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Moving beyond calories and protein: Micronutrient assessment of UK diets and land use

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ABSTRACT

In the next decades, an increasing demand for the amount and types of food will have to be produced on decreasing per-capita available land areas, while the current environmental impact of agriculture also needs to be reduced. This confluence of the need for an adequate and healthy diet for everyone and the need for a sustainable use of land requires new agricultural metrics that consider human nutrition as a primary objective of agriculture. In this case study for the United Kingdom, we link agricultural yield statistics with UK-specific food composition data to analyse the land use efficiency of food items for 23 different nutrients. We show that, from a land use perspective, roots & tubers and vegetables are the most land-efficient producers for these 23 nutrients. Our results indicate further that, across all 23 nutrients, roots & tubers and vegetables deliver enough nutrients to feed a median number of 43 and 42 people per hectare for one year, respectively, while a hectare of cereals feeds a median of 21 people. Eggs, the most land-efficient animal product, only feed a median of four people per hectare. We conclude that a focus on a wide range of nutrients may lead to different conclusions about an efficient use of land compared to previous analyses that tend to only consider dietary energy and protein.

1. Introduction

Demand for food, and in particular demand for animal products, is projected to increase substantially in the coming decades, because of an increasing world population and rising wealth across the globe (Tilman et al., 2011). At the same time, this increasing demand for food has to be met on decreasing per-capita available areas of land. Currently, it is estimated that the agriculture and land use sector is responsible for about a quarter of all greenhouse gas emissions, and uses about 40% of the total global ice-free land area (Foley et al., 2011; Smith et al., 2014). Therefore, it is becoming increasingly important to consider humanity's need to produce and consume within planetary boundaries in order to safeguard global food security (Rockstrom et al., 2009, Lang and Barling, 2013). Food security and global environmental change are often not considered concurrently. Food security has commonly been conceptualised as resting on three pillars: food availability, access to food and utilisation of food, with the most common association with supply-side indicators, focusing primarily on dietary energy available per person (Barrett, 2010). For instance, Food Balance Sheets (FBS) of the Food and Agricultural Organization (FAO) record the availability of protein, fat and energy per capita on a national level (FAOSTAT, 2012). However, the recognition that food security is more than just the provision of calories and protein, has led to the inclusion of "access to safe and nutritious food" within the definition of food security at the World Food Summit in 1996 (FAO, 1996; Pinstrup-Andersen, 2009). Therefore, the last decades have seen a greater emphasis on "nutrition security" as a vital component of "food security" (FAO, 2009). However, despite the stronger focus on nutritious food and not just protein or calories, only recently have scholars begun to link human health and environmental sustainability, as it is increasingly recognised that the nature of global diets is crucial to solve both environmental and human health problems.

In order to do so, several scholars have argued that global agricultural systems should be analysed from a "people nourished per hectare" perspective – i.e. assessing the number of people who would be able to obtain 100% of their recommended dietary requirements of nutrients for one year from a hectare of land – instead of limiting the focus on increasing the yield of commodities (Cassidy et al., 2013; DeFries et al., 2015; van Zanten et al., 2015). This approach offers a more explicit link between natural resource use (i.e. land) and nutritional output. Initially, studies primarily assessed how many people would be able to obtain 100% of their dietary energy or protein

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requirements from a hectare. These studies show that there are many places on earth that are relatively unproductive from a yield perspective, but are in fact feeding more people per hectare, at least in terms of dietary energy and protein, than highly productive areas that are used to produce animal feed or crops for bioethanol production (Cassidy et al., 2013). For example, many parts of Africa produce more food for human consumption per hectare than does an average U.S. hectare. Other studies show, for instance, that a hectare of millet is able to fulfil the annual iron requirement of 15.3 people, while higher-yielding rice fulfils the annual iron requirement of only 7.6 people per hectare (DeFries et al., 2015). In general, these efforts to assess how many people can be fed per hectare are hampered by the lack of reliable micronutrient data for agricultural commodities. Detailed nutritional data are widely available in developed countries; however these data are mainly available at the point of consumption (e.g. breakfast cereals). Detailed nutritional data at the point of production is less available (commodity level, e.g. rye) and food commodities can vary widely in nutritional content, based on, for example, type of commodity, yield, variety, time of harvesting, or storage. The lack of comprehensive nutritional data at the commodity level has hampered analyses to move beyond analysing calorie and protein availability at the national level. This limits the scope of scientific studies trying to analyse the productivity of certain agricultural systems or the magnitude of nutrient losses along the food chain. Therefore, recent studies have tried to link national-level food supply with individual-based dietary surveys to extend the nutritional scope of the FAO data (Del Gobbo et al., 2015), or have combined micronutrient data with FAO commodities (Kumssa et al., 2015; Wessells and Brown, 2012; Smith et al., 2016; Macdiarmid et al., 2018).

Better estimates of "nutritional yields" are thus not only important in the context of food and nutrition security, but also in the context of environmental sustainability (DeFries et al., 2015; Berry et al., 2015). A growing world population with a growing appetite for animal products is increasing the pressure on scarce land resources (Kastner et al., 2012; Alexander et al., 2015). Therefore, the confluence of the need for efficient land use and an adequate diet for everyone *"calls for new alliances, metrics and analyses for incorporating human nutrition as a primary consideration for sustainable agriculture"* (DeFries et al., 2015). Metrics should explicitly consider the quality of agricultural products (i.e. nutrient content), and not just the quantity of food production (i.e. total yield) (Lang and Barling, 2013, DeFries et al., 2015).

In this paper, our main research aim is therefore to explore how the link between metrics for environmental sustainability and human nutrition can be strengthened. We do this by explicitly analysing the land use efficiency of commodities to deliver a wide range of nutrients, using the "people nourished per hectare" concept. We use the UK, a high-income country, which is heavily dependent on imports of food and feed, as a case study. We combine detailed micronutrient data for food products with FAO trade and food supply data for the UK, using methods derived from a recent study (Macdiarmid et al., 2018).

Our starting point is that a healthy diet consists of a range of different macro- and micronutrients for which dietary recommendations are set. These nutrient requirements can be met by consuming different commodities. Although, in reality, nutritional requirements are met through a combination of different food items, in this study we primarily focus on the efficiency of individual food commodities, and consider how the different food categories (e.g. cereals, oil crops) can achieve the supply of 23 nutrients (including dietary energy). We compare how many nutrients are derived from the same area of land. We highlight which food categories are most efficient in producing a wide range of nutrients, by comparing their relative efficiency for individual nutrients but also for a whole "basket" of nutrients. While the current study focuses on a limited number of nutrients and only on the environmental indicator land use, our methodology can also be used to analyse specific nutrients or other environmental indicators. Therefore, the methodology presented in this study will contribute to a more explicit link between metrics relevant for environmental sustainability and for population health.

2. Methods

In this study, we combined FAO data on food supplies, environmental land use data based on Kastner et al. (2014) and de Ruiter et al. (2017), and UK nutritional data using methods derived by Macdiarmid et al. (2018). Food supply data are for the period 2009–2011 and land use data for the ten-year period 2001–2011. Fig. 1 gives an overview of the data sources and methods used in this study.

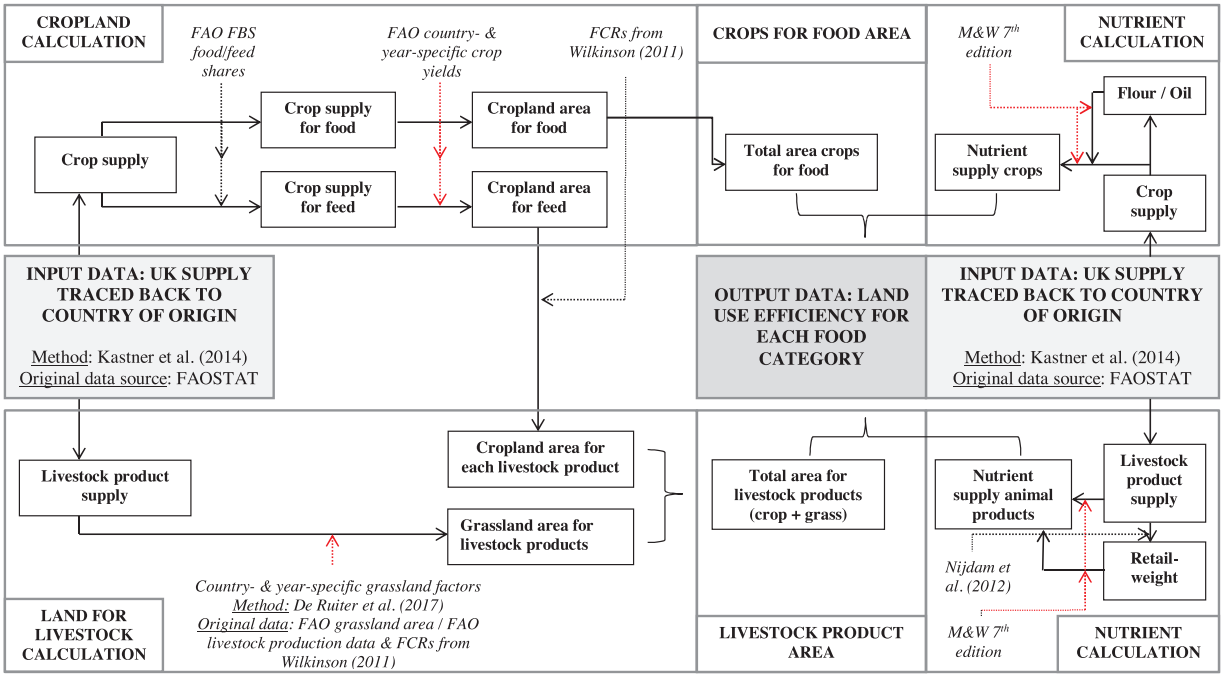

Fig. 1. Overview of calculation steps and associated data sources and methods used in this study. A sensitivity analysis was carried out for calculation steps represented by the red arrows.