The hidden role of small-scale farmers in global food security

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Abstract

In our globalised food system, farmers meet domestic and transboundary food needs. As a result, the contribution of farmers to domestic food production is a poor proxy for their role in national food security. This study offers the first global assessment of how small-, medium-, and large-scale farmers contribute to global food security. We find that the role of small-scale farmers in national and global food security has been significantly underestimated due to the localised focus of previous studies, particularly in high-income nations. Future research must account for the differentiated roles, impacts, and vulnerabilities of farmers within a global context.

Despite the critical role of farmers in our daily lives, we know little about who grows our food. When production is the subject of inquiry, analyses of farmer roles in food supply begin and end at national borders. Yet, in most countries, food demand is sourced from farms and farmers across multiple continents [1]. Two-thirds of the global population rely on non-domestic food production to meet their basic food needs [2]. This is symptomatic of a decline in domestic food self-sufficiency over the past four decades [3]. Today, in many countries, remote food producers have even greater influence over national food security than local farmers [4]. Hence, a global perspective is needed to answer the fundamental question of who feeds us.

The contribution of and need for different farms - small or industrial, organic or non-organic, intensive or agro-ecological - remains anchored to the study of domestic food systems. Within this context, the challenge of 'feeding the world' is routinely accepted as the preserve of larger farms, owing to their high output in most countries [5]. While small- and medium-scale farms have gained recognition as important sources of food security within specific geographies - China, India, Southeast Asia, Africa [6] - their role in the global food system is largely ignored.

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The roles of different farmers in agricultural production have been elucidated in recent years owing to the use of more granular data, from agricultural census surveys [7, 5], geospatial analysis of farms[6, 8, 9], and field-level assessment [10]. However, such datasets are typically used to compare the role of farmers in domestic food production and not national food security. By ignoring the distribution of farm output within global food supply chains, the true contribution of farmers to meeting national food demand remains poorly understood.

In this study, we construct a global picture of farmers' roles in national food security by coupling country-sector-specific agricultural production profiles with agri-food trade data. The resultant database estimates the contribution of agricultural production by farm size in five classes, across 236 countries and 559 products. These were grouped into small-scale (0-20ha), medium-scale (¿20-50ha), and large-scale (¿50ha). We compare our global consumption-based estimate to an equivalent territorial production-based assessment to illustrate the significance of our findings and their implications for national and global food security. Viewed through a consumption lens, we find the contribution of farmers to country food supply chains to bear little resemblance to their territorial production systems. This is due countries' reliance on, and export to, other countries with different agricultural systems.

Although geographically concentrated, small-scale farmers (0-20ha) exhibit a major role in national food supply across all countries studied (Figure 1a). Noteworthy is their contribution to nearly one-third (32.2%) of OECD average food demand. In several OECD countries small-scale farmers occupy a major role in food supply, such as in Ireland (40.1%), Spain (40.2%), Sweden (40.5%), the Netherlands (40.1%), Germany (42.1%), France (41.3%), and Austria (45%), despite their minor contribution to domestic food production (Figure 1b). Reliance on medium-scale farms closely mirror their role in national production systems, explained by the low agricultural trade flows (mean = 8.2%, median = 4.5%) linked to their production. Large-scale farmers, above 50 hectares, remain more important to OECD countries (19.4% of total average food demand) than non-OECD countries (12.3% of total average food demand). A high variation can be found between profiles of countries (Figure 1c).

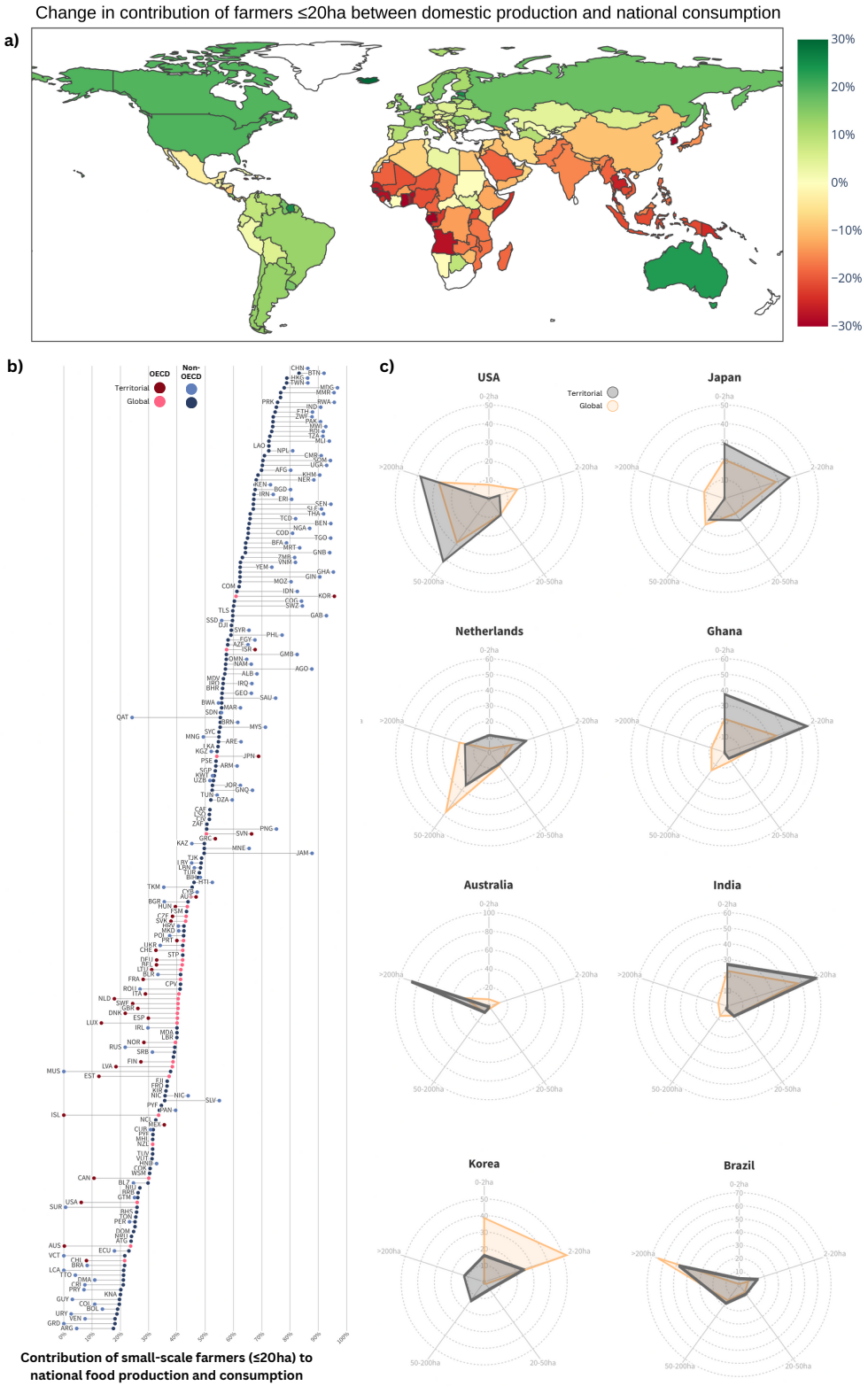

Figure. 1. Consumption-based assessment of farmer dependence by country
a) net difference in contribution of small-scale farmers to national food supply, between production and consumption perspectives, and b) these respective values for OECD and non-OECD countries marked. c) country production and consumption based farming profiles within the five size classes analysed.

Table. 1. Consumption-based reliance on farmers per agricultural sector (% of total). Largest contribution to food supply by sector and farm size is shown in bold per country group.

	>2ha		2-20ha		20-50ha		50-200ha		>200ha	
	OECD	**non-OECD**	**OECD**	**non-OECD**	**OECD**	**non-OECD**	**OECD**	**non-OECD**	**OECD**	**non-OECD**
Cereals	6.9	13.6	22.4	26.1	10.9	8.1	**30.2**	19.8	20.4	19.1
Fibre	10.6	14.6	27.2	30.2	5.8	5.3	9.7	9.7	8.2	7.8
Fruit	8.8	13.3	24.7	27.4	11.7	8.8	21.7	14.3	19.8	14.9
Livestock	8.5	14.5	23.2	29.1	11.9	8.5	25.9	15.0	13.4	12.3
Oil crops	11.2	14.4	24.2	27.0	8.5	7.0	25.9	**21.2**	**21.7**	**18.5**
Pulses	13.2	15.6	**31.4**	31.5	10.3	**8.8**	22.0	17.2	15.3	15.1
Roots/tubers	**18.7**	**22.7**	23.6	28.2	10.2	7.2	21.2	12.2	12.7	10.0
Sugar crops	8.7	15.1	26.0	**32.6**	**12.1**	8.4	24.4	13.5	17.9	17.1
Vegetables	12.9	16.4	28.8	29.9	10.1	8.2	23.3	16.5	13.9	11.6
Total	10.5%	14.5%	24.5%	27.5%	10.0%	7.7%	21.9%	14.9%	15.4%	13.0%

Farmers' roles also differ substantially among different agricultural sectors, based on their production regimes and integration within global food supply chains (Table 1). High reliance on small-scale farming is observed for OECD and non-OECD consumption of roots and tubers, pulses, vegetables, and fibre, but large-scale farms (>50ha) account for the main source of national cereal and oil crop supply. Understanding the differentiated contribution that farmers make to national food supply can help identify their roles in a sustainable dietary transition.

Alongside domestic food self-sufficiency, the scale and composition of agricultural trade between nations shapes the role that farmers play in their overall food supply. We find large differences between the trade networks of different farm sizes, as illustrated in Figure 2. While agricultural trade from small-scale farms is highly decentralised, medium- and large-scale farm output is highly concentrated by source and destination. Network analysis reveals farms <2ha are more densely connected than other farm sizes across 70% of agri-commodities.

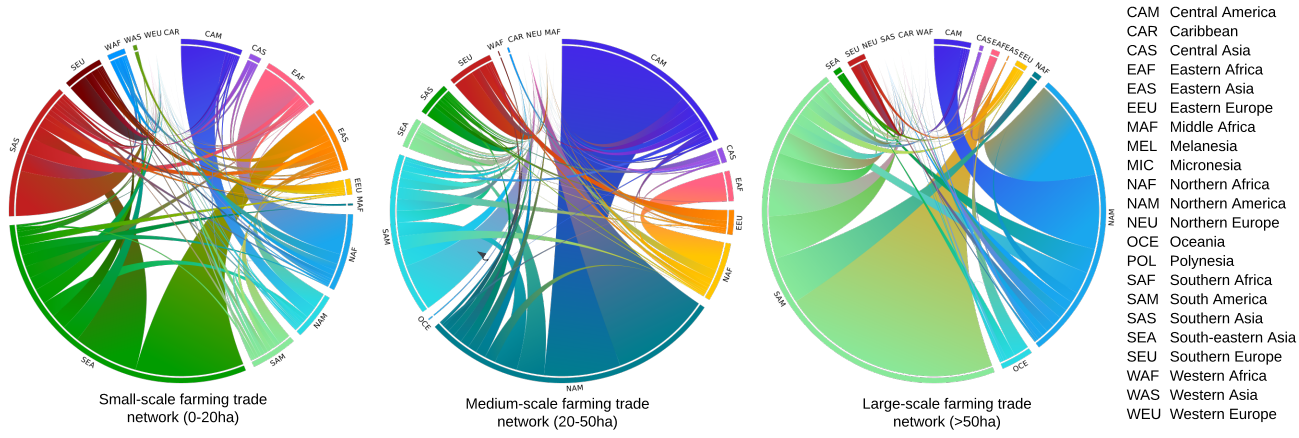

Figure. 2. International agricultural trade by farm size

In this study, we show that the contribution of farmers to national food production is a poor proxy for their role in national food security. Yet, prevailing assessments conflate these two figures, inflating the perceived role of large-scale farming in meeting current and future food needs. Calls for further consolidation and industrialisation of farming to meet growing global food demand are symptomatic of this. By mapping the global footprint of national food systems, we can more accurately quantify the global contribution of small-, medium-, and large-scale farms in meeting national food demand. Despite their minor role in domestic food production, we find that small-scale farmers play a critical role in meeting food demand in the USA, Canada, Australia, the EU-28, and other OECD countries. Moreover, the produce of small-scale farms reach more countries through international trade compared with medium- or large-scale farms. Foremost, this study highlights the need for global consumption-based assessment of how farmers contribute to domestic and transboundary food needs. This is not only pertinent to current approaches to assess national food security but also to evaluate the role farmers play in future sustainable food systems.

Despite the burgeoning number of studies on sustainable food consumption and sourcing [11, 1, 3], the role that different farmers play in these efforts remains chronically understudied. A more complete picture of the contribution farmers make to global food markets, as developed in this study, provides a basis to assessing their contribution to sustainable dietary transition and sustainable food trade. Future food system research must recognise the uneven influence farmers exert across the global food system, the unequal responsibility they bear for its impacts and the distinct roles in delivering a sustainable food future. Understanding the web of global linkages connecting farm to fork is crucial towards this end.

Methods

This study couples models of farm production profiles and pathways of agri-commodity sourcing to study the reliance of nations on small-, medium-, and large-scale farmers within a global context. Farm production profiles are sourced from Herrero et al. [6], based on the integration of geospatial crop and livestock maps with national agricultural production data, covering 85% of global cropped area and 161 countries, nine agricultural sectors, and five farm sizes.

To assess how farmers meet domestic and transboundary food needs, farmer profiles were coupled with a global model of agricultural production, consumption, and trade flows constructed from FAOStat data [12], covering 559 agricultural commodities and 236 countries. Data were sourced for 2019, as the most complete and up-to-date food flow accounts available, and due to the pandemic of 2020 representing irregular agricultural trade flows. The direct use of bilateral physical trade statistics can lead to the misidentification of the origin of commodities, where they are re-exported and the country of dispatch does not represent the source of production, resulting in double counting. To address this, we applied a re-export algorithm from Croft et al. [13] to correctly identify the production sources of national agricultural consumption. During processing of the data, irregularities in the production and trade of the Central African Republic were evident and subsequently removed. For minor countries where domestic farm production profiles were not available, their non-domestic reliance on farmers could still be established using trade data.

Agricultural production by different farmers for domestic and export markets were assumed to follow the same product-country profiles reported in Herrero et al. [6]. Although complementary algorithms to differentiate farm-level output to domestic and export markets exist (e.g. based on road network proximity [14], farmer irrigation use [15], and econometric analysis of sub-regional economies [16]), these are not yet corroborated with sub-national production data on the market preferences and behaviours of farmers. Therefore, we follow a proportionally weighted approach in the absence of available sub-national production and trade data at the scale of this analysis. Where more granular data becomes available toward this end, it can be readily integrated into this analysis. To enable a comparison between the primary commodity and territorial analysis in the study of Herrero et al. [6], we analysed food consumption flows at this level. However, integration of secondary agri-food flows (e.g. soybeans to livestock) offers the potential to capture indirect sectoral dependencies of countries on farmers for more complex supply chains [17].

Several lines of future research inquiry emerge from the limitations of this analysis and its underlying data. Foremost, the profiles of agricultural production by farm size remain outdated due to the lack of recent geospatial crop and livestock maps and do not capture fragmentation or consolidation in farmland over the past decade [18, 19, 20]. Higher sectoral resolution of these maps would also enable a more accurate assessment of the contribution of farmers to different product systems. Extending this assessment to incorporate the environmental impacts that farmers face and drive would also help to distinguish their roles in sustainable food transitions. Improvements in the scope and availability of farm-specific environmental impact data are critically needed to advance such assessments.

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