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From Farm to Fork: Growing a Scottish Food System That Doesn't Cost the Planet

Dave S. Reay[1*†], Erika A. Warnatzsch[1†], Ed Craig[2], Lorna Dawson[3], Sheila George[4], Rachel Norman[5†] and Pete Ritchie[6]

[1] School of GeoSciences, The University of Edinburgh, Edinburgh, United Kingdom, [2] Edinburgh Centre for Carbon Innovation, Edinburgh, United Kingdom, [3] James Hutton Institute & SEFARI, Aberdeen, United Kingdom, [4] WWF Scotland, Edinburgh, United Kingdom, [5] Faculty of Natural Sciences, University of Stirling, Stirling, United Kingdom, [6] Nourish Scotland, Edinburgh, United Kingdom

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***Correspondence:**
Dave S. Reay
david.reay@ed.ac.uk

†ORCID:
Dave S.Reay
orcid.org/0000-0001-8764-3495
Erika A. Warnatzsch
orcid.org/0000-0002-9705-7876
Rachel Norman
orcid.org/0000-0002-7398-6064

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Our global food system is under immense pressure. Feeding a growing human population well while simultaneously delivering required climate, biodiversity and other key outcomes arguably represents the biggest challenge of our civilization in the twenty-first century. Here we discuss this growing challenge in the context of Scotland, its progress to date, its new target of "net zero" greenhouse gas emissions by 2045, and its potential to be an exemplar for well-integrated land use policy that delivers on multiple aims. We highlight the role of research in informing rural policy and landowner actions and stress the importance of social science in helping to ensure a sustainable net zero transition that takes full account of socioeconomic contexts and avoids the big potential pitfalls of ignoring local contexts.

Keywords: climate change, food security, sustainable food, food policy, Scotland, net zero

AGRICULTURE: CLIMATE VICTIM OR VILLAIN?

Attaining sustainable food security is a global challenge linked to multiple targets under the UN's Sustainable Development Goals (SDGs), particularly the focus on ending poverty and hunger (UN General Assembly, 2015). Our global agricultural system has the potential to provide all the necessary nutrients, income, and environmental protection to support both the current and future generations (Foley, 2011). However, inefficiencies and unsustainable practices have led to a breakdown of this global ecosystem, with natural systems being badly degraded and human populations facing increased risks to their health and well-being. Today, around 820 million people have insufficient food, while more than 2 billion consume too much (Willett et al., 2019).

The global agricultural system is intrinsically linked with the functioning and health of the wider biosphere, hydrosphere, geosphere and atmosphere. All play an important role in the success or failure of our food systems. A major and intensifying interaction that cuts across all these spheres is the link between agricultural systems and climate change, where agriculture is often seen as both a villain [through its greenhouse gas (GHG) emissions] and a victim (through the impacts of climate change).

As the human population expands toward 10 billion during this century, finding a balance between feeding everyone well and cutting GHG emissions has never been more challenging. Climate change has already had negative impacts on food production in some regions (Lobell et al., 2011). Further increases in global average temperature risk more severe negative impacts, and at larger scales—an increase from 1.5 to 2°C of warming is expected to further reduce food security and exacerbate malnutrition (IPCC, 2018). While the UN's Paris Climate Agreement aims to limit global average temperature increases to 2°C (with a further ambition to limit increases to just 1.5°C), current emission reduction commitments would likely lead to more the 3°C of warming during this century (Hausfather, 2018).

As a source of around one quarter of anthropogenic GHG emissions (Vermeulen et al., 2012, Arneth et al., 2019), our global food system must somehow help deliver on the Paris Climate Goals and the SDGs. It must be part of a rapid transition to a "net zero" future (where emissions are balanced by sequestration) to secure the livelihoods of many millions of smallholders and food system workers. Furthermore, all this must be done while ensuring improved nutrition, protection of natural ecosystems, and reduced risks to soil, water and air quality- all impacting upon health. It's a big ask.

Food production, its related emissions, and its vulnerability to climate change are often inherently local. Any broad brush "food and climate change" policy approach that fails to account for these local contexts risks unintended consequences, such as enhanced emissions, maladaptation, and increased food insecurity. At national and sub-national scales there is greater opportunity to align climate change mitigation aims with physical and socioeconomic realities. To identify least-cost interventions and to make informed decisions on the local trade-offs between one form of land management strategy and another is vital to our future. Scotland, as a developed nation with both a large and highly developed agriculture sector and ambitious climate change mitigation targets, provides an exemplar of the challenges climate change poses to our food systems and, potentially, how these challenges can be best addressed.

SCOTLAND'S CURRENT FOOD SYSTEM

Agriculture has always been an important sector in Scotland and is responsible for shaping much of the landscapes the country is famed for. Despite the impacts of past climate, policy and price shocks, the industry has grown significantly. It is now the largest user of land, with roughly three quarters of Scotland's land used for agricultural production (Scottish Government, 2017). Scotland's weather is famously unpredictable, with levels of unpredictability increasing, and 85% of agricultural land is currently designated as "Less Favored Area" by the EU (RSPB, 2019); despite these challenges the Scottish food and drink sector has grown to be the largest manufacturing sector in the country (NFU Scotland, 2019).

As of 2017, the agriculture and related land use sector was responsible for just under a quarter of Scotland's total GHG emissions (Scottish Government, 2019c), and this contribution would be higher if the wider food manufacturing and processing emissions associated with getting the food from the "farms to our forks" were included. While the relative contribution to national emissions from agriculture today is up from 18% in 1990, the absolute emissions from the sector have fallen by almost a third between 1990 and 2017 (Scottish Government, 2019c). This dichotomy in trends reflects the fact that the agricultural sector is not reducing emissions as quickly as other major sectors like energy generation. It should also be noted that a large competing land user, forestry, has been expanding over the same period, increasing its associated carbon uptake. However, in recent years the growth in the forestry sector has slowed and even shown some decreases. Combined, these trends in the agriculture, land use and forestry sectors do not show adequate action to meet Scottish Government targets for net zero emissions by 2045 (Scottish Government, 2019a).

Improving land use practices have been responsible for most of the absolute emissions reduction from the agriculture and related land use sector since 1990. However, when the emissions from this sector are broken down by gas type, it becomes clear that increasing carbon sinks through land use and forestry policy alone will not tackle a large portion of the emissions; In 1990 carbon dioxide (CO_2) formed two fifths of the emissions based on global warming potential, however this dropped to just under a third in 2017 (Scottish Government, 2019c)—most of the emissions reductions since 1990 have been in the form of CO_2, with less progress made in reducing methane (CH_4) and nitrous oxide (N_2O) emissions.

Agriculture's contribution to climate change is not homogenous for every product, or even for the same product produced in different locations or by different farmers. Most of the absolute emissions from Scottish agriculture comes from livestock rearing (Scottish Government, 2018, 2019c). Recent studies have concluded that a shift to a more vegetable-based diet, along with only low GHG intensity animal proteins (e.g., monogastric meat), would reduce the GHG emissions intensity of the sector as a whole (CCC, 2018; Arneth et al., 2019). While little progress has been made in reducing Scottish livestock and crop emissions in absolute terms over the past decade, both have shown lower emission intensities per unit value and per unit weight (Scottish Government, 2018, 2019c).

The food system in Scotland is likewise having to cope with climate change impacts, both domestically and through international supply chains. In recent years, 40% of food consumed in the UK has been imported from abroad, including 25 percent of food types that are also produced in the UK (based on the production to supply ratio) (DEFRA, 2018)—a resilient food system in Scotland will therefore need to take account of climate change risks to overseas producers and international supply chains, as well as those challenges faced at home. Domestically, Scotland is projected to see higher temperatures all year round, with more seasonal variation in precipitation—broadly we are projected to experience drier summers and wetter winters (Adaptation Scotland, 2018). Extreme events, such as high winds, floods and droughts are also expected to increase in frequency and intensity, with consequent risks to food production (Reay, 2019). Climatic changes have already begun to affect farmers in Scotland, with prevalence of some livestock pests and diseases, such as liver fluke, on the rise. However, changing climatic conditions and atmospheric CO_2 enrichment are also expected to create opportunities for the sector. Yields, and the length of growing seasons for existing crops, may increase, while changes in viable growing areas could help to diversify the types of crops that can be grown (ClimateXchange, 2016a; Reay, 2019).

SCOTLAND'S FUTURE FOOD SYSTEM: SUPPORTING OUR FARMERS TO ACHIEVE "NET ZERO"

The exit of the UK (including Scotland) from the European Union poses major risks to farmers and the food supply system of Scotland as a whole. However, replacement of the EU's Common Agriculture Policy (CAP) does provide an opportunity to better align land use strategy and support systems with local contexts; in particular with Scotland's net zero by 2045 target. The UK's Committee on Climate Change (CCC) has already highlighted the leading role the land use and agriculture sectors in Scotland can play in helping the whole of the UK achieve net zero. A core element of this transition is improved efficiency of food production in some areas to free up land elsewhere for enhanced CO_2 sequestration (e.g., afforestation). For Scotland this would involve an increase from ~20% woodland cover today to 30% by the middle of the century (CCC, 2019).

Again, successfully realizing these changes will require deep understanding of local contexts and well-informed, evidence-based policy that integrates the multiple demands on land use and avoids the unintended consequences that can arise from broad brush approaches—food waste under CAP being a good past example of this (Porter et al., 2018).

In its recently published "Programme for Government" the Scottish Government announced the creation of "regional land use plans for maximizing the potential of every part of Scotland's land to contribute to the fight against climate change" (Scottish Government, 2019b). These plans will be vital in engaging stakeholders and identifying support and interventions in the local context that can give the closest to optimal outcomes possible. Physical science will play a key role here, providing the high-resolution (<1 km^2) decision support on, for instance, what tree will grow best where, which mitigation strategies will be most effective on which farms, and exactly how progress (or lack thereof) can be measured and verified. Likewise, scientific research can help inform specific changes to agricultural practice in Scotland that radically lower emissions, such as through improved nitrogen use efficiency, livestock feeds, health and breeding, and manure management (ClimateXchange, 2016b).

The role of social science is even more vital in meeting this challenge. Integrating assessments to elucidate the impacts of new land use strategies and support systems on farmer incomes, community cohesion, employment, skills gaps and more will help to avoid "carbon blinkers" inducing unsustainable land use change that ultimately sees any short-term climate change benefits being reversed. Improved understanding, modeling and monitoring of integrated land use change impacts really could make that fiendishly-difficult balancing act of food, climate, ecosystems, and livelihoods possible.

Our agricultural system doesn't have to be a climate villain or a victim, instead it should be considered a big part of the solution as we face the challenge of climate change. In a net zero-focused Scotland, agriculture is the sector with potentially the most to lose, and possibly the most to gain. If it becomes a loser then our net zero ambitions will be lost along with it.

AUTHOR CONTRIBUTIONS

DR led the development and writing of the paper. EW led coordination of inputs. EC, LD, SG, RN, and PR contributed inputs to text and revisions.

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