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Total global agricultural land footprint associated with UK food supply 1986–2011

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ABSTRACT

Over the coming decades the global demand for food, and especially for animal products is projected to increase. At the same time, competition for agricultural land is projected to intensify due to a wide range of drivers, including a growing world population, changes in food consumption patterns and bioenergy production. It is therefore vital to understand the relationship between global agricultural land use and the consumption of food. Here we use the United Kingdom as an example to show the agricultural land footprint of a highly developed country over the period 1986–2011. Our analysis shows that the total land footprint of the UK has decreased over time from 25,939 kha in 1987 (3-year mean) to 23,723 kha in 2010 (3-year mean), due to a lower grassland footprint resulting from lower ruminant meat supply. Cropland use has increased slightly from around 8400 kha in 1987 to about 8800 kha in 2010, but has decreased slightly on a per-capita basis as the UK's population increased over time. Our analysis shows that 85% of the UK's total land footprint is associated with meat and dairy production, but only 48% of total protein and 32% of total calories derive from livestock products. Our results suggest that, if countries reduce their ruminant product consumption, land could be freed up for other uses, including bio-energy production, forest regrowth, and biodiversity conservation.

1. Introduction

Global agricultural land is a finite resource, and competition for land is projected to intensify in the coming decades due to a range of drivers, including a growing world population, changes in global food consumption patterns and increasing demand for bioenergy (Haberl, 2015). It is projected that food production has to double in the coming decades to keep up with increasing demand (Tilman et al., 2011). In theory, an increase in food production can be achieved by expanding current agricultural areas. Global assessments on the availability of suitable land for agricultural expansion, such as the FAO report "World Agriculture Towards 2030/2050", indicate that about 1400 Mha are still available for further expansion (Alexandratos and Bruinsma, 2012). However, taking into account comprehensive social and environmental constraints leads to much lower estimates of available land (Lambin et al., 2013). Moreover, most of the historical expansion of cropland area has been at the expense of forests (Gibbs et al., 2010), which play a critical role in safeguarding global environmental sustainability. Forests deliver multiple ecosystem services, store large amounts of carbon and are vital for preserving global biodiversity (Machovina et al., 2015), and thus further deforestation is an extremely undesirable option. Hence, meeting increasing demand for food by expanding current agricultural areas, while taking into account social and environmental constraints, will be very challenging. On the other hand, it is also possible to increase food production without expanding current agricultural areas, but in order to achieve this, agricultural yields need to increase considerably or diets need to change to a much lower consumption

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of land-intensive livestock products (Erb et al., 2016; Tilman and Clark, 2014). In a world without deforestation, human diets are the strongest determinant of projected total available land area by 2050, implying that shifts towards diets with lower consumption of animal products represent the best option to increase production while limiting land use (Erb et al., 2016). However, the feasibility and desirability of such a global strategy towards such a large reduction of animal product consumption is the subject of much debate.

It is widely accepted that current animal product consumption patterns, especially in Western countries, are unsustainable and reductions in meat consumption are needed to decrease the pressure on natural resources (Herrero et al., 2016). Therefore, studies on the environmental consequences of agriculture have focused particularly on the environmental impact of livestock systems (Garnett, 2009). Livestock systems occupy about 30% of the world's ice-free surface and contribute about 15–20% to all global greenhouse gas emissions (Steinfeld et al., 2006). It has been shown that diets rich in meat and dairy products have generally higher associated greenhouse gas emissions and a higher water and land use (Nijdam et al., 2012). Moreover, it is projected that changes in global dietary patterns will soon overtake population growth as the main driver behind the increased pressure on global agricultural land (Kastner et al., 2012; Alexander et al., 2015). As countries become wealthier, populations tend to consume more meat and livestock products. This global increase in consumption of livestock products has major implications for food security and the environment, because the production of livestock products is less efficient compared to producing the same amount of calories or protein from vegetable sources (Nijdam et al., 2012). More than one third of all crop calories produced are currently fed to animals, with only 12% of those feed calories coming back as human food (Cassidy et al., 2013).

Demand management for animal products is thus an important mitigation strategy in the context of climate change (Bajzelj et al., 2014; Hedenus et al., 2014), and could also limit the amount of land and water currently used to produce food. Furthermore, the restriction of animal products in the human diet has received considerable attention since a lower consumption of animal products, particularly of processed red meat, could be beneficial for human health (McMichael et al., 2007; Friel et al., 2009). For instance, it has been suggested that a global shift toward a more plant-based diet, in line with standard dietary guidelines, could reduce global mortality by 6–10% (Springmann et al., 2016). Because of the potential for environmental and health benefits, it is vital to determine land use associated with all food consumption in general, as well as with the consumption of livestock products in particular.

While global analyses are important to highlight the potential of certain strategies, such as demand management for animal products, studies at country-level are needed to inform national policies, because local analyses may lead to different insights. For instance, we have recently shown that while global trade is contributing to more efficient global land use (Kastner et al., 2014), UK trade patterns are displacing cropland use to other countries (de Ruiter et al., 2016). This highlights the importance of analysing environmental consequences at different scales.

In this study, we consider the UK as a case study to examine the total land footprint associated with the total livestock product supply. The production of livestock depends on two broad land use categories: croplands and grasslands: ruminants, such as cattle, dairy cows and sheep, use large areas of grassland for grazing or use grasslands indirectly by consuming silage. Monogastrics such as pigs and chickens, but also ruminants, depend on croplands for much of their feed crops, which primarily consist of cereals and oil crops. Here we calculate the total livestock land footprint of UK supply by combining cropland area required for feed crop production and grazing areas required to produce ruminant products, such as milk and meat. We then compare the land footprint of livestock supply with the total cropland footprint of crops directly consumed by humans to obtain the total land footprint associated with UK food supply.

2. Methodology

We consider three different types of land in this study: grasslands, croplands used to produce feed crops, and croplands used to produce crops for human food (see Fig. 1 for a summary of our methodology). To calculate grassland area, we use an adapted version of the methodology developed by Alexander et al. (2015).

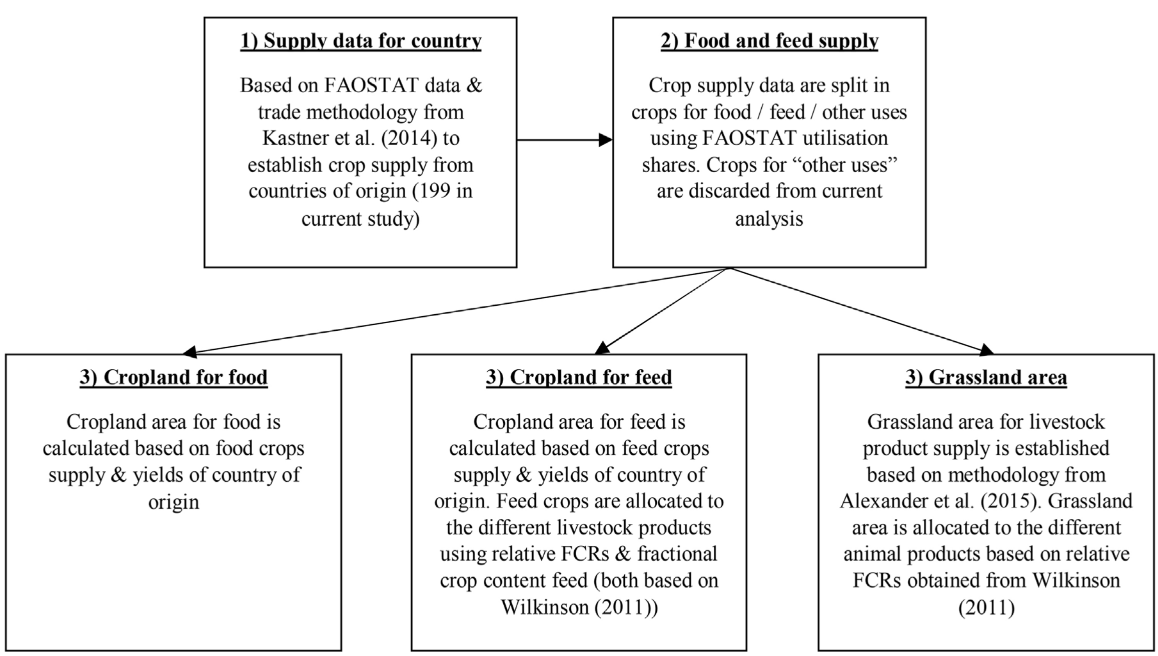

Fig. 1. Summary of data sources and methodology used in the current study.