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EDITORIAL

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 4YW, UK
2 National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China

Despite the considerable achievements of science and agriculture in feeding more people with more food, we are now more concerned than ever that global demand for food is still on the increase. It is unlikely that world population will peak until it is higher than 10 billion or perhaps even 11 billion. Our society, and not-least the operation of the global food system, is putting considerable pressure on our planetary systems. One dramatic example of this is that apparent climate change or the "climate emergency" as it is now known is never out of the headlines for long. While climate change is causing great problems for agriculture in many parts of the world, it is also clear that the operation of our current food system is responsible for significant degradation of terrestrial and aquatic ecosystems. Consequently, there is much interest in the greening of world food production known in China as Agriculture Green Development (AGD).

There is growing awareness that the current food system is responsible for a broad range of environmental degradation which is causing concern in many parts of the world. These problems include excessive water and fertilizer use resulting in falling ground water levels, desertification, pollution of ground water and surface water bodies, soil degradation, and wide-scale reductions in biodiversity. These problems mean that the challenge of modifying current food production and farming methods must take top priority in order to limit further development of the climate emergency and related challenges. This issue highlights the nature of this challenge and reviews some means of addressing the developing problems of our global food system.

In addition to the environmental problems noted above, the Intergovernmental Panel on Climate Change (IPCC) has recently released a major report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems[1]. This has highlighted some of the problems that agriculture, forestry and other land use (AFOLU) activities are creating for our planet. The panel concluded with moderate confidence that these activities accounted for around 13% of CO_2, 44% of methane, and 82% of nitrous oxide emissions from human activities globally during 2007–2016, representing 23% (12 ± 3 Gt·yr^{-1} CO_2-e) of total net anthropogenic emissions of greenhouse gasses.

Despite the considerable achievement of the Paris Accords of 2015[2] and more recent UN Climate Change Conferences, pledges to reduce our carbon emissions are still only enough to hold temperature increases at around 3.3°C. A business-as-usual approach will result in global temperature increases of more than 4°C, with significant consequences for many. Whatever our success in limiting greenhouse gas emissions, feeding the world in the future will certainly not get any easier.

Different countries and regions of the world are starting to develop policies to address a broad range of planetary degradation and many of the changes necessary to bring about change are encapsulated in the UN Sustainability Goals (SDGs), which will provide much-needed targets for societal change. People and governments from many regions are demanding change and asking for development of national strategies and China has been prominent in this regard. Much of the stimulus for this issue has come from developments at China Agricultural University where to

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Correspondence: jbshen@cau.edu.cn

support the implementation of interdisciplinary research innovations necessary for AGD, the National Academy of Agriculture Green Development and the International School of Agriculture Green Development were launched in July 2018. These centers of excellence have been established in line with strong developing government policies for green development and rural revitalization in this area of concern in China and many other countries.

Shen et al. (this issue) note that as a result of a green revolution in China which resulted in startling increases in agricultural productivity, China has succeeded in producing 25% of the world grain harvest and feeding 20% of the global population while using less than 10% of world arable land (https://doi.org/10.15302/J-FASE-2019300). Currently, China is the largest producer of cereals, cotton, fruit, vegetables, meat, poultry, eggs and fishery products. However, this advance in food production has not been without its problems. One example of this is a doubling of grain production since 1978, accompanied by a threefold increase in nitrogen (N) fertilizer use, an eleven-fold increase in phosphorus (P) fertilizer use, and a 1.5-fold increase in irrigation water use. Shen and coauthors outline the measures proposed in the National Academy program that will address a broad range of China's land use as well as AGD challenges and note that the approaches taken will be relevant also in a number of developing countries in the region. The major objective of AGD is to coordinate "green" with "development", and 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. Three key aspects for AGD involve interdisciplinary innovations, whole food chain improvement and regional solutions, with four themes of green crop production system, integrated animal-crop production systems, green food products and industry, and rural environment and ecosystem services. Such a broad approach is critical for realizing AGD and even delivery of progress on achieving the SDGs (https://doi.org/10.15302/J-FASE-2019300). Importantly and in agreement with the proposals of Willet et al., the focus of change should be on planetary health and human health as affected by food quality[3].

In a related paper, Liu et al. (this issue) define a green eco-environment as including four key elements or measures (https://doi.org/10.15302/J-FASE-2019297): (1) a green eco-environmental indicator system, (2) environmental monitoring and warning networks, (3) emission standards and environmental thresholds for key pollutants, and (4) emission controls and pollution remediation technologies. They describe how Quzhou County (a typical county in the central North China Plain) has been developed as a demonstration area to show how detailed air, water and soil monitoring networks as well as improved farmer practices and pollution control measures (especially ammonia emission mitigation and $PM_{2.5}$ pollution reduction) can begin to create a green eco-environment in China.

One of the foci in the National Academy program is recoupling of livestock and feed production systems. This is a focus of the paper by Chadwick et al. (this issue) who highlights the challenge of reducing nutrient accumulation in regions with little available land bank, while minimizing the risk of pollution swapping from one region to another (https://doi.org/10.15302/J-FASE-2019293). In China, increasing quantities of manure must be managed as diets change and demand for animal protein increases. Chadwick et al. review strategies to improve management at each stage of the manure management chain, and at different scales. These authors stress that a range of stakeholders are needed to support the step change and innovation required to improve manure management, reduce reliance on inorganic fertilizers, and generate new business opportunities (https://doi.org/10.15302/J-FASE-2019297).

Another innovative approach for increasing nutrient use efficiencies in agriculture is described by Cui et al. (this issue), namely an integrated soil-crop system management (ISSM), a strategy designed to deliver more grain production with greater nutrient use efficiencies and less environmental pollution (https://doi.org/10.15302/J-FASE-2019295). The ISSM approach has been used in China on thousands of farms, to substantially increase the yields of maize, rice and wheat while simultaneously increasing nitrogen efficiency and reducing environmental footprints. The paper reports successes at local and regional levels across the nation.

As noted above, greenhouse gas emissions from agricultural systems have a disturbingly large effect on global warming. In this issue, Rees et al. note that nitrous oxide emissions make up a significant part of the agricultural contribution to greenhouse gas emissions (https://doi.org/10.15302/J-FASE-2019294). There is an urgent need to identify new approaches to the mitigation of these emissions. Rees et al. suggest that precision management of agricultural systems offers the opportunity for nitrous oxide mitigation without any reduction in productivity. These approaches depend upon new sensor technology, modeling and spatial information on which to make management decisions and interventions that can improve both agricultural productivity and environmental protection.

Importantly most of the options assessed by the National Academy as means to reduce the environmental footprint of agriculture contribute positively to sustainable development and other more general societal goals and often provide multiple co-benefits. These are points also made in the IPCC report discussed above[1]. The IPCC panel notes that sustainable land management can prevent and reduce land degradation, maintain productivity, and sometimes reverse the adverse impacts of climate change. They stress that reducing and reversing land

degradation, at scales from individual farms to entire watersheds, can provide cost effective, immediate and long-term benefits to communities and support several SDGs. Davies et al. (this issue) have also stressed the importance of setting goals not just for climate change remediation but more generally for societal development (https://doi.org/10.15302/J-FASE-2019299), as exemplified by the SDGs. These authors note the importance of the production of nutritious food (not just more food) as diet-related health problems are now increasingly common in many countries. Hassan et al. (this issue) summarize the developmental history of green food in China and current achievements, analyze major challenges that may hamper further development of the industry, and propose strategies to address these challenges, i.e., optimization of food supply chain, deep food processing, and reutilization of food wastes (https://doi.org/10.15302/J-FASE-2019296). Davies et al. also highlights developments in crop science (genetics and agronomy) and engineering science that can help develop a revolution in food and farming (https://doi.org/10.15302/J-FASE-2019299).

The focus of the paper by Firbank (this issue) is on the sustainable intensification of agriculture as a component of AGD (https://doi.org/10.15302/J-FASE-2019291). Other authors in this issue highlight the importance of developments in this area, as do Willett et al. in a very important paper where they propose a diet for the planet[3]. Munier-Jolain and Lechenet (this issue) has stressed the importance of redesigning cropping systems for improving agricultural sustainability and focusses attention on participatory research based on farm networks as a way of revolutionizing agricultural practice (https://doi.org/10.15302/J-FASE-2019292).

There is also general consensus through this issue on the key role of effective knowledge exchange (KE) mechanisms in ensuring that appropriate innovations are brought to the attention of practitioners and that researchers properly appreciate the food production practice in different societies. It is equally important that the general public is involved in conversations about an agricultural revolution. The paper by Smith (this issue) analyzes the public policy challenge of agricultural green development and makes the case for a location-sensitive policy mix made up of regulation, advice provision, voluntarism and targeted incentives (https://doi.org/10.15302/J-FASE-2019290). Smith notes that the public agricultural extension service in China is a key resource, but one that requires reorientation and reform with the aim of better balancing high farm productivity with environmental protection. In a further policy-focused paper, Lu et al. (this issue) examines how the negative environmental consequences of intensive agriculture have driven China and the UK to shift away from narrowly focused farm output policies and adopt more holistic green development pathways (https://doi.org/10.15302/J-FASE-2019298). He then explores the policy objectives they have in common and assesses the numerous opportunities for joint research and knowledge sharing through the Sustainable Agriculture Innovation Network (SAIN) and other existing institutional mechanisms.

The IPCC report introduced above makes several important policy recommendations, points which are also emphasized by authors in this issue. We highlight several of the key IPCC points relevant to the focus of this issue and to the establishment of a broad-scope National Academy of Agriculture Green Development:

(1) Appropriate design of policies, institutions and governance systems.

(2) Policies that operate across the whole food system, including those that reduce food loss and waste and influence dietary choices.

(3) The adoption of sustainable land management and poverty eradication can be enabled by improving access to markets, securing land tenure, factoring environmental costs into food, making payments for ecosystem services, and enhancing local and community collective action.

(4) The effectiveness of decision-making and governance is enhanced by the involvement of local stakeholders.

We hope that the breadth and coverage of AGD in this issue will be of value to those who have a commitment to revolutionizing food and farming to the benefit of human and planetary health.

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Dr. William J. Davies, Emeritus Distinguished Professor of Plant Biology at Lancaster University, UK. He has published more than 250 papers in the international literature and has an H-index of 66. His research group develops interventions that are aimed at enhancing global food security, while particularly focussing 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 with CIMMYT has resulted in the development of new pre-breeding crop screening methods. He has an interest in helping farmers profit from novel science and he directs a professional postgraduate programme for those who work in the global food supply chain. He was Editor-in-Chief of the *Journal of Experimental Botany* for 10 years and is currently an Associate Editor-in-Chief of *Food and Energy Security* and *Frontiers of Agricultural Science and Engineering*. In 2011, he was awarded a CBE for services to science.

Dr. Jianbo Shen, Professor of Plant Nutrition, National Academy of Agriculture Green Development, College of Resources and Environmental Sciences, China Agricultural University, China. 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 won the 2nd prizes of the State Natural Science Award and State Science and Technology Progress Award. He has published more than 100 peer-reviewed papers in international journals, and was selected as a global "highly cited researcher" in 2019. He is currently a member of Editorial Board of *Food and Energy Security*.