Transforming Agrifood Systems in South Asia

Ecological footprints of food systems in South Asia

Preliminary findings of a systematic scoping Review

Research Note 6, Work Package 5
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SUMMARY

Food systems in South Asia exert considerable pressure on climate systems, water systems, and biodiversity. Quantifying these impacts and is crucial for steering food system transitions. However, approaches and assessments for environmental footprints of food systems remain largely fragmented in South Asia, especially for low-income and data-scarce regions. We address this knowledge gap with a systematic scoping review of peer-reviewed literature to identify existing methods and datasets applicable for assessing the environmental footprints and planetary boundaries of food systems in South Asia. We find that such assessments have started to become more common, although many remain narrowly focused or reliant on Tier 1 type of approaches. Others are singular case studies or describe experiments. For example, most studies look either at carbon and/or water footprints of national dietary or production patterns and their relationship to ecosystem functioning. We also find a concentration of studies on specific crops or food products in select locations, indicative of heterogeneity in data availability. Only a few consider locally relevant ecological boundaries. We consequent suggest two avenues for future research: First, consolidating a meso-scale overview of environmental impacts of food systems through existing data and basic footprint functions to support participatory priority setting exercises and strategy development. Second, research is needed to generate sub-regional diagnostic datasets. These could be helpful in developing context-specific, data-driven, and socially desirable solutions to address the most actionable environmental impacts of food systems in South Asia.

Photo: Farmer's field in Nalanda. Photo credit: Mahesh Kumar Gathala

CIMMYT International Maize and Wheat Improvement Center · IFPRI International Food Policy Research Institute · IRRI International Rice Research Institute · IWMI International Water Management Institute · CIP International Potato Center · WorldFish · ILRI International Livestock Research Institute

KEY RESULTS

Food systems are putting substantial and increasing pressure on core earth system functions (Gerten et al., 2020; Rockström et al., 2020; Springmann et al., 2018; Willett et al., 2019). Understanding the extent of these pressures and, ideally, transforming food systems so that they can maintain or augment earth system functions, rather than deprecate them, is a critical aspect of food system transitions. To steer thinking and action, both environmental footprint and planetary boundary assessments have gained prominence over the last decades as concepts that seek to elucidate the environmental impact of human activity and defining a safe operating space (Figure 1; Rockstrom et al., 2009).

However, a understanding of the environmental impacts and the safe operating space of food systems in low-income regions remains fragmented at best and is often elusive. To start addressing this knowledge gap, the One CGIAR Initiative on Transforming Agri-Food Systems in South Asia (TAFSSA), has conducted a systematic scoping review to map key approaches and methods for assessing the sustainability of food systems in South Asia (Tricco et al., 2018). We focused on general frameworks, datasets and methods that are particularly relevant for South Asia (see Methods section for more details).

The preliminary findings reported here suggest that substantial progress on multiple dimensions is required to adequately develop datasets, research, and actions towards more sustainable food systems in South Asia. Our search within the Web of Science Core Collection database returned a total of 728 articles, out of which 140 articles within the scope of this study (Figure 2). Out of these, all 140 articles to some extent studied environmental footprints, while only 32 also looked at ecological boundaries.

Figure 3 shows the top seven journal names where most studies inside the database were published with the remainder grouped under 'Other' . Most of the publications appeared in mid to high impact factor journals (Q1) within environmental sciences and food sciences. Importantly, all of these journals specifically state an interest in interdisciplinary science and cover both natural as well as social science domains.

Figure 1. Conceptual figure of environmental footprints assessments of food systems.

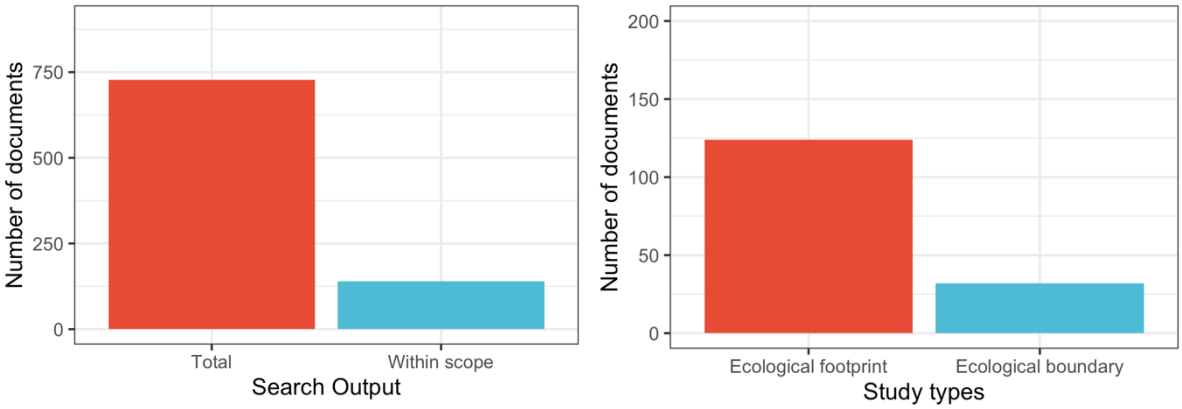

Figure 2. Overview of results contained within the scope of the study and whether they consider ecological footprints, boundaries or both.

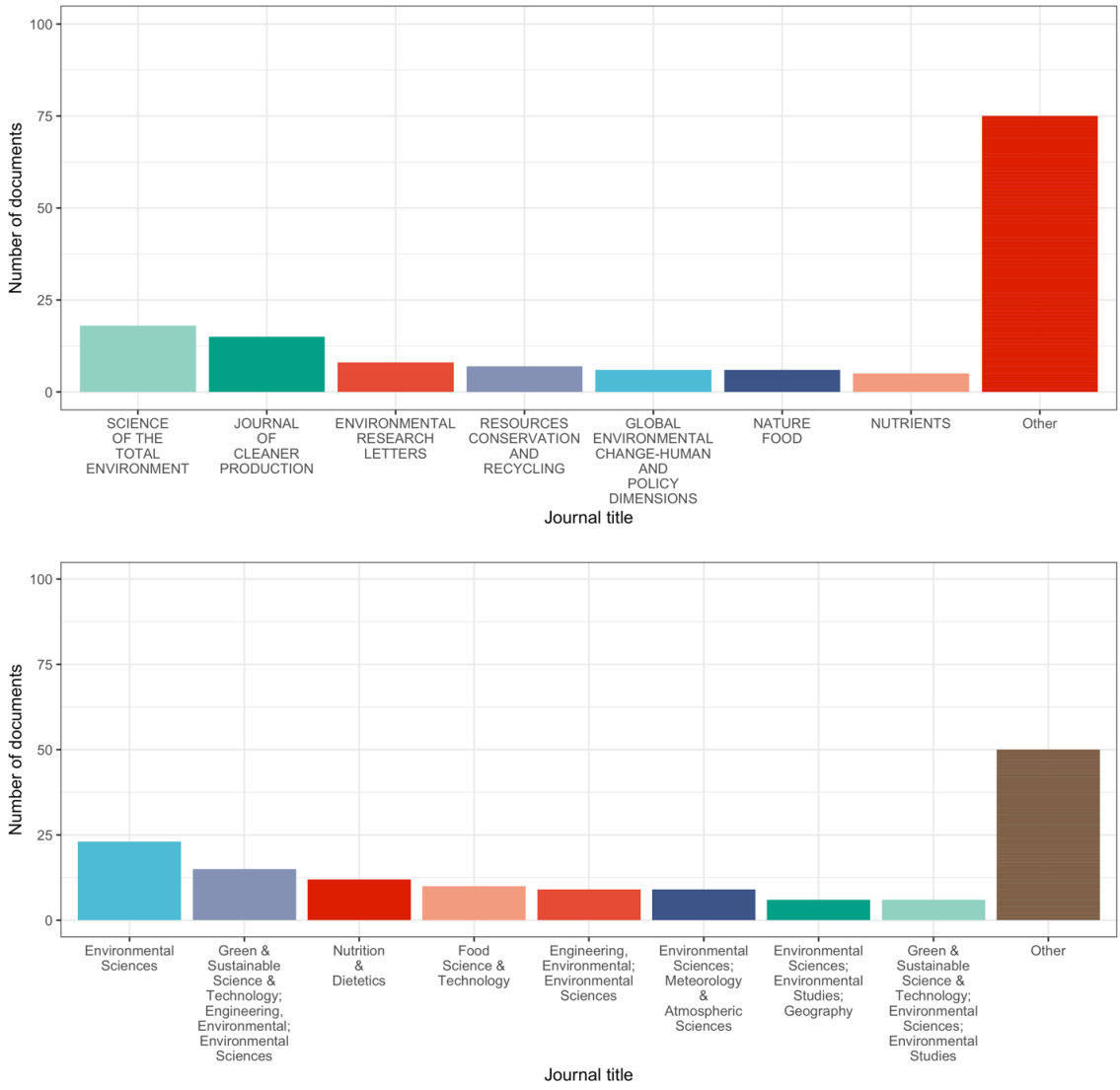

Figure 3. Most frequent journal titles (top) and Web of Science categories (bottom) contained within the scoping review database.

Our preliminary analysis suggests that environmental assessments of food systems can be roughly grouped into three types that correspond to different scales.

First, large-scale assessments at the cross-sectoral level have been deployed in much of the developed world (and China) to coherently track food systems impacts on the environment throughout the economy. These assessments require harmonized and detailed data available across all sectors of the economy. In addition, sophisticated footprint accounting data across all sectors is required for such a complete assessment. Data scarcitymakes the application of this approach to South Asia's food systems difficult, likely owing to the relatively low number of regional- our countrt-level datasets used (50) compared to global ones (122) and the relative novelty of the field as represented in recent surge in publication numbers (Figure 4). Although some of this rise may be attributable to COVID-19 related rise in publication.

Second, assessments of the environmental footprint of diets or food production have been increasing. These assessments are either based on representative – often at the national level – dietary surveys or using FAO Food Balance sheets or similar datasets (Kelly et al., 1991). These datasets and indicators are generally available for most countries. The footprints of these diets have often been compared to the footprints of an EAT-Lancet diet or the footprints of other diets recommended by national health institutes (Willett et al., 2019). Nevertheless, the locally specific footprint functions are often not available for all food products and thus often rely on Tier 1 type of approaches that risk masking large international differences in footprint functions as well as sub-national heterogeneity. Systematic reviews of Life-Cycle Assessments (LCA) have conversely been used to overcome this bottleneck but require a solid foundation of LCA studies that may not be available in low-income contexts.

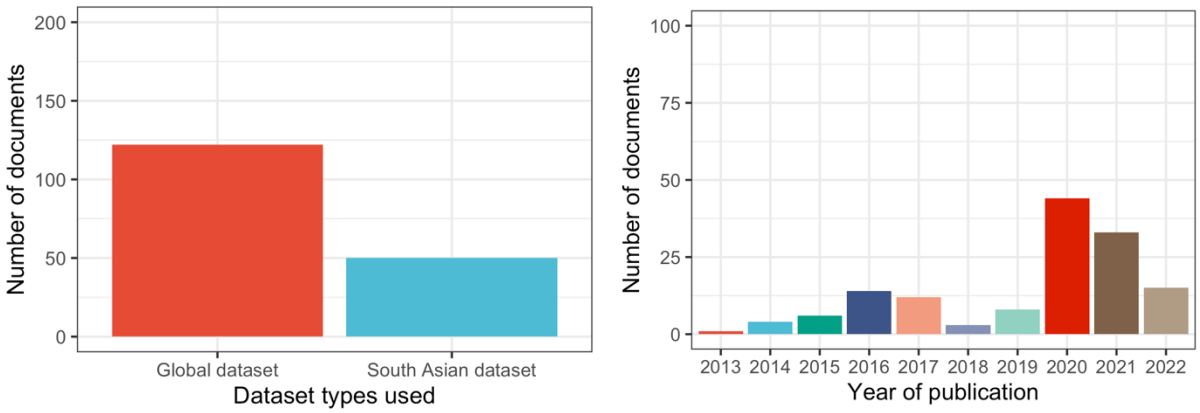

Figure 4. Showing number of studies using global datasets as well as South Asian datasets (left) and number of publications per year (right).

Third, local assessments of the environmental footprint of specific food products based on LCA for food products, often focused on agronomic trials, have increased significantly over the last decade. These are very useful to map the footprints and impacts of major crops that are produced, but do not yet cover all crops or most processed food products. At the same time, since they are based on experimental trials often reflecting good management practices – these assessments do not reflect the heterogeneity in prevailing management practices, nor can they be described as true 'food systems' studies. Similarly, our results suggest that the environmental impact of unhealthy foods, such as instant noodles that are increasing in consumption, in South Asia's food systems has not yet been assessed systematically due to a lack in dietary data as well as relative information on footprint functions. Similarly, the complexity and heterogeneity of South Asia's geography, agricultural and food consumption contexts – which also differ considerably across and within cultures, genders, agre groups and even castes, can lead to high uncertainty of outputs when using global coefficients and extrapolating from small-scale experiments.

Our results also show that the scope of most footprint assessments is largely limited to greenhouse gases (GHGs; 129 articles) and water use (109 articles). With land (64 articles) and nitrogen footprints (37 articles) being substantially less often included (see Figure 5). This trend is also visible when ranking the word stems contained in the abstracts by their frequency, showing that water, emissions, and global rank amongst the highest (Figure 5). This trend can likely be attributed to the readily available global footprint functions provided by the IPCC, the Water Footprint Network (Hoekstra & Mekonnen, 2012; IPCC, 2022), or other organizations. Land use has most often been calculated based on food and fodder crop yields from national statistics or FAOSTAT, but is nonetheless less often considered. Similarly, nitrogen footprints have not received much attention but are mostly considered as part of GHG calculations and assesments.

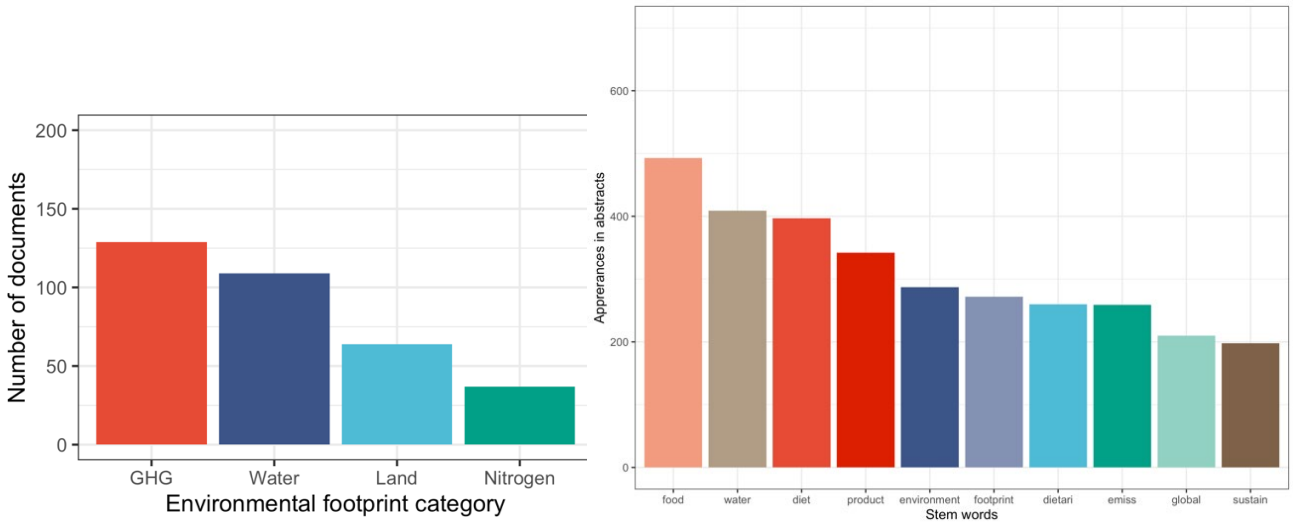

Figure 5. Number of studies that treated each environmental footprint category (left) and frequency of word stem occurrence across all abstracts in the study database (right).

The major limitation of the literature on food systems and their environmental impact is that change is normally positioned on the left side of the equation in Figure 1 (*i.e.* in diets or production) – while assuming largely stable footprint coefficients that are often averaged at the country level. This reflects a longstanding criticism of footprint assessments, that they are not context-specific enough to encourage policy action, and that they may provide little diagnostic help as they do not consider variation in resource availability, input use intensity and efficiency (in the case of production systems) and other factors related to heterogeneity in resource endowments and agricultural practices prevalent in low-income contexts (Chenoweth et al., 2014; Fereres et al., 2017; Hoekstra, 2016).

Similarly, very few studies reflect on contextually-relevant ecological boundaries. This also relates to a poor understanding of local ecological boundaries that appears to be common in our sample of papers. For GHG emissions, this may be defensible as the boundary is of global nature. But for water and land systems, a footprint's implication for the region or sub-region depends on local conditions, and larger footprints may be acceptable in more water-abundant places than, for instance, more arid regions. In fact, water-intensive food production practices might be favorable in water-abundant regions as they are also more adapted to the excess moisture that might harm crops that are more suited to arid regions. Admittedly, some of these limitations have been addressed through approaches like the water scarcity weighted water footprint, but nevertheless, do not allow for context-specific diagnostics but are more adept for priority setting.

METHODS

We largely followed the PRISMA guidelines for systematic scoping reviews (Tricco et al., 2018). Accordingly, based on an initial scan of the literature we, a team of identified six scientists from several food system related disciplines (four of which are South Asian nationals and two of which hold substantial experience in South Asia) developed five inclusion criteria and eight categories for coding.

Final research design, data collection. coding, and analysis was done by the first four authors, while the last two authors assisted in envisioning the research, guiding research methods, providing analytical supervisory support and guidance. The articles were equally divided into four sections for each reviewer for this preliminary analysis, with a second pass by another reviewer to be conducted to verify the coding in the future. The main goal of this scoping review, inclusion criteria, and coding criteria were defined as follows:

Research Main Goal:
"Mapping the existing approaches, methods, and datasets used to assess the environmental footprints and ecological boundaries of food system in South Asia."

Study Inclusion Criteria:
IC0: Fits within the conceptual framework of the scoping review
IC1: Considers environmental footprint or Ecological boundaries of the food system
IC2: Considers water, GHG emissions, land, or nitrogen footprint or boundary
IC3: Uses global datasets or datasets for South Asia
IC4: Specifically treats crops/foods that are commonly grown or consumed in South Asia

Coding Criteria:
Q0: Name or brief descriptor of approach or methodology used?
Q1: Which datasets were used for diets?
Q2: Which datasets were used for food processing?
Q3: Which dataset were used for agricultural production?
Q4: Which datasets were used for calculating the footprint?
Q5: Which datasets were used for calculating the boundary?
Q6: What are the major advantages for the method used in this study?
Q**7:** What are the major limitations for the method used in this study?

Table 1. Overview of search terms and corresponding results numbers.

Search Terms and Results **Scoping review on planetary boundaries and environmental footprints of food systems in South Asia: Methods and approaches**		
Document type: Article, review article, meeting abstract, data paper, proceeding paper		
#	**Search term**	**Number of results**
1	Planetary boundary' and 'Food system'	134
2	Footprint' and 'Diet' and 'Global'	292
3	Footprint' and 'Food' and 'South Asia'	11
4	Footprint' and 'Diet' and 'South Asia'	4
5	Footprint' and 'Diet' and 'India'	24
6	Footprint' and 'Diet' and 'Nepal'	0
7	Footprint' and 'Diet' and 'Bangladesh'	0
8	Footprint' and 'Diet' and 'Global'	292
9	Biodiversity' and ('Diet' OR 'agricult*') and 'South Asia'	162
10	Nitrogen' and ('Diet' OR 'agricult*') and 'South Asia'	165
11	GHG' and ('Diet' OR 'agricult*') and 'South Asia'	39
	Total with duplicates	**1123**
	Total without duplicates	**794**
	Total after 2000	**783**
	Total after 2010	**728**
	Highly cited papers	**32**
	Review papers	**105**

For the literature search, we focused on peer-reviewed articles of journals included in the Web of Science Core Collection to gain a 'birds-eye' view of the published and refereed corpus. Since the main goal of this scoping review was to map methods and datasets, rather than conduct meta-analysis, we did not identify any variables or record any effect sizes during this scoping review. We did, however, record the datasets and approaches, a concrete mapping of which still requires additional study. The search terms where iteratively developed to ensure they cover key topics with a reasonable number of search results.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, comprehensively mapping and understanding the environmental footprint of food systems in South Asia requires further progress, especially in the development of foundational datasets. Nevertheless, rudimentary datasets at Tier 1 type of equation exist and can be used to map and compare the environmental impact of different food system configurations. However, time is short and pressure high to reverse the negative trends in food security and malnutrition. At the same time, new large scale and digital data collection approaches allow to develop rapid and novel insights. For science to support rapid food system transition that bolster earth system functions – the most effective way forward is likely to use the available Tier 1 data with emerging data on food production and diets to prioritize novel data collection and diagnostic efforts to identify hotspots of environmental degradation caused by the food system and identifying solutions that score multi-dimensional wins for diets, climate, biodiversity that are also economically attractive to smallholder farmers and other food system actors.

Above: Farmers engaged in diverse food production in Dinajpur, Bangladesh. Photo credit: Timothy J. Krupnik

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