ANNEX: Priority Topics for the Third AGD-CSC Call, 2020

This document describes the priority topics for the third call of the Agricultural Green Development Program of China Agricultural University and Wageningen University & Research. The AGD program follows three main research themes (Green crop production, green integration of crop and livestock production, and Green eco-environment). For the third call, additional topics are prioritized in order to reach the overall AGD goal. In the following, for each theme, three aspects are included: 1) the overall goal or framework of the theme; 2) a summary of already granted proposals (to identify gaps/focus), 3) the priority topics for the call 2020. The descriptions are on the one hand general, but on the other targeted, to allow applicants some freedom when defining their project proposals.

1. Green crop production: from science to solution

1.1. Overall goals and ambitions of Theme 1:

The overall objective of Theme 1 is to achieve the three pillars of Agriculture Green Development: food and nutrition security, resource conservation and environmental sustainability. Theme 1 projects will conduct fundamentally innovative and trans-disciplinary research to reveal the 'plant-microbiome interactions' mechanisms underlying green cropping system designs, green crop production technologies and healthy soils, with the aim of providing green, efficient, qualified and healthy food products (Fig. 1). The aim is to identify systematic and integrated technologies through long-term field experiments, and in farmers' fields associated with Science & Technology Backyards (STB). Field- and farm-level knowledge can then be upscaled to Quzhou county and the North China Plain to provide regional solutions.

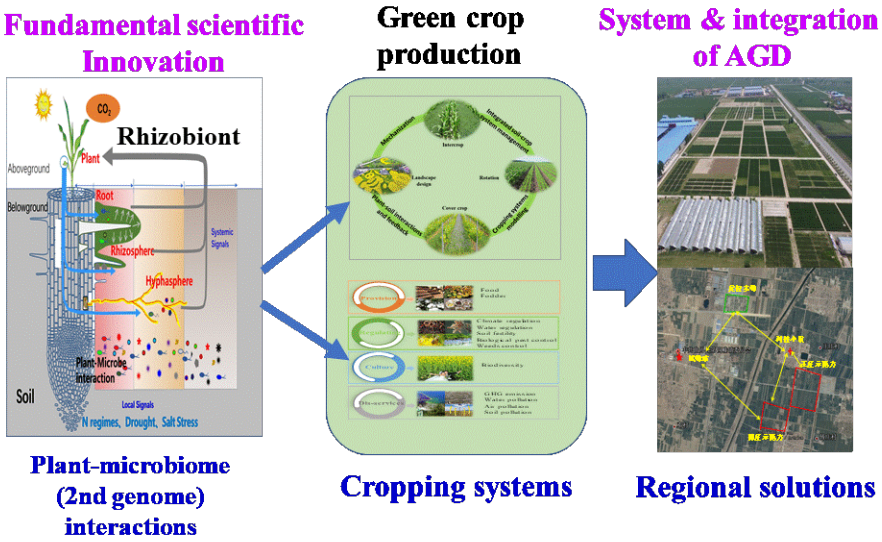

Fig. 1. Theme 1 theoretical framework: from fundamental research to green cropping systems, to regional solutions

1.2. Summary of already granted proposals

Theme 1 now includes 9 funded projects: 4 proposals (1st round) and 5 proposals (2nd round) (Fig. 2). The topics range from rhizosphere ecology, to green crop genotypes, aboveground-belowground interactions, green cropping systems, green crop production technologies and soil health. The projects can be classified into three blocks: 1) fundamental scientific innovation; 2) sustainable cropping systems design and crop production techniques optimization; and 3) regional examination and solutions at farmers' field scale. Within the fundamental innovation, current projects focus on understanding the interactions between plant and soil pathogens within predominant wheat-maize cropping systems (P1), integrating functional structural root modelling and breeding to increase nutrient use efficiency (P2), and creating multifunctional soils by synergizing aboveground and belowground interactions (P8). Within sustainable cropping systems and green production technologies, current projects emphasize on designing cropping systems to achieve multiple objectives from yield, resources, environmental sustainability and ecosystem services using modelling approaches, decision-making tools and social-economical approaches (P4-P7). Green production technologies include one project (P9) focusing on adapting robotic harvesters for efficient crop production. Within regional examination and solutions at farmers' fields, Project 3 will link field measured soil attributes to ecosystem functions and applying the developed models to facilitate farmers to make decisions.

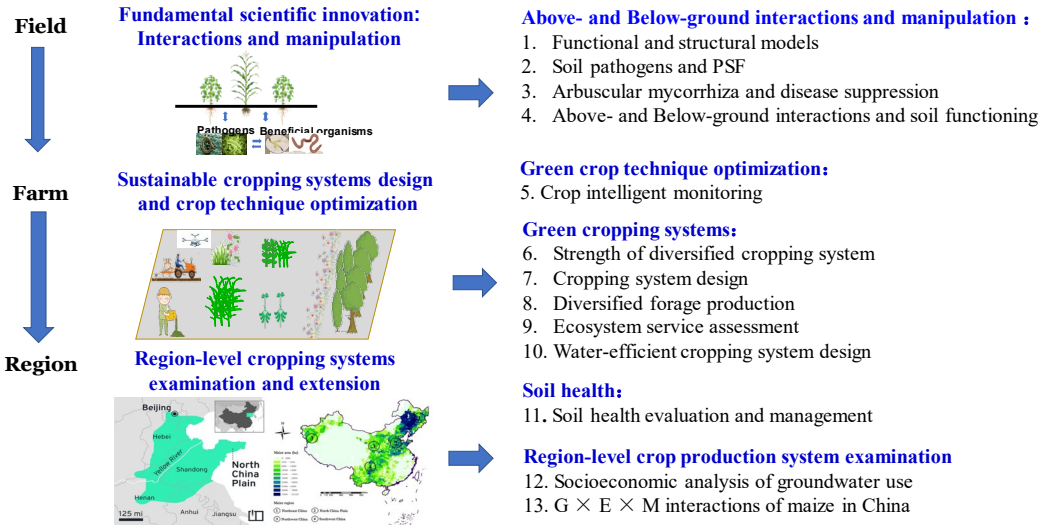

Fig. 2. Overview of current AGD-CSC PhD projects under Theme 1

1.3. Proposed priorities for call in 2020

Two research directions are proposed for the 3rd round of projects. First, projects are needed to deepen the understanding of the mechanisms of plant-microbiome genomes interactions at individual plant level, at cropping systems level, as well as in the context of environmental changes. Second, inter- and transdisciplinary research is needed to achieve Agriculture Green Development.

Priority Topic 1: Fundamental scientific innovation

Projects under this theme can include one or more of the following topics: (1) The composition and function of plant microbiome at the critical interfaces in the 'rhizobiont', (2) Root exudates driven microbiome-soil microsite interactions to improve soil nutrient retention and supply capacity for sustainable crop production, (3) Deciphering molecular and chemical languages of plant-microbiome communication for plant-soil health, (4) Exploring the signal mechanisms between arbuscular mycorrhizal fungi and hyphobiome to improve P use efficiency, (5) Crop diversification enhances resistance and resilience of ecosystem C and N cycling to drought: patterns and mechanisms, (6) Uncovering the molecular mechanisms of plant-microbe interaction for enhancing plant nutrient utilization and environmental adaptation, (7) Manipulating 'Rhizobiont' to enhance crop productivity and nutrient use efficiency, and (8) Synergizing root-driven plant-microbiome interactions to design sustainable diversified cropping systems

Priority Topic 2: System & integration including regional solutions.

Under this topic we seek for inter- and/or transdisciplinary research projects, that aim for optimized crop production and regional solutions. Projects may aim to optimize crop production systems to enhance nutrient supply through designing novel cropping systems, with a focus on improved management practices and national trade. One of the projects may study how to close the dietary and nutrition gap in China with healthy diets. The projects under this topic could be done through participatory scenario analyses and multi-objectives evaluation of sustainable food production for healthy diets in China, meanwhile considering resource conservation and environmental protection.

2. Green integration of animal and crop production

2.1. Overall goals and ambitions of Theme 2

In brief, the overall goal of Theme 2 is to reduce external inputs and environmental pollution for the crop-animal food produciton systems, with increasing social welfare. This requires technical, institutional and policy innovations to increase nutrient recycling towards coupling crop and livestock production (Fig. 3). This theme seeks for a scientific foundation for integrating animal and crop production systems, with a focus on different ecological regions and climatic zones. We aim for integrated systems which are (i) productive and competitive, (ii) ecologically sound, and (iii) accepted by the society. Integration of animal – crop production systems may be done at farm level and regional level, each requiring specific institutional arrangements, market conditions and adjusted technologies. Our hypothesis is that technologies will have to follow institutions and markets.

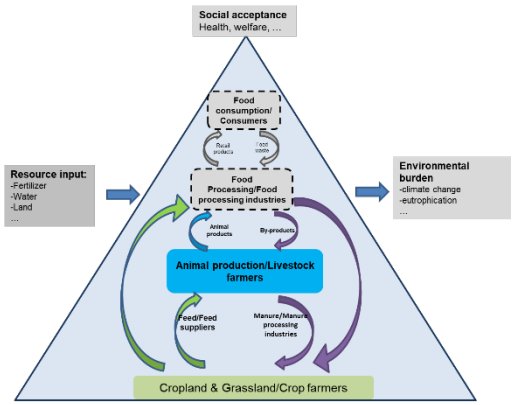

Fig. 3 Framework of integrated animal and crop production, in which the main gaols, key production processes, and also associated stakeholders are illustrated.

2.2. Summary of already granted proposals

In total, seven proposals were granted within this theme. Six proposals focus on technical innovations at the process level (e.g. forage production, pig feeding and nurtition, dairy breeding, manure treatment) of the crop-livestock system (as illustrated in Fig. 4). Only one proposal explores social welfare and envrionmental impacts from an integrated crop and livestock production system perspectives.

The previously granted proposals on technical innovations aim to provide novel specific strategies to improve specific parts of the system, with a focus on the underpining mechanisms. However, to achieve the overall goal of this theme and of the whole AGD project, there is need for interdisciplinary cooperative proposals, e.g. combining plant, animal and environmental sciences. The program lacks projects that systematically explore strategies for sustainable crop and livestock production, particularly from a circular economy perspective. Moereover, there is lack of

understanding of institutional and political innovations and strategies.

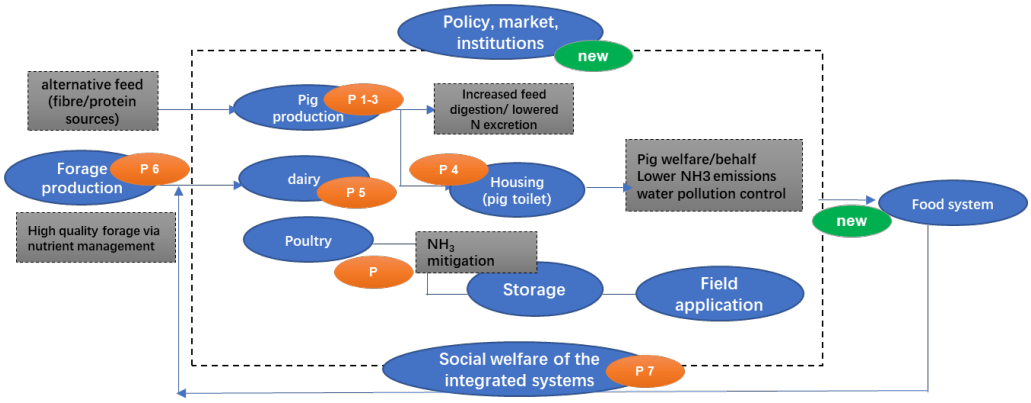

Fig 4. Illustration of possible linkages among granted proposals (P1-7) and identification of the existing proposal gaps under the framework of this theme .

2.3. Proposed priorities for the call in 2020

To fill in the research gaps in this theme, we will prioritize proposals focusing on systematical and interdisciplinary research to provide joint/integrated solutions across plant, animal, envrionmental and economic science.

Priority Topic 1: Sustainable crop and livestock integration from a circular food system perspective.
Projects under this topic aim to (1) further explore pathways towards integrated crop and livestock production at different scales and ecological zones, and (2) analyze integrated strategies towards sustainable livestock production in a circular economy perspective. Quantifying resource use and environmental impacts of these strategies in a systematic manner is key.

Priority Topic 2: Political, institutional and marking strategies towards increased recycling of manure and feed at and beyond farm scales
Projects under this topic aim to increase our understanding of political, institutional and marketing barriers and opportunities to improving manure recycling in livestock farms and cropland at particularly local and regional scales. The potential impacts of newly developing healthy and effective political and institutional schemes on manure recycling, environmental reduction and economic benefits should be quantified systematically.

3. Green eco-environment

3.1. Overall goals and ambitions of Theme 3

A green eco-environment can be defined as a combination of excellent air quality, healthy soils, clean waters, high biodiversity and a beautiful rural landscape. To realize these five goals, we developed a conceptual model for high environmental quality of the water-soil-air system in relation to agricultural production (Fig. 5). To achieve a green eco-environment, the following four actions are required: (1) develop green eco-environmental indicators; (2) establish monitoring and warning networks; (3) set emission standards and environmental thresholds for key pollutants; (4) develop new emission control measures and pollution remediation technologies. Measures (1–3), in turn, provide feedback to optimize measure (4).

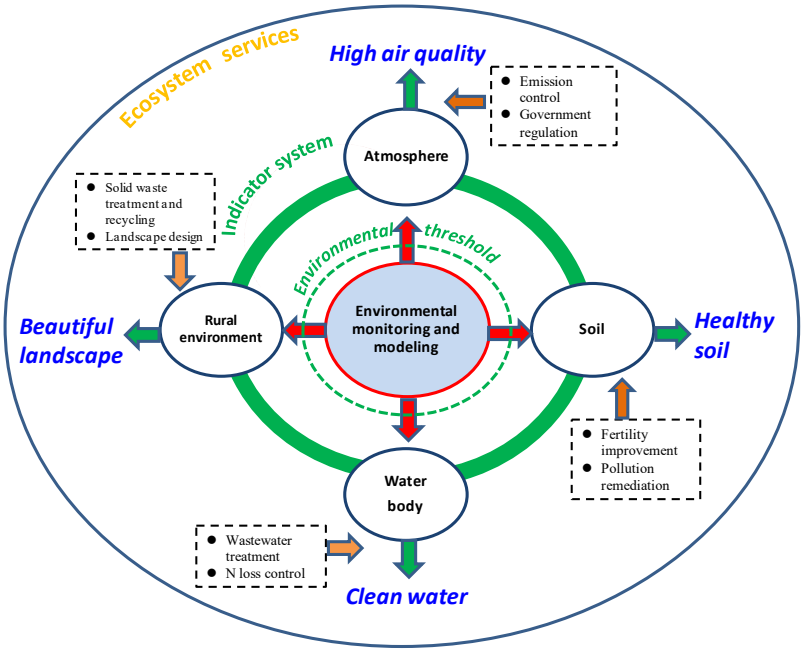

Fig. 5 Conceptual model of a green eco-environment with five ultimate goals: clean air, clean waters, healthy soils, high biodiversity, and a beautiful landscape

3.2. Summary of already granted proposals

In total, nine proposals were granted regarding the four topics (i.e., air, water, soil, and rural environment) within Theme 3 (Fig 6). For air pollution, $PM_{2.5}$ is currently a key issue in China, primarily associated with NH_3 pollution. Now we have two projects focusing on controlling agricultural NH_3 emissions to meet the national $PM_{2.5}$ standards, and on the abatement potentials for NH_3 from lay hen breeding in Quzhou County. For soils, we mainly concentrated on how to control soil pollution by pesticides, heavy metals, and acidifying compounds. We considered the whole process of all pollutants from source control to pollution assessment (including pollution status, the transport process, and environmental impacts) and solutions. For water, now we have two projects on water pollution control and clean water availability. For the rural environment, we have three projects concerning recycling of waste from agricultural production (crop residues and manure) and domestic living (households wastes).

However, from the perspective of the whole agricultural production chain, a green eco-environment runs through "green" cropping, "green" livestock breeding, "green" processing, and "green" consumption. Thus, a green eco-environment should be built on the whole "green" agricultural production process. For this, on the one hand we should put source control in the first place, which establishes limits of inputs of chemicals (N, P, pesticide, etc.) based on the setting of environmental thresholds. This work will be done by the CSC PhD candidates in this Theme. However, there are still research gaps to be filled in the search for integrated green technologies and policies needed for the realization of agricultural green eco-environment at the county, regional and national scale in China.

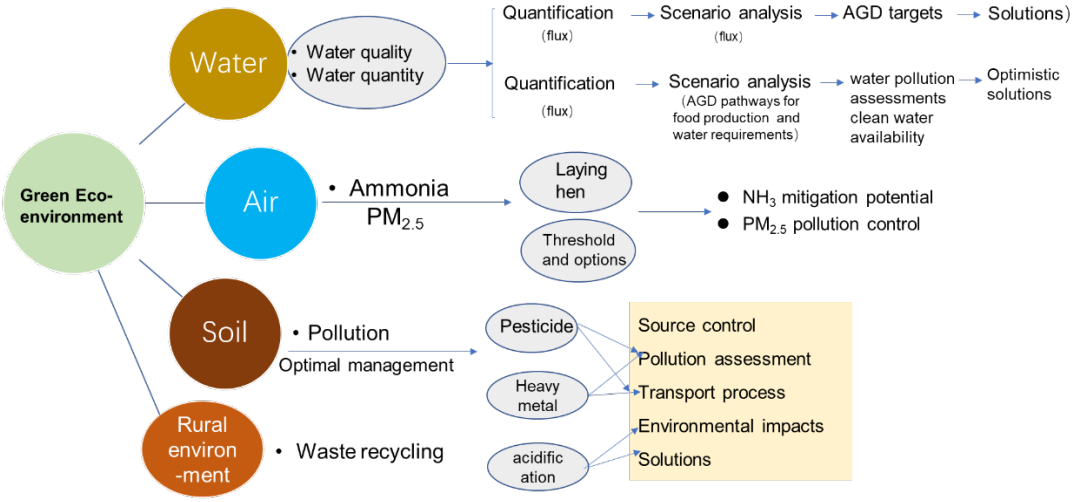

Fig 6. Overview of granted green eco-environment projects.

3.3. Proposed priorities for the call in 2020

The third round proposals build on the already granted projects, and focus on how to build a green eco-environment when considering the whole agricultural production chain.

Priority Topic 1: Contributions of AGD to the national Water-Soil-Air Clean Actions

Projects under this topic will assess the effectiveness of AGD-related national policies and China's recent Water, Soil, and Air Pollution Prevention and Control Action Plans (Action Plans), and also to formulate more ambitious and feasible policies to meet middle-long term goals of the three Action Plans and the United Nation's Sustainable Development Goals (3, 6, 13, and 14). Measure/technology-specific contributions of different national policies to the improvement of environmental and human health and socioeconomic development will be quantified, and a database of integrated and the most effective policies and technologies towards AGD will be established.

Priority Topic 2: Agricultural ammonia emission reduction strategies and its comprehensive impacts on eco-environment health.

Projects under this topic identify ammonia emission abatement strategies to reduce the

negative impacts of ammonia on human health and natural ecosystems in different agricultural regions of China. The focus will be on regions in China where ammonia-induced ecologic risks are high. Abatement strategies include integrated cropping and livestock breeding management strategies at the city level to reduce ammonia emission through China.