Front. Agr. Sci. Eng. 2024, 11(1): 1–4 https://doi.org/10.15302/J-FASE-2024549

EDITORIAL

Promoting green transformation by ensuring food security while reducing the environmental footprint of food and farming with agriculture green development

William J. DAVIES[1], Jianbo SHEN (✉)[2]

1 Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK.
2 State Key Laboratory of Nutrient Use and Management, National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China.

Received February 2, 2024.

Correspondence: jbshen@cau.edu.cn

Reconciling the challenges of producing adequate amounts of nutritious food for the increasing global population while limiting environmental damage that can result from operations of our food systems is an enormous challenge. In many parts of the world, agriculture is undergoing major transformations and this has been and still is particularly the case in China. In many countries, historical increases in food production have largely been achieved by increasing inputs of a range of resources, resulting in increased environmental footprints of the food produced. Agricultural development in China has resulted in unprecedented environmental degradation. Demand for food in China remains high and with an emphasis on national self-sufficiency in production of many food crops. There is an urgent need for the development of productive and more environmentally-friendly agricultural systems and improved environmental-economic-social resilience.

The concept of green development in China was announced as a priority of the Central Government in 2015, while the concept of agriculture green development (AGD) was subsequently detailed in 2017. AGD ultimately aims to achieve multiple societal goals, including increased food security, resource conservation, environmental sustainability, and social equity, thereby promoting rural revitalization and building a more attractive rural landscape. Over the past 5 years, policy makers and researchers have made significant efforts to further develop the concepts and targets for AGD and to more widely communicate these proposals to a wider population. This special issue (15 articles) presents some of the progress that has been made towards these ends over the past 5 years. AGD incorporates many ideas that are central to the concepts and practices that are important to the development of regenerative and restorative agriculture in many parts of the world. Recognising this, we present here both an overview of AGD projects that are already producing developments of note and make recommendations for more research and development, in order to better deliver agricultural green and sustainable development on both national and international scales. Other papers discuss particular aspects of growing food and environmental challenges which are common to many countries. Successful examples of responses to these challenges are presented.

Shen et al. (https://doi.org/10.15302/J-FASE-2024535) briefly review the progress that has been made in both theoretical and conceptual developments as well as in practical implementation of AGD in China. AGD emphasizes the synergy between the introduction of green practices and

development; current agriculture has to transform from intensive farming with high inputs, high environmental impacts and low resource-use efficiency to a more sustainable agriculture, in order to ensure an adequate supply of nutritious food while delivering environmental gains, improved economic profitability, and social equity. In the early days of this journey, to provide a scientific basis for future developments and to facilitate the implementation of AGD in practice, the first research program on AGD was established by China Agricultural University. This had four research themes, namely: Green Crop Production, Green Integrated Crop-animal Production, Green Food and Industry, and Green Ecological Environment and Ecosystem Services, Over the last five years of innovative development in theory and practice within the program, a series of new understandings in all four themes has been acquired. These have important implications for the implementation of AGD in practice. AGD requires a multi-stakeholder approach, fueled by innovative and interdisciplinary research. Joint actions have to be taken by governments, farmers, supply industries, consumers, educators, extension services and researchers to support AGD. This requires strong coordination and work to raise public awareness.

A need to develop a systematic understanding of AGD is the justification of much research. We present here four papers offering new perspectives on evaluation indicator systems and progress towards AGD. Zhang et al. (https://doi.org/10.15302/J-FASE-2024548) conduct a comprehensive comparison of the distinctions between AGD and Sustainable Development Goals (SDGs) in terms of their definitions and the establishment of indicator systems. China's AGD indicator system comprises 53 indicators, and 51 of these indicators exhibit a strong alignment with the SDGs indicators. The authors argue that compared to the SDGs indicator system, the majority of AGD indicators are more easily attainable, more specific, and more conducive to quantification. The paper presents an analysis of the disparities between the current status of each indicator and the benchmark, and notes that China's remarkable growth in food production and rural income has generally been accompanied by resource overuse and growth of the magnitude of environmental challenges. The authors argue that the chances of success in the establishment of AGD in China can be bolstered through technological refinements and regulatory policies.

In a related article, Zhang et al. (https://doi.org/10.15302/J-FASE-2023512) propose a national-scale indicator system consisting of three dimensions (socioeconomic, food production and eco-environmental) and ten sub-dimensions to quantify the AGD score. The authors recognize that China has made progress in agricultural transformation, transitioning from conceptualization to actions through the implementation of various policies and projects. Despite the progress made thus far the paper argues for an increased effort to address what is recognized as insufficient and unbalanced development, along with growing eco-environmental challenges, especially trade-offs between dimensions. At the regional level, Yu et al. (https://doi.org/10.15302/J-FASE-2024538) developed a systematic index evaluation system to assess socio-economic performance, food production and environmental quality in a key economic region (Hainan Province) of China from 1988 to 2019. The results provide new insights for the future development of green and sustainable agriculture as well as formulation of agricultural policies in Hainan, China and potentially also in other developing countries that are facing or will soon face similar challenges. At the county level, Xu et al. (https://doi.org/10.15302/J-FASE-2024536) established an AGD evaluation indicator system, comprising three dimensions: food production, ecological environment, and socioeconomic development, encompassing a total of 20 indicators. The assessment showed historical trends as well as the current status of development in these three key dimensions, utilizing Spearman rank correlation analysis to analyze trade-offs and synergy in relationships. Quzhou County is used as a case study.

In a paper focusing on the selection of rice cultivars that might show both high and stable yields on farms in regions where availability of water and nutrients may be limited and environmental stresses are likely to limit yield, Thiry et al. (https://doi.org/10.15302/J-FASE-2023521) applied a novel score index to previously-published rice yield data. The new methodology identified three genotypes with higher and stable yield under moderate to severe environmental stress. The authors argue that genetics × environment × management interactions are key to determining the impacts of new agricultural developments, a point also made in a later paper by Davies. Thiry et al. show that their score index selection method offers improved precision over conventional breeding selection methods in identifying genotypes that are well-suited to a range of stress levels within target environments for AGD.

High resource use efficiency in food systems is one of the core components of AGD. Meng et al. (https://doi.org/10.15302/J-FASE-2024540) present an example of sustainable nitrogen (N) management in food systems in Quzhou County, North China Plain, and redefined sustainable N management in terms of food security, environmental sustainability and economic

sustainability. They also emphasize how to develop N management strategies and engage different stakeholders to jointly develop effective options for sustainable N management. Taking Baiyangdian Basin as a case study, Zhang et al. (https://doi.org/10.15302/J-FASE-2023533) employed a multi-objective zoning management approach to comprehensively analyze variation in four indicators: ammonia volatilization, N surplus, soil carrying capacity and ecological red line area. Compared with the unified management system, the multi-indicator partition optimization method represents a more advanced and efficiency-oriented management approach. For example, implementation of this method, could potentially bring more than 50% of the cultivated area in the study region below the threshold for environmental damage. Areas with high ammonia emissions and N surpluses could be reduced to less than 16%. The authors argue that this approach could be regarded as the best available option to help China achieve agricultural transformation to improve both efficient production and reduce environmental pollution. It is recommended that current policies aimed at better nutrient management and more sustainable agricultural development should shift toward the use of multi-indicator partition optimization.

Excessive application of chemical fertilizer, organophosphorus pesticides and inappropriate disposal of agricultural waste all generate water pollution challenges and potentially threaten AGD. Ma et al. (https://doi.org/10.15302/J-FASE-2023511) considered the impact of multiple pollutants on N and phosphorus cycles for crops in the Yangtze River Basin. They also present perspectives on theory, modelling and multi-pollutant control in the Yangtze River Basin that are of potential value for other developing regions. Cusworth et al. (https://doi.org/10.15302/J-FASE-2023508) examined the extent of plasticulture in China, the implications of the practice across decades of use and the legislative instruments used to resolve those issues. Use of plastic is common in crop production in China and can be particularly beneficial for crop production and water use efficiency in areas where water is in short supply. The paper notes that if it is not managed appropriately, plasticulture can inevitably lead to the accumulation of microplasics in soils. In turn, this can jeopardize soil health, crop quality, food security and sustainability of agricultural systems in the long term. The authors briefly assess the effectiveness of new policies on the use of plastics and propose possible future innovations to promote increases in long-term food- and eco-security. They propose that sustainable plasticulture is a key agent for change in global agriculture and that this can particularly be the case in China.

He et al. (https://doi.org/10.15302/J-FASE-2024539) focus on reviewing agricultural development in three reaches of the Yellow River and present three sets of recommendations to increase the sustainability of agriculture. Jin et al. (https://doi.org/10.15302/J-FASE-2024545) elucidate particular methodologies and outcomes of the STBs (Science and Technology Backyards) initiative, highlighting its pivotal role in spearheading Erhai's sustainable transition. Preliminary findings underscore the potential of the STB model as an efficacious tool for harmonizing environmental conservation and agricultural practices that are both financially and environmentally sustainable, rendering it a potentially replicable blueprint for analogous regions in China and other counties. Erhai's impressive success in combatting nutrient runoff from both domestic and farming sources highlights a problem for agriculture not only across China but also in much of the rest of the world. Currently European farmers are under pressure to significantly reduce N use, thereby benefitting soil biodiversity and water quality, as well as reducing emissions from the soil. China has suffered from many of these fertiliser-related challenges and Wang et al. (https://doi.org/10.15302/J-FASE-2024547) promote the development and use of green intelligent fertilisers as a novel approach to align sustainable agriculture with green development, thereby benefitting sustainable agriculture and sustainable development more generally.

Davies (https://doi.org/10.15302/J-FASE-2023514) highlights the need for transformations in agricultural practices and land use in different parts of the world and the common lessons that can be learned. There is full recognition in Europe and beyond that agriculture contributes heavily to environmental change, while many cropping systems struggle to cope with these changes, threatening future food security. Davies argues that regenerative agricultural practices can result in greater C capture, reduced greenhouse gas emissions, more efficient water and N use, enhanced soil quality and enhanced biodiversity. However, it is questioned if such farming systems will be productive enough to feed a growing world population with the food required for social and health benefits. Another strong recommendation is that to fully exploit the impact of new plant science in farmer fields, it is imperative to effectively link science to farming practices and conduct a broader conversation around the food revolution with social scientists and with the general public. Fan et al. (https://doi.org/10.15302/J-FASE-2024544) have developed a framework of food system transformation based on AGD and put forth a three-step strategy for future agricultural development based on food security, quality, and selected environmental variables. The objective is to align with global SDG indicators and to maintain natural resource consumption and pollutant emissions within

planetary boundaries. The concept of planetary boundaries has been much in the news across the world with economists joining food specialists and environmental scientists in the debate around future development.

The breadth and severity of many current challenges to world agriculture are discussed in this focussed collection of papers. Addressing these and related challenges by the introduction of AGD programmes constitutes a significant response to a grand challenge. We hope that these papers will be of value to those who have a commitment to revolutionizing global food and farming for the benefit of human and planetary health.

William J. Davies is Emeritus Distinguished Professor of Plant Biology at Lancaster University, UK. He has published more than 300 papers in the international journals. His research group develops interventions that are aimed at enhancing global food security, while particularly focusing on understanding how crop plants might sustain yield under increasingly challenging environmental conditions. The Davies lab has won a 'Queen's Award for Innovation' for work on sustainable resource use in agriculture. Recent work has highlighted the accumulation of microplastics in agricultural soils across the globe. He has an interest in helping farmers profit from novel science and until recently directed a professional postgraduate programme for those who work in the global food supply chain. Davies was Editor-in-Chief of the *Journal of Experimental Botany* for 10 years, he is currently an Associate Editor of *Food and Energy Security* and an Associate Editor-in-Chief of *Frontiers of Agricultural Science and Engineering*. In 2011, he was awarded a CBE for services to science.

.

Jianbo Shen is Professor of Plant Nutrition, Deputy Dean of National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University. He has been engaged in studies on plant–soil interactions and interventions that are aimed at enhancing resource use efficiency and food security, particularly focusing on root/rhizosphere nutrition and management for improving nutrient/water use efficiency and crop productivity with environmental resilience. He is also interested in innovating Green Intelligent Fertilizer, efficient use of phosphate rock and new phosphorus fertilizers. He is a recipient of the National Outstanding Youth Fund of China. He won the second prizes of the state natural science award and state science and technology progress awards. He has published more than 160 peer-reviewed papers in international journals, and was selected by Clarivate Analytics as a global 'highly cited researcher' during 2019–2023. He is a fellow of 'The African Academy of Sciences', and serves as a member of Scientific Advisory Committee to the Our Phosphorus Future Report and a member of the Global Phosphorus Institute's (GPI) Science Committee. He is currently an Associated Editor of *Food and Energy Security*, and a Guest Editor of *Frontiers of Agricultural Science and Engineering*.