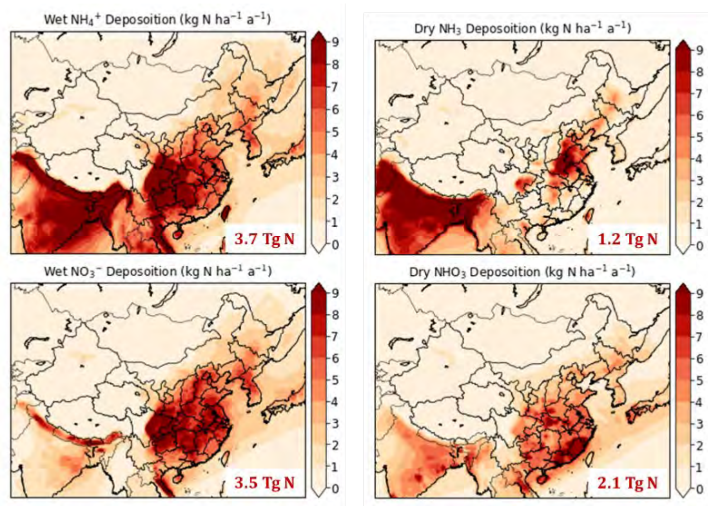


Figure1. Simulated annual total NH_4^+ wet deposition, NH_x dry deposition, NO_3^- wet deposition, and HNO_3 dry deposition in 2011. Annual totals over China from each process are shown inset.

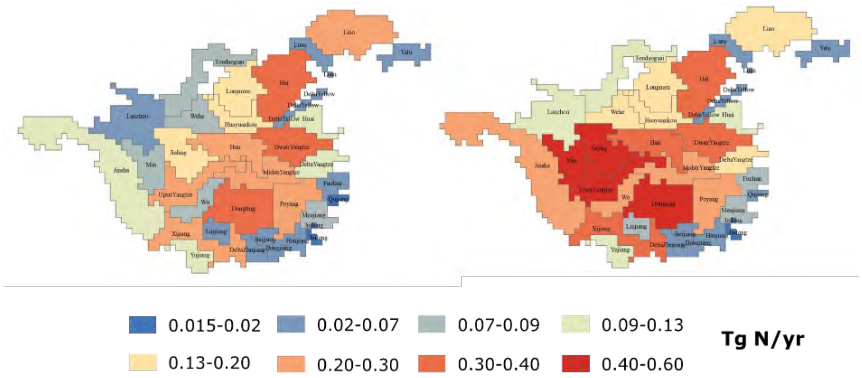


Figure2. Simulated annual average dry (left) and wet (right) deposition over China's 33 sub-basins in 2011.

Other activities

- Publication

  Feng SJ, Xu W, Cheng MM, Ma YX, Wu LB, Kang JH, Wang K, Tang AH, Collett Jr. JL, Fang, YT, Goulding K, Liu XJ, Zhang FS (2021) Overlooked nonagricultural and wintertime agricultural NH_3 emissions in agricultural Quzhou County, North China Plain: Evidence from ^{15}N-stable isotopes. Environmental Science & Technology Letters (under review)

- Meeting

  PhD AGD workshop (3rd Nov)

Green ecological environment - 4

Reporter: Donghao Xu

Supervisors: Prof. Wim de Vries, Dr. Qichao Zhu, Dr. Gerard Ros, Prof. Xuejun Liu, Prof. Fusuo Zhang

Date: 2021/12/20

Background information

1. PhD Topic: Large scale impacts of management approaches on soil acidification and cadmium mobilization of Chinese croplands
2. Period of appointment: from 2020/07/01 to 2024/07/01
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

The overall objective of this project is to develop a sustainable management strategy to ameliorate crop yield decrease and cadmium (Cd) accumulation in crops due to soil acidification at county scale, mainly focusing on liming and replacement of chemical fertilizers by local manure resources. The objectives of the project are the assessment of:

1. The spatial variation of soil acidification of croplands and related lime application rates and intervals to counteract current and future acidification at county scale.
2. Impacts of various nutrient management scenarios on cropland soil acidification at county scale.
3. Impacts of various nutrient management scenarios on cadmium mobilization and cereal pollution at county scale.
4. Optimal strategies to avoid soil acidity-induced yield losses and cadmium (Cd) uptake of major crops at county scale.

Report on a specific research chapter

- Research title of this chapter: Calculation of spatially explicit amounts and intervals of agricultural lime applications at county-level in China
- Short background: Liming is a long-established and widely used agricultural practice to ameliorate soil acidity and improve crop production. Sustainable liming strategies for regional applications require information on both lime requirements and liming intervals for given land use and soil dependent acidification rates. Up to now there is no tool underpinning appropriate liming strategies to counteract soil acidification at regional level, given costs, soil improvement and crop production.
- Scientific question or research objectives: The aim of this research is to develop a method to optimize lime requirements and liming intervals at regional level. Lime requirements are based on soil pH buffering capacity and liming intervals are estimated from soil acidification rates derived from major cations and anions balances in cropland systems.
- Primary/Main results: About 66% of croplands in Qiyang required liming to raise soil pH to 6.5, with an average rate of 2.4 t ha^{-1} for paddy soils and 2.6 t ha^{-1} for upland soils (Fig 1a). Under current soil acidification rates, 33% of Qiyang's croplands would need liming within 30 years after raising the soil pH to 6.5 (Fig 1b). Areas with high soil acidification risk were mostly located in the southeast of Qiyang. Nutrient management practices and crop rotations, affecting N transformation and crop removal, were the main drivers controlling the spatial variation in total acid production in non-calcareous soils, on average contributing 73% and 25%, respectively (Fig 1c).

(a) (b) (c)

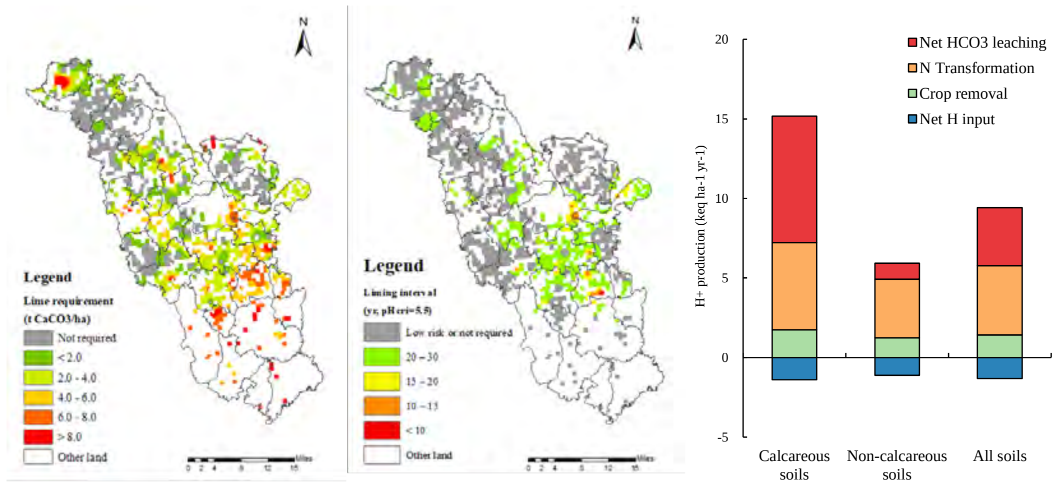


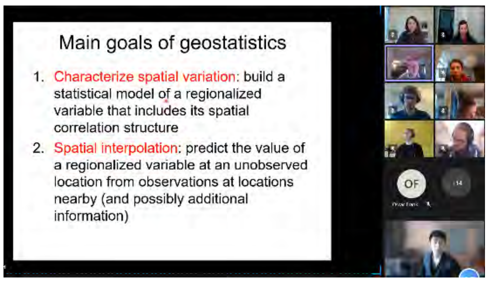
Fig 1 Lime requirement (a) and liming interval with a critical pH at 5.5 (b) to eliminate soil acidity on Qiyang's croplands and average total acidity (H^+) production per soil type (c). For lime requirement, the area with "not required" means that the initial soil pH is over 6.5; for the liming interval, the area with "low risk or not required" indicates that the interval is over 30 years. Main H^+ production processes including nitrogen (N) transformation ($NH_{4}{}_{in}^{+} + NO_{3}{}_{le}^{-} - NH_{4}{}_{le}^{+} - NO_{3}{}_{in}^{-}$), crop removal ($BC_{rem}^{+} - SO_{4}{}_{rem}^{2-} - H_2PO_{4}{}_{rem}^{-}$); (c) net H^+ input ($H_{in}^{+} - H_{le}^{+}$) and (d) net HCO_3^- leaching ($HCO_{3}{}_{le}^{-} - HCO_{3}{}_{in}^{-}$).

- Conclusions: A total lime requirement for Qiyang County is 2.4×10^5 t $CaCO_3$, with an averagely 20-years liming interval.

Other activities

- Publication: Xu, D., Zhu, Q., Ros, G., Cai, Z., Wen, S., Xu, M., Zhang, F., & de Vries, W. (2022). Calculation of spatially explicit amounts and intervals of agricultural lime applications at county-level in China. Science of the Total Environment, 806, [150955]. https://doi.org/10.1016/j.scitotenv.2021.150955

- Courses (including pictures): "A1 Sense Introductory Course" and "Geostatistics".



Green plant production - 1

Reporter: Zhaoqi Bin

Supervisors: Prof. Wim van der Putten, Dr. Ciska Veen, Prof. Junling Zhang, Prof. Guangzhou Wang

Date: 2021.12.20

Background information

1. PhD Topic: Learning from nature: manipulation of plant functional trait-driven plant-soil feedback towards agroecosystem optimization
2. Period of appointment: from 2020.09.01 to 2024.08.31
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

Ecological concepts, such Plant-Soil Feedback (PSF) has great potential to build healthy agroecosystems. PSF means that plants alter the soil community, which in turn affects subsequent plant growth. PSFs are often negative in intensive agriculture due to low crop diversity, but if we can steer towards positive PSFs, this may contribute to sustainable agriculture by reducing the need to use crop protection chemicals.

From natural ecosystems we know that positive PSF exists and that plant functional traits influence the direction and magnitude of PSF. Moreover, plant traits may be connected to ecosystem functions and hence can help to link PSF to soil multifunctionality. However, how to optimize PSF effects through combining plant traits and manipulating cropping patterns for plant growth and multifunctionality in agroecosystems is not well understood.

The main objective of this research is to test how plant functional traits drive the direction and the strength of plant-soil feedback and disentangle suitable plant functional trait combinations that shape positive plant-soil feedback in agroecosystems.

Report on a specific research chapter

- Research title of this chapter

Relationship between plant functional trait and plant-soil feedback

- Short background

Plant-soil feedback (PSF) and plant functional traits are two active but not well theoretically integrated areas of research. Here we hypothesis that some plant functional traits may play big role on direct PSF. We performed meta-analysis to test this hypothesis by compiling currently available plant functional trait related plant-soil feedback experiment dataset.

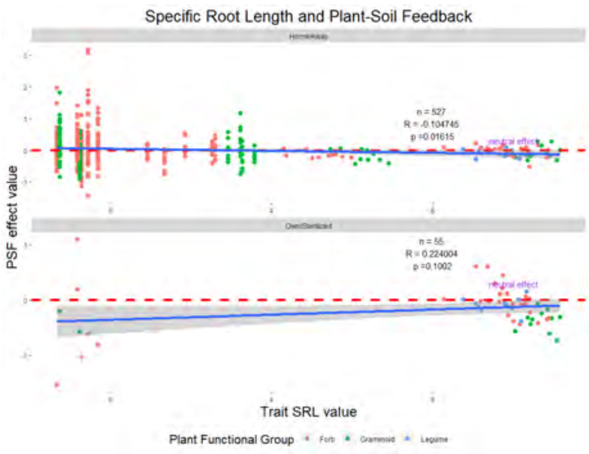
- Scientific question or research objectives

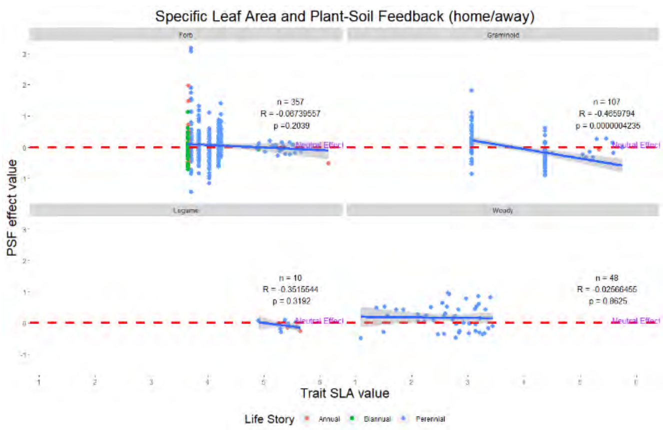
The objective of this research is to disentangle the relationship between plant functional traits and PSF in natural and agricultural systems, and provide possible plant trait combinations that can shape desirable plant-soil feedback on target crops.

- Primary/Main results

Currently, our meta-analyses show that no plant functional trait is significantly correlated with PSF. This may be due to the insufficiency of available relevant studies, or the trait that most studies measured is not the one that would impact PSF.

Moreover, plant functional trait may not be a good factor to explain PSF patterns in a general scale. In the result, trait variation has been observed and this may be due to different experimental methods and climate and soil texture. There are some publications indicate that plant functional trait such as specific root length and specific leaf area is negatively correlate with PSF. However, these findings are constrained in a related control environment.





- Conclusions

Our result show that plant functional trait may not be a good explainer of plant-soil feedback. Further research is needed to understand PSF from other perspectives.

Other activities

- Publication: None
- Courses: Tidy data in R
- Meeting etc.
    1. Departmental meeting at Terrestrial Ecology, NIOO https://twitter.com/terrecol_nioo
    2. Netherlands Annual Ecology Meeting Poster presentation

Lessons learned

1. It's important to have regular meetings with your supervisors. The role of supervisor is not only reviewing and advising on the PhD project, but also includes building networks and encouragement when you are down.
2. PhD is not only about doing research, but also learning to cooperate and communicate with each other. Never do research alone.

Green plant production - 2

Reporter: Ruotong Zhao

Supervisors: Junling Zhang; Guangzhou Wang; Wim H. van der Putten; Ciska Veen

Date: 2022.12.20

Background information

1. PhD Topic: Building up healthy soil to reduce N_2O emission by strengthening belowground interactions.
2. Period of appointment: from 2020.09 to 2024.09
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Return of crop residues in intensive agricultural system has great potential to improve soil organic carbon stores, a key process in soil fertility and climate change mitigation strategies. However, residue decomposition can create anaerobic micro-environmental conditions, which is the hotspots of denitrification, hence partially thwarting such benefit impacts if residue retention substantially increases soil emissions of N_2O. Arbuscular mycorrhizal fungi (AMF) are widespread soil microorganisms and constitutes a major element of agroecological production. Moreover, it is successively acknowledged that these fungi playing a previously unrecognized role in mitigating N_2O. The hyphal of AMF may proliferate into the microsites and interact with soil microbes to reduce N_2O emissions. Yet, the mechanisms by which or how mycorrhizal hyphae affect nitrifiers and denitrifiers in the crop residues remain ambiguous. If AMF hyphae can directly reduce N_2O production from crop residues, this could have significant implications for global N_2O production.

Report on a specific research chapter

- Research title of this chapter

  Enrichment of *nosZ*-type denitrifiers by arbuscular mycorrhizal fungi mitigates N_2O emissions from soybean stubbles

- Short background

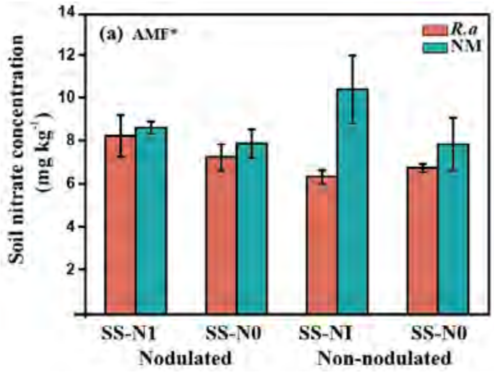
  Crop residues absorb water from surrounding soil and thus acts as hotspots for N_2O emissions via denitrification. Globally, crop resides are estimated to be as high as 5 thousand Tg annually and generate on average 0.4 Tg N_2O-N yr^{-1}. Understanding the process and mechanisms that ocntrol N_2O emissions from crop resides is important in increasing the precise prediction of N_2O emissions and the development of mitigation strategies. Previous studies showed that AMF play an important role in the N cycling. Existing studies suggested AMF could acquire N to alter nutrient availability, or reduce potential nitrification rates by competition with nitrifiers. Furthermore, the current research on the influence of AMF on denitrifiers is controversial, some evidences suggested AMF inhibits denitrification process. Hence, despite substantial advances in our understanding of AMF in mediating N cycling, the molecular mechanisms underlying AMF mediated N_2O emissions are poorly understood.

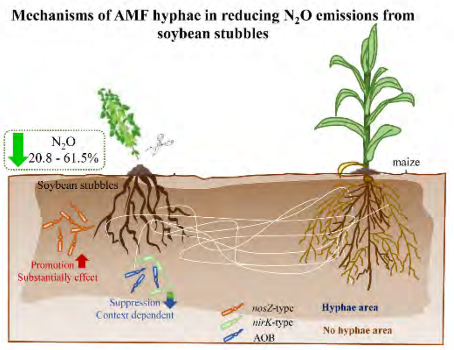
- Scientific question or research objectives

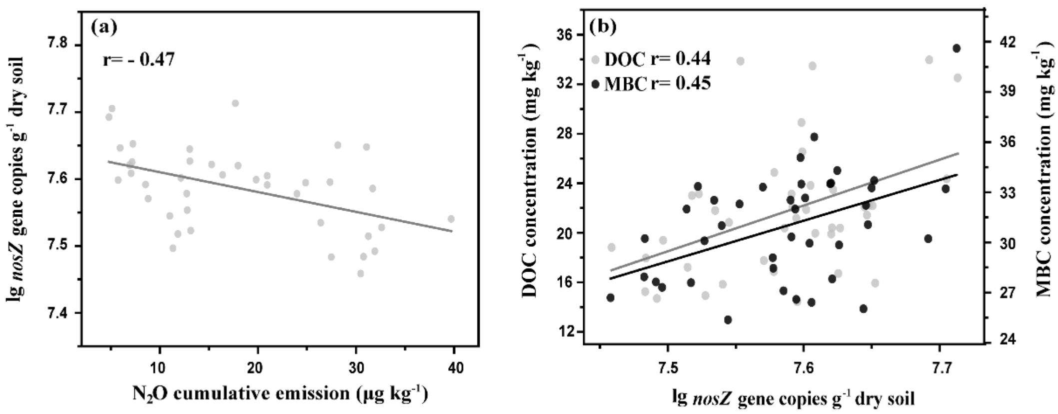
  Whether AMF mitigate N_2O emissions by modifying the abundance and community structure of denitrifiers?

  Whether the mitigation effect of AMF related to the nodulation of legume plants and microbial legacy associated with N fertilization?

- Primary/Main results







Cumulative N_2O emission was negatively correlated the abundance of *nosZ* gene. The abundance of *nosZ* gene (but not *nirK* or *nirS*) was positively correlated with the concentrations of DOC and MBC.

- Conclusions

AMF hyphae can selectively recruit soil microbes that have considerable potential for reducing stubble N_2O emission via synergistic changes in N_2O producing and reducing denitrifiers, and likely also AOB abundance and substrate N availability.

Other activities

- Publication

Zhao, R., Li, X., Bei, S., Li, D. et al. (2021) Enrichment of *nosZ*-type denitrifiers by arbuscular mycorrhizal fungi mitigates N_2O emissions from soybean stubbles. *Environmental microbiology* **23**: 6587-6602.

Green plant production - 3

Reporter: Bowen Ma

Supervisors: Dr. Wenfeng Cong; Dr. Chaochun Zhang; Prof. Fusuo Zhang; Dr. Jeroen Groot; Dr. Wopke van der Werf; Dr. Xueqin Zhu

Date: 14 January 2022

Background information

1. PhD Topic: Evaluation and simulation of soil ecosystem services of diversified cropping systems in the North China Plain

2. Period of appointment: from 2020/9/1 to 2024/6/30

3. Model: 2+2

4. Titles of each chapter in the thesis:

Chapter 1. Greenhouse gases (GHG) emissions, net global warming potential and net ecosystem economic benefits of different cropping systems and management practices in the North China Plain (NCP)

Chapter 2. Calibration and validation of the NDICEA model for diversified cropping systems in the NCP

Chapter 3. Assessment of soil ecosystem services (SESs) of by coupling simulation modelling and field measurement in the NCP

Chapter 4. Exploration of alternative diversified cropping systems of the multi-objective optimization of SESs on the North China Plain

Report on Chapter 1

- Title: GHG emissions, net global warming potential and net ecosystem economic benefits of different cropping systems and management practices in the NCP
- Background: Maize-soybean intercrop can improve nitrogen use efficiency and reduce chemical nitrogen fertilizer input, and ultimately reduce GHG emissions.
- Main results:

1. There is no significantly difference between SF treatment and OF treatment under three crop patterns. Compared with expected grain yield of intercrop, observed grain yield of intercrop significantly increased by 23%.

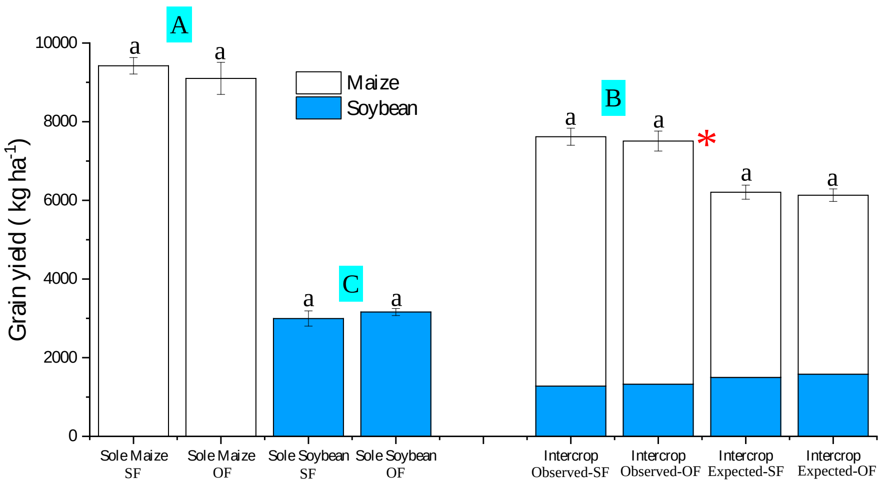


Fig. Grain yield of maize, soybean and intercrop under two fertilizer treatment (SF: synthetic fertilizer; OF: 70% Synthetic N fertilizer + 30% Organic N fertilizer) . For intercrops, the expected value is shown alongside observed value. Expected value is calculated as the weighted mean value in the sole crops, with weighing according to the relative density (intercrop/sole crop) of each species in the intercrop. Means not sharing any capital letter among all cropping system treatments are significantly different by the LSD-test at the 5% level of significance. Means not sharing any small letter between two fertilizer managements under the same cropping system are significantly different by the LSD-test at the 5% level of significance.

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

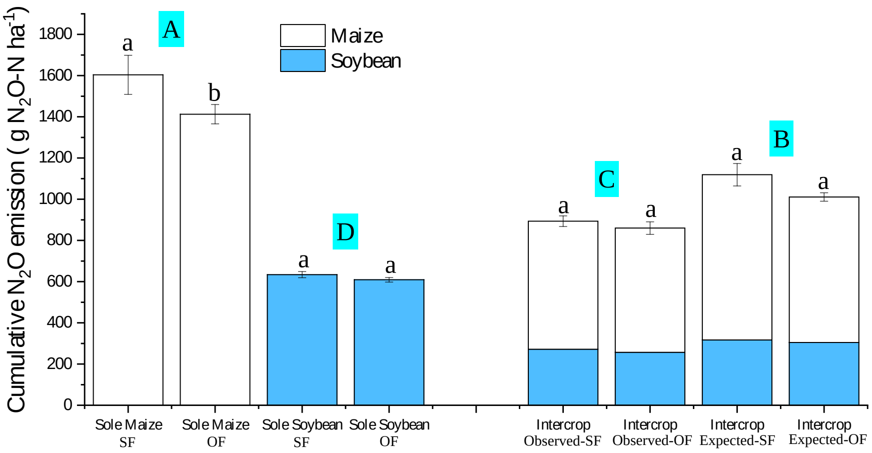


Fig. Cumulative N_2O emission of maize, soybean and intercrop under two fertilizer treatment (SF: synthetic fertilizer; OF: 70% Synthetic N fertilizer + 30% Organic N fertilizer).

- Conclusions:

Maize-soybean intercrop has the potential to increase the land productivity and decrease GHG emissions, and this study will prove the suitability of maize-soybean intercrop as a system for low C agriculture in the North China Plain.

Green plant production - 4

Reporter: Laiquan Luo

Supervisors: EJ van Henten, GW Kootstra, A Leylavi Shoushtari, Lujia Han, Kailiang Zhang

Date: 2021/12/01

Background information

1. PhD Topic: Digital twin driven design and control for a safe and versatile soft robotic gripper
2. Period of appointment: from 2020/09/01 to 2024/09/01
3. Model: 1+3
4. Brief of research objectives in PhD thesis:

The objectives are to design, build and test a safe, versatile gripper including mechanism, sensor, actuator and autonomous grasping controllers to deal with the variability of appearance, geometrical and mechanical properties in agroforestry system.

For soft robotics, the softness of structure make their behaviors unpredictable. There are many uncertain design parameters in soft gripper design, even given the existence of suitable mechanisms, there are still many possibilities such as different combinations of hybrid mechanisms, the design dimensions of gripper, sensor allocation and so on. Building and testing all of these will be very time-consuming and laborious. Therefore, we have proposed a digital twin (DT) technology for optimised design. By modelling various possibilities, they can be viewed and customised in a virtual environment, which will facilitate the design process. The developed gripper and the controller will be tested to evaluate its ability to adapt to a variety of different crops and provide suitable gripping force to avoid slippage and squeezing simultaneously.

Report on a specific research chapter

- Research title of this chapter

  An overview of the safety and versatility performance of existing soft robotic grasping mechanisms on vegetable and fruits grasping.

- Short background

  The emergence of soft grippers provides new opportunities to solve the safety and variability challenge of agroforestry harvesting. Challenges for soft robotic gripper include variability, robustness, miniaturisation, speed, integration of sensing, and control. Soft robotic gripper has gained lots of attention. However, most of the current soft grippers are designed for specific objects or objects with similar characteristics; some soft grippers can complete picking tasks of various crops, but placing abilities were not demonstrated, which lacks the evidence of usability in real harvesting tasks. Some soft grippers are too big and need miniaturisation to fit the real harvesting tasks. Moreover, for most soft grippers, there is no sensor mounted and delicate grasping control. In this work, we focus on the versatility and safety grasping challenges. All the related published papers were involved to do a comprehensive analysis. Aiming to figure out the most suitable existing grasping mechanism for vegetable and fruits grasping in agroforestry system.

- Scientific question or research objectives

  To give a view on the performance of the existing soft robotic grasping mechanisms in terms of safety and versatility.

- Primary/Main results

  Grasping mechanism can be classified as grasping by actuation, by stiffness and by adhesion. Each grasping mechanism has its advantages and disadvantages. Here we make a table that list different grasping mechanisms of actuation and the various properties of the objects.

		By actuation				
		Passive structure with external motors	Fluidic elastomer actuators (FEAs)	Electroactive polymers: dielectric elastomer actuators (DEAs)	Electroactive polymers: Ionic polymer metal composites (IPMCs)	Shape memory materials: shape memory alloys (SMAs)
Level 1 (Soft; eg, strawberry, grape...)	Stiffness variabilities	[3][4][5][6][7]	[8][88][93][91]	[52][80]	[80][81][82][83]	[95]
Level 2 (Relaive soft; eg, tomato,peach...)		[3][4][5][6][7][10][12][13][14][15][16][17][18][19][20][21][22][23][24]	[8][71][72][73][74][75][76][77][78][79]-145]	[50][51][52][53][54][80]	[80][81][82][83]	[95]
Level 3 (Rigid; eg, apple, pear...)		[3][4][5][6][7][10][12][13][14][15][16][17][18][19][20][21][22][23][24]	[8][71][72][73][74][75][76][77][78][79][80-145]	[50][51][52][53][54][80]	[80][81][82][83]	[93][94][95]
Convex	Shape variabilities	[3][4][5][6][7][10][12][13][14][15][16][17][18][19][20][21][22][23][24]	[8][71][72][73][74][75][76][77][78][79][80-145]	[46][47][48][49][50][51][52][53][54][80]	[80][81][82][83]	[93][94][95]
Non-convex		[4][5][6][7][10][12][13][14][15][16][17][18][19][20][21][22][23][24][25-	[8][71][72][73][74][75][76][77][78][79][80-145]	[48][49][51][52][53][80]	[80]	
Deformable		[3][4][5][6][7][10][12][13][14][15][16][17][18][19][20][21][22][23][24]	[8][71][72][73][74][75][76][77][78]	[48][49][51][52][53][80]	[80][81][82][83]	
Flat		[3][4][5][6][7][10][12][13][14][15][16]	[8][71][72][73][74][75][76][77][78]	[80]	[80]	[95]

Figure 1. A literature review chart of actuation based grasping mechanism.

- Conclusions

  From the above-mentioned literature review, of the many actuation type approaches, those with external electromagnetic motors and FEAs are the most mature and wildly used in agri-food and industry application. However, They also have shortages, such as, soft grippers using external motors difficulty of miniaturization of the entire system, which can limit the use of the technology in compact mobile platforms. Pneumatic gripper has the advantage of hygiene, relative mature, easy to fabricate. It is capable to lift convex, flat, smooth objects in semiconductor industry and food industry. So a mechanism hybrid design is still needed, maximise the advantages and minimise the disadvantages, to deal with the safety and versatility challenges in vegetable and fruit grasping.

Green plant production - 5

Reporter: Yuxiang Wang

Supervisors: Zengling Yang, Xin Wang, Haris Khan, Gert Kootstra, Dirk van Apeldoorn

Date: 20/12/2021

Background information

1. PhD Topic: Monitoring the growth of crops by UAVs in intercropping systems
2. Period of appointment: from 2020/09/01 to 2024/06/30
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

Intercropping or stripcropping is a more advanced farming system as it helps improve the stability of the ecosystem due to its biodiversity. However, low-level mechanisation hinders its development. In this study, we will focus on monitoring task, which requires the development of advanced machine-vision methods to deal with the variations and to monitor crop development for every individual plant over time. UAVs equipped with consumer-grade cameras are the most attractive option for monitoring crop growth characteristics due to ease of operating, inexpensive and flexibility. Nonetheless, monitoring of intercropping systems by UAVs will face the following challenges: 1) Variable illumination conditions. In many climate regions, especially in the Netherlands, the weather situation changes rapidly from sunny to cloudy sky, Unpredictable and uncontrolled outdoor illumination directly affects the quality of captured images. 2) High-level variation. More types of crops will bring different canopy structures, color and shape, which increases the difficulty of crops classification and segmentation. Based on those challenges, we propose three studies of my research:

1) Dealing with illumination variation on aerial spectral images
2) Investigating and optimizing a deep-learning based framework for crops segmentation and species classification at each stage of crops
3) Estimating leaf area of crops and monitor their development in the stripcropping field over time

Report on a specific research chapter

- Research title of this chapter:
  Assessing the impact of illumination on vegetation indices derived from low-altitude RGB aerial images and evaluation of different illumination compensation methods
- Short background:

UAV can operate under cloud cover, expanding the data collection window, but this increases the amount of dynamic lighting variation, due to variable cloud cover density. Different solar radiations cause a difference in the observed reflectance for the same object, thereby, affecting vegetation indices. In some cases, VIs are able to mitigate the impact of illumination and atmosphere due to the division of spectral bands. However, the illumination effects they are intended to reduce are due to changes in solar zenith angles across latitudes rather than the differences in illumination under different cloud cover as VIs were initially developed for satellite-based earth observation. Thus, our study aims to quantitatively assess the potential impact of various illumination conditions.

Another issue related to the UAV monitoring is the variable illumination induced by cloud movement during the flight campaign. In order to cover the whole survey areas, flights campaign usually take 10-20 min acquiring hundreds of images. Longer total scan durations increase the likelihood that irradiance of images taken at different times changes due to floating clouds resulting in irradiance inconsistency across images. A method frequently used for illumination correction is empirical line method (ELM) in which several panels with known reflectance are placed on the ground to build a relationship between DNs and reflectance. However, the process of calibration was usually carried out prior to flights assuming the same illumination conditions for this flight which was impractical. Another purpose of our study is to investigate the performance of image-based illumination compensation methods for vegetation indices.

- Scientific question or research objectives

Research objectives:

Assess the potential impact of illumination on vegetation indices.

Investigate and develop methods to mitigate the influence of variable illumination on vegetation indices, in other words, to generate illuminant homogenous RGB orthomosaic.

- Primary results

Soybean	Equations	Mono soybeans	Mono corn	Intercrop soybeans	Intercrop corn
E1	$EXG = 2 * G - R - B$	<0.05	<0.05	<0.05	<0.05
E2	$EXR = 1.4 * R - G$	<0.05	<0.05	<0.05	<0.05
E3	$VDVI = \frac{(2 * G - B - R)}{(2 * G + R + B)}$	<0.05	0.914	<0.05	<0.05
E4	$EXGR = 2 * G - R - B - 1.4 * R - G$	<0.05	<0.05	<0.05	<0.05
E5	$NGRDI = (G - R)/(G + R)$	<0.05	0.762	<0.05	<0.05
E6	$NGBDI = (G - B)/(G + B)$	<0.05	0.102	0.147	0.143
E7	$CIVE = 0.441R - 0.8818G + 0.385B + 18.787$	<0.05	<0.05	<0.05	<0.05
E8	$CRRI = G/R$	<0.05	0.491	<0.05	<0.05
E9	$VEG = G/R^a B^{1-a}$	<0.05	0.361	<0.05	0.08
E10	$COM = 0.25E1 + 0.3E4 + 0.33E7 + 0.12E9$	<0.05	<0.05	<0.05	<0.05
E11	$RGRI = G/B$	<0.05	0.11	0.14	0.074
E12	$VARI = (G - R)/(G + R - B)$	<0.05	0.692	<0.05	<0.05
E13	$EXB = 1.4 * B - G$	<0.05	<0.05	<0.05	<0.05
E14	$MGRVI = (G * G - R * R)/(G * G + R * R)$	<0.05	0.239	<0.05	<0.05
E15	$WI = (G - B)/(R - G)$	0.976	0.467	<0.05	0.342
E16	$IKAW = (R - B)/(R + B)$	0.682	0.246	<0.05	0.058
E17	$GBDI = G - B$	<0.05	<0.05	<0.05	<0.05
E18	$RGBVI = (G * G - B * R)/(G * G + B * R)$	<0.05	0.672	<0.05	<0.05

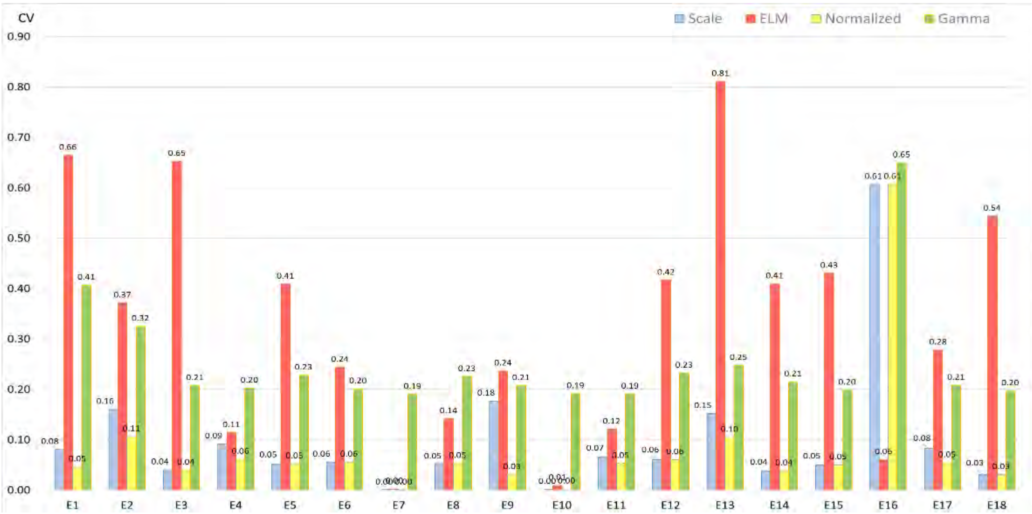
1) For monoculture soybeans, almost all the vegetation indices are affected by the change of illumination except E15, E16. For monoculture corn, part of the vegetation indices are affected by the change of illumination.

2) In intercropping systems, there are more affected vegetation indices for corn. For soybeans, the affected vegetation indices are E6 and E11

Illumination compensation methods:

Normalization: $r = \frac{R_n}{R_n+G_n+B_n}$, $g = \frac{G_n}{R_n+G_n+B_n}$, $b = \frac{B_n}{R_n+G_n+B_n}$, $R_n = \frac{R}{R_{max}}$, $G_n = \frac{G}{G_{max}}$, $B_n = \frac{B}{B_{max}}$

Scaling: $R = \frac{R}{R_{max}}$, $G = \frac{G}{G_{max}}$, $B = \frac{B}{B_{max}}$ $R_{max} = G_{max} = B_{max} = 255$ for 24-bit color images



Gamma correction: $DN_{recover} = (DN_{shadow})^{\frac{1}{\gamma}}$ $\gamma = \frac{\mu_{Ln(DN_{shoadow})}}{\mu_{Ln(DN_{bright})}}$

Result of Coefficient of variation: soybeans

1. Band normalization can to some extend mitigate the influence of changing illumination on VIs, both for corn and soybeans
2. For corn, gamma correction can help mitigate the influence of illumination. But gamma correction is no helpful for soybeans

Green plant production - 6

Reporter: Jiyu Jia

Supervisors: Junling Zhang; Guangzhou Wang; Rachel Creamer; Ron de Goede

Date: 2021.12.20

Background information

1. PhD Topic: The mechanism and process of soil microbiomes driving ecosystem multifunctionality.
2. Period of appointment: from 2020.09 to 2024.09
3. Model: 2+2
4. Brief of research objectives in PhD thesis

Healthy soils provide regulating and supporting ecosystem functions such as nutrient cycling, water infiltration and retention, gas exchange, pest and disease regulation, biodiversity, and storage of carbon, many of which highly impact agricultural productivity. Soil microorganisms are crucial for the maintain and provision of soil multifunctionality. It has been reported there was a significantly positive relationship between soil microorganisms and multifunctionality. However, soil microbial community and biodiversity could be affected by soil managements, so it is important for us to understand how soil microbiomes driving soil multifunctionality.

Report on a specific research chapter

- Research title of this chapter

  Sensitive species is the major driver of soil multifunctionality.
- Short background
- Soil microorganisms play a crucial role in driving soil multifunctionality (MF), but the contribution of microbes is context-dependent, as the composition and diversity of soil microbial communities are affected by various edaphic factors. The soil environment is altered in agricultural ecosystems due to the human disturbances, and it is still unclear how theses altered soil microbes contribute to the maintenance and promotion of multifunctionality in croplands
- Scientific question or research objectives
- There will be a significantly positive relationship between soil biodiversity and soil MF in agricultural croplands; sensitive microbes may play a crucial role in driving these relationships; Soil pH, SOM and salinity would interactively affect the microbial multi-functions and be the main mediators of these microbial-driven biogeochemical processes; Carbon cycling and micronutrient cycling may respond positively to microbial diversity due to low organic fertilization and micronutrients fertilization input while high nitrogen and phosphorus input may lead to a low capacity of nitrogen and phosphorus cycling.
- Primary/Main results

  There was a significantly positive relationship between MF and bacterial diversity while not with Fungi in agricultural ecosystem (Fig1).

  EC and SOC was the major driver of soil microbial community. SOM and bacterial sOTU diversity showed significantly positive effects on MF. And EC showed an indirect effect on MF by affecting bacterial sOTU diversity (Fig2).

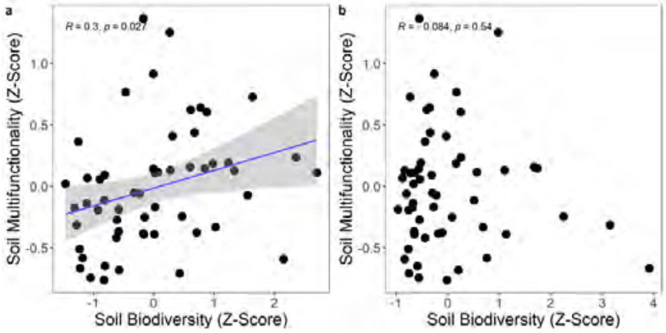


Fig. 1. Relationships between the bacterial (a) and fungal (b) diversity and soil multifunctionality for all 55 farms. Solid blue line represents the fitted ordinary least squares (OLS) linear regressions. The gray shaded area shows the 95% confidence interval of the fit.

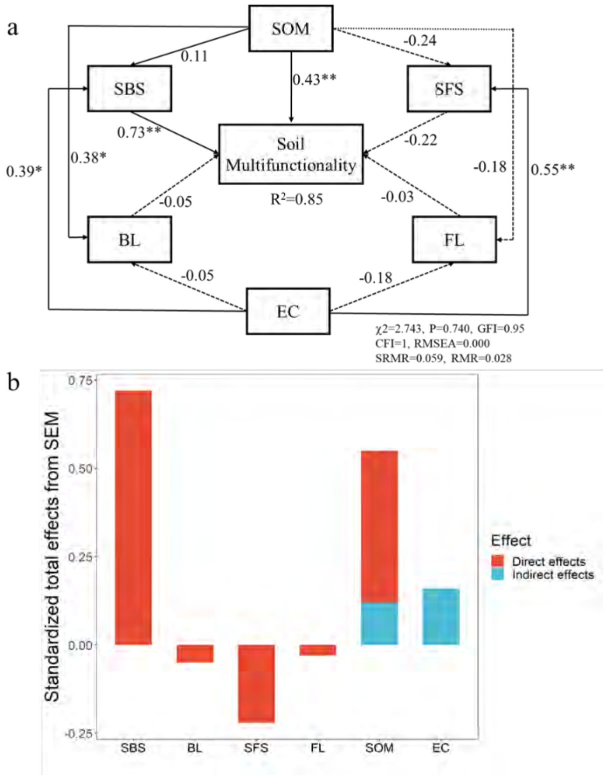


Fig. 2. Effects of abiotic and biotic factors on soil multifunctionality in HS-LEC group (a). * indicate P < 0.05; ** indicate P < 0.01. Continuous and dashed lines indicate significant and non-significant relationships, respectively. R^2 denotes the proportion of variance explained. (b) Standardized total effects (direct and indirect effects combined) derived from the structural equation model depicted above. SBS: bacterial sOTU diversity; SFS: fungal sOTU diversity; BL: relative abundance of bacterial sOTU; FL: relative abundance of fungal sOTU.

- Conclusions

Soil MF in in agricultural ecosystem responded positively to soil bacterial diversity but not fungal diversity, and that sensitive microbes and their diversity were the main drivers of MF. Furthermore, sensitive microbe abundances were mediated by SOM and EC. Soil multifunctionality was mainly determined by soil carbon and micronutrient cycling, but not by N and P cycling, indicating that negative effects impair MF functions derived from the extensive chemical fertilizers' applications.

Green plant production - 7

Reporter: **Yizan Li**
Supervisors: Rachel Creamer, Ron de Goede, Junling Zhang
Date: 20-12-2021

Background information

1. **PhD Topic:** Building a Hospital for Soil Health Diagnosis and Treatment: a Modelling Approach
2. **Period of appointment:** from 2020/09/01 to 2024/08/31
3. **Model:** 1+3
4. **Brief of research objectives in PhD thesis**

1) To establish a soil database of the wheat-maize rotation system in Quzhou to provide data support of modelling work;
2) To develop knowledge-based Decision Expert Integrative (DEXi) models to evaluate the capacity of 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 Quzhou soil database collected in objective 1;
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.

Report on a specific research chapter

- **Research Progresses on Farmland Soil Ecosystem Multifunctionality**

Building healthy soil is a prerequisite for the improvement of cultivated land productivity. It is fundamental for meeting the challenges of food security and environmental protection, and realizing the agriculture green development and the community of shared life. The core of building healthy soil is to realize the soil ecosystem multifunctionality. In the new era of the ecological civilization construction, the research on the evaluation and cultivation of soil multifunctionality, and underlying mechanisms have become the hotspots and frontiers of global soil health initiatives.

In this paper, we systematically review the concepts of soil functions, soil ecosystem services and soil ecological multifunctionality. The impact of soil biodiversity on soil multifunctionality, and the synergies and trade-offs between soil functions are discussed. Besides, the approaches to evaluation and quantify soil functions are summarized. Finally, we put forward the pathways of healthy soil cultivation based on the integrated regulation of soil multifunctionality beyond the single pursuit of high grain yield. Different strategies to increase soil multifunctionality are proposed: adjusting the way of land use and agricultural structure at the national scale, coordinating resource allocations at regional scale, constructing agricultural infrastructure and landscape pattern at

the landscape scale, optimizing the field soil management practices to improve soil health and multifunctionality at the field scale.

It is necessary to explore the maintenance mechanism of soil multifunctionality at different temporal and spatial scales, and to combine modern technologies with relevant policies and implementation plans for functional soil management, emphasising the multi-dimensional role of soil multifunctionality in sustainable environmental policy and management. It will provide important support for the coordinated development of mountain, water, forest, farmland, lake and grass life community and the implementation of the national strategy of "carbon peak and carbon neutral".

Other activities

Publications

- ZHANG Jiangzhou, **LI Yizan**, LI Ying, ZHANG Junling*, ZHANG Fusuo. Advances in the Indicator System and Evaluation Approaches of Soil Health[J]. Acta Pedologica Sinica, 2021. (In Chinese)
- **LI Yizan**, ZHANG Jiangzhou, JIA Jiyu, FAN Fan, ZHANG Fusuo, ZHANG Junling*. Research Progresses on Soil Ecosystem Multifunctionality[J]. Acta Pedologica Sinica. Under review. (in Chinese)

Courses

- System thinking and analysis in agricultural green development
- Agriculture green development
- Scientific Writing and Presenting
- Scientific publishing
- Stress Identification & Management
- Ethics in Plant and Environmental Sciences
- Supervising BSc & MSc thesis students

Meetings

- The 3rd Agriculture Green Development Symposium Sino-Dutch AGD project annual meeting
- Soil4Food Forum (Online seminar series)
- The 14th National Congress of the Soil Science Society of China

Green plant production - 8

Reporter: Yanjie Chen

Supervisors: Chaochun Zhang, Wenfeng Cong, Wopke van der Werf

Date: 2022/01/14

Background information

1. PhD Topic:

Quantifying and promoting farmland ecosystem services for agricultural green development in the North China Plain

2. Period of: from 2020/7/1 to 2024/7/1
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

The aim of this project is to estimate the current status of pollination services under intensive agriculture dominant by smallholder farmers in China. Furthermore, the effect of agrochemical inputs and crop diversity on pollination service will be analyzed. Through the research, I aim to find out the factors that limited the pollination services and find measures that make optimal use of ecosystem services to support agricultural green development.

Report on a specific research chapter

- Research title of this chapter

The status of pollination service in farmland under different agricultural intensification degrees

- Short background

Pollination service is an essential ecosystem service, three fourth global crops are pollination dependent and 35% of global production is contributed by pollinators (Klein et al., 2007). In intensive agriculture, farmland scape homogenization and crop simplification, and management practice, such as high inputs of fertilizer and pesticides, these factors all affect the abundance and richness of pollinators, furthermore affect the pollination service (Garibaldi et al., 2014; Pfister et al., 2018).

In China, smallholders tend to use high inputs of nitrogen fertilizer and pesticides to attain maximum crop yields. And the arable land area per head of population was not more than 1 ha, making the crop species more diverse in small areas. However, little is known about the response of pollinators and pollination services to the combination of different agricultural landscapes and artificial inputs in smallholder farmland. Whether the pollination service of intensive agriculture in smallholder farmland exists deficit is not clear.

- Scientific question or research objectives

Based on the situation, we put forward these research question: (1) Is there a pollination limitation in farmland under different agricultural intensification degrees? (2) How does crop diversity and agrochemical inputs affect pollination service?

- Primary/Main results

1. Biodiversity of insect caught by pan traps at different site

In general, the biodiversity of insects caught by pan traps was low in Quzhou County. At different sites, the dominant insect nearly accounted for 50% and the insect diversity at Yu Miaoyuan and Experimental station was higher, while the insect diversity was lower at other sites (Fig 1).

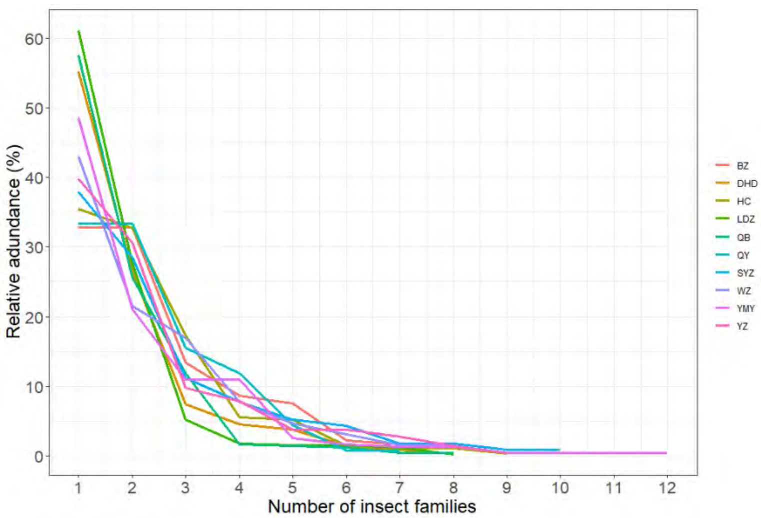


Fig 1. Rank abundance curve of insects caught by pan traps at different sites

2. Composition of pollinator at different site

The *Syrphidae* was the dominant pollinator at all sites. The biodiversity of pollinator at Da Hedao was higher than other sites. The biodiversity was the lowest at Wang Zhuang and the relative abundance of *Syrphidae* account for 90% (Fig 2).

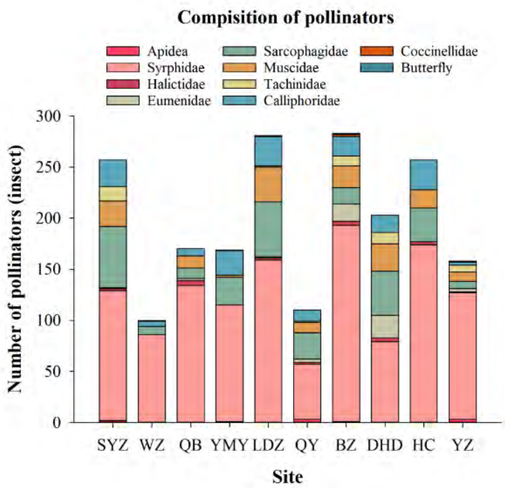


Fig 2. Composition of pollinator visitors at different sites

- Conclusions

The diversity of insect and pollinator was low at Quzhou County. The *Syrphidae* was the dominant pollinator at all sites.

Green plant production - 9

Reporter: Bo Wang

Supervisors: Dr. Xiaolin Yang (CAU); Prof. Coen Ritsema, Prof. Joop Kroes, Prof. Jos van Dam (WUR).

Date: December 20th, 2021.

Background information

1. PhD Topic: Study on suitable water planting of diversified planting system in North China Plain Based on SWAP model under climate changing
2. Period of appointment: from 2020/09/01 to 2024/06/30
3. Model: 2+2
4. Brief of research objectives in PhD thesis:
    1) The potential of irrigation water saving in winter wheat summer maize cropping system in the North China Plain, A Meta-Analysis.
    2) Research on water saving optimization regime of winter wheat-summer maize system in the North China Plain Based on SWAP (soil-water-atmosphere-plant) model under historical/ future climate change conditions.
    3) Research on water saving optimization regime of diversified planting system in the North China Plain Based on SWAP (soil-water-atmosphere-plant) model under historical/future climate change scenario.
    4) Optimization scheme of water suitable planting of diversified planting systems on regional scale in the North China Plain based on SWAP (soil-water-atmosphere-plant) model and GIS (Geographic Information System).

Report on a specific research chapter

Chapter 1: The potential of irrigation water saving in winter wheat summer maize cropping system in the North China Plain, A Meta-Analysis.

- **Background:** In the past 30-40 years, with the increase of agricultural production demand, irrigated land has also increased by about 300% (Mostafazadeh Fard et al., 2007) The agricultural exploitation of groundwater in the North China Plain accounts for more than 70% of the total groundwater exploitation, and about 80% of the agricultural irrigation water comes from groundwater (Zhang Kai et al., 2017)
- **Scientific question or research objectives**

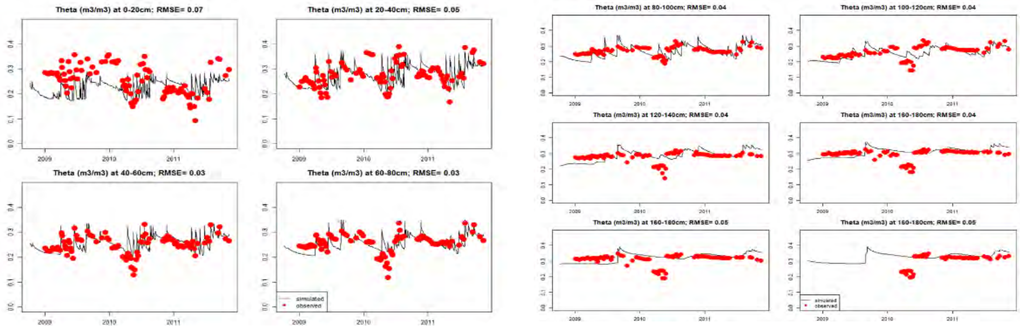
  What is the water saving potential of the current winter wheat summer maize Multiple Cropping Model in North China plain?

Chapter 2: Research on water saving optimization regime of winter wheat-summer maize system in the North China Plain Based on SWAP (soil-water-atmosphere-plant) model under historical/ future climate change conditions.

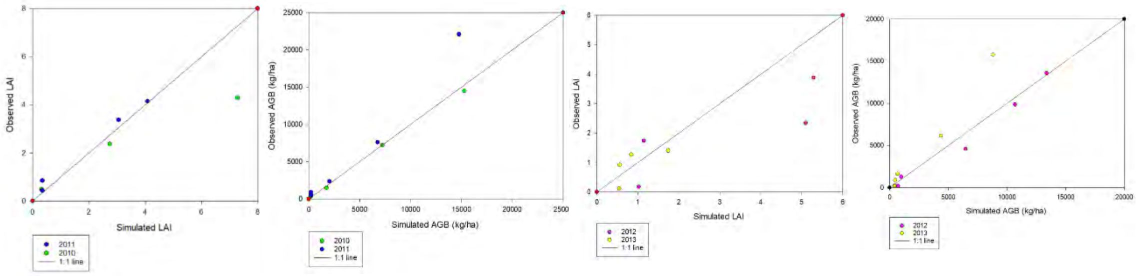
- **Background:** There is room for optimization of wheat maize water use in North China Plain. Optimizing irrigation schedule can significantly increase the water use efficiency of wheat maize planting system.
- **Scientific question or research objectives**

  What is the water-saving effect of winter wheat summer maize rotation and diversified cropping system in the North China Plain under the historical climate scenario?

- **Primary/Main results**



Model soil water content calibration/validation

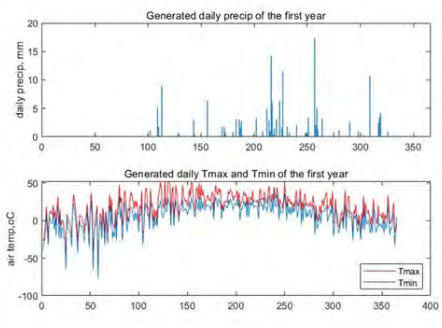


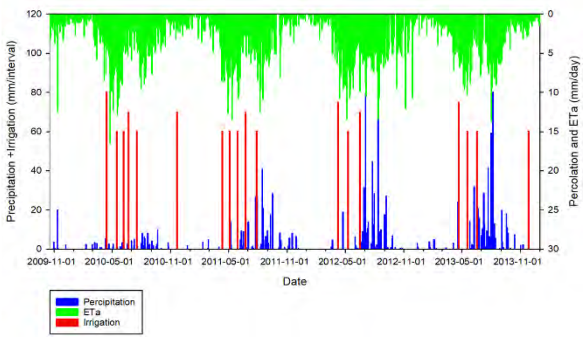
Model Leave Area Index/Aboveground biomass calibration/validation

- **Conclusions:** SWAP-WOFOST model can better simulate soil water content and biomass in winter wheat-summer maize rotation system.

Chapter 3: Research on water saving optimization regime of diversified planting system in the North China Plain Based on SWAP (soil-water-atmosphere-plant) model under historical/future climate change scenario.

- **Background:** Diversified planting has been proved to be an important method to deal with extreme climate conditions and improve water stress (Bowles et al., 2020).
- **Scientific question or research objectives:** Under the future climate change, what is the current optimal irrigation system for multiple cropping of winter wheat-summer maize? What is optimization diversification rotation system?
- **Primary/Main results**





Future weather Data   ETa distribution under different precipitation irrigation conditions

- **Conclusion:** Under future climate condition, extreme weather conditions increase.

Chapter 4: Optimization scheme of water suitable planting of diversified planting systems on regional scale in North China Plain Based on SWAP and GIS

- **Background:** Under the future climate change scenario, crop growth cycle will be shortened, and adjusting irrigation schedule can optimize water use. The distributed simulation unit can better simulate and compare at the regional scale

Green plant production - 10

Reporter: Yalin Liu

Supervisors: Zhenling Cui, Chunjie Li, Chaochun Zhang, Wenfeng Cong, Fusuo Zhang, Wopke van der Werf, Tjeerd Jan Stomph

Date: 2022/12/19

Background information

1. PhD Topic: Meta-analysis on nitrogen use efficiency and biological nitrogen fixation in intercropping system
2. Period of appointment: from 2022/06/01 to 2024/06/01
3. Model: 2+2
4. Brief of research objectives in PhD thesis:

1. Do intercrops take up more nitrogen (N) than sole crops?
   a) Does the intercrop as a whole take up more N than sole crops (net effect > 0)
   b) Does intercropping reduce the area of land required to take up the same amounts of N per species as pure stands do (LER_N>1)?
2. Whether the conversion of plant biomass to grain (HI) or the conversion of acquired N to grain (NHI) differ between species grown in mixtures and pure stands. ($\ln(X_{ic}/X_{sc})$ >0)?
3. How do the fertilizer N, species and other factors (rate of N fertilizer input, spatial arrangement (strip, row and mixed), plant density, with/without maize, intercropping pattern etc.) affect the N fixation to the overyielding of intercropping?

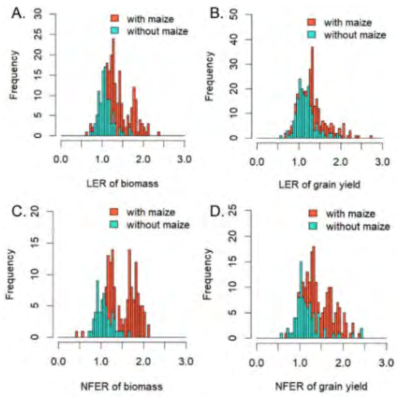
Report on a specific research chapter

- Research title of this chapter
  Intercropping saves land and nitrogen fertilizer without decreasing harvest index and N harvest compared to monoculture; a meta-analysis
- Short background
  Nitrogen (N) is critical for plant growth and yield formation and thereby ensuring food security of the world population. Many previous studies have shown that legume-based intercropping can improve NUE and save more N than sole cropping. However, it is not clear whether intercropping can improve harvest index (HI), N harvest index (NHI) and what management factors affect NHI or HI.
- Scientific question or research objectives

1.1 To determine whether intercropping allows to produce the same yield as pure stands do (LER) with less land.
1.2 To explore whether intercropping allows to produce the same yield as pure stands do (NFER) with less fertilizer.
1.3 To explore whether the conversion of plant biomass to grain (HI) or the conversion of acquired N to grain (NHI) differ between species grown in mixtures and pure stands.
1.4 To estimate the effect of different management factors (rate of N fertilizer input, spatial arrangement (strip, row and mixed), with/without maize, intercropping pattern, TND) on NHI or HI of intercropping and the LER, NFER, HI and N.

- Primary/Main results

1.1 Frequency distributions of the LER and NFER of intercrops at grain and total biomass level.

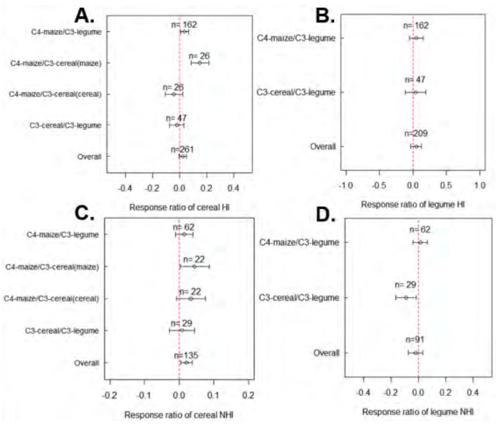


1. Intercropping can save an average 27% land to produce the same yield as sole crops.

2. Intercrops can save an average 33% and 34% fertilizer N use, respectively, compared to sole crops to obtain the same grain yield and total biomass yield as sole crops.

3. NFER of biomass (average 1.33 ± 0.05) and grain yield (average 1.34 ± 0.05) were not significantly larger than respectively LER of biomass (average 1.27 ± 0.04) or grain yield (average 1.27 ± 0.05), indicating that N fertilizer saving is due to increased productivity per unit land.

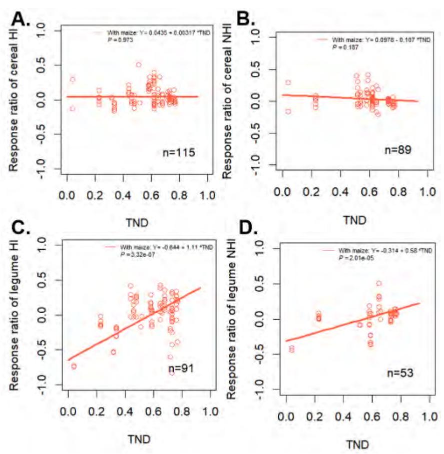
1.2 Differences in HI and NHI across species combinations. Note: species combinations were selected with a sample size greater than 10 for analysis. Results were expressed as mean ± CI.



1. The average response ratio of cereal HI was 0.024±0.028; Response ratios of maize HI in C4-maize/C3-legume (0.04±0.03) and in C4-maize/C3-cereal (0.15±0.06) were greater than zero while response ratios of legume HI were similar across species combinations.

2. The average response ratio of cereal NHI (0.021±0.017) and the response ratio of mazie NHI in C4-maize/C3-legume (0.045±0.042) were greater than zero, while the response ratio of legume NHI in C3 cereal/C3 legume was smaller than zero (-0.091±0.074).

1.3 Relationship between response ratio of HI and TND (A, B), response ratio of NHI and TND (C, D). *p*-values relate to the slopes of the regressions. Note: only the sample size of metrics greater than 10 were analysed.



Response ratios of cereal HI and NHI were independent of TND while response ratios of legume HI and NHI increased with increasing TND, indicating that legume HI and NHI increased by reducing co-growth period of two species in intercropping system.

- Conclusions

1. Intercropping can result in major increases in the efficiency of land and N fertilizer use.
2. Maize in C4-maize/C3-cereal has the highest HI and NHI.
3. The improvement of HI and NHI of legumes can be realized by shortening the co-growth period of the two species in intercrops.

Overview PhD projects – starting year 2021
Posters, December 2021

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. Chuansheng He	1+3	Designing and optimizing sustainable food supply chains for healthy diets in China
21. Yijun Li	1+3	Designing and optimizing sustainable food supply chains for healthy diets in China
22. Xin Zhang	2+2	Designing and optimizing sustainable food supply chains for healthy diets in China
23. 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
24. Mengxue Mao	2+2	Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production
25. Man Pu	1+3	Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production
26. Xiaofan Ma	1+3	The mechanisms of plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction involved in stimulating AM symbiosis and plant performance
27. Zihang Yang	2+2	The mechanisms of plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction involved in stimulating AM symbiosis and plant performance
28. Wenying Huo	1+3	Uncovering how plants discriminate mutualistic microbes
29. Pugang Yu	2+2	Uncovering how plants discriminate mutualistic microbes
30. Zemen Hei	2+2	Understanding and manipulating the rhziobiont to enhance crop productivity and nutrient use efficiency
31. 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, Eating 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

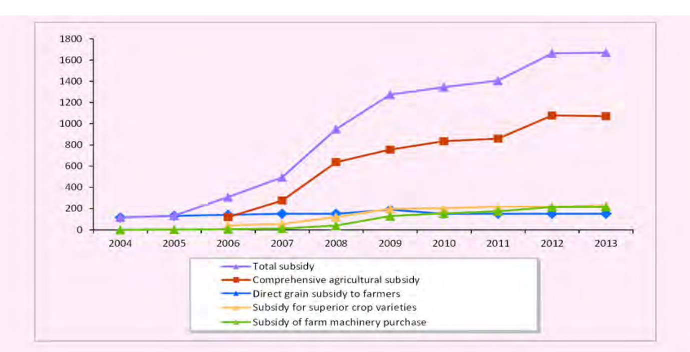
Agriculture, as the one of the most fundamental sectors of a country, has consistently attached people's attention to its development around the world. Recent years, due to the growing population and climate change, a worldwilde green and sustainable development advocation has also been adopted to the agriculture sector.

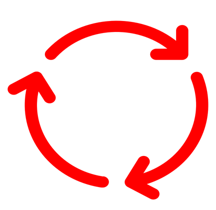
In China, smallholders are the main food producers that there are 200–300 million households engaged in agriculture. At the same time, they are also the consumers of the food consumption, even exist more problems of malnutrition. In order to change the unbalanced eating structure for agro-food system transformation, it is considerable to make adjustments from smallholders. So far, almost them are consider more to their personal interests, while production, rather than the social benefits. Thus, thinking about feasible strategic support actions are necessary for the transformation.

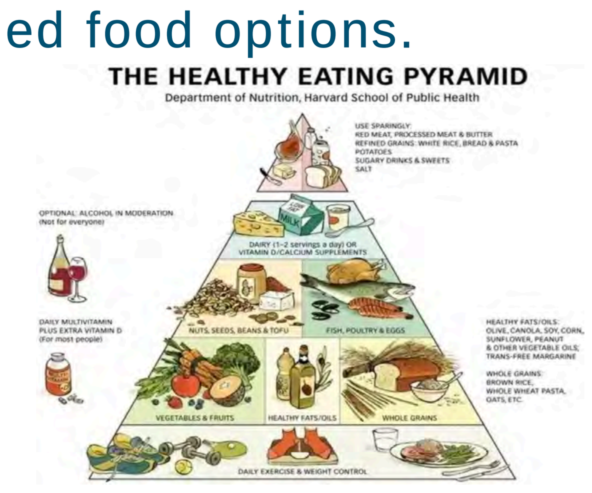
On one hand, the support actions could be considered from the subsidy's adjustment. It is uniformed adjustments for the agro-food system in the whole value chain. On the other hand, increasing the opportunities of market accesses to diversified food is another action that could promote the transformation.

E-commerce, as an innovative market channel, has evolved rapidly in the value chain recent years. It has transformed the whole value chain toward a more convenient and fragmented formation, which is more adaptable for the current development tendency. Hence, to transform the agro-food system, it is considerable to utilize the e-commerce model for better strategic adjustments.

Based on the above statement, this research is an interdisciplinary project to integrate multiple stakeholders in the value chain for China's agro-food system transformation. E-commerce will be used as a new platform to induce better consumption and production behaviors of smallholders in the rural areas. At the same time, by adopting the strategic management through the subsidy's adjustments, feasible support actions will be proposed to influence the food-environment. The market access will be promoted for more diversified food options.







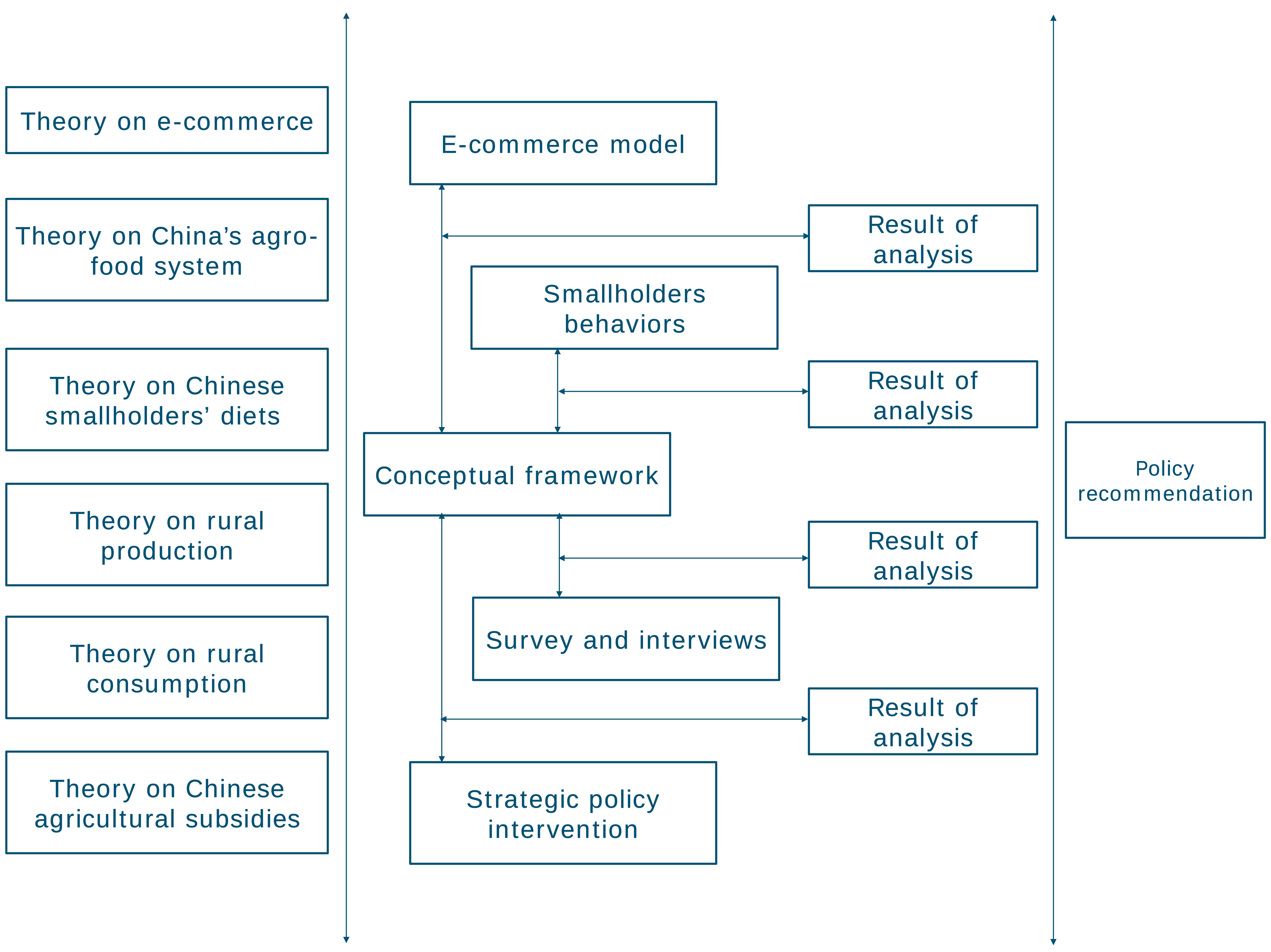
Research objective

Based on the above statement, this thesis will focus on making the connections between the Chinese smallholders, agricultural subsidies, e-commerce model and the agro-food system. It is supposed to achieve the objective of improving the nutrient condition in the rural area of China. By adjusting Chinese agricultural subsidies and utilizing e-commerce, feasible strategic actions will be proposed for changing smallholders' behaviors of vegetables production and consumption.

Research questions:

1. What is the current situation of e-commerce development and agro-food system in China's rural areas?
2. What are the impacts of e-commerce on changing diet habits of Chinese smallholders?
3. What are the impacts of e-commerce on the Chinese smallholders' production behaviors?
4. What are the feasible adjustments of China's agricultural subsidies to transform its agro-food systems for better nutrition and health through e-commerce?

Research framework



Acknowledgements

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

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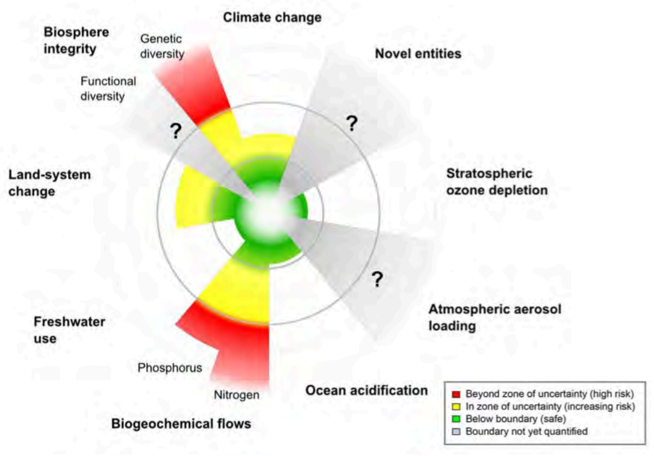
Conceptualizing Agriculture Green Development Framework and discover China AGD's contribution to SDGs

Yuan Feng

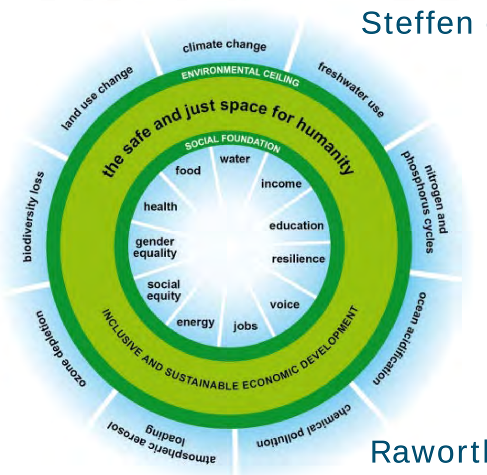
CAU Supervisors: Zhu, Qichao, PhD
Hou, Yong, PhD
Zhang, Fusuo, PhD

WUR Supervisors: Hans-Peter Weikard, PhD
Fransico Alpizar Rodriguez, PhD

Background



Steffen et al., Science 2015

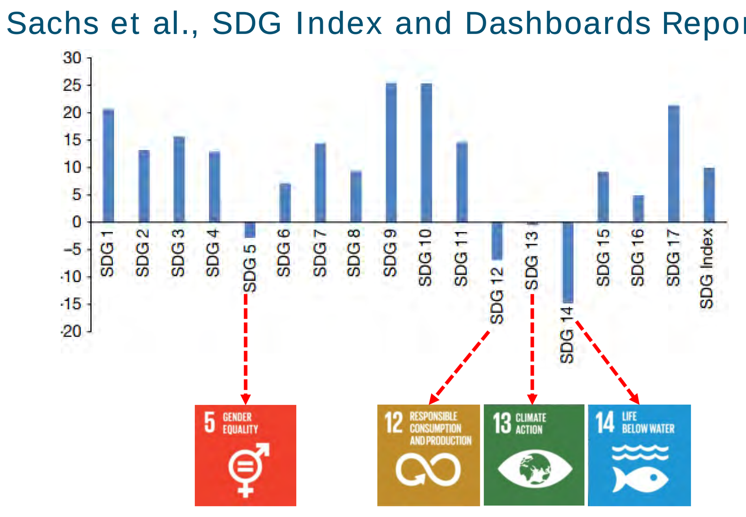


Raworth, Oxfam, 2012

Based on planet bio-physical threshold and social targets, a global framework for development defined a safe operating space for human beings. Under this framework, human development faced a double burden from the social and the environmental dimensions.

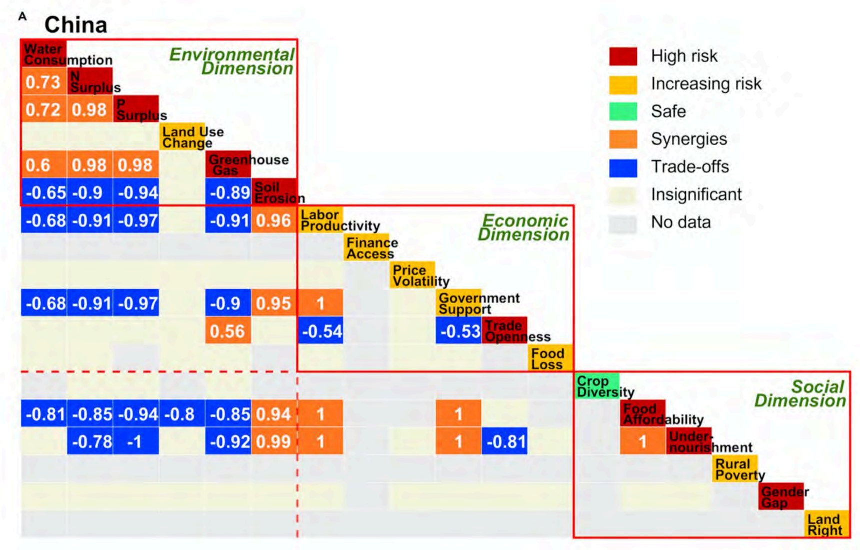
In 2015, the UN replaced the Millenial Development goals with Sustainable Development Goals (SDGs). Besides human rights such as poverty, nutrition, and diseases, the new goals target sustainability, the environment, and global partnership.

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



Xu et al., Nature, 2020

Studies showed that China's overall performance on SDGs increases over time. The related social goals have, in general, behaved better than the environmental goals.



Zhang et al., One Earth, 2021

A study showed that China's performance on agricultural sustainability within the economic and social dimensions performed better than the environmental dimensions. However, social and economic development is in a trade-off situation with the environment.

China Agriculture's contribution to SDGs?

Future pathway of change to achieve environmental, economical, and social synergy development?

Research Objectives

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

Simplified Flow Diagram: demonstrates the concept for making intervention decisions based on an evaluation of resource, social, and environment status for their vital link to our agri-food system.

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.

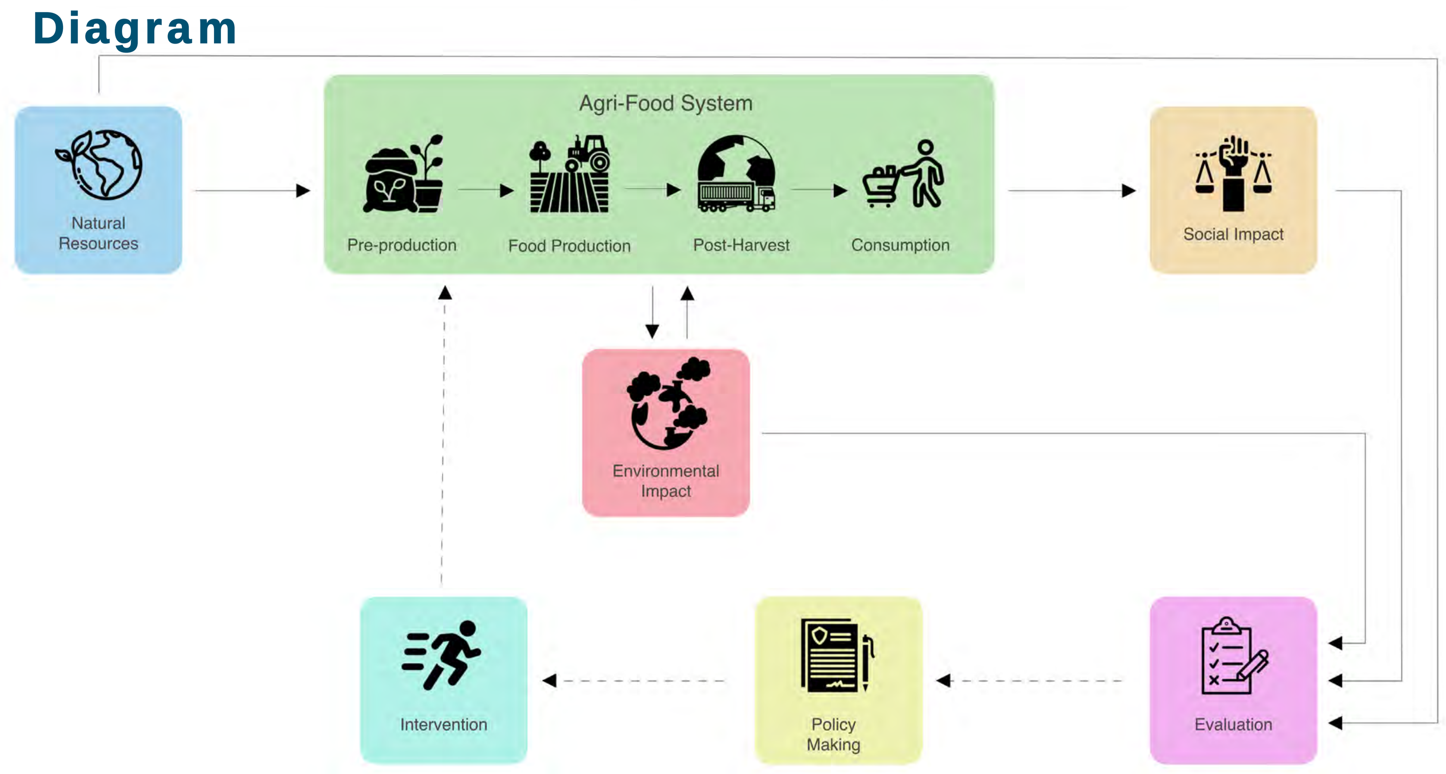
Social Outcome: agri-food system's impact on human society, such as income, nutrition, health, etc.

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.

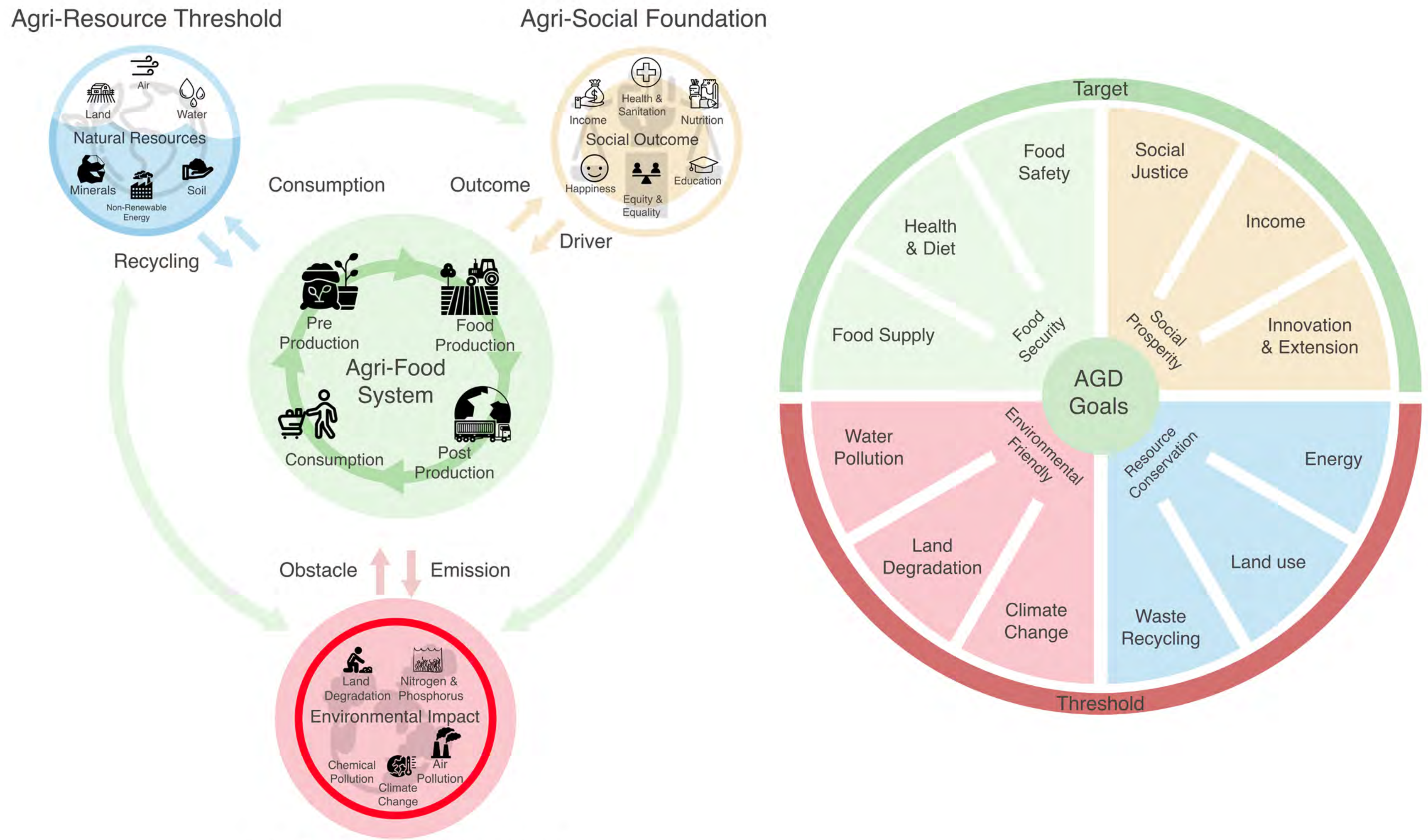
Agri-Food System: the whole industry chain for food production, including **pre-production** such as seeds, fertilizer, machinery; **food production** such as agronomy, horticulture, livestock; **post-production** such as logistics, cold-chain, storage, sales; and **consumption**.

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**.

Conceptual Simplified Agri-Food System Flow Diagram



Conceptual Agri-Food System and Evaluation Framework



Research Plan

1. (in progress) Comprehensive literature review of sustainable agriculture development frameworks and conceptualizing the AGD framework

2. Develop the AGD framework, including system boundaries, flow models, and impact assessments

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

4. Strengthen and elaborate the AGD framework drawing on China's historical agriculture development, focusing on national actions and policies in the past

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Acknowledgements

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

Pathways of China's Agriculture green development: From quantitative assessment to future interventions

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.
- The AGD includes four key themes: green crop production systems, green livestock and integrated animal-crop production systems, green food products and industry, and a healthy rural environment with stable ecosystem services. 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 SDG?
- How can the goals of AGD be aligned with the demands in the coming decades?

Methods

- **Step 1: Literature review** based on the following keywords: 'food system(s)' AND 'sustainability' OR 'sustainable' in title or abstract, and we found some documents including reports and articles.
- **Step 2: Building the AGD evaluation system metric:** identification of the dimensions of the metric based on the literature, and 4 dimensions was identified including Food security, Social prosperity, Environmental Friendly and Resource conservation.
- **Step 3: Compilation of existing indicators:** identification of the indicators proposed in the literature.
- **Step 4: Application of inclusion criteria:** selection of consistent and coherent indicators.

Figure 1. The evaluation system and the metric of Agriculture Green Development

Research content

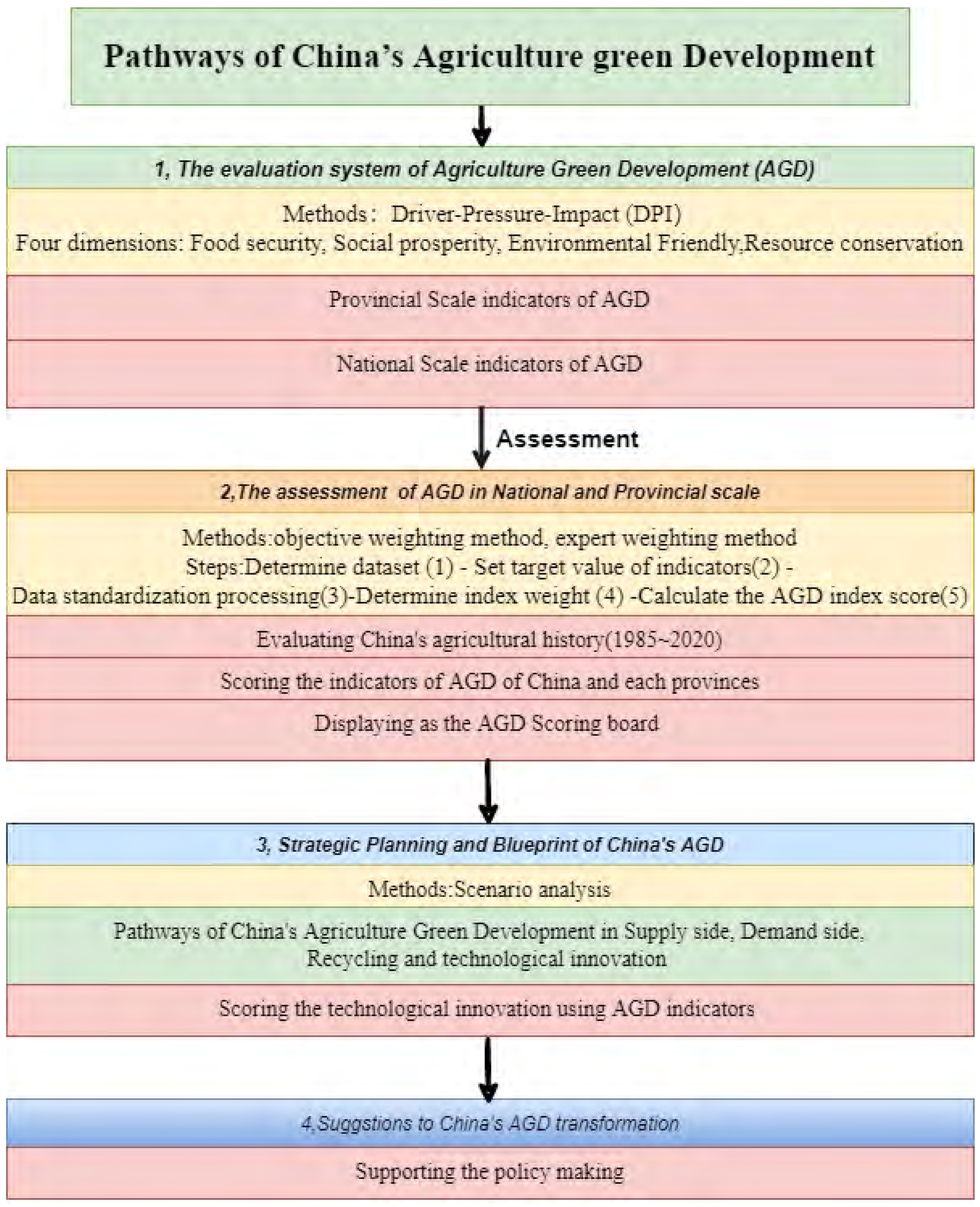

Figure 2. Methodology framework

Novelty

- An evaluation system of Agricultural Green Development will be developed based on a systematic set of indicators.
- Using scientific and systematic research to support the formulation of national policies.
- From the methodological perspective, existing integrated assessment will be merged with improved models. This covers a broad sustainability indicator system (Food security, Social prosperity, Environmental Friendly and Resource conservation).
- The promising pathways of AGD in China are explored in a wider context.

Acknowledgements

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

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Early prediction of pregnancy status by machine learning to promote sustainable development

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Background

- Pregnancy status (PS; Pregnant and non-pregnant) is an essential phenotype of dairy cattle and important in managing the fertility and subsequent production of the herd
- The longer it takes to determine that the cow has not maintained the pregnancy, the greater the financial implications. Thereby early diagnose of pregnant is a key driver in the profit
- Milk composition is influenced by the PS of dairy cows, and routinely quantified by mid-infrared (MIR) spectra
- It provides a novel, convenient, and lower-cost way to observe PS from MIR spectra

Objectives

This study aimed to :

(1) evaluate the accuracy of using MIR spectra before insemination to predict pregnancy or not after insemination

(2) evaluate the influence of different preprocessing in MIR data on prediction accuracy

(3) compare the power of different machine learning methods

(4) find related wavenumbers in MIR spectra

Methods

Definition of PS:

The PS defined as pregnant or non-pregnant

- For cow is pregnant after the first insemination, the MIR record before the first insemination is set to the pregnant status
- For the cow is pregnant after multiple inseminations, the MIR record before the first insemination is set to the non-pregnant status, and the MIR record before the others insemination is set to the pregnant status

Calculation:

Step 1: Spectral processing was used to enhance the relationship between trait and MIR spectra. Ten methods used in this study, such as multiplicative scatter correction (MSC), standard normal variate (SNV), and others

Step 2: The outlier in MIR spectra was detected by the standardized Mahalanobis distance (GH) combined principal component analysis

Step 3: Logistic regression (LR), partial least squares discriminant analysis (PLS-DA), random forest (RF) were used to established the discriminant model. The optimal parameters come from iterations. The independent variables in model include individual information (days in milk, parity, milk yield and others) and MIR data.

Step 4: 20% data randomly used for external validation, the remaining (80%) data used for train model and internal validation (random, 5-fold cross-validation). Cross-validation was used to evaluate model performance and enable comparison between the different models

Step 5: Accuracy, AUC, specificity (Recall), and sensitivity were used to defined whether the model good or not

Results

✓ Since detecting non-pregnant is more important than the pregnant in management, so specificity is the best indicator to quantify the model performance. The prediction results are shown in Table 1, the MIR data within 21d before insemination had a better prediction in non-pregnant (83.7%)

Table 1. The Prediction results based on MIR data at different intervals before insemination

Records	Interval	Internal validation accuracy	External validation accuracy	AUC	Sensitivity	Specificity
2,021	7	67.3%	64.6%	0.649	77.4%	81.5%
3,728	14	66.6%	67.3%	0.682	67.7%	81.6%
5,375	21	66.6%	68.8%	0.695	66.7%	83.7%

✓ Compared with the original data, the preprocessing in the MIR data has no effect on the prediction

✓ The prediction performance of PLS-DA is the best, and the optimal parameter is always equal to 2

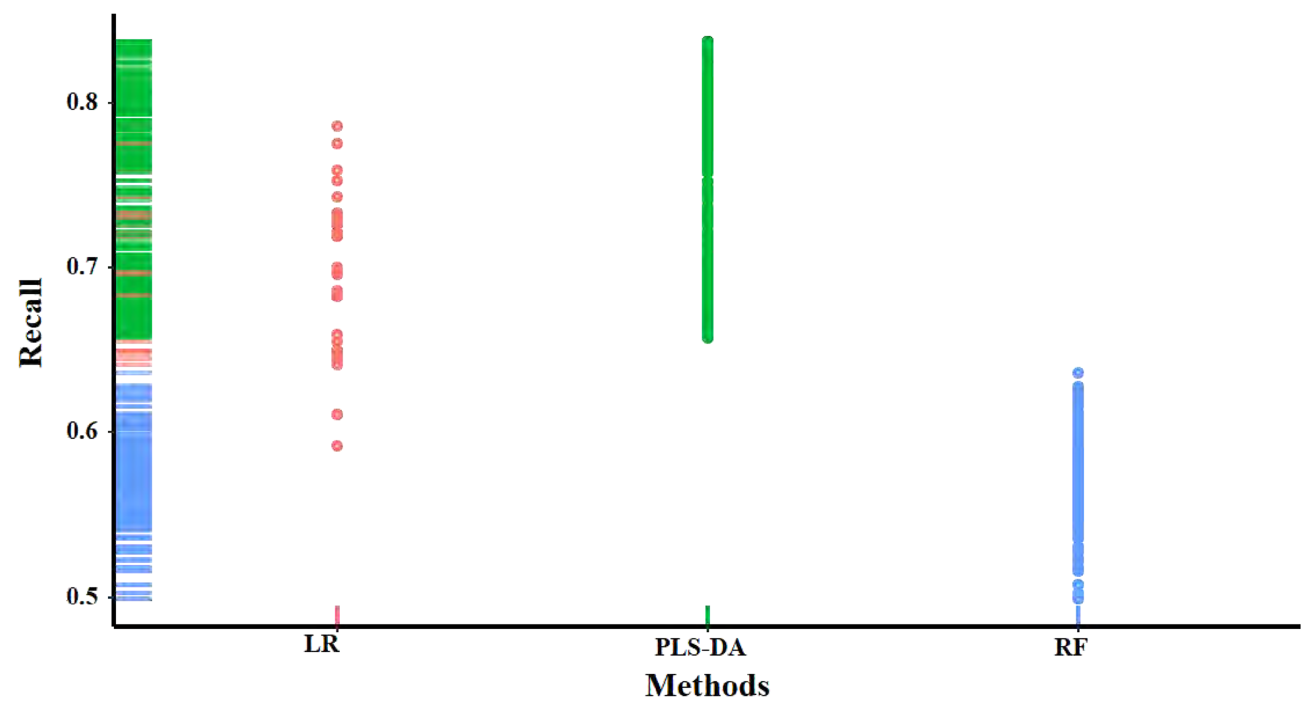

Figure 1. The Prediction results for the three machine learning methods

✓ The more related MIR regions include 1525-1562, 1741-1754, 2849-2942 cm^{-1}

✓ These areas are related to the hormone

Conclusions

① Non-pregnant individuals can be predicted well (83.7%) before insemination, which is a good indicator for individuals with abnormal physiological conditions. It can help to improve the efficiency of management and reduce the extra cost

② The reprocessing in the MIR data seems to have no effect on the prediction results, but it still has effect in other research

③ Reasonable threshold (95%) for outlier filtering can improve the prediction effect

④ PLS-DA is the best method to compare with others

Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO. 202106350126)

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Exploring the circularity of crop-livestock system through spatial planning and structure adjustment

Yuhang Sun Supervisors: Y. Hou, A.G.T. Schut, M.K. van Ittersum, P. J. Gerber and S. J. Oosting

Background

- Due to high population density and economic growth, intensive high-input agriculture is prevalent to meet increasing food demand.
- Specialized agriculture has caused widespread environmental issues, such as nutrient surplus and air pollution.
- Integrated crop-livestock system can enhance nutrient circularity, mitigating the environmental issues caused by intensive agriculture.
- A major barrier of improved nutrient management is high transportation cost due to uneven distributions of crop land, livestock, and people within the country (Figure 1).

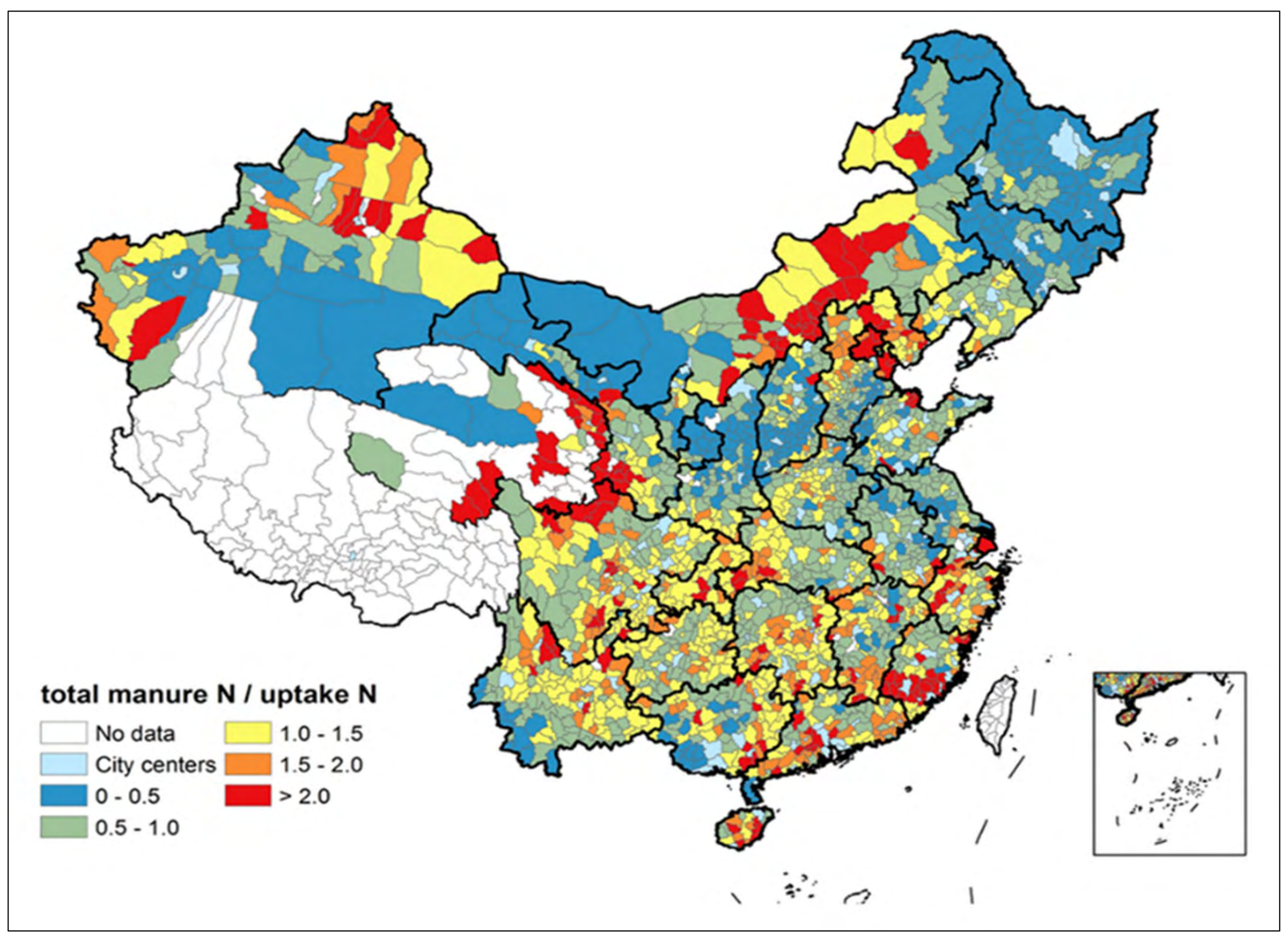


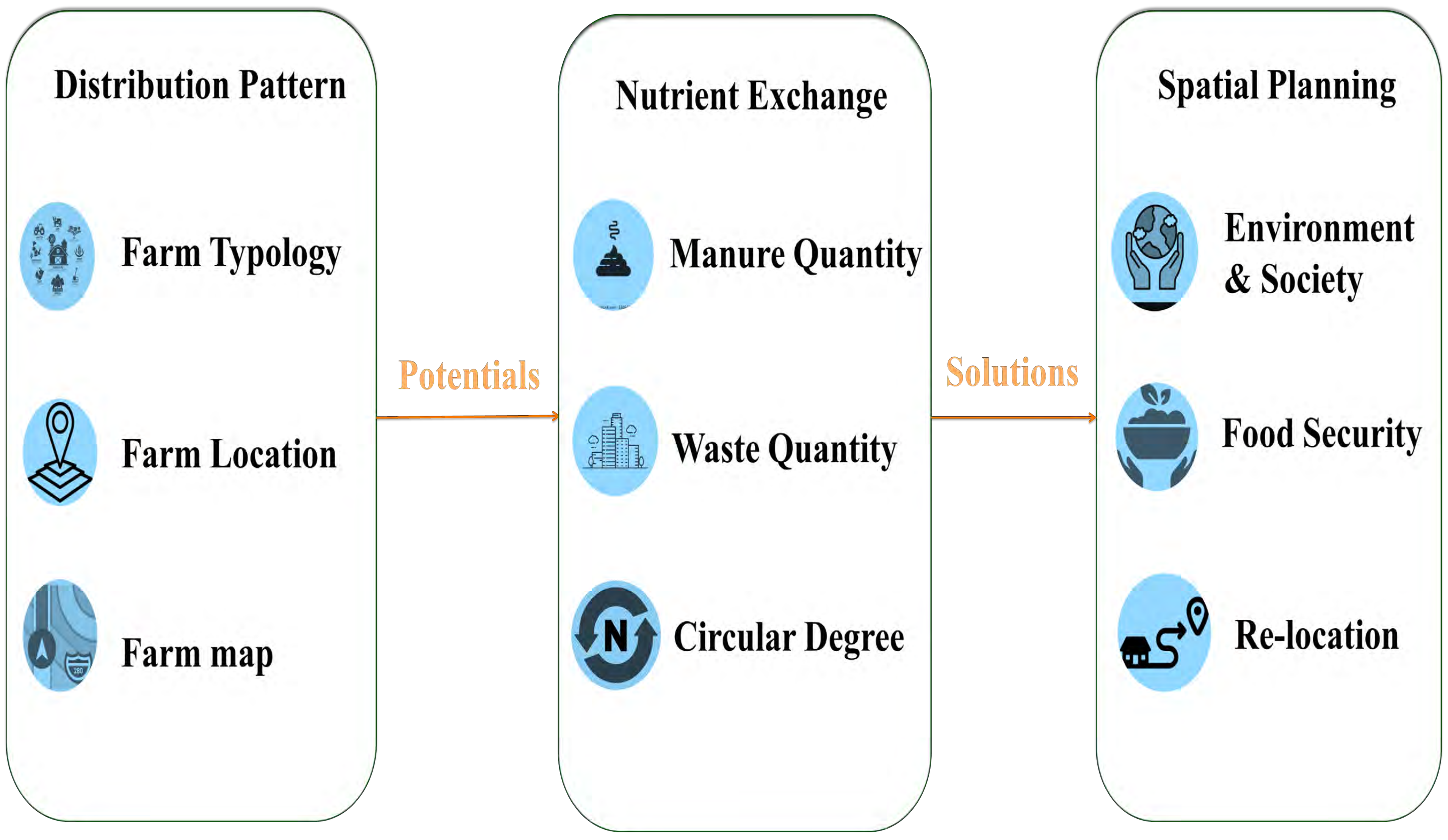
Figure 1. Map of the distribution of the manure N loading in 2012
(Jin et al., 2020 *Environmental Science & Technology*)

Objectives

- To understand characterization of the spatial distribution of farming systems: drivers, trends and consequences
- To assess the contribution of exchanges among farms to nutrient (N&P) cycling in regional level under current distribution
- To explore a balanced farming systems to reduce externalities and provide sufficient food within environmental thresholds though spatial planning and structure optimization

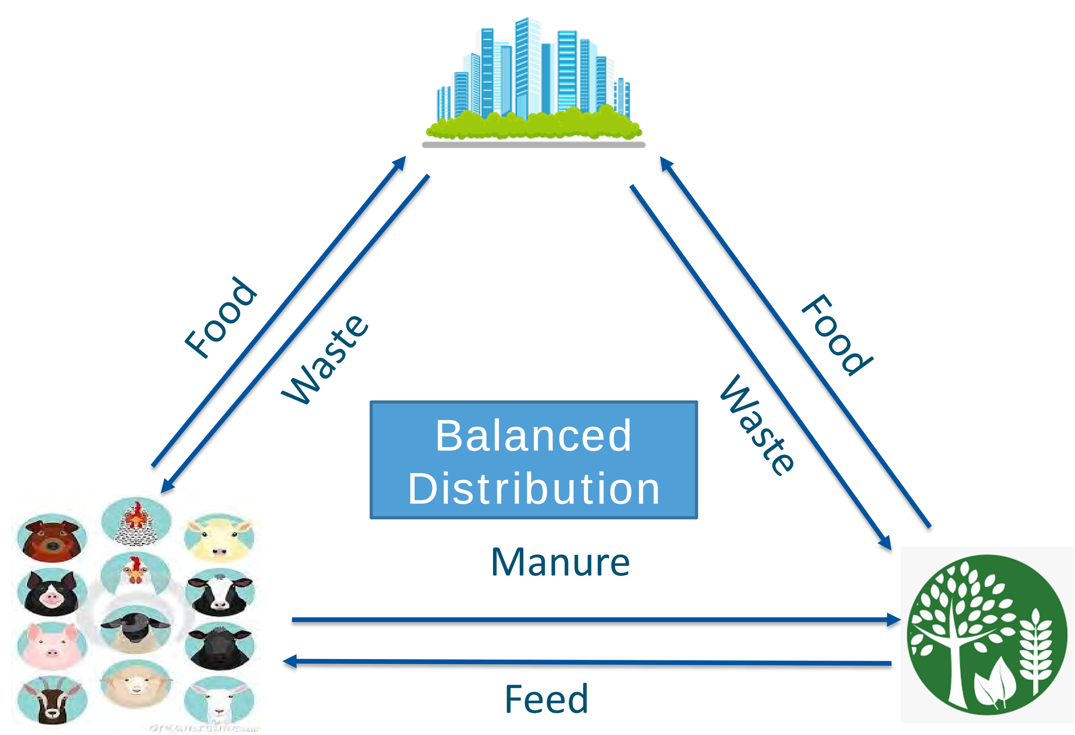
Methods

- Farm typologies based on survey data to map farm type distribution.
- Use NUFER model to calculate nutrient flows, losses and production through system and estimate the dependency on externalities.
- Scenarios with various degrees of circular agriculture are developed to analyse the effects of an optimized distribution of farming types on nutrient cycling, environmental impacts and feed and food self-sufficiency rates.



Expected outcomes

- Current farm types are geographically clustered in regions with on-going specialization, such as livestock farms near cities.
- Nutrient recycling within the farming system is limited with large dependency on external inputs
- Spatial planning to optimize farm type distribution strongly reduces externalities and can provide sufficient food within environmental thresholds



Acknowledgements

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

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To waste or to use?
Exploring pathways towards more sustainable food systems in the North China Plain from a circular economy perspective

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M.K. van Ittersum and A.G.T. Schut (WUR-PPS)
Y. Hou and HL. Wang (CAU)

Background

- Food systems include production, storing, processing, packaging, transporting, marketing, consuming food and managing food and food-production-related waste streams (Berkum *et al.*, 2018).
- Food systems should not only meet the food production objective, but also environmental and social-economic objectives.
- Circular food systems are food systems which minimize waste streams and reuse inevitable wastes.
- The North China Plain is the main food production area of China and has been a hotspot area with respect to environmental pollution and excessive use of resource.

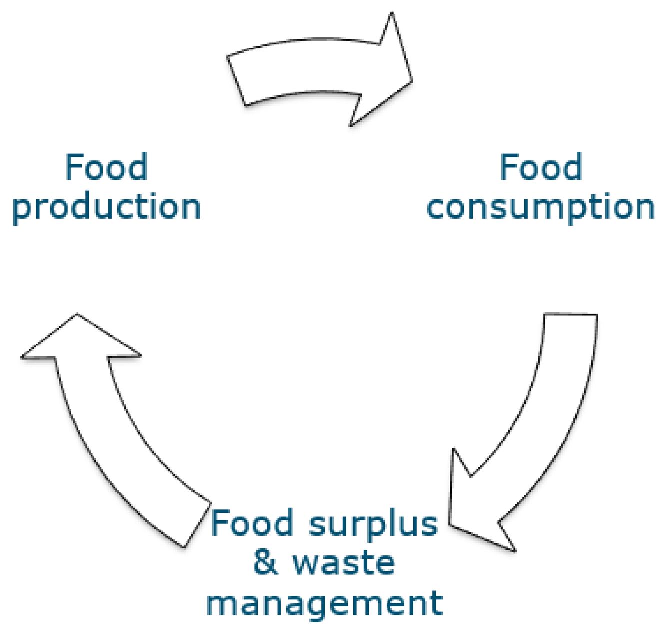


Figure 1. The simplified three stages of the food system in circular economy

System diagram

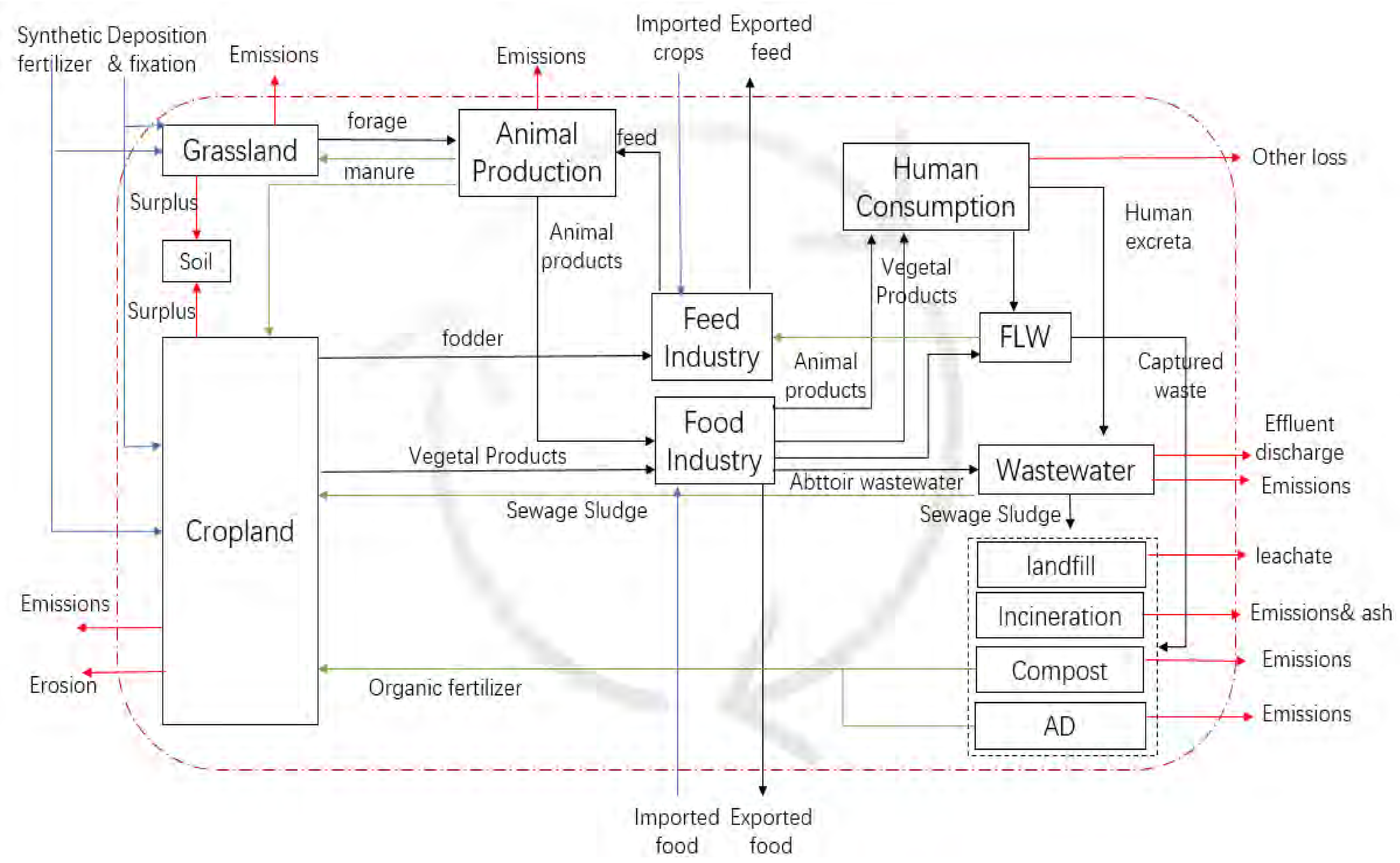
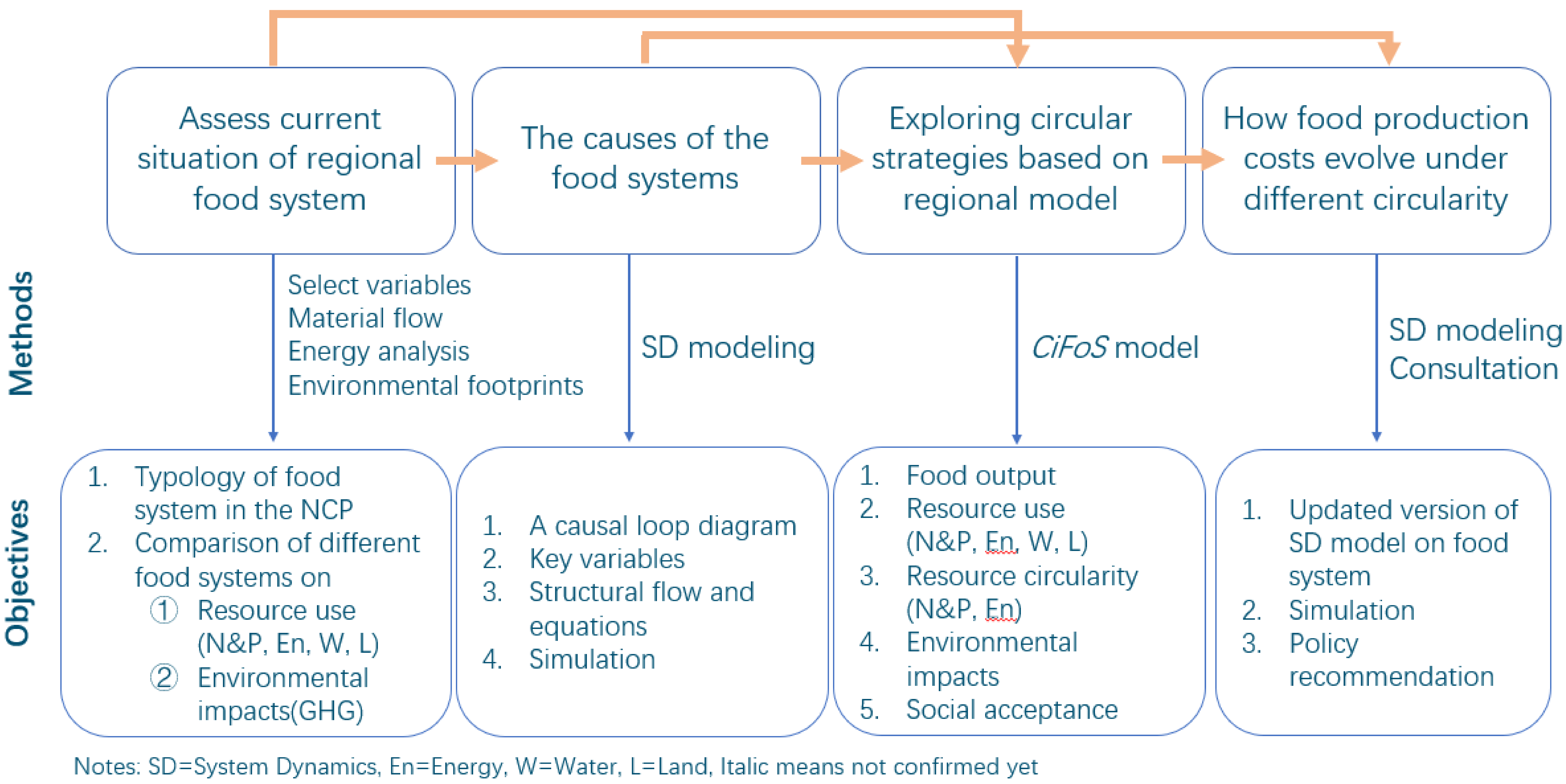


Figure 2. System diagram including processes, flows, and boundaries for the whole system

Research framework



Notes: SD=System Dynamics, En=Energy, W=Water, L=Land, Italic means not confirmed yet

Figure 3. The research framework of this study

Expected outputs

- The resource(N/P, energy, water, land) use and environmental impacts such as GHG emissions of various regional food systems;
- A system dynamics model on the causes of the food systems;
- Resource use and other environmental and social impacts under different conditions of food demand and circularity;
- A system dynamic model on how food production costs evolve for selected value chains under different levels of circularity, and policy recommendation.

Reference

Berkum, S.v., Dengerink, J., Ruben, R., (2018). The food systems approach: sustainable solutions for a sufficient supply of healthy food. Wageningen Economic Research, The Hague.

Acknowledgements

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

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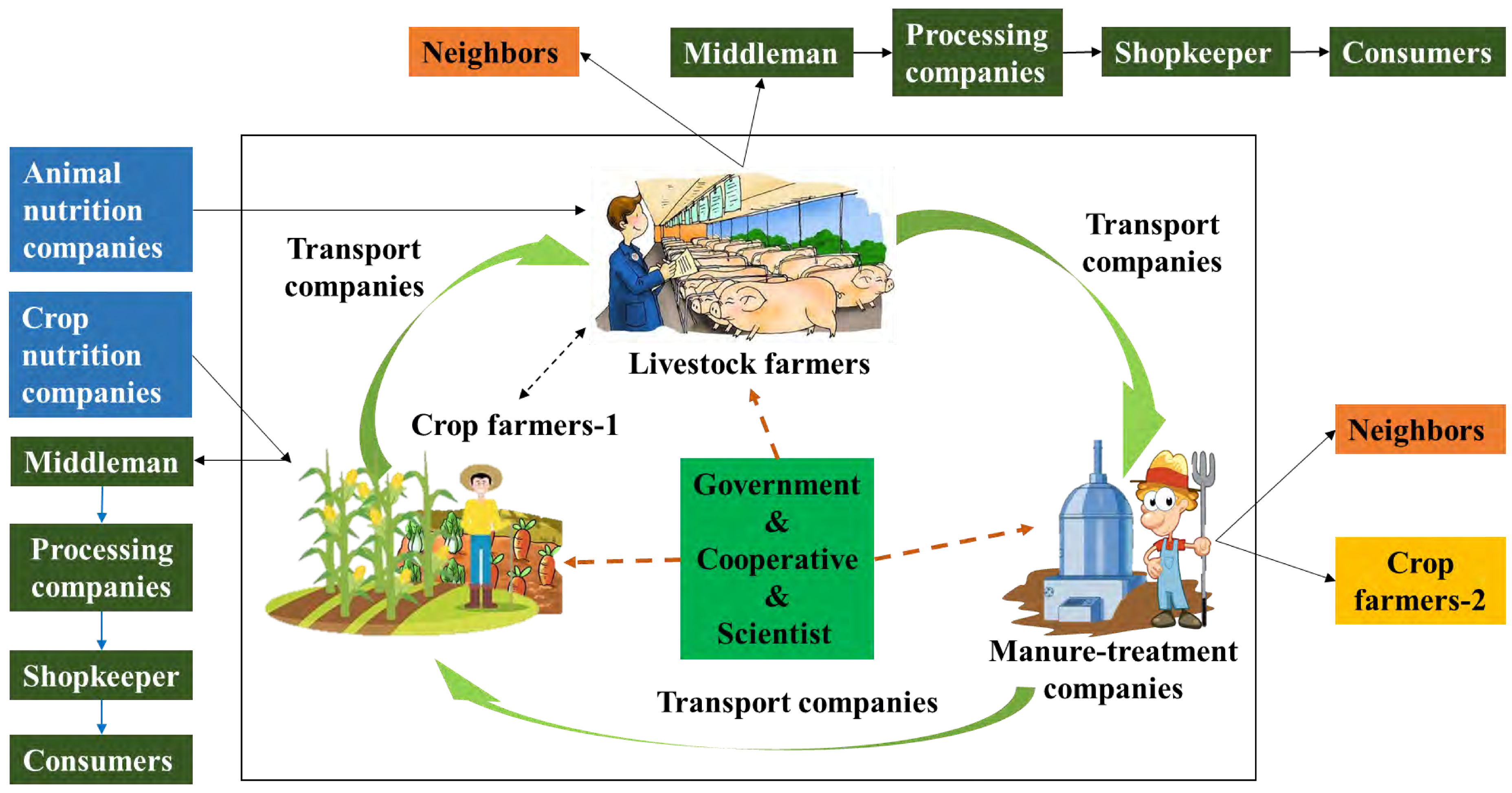
Enhancing circularity of crop-livestock systems through technical and organizational intervention

Xiaoying Zhang

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

Background

1. Integrated crop and livestock system (ICLS) as a powerful strategy can improve sustainability in agriculture.
2. ICLS always constrained by organizational and technical issues at the farm level.
3. In future, it is necessary to design feasible technical and organizational intervention among stakeholders according to the actual situation in different regions, to ensure the sustainable agricultural development and food security in China.



Research objectives & Methods

(ICLS _ Integrated crop-livestock system EI _ Environment impact SEP _ Socio-economic performances)

Enhancing circularity of crop-livestock systems through technical and organizational intervention

Step 1 To identify the EI and SEP of varied ICLS types

Interview
(Rural Household Multi-Indicator Survey)

Type 1	Type 2	Type 3	Type 4
Co-existence	Complementarity	Farm-level synergy	Territory-level synergy

Evaluation indicators

Productivity Environment Resources Economy

T1: - Exchange of materials (grain, forage, manure, etc.) between specialized farms
T2: - Exchange of materials between sphere at the farm or territory level
T3: - Stronger temporal and spatial interaction among the three spheres at farm level
T4: - Stronger temporal and spatial interaction among the three spheres at territory level

Model validation
(Optimization design)

Step 3
To evaluate the realization potential of ICLS in regions

Spot research
(Light-design methodology)
Three steps:
1. Context setting
2. Brainstorming of options of change
3. Ex-ante assessment

Based on workshops with local stakeholders, aims: to design options for crop-livestock integration that they judge to be relevant and interesting for dealing with local issues.

Steps:

1. Context setting - a multi-stakeholder participatory approach (four perspectives)
2. Brainstorming of options of change - a card-sorting method (technical experts, farmers and advisors)
3. Ex-ante assessment - qualitatively assessed, a multicriteria assessment grid

(Moraine et al., 2017, Renewable Agriculture and Food Systems)

Step 2 To optimize the combined measures to realize ICLS

Obj 1. Quantifying the characteristics of environment impact and socio-economic performances among varied ICLS types
Obj 2. Exploring the technology which can improve circularity of crop-livestock systems based on multi-objective collaboration
Obj 3. Exploring the most appropriate technology and organization form to improve the circularity of crop-livestock systems

Expected outcomes

1. Summarize the types of ICLS in different regions of China
2. Explore key technologies to balance the trade-offs between EI and SEP
3. To clarify the decisive role of different stakeholders in ICLS
4. Put forward policy recommendations for the ICLS

Acknowledgements

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

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Assessment and improvement of national nutrient policies in China

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

Background

China faces the challenges of feeding 20% of the world's population with 9% of the arable land in the world (Wu et al., 2018). During the last few decades, China has strongly increased its crop and animal production. The rapid growth of livestock production and the decoupling of livestock manure and crop production strongly hinder the achievement of green agricultural development.

At present, the total nutrient content of organic resources in China is about 75 Mt, among which the N, P_2O_5, K_2O are 30.9 Mt, 11,7 Mt, and 32.5 Mt, respectively. However, there are problems in the utilization of organic fertilizers. The utilization of these abundant organic fertilizer resource is low input ration and low utilization rate. In addition, the average manure-recycling ratio is lower than 40% in China (Jin et al., 2020), indicating that over half of manure nutrients are lost to the environment, leading to great pressure on environmental quality.

Since 2017, a national action plan has been released to promote the coupling of livestock and crop production by increasing the replacement of mineral fertilizer by manure in cash crops (i.e., fruit trees, vegetables and tea plants), indicating that 50% of applied N in these crops should come from chemical fertilizer and the rest from manure. Science-based evidence on the current state of the different types of animal manure markets and the bottlenecks faced by middlemen and by farmers at the demand and supply sides is urgently needed to identify appropriate policy interventions and regulations to reach this goal. However, the integrated effects of these national policies on food production, the quality of environment and welfare changes of different socioeconomic groups have not been quantified yet.

Objectives

- Quantify the nutrient requirements of cereal crops and cash crops and available organic nutrient resources in China
- Quantify the impacts of a series of nutrient policies (i.e., replacement of chemical fertilizer by manure and straw returning to the field) on crop yield, nutrient surpluses , eco-environmental (soil quality, N and P losses) impacts of current and desired agricultural practices, and farmer income
- Formulate policy recommendations on the limiting factors of nutrient policies and on the interventions that would contribute to the green development of livestock as well as arable farms in China

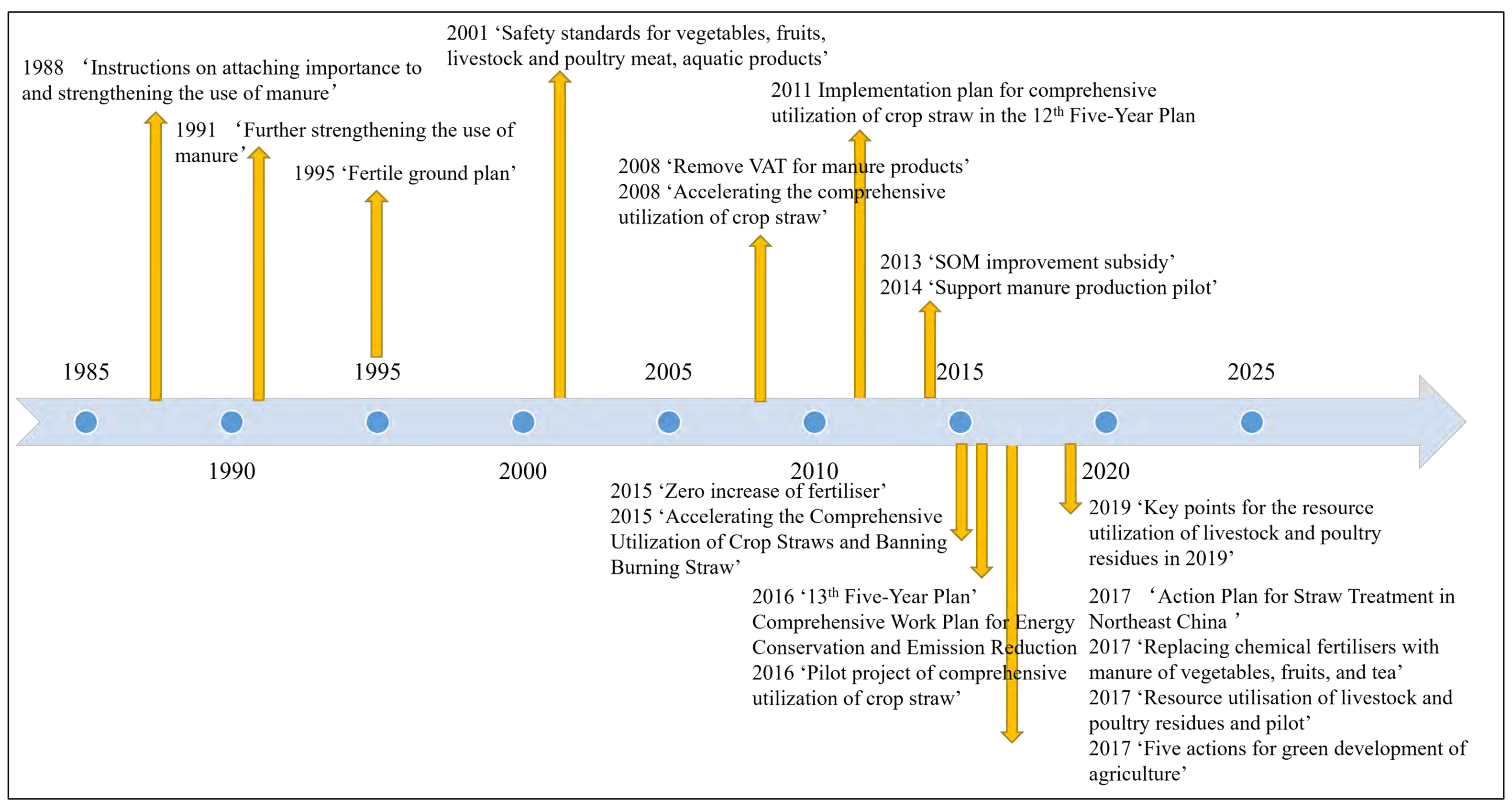
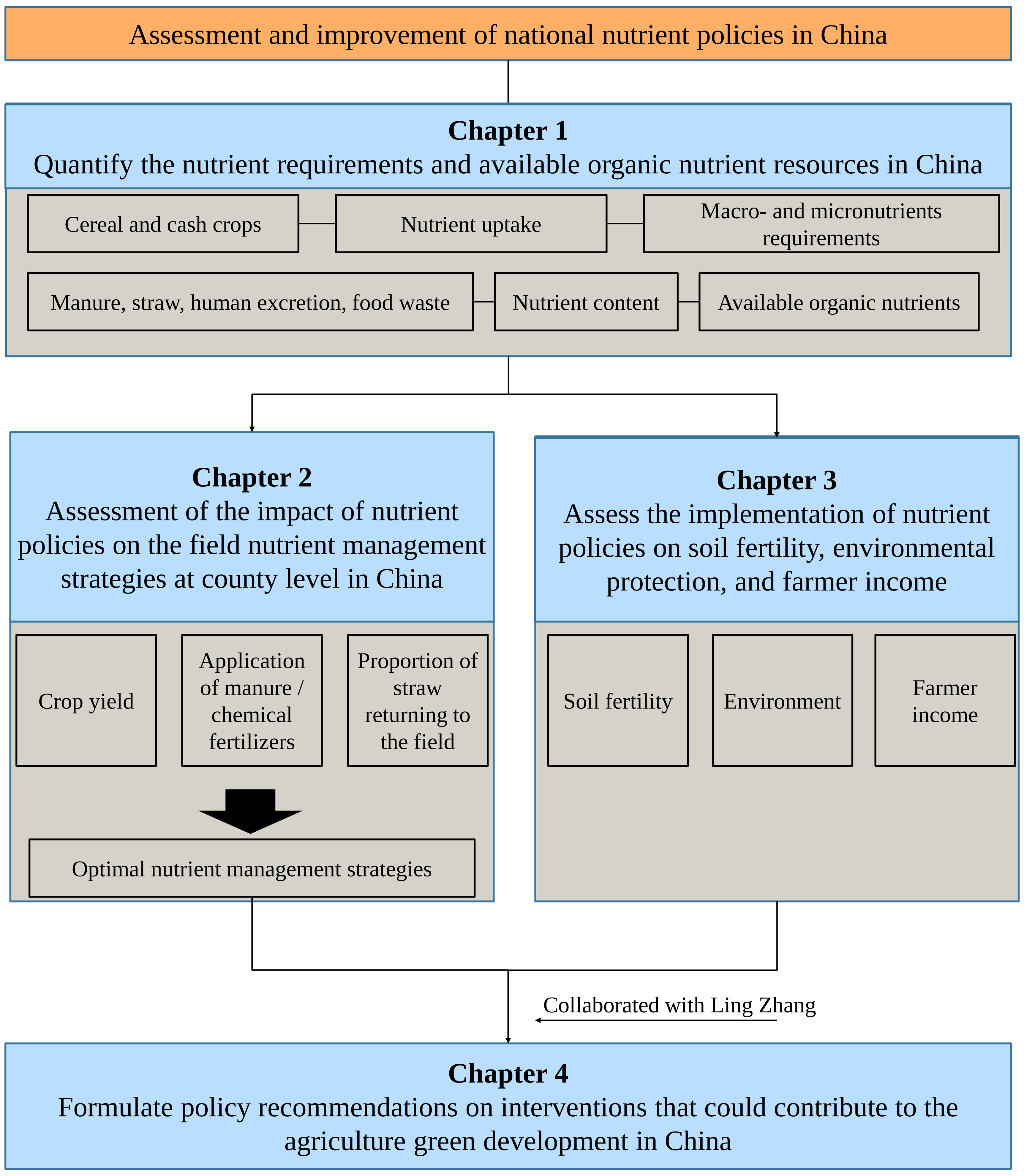


Fig. 1 Manure policies in China from 1985-2020.

Framework



Method

- ✓ Data collection: Potential and target yield for crops, nutrient content in crops, manure, straw, human excretion; farmer practice, e.g., manure application, proportion of straw returning to the field, soil fertility, environmental and economic indicators
- ✓ Policy assessment: Differences-in-Differences (DID)
- ✓ Environment assessment: Life cycle assessment (LCA)

Reference

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Jin, S., Zhang, B., Wu, B., Han, D., Hu, Y., Ren, C., ... & Chen, J. (2021). Decoupling livestock and crop production at the household level in China. *Nature sustainability*, 4(1), 48-55.

Acknowledgements

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Assessment of national fertilizer policies in China on sustainable development

PhD candidate: Ling Zhang

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

Background

China is the world's largest consumer of synthetic fertilizers applied to croplands, accounting for about one-third of global total nitrogen fertilizer consumption (FAOSTAT, 2020). The overuse of chemical fertilizer has led to great environment problems, such as eutrophication (Strokal et al., 2014), soil acidification (Zhu et al., 2020). Therefore, in 2015, the Chinese government has released the so-called 'zero increase of chemical fertilizer' policy, which has large effects on the fertilizer application in China.

The chemical fertilizer applied on cropland has decreased from 60.2 million ton at 2015 to 54.03 million ton at 2019 (NBSC, 2020). This indicates that at least 10% of chemical nutrients were saved, as well as the pollutant emissions from agricultural production has been reduced.

On the other hand, it's clear that the policy has a profound implication on the chemical fertilizer industries, by decreasing the income and benefits, and forcing them to strengthen the research of new products and enhance the competitiveness. The policy has aggravated the competition among fertilizer enterprise, and the total market has shrunk.

Objectives

- To quantify the impacts of 'Zero increase of chemical fertilizer' policy on farm management practice, which including the crop production, farmer income and environment
- To quantify the impacts on fertilizer industries development, which including enterprises income, energy intensity, pollution production and products quality
- Formulate policy recommendation on interventions that would contribute to green development of crop production and fertilizer industries
- To quantify the sustainability changes under the interventions of chemical fertilizer policies

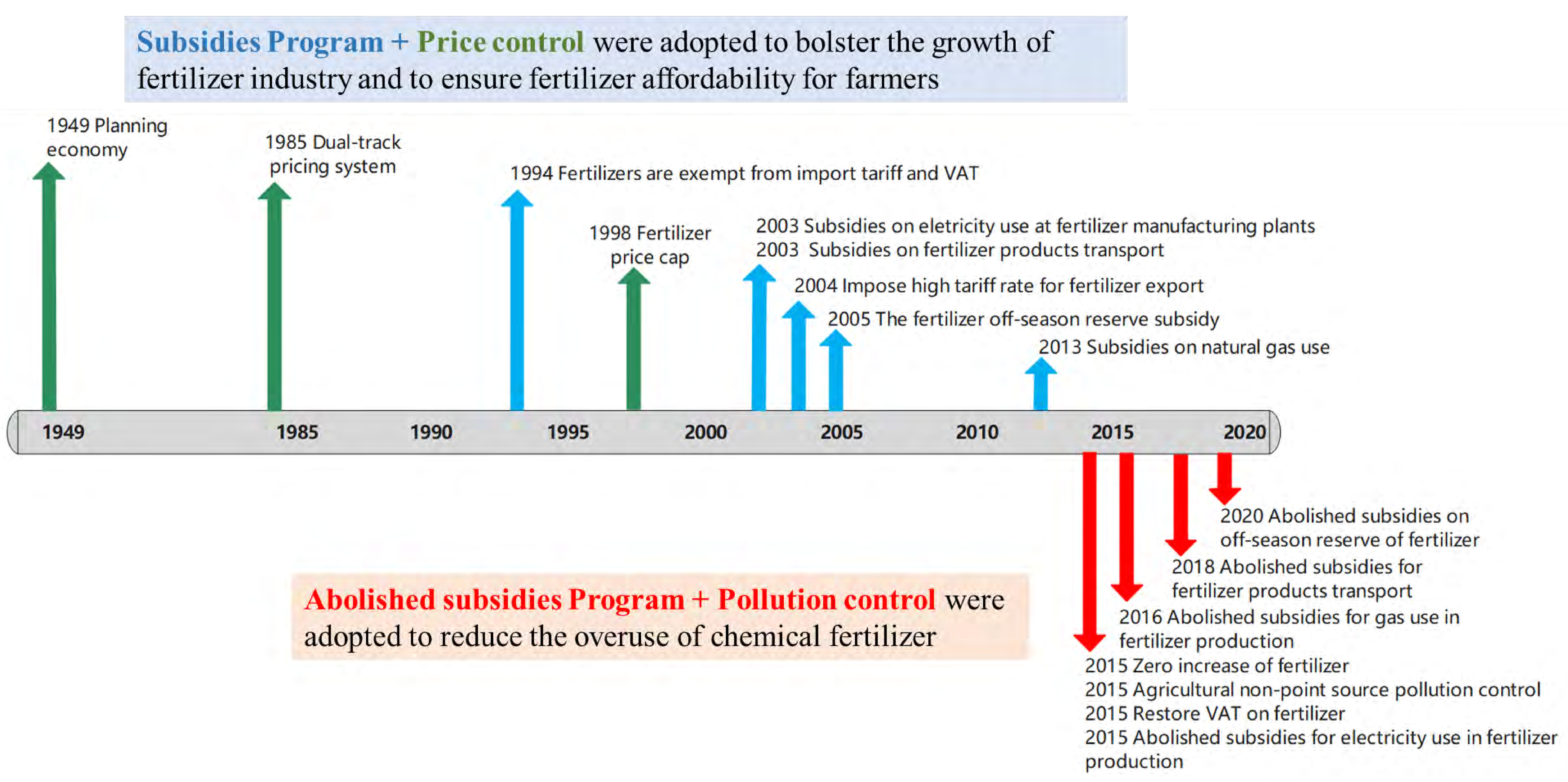
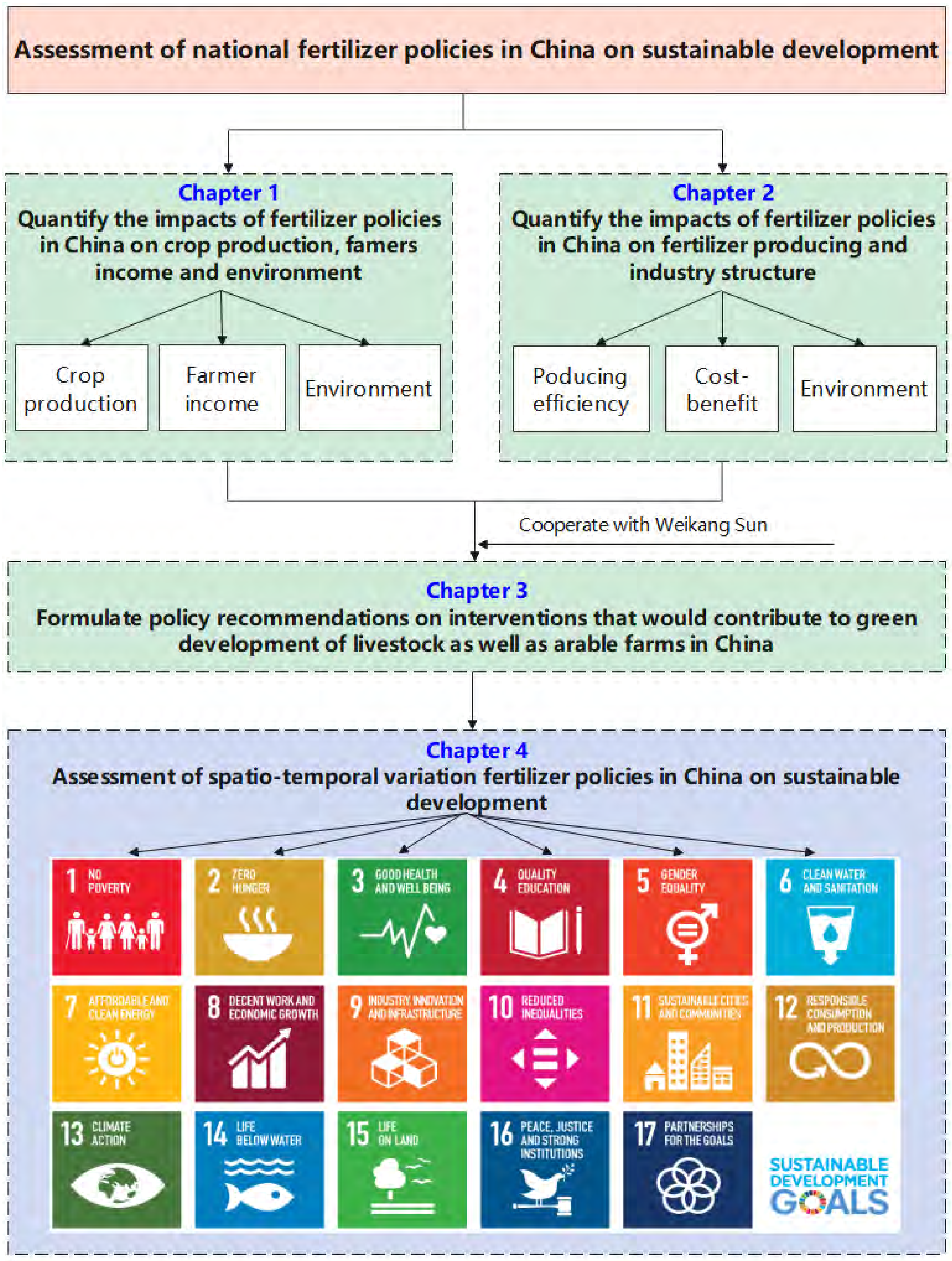


Fig. 1 Chemical fertilizer policies in China from 1949-2020

Framework



Methods

- Data collection: farm survey and statistical book
- Policy assessment: Differences-in-Differences (DID), and combined with LCA

References

National Data, (2019) National Bureau of China, 2019. https://data.stats.gov.cn/

Strokal, M. , Yang, H. , Zhang, Y. , Kroeze, C. , Li, L. , & Luan, S. , et al. (2014). Increasing eutrophication in the coastal seas of china from 1970 to 2050. Marine Pollution Bulletin, 85(1), 123-140.

Zhu, Q., Liu, X., Hao, T., Zeng, M., Shen, J., Zhang, F. & de Vries, W. (2020) Cropland acidification increases risk of yield losses and food insecurity in China. Environmental Pollution, 256, 113-145.

Acknowledgements

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Benefits of large-scale agricultural ammonia emission reduction strategies for air quality, ecosystems and human health

PhD student: Rong Cao
WUR Supervisors: Wim de Vries, Gerard Ros, Maarten Krol CAU supervisors: Wen Xu, Qichao Zhu

Background

As the main alkaline gas in the atmosphere, ammonia (NH_3) has widespread impacts on ecosystems, through enhanced nitrogen and acid deposition causing eutrophication, and on human health, by increasing particulate matter exposure. The Chinese agricultural sector emits large amounts of ammonia as a result of the large-scale application of fertilizer. The consequent high deposition and concentrations of NH_3 (can) cause damage to sensitive ecosystems and humans.

Objectives

1) Improvement of NH_3 emission totals and spatial and temporal patterns of NH_3 emissions based on bottom-up methods;
2) Assessing impacts of abatement strategies on the spatial NH_3 emission and thereby on deposition and impacts.

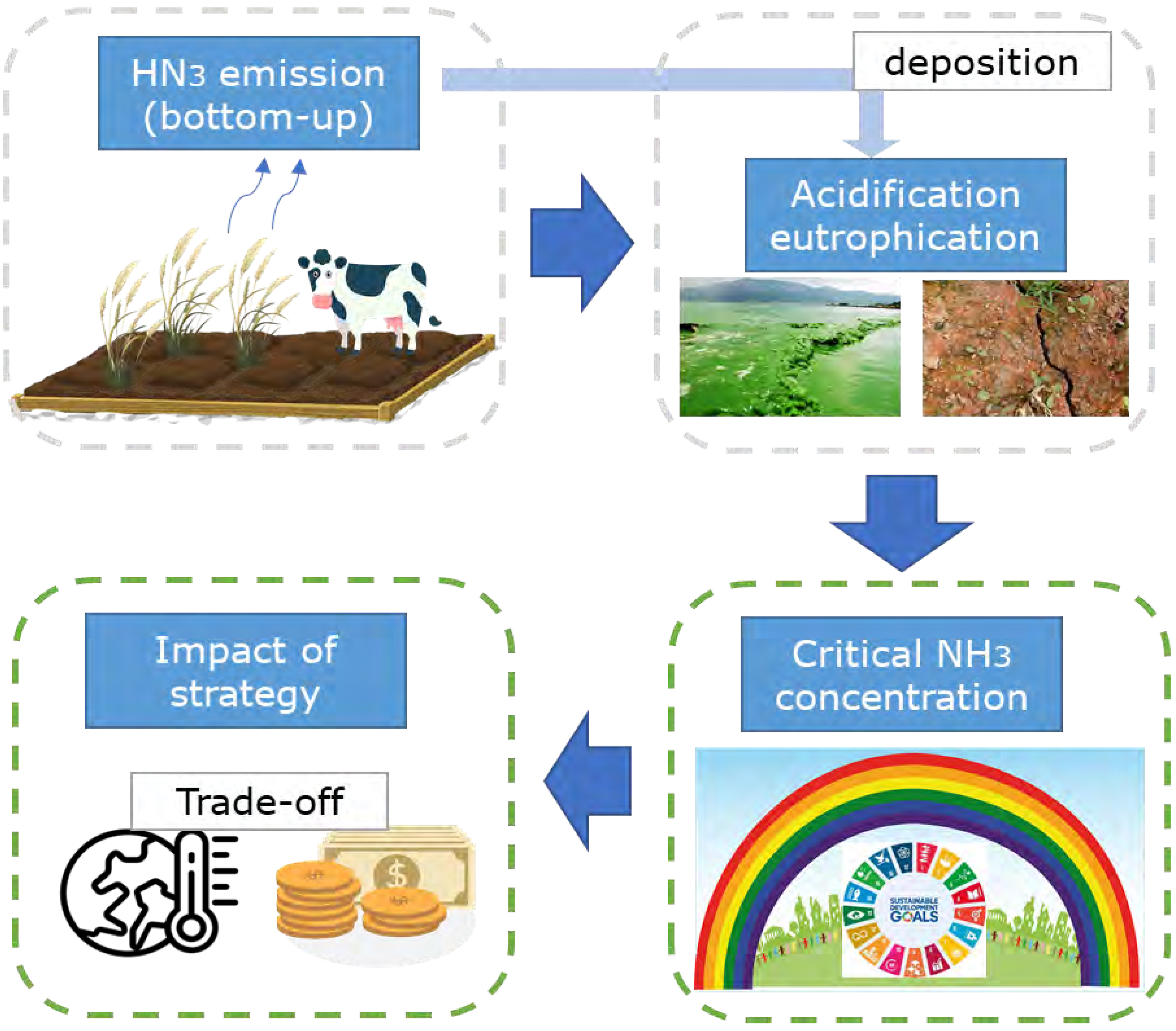

Figure 1. Research roadmap of the project

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 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?

Methods

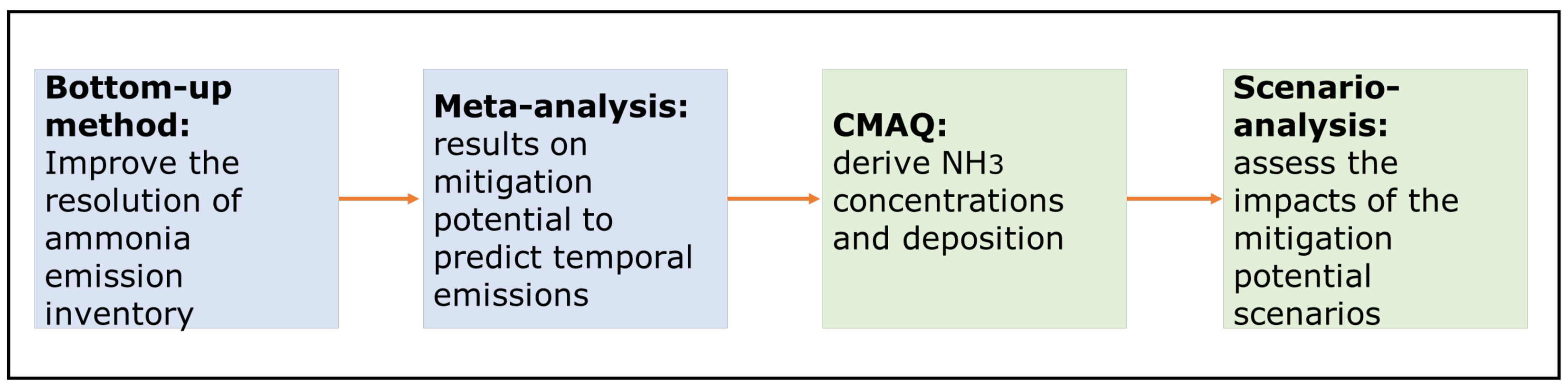

Figure 2. Connection diagram of research model

Framework

- improve NH3 emission totals and spatial pattern of NH_3 emissions using bottom-up methods.
- improve temporal patterns of NH_3 emissions considering timing of agricultural activities and environmental conditions.
- assess the spatial variation in critical nitrogen loads for terrestrial ecosystems in China.
- assess the effects of region-specific management strategies on NH_3 emission reductions.

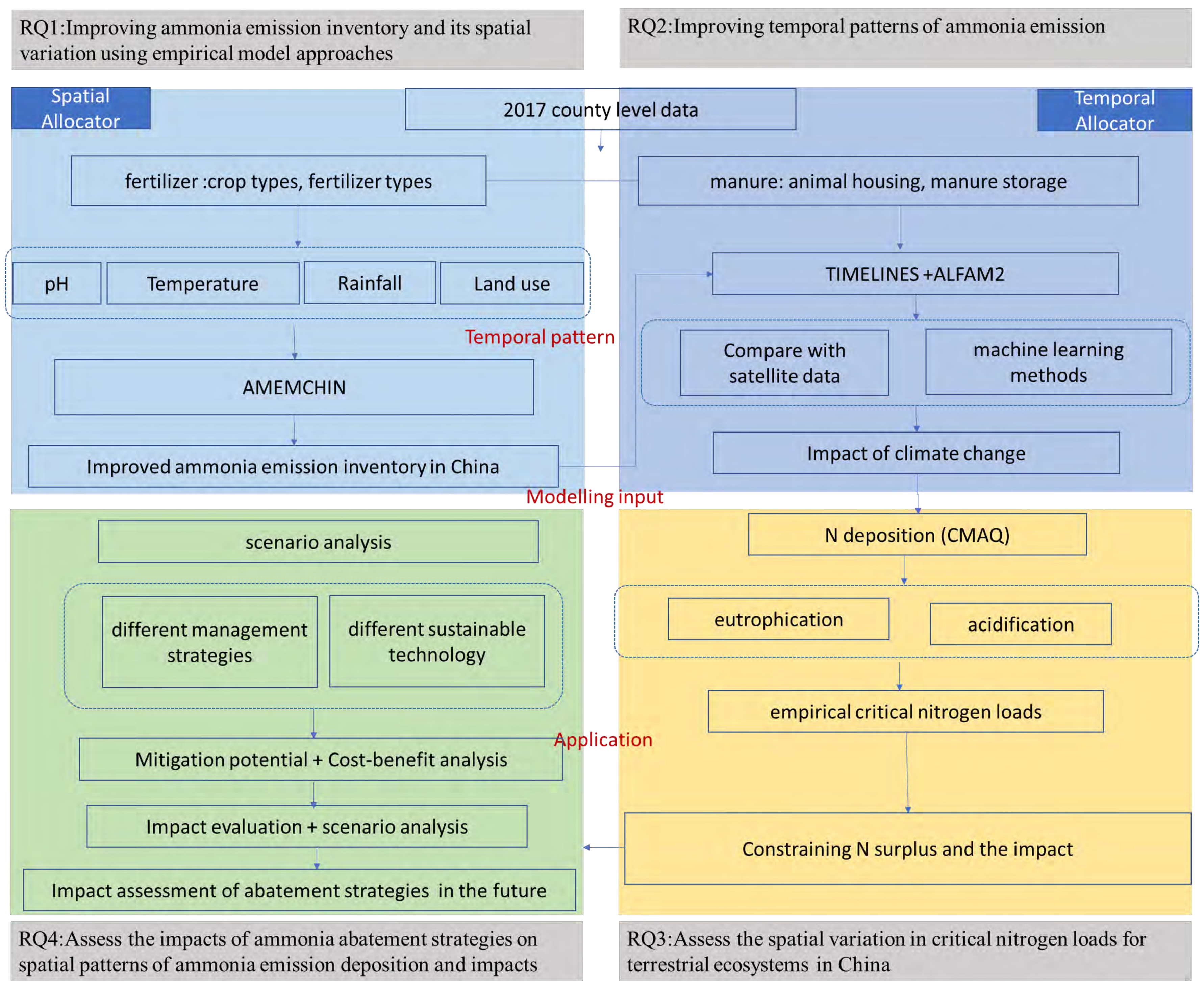

Figure 3. Details of research framework

Expect results:

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

Acknowledgements

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

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Emission characterization and mitigation strategies of ammonia derived from satellite observations with atmospheric chemistry transport modeling

PhD student: Jianan Chen
Supervisor: Wen Xu, Qichao Zhu, Wim de Vries, Gerard Ros, Maarten Krol

Background

Ammonia (NH_3), the most prevalent alkaline gas in the atmosphere, plays a significant role in $PM_{2.5}$ formation and atmospheric chemistry.

Current NH_3 emission inventories by bottom-up have great uncertainties due to the lack of accurate data on emission factors and human activity level. Recent advancement of remote sensing techniques combined with atmospheric chemical transport model has offered great opportunities for improving these inventories and our understanding of NH_3 emission.

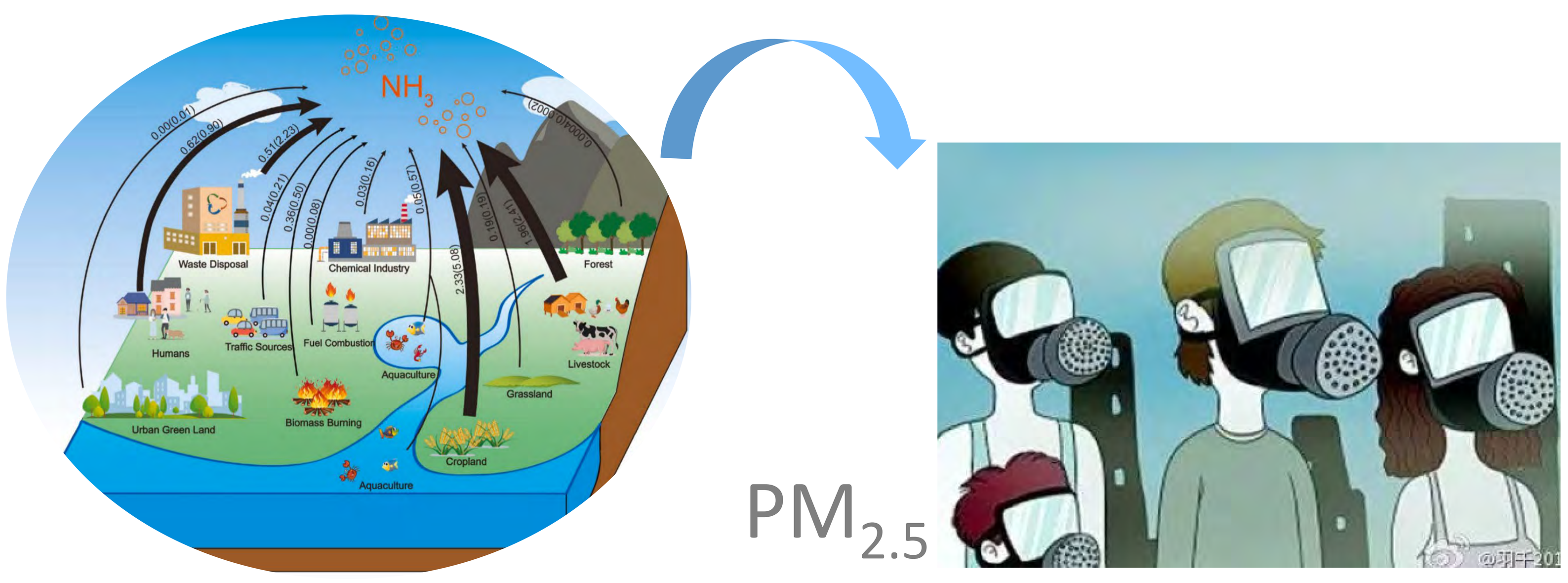

Figure 1. Ammonia emission from anthropogenic sources and negative effects.

Objectives

This project aims at

- providing improved ammonia emission inventory based on the satellite observations and model
- evaluating impacts of NH_3 emission on air quality and terrestrial ecosystem in China
- helping formulate cost-effective mitigation strategies on NH_3 and haze pollution.

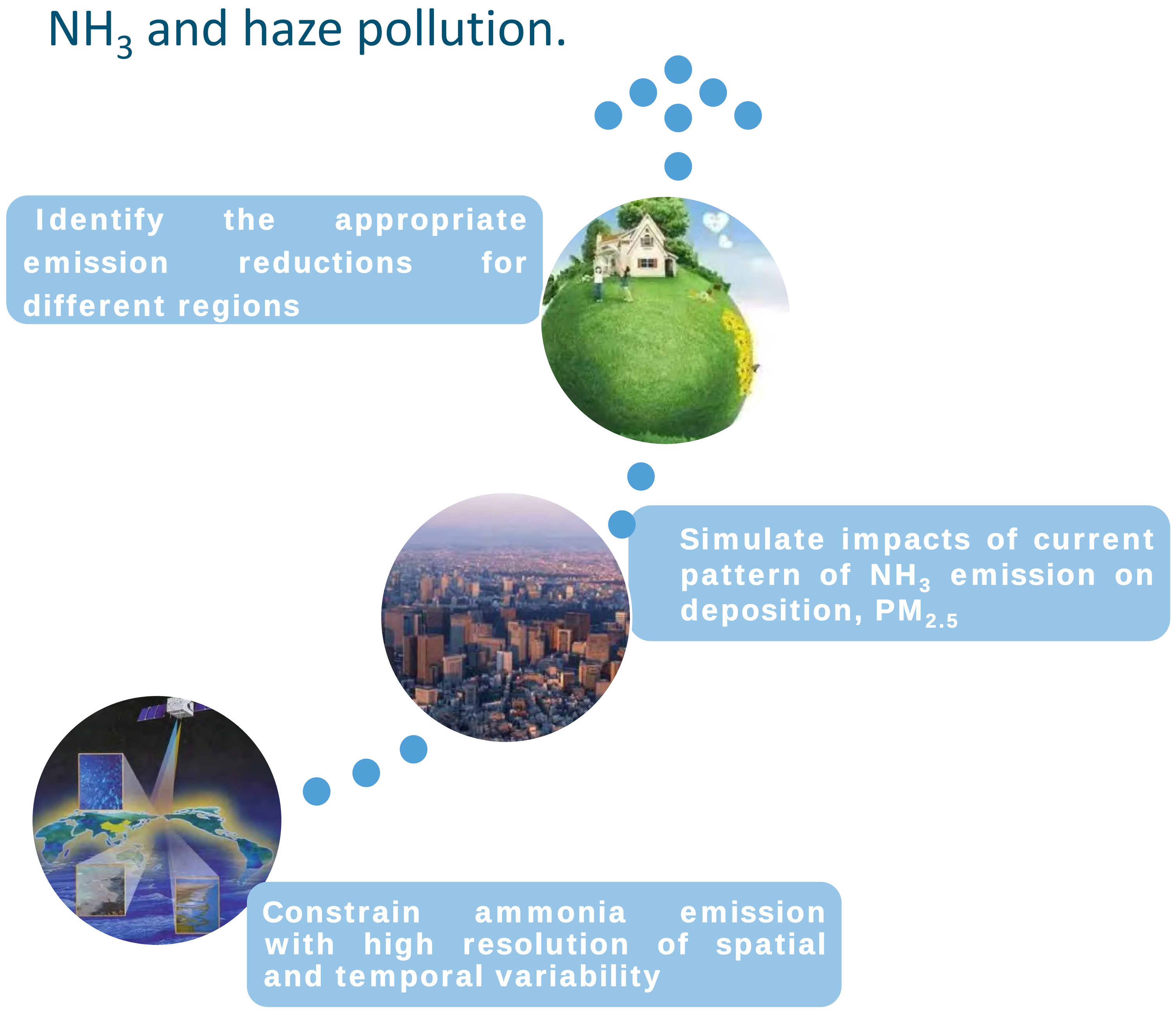

Figure 2. The diagram of research objectives

Methods

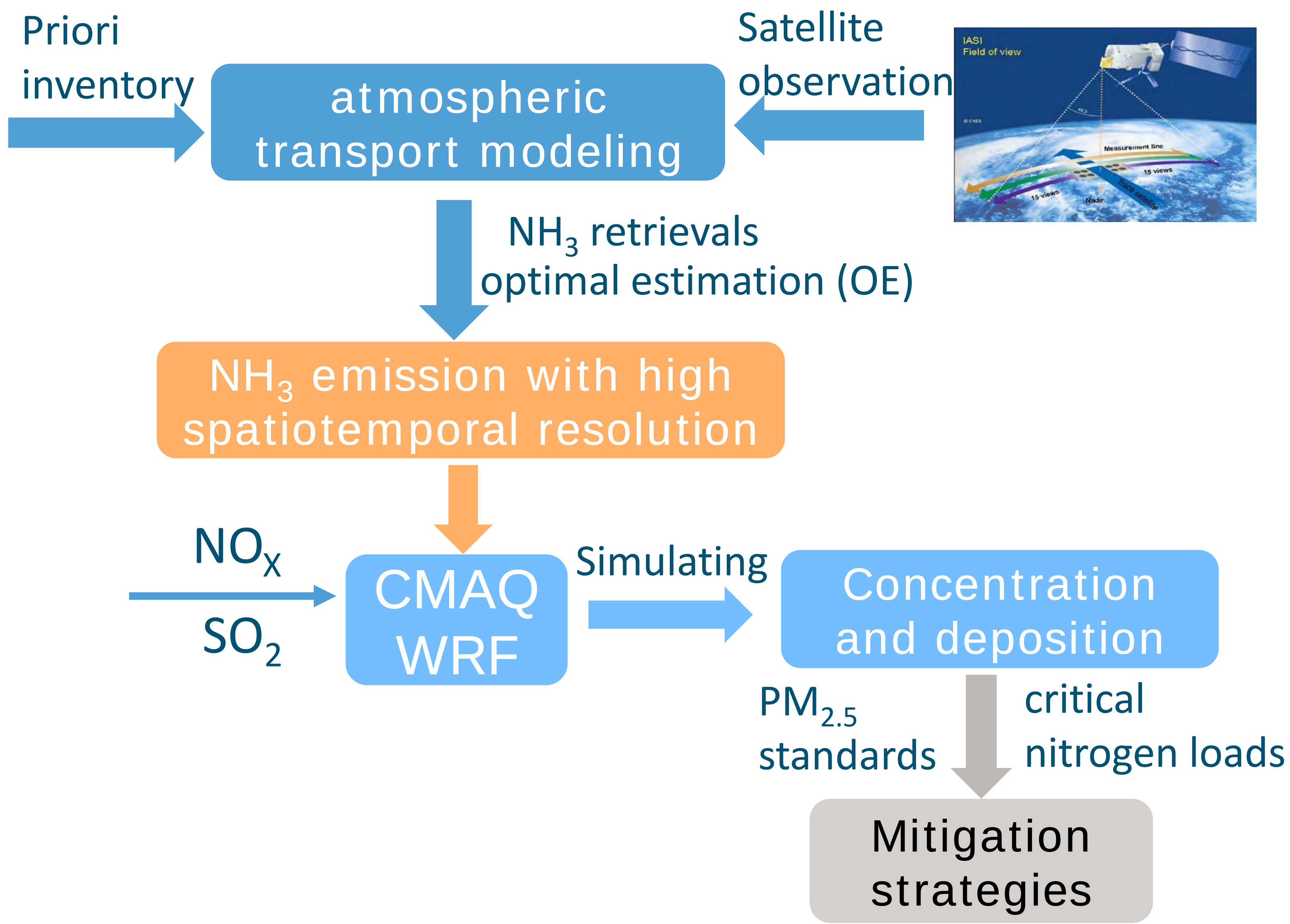

Figure 3. The framework of research methods

Results

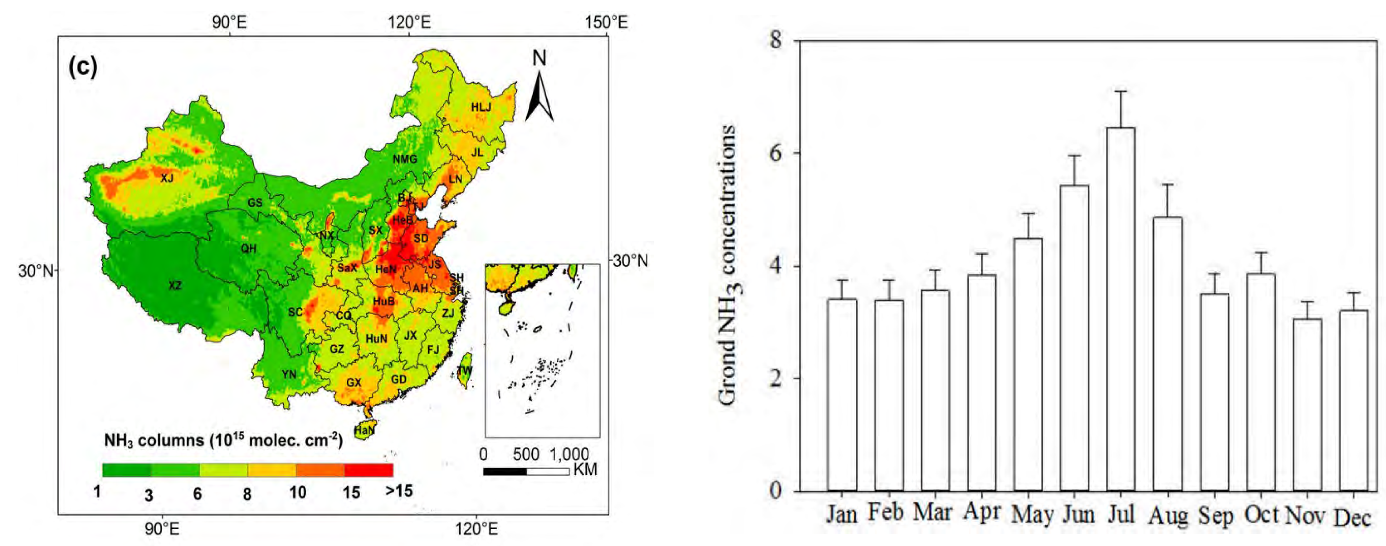

Figure 4. Spatial distribution and seasonal patterns of ground NH_3 concentrations derived from satellite

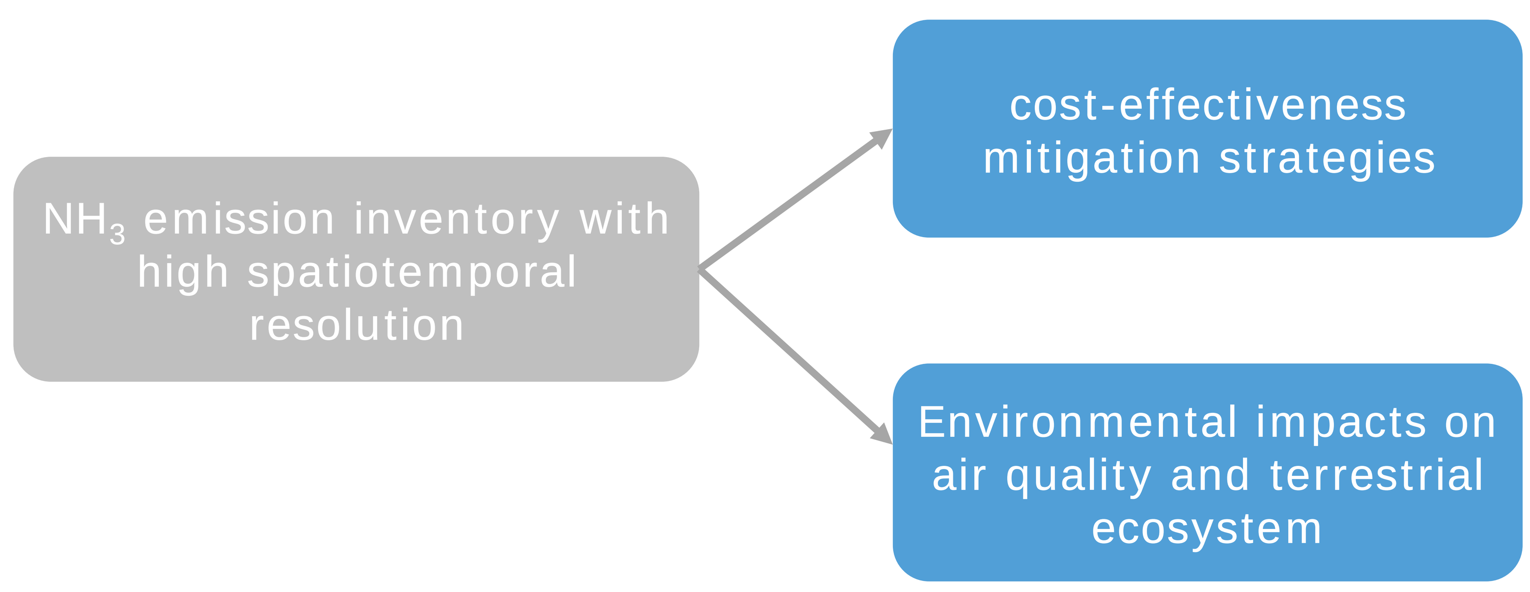

Figure 5. The expected results in this research project

Conclusions

- Satellite remote sensing of NH_3 can provide constraints towards improvement of NH_3 emission inventory
- Atmospheric modeling is an useful tool to evaluate the environmental impacts of NH_3 emissions and depositions, improving our understanding of the processes controlling atmospheric NH_3

Acknowledgements

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Quantify the off-site impacts of existing and promising agricultural measures on water quantity and quality

Presenter: Yinan Ning

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

Background

The Yangtze River Basin has the largest area and amount of soil erosion in China. The input of chemical fertilizer, pesticide and other agricultural chemicals has caused serious agricultural non-point source pollution. To prevent nitrogen, phosphorus and sediment from agricultural land entering into aquatic environments by surface runoff, appropriate tillage methods and land cover patterns have been developed and implemented. Reducing the use of chemical nitrogen fertilizers, especially NH_4^+, and protecting soil from erosion may be effective measures to improve water quality in the YRB.

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.Make an inventory of existing national and regional policies and (agricultural) SWC measures

2.Quantify the impact of these measures using the SWAT model

2a. Temporal and Spatial Variation and attribution analysis of runoff, sediment, nitrogen and phosphorus loads in the Yangtze River Basin

2b. Study the contribution of runoff, sediment, nitrogen and phosphorus loads in wet season and dry season in the Yangtze River Basin

3.Predict and simulate the migration of runoff, sediment, nitrogen and phosphorus under future climate change and policy regulation

4.Create a database of most effective measures and formulate ambitious policies regarding water quality and quantity protection

Methods

- Study area

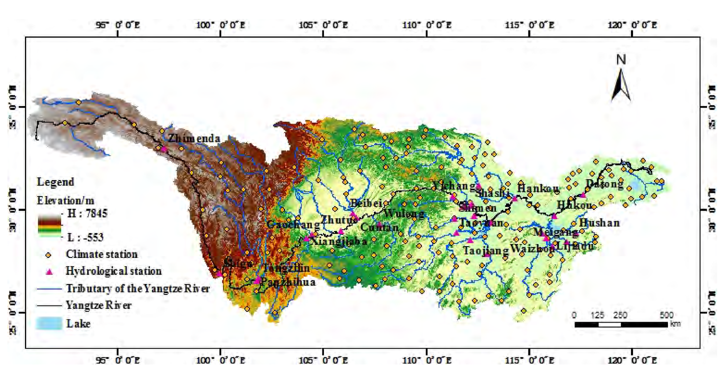

Fig. 1 DEM, climate and hydrological stations, river network of Yangtze River Basin

- The non-parametric Mann-Kendall (MK) in the study is used to analyze the trends and mutational site in hydro-climatic variables, such as precipitation, runoff, sediment, etc.
- GeoDetector assume that if an independent variable has an important influence on a dependent variable, the spatial distribution of the independent variable and the dependent variable should be similar(Fig.2).

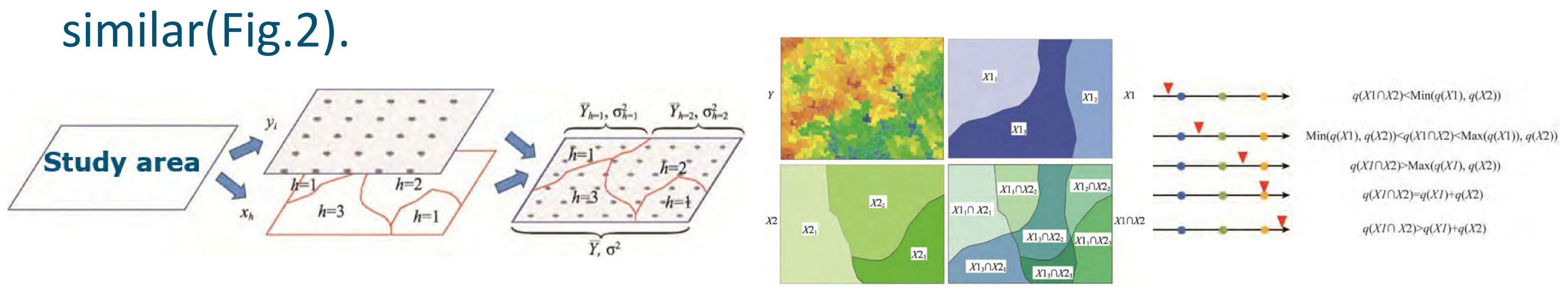

Fig. 2 The principle of GeoDetector

- The Soil and Water Assessment Tool (SWAT) is a widely used model which can explicitly simulate the impacts of measures on soil, water, vegetation and nutrient (N and P) processes, and calculate runoff and exports of nutrients to groundwater and the river network (Fig. 3).

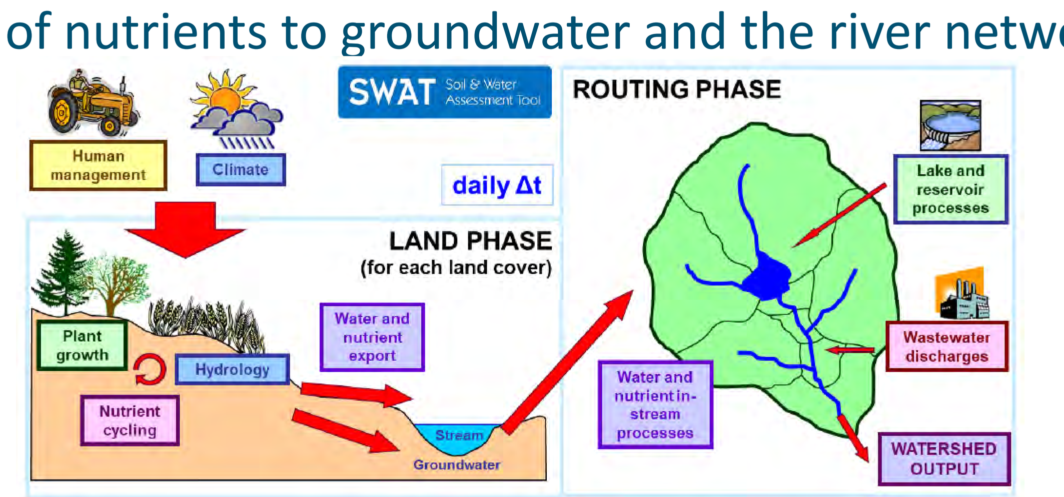

Fig. 3 Schematic overview of processes in the SWAT model

Results

- Temporal and Spatial Variation of runoff and sediment discharge

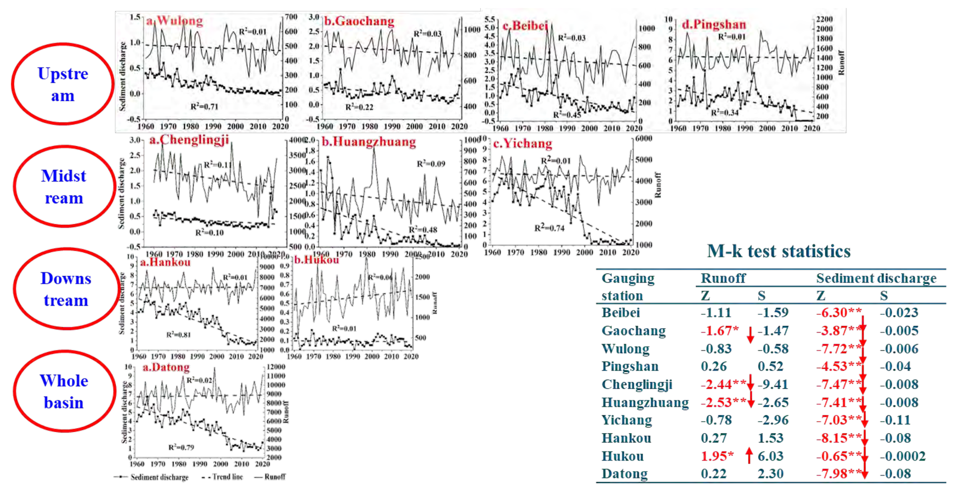

Fig. 4 M-K trend analysis in the YRB

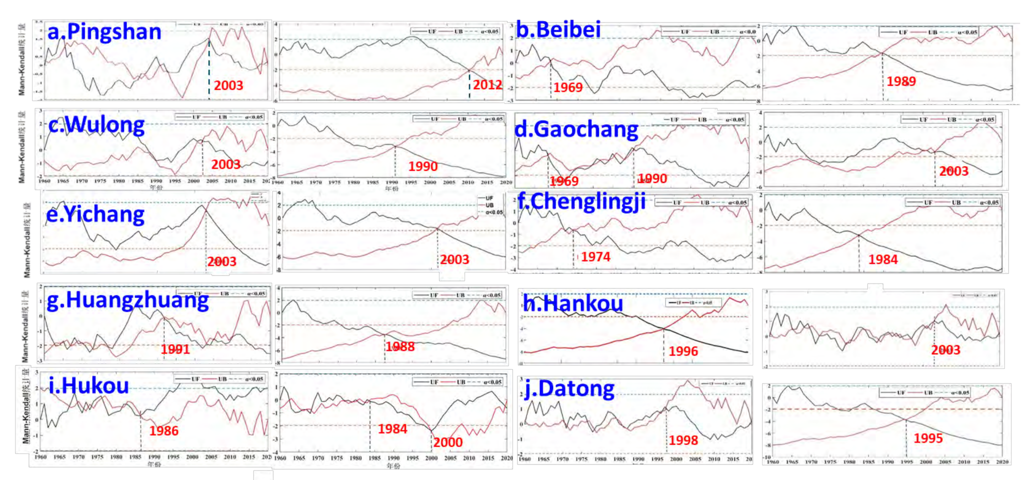

Fig. 5 Abrupt analysis in the YRB

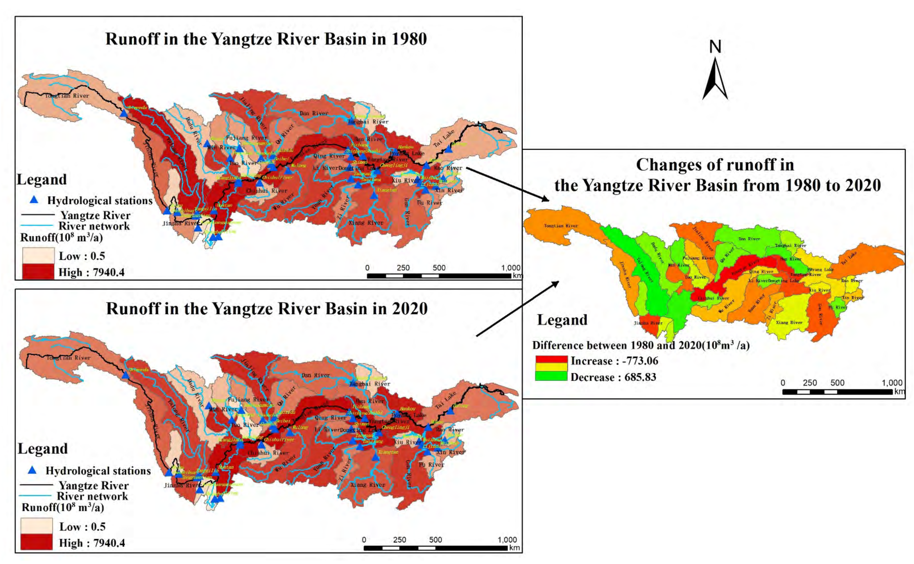

Fig. 6 The change of runoff between 1980 and 2020 in the YRB

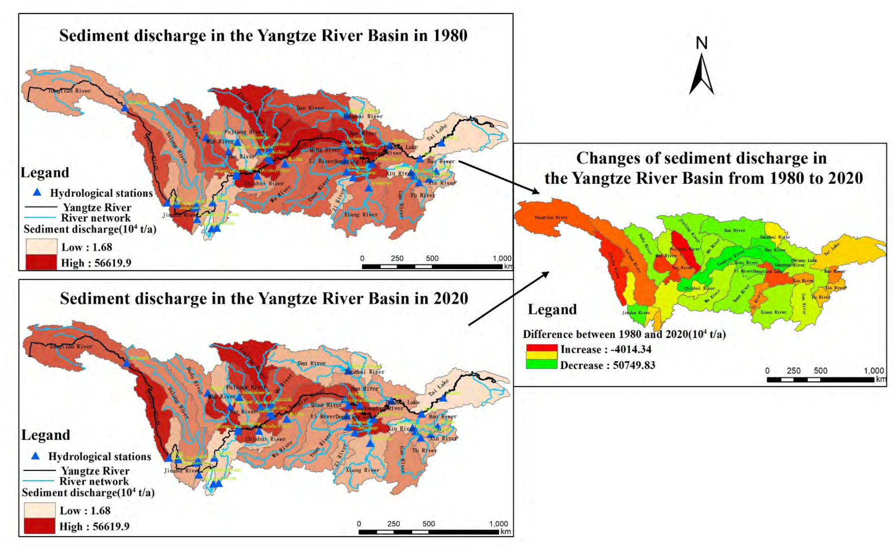

Fig. 7 The change of sediment discharge between 1980 and 2020 in the YRB

- Attribution analysis of runoff and sediment discharge

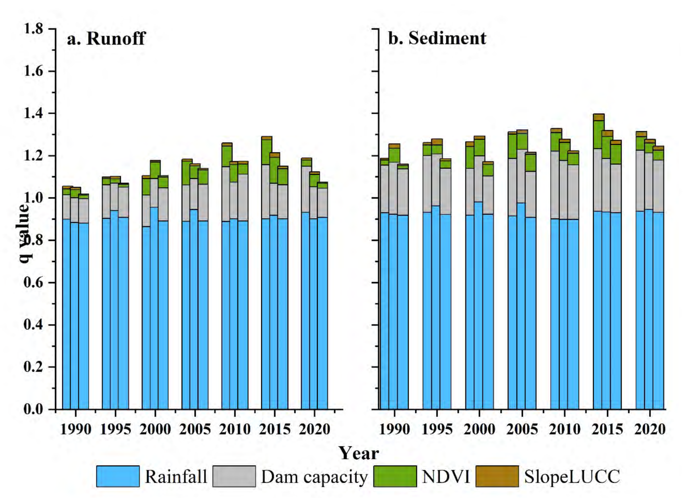

Fig. 8 Contribution of single factor to the variation of runoff and sediment discharge in the YRB

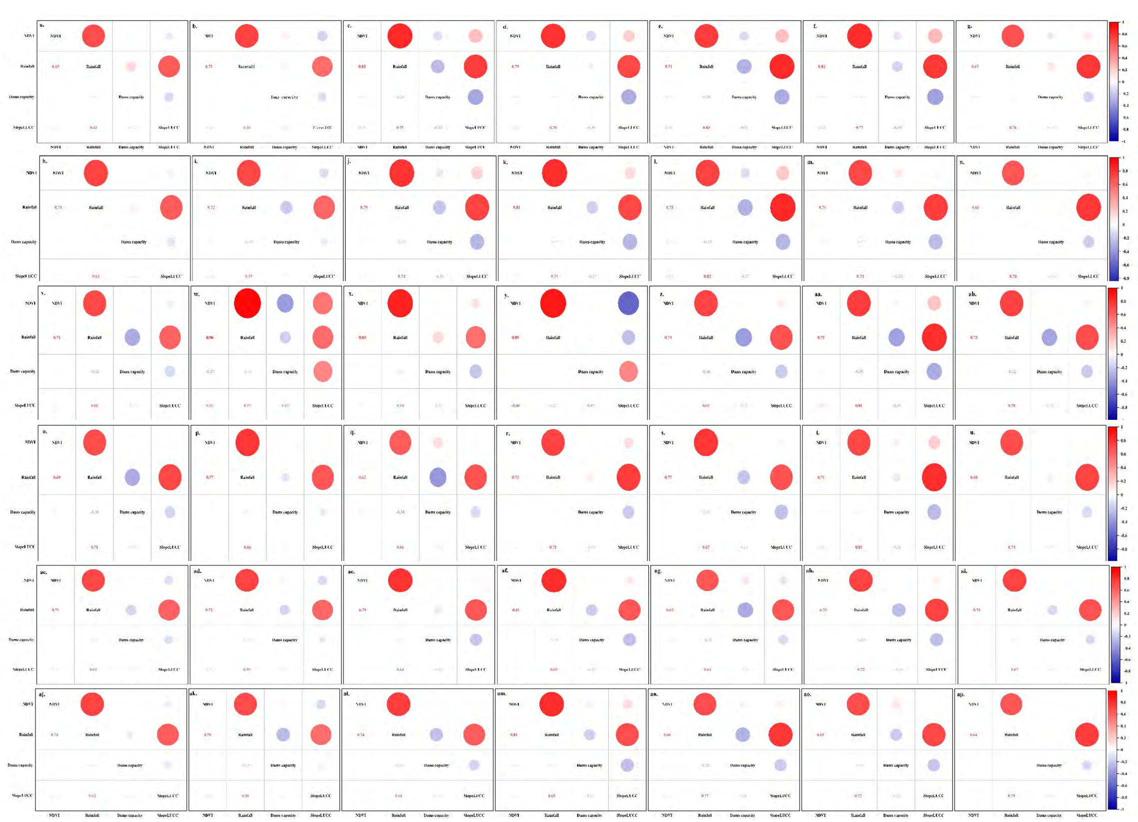

Fig. 9 Contribution of factors interaction to the variation of runoff and sediment discharge in the YRB

Conclusions

- The suspended sediment in the Yangtze River Basin mostly comes from the upper reaches of the river.
- From 1980 to 2020, sediment discharge of all hydrological stations decreased significantly while the variation of runoff did not change significantly. Until 2020, the high-value area of sediment discharge still be located in the upper reaches of the YRB.
- For the variation of runoff and sediment discharge in the YRB, the contribution of each factor is different at different times, but rainfall is always dominant, followed by dams capacity that reached the maximum value in 2010. The contribution of dams capacity to sediment discharge are bigger than that for runoff.
- The interaction values of dams capacity and rainfall and slopelucc and rainfall are large, and these two interactions contributed the most to the change of runoff and sediment discharge no matter in the upstream or middle and downstream.

Acknowledgements

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

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Quantify the on-site impacts of existing and promising agricultural measures on land degradation and soil quality

Author : Jichen Zhou

Supervisor: Lihua Ma, Jantiene E. M. Baartman, Joao Carvalho Nunes, Xinping Chen, Xuejun Liu

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.

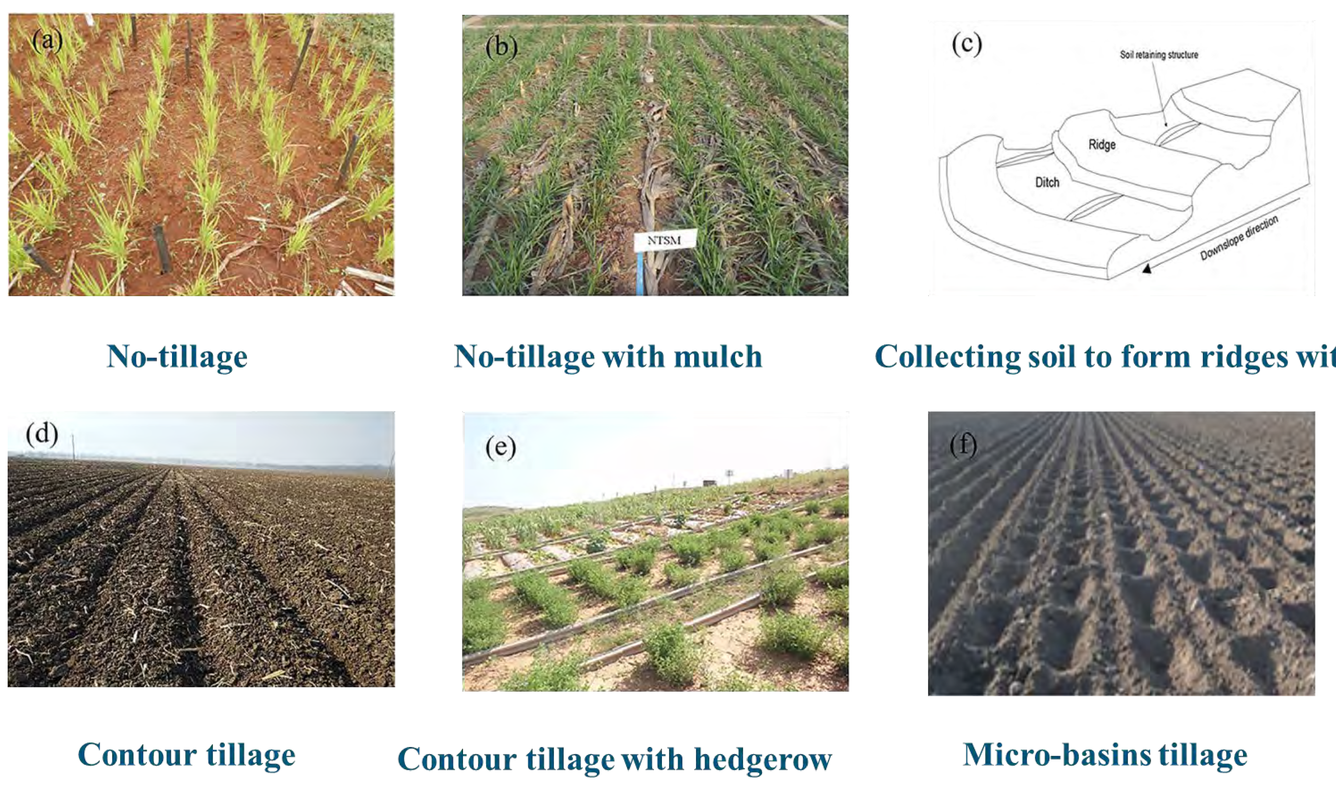

Fig. 1 Existing agricultural soil and water conservation measures in the YRB

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

Methods

We conducted a meta analysis to evaluate the efficiency of different SWCMs and identify optimal conservation practices in the YRB. Papers published were collected from the China National Knowledge Infrastructure, the Web of Science and Science Direct. The final database comprised a total of 243 runoff and 264 sediment data entries at 43 sites.

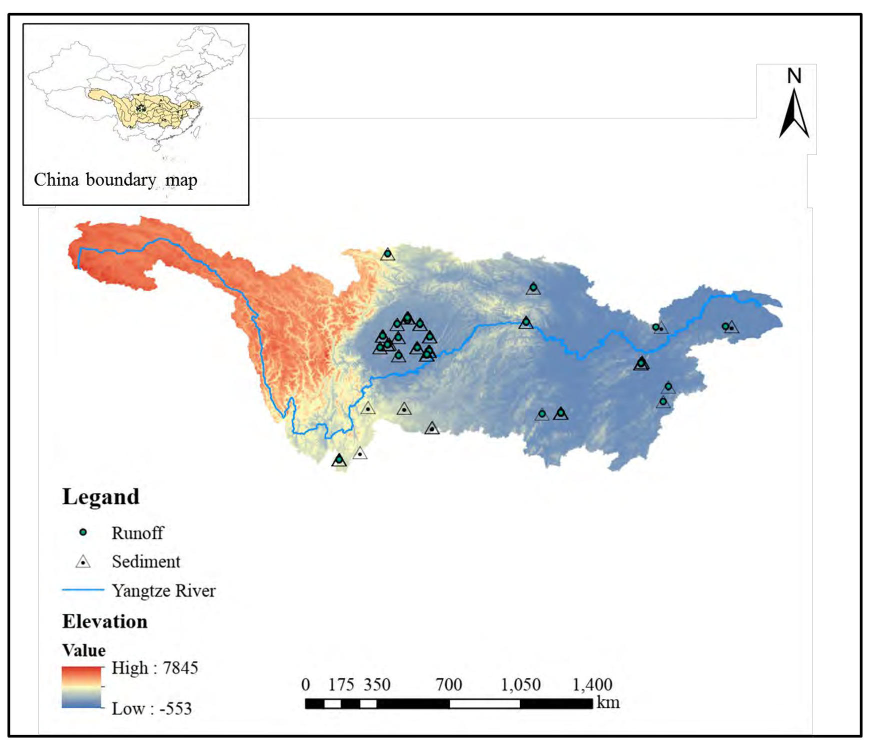

Fig. 2 Site distribution of field plots in the YRB

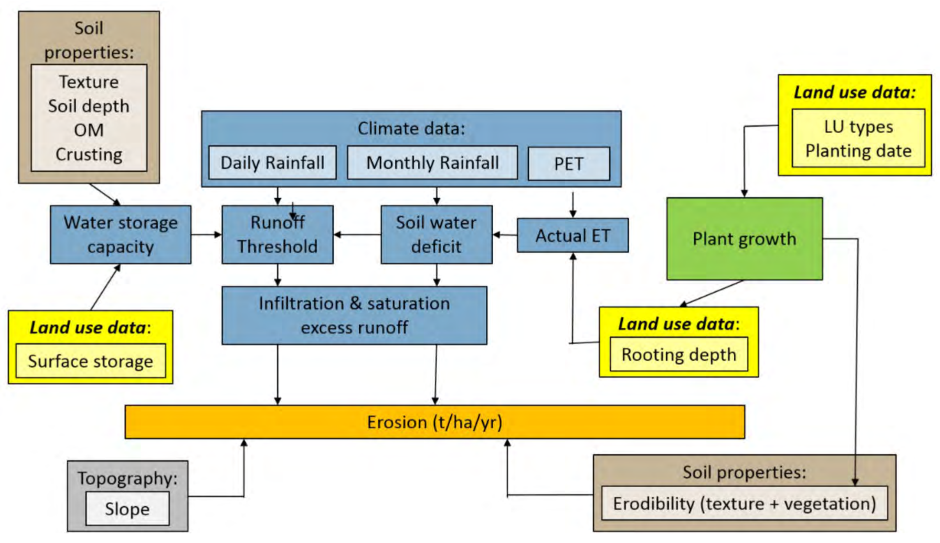

Fig. 3 Schematic overview of processes in the PESERA model

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.

Preliminary results

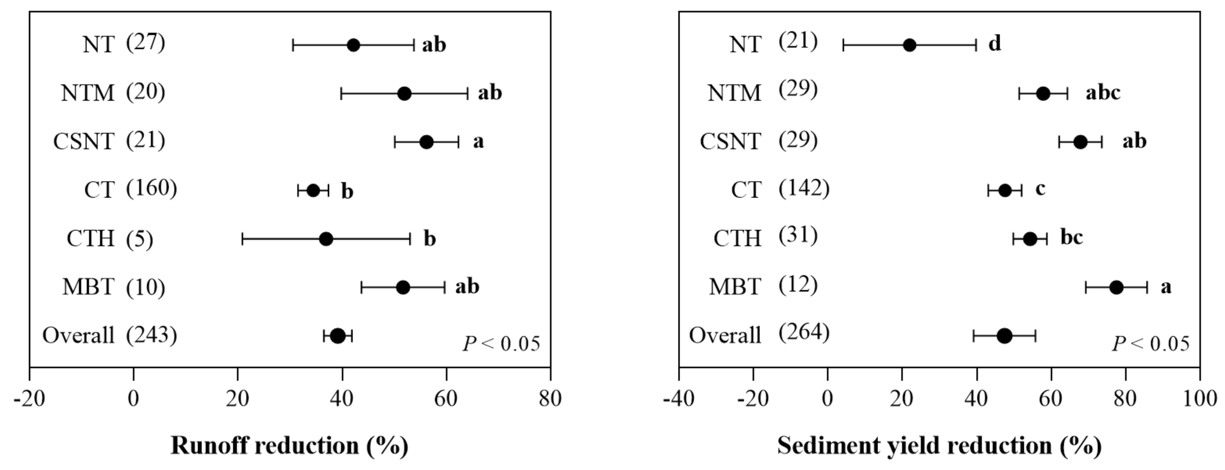

Fig. 4 The overall effectiveness of agricultural SWCMs in reducing runoff and sediment yield in YRB

Soil and water conservation measures reduced runoff by 39.2% and 38.7% compared with conventional tillage, respectively. Collecting soil to form ridges with no-tillage demonstrated significantly greater runoff reductions (51.7%) than the other three practices. Micro-basins tillage reduced sediment yield more effectively (77.5%) than the other practices.

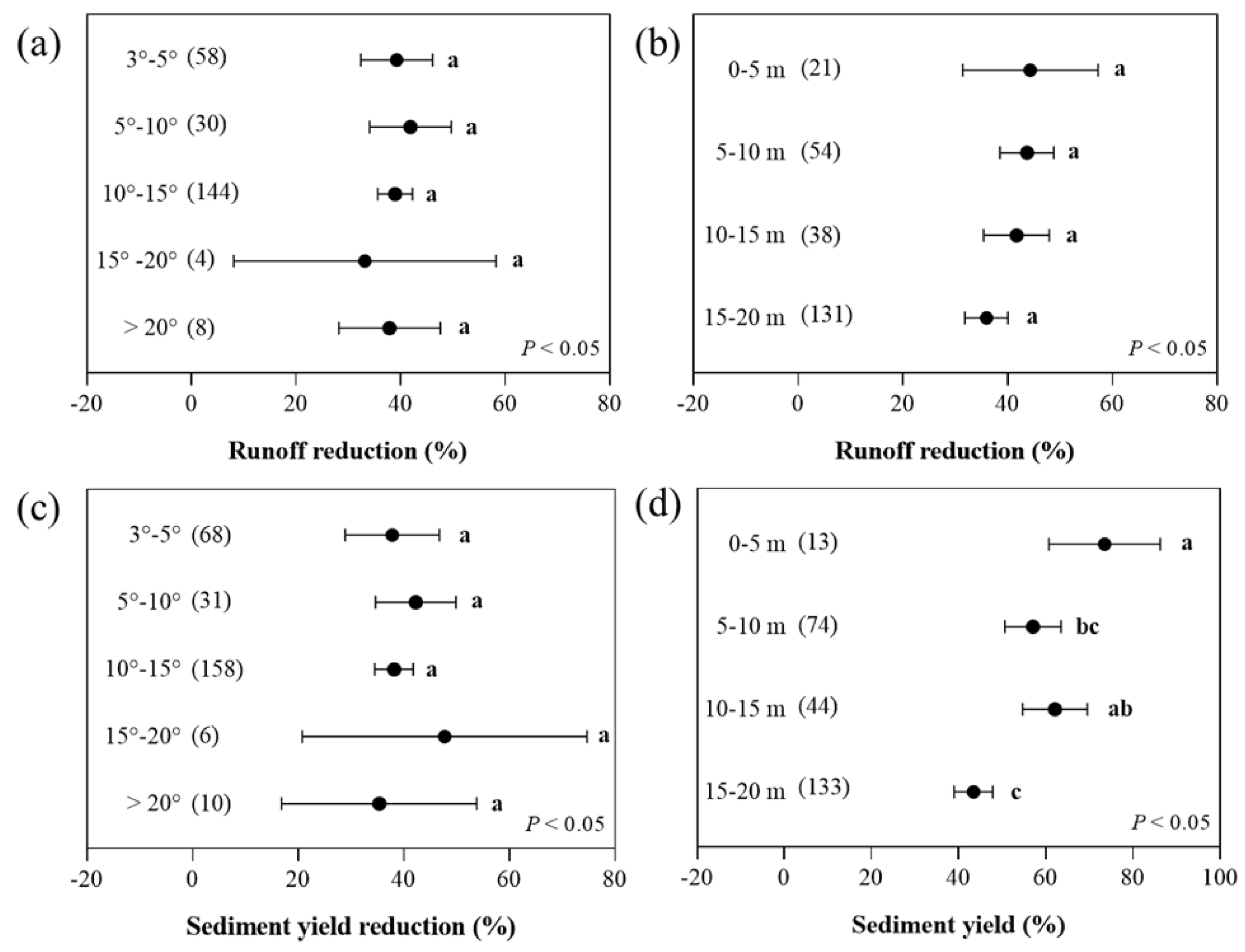

Fig. 5 Runoff reduction by SWCMs under different slope gradient and slope length

No significant difference are found in the efficiency of SWCM in runoff and sediment reduction yield between different gradient. At different slope lengths, the effect of SWCMs on runoff reduction is about 40%, and the effect of SWCMs on sediment reduction at 0-5m slope lengths is significantly higher than that of other slope lengths (73.54%).

Acknowledgements

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

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Sustainable management of antibiotics, pathogen and antimicrobial resistance for green eco-environment: A systematic modelling approach

PhD candidate: Songtao Mei
CAU supervisor: Kai Wang
WUR supervisor: Nynke Hofstra, Carolien Kroeze

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 surface waters 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.

Reserach objective

The objective of this research is to help design intervention policies and technologies for a sustainable management of antibiotics, pathogen and antimicrobial resistance in China through a modelling approach.

Research content

RQ1: What are the current concentrations of antibiotics and pathogen in surface waters in China?

- **Antibiotics model:** Antibiotic models from two ongoing PhD students (Qi Zhang from AGD project and Shiyang Li) will be modified to answer this research question. The antibiotic model will simulate the load from humans and animals and the concentration of antibiotics in surface waters in China.
- **Pathogen model:** The Global Waterborne Pathogen model will be adapted for *Escherichia coli (E. coli)*, to simulate its concentration in surface waters in China. Figure 1 shows the flow chart of the *E. coli* model.

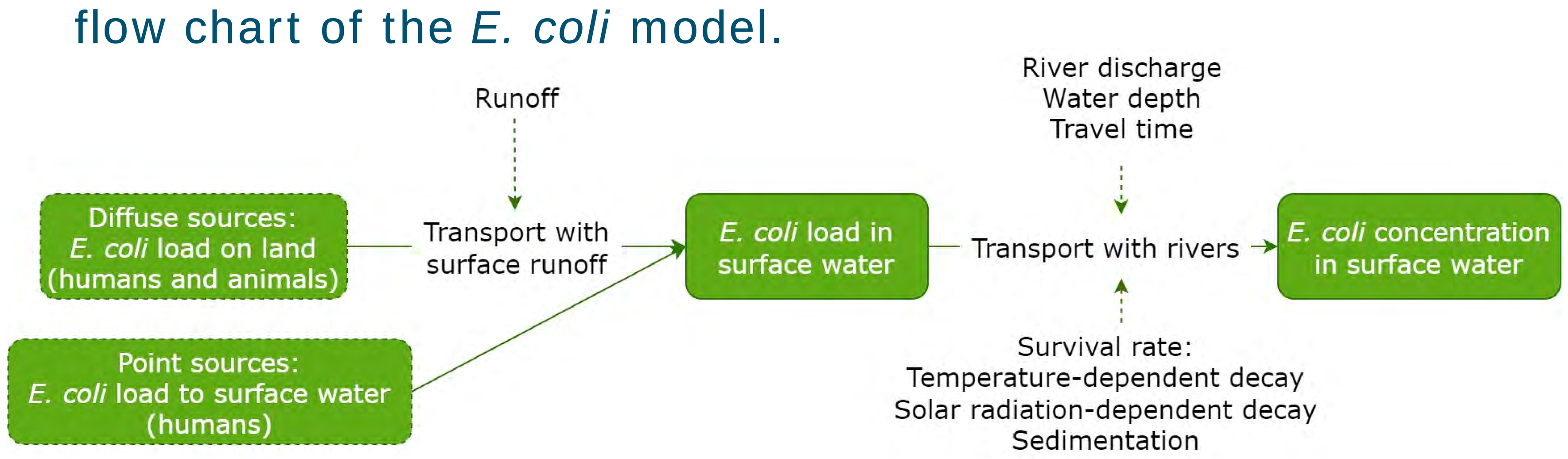

Figure 1 Flow chart of the pathogen model

RQ2: How to simulate concentrations of antimicrobial resistant bacteria (ARB) in surface waters in China by modelling?

- **ARB model:** Based on the models from RQ1, a model of antimicrobial resistant *E. coli* will be developed. Figure 2 shows the flow chart of the ARB model.

RQ3: What is the current situation of environmental and human health risks related to antibiotics, pathogen and antimicrobial resistance in surface waters in China?

- **Antibiotics:** Concentrations of antibiotics will be compared to the tolerable daily intake of aquatic ecosystems and humans.
- **Pathogen:** Quantitative microbial risk assessment will be applied for pathogenic *E. coli*.
- **ARB:** Human exposure to ARB through drinking water in China will be evaluated using the ARB concentration from RQ2.

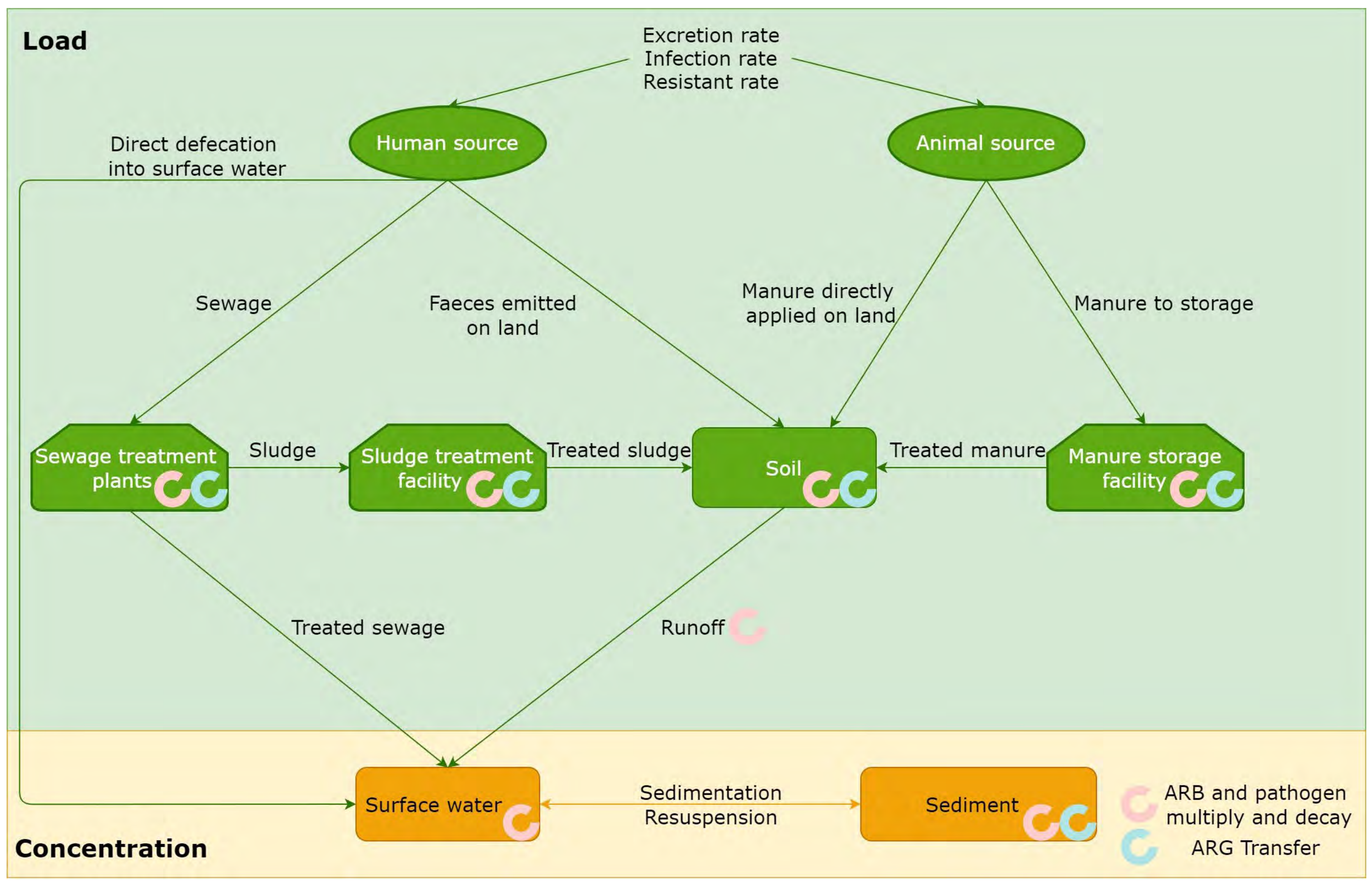

Figure 2 Flow chart of the ARB model

RQ4: What potential intervention policies and technologies can be designed to reduce the environmental and human health risks of antibiotics, pathogen and antimicrobial resistance in China?

- **Policy and technology**: Targeted policies and technologies will be formulated considering the model outputs and the current economic and social development conditions in China.
- **Scenario analysis:** Scenario analysis will be conducted to evaluate the effectiveness of these interventions.

Research framework

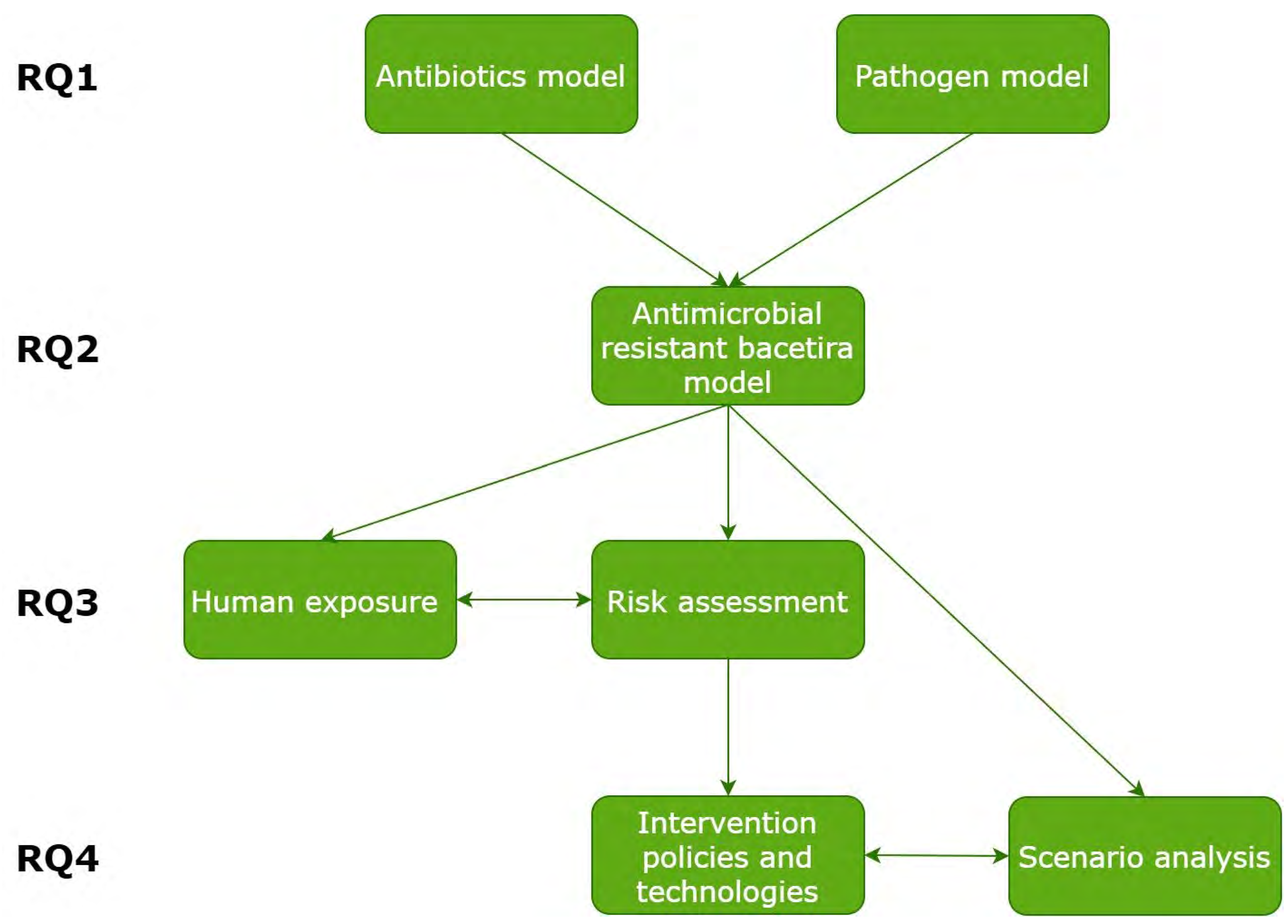

Figure 3 Research framework of the PhD project

Acknowledgements

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From white to green: sustainable management of agricultural mulch films and derived microplastics for green eco-environment

Hanyue Zhang, Coen Ritsema, Violette Geissen, Xiaomei Yang, Xuejun Liu, Kai Wang

Background

To improve crop yields, agricultural mulch films (AMF) have been applied in China since 1978 and the amount of AMF used in Chinese farmland has reached 1.38 million tons in 2019. However, due to inadequate management, the residual plastic film is buried into the farmland and even degraded into microplastics (MPs). MPs are usually defined as tiny ubiquitous plastic particles with diameter less than 5 mm. The presence of excessive microplastics in the soil can damage the soil structure, be absorbed by plant roots as well ingested by animals. Worse still, MPs could threaten human health by polluted food.

Main Research Question

The main research question is:

What strategy of plastic film mulching can be used to mitigate microplastics pollution in farmlands of the North China Plain?

Study sites

The NCP is selected as the key research region for this study. It is one of the most important food production regions in China with nearly 30% of Chinese food production. The NCP faces serious plastic film residue, for instance, the average amount of plastic film residue vegetable fields and crop fields of the NCP 7.369kg/ha and 2.822 kg/ha, respectively.

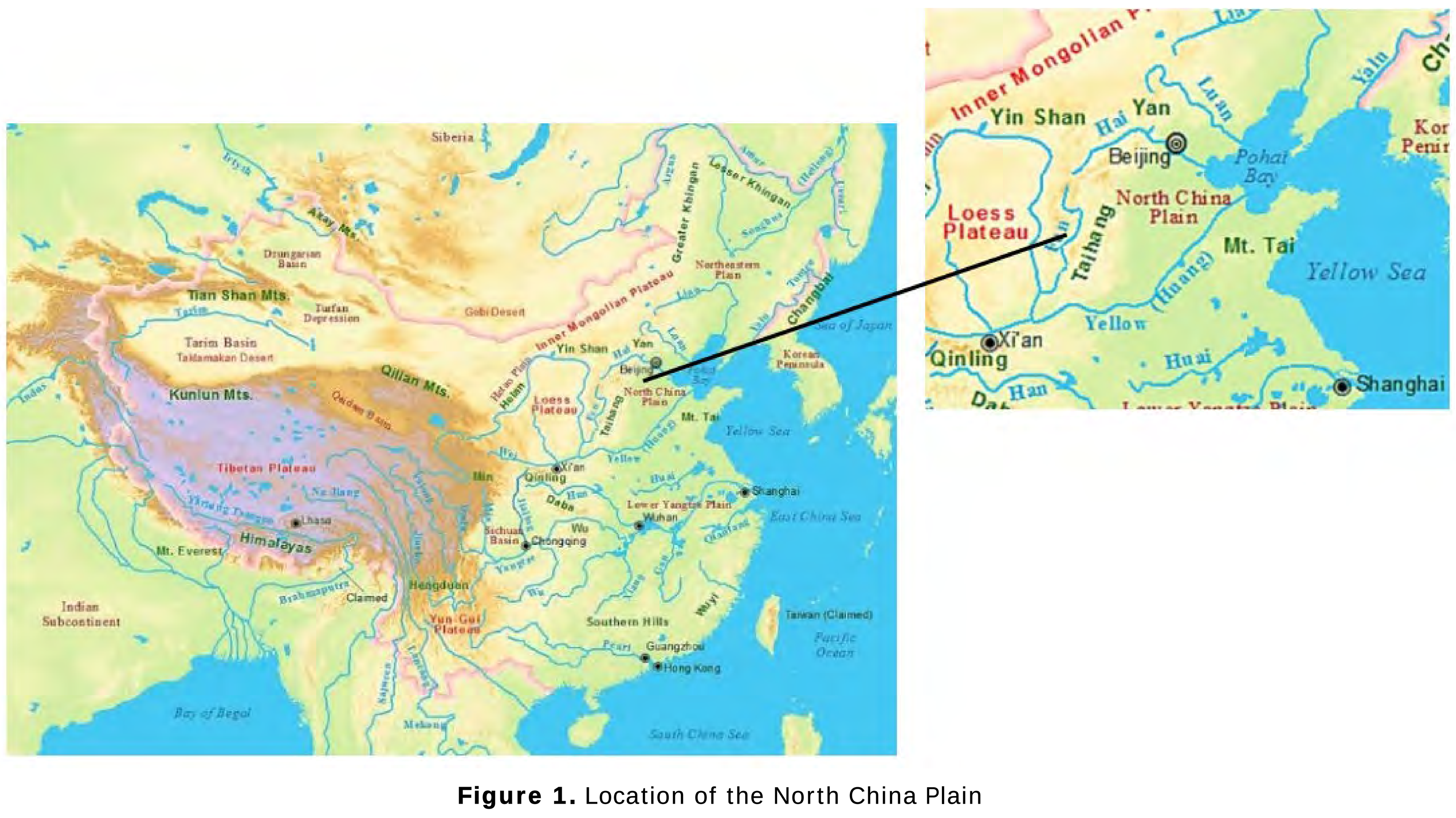

Figure 1. Location of the North China Plain

Sub research questions & Research content

RQ1: What is the current strategy of plastic film mulching and the status of microplastic pollution in farmland in the North China Plain, especially in Quzhou county?

- Collect the current plan of AMF application as well as the status of MPs pollution in farmland in the NCP.
- Quantify the MPs collected in the soil samples from different cropping systems in Quzhou county. The field vegetables and cottons are selected in this project.

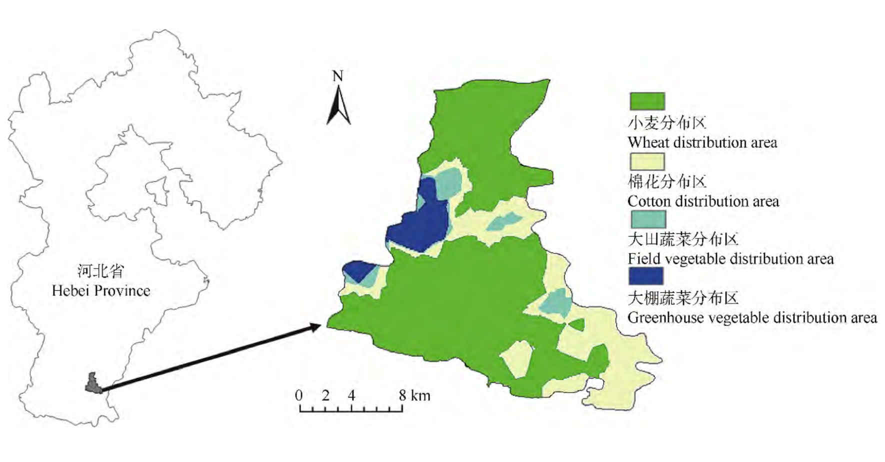

Figure 2. Location of the study area, Quzhou county. The gray and light blue represent cotton distribution area and field vegetable distribution area, respectively.

RQ2: What are the factors driving the release of MPs from AMF?

- Quantify the emission factors of MPs, i.e., photooxidation, mechanical abrasion and thermal-oxidation by lab experiments.
- Validate the emission factors by field experiment with AMF application in Quzhou county.

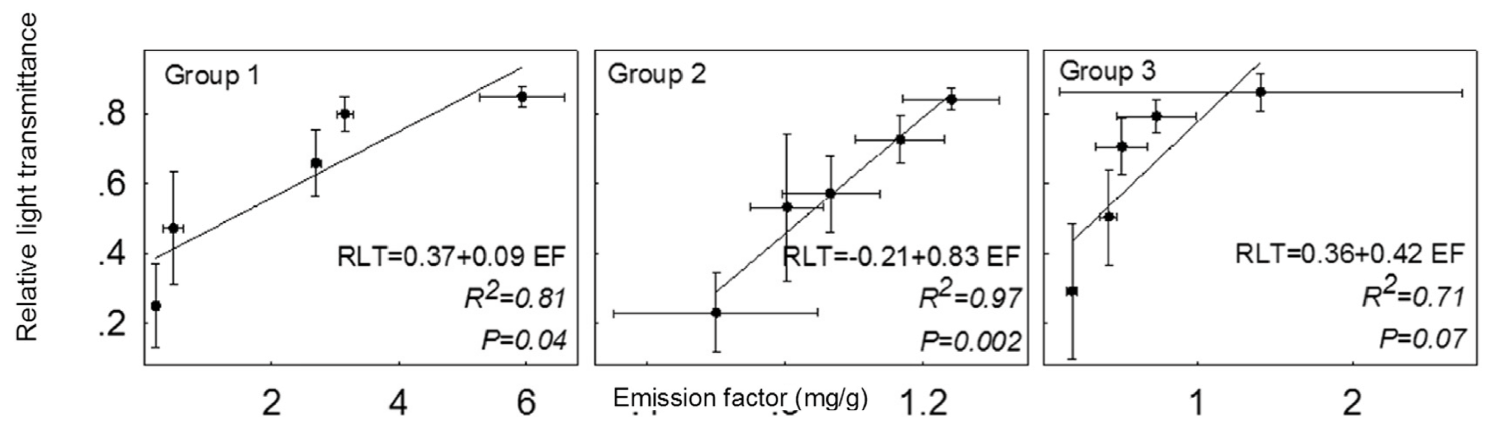

Figure 3. An example of emission factors of mechanical abrasion. The experimental material is polyethylene (PE). Relative light transmittance can be roughly quantified MMPs. Different groups refer to various mechanical abrasion.

RQ3: What is the fate of MPs in the soil environment of the NCP?

- Literature review: initial MPs-colloid transport model in soil systems
- Calibration: conduct MPs transport experiment with soil column, considering the influence of shape and size of MPs
- Validation: field experiment of MPs in farmland in Quzhou county

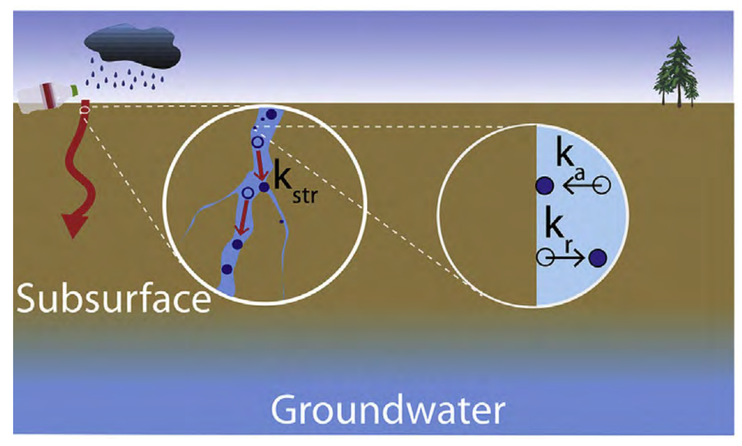

Figure 4. Modelling framework for emission potential of MPs through the soil. Ka and Kr are the rate of attachment and detachment of MPs on the soil surface, respectively.

RQ4: How to mitigate MPs pollution from the strategy of agricultural mulch film application?

- Evaluate current MMPs pollution in the NCP.
- To mitigate MMPs pollution, evaluate the performance of potentially political and technological interventions in the NCP from the perspective of AMF application using a scenario analysis.

Framework

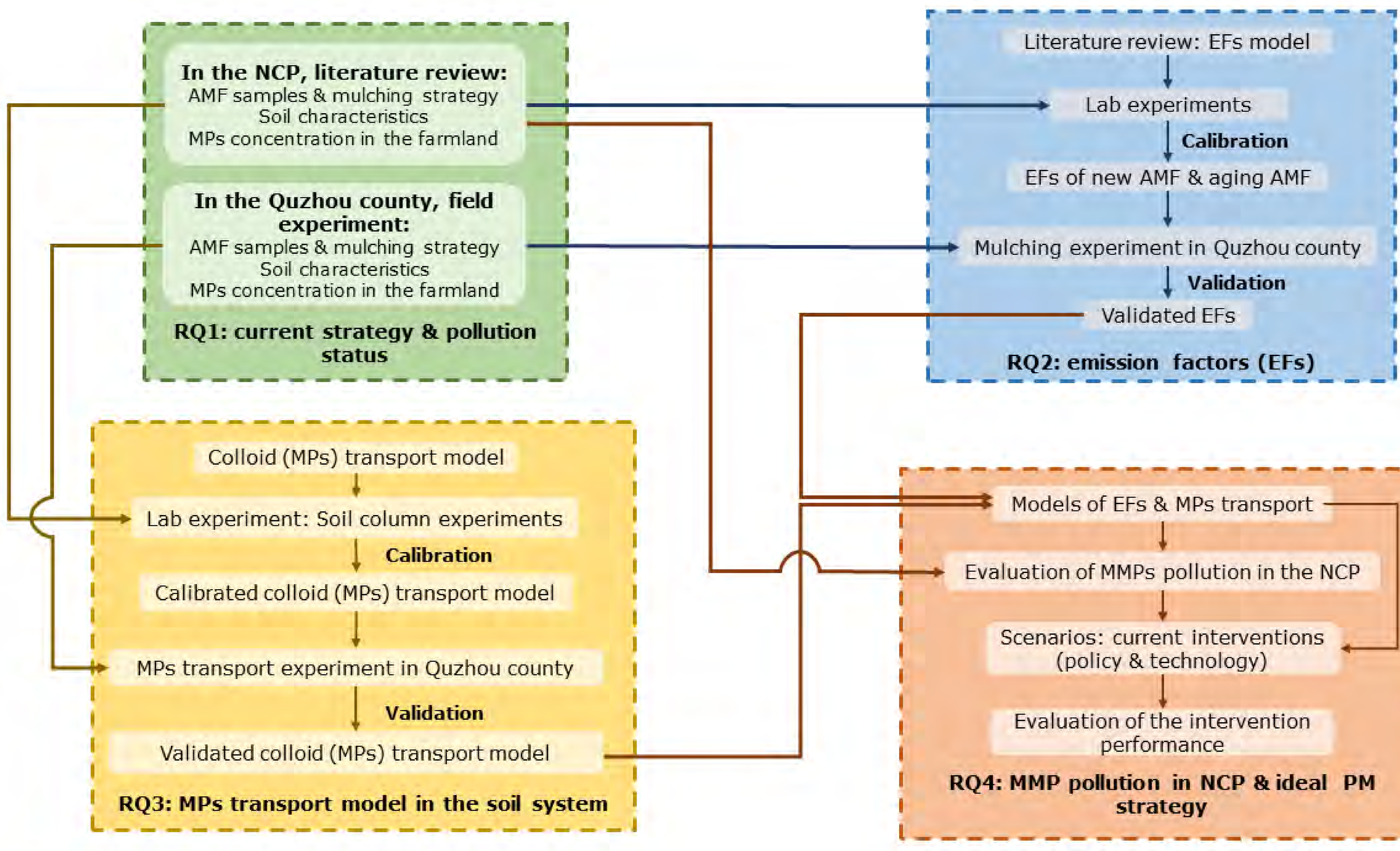

Figure 5. The concrete framework of this project. A dotted box represents a sub research question. The arrows point from data source to destination.

Acknowledgements

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

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Sustainable management of pesticides for green eco-environment: A systematic modelling approach

Mingyu Zhao, Kai Wang, Daniel Figueiredo, Xiaomei Yang, Coen Ritsema, Violette Giessen

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 field work. Model approach has become increasingly popular in environmental monitoring method 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. In order to quantify the flow of pesticides and assess their adverse impacts, a systematic modelling approach for the sustainable management of pesticides needs to be developed.

Research questions

- What is the current atmospheric pesticides pollution in Quzhou county, the NCP?
- How do the pesticides transport from soil to atmosphere in the NCP?
- How is pesticide exposure related to human health in the NCP?
- What potential targeted policies can be designed to reduce the input of pesticides into the agricultural system in China?

Field experimental site

Air, dust and soil samples will be collected to understand the spatial variations of pesticide residues in the atmosphere and the soil across Quzhou county. Several passive air samplers (see Fig. 1) will be installed in 10 field observation stations to collect atmospheric pesticides monthly and soil samples will also be collected at these sampling sites. Different agricultural production (e.g. wheat, maize, vegetables and fruits) are carried out close to these 10 stations. The detailed positions of sampling site are presented in Fig. 2.

Fig. 1 Passive air sampler

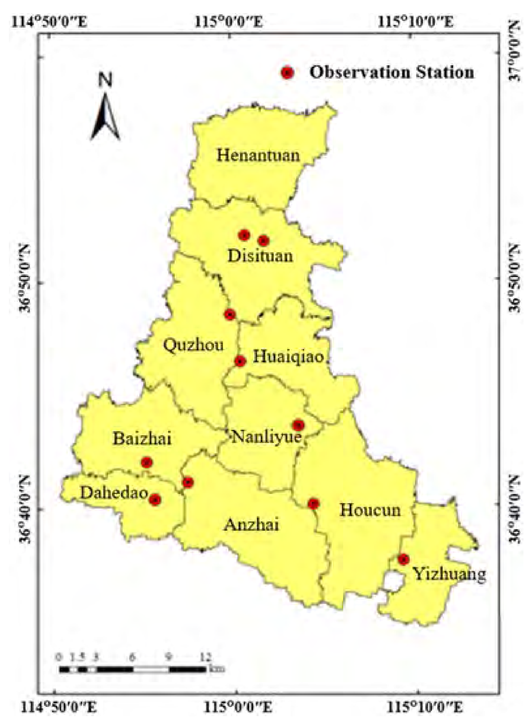

Fig. 2 Location of 10 observation stations in Quzhou county

Analytical method

After a proper sample preparation procedure, such as accelerated solvent extraction method (see Fig. 3), all these samples will be detected by liquid chromatography-tandem mass spectrometry (LC-MS/MS, as shown in Fig. 4) to compare the difference of pesticide types and concentrations in these samples collected in 10 stations. A novel sensitive method for simultaneous determination of various pesticides will be established and validated.

Fig. 3 Accelerated solvent extraction system

Fig. 4 LC-MS/MS

Modelling approach

To obtain a picture of the spatial pattern of pesticide levels in the soil and the atmosphere (air/dust) in the NCP, a wind erosion model for pesticides migration will be developed and verified. The conceptual framework of the model is shown in Fig. 5.

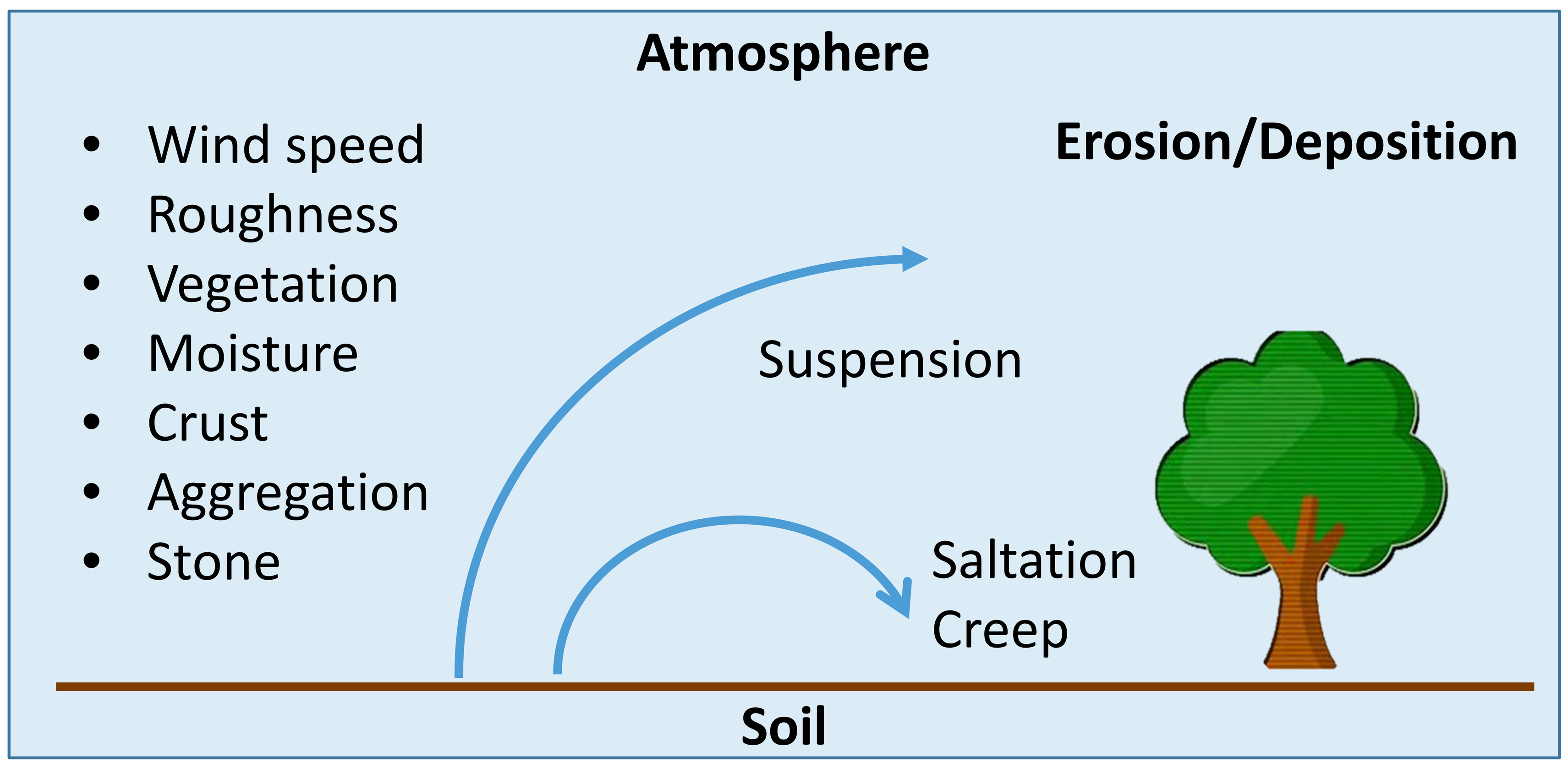

Fig. 5 Graphical scheme of soil wind erosion model

Databases, yearbooks and published literature will be used as data sources to develop and verify the wind erosion model related to the transport of pesticide residues from soil to atmosphere.

Residential exposure to airborne pesticides may occur via inhalation and direct skin contacts. The aim of BREAM model (see Fig. 6) is to study the relationship between pesticides exposure and the human health. The toxicity of pesticides will also be carefully considered.

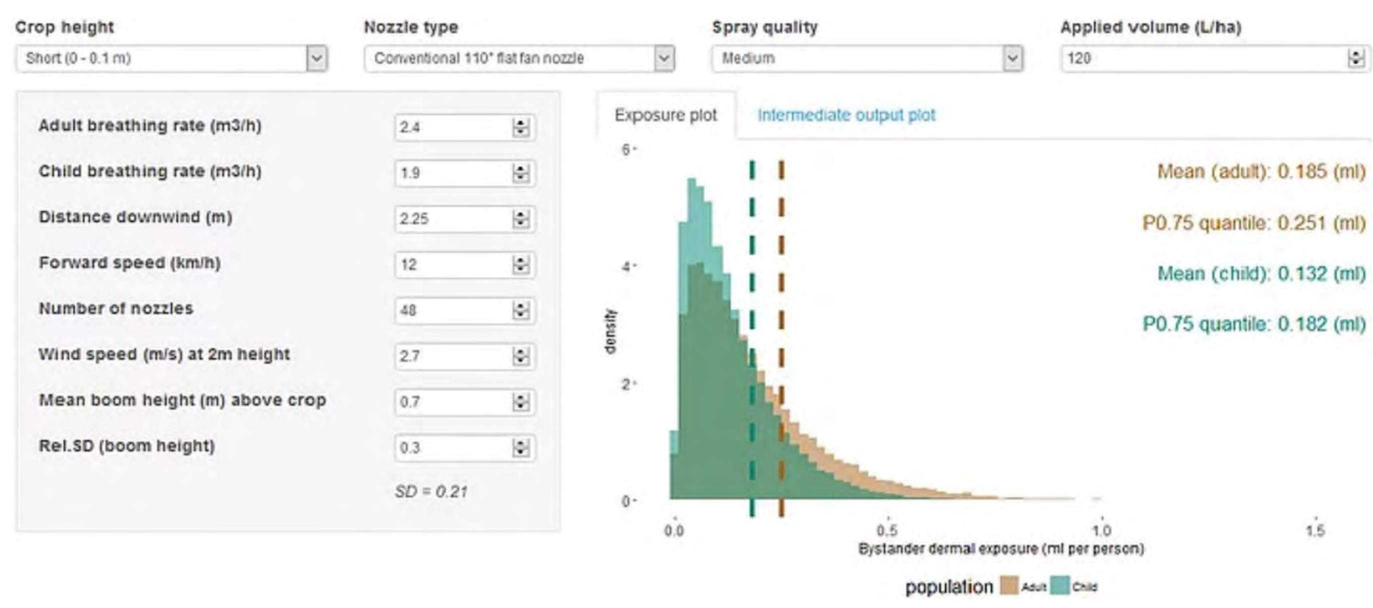

Fig. 6 Operation interface of BREAM model

Outlook

A system for the sustainable management of pesticides will be developed to assess the environmental impact and human health cost of pesticides application. Alternative sustainable agrochemical application strategies should be proposed. This study will contribute to the Agriculture Green Development in China.

Acknowledgements

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

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China's Practice in Improving Cultivated Land Productivity: Experience and Challenges

PhD candidate：Xueyuan Bai(白雪源)
Supervisors：Dr. Jie Zhang(张杰 副教授), Prof. Fusuo Zhang（张福锁 教授), Prof. Coen Ritsema

Background

The low and medium yield cultivated land in China was exceeds 9.26×10⁵ km², accounting for 68.76% of the cultivated land, but the spatial distributions are still unclear (Ministry of Agriculture and Rural Affairs, 2019). By eliminating obstacles, the productivity of the low and medium yield cultivated land has great potential for growth. In the past three decades, in order to improve food production, China has successively carried out a series of national projects to improving the low and medium yield cultivated land. Till 2021, China's food production has exceeded 650 million tons for seven consecutive years, which led to drastic reduction in the numbers of hungry and malnourished people. Therefore, analyzing the spatial and temporal changes of the low and medium yield cultivated land, summarizing the experience of China's cultivated land improvement practice is of great significance for ensuring food security and achieving sustainable development goals(SDGs)

Objectives

- ➢ Analyze the spatial and temporal changes of low and medium yield cultivated land in China;
- ➢ Determine the key driving factors of low and medium yield cultivated land in different period and region;
- ➢ Analyze the impact of national land improvement projects on cultivated land productivity;
- ➢ Explore the global contribution of China's cultivated land productivity improvement experience for the food security and SDGs.

Anakytical method

Geographic Information System (GIS) is a computer-based tool that can analyze and process spatial information. By combining geographic analysis functions and database operations (such as query and statistical analysis, etc.), GIS could effectively integrate multi-source data, and realize the extraction and analysis of the distribution and dynamic changes of low and medium yield cultivated land.

Remote sensing (RS) is an effective method for rapid and large-scale ground object monitoring. We use the **Google Earth Engine (GEE)** platform to visualize, calculate and analyze the large number of data, especially the RS data. The platform can access satellite images and other earth observation data databases online and provide sufficient computing power to process these data.

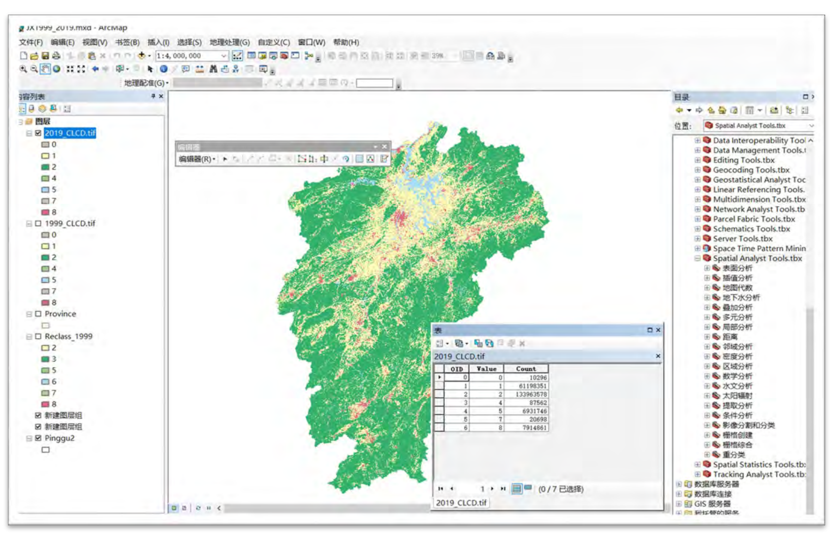


Fig. 1 ArcGIS platform

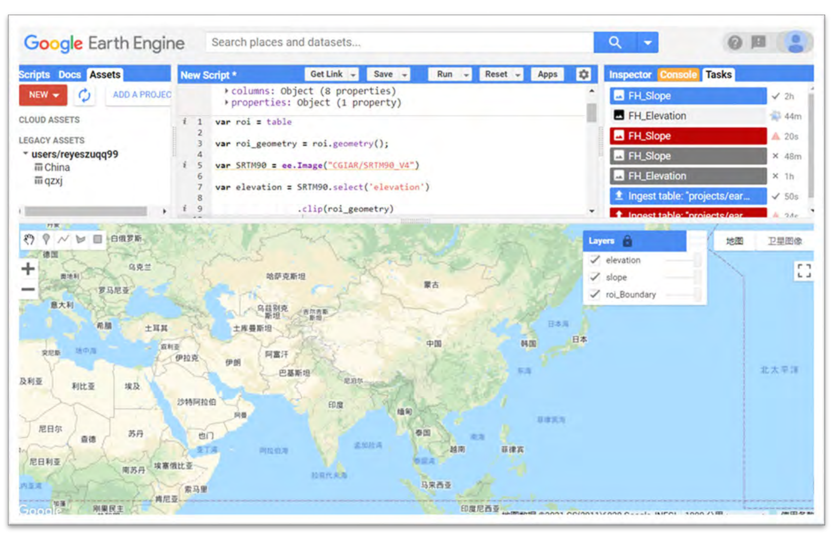


Fig. 2 GEE platform

Research progress

➢ literature review

Summarize the concepts, indicators and assessment methods of low and middle yield cultivated land.

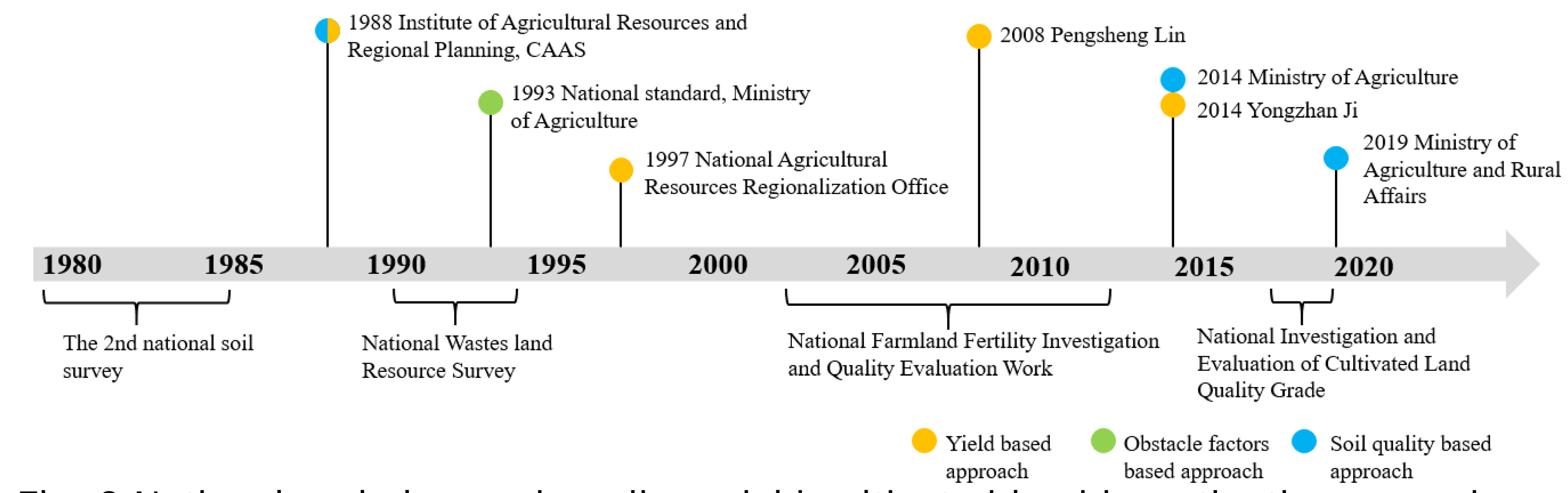
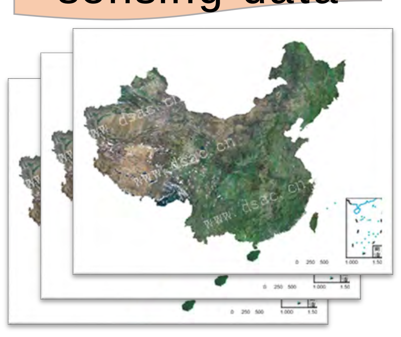
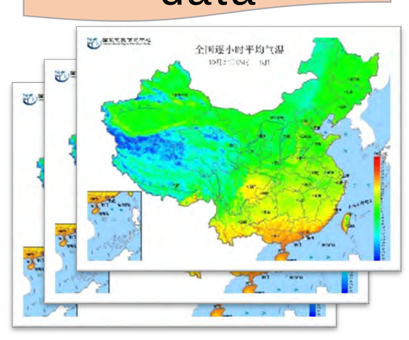


Fig. 3 National scale low and medium yield cultivated land investigation campaign

➢ Data collection and processing

This research mainly includes the following data

Basic data	Sampling data	Remote sensing data	Meteorological data
◆LULC ◆Administrative Districts ◆Agro-ecological Zone	◆Soil profile ◆Physical characteristics ◆Soil nutrients ◆Soil management		

Mapping 1 km resolution National Soil Information Grids of China

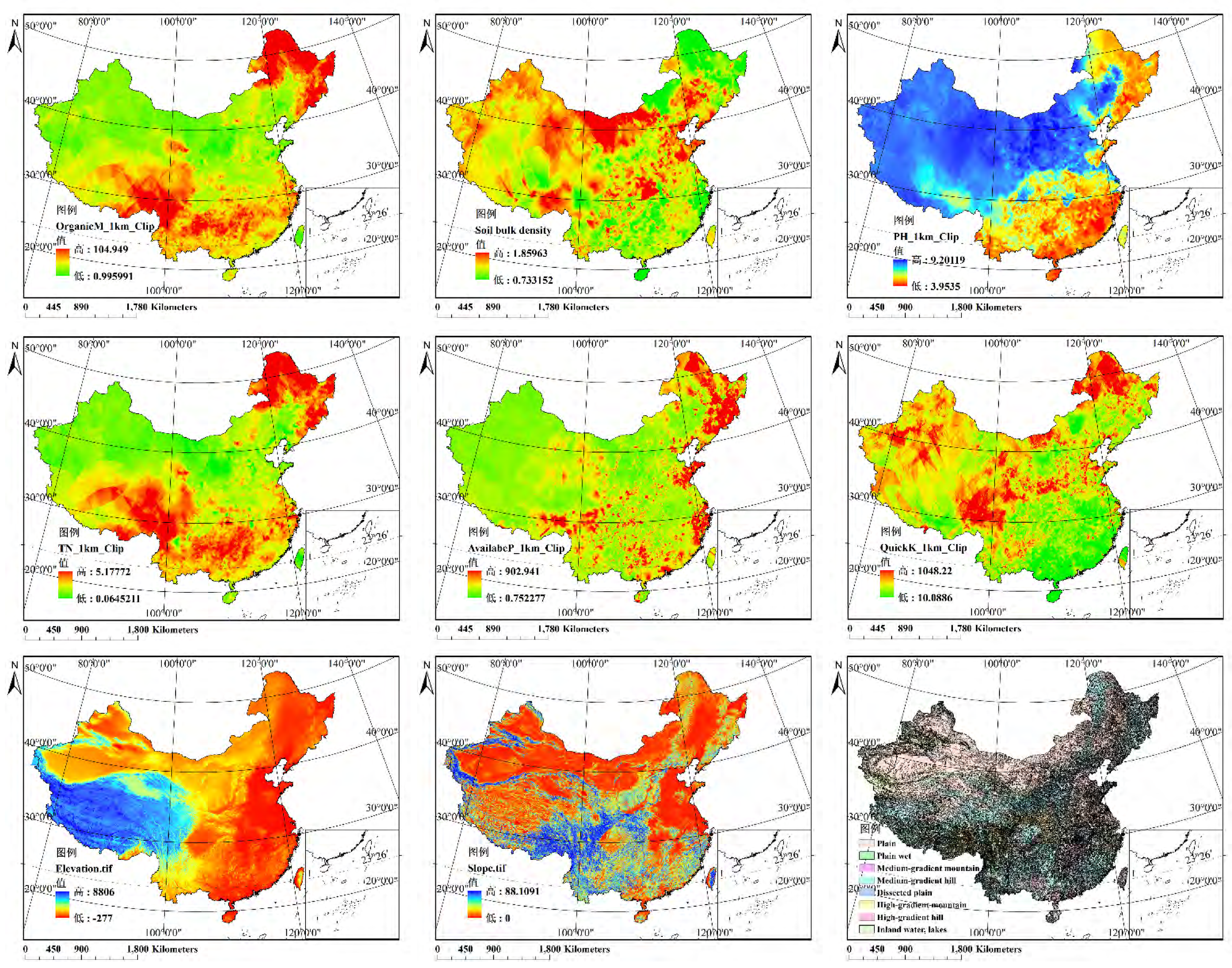


Fig. 4 The predicted maps of soil properties

Summary

Combining GIS and RS technology can realize multi-temporal and spatial analysis for low and medium yield cultivated land. Based on the temporal and spatial change, analyzing the impact of national land improvement projects on the cultivated land productivity is helpful to explore effective ways to increase the productivity of cultivated land, and further to achieve food security and the SDGs.

Acknowledgements

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

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Deciphering the underground language:

A systematic study on the root-microbe communication against foxtail millet blast disease

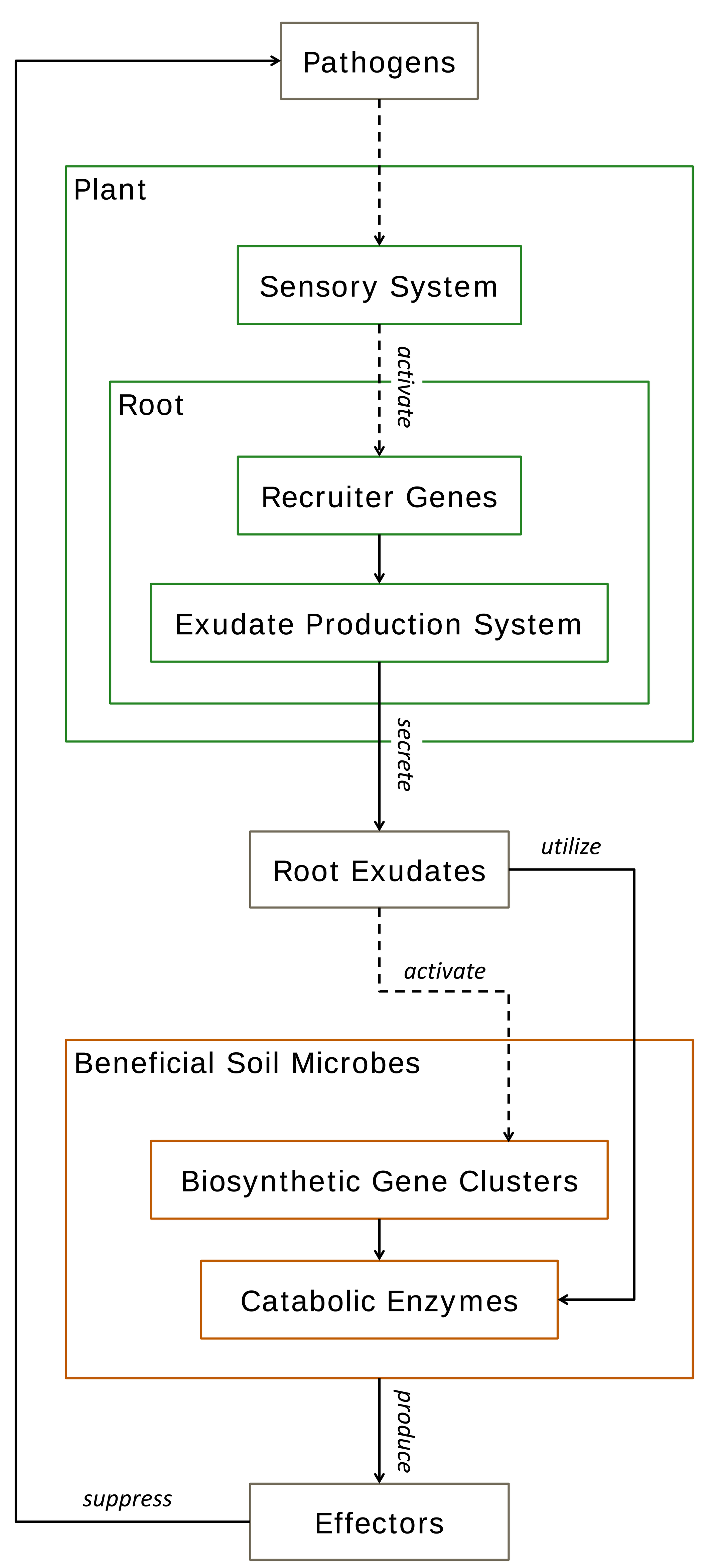
PhD Candidate: Yuze Li, collaborating with Mingxue Sun
Supervisors: Marnix Medema, Liesje Mommer, Jos Raaijmakers (Dutch), Chunxu Song (Chinese)

Background

Foxtail Millet (*Setaria italica*) is a popular crop wildly cultivated among Asian and south European countries. It has been domesticated by the early Neolithic Chinese people since about 8700 B.C. among the Yellow River basin area [1]. It counts for above 2 million tons of crop production per year and contributes largely to the agricultural diversity in nowadays China [2]. The millet blast disease, caused by the fungal pathogen *Pyricularia grisea*, is an important production limiting factor for foxtail millet and can lead to up to 60% economic loss in its major production areas [3]. Overuse of fungicides against blast has led to development of resistance and environmental damage [3]. Rhizosphere microbial communities recruited by plant roots have shown high potential in suppressing aboveground diseases, including blast disease in rice [4] and smut disease in foxtail millet [5]. A recent study in *Arabidopsis thaliana* also showed the capability of rhizosphere microbes to help plant resist against pathogenic *Pseudomonas syringae* infection [6].

Therefore, we propose that some cultivars of blast-resistant foxtail millet can also recruit beneficial soil microbes to develop resistance against *Pyricularia grisea*. My part of work will focus on deciphering the communication "language" between foxtail root and soil microbes. The alphabet (genes) and vocabulary (secreted molecules) of this language will be discovered, and their conversations (interaction) will be analyzed. And finally, we will show our understanding of their language by constructing predictive models to these interactions.

System Model



Objectives and Research Questions

Learn Their Alphabet
*find related **genes** in plant and soil microbes*

- Which *genes* are activated to produce recruiting root exudates
- Which *soil microbe families* are enriched by the resistant plant cultivars
- Which microbial *biosynthetic gene clusters* (BGCs) are activated

Record Their Vocabulary
*identify active **molecules** in the exudates*

- What are the *root exudate compositions* in sensitive and resistant cultivars?
- Which fraction of the root exudates are *utilized* by the beneficial soil microbes?

Interpret Their Conversations
*confirm the **molecular interactions***

- Which BGCs are *activated* by each fraction of the exudates?
- Which *molecules* are in each fractions and how are they produced by the plant?

Understand Their Language
*make **predictive models** to the interactions*

- What are the *characteristics* of the gene clusters that are activated by plant?
- How to *predict* if a BGC can utilize these components of exudates?

Study Design

My part of work	Mingxue's work	Year
Work together		
In China		
Phenotyping to find foxtail millet cultivars whose resistance is depending on soil microbes		1st Year
Omics experiments: Amplicon sequencing of rhizosphere microbiome; Metagenome and metatranscriptome sequencing; RNAseq of root tissues; LC- and GC-MS/MS of root exudates		1st Year
Analyzing omics data	Isolating functional strains with plate confrontation assays	2nd Year
Set up reporting strain to test molecular interactions	Soil inoculating test to validate stain function	2nd Year
Finding candidate BGCs with comparative genomic and metatranscriptomic analysis		3rd Year
Validating the activation of gene clusters using the reporting strain	Validating the function of gene clusters using genetic editing	3rd Year
Constructing prediction model for functional gene clusters		3rd Year / 4th Year
Writing thesis report	Writing thesis report	4th Year
In the Netherlands		

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

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Unravel the impact of domestication on foxtail millet microbiome composition and functions under biotic stress

Reporter: Mingxue Sun, collaborating with Yuze Li

Supervisors: Chunxu Song (CAU); Marnix Medema; Liesje Mommer (WUR); Jos Raaijmakers (NIOO-KNAW; Leiden University)

Background

- The plant microbiome plays crucial roles in nutrient acquisition, growth and health of plants, and has the potential to reduce usage of fertilizers and pesticides on crops.
- Plants can impact their associated microbiome as an adaptation strategy when confronted by biotic and abiotic challenges (Toju et al., 2018; Ravanbakhsh et al., 2019). Especially, plants are capable of releasing specific root exudates to recruit beneficial rhizosphere microbes upon foliar pathogen invasion attack, such as: amino acids, short-chain organic acids and sugars (Yuan et al., 2018; Wen et al., 2021).
- Plant domestication shows a significant impact on composition and functions of the microbiome. However, rhizomicrobiome of cultivated plants may be more sensitive to the introduction of the fungal pathogen and more easily disturbed than the rhizosphere community of their wild relatives (Shi et al., 2018). It is vital to reinstate the beneficial plant-microbe associations to enhance crop productivity.
- Foxtail millet (*Setaria italica*) is one of the oldest cultivated cereal crops, domesticated from the wild species green foxtail (*Setaria viridis*) more than 8,000 years ago in northern China (Figure1) (Barton et al., 2009; Doebley et al., 2006); Foxtail millet blast (*Pyricularia grisea*) is an important disease, which caused reduced production and quality of foxtail millet. However, very few studies to date have shown the impact of host and environmental factors on microbiome assembly of *S. viridis* and *S. italica* and limited information is available on the reciprocal effects of specific microbiome members on foxtail millet phenotypes (Simmon et al., 2020; Chaluvadi and Bennetzen, 2018; Debenport et al., 2015) . Therefore, foxtail millet is used here as the research object to link the changes of plant exudations to the rhizosphere microbiome functions upon pathogen invasion, thereby, to serve the green development of agriculture.

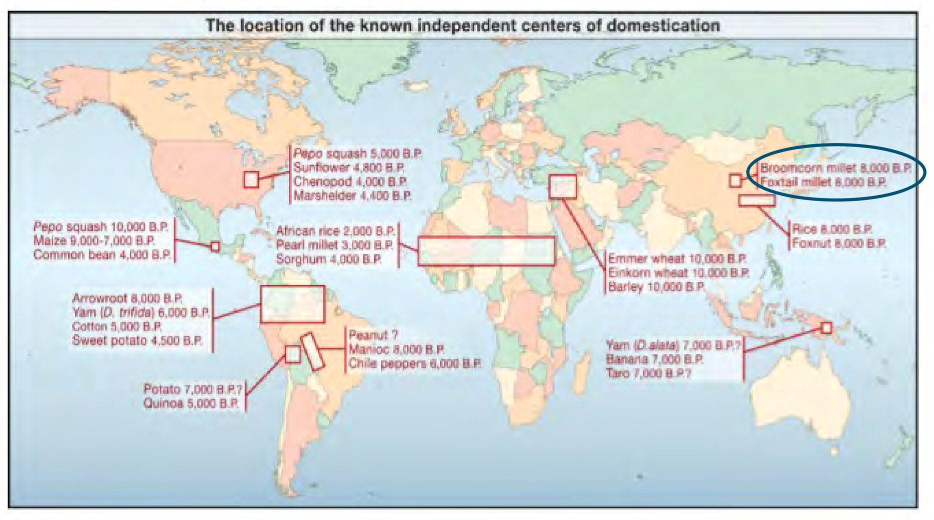
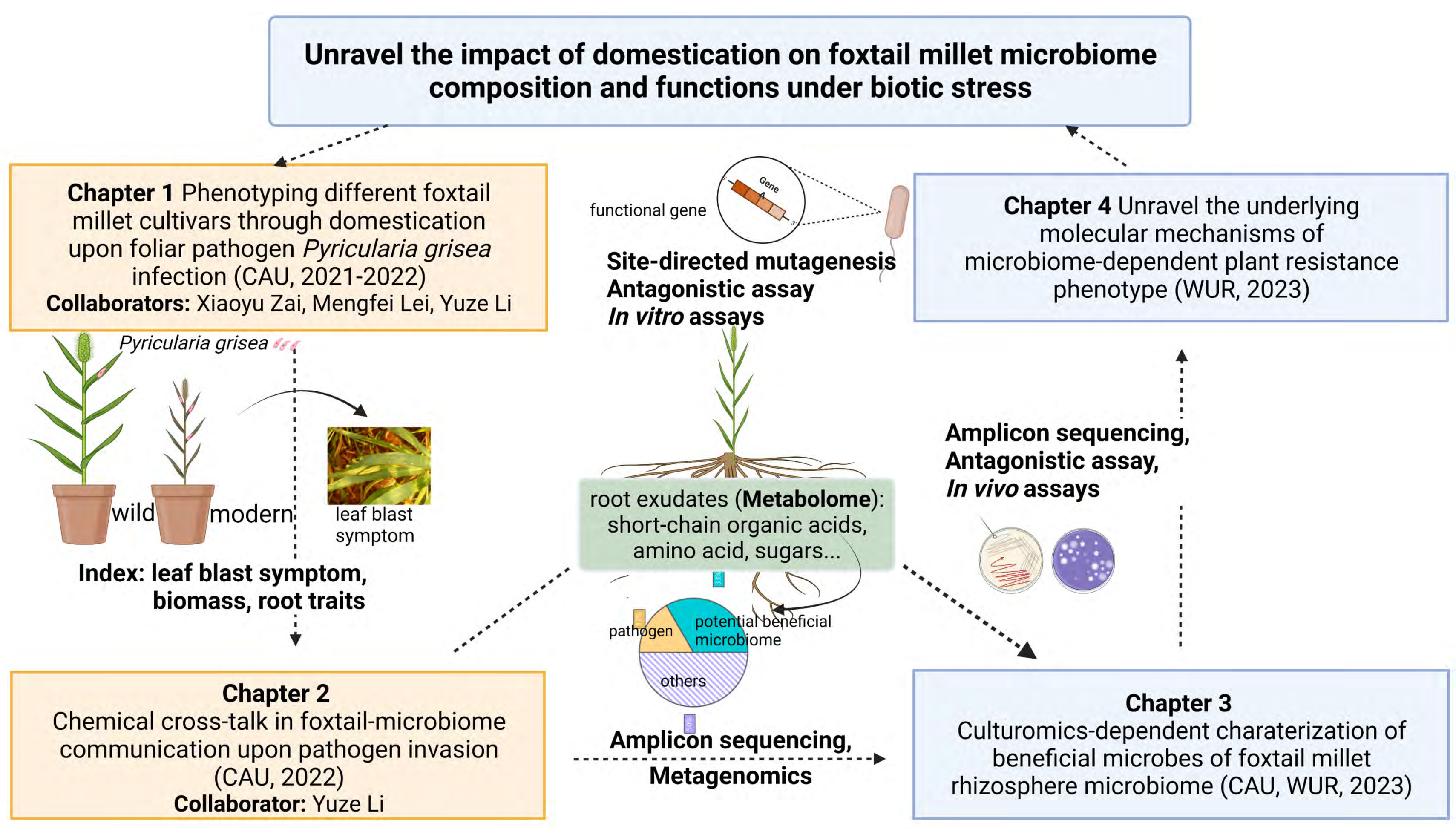


Figure1. The independent centers of domestication (Doebley et al., 2006)

Objectives

I. Phenotyping different foxtail millet cultivars through domestication upon foliar pathogen *Pyricularia grisea* infection ;
II. Decipher the molecular and chemical cross-talk in foxtail-microbiome communication upon pathogen invasion ;
III. Unravel the underlying molecular mechanisms of microbiome-dependent plant resistance phenotype.

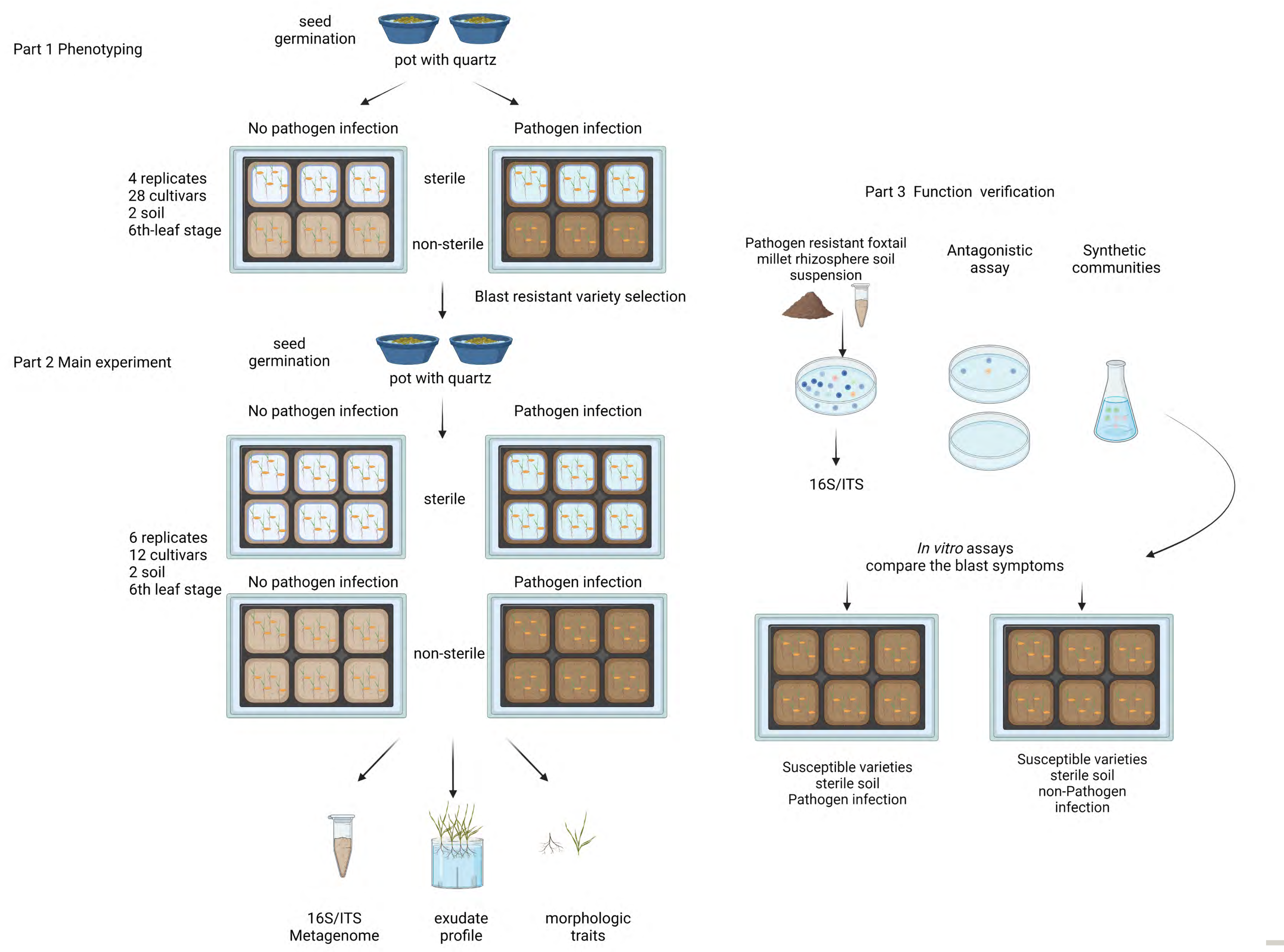
Framework



Materials and Methods

(1) Phenotyping experiment: The effects of 28 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 traits 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 for microbial diversity and composition;
(3) Metagenome: Metagenomic analysis will be performed on selected samples to analyze the functional potential of differentially recruited microbes;
(4) Metabolome: Root exudates will be collected (Williams et al., 2021) and subjected LC-MS/MS analysis, 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



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Acknowledgements

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

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Changing the Food Environment for Healthy Diet:

a case study of foxtail millet supply chain in Gansu

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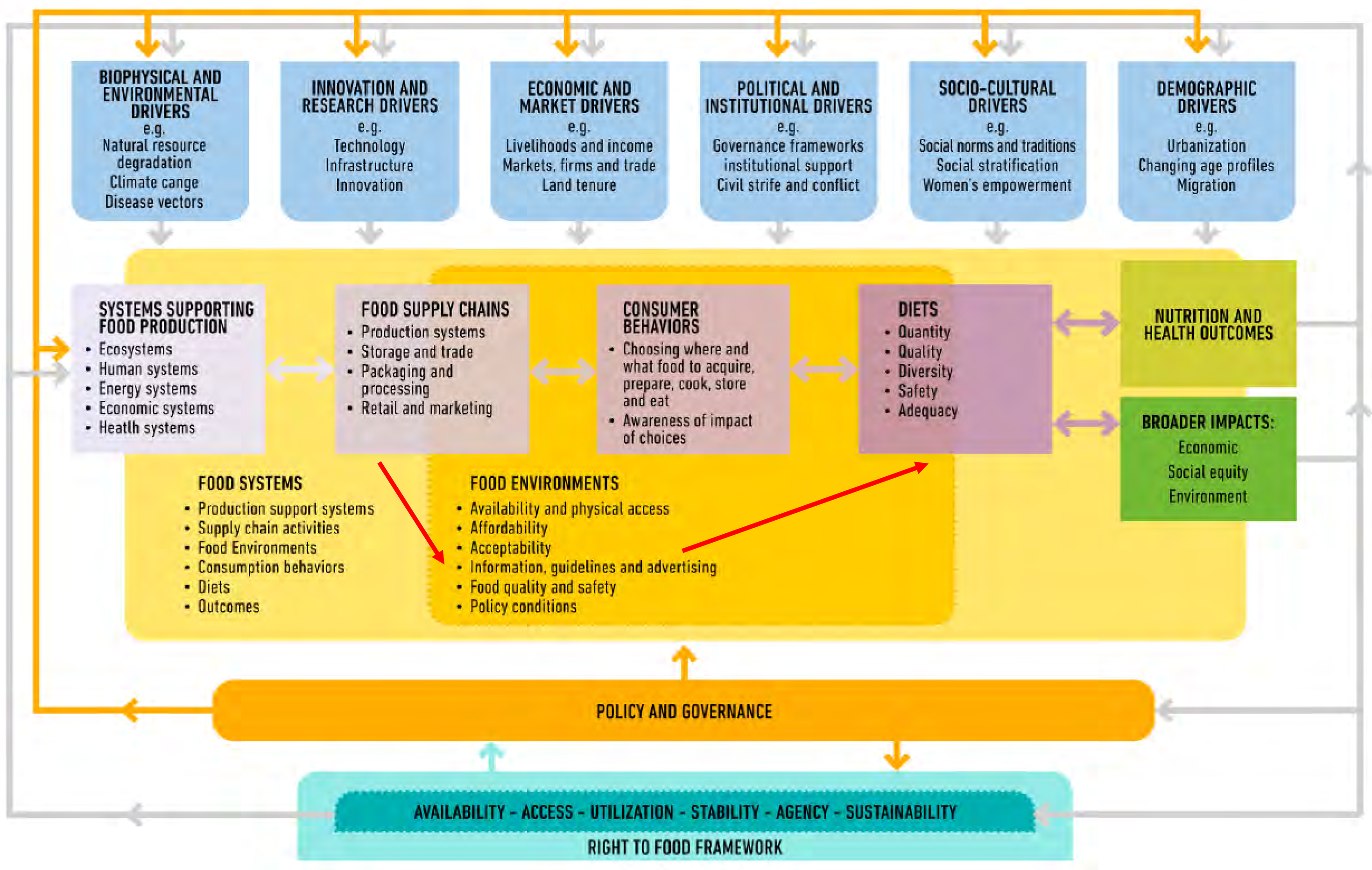
WUR supervisors: Sander de Leeuw, J.C. van Lemmen-Gerdessen, Wopke van der Werf, Tjeerdjan Stomph, E.J.M Feskens
CDC supervisors: Chao Gao

Background

Globally, 8.9 percent of world people were undernourished in 2019 (FAO et al., 2020). One in two could be malnourished by 2030 if nothing is done (HLPE report, 2017). In China, people are facing multiple malnutrition problems. In 2019, 35 million of Chinese people are undernourished (The World Bank, 2020). Chinese residents' dietary calcium (97.2%), vitamin A (75.9%), vitamin B1(83.5%), and vitamin C (68.9%) intake are severely insufficient (Yu et al., 2021). An estimated 85 million adults aged 18–69 years in China were obese in 2018, which was three times as many as in 2004 (Wang et al., 2021). 590 thousand people died of cardiovascular diseases related to overweight and obesity (Chinese nutrition society, 2021).

Malnutrition is related to dietary pattern. People always obtain essential nutrients from their daily food. Shifting to balanced dietary patterns is a key strategy to tackle the malnutrition problems. It is also important to note that Vermeulen et al. (2012) argue that today's food system accounts for 20%-30% of the globe greenhouse gas emission. Moreover, food consumption is the main driver for environment burdens in terms of land use and water use (Notarnicola, 2017). Thus, sustainable diets are the consumption patterns that are beneficial for human health, nutrition, environmental, social and economic aspects (Willett, et al., 2019).

Dietary patterns are also a vital part of food systems as below shows (HLPE repot, 2020). Another important parts are food supply chains and food environment. Food supply chains then could transform food environment for healthy diets. Furthermore, sustainable food supply chain (SFSC) is considered from a network perspective as the picture in the method, including crop planning,, processing, transportation and storage. Supply chain decisions at one stage have implications for other stages (Rohmer et al., 2019). Thus, it is very crucial to understand how the food supply chain network (FSCN) could be optimized and designed to improve food environment and then promote healthy diets .

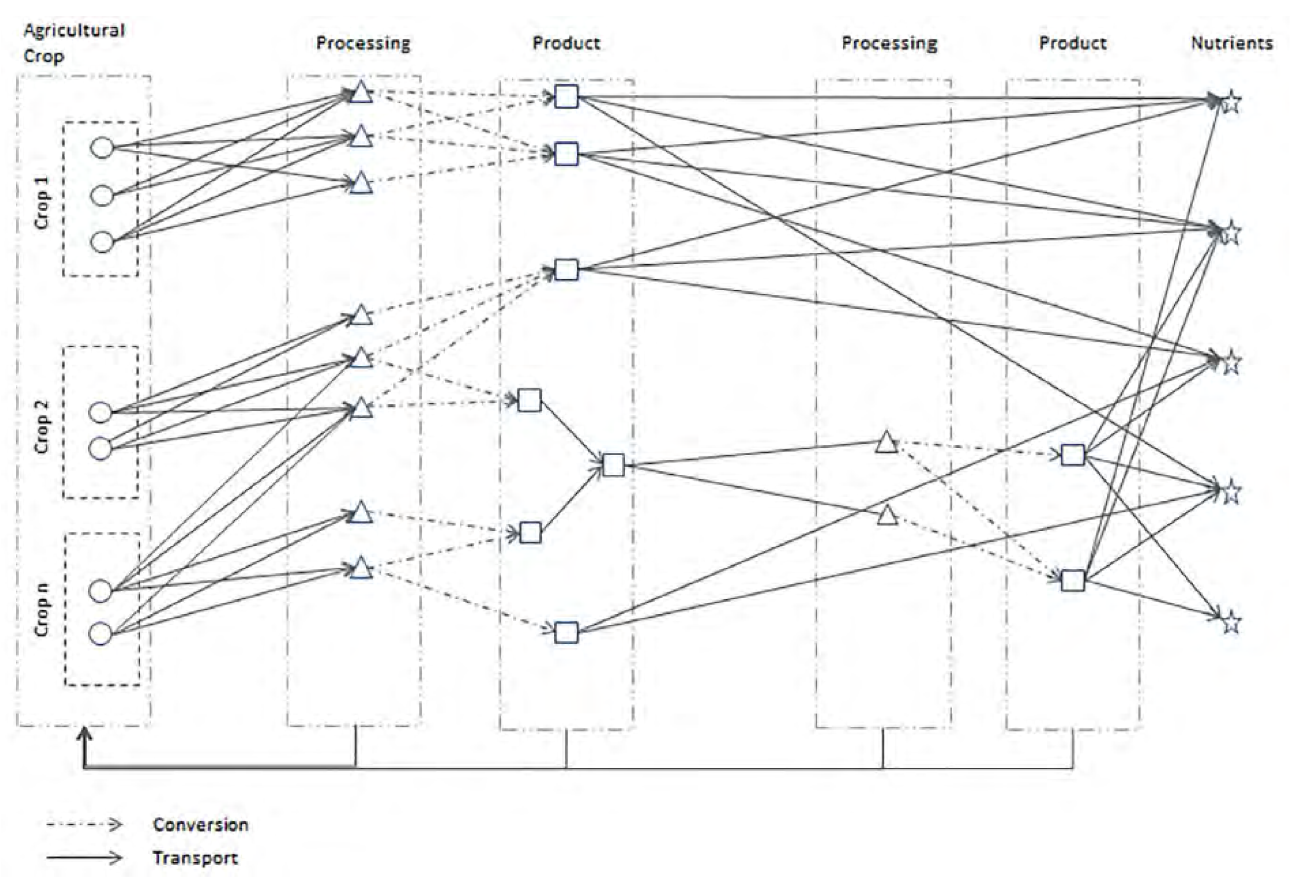


Objectives

- The cropping system will be developed to provide sufficient nutrition with less environmental impacts, land use and water use
- The food supply chain will be integrated to lower the malnutrition loss, supply chain operation costs and environmental impacts
- The composition of diets will be changed and then provide residents with various nutrition that meet the recommendation intake
- The regional model will be formulated through achieving three objectives above, which can be recommended to another region

Methods

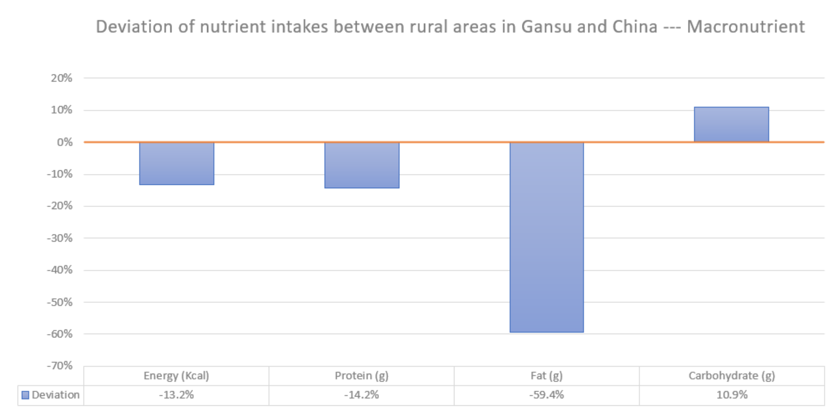
Based on the formulated SFSC, this project will adopt multi-objective decision-making method. The objective function would include three parts, namely, costs, nutrition outcomes and environmental impacts. First, cost is a widely used indicator for economic performance. If supply chain cost gets lower, food would become accessibly for consumer at the right hand of the model. Secondly, this project assumes that people would be in a healthy situation when those main nutrients could be absorbed in suggested amounts. In order to keep healthy, people should obtain sufficient nutrients, such as Zinc, Iron and Vitamin. Thirdly, environmental impacts are multi-dimensional problems. Previous literature supports different impacts including greenhouse gas emission, land use and water use.

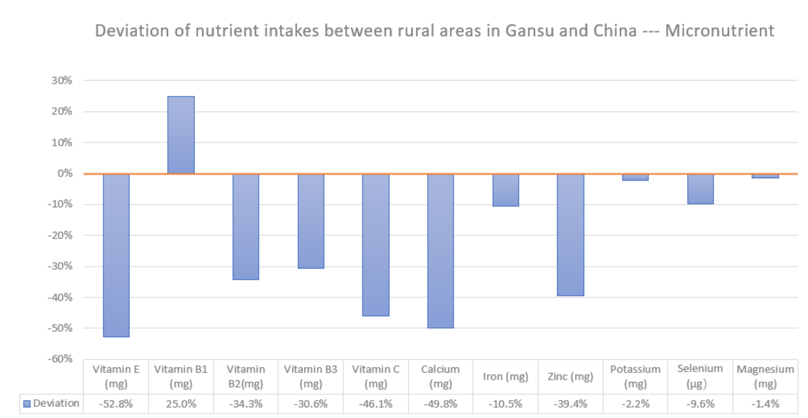


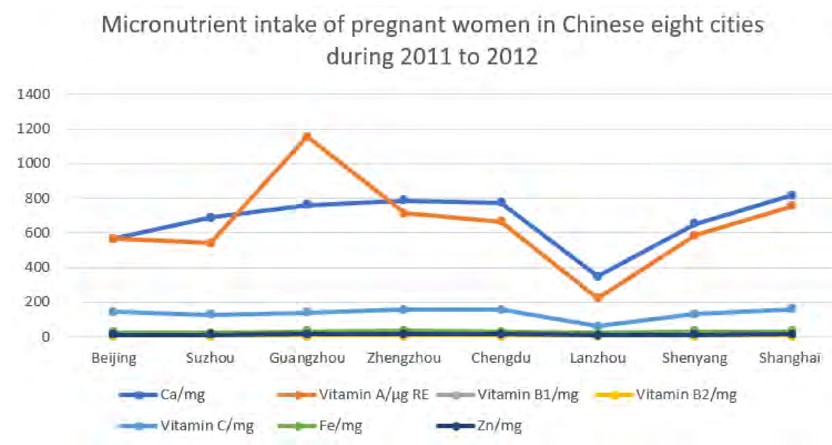
Current work

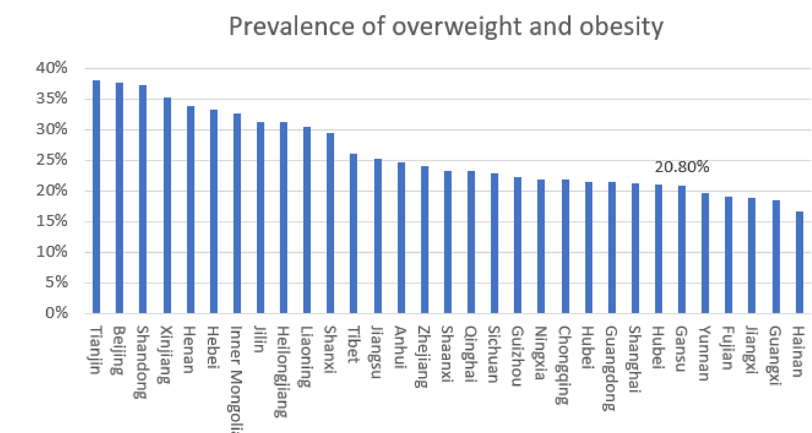
Two aspects are researched after this project begins. One aspect is about the region where people are facing severe malnutrition problems. We found Gansu should be way more focused on:

- The nutrient intakes in rural Gansu are lower than those in rural China areas.
- For energy and micronutrient intake, rural Gansu ranks lowest among 13 provinces and cities.
- For special group, the capital of Gansu ranks lowest in 8 cities.
- The prevalence of overweight and obesity is lower than other provinces and cities, but is still serious.









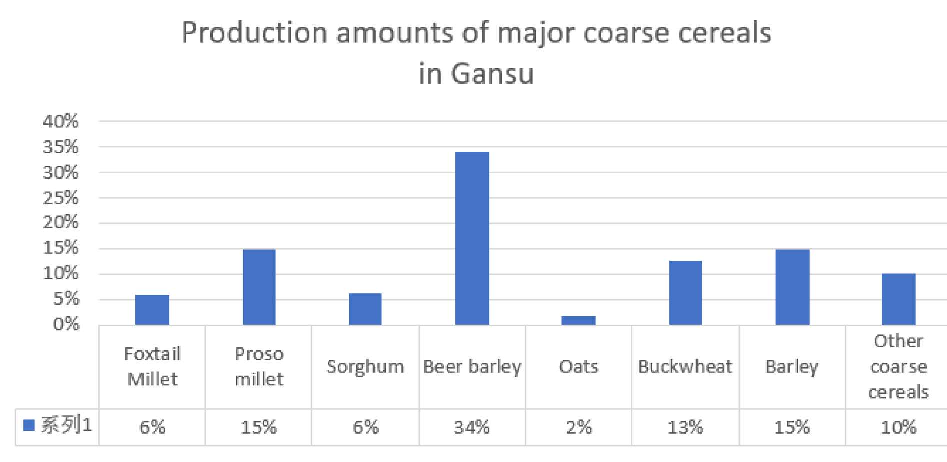
The other aspect is about the local diet. We found foxtail millet consumption should be given the priority in Gansu:

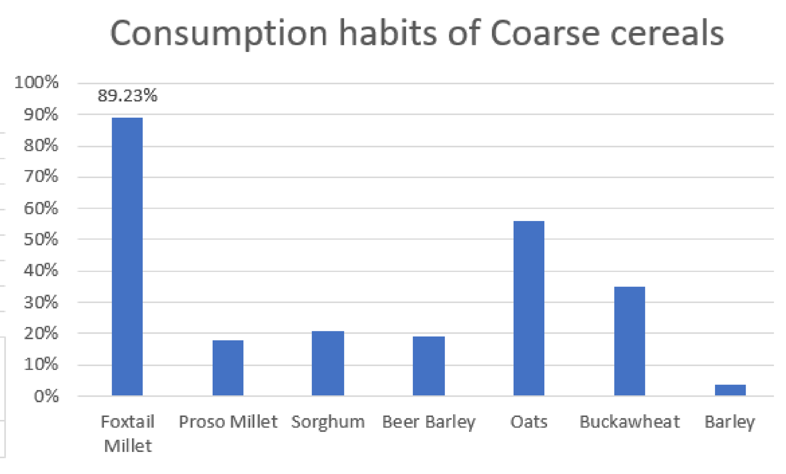
- Coarse cereals are beneficial to human health. The consumption of coarse cereals is low in Gansu. Improving the consumption could contribute to human health in Gansu.
- Foxtail millet is a major production coarse cereal in Gansu. And people would like to consume this crop. Local millet production has potential for recovery.
- Foxtail millet is rich in protein, fat, fiber, minerals and vitamins.

Consumption of coarse cereals in Gansu

unit: g per day per capita	Year 2019	
	Rural areas	Cities
Refined Cereals	378.90	319.73
Coarse Cereals and Legumes	69.86	48.77
Coarse Cereals	55.62	25.48
Legumes	14.25	23.29
Tubers	20.55	13.70
Total	469.32	382.19

Refined cereals: Wheat and Rice
Legumes: Soy bean, Mung beans, Red beans, etc.
Coarse cereals: Corn, Millet, Buckwheat, Oats, etc.
Tubers: Potatoes and Sweet potatoes





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Acknowledgements

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

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Designing and optimizing sustainable food supply chains for healthy diets in China

PhD candidate: Yijun Li

CAU supervisors: Wenfeng Cong, Xin Wen, Shenggen Fan, Chao Gao, Mo Li, Fusuo Zhang, Yuanying Ni

WUR supervisors: E.J.M Feskens, J.C. van Lemmen-Gerdessen, Tjeerdjan Stomph, Wopke van der Werf, Sander de Leeuw

Background

Problem	Results	Directions
General malnutrition problem	• Micronutrient, overweight/ obesity is more prominent, dietary-related diseases (Yu et al., 2021; Wang et al., 2021)	- Focus on solving micronutrient, overweight/obesity, dietary related diseases
Regional malnutrition problem	• Risk of insufficient dietary micronutrient intake: Eastern < Central and Western regions • Difference between rural and urban area • (Yu et al., 2021) • The south China faces risk factors jeopardizing public health, such as unhealthy staple food factor (low intake of whole grains and beans), e.g., Hunan and Guizhou provinces. (Li et al., 2020) • Dietary intake of Vitamin B1, Vitamin B2, calcium, zinc, iron is insufficient in Hunan and Guizhou provinces. (China health and nutrition survey, 2011)	- Geographical targeted situation is required - South China such as Hunan and Guizhou provinces need to increase the intake of whole grains and beans
Nutritious food groups	• Whole grains, dry beans are beneficial to alleviate micronutrient deficiency, overweight/obesity, dietary-related diseases； • Diversity in cereals and beans are crucial (CNS, 2016)	- Start from millet, other cereals, and other dry beans, e.g., mung bean, adzuki bean, etc. - Take staple food diversity into account

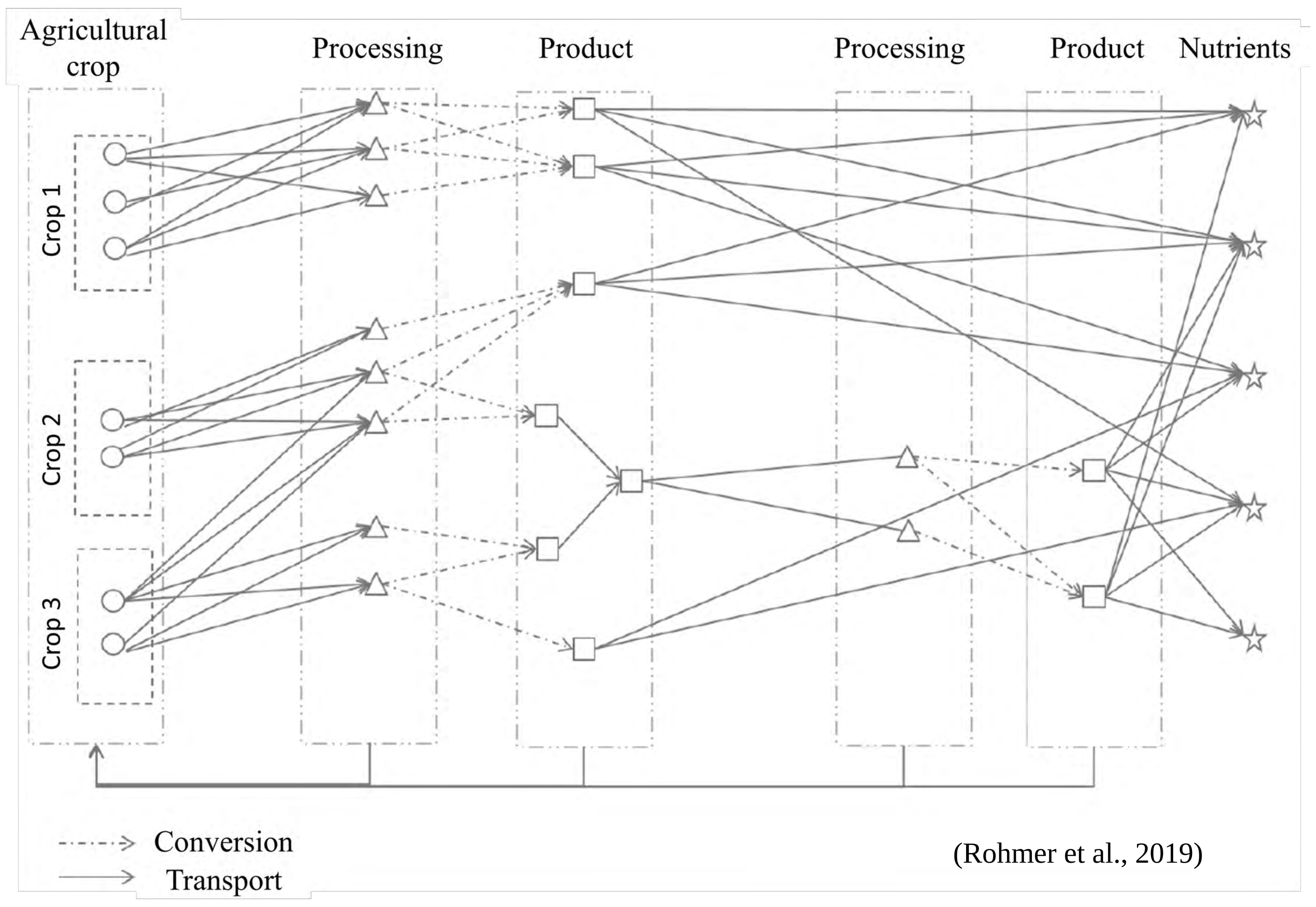
Objectives

Supply nutritious foods to everyone at affordable prices with lower environmental burdens is the ultimate goal of this project.

1. Improve the micronutrient deficiency, dietary-related diseases: this objective is used to measure societal sustainability. Some overall measures of nutrition quality can be applied. This goal is to increase the dietary intake of key micronutrients that are crucial or insufficient for the consumption areas' residents as possible as we can.
2. Decrease the environmental externalities: this objective is used to measure environmental sustainability. To incorporate environmentally conscious thinking in all stages and links in the food supply chain, such as the GHG emissions, fertilizer use, land use in the production stage, the energy use in the processing and transportation stage, etc.
3. Decrease the total supply cost: this objective is used to measure economic sustainability. Total cost is a conventional measure, which is widely used in the design of the supply chain. The cost of supply is closely related to the food prices and thus influences the accessibility of food products.

Methods

➢ Supply chain network model → To capture the planning problem



➢ Linear programming + multi-objective optimization

➢ A simulation-optimization approach

Expected results

This research will apply a systematic approach to optimize and design the food supply chain network for the selected research areas. A multi-objective optimization model is used, after quantitative analysis, the following results will be obtained:

(1) what kind of planting system should be used in the selected research areas?

(2) what kind of crops and what quantity should be planted?

(3) what kind of transportation modes, transportation routes, processing options should be used to supply what kind of consumer groups.

Ultimately, the negative impact of the entire food supply system on the environment should be as small as possible; the economic cost of the entire food supply chain system should be as low as possible; the residents' diet should be as healthy and nutritious as possible.

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Acknowledgements

We gratefully acknowlege the sponsors of this research:China Scholarship Council (NO.202106350114)

Thank Wageningen University & Research and China Agricultural University for providing the collaboration platform.

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Designing and optimizing sustainable food supply chains for healthy diets in China

—The case of whole-grain industry

Repoter:Xin Zhang (2+2 PhD)

Supervisor:Shenggen Fan Jinjing Wang Haixiu GaoInge Brouwer

Background

➢Benefits of whole-grains:
Multiple studies show reduce the risk of heart disease, type 2 diabetes and some cancers.
Some studies show reduce GHG and energy use.
Some studies show reduce food wast and health care cost.

➢Intake gap
However more than 80% of adults can't reach the recommendation 50-150g/day.

Objectives

1.Identify the problems that restrict and opportunities that foster the development of the whole wheat.

2.Analyze the potential impact of relevant interventions of whole wheat industry.

3.Recommend pathway to strengthen whole wheat supply chain.

Methods

1.Systematic literature review

2. Conduct surveys/case studies

3.Empirical analysis method

Results

1.Participated in household survey related to residents' diet during summer vacation.And know more about the dietary structure of rural residents in China.

2.Completed the required doctoral courses of first semester at China Agricultural University. Learned economic theories and empirical research methods.

3.Have finished the first draft of literature review on the current food systems of whole and refined wheat.

Conclusions

1.Establish a theoretical framework to analyze the supply and demand of whole wheat products.

2.Conduct surveys/case studies to collect data.

Acknowledgements

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

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Diversity of intercropping systems across China: tailoring species combinations in intercropping to soils and climates

Tao Song*, Chunjie Li, Chaochun Zhang, Lizhen Zhang, Wopke van der Werf, Heerink Nico, Stomph Tjeerd Jan, Marrit van den Berg

Background

◆ Chinese government has introduced a policy of cropping transformation to increase soil quality and ensure diet diversity, for instance, by increasing the planting area of grain legumes and encouraging intercropping in China.

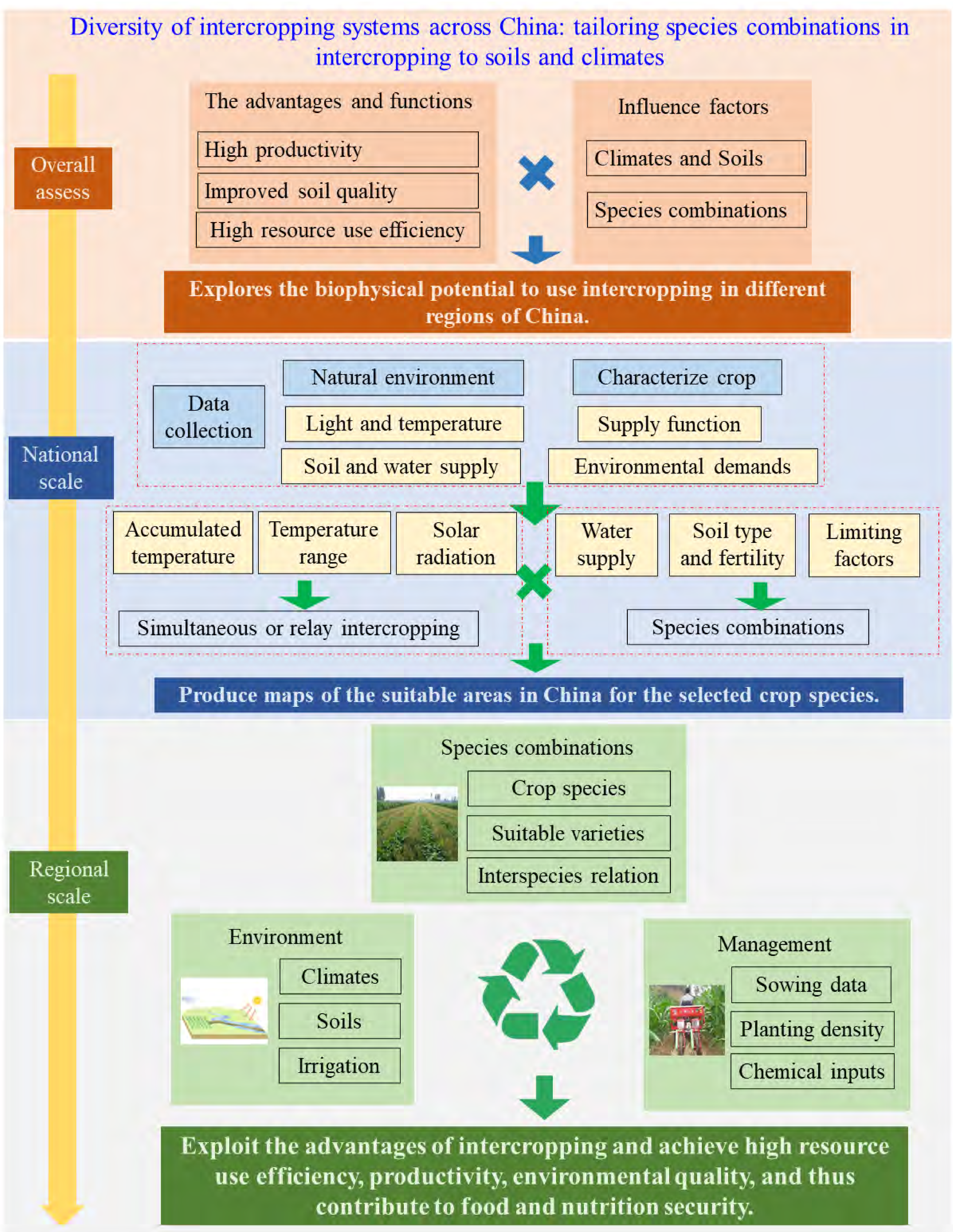
◆ It is still unclear how the choice of intercropping system in terms of species choice, sowing dates, input levels and spatial arrangements should best be tailored to different agroecological environments, production objectives and biophysical constraints in different regions of China.

Objectives

◆ Explores the biophysical potential to use intercropping in different regions of China.

◆ Elucidate how species choice and management of intercropping can be tailored to pedo-climatic conditions to exploit the advantages of intercropping and achieve high resource use efficiency, productivity, environmental quality, and thus contribute to food and nutrition security.

Research framework



Results

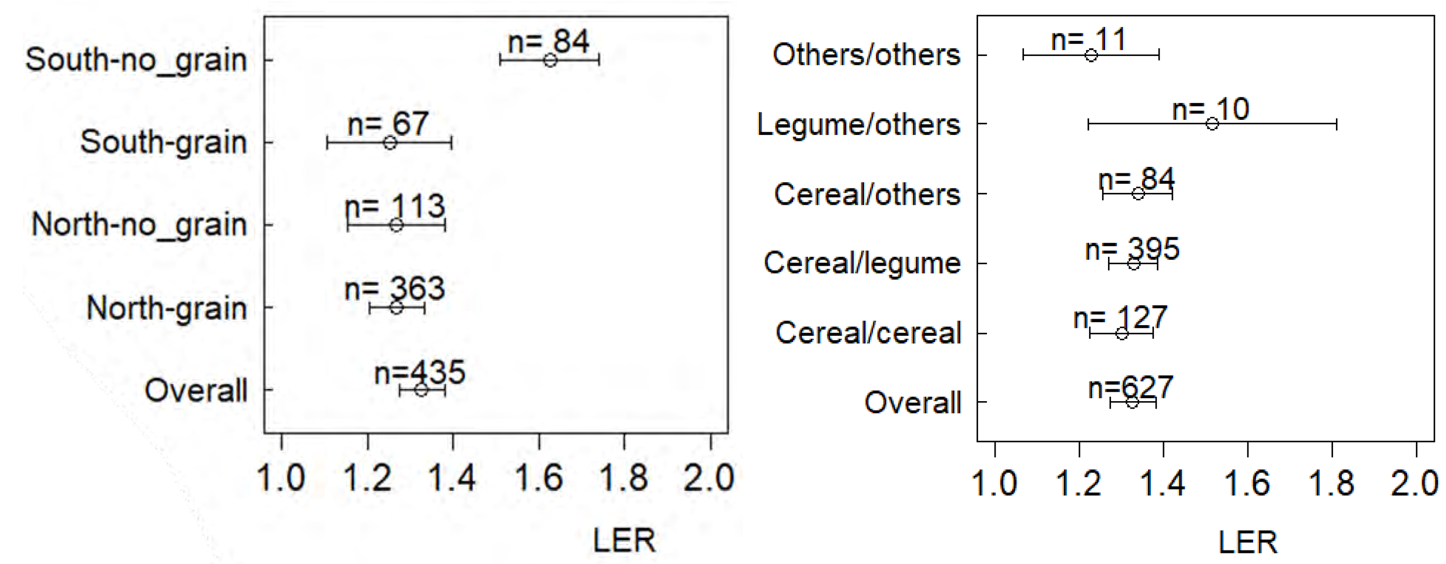


Fig. 1 Estimated LER (Land equivalent ratio) of intercropping system in different regions. "South" is subtropical region of China; "North" is the temperate zone of China; "grain" represents both grain crops in intercropping; "no-grain" represents at least one no-grain crop in intercropping.

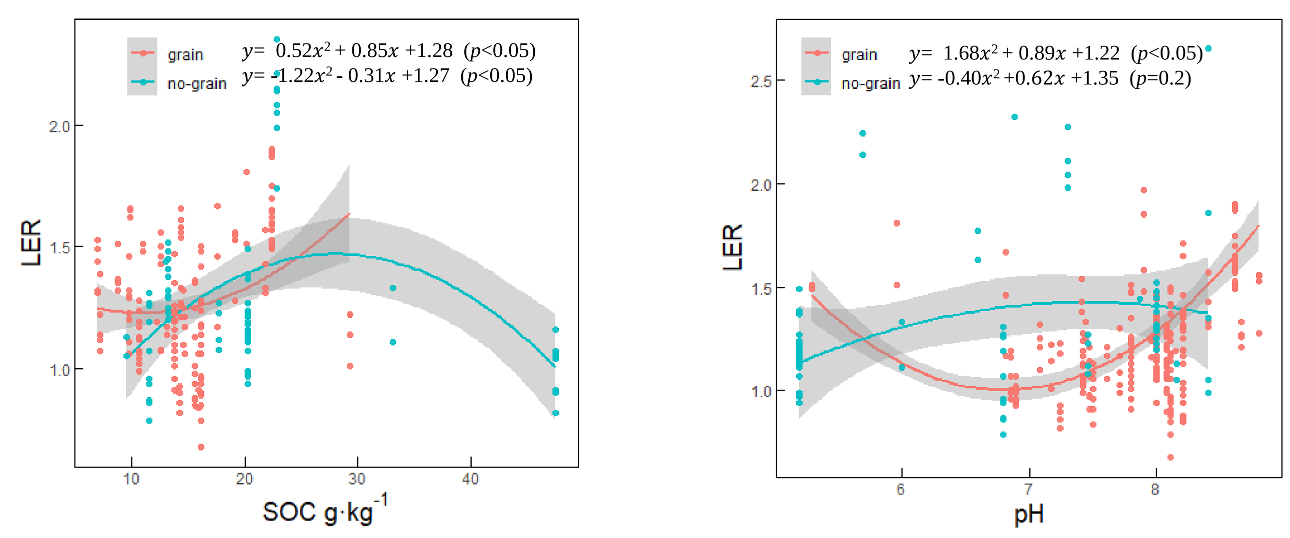


Fig. 2 Estimated LER (Land equivalent ratio) of intercropping system affected by soil indicators. "grain" represents both grain crops in intercropping; "no-grain" represents at least one no-grain crop in intercropping.

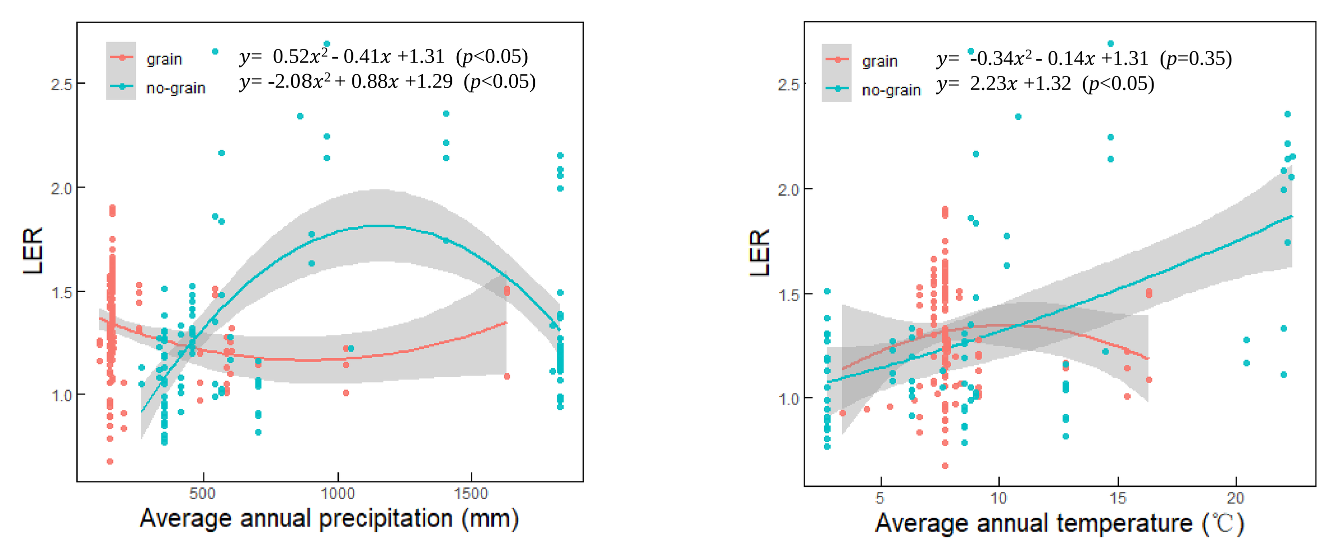


Fig. 3 Estimated LER (Land equivalent ratio) of intercropping system affected by meteorological indicators. "grain" represents both grain crops in intercropping; "no-grain" represents at least one no-grain crop in intercropping.

Conclusions

◆ The intercropping system with no-grain crops in subtropical climate of China has higher land use efficiency.

◆ Both grain and no-grain intercropping have higher land use efficiency when SOC between 20~30 g·kg $^{-1}$, while grain intercropping has advantage in alkaline soils.

◆ No-grain intercropping is significantly affected by meteorological conditions, and the advantage is more obvious in areas with high temperature and rainfall, but too much rainfall will weaken this advantage.

Acknowledgements

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

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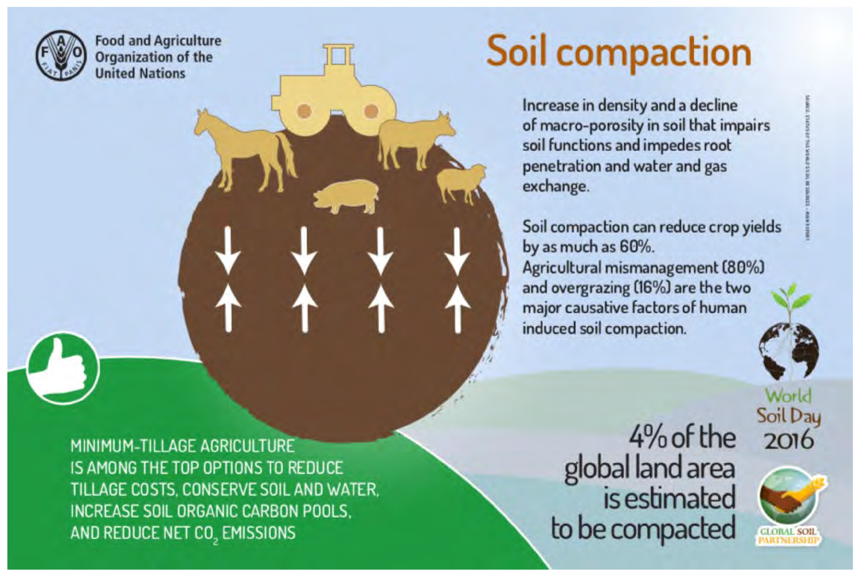
Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production

PhD candidate: Mengxue Mao
Supervisor : Kemo Jin, Liping Weng, Walter schenkeveld

Background

Present situation and harm of compaction stress

In recent years, with the rapid development of agricultural modernization, the problem of soil compaction has become increasingly prominent. Compaction stress increases soil bulk density and penetration resistance, reduces soil porosity and hydraulic conductivity, and then inhibits the acquisition of soil water and nutrients by plant roots, resulting in plant growth restriction and yield reduction.



Besides, soil compaction is one of the main causes of soil degradation and has gradually become one of the world problems restricting the sustainable development of agriculture.

Soil compaction inhibits phosphorus uptake by plants

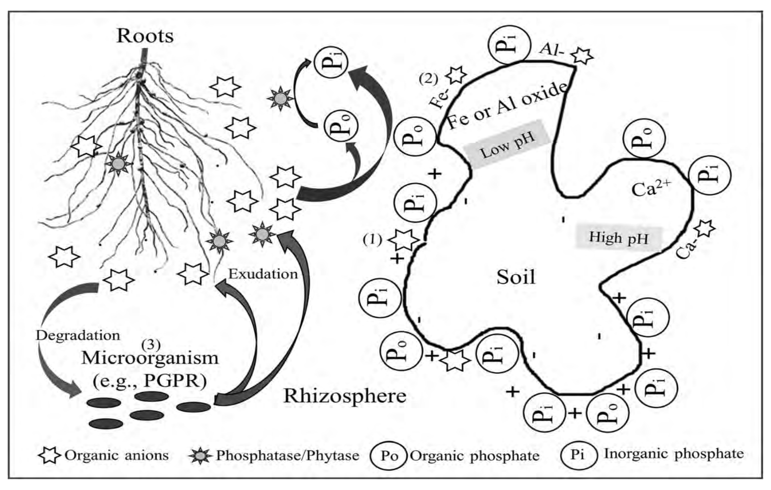
Phosphorus is an irreplaceable element in plant growth and development. It participates in many physiological and biochemical processes in plant life activities. However, compared with other elements such as nitrogen and potassium, phosphorus moves slowly in the soil and is easy to be fixed by soil particles. Compaction stress will further weaken the mobility of soil phosphorus, reduce the absorption and utilization rate of phosphorus by plants, and show an obvious phenomenon of phosphorus deficiency.

Plant response to soil compaction

Root exudates are the products of plant physiological activities and play an important role in plant response to stress, mainly including carbohydrates, amino acids, organic acids, enzymes and so on. Carboxylates (e.g. citrate, malate) can be major components of exudates released by roots, especially under P deficiency. Moreover, it is found that soil compaction stress can stimulate plants to release organic acids, and the composition and content of organic acids released by different genotypes are different.

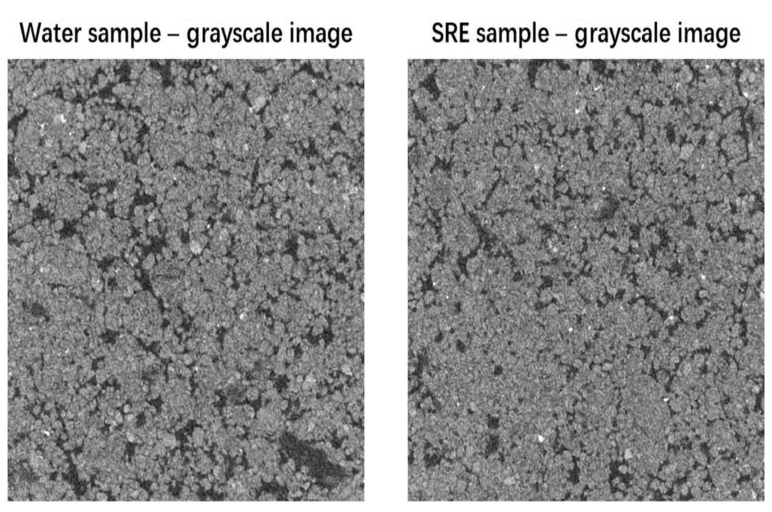
The effects of organic anions on soil P mobilization

organic anions can increase soil P availability by competing for sorption sites with inorganic and organic P, ligand-promoted mineral dissolution, and stimulating plant growth-promoting microorganisms .



The effects of organic acids on soil microstructure

Root exudates will constantly change the physical properties of the surrounding soil, resulting in differences in soil aggregate quantity, stability and porosity (McCully, 1999). The effect of root exudates on the microstructure of root-soil interface can greatly affect the diffusion and migration of phosphorus to the root surface, and then affect the efficient use of phosphorus by roots (van Veelen et al., 2020).



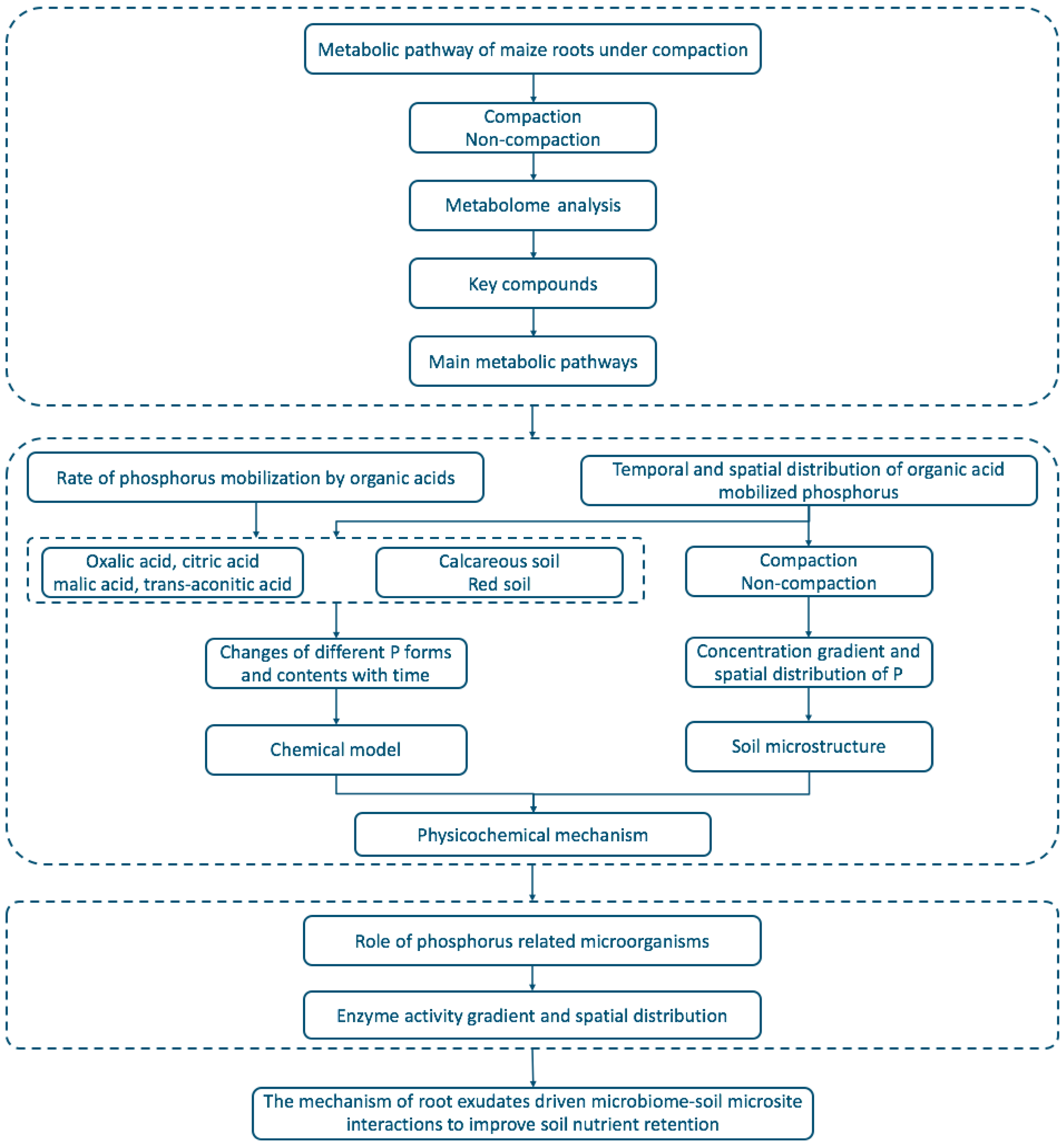
In this study, we will explore the key compounds secreted by maize under compaction stress, the mechanism of these compounds changing soil microstructure and affecting phosphorus release through soil chemical reaction, and the role of microorganisms in this process. This project will help us to answer the question that how root exudates drive microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity.

(FAO, 2016; Lambers *et al*.,2006; Wang and Lambers, 2020; Zhang *et al*., 2020)

Objectives

- Exploring the key metabolites and main metabolic pathways of different genotypes of Maize under compaction stress.
- Clarifying the effects of different low molecular organic acids on the mobilization rate of phosphorus in different soil types and its chemical mechanism.
- Exploring the effect of low molecular organic acids on the temporal and spatial distribution of phosphorus and its chemical mechanism.
- Clarifying the role of phosphorus-related microorganisms in the mobilization of phosphorus by organic acids.

Methods



1. Study on the composition and key Compounds of maize root exudates of different genotypes under compaction stress.

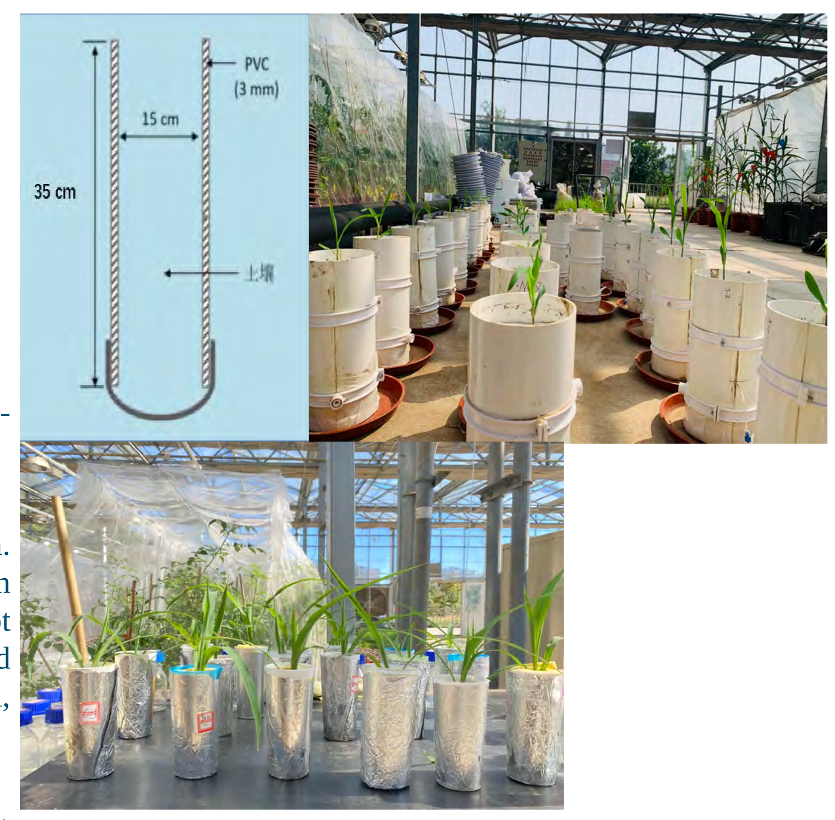
Experimental sites
Greenhouse of China Agricultural University

Maize variety
CIMBL92 (High secretion), 7327 (Low secretion)

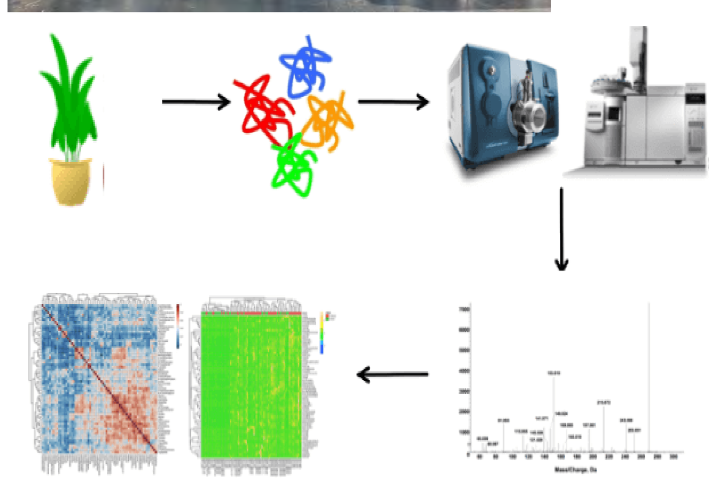
Soil
Calcareous soil

Treatments
Compaction (soil bulk density is 1.3 g cm^{-3}) and non-compaction (soil bulk density is 1.6 g cm^{-3})

Cultivation
After germination, the corn is cultured in PVC soil column. Each treatment is repeated in 6 pots, and 2 seeds are sown in each pot. One seedling with relatively consistent growth is kept within 5 days after emergence. Two pots of natural and compacted soil columns without corn were set as blank control, with a total of 28 pots.



Collect root exudate solution
Sampling at the third leaf stage of maize: take out the plant roots from the soil, wash them, immerse them in a light proof container filled with sterile deionized water, continuously collect them for 2 h, filter the collected solution, freeze them in a refrigerator at - 80 ℃, dry them into powder with a vacuum freeze dryer, and store them until non targeted metabolome determination.



Acknowledgements

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

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Increase nutrient adsorption: Effect of root exudates on soil particle characteristics and nutrient absorption

PhD candidate: Man pu
Supervisors: Walter Schenkeveld (WUR), Liping Weng (WUR), Kemo Jin (CAU), Rob Comans (WUR)

Background

Food production is being threatened by global developments, which requires us to expand global crop production. To increases crop yields, it is important for plants to take up nutrients from the soil. And root exudates play a critical role for plants in improving their nutritional status (Tu et al., 2000). The organic compounds released by the root system mediate multilateral interactions in the rhizosphere, where plant roots constantly adapt to and change their immediate surroundings and have various effects on soil structure (Badri & Vivanco, 2009; Traoré et al., 2000).

Previous studies have investigated the main components of root exudate in different plants. For example, Tu et al. (2000) pointed out that low molecular weight organic acids like citrate and oxalate, as well as (phyto)siderophores are mostly found in maize root exudates. Other studies have demonstrated that apart from released ions (i.e. H+), inorganic acids, oxygen, and water, root exudates mainly constitutes of carbon-based compounds (Bais et al., 2006; Uren, 2000). These organic compounds can often be separated into two classes: low-molecular-weight compounds, which include amino acids, organic acids, sugars, phenolics, and an array of secondary metabolites, and high-molecular-weight compounds like mucilage and proteins (Kothandaraman, 2003). Distinct plants release different root exudates. We are more interested in the main compounds of root exudate for maize under specific conditions. Some research studies have linked particular root exudates to specific functions, such as the acquisition of nitrogen, phosphorus, potassium, zinc and iron (Kraffczyk et al., 1984; Linkohr et al., 2002; López-Bucio et al., 2003; Moog et al., 1995). However, these studies only focus on one factor's link with maize root exudates and did not connect multiple relationships, thus a comprehensive research is still required. Therefore, the goal of this study is to fill the gap of identifying the primary components of maize root exudates in the soils.

Most dynamic interactions occur near the plant roots and at the root-soil interface, the area called the rhizosphere (Bais et al., 2006; Barea et al., 2005; Lynch et al., 2001). Although the quantities of organic compounds exuded from roots into the rhizosphere are not large, seldom exceeding 0.4% of the carbon photosynthesized, they do exert a very strong influence on the soil structure and properties, which may be significant in affecting plant nutrient availability (Rovira, 1969). For example, root exudates can enhance soil structure, accelerate weathering of soil minerals, increase soil CEC, and influence soil pH, sorption properties of the soil surface, and soil nutrient retention and supplication (Tu et al., 2000). In this study, we are most interested in the underground interaction linked to soil particles, particularly the impacts of plant root exudate compounds on the physical structure and chemical properties of rhizosphere soil, as well as the corresponding influence on the release and supply of different nutrients.

Two critical nutrients for plant growth are iron (Fe) and phosphate (Pi). Both have diverse effects on plant development, and their absence causes a variety of physiological problems, resulting in a significant drop in crop yield. The chemistry of these two elements is intricately linked, as phosphate in the soil spontaneously binds to ferric oxides (produced by aerobic conditions seen in most agricultural soils) to form insoluble complexes that can no longer be absorbed by the plants' import systems. Phosphate or iron concentrations in the environment (as a result of interaction with the soil surface, for example) have a direct impact on the bioavailability of the second element. As a result, it's not surprising that the Fe/Pi combination, in addition to its chemical interactions, stimulated adaptive responses in living beings. Plants, for example, deal with iron shortages by secreting organic molecules like malate or citrate, which release complexed iron. Researchers have made significant progress in understanding the composition of root exudates and their interactions with soils in rhizosphere in recent years (Kothandaraman, 2003; Neumann & Romheld, 2000). Bertin et al. (2003) pointed out that the secretion of chemicals by plant roots is assumed to be a passive process mediated by three distinct pathways: diffusion, ion channels, and vesicle transport. However, the mechanisms of these relationships between root exudates and soil particles in the rhizosphere are yet unknown (Badri & Vivanco, 2009).

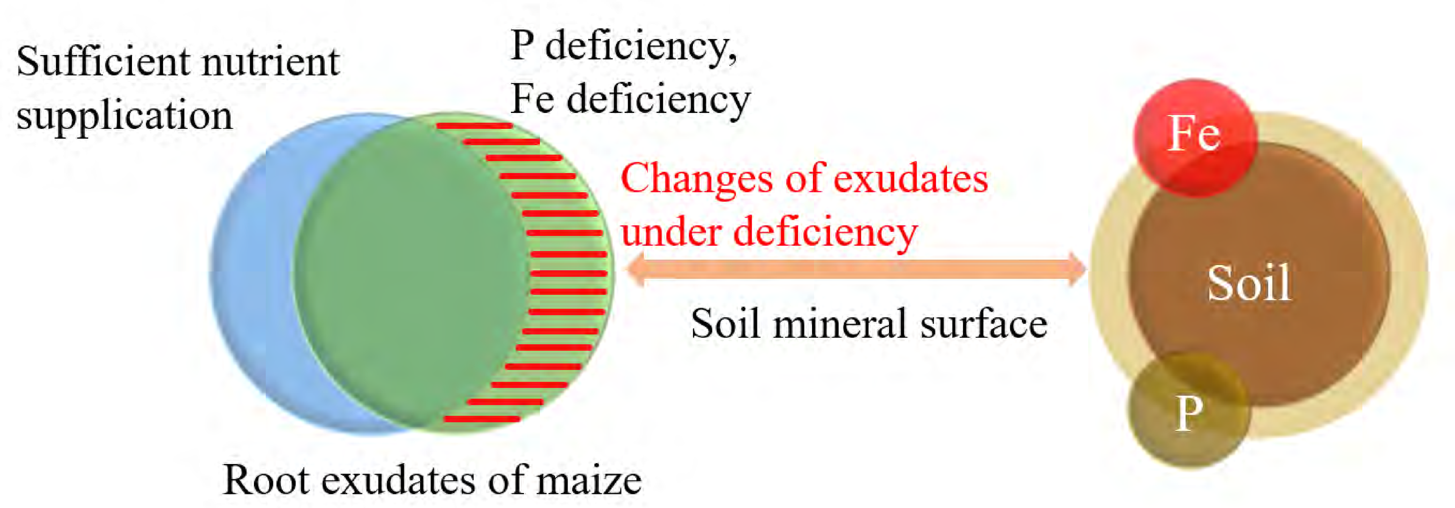

Figure. project framework

Objectives

1. Identify the main compounds in root exudates under phosphorus deficiency and iron deficiency.
What are the constituents in maize root exudates that are upregulated under conditions of phosphorus and iron deficiency?

2. Determine the interaction of exudate constituents with reactive mineral surfaces.
How do surface properties of soil minerals affect the interaction with different types of exudate constituents released in relation to P and Fe deficiency? Specifically, the adsorption of the exuded compound and the mobilization of the target nutrients P and Fe will be examined. The influence pH, Ca concentration, humic substance and P surface loading, and different types of exuded compounds (LMWOA, siderophores, etc) will be considered.

3. Determine the effect of soil properties and environmental conditions (temperature/SSR) on synergistic Fe mobilization by ligands and reductant.
Synergistic Fe mobilization by ligands and reductants has been established for a single calcareous soil. Is this a general phenomenon that applies to all soils, and how does its extent relate to different (types of) root exudate constituents, soil properties and environmental/experimental conditions?

4. Determine the effect of released root exudate constituents on the increasing in phosphorus availability in soils.
It will be examined how the directly available ($CaCl_2$) and potentially available (AmOx) P-pools change as a result of application of different (types of) root exudate constituents to soil, how this change develops over time and how it relates to soil properties. Also, the potential for synergistic effects will be explored.

5. Determine the synergistic effects between different (types of) exudate constituents in mobilizing nutrients from reactive mineral surfaces.
Can different types of root exudate constituents mobilize more nutrients when applied as a mixture, compared to the sum of the nutrient mobilization when the constituents are applied separately? Different mixtures will be considered.

Methods

1. Hydroponic experiments
Collected root exudate of maize from different growth stage in hydroponics will be examined to establish the dynamic of composition of different types of root exudate under phosphorus deficiency (10 μM) and iron deficiency (without iron).
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 description
Interaction of root exudate compounds with soil will be estimated in a modelling system.
Metal speciation (Fe) 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).

3. Adsorption experiments
Adsorption kinetics of root exudates will be examined to establish the time required to reach adsorption equilibrium, in order to interpretate the phosphorus and iron mobilization capacity of root exudates in soils.

Acknowledgements

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

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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

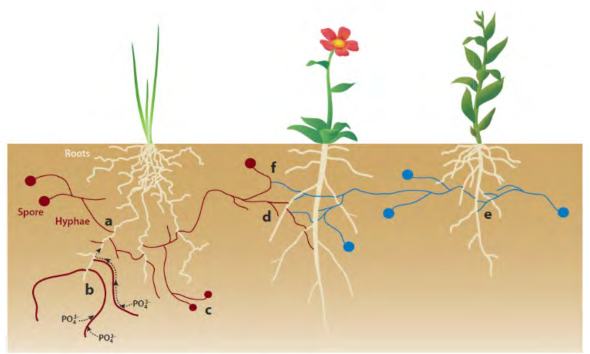
Arbuscular mycorrhizal (AM) fungi can colonize more than 80% of land plants, recent studies have shown the existence of a microbial community on the surface of extraradical hyphae and spores (Iffis et al., 2016). Similar to the microbiome in the rhizosphere of plants, the microbiome associated with AM fungi will have important functions in biogeochemical processes of various mineral elements and therefore plant nutrition and performance.

During the co-evolution with plants, AM fungi have lost some saprophytic function genes, such as genes encoding plant cell degrading enzymes and phytase (Morin et al., 2019). 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, such as stimulating spore germination, mycelial growth and facilitating colonization (Frey-Klett et al., 2007). However, the molecular mechanism that MHB promotes the establishment of symbionts is still rarely studied.

On the other hand, our group have already showed that different AM fungi co-colonizing on a single plant root recruit distinct microbiomes (Zhou et al., 2020). And different combinations of plant-AM fungi also habour distinct hyphosphere bacteria. But how plants-AM fungi regulate hyphosphere bacteria, the mechanism underlying is still unclear.

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.

Objectives



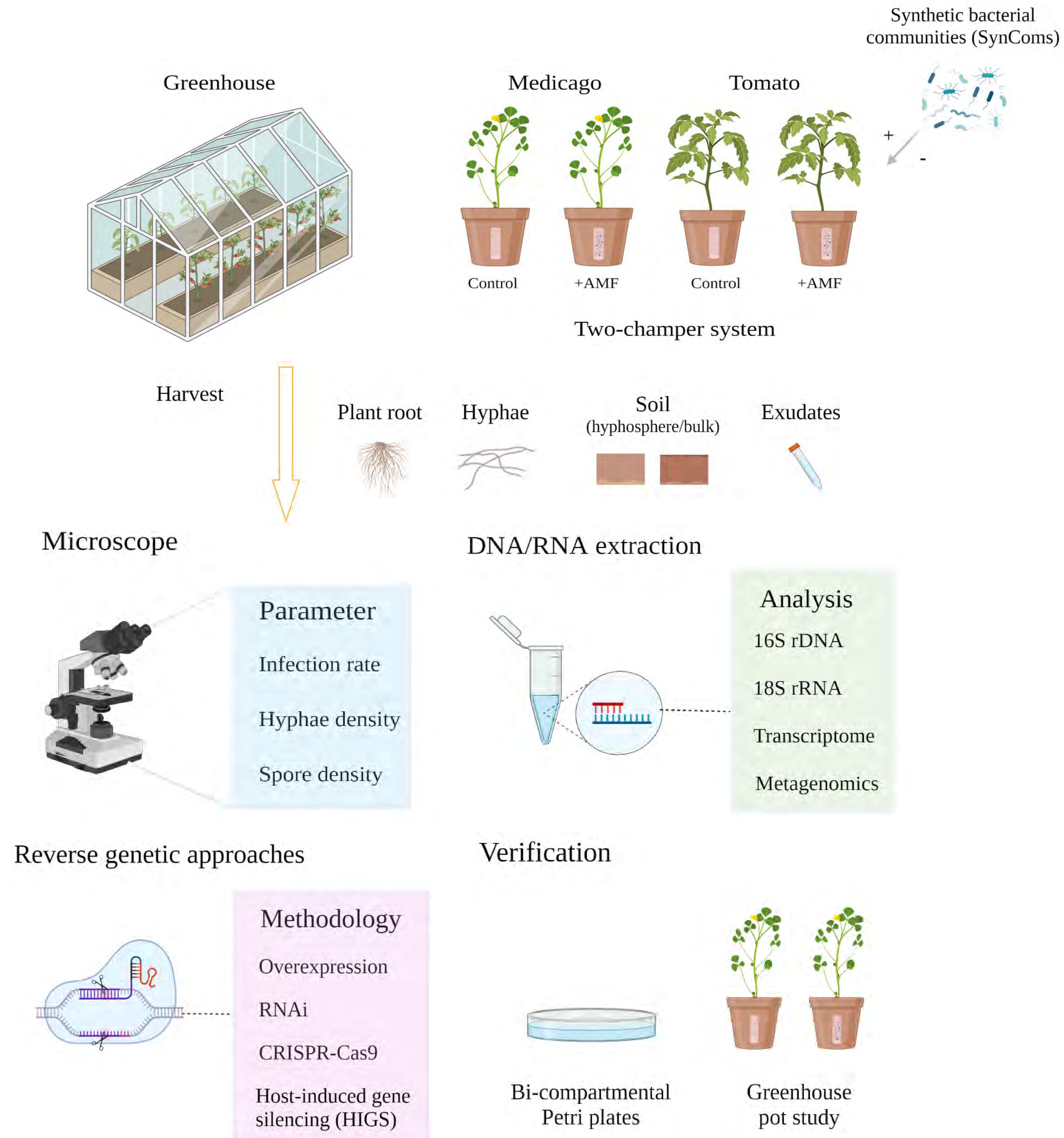
In this project, I want to use different host and AM fungal species to
1) identify the diversity and function of bacteria in AM fungal hyphosphere,
2) reveal how plant and AM fungi shape the hyphosphere microbiome at the genetic and metabolic levels;
3) uncover the mechanisms by which hyphosphere bacteria influence the fitness of AM fungi and the plant colonization.

Framework

How plant-arbuscular mycorrhizal fungi-bacteria tripartite interaction promote AM symbiosis and plant performance

WP1	Analysis of the function and diversity of culturable bacteria in hyphosphere	Isolation; Function analysis; Build synthetic bacterial communities
WP2	The influence of hyphosphere interactions on symbiotic performance	Two-champers system; Biomass; infection rate; transcriptome
WP3	The mechanism by which plants and AM fungi shape the hyphosphere bacteria	Reverse genetic approaches; Host induced gene silencing (HIGS)
WP4	Molecular mechanisms underlying mycorrhizal helper activity	Untargeted metabolomics; Reverse genetic approaches

Conceptual model



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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Acknowledgements

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

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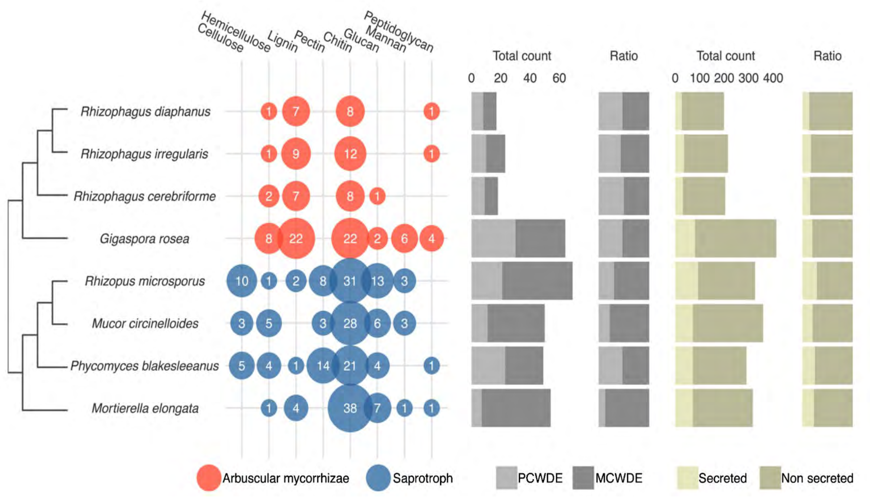
Unraveling mechanisms for arbuscular mycorrhizal fungi recruit and activate hyphosphere bacteria to improve plant phosphorus uptake

PhD student：Zihang Yang

Supervisor：Lin Zhang, Gu Feng, Erik Limpens, Cheng Xu

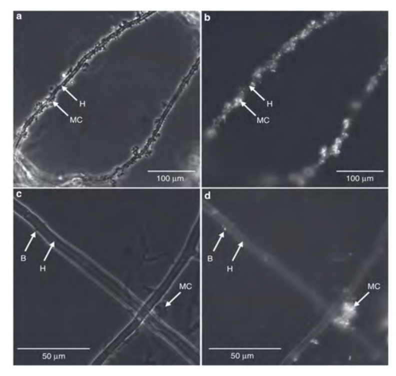
Background

- 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).



(Morin et al., New Phytologist, 2019)

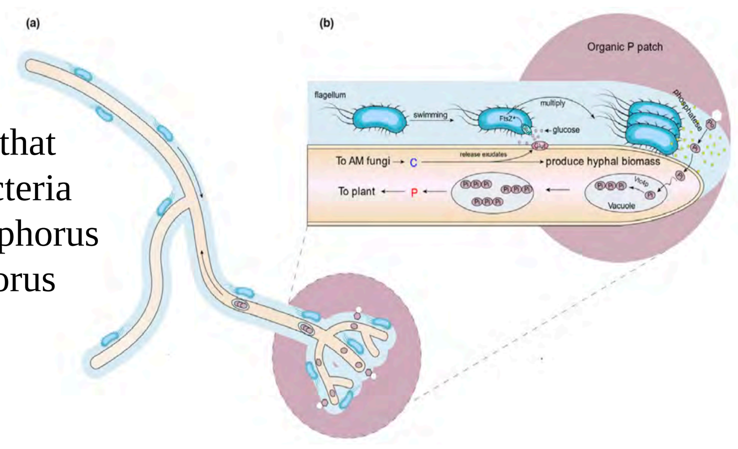
- During the co-evolution with plants, AM fungi have lost some saprophytic function genes compared with other filamentous fungi, such as genes encoding plant cell degrading enzymes and phytase (Tisserant et al., 2013; Morin et al., 2019). This suggests that AM fungi have relatively weak abilities to directly mobilize soil organic nutrients compared with other kinds of fungi (Zhang et al., 2021).



(Scheublin et al., ISME, 2010)

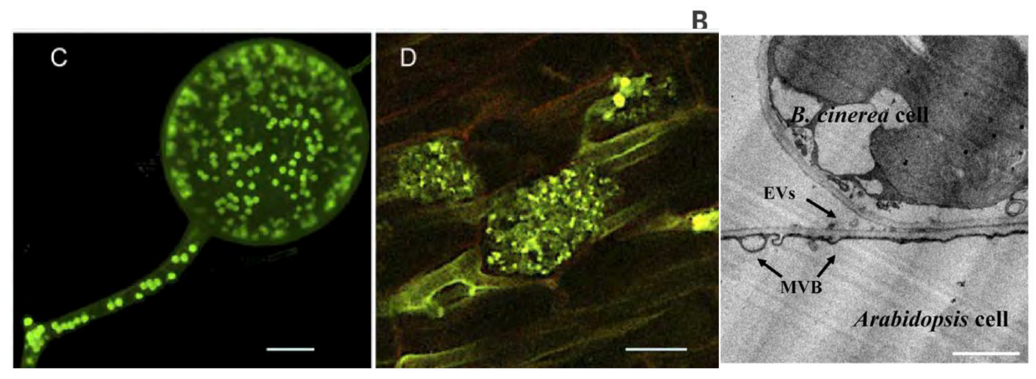
- By colonizing the hyphosphere of AM fungi, soil microbes may significantly increase the turnover of soil organic nutrients (Falkowski et al., 2008), which complement the capabilities of AM fungi.

- Recently research found that AM fungi can recruit bacteria to mobilize organic phosphorus to improve plant phosphorus uptake.



(Jiang et al., New Phytologist, 2021)

? The mechanisms by which hyphosphere bacteria are recruited and activated to improve plant phosphorus uptake are still less understood.



(Emilie Tisserant et al., PNAS, 2013; Cai et al., Science, 2018)

- 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.

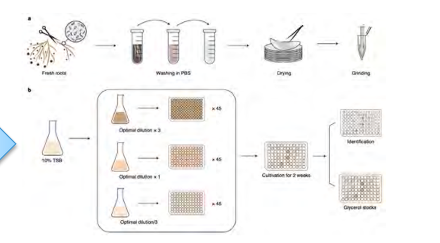
Objectives

- 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.

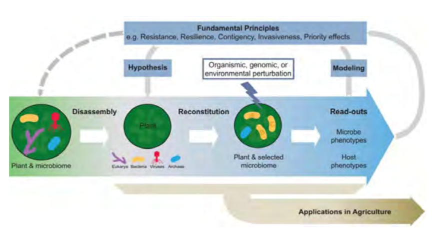
Framework

AM fungi recruit and activate hyphosphere bacteria mechanism

1 Construction of a library of hyphosphere bacteria → High-throughput cultivation and building SynComs

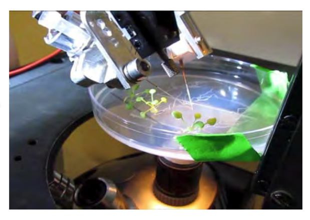


High-throughput bacterial isolation



Build SynComs

2 The mechanisms of AM fungi recruit bacteria to improve plant phosphorous uptake → Influence mechanism of key substances on hyphosphere bacteria



NanoDESI

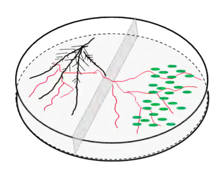
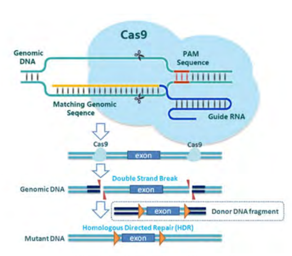


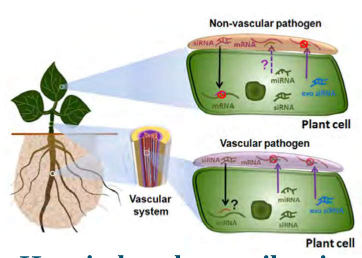
Plate experiment

Pot experiment

3 Genetic manipulation of AM fungi and its influence on the hyphosphere microbiome → The molecule mechanism of AM fungi influence hyphosphere microbiome.

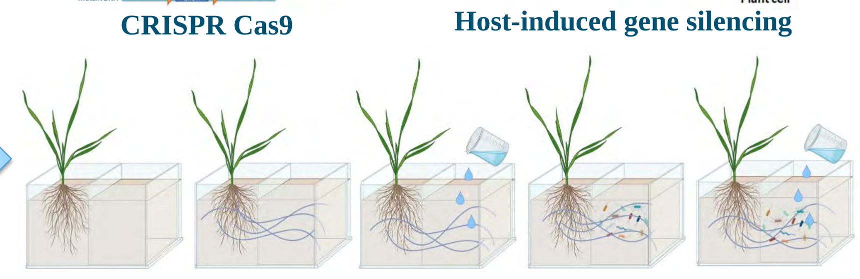


CRISPR Cas9



Host-induced gene silencing

4 Regulation hyphosphere microbial community and improving plant phosphorus nutrition → Contribution of hyphosphere microbiome to plant phosphorus uptake



SynComs contribution rate

Construction of a library of hyphosphere bacteria

- [exp1] Use maize, barley, potato as crops and *Medicago truncatula* as a model plant to set up a pot experiment. Four different AM fungi were inoculated, respectively. Separate the hyphosphere bacteria from the fresh soil sample to build a library of hyphosphere bacteria and SynComs.

The mechanisms of AM fungi recruit bacteria to improve plant phosphorous uptake

- [exp2] Bi-compartmented Petri plates will be used to grow axenic *Agrobacterium rhizogenes* transformed maize and Medicago roots and AM fungi. Four different AM fungi were inoculated, respectively. Added SynComs and analyze hyphal extracts and hyphal exudates to acquire key substances which influence AM fungi to recruit bacteria. To test the effects of identified hyphal metabolites on recruitment of bacterial communities, characterized hyphal metabolites will be added to bacterial communities in vitro (plate systems) and in vivo (soil environment).

Genetic manipulation of AM fungi and its influence on the hyphosphere microbiome

- [exp3] Use nano-vesicles to introduce transgene expression to silence genes in AM fungi. Candidate genes for gene silencing (or overexpression) via this approach will be selected based on the metabolic pathway analyses in exp2 and the transcriptome analyses in exp1. Use these plant materials to identify the influence of key substances or SynComs on AM fungi recruiting bacteria.

Regulation hyphosphere microbial community and improving plant phosphorus nutrition

- [exp4] Use pot experiments to add key substances or function SynComs to regulate the hyphosphere microbial community to improve plant phosphorus uptake and identify the contribution rate.

Reveal the mechanism of plant AM fungi recruiting hyphosphere bacteria at the gene and metabolic levels

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Acknowledgements

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

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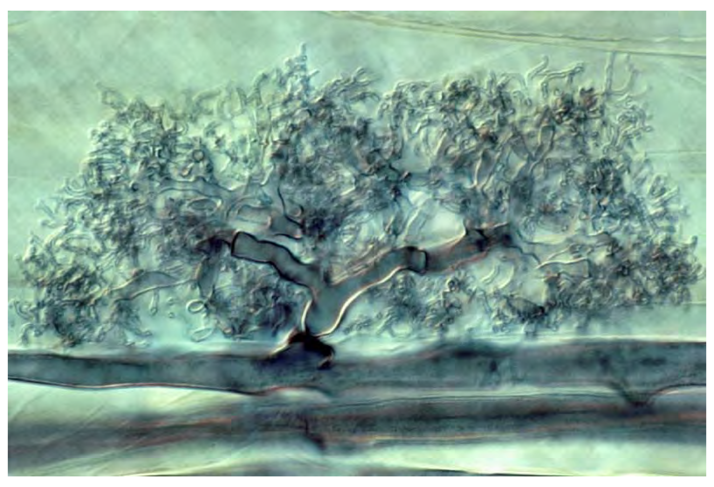
Finding adaptations to an ancient mycorrhizal symbiosis signalling cascade that enables its use in nitrogen-fixing symbiosis

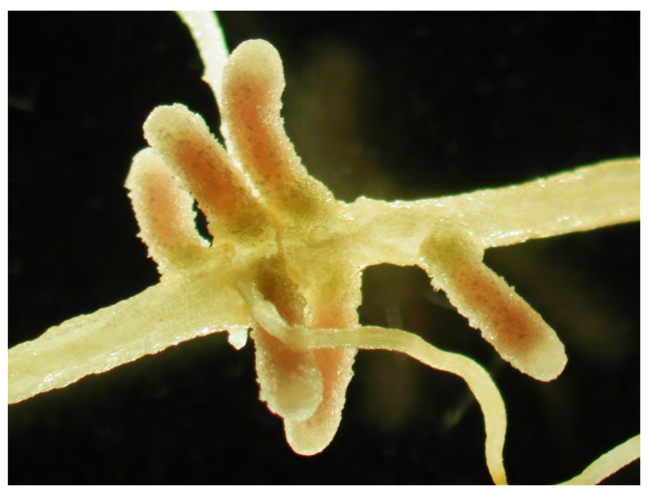
Wenying Huo
Supervisors: Prof. Jianbo Shen, Prof. Bin Ni, Dr. Rene Geurts

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, which increase access to nutrients by forming an extension to the plant roots[1] . Some plant species evolved a 'second love' by cooperating with nitrogen-fixing soil bacteria, providing the plant with an unlimited resource of fixed-nitrogen.

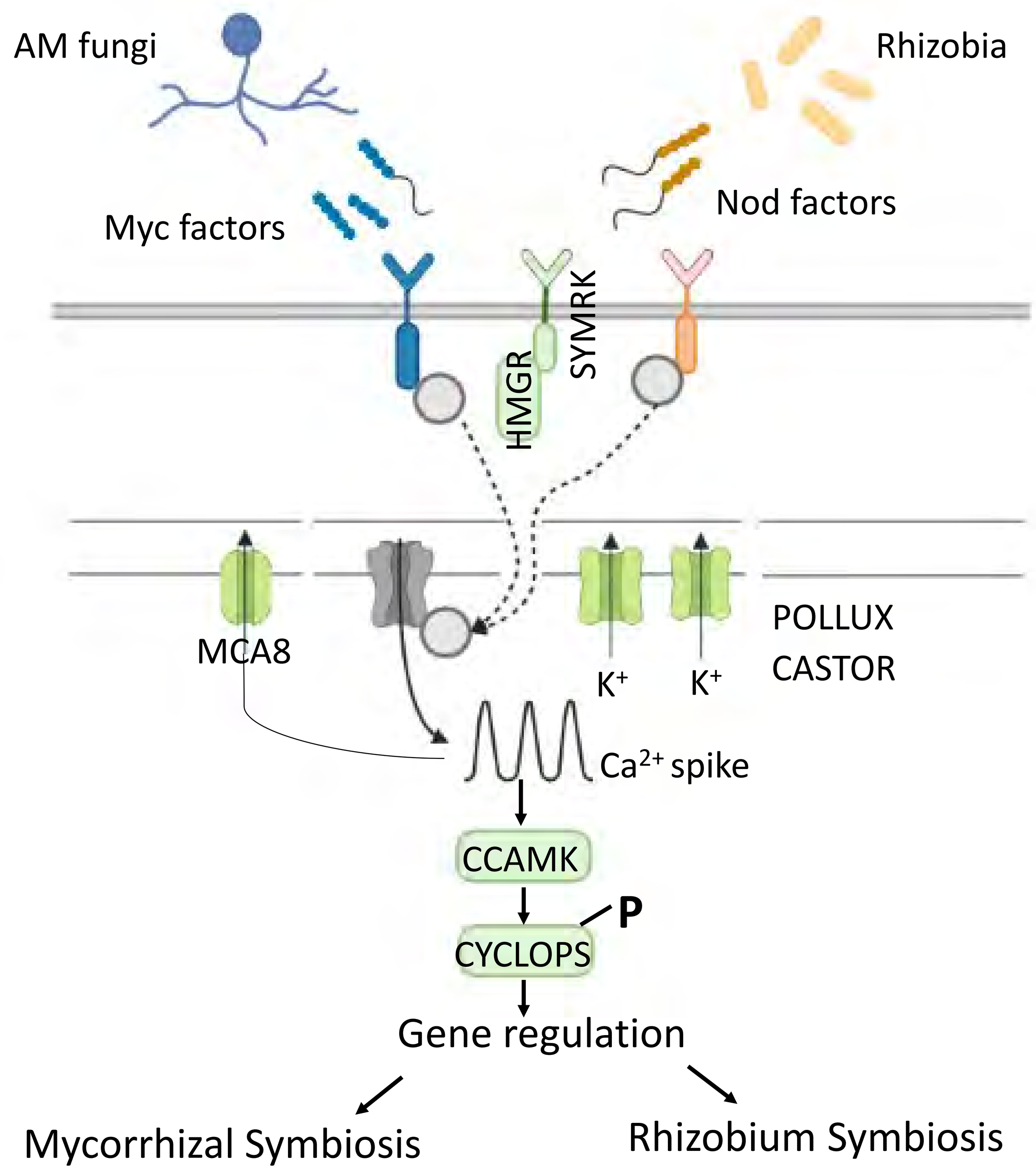


Mycorrhizal symbiosis: arbuscule



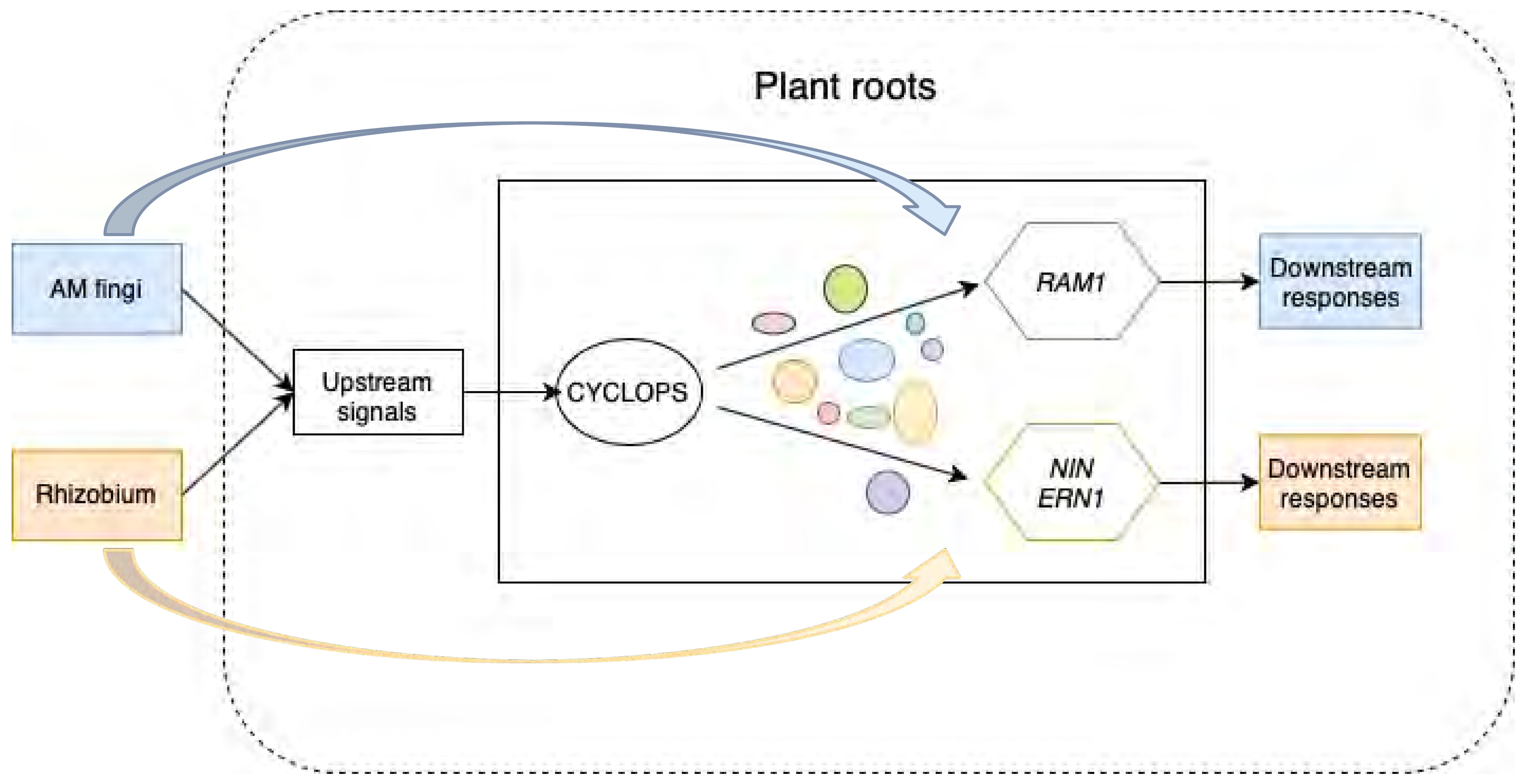
Rhizobium symbiosis: nodules

AM fungi and rhizobia produce signal molecules with similar structures, thereby activating the same signalling network, 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 show little overlap[6-8]. Thus, the co-option of symbiotic signalling in nodulation involves additional signals to enable multiple different outputs and requires genetic adaptations essential to establish nodulation.

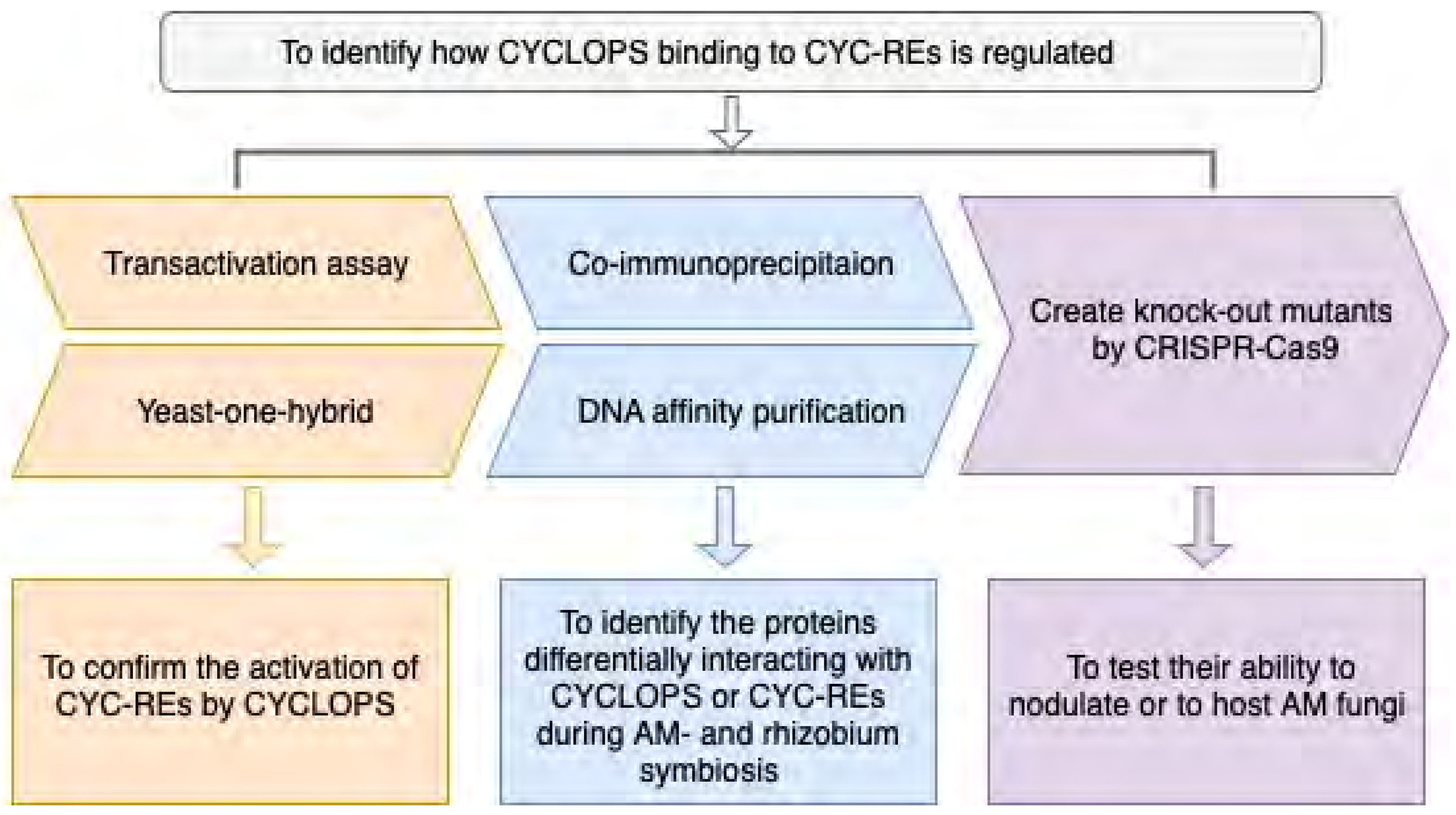
A solid starting point to uncover symbiosis specific signalling, is to understand how downstream targets of CYCLOPS are transcriptionally regulated, which leads to the objectives of this project.



Objectives

- To identify the molecular mechanism that determines which genes are activated by the common symbiotic signalling pathway.
- To identify how CYCLOPS binding to the key cis-regulatory elements in the promotors of *NIN*, *ERN1* and *RAM1* (CYCLOPS-responsive elements, CYC-REs) is regulated.
- To identify the genetic adaptations that allow the specific expression of nodulation genes in response to rhizobia, and engineer this adaptation into crops to reduce the dependence on chemical fertilizers.

Methods



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Acknowledgements

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

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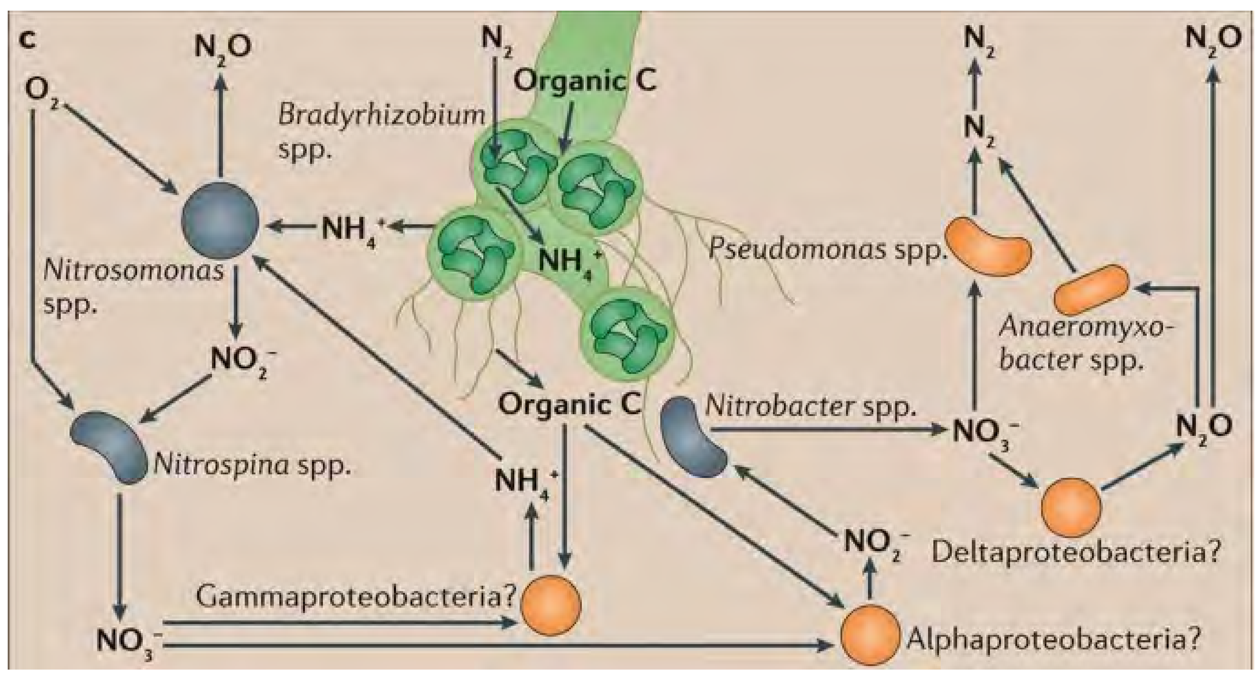
Coordinations between rhizosphere microbiome and root regulate plant nitrogen homeostasis

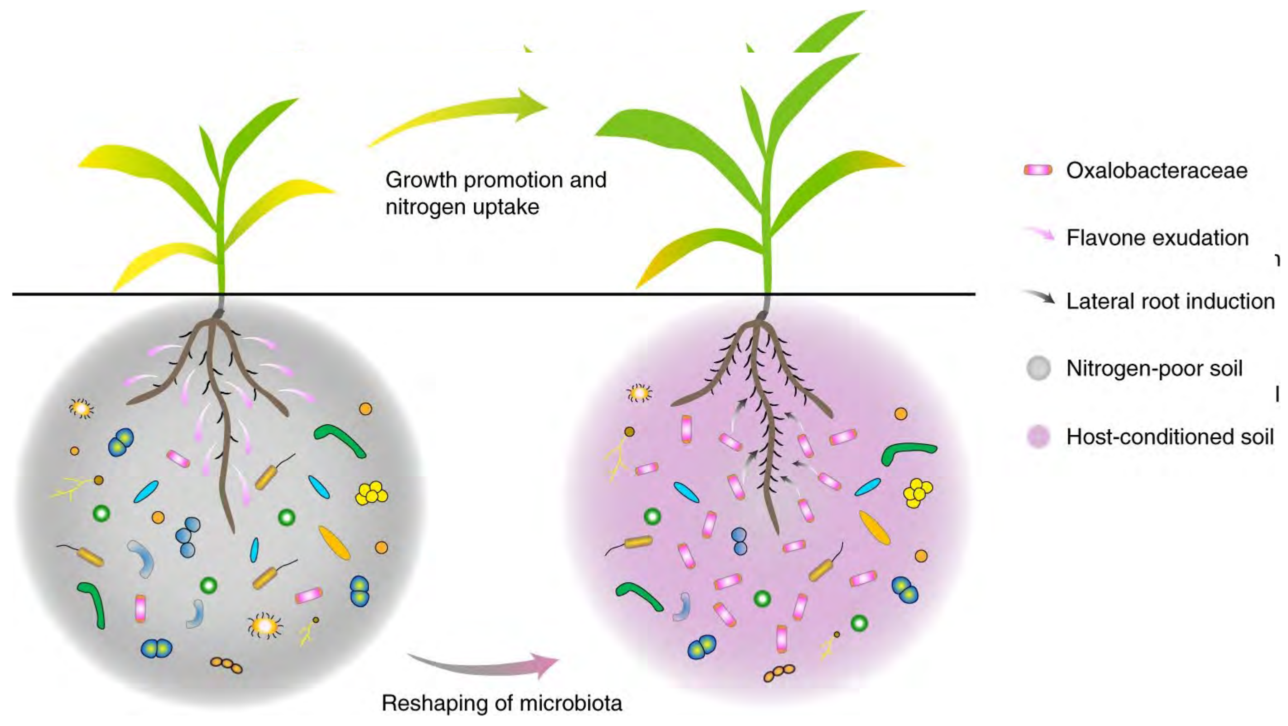
PhD student: Pugang Yu
Supervisors: Prof. Bin Ni, Prof. Jianbo Shen, Dr. Rene Geurts

Background

Nitrogen is an important element of proteins and nucleic acids. In the past decades, the applications of nitrogen fertilizer have greatly improved the yeilds of major food crops. At the same time, overuse of nitrogen fertilizers caused a lot of environmetal pollutions. To achieve the agriculture green development of China, it's time to reduce the applications of nitrogen fertilizer.



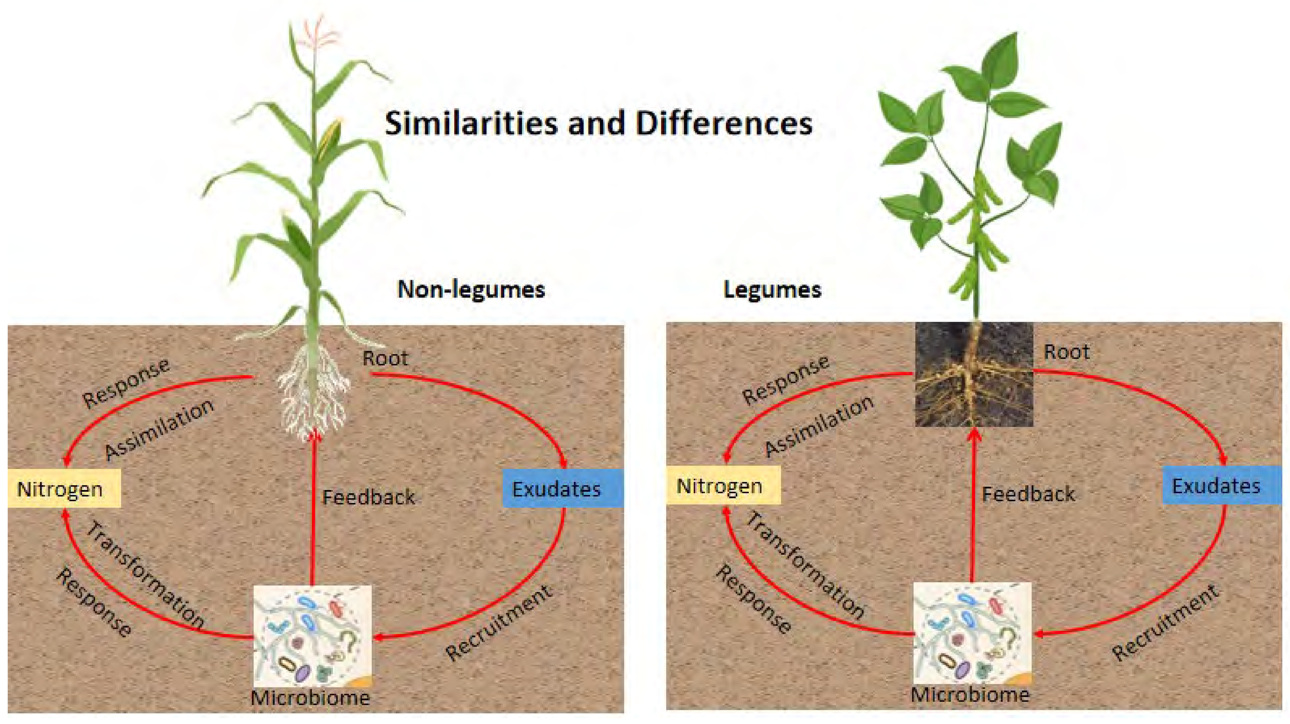
The microbe drives farmland N cycle[1]



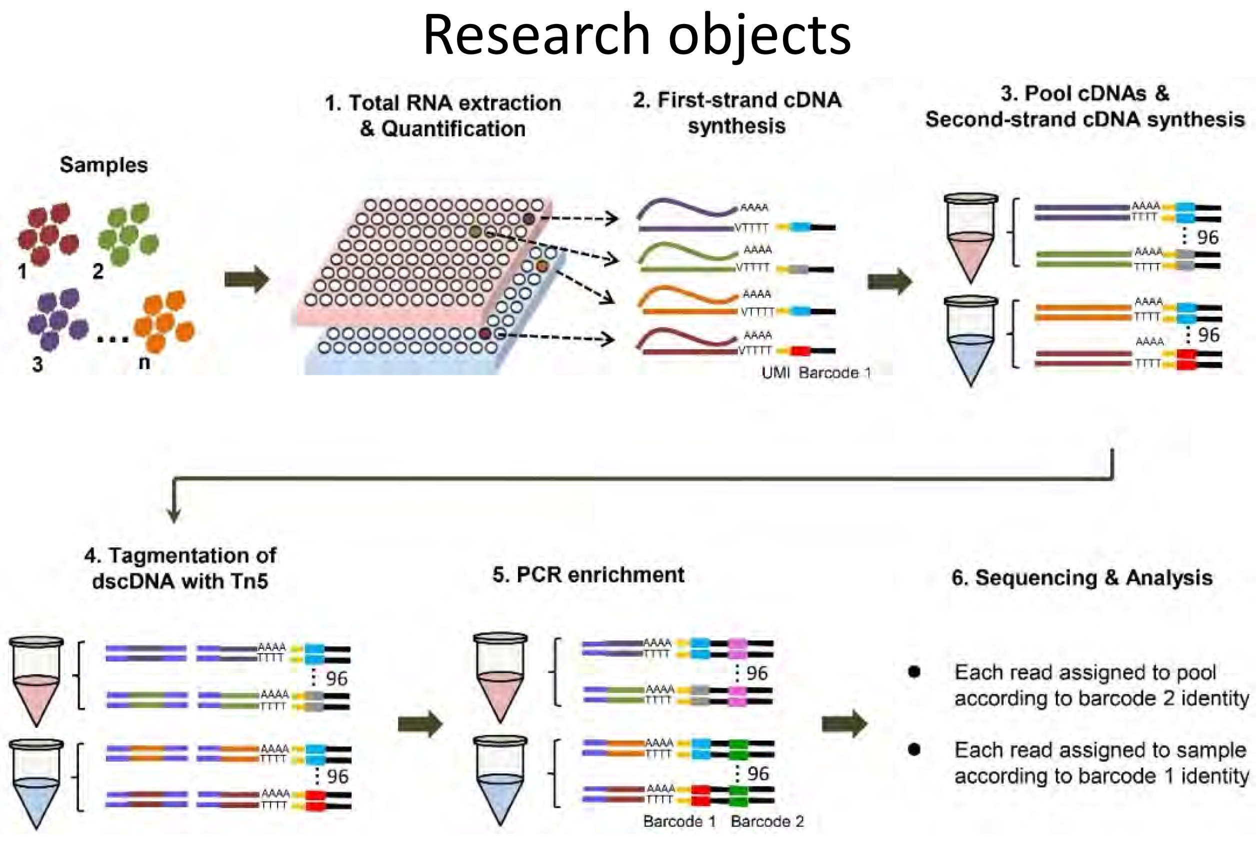
Maize roots recruit *Oxalobacteraceae* to improve N assimliation[2]

Research questions: To understand the coordinations between rhizosphere microbiome and root under different nitrogen levels.

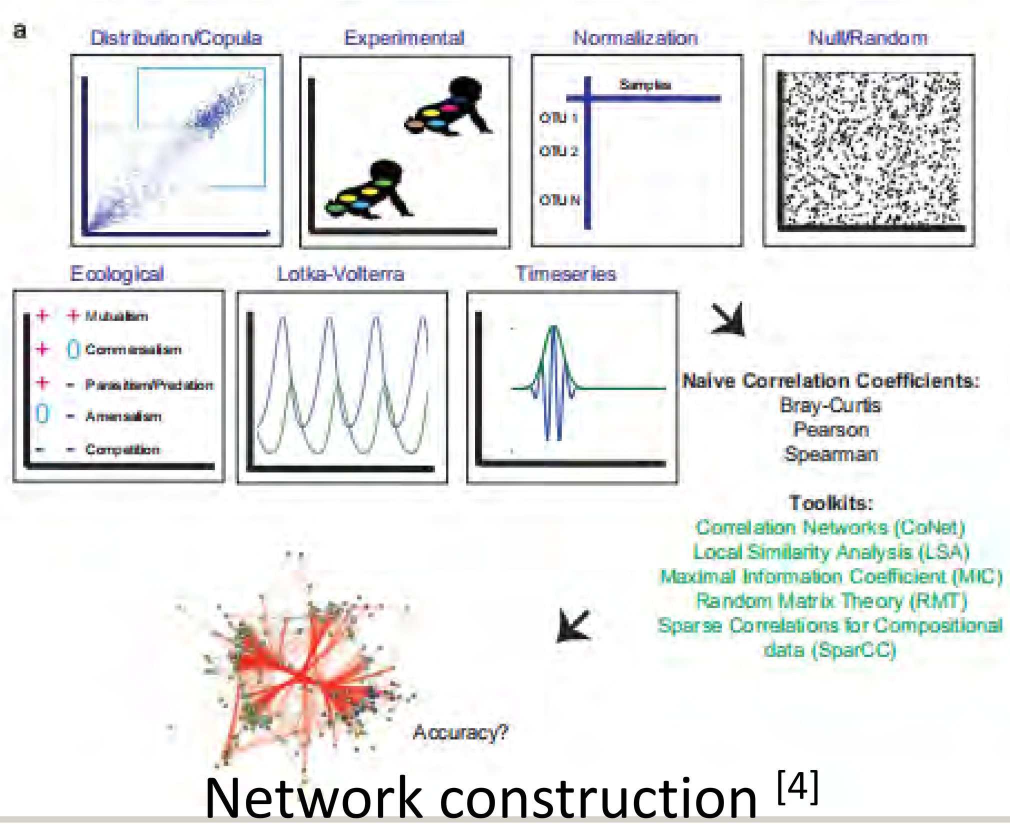
Research methods



Research objects



MP3RNA-seq library construction procedure[3]



Network construction [4]

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

- Based on the research, coordinations between rhizosphere microbiome and plant roots under different nitrogen levels will be partly clarified.
- Based on the theoretical breakthrough, new microbe fertilizer will be developed. Then to partly replace the applications of nitrogen fertilizer.
- To develop new crops systems: maximize the coordination between plants and rhizosphere microbiome.

Reference

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Acknowledgements

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

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Soil N cycling process and microbial metabolic response in long-term wheat-maize rotation system across aggregate size class

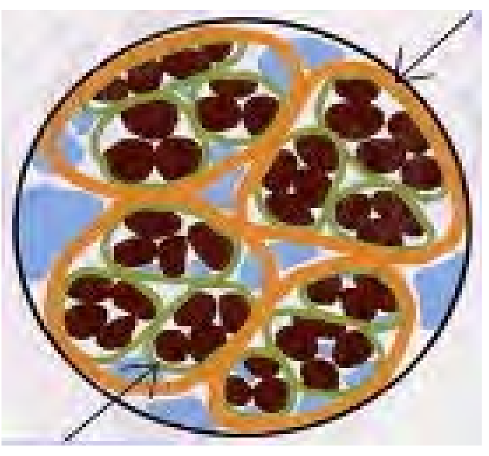
Candiate：Zewen Hei

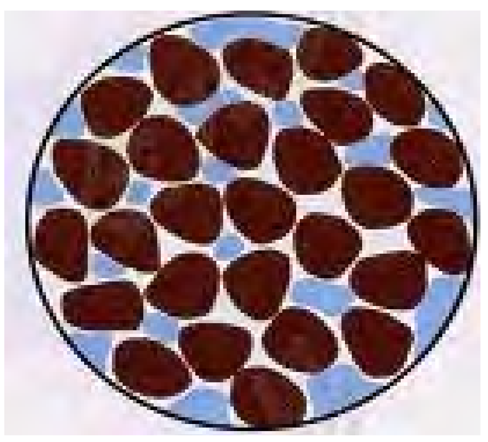
Supervisors: Yongliang Chen, Jan Kammenga, Stefan Geisen

Background

Aggregates

Soil aggregates are important in nutrients turnover, serving as an important niche for microbially mediated soil nutrients cycling and physically protected nutrients sequestration.





Macroaggregates

Bound together with fungal hyphae, roots and polysaccharides, and the fresh soil organic matter, have more oxygen, porosity.

Microaggregates

Have greater physical protection and more recalcitrant nutrients, more suitable for oligotrophs bacterial.

Central question

What's the N cycling function of different aggregate in wheat-maize rotation system？

Important in Science

Aggregates were important in agricultural soil, crop N use efficiency and productivity.

Microbial community and N function gene in different aggregate were not fully understood.

Important in Society

Using agricultural practice (organic fertilizer or no tillage) to:

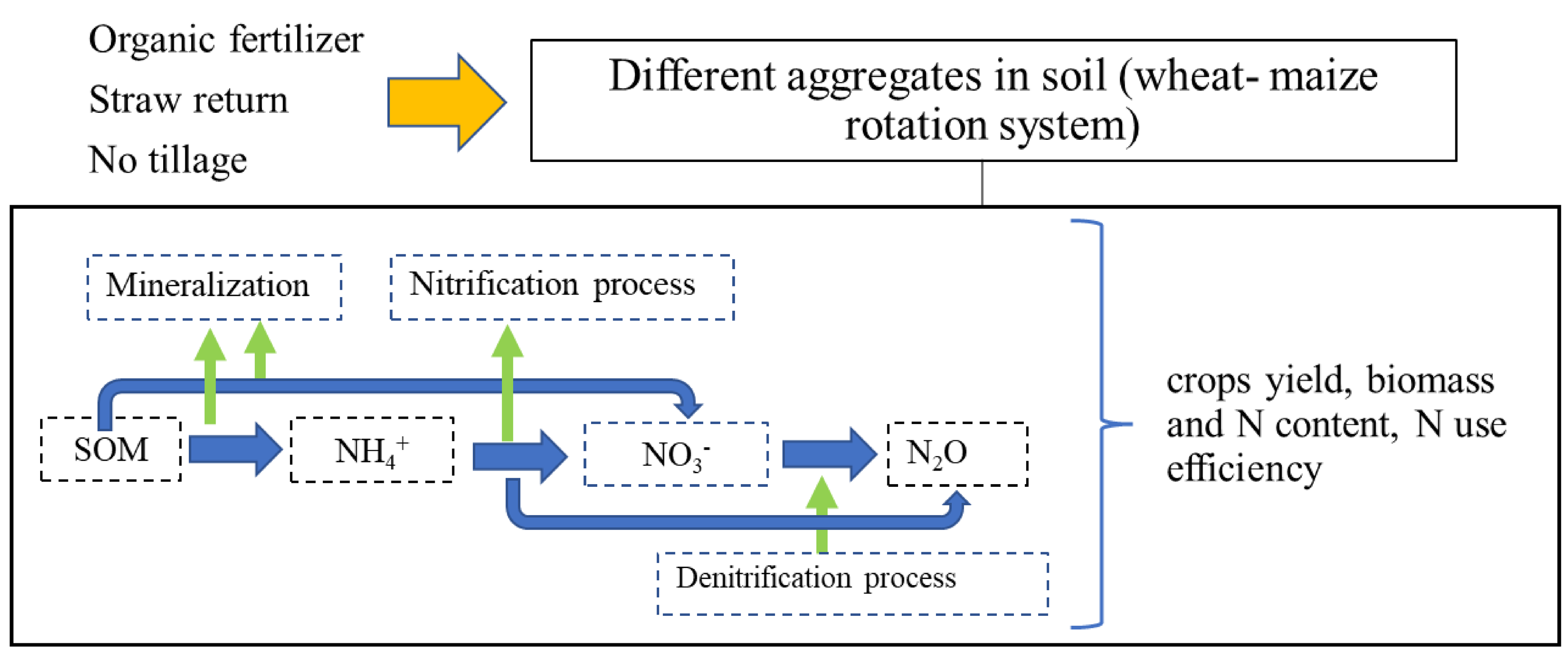
1. Improve the proportion of macroaggregate
2. Protect soil function
3. Increase crop N use efficiency
4. Increase crop productivity.

Objectives

(1) Explore the effect of long-term organic fertilizer, tillage and straw return management on the N transformation process and N_2O emission of different soil aggregates in winter wheat-summer maize rotation system;

(2) Explore the effect of long-term organic fertilizer, tillage and straw return management on the N cycling functional gene and microbial community in winter wheat-summer maize rotation system across different soil aggregates.

Research route



N cycling

Expectation

Revealing the mechanisms of soil N cycling process in winter wheat-summer maize rotation system across aggregates.

Understanding the N cycling microbial process in winter wheat-summer maize rotation system.

Extended the results to N use capacity of crops, and N_2O emission, soil N pools, and global climate change in winter wheat-summer maize rotation system.

Acknowledgements

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

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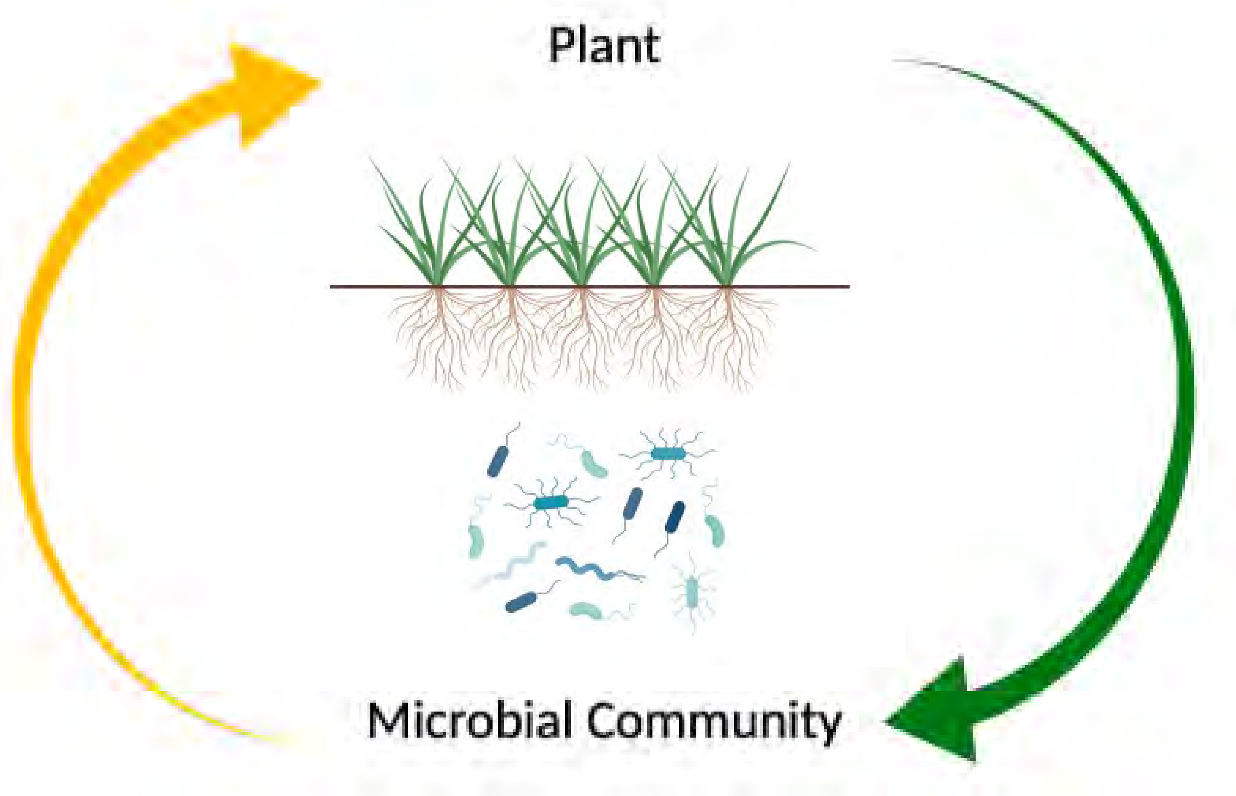
Understanding and manipulating the plant-microbiome interactions to enhance nutrient use efficiency in rotation systems

PhD candidate: Shunran Hu

Supervisors: prof.dr.ir. Jan Kammenga, dr. Stefan Geisen, dr. Yongliang Chen

Background

- High and sustainable production of crops is needed to cope with the expanding world populations, while a concomitant increase in environmental costs also incur nonnegligible problems
- Overusing chemical fertilizer to raise crop yields leads to soil degradation, surface water pollution, and increased greenhouse gas emission.



- With the assistance of rhizosphere microbiomes, plants might perform better in their growth, health, and nutrient absorption while reducing the input of chemicals in agricultural systems
- Therefore, more attention on plant-microbe interactions is needed to understand how can the plant-associated microbiomes bring positive influences to plants and to optimize cultivation in agriculture.

Research Question

How do rhizobiomes interact with crops at different growth stages in rotation systems?

Importance

Science

- Explore the functional importance of rhizobiomes
- Investigate the two-way effect in interactions
- Understand the mechanisms of plant-microbiome interactions

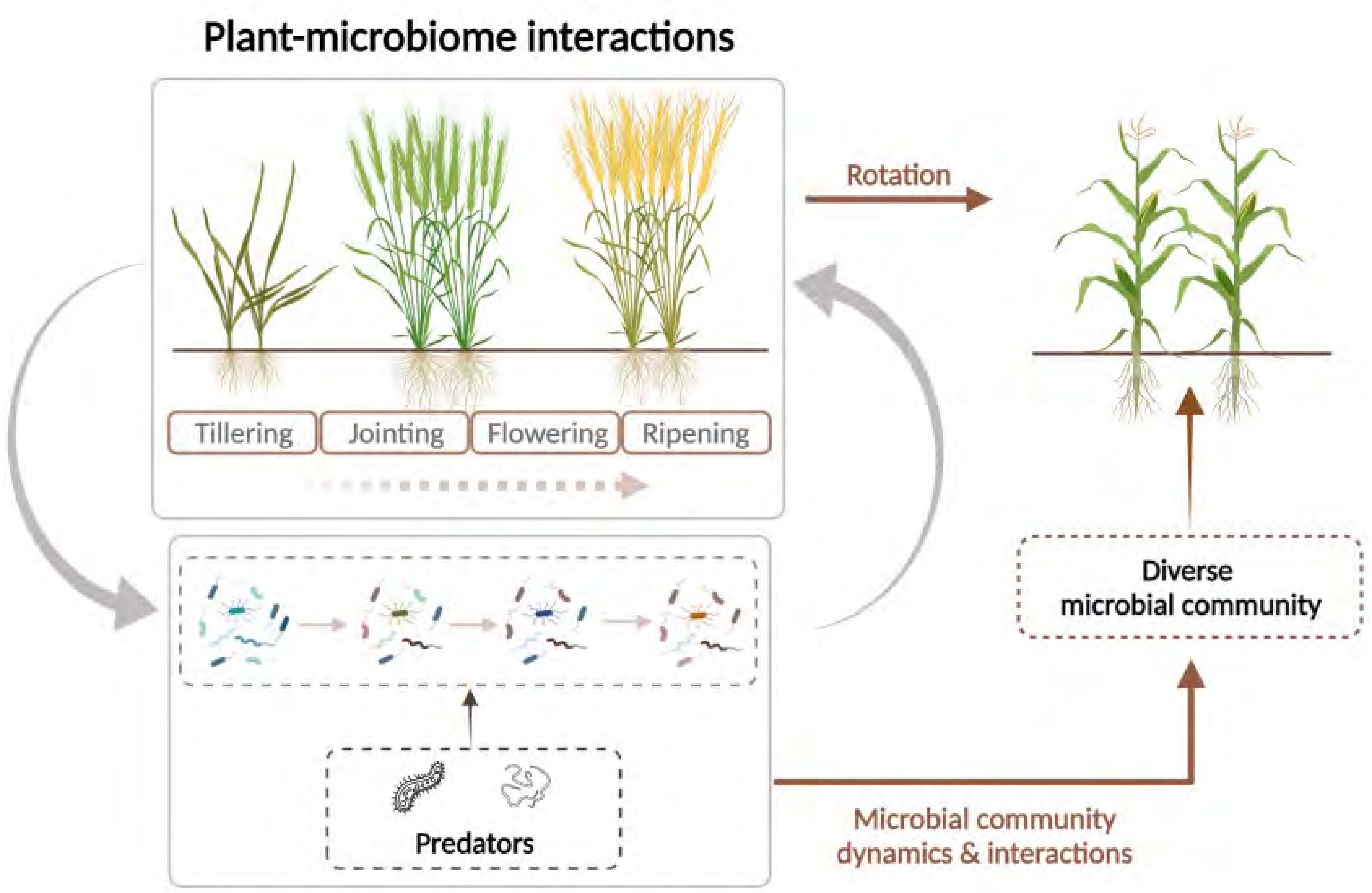
Society

- Enhance productivity and nutrient use efficiency
- Reduce environmental impact

Objectives

- Explore the response of rhizobiomes to higher plant diversity, and their influences on nutrient use efficiency, soil properties, and the growth of subsequent crops in rotation systems.
- Investigate the dynamics of rhizobiomes affected by the interactions with the artificially added microbes, and their influences on crop growth, nutrient use efficiency, soil properties, and greenhouse gas emission.

Research Plan



Expectations

- We investigate the temporal change of the rhizobiomes, which might contribute to understanding how the crops attract or select the microbiomes across different growth stages in rotation systems.
- We hope that a better understanding of the plant-microbiome interactions can help to improve nutrient use efficiency and environmental-friendly management in agriculture via adding specific microbes or developing soil management to contribute to the growth of beneficial microbes in the soil.

Acknowledgements

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

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Summary reports and posters
submitted for the fifth
AGD symposium
12-14 January 2022

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