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PERSPECTIVE

Integrating blue foods into food system approaches and frameworks

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Abstract

Despite supplying essential nutrients to billions of people and sustaining hundreds of millions of livelihoods, blue foods are overlooked within food system frameworks and debates. This Perspective highlights the shortcomings and potential of the High-Level Panel Of Experts (HLPE) sustainable food systems (SFS) framework in addressing blue food dynamics. Drawing on a review of 124 peer-reviewed articles that cite the HLPE framework, and an examination of its authorship and values, we demonstrate that blue foods are rarely integrated into food systems analyses, reflecting epistemic inequalities in the field. We identify critical omissions—including production dynamics, food loss and waste, consolidation in supply chains, and normative values shaping decision-making—that constrain the framework's application to blue foods (and other diverse contexts). To advance more inclusive and effective food system approaches, we recommend (1) greater use of food systems frameworks to examine blue food dynamics and other diverse food systems contexts, (2) updates to the SFS framework to integrate blue food contexts, and (3) guidance to operationalize these frameworks for research and policy action. We call on the HLPE to update the SFS framework, particularly through the forthcoming (2027) report on fisheries and aquaculture, to spotlight the framework's utility for capturing the complexity of diverse yet essential food systems beyond production, including aquatic food systems.

1. Blue foods are essential yet under-represented in food systems dialogues

The concept 'blue foods' refers to the diverse aquatic animals (e.g., finfish, shellfish), plants, and algae sourced from capture fisheries or aquaculture for direct human consumption. Blue foods are vital for global nutrition, health, and livelihoods. However, the level of attention they receive in food system policy debates, scientific funding, and analytical frameworks does not reflect their global importance (Bennett *et al* 2021, Koehn *et al* 2021). Why are blue foods often overlooked within food systems dialogues? How does this oversight reflect underlying limitations of existing frameworks and affect our ability to understand and address challenges in our food system?

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Despite the interconnections between blue food systems and terrestrial or 'green' food systems (Cottrell *et al* 2018), we argue that dominant approaches to examining food systems, notably the frameworks that organize and define them, can render blue foods less visible. This lack of visibility is symptomatic of broader framework shortcomings that, in turn, hinder the integration of blue foods and limit the evidence base for their inclusion in food system science and policy agendas. Although a growing body of research highlights the importance of blue foods and advocates for examining them from a food systems lens (Halpern *et al* 2019, Troell *et al* 2019, Bennett *et al* 2021, Gephart *et al* 2021, Golden *et al* 2021, Simmance *et al* 2021, Tigchelaar *et al* 2022, Vogliano *et al* 2024, etc), the influence, limitations, and potential of widely used food systems frameworks in shaping blue food research are underexplored.

Frameworks are theoretical or conceptual models that help define the key elements and relationships of complex systems, such as food systems, facilitating their analysis (Partelow 2023). Understanding the extent to which blue food characteristics are integrated in food systems frameworks and policy discourses matters because, like other sustainability frameworks, food system frameworks help structure empirical inquiry and governance interventions, making them important tools for translating systems thinking into practice (Partelow 2023). For instance, food systems frameworks often play a pivotal role in policy discourses and decision-making, guiding priorities and investments to address hunger, malnutrition, and sustainability challenges (IPES Food 2019, Brouwer *et al* 2020). While multiple frameworks and related definitions of food systems exist (Béné *et al* 2019, Brouwer *et al* 2020), the guidance from the High-Level Panel Of Experts (HLPE) on Food Security and Nutrition has been widely adopted (Brouwer *et al* 2020). The HLPE defines food systems as encompassing all elements, activities, and actors involved in food production, processing, preparation, and consumption, as well as the drivers, interactions, and outcomes of these activities (HLPE 2017). The HLPE framework, like other food systems frameworks, visually depict key components of these complex systems, their boundaries, and relationships, including among *food system drivers* (e.g. biophysical, technological, economic, political and institutional, sociocultural, and demographic), interacting *food system activities* (production, storage and distribution, processing, packaging, marketing, and consumption), *food environments*, and the *outcomes and impacts* of these activities, including on diets, human health and nutrition, social equity, economics, and the environment2019 (Ingram 2011, HLPE 2017, 2020, Brouwer *et al* 2020).

By providing common vocabulary, frameworks facilitate knowledge synthesis, interdisciplinary collaboration, and guide future research partnerships (Partelow 2023). Every framework has a position that often reflects the backgrounds, biases, and interests of its creators. For example, the social-ecological systems framework developed by Elinor Ostrom (Ostrom 2009) and colleagues is portrayed as broadly applicable for environmental sustainability research but is strongly shaped by her local-level institutional analysis and collective action approaches to natural resource management. Yet, the 'black box' nature of frameworks means that the reasons and mechanisms for choosing which concepts and relationships to include and which to exclude are often not transparent. Understanding the positionality of frameworks is important because, as positioning and even value-articulating tools, frameworks can 'populate the scientist's world with a set of conceptual objects and (non-causal) relationships among them,' in the process shaping and sometimes limiting how we diagnose and tackle problems and design solutions (Cox *et al* 2016, p 47, Partelow 2023). When the positionality and limitations of a framework are not evident, it can have significant implications for research and practice. For example, failing to acknowledge these limitations may reinforce the exclusion of blue foods, thereby reducing the framework's comprehensiveness and relevance across diverse contexts. If food systems analyses intend to identify interlinkages among different system levels, outcomes, and interactions to pinpoint effective entry points for improving outcomes and actor engagement (Ruben *et al* 2018, Brouwer *et al* 2020), then neglecting blue foods risks drawing incomplete, ineffective, and potentially inequitable conclusions about system performance and needed interventions.

In this context, we argue that integrating blue foods into food systems research and policy agendas can support more holistic and effective approaches to addressing complex equity and sustainability challenges. This focus will also help ensure that the comparative impacts of blue foods are better understood (Halpern *et al* 2019) and that their vital contributions to nutrition, well-being, and livelihoods are recognized. Numerous recent studies have highlighted the importance of blue foods for social, economic, and nutritional outcomes, including those related to the Sustainable Development Goals (Ahern *et al* 2021, Vogliano *et al* 2024). For example, over 900 million women derive an estimated 50% of their essential Omega-3 fatty acids from fish caught by small-scale fisheries, while around 500 million people partially depend on them for their livelihoods (excluding industrial fishing and near-equivalent aquaculture contributions (FAO *et al* 2023).

Diverse blue foods, encompassing over 3600 aquatic species consumed globally, provide vital nutrients to three billion people and at least 20% of their animal protein (Golden *et al* 2021, FAO *et al* 2024).

The landmark EAT-Lancet commission report provides scientific targets for healthy diets, highlighting the importance of consuming fish at the highest daily recommended serving amount (28 g), compared to all other animal-source foods, and with the same healthy consumption range flexibility per day (0–100 g per day) as beans, lentils, and peas. This suggests that fish are among the most crucial non-plant protein sources for a healthy diet and are often a more sustainable option than terrestrial animal-source foods (Gephart *et al* 2021). However, only 5% of the scientific literature on food systems considers blue foods (Simmance *et al* 2021) while less than 40% of national public health and nutrition policies recognize the importance of blue foods in their objectives (Koehn *et al* 2021).

In this Perspective, we analyze the influential sustainable food systems (SFS) framework to highlight gaps in how blue foods and other diverse food system contexts are included and represented in these influential tools. The SFS framework was developed by the HLPE, which serves as the science-policy interface of the United Nations Committee on World Food Security (CFS). While numerous food systems frameworks exist (Ericksen 2008, Ingram 2011, Global Panel on Agriculture & Food Systems for Nutrition 2016, HLPE 2017, 2020), we focus on the HLPE's framework given its comprehensiveness and widespread use by researchers and decision-makers (Brouwer *et al* 2020, Simmance *et al* 2021). To understand the HLPE framework's positionality, we examined how researchers have used it to date, which systems have been studied, and which research questions have been explored (Partelow 2023). We further investigate the positionality of its creators by examining who developed it, the fields in which they are embedded, and the values articulated (Partelow 2023), while acknowledging that positionality is constituted through many factors. Based on our analysis, we identify patterns and gaps in the current use of the framework and highlight specific areas for action, both to better integrate blue foods into food systems research and policymaking, and to enhance the framework's relevance and utility for a wide range of terrestrial and aquatic systems (e.g., wild foods, urban coastal foods, small-scale agricultural contexts, etc).

2. The HLPE food systems framework

The HLPE has published two versions of the SFS framework: first, in a 2017 report focused on nutrition and food systems, and then, in an updated version in 2020, focused on building new narratives about food systems. While the original 2017 HLPE food systems framework remains popular, the 2020 framework (figure 1) offers several critical updates and improvements. Notable among these are the recognition of economic and market drivers as distinct from political and institutional drivers; additional components of food environments (e.g., acceptability and policy conditions); consumer behaviors (e.g., awareness of the impacts of choices); and diets (e.g., adequacy). Furthermore, the new framework illustrates a separation between the elements that compose the food system and the drivers that act upon it. The new version also expands the notion of food security to consider six dimensions (availability, access, utilization, stability, agency, and sustainability) as parts of the Right to Food Framework and replaces the explicit focus on the Sustainable Development Goals (SDGs) with a broader recognition of the 'policy and governance' context. However, the 2020 report, with the updated SFS framework, provides little direct discussion of the framework itself.

2.1. How the HLPE food systems framework is being used at present

To understand how the SFS framework is currently used, we retrieved 124 peer-reviewed articles that cited the HLPE's 2017 or 2020 food systems reports (obtained from Google Scholar on 8 August 2023). These articles were coded and assessed for whether and how they recognized blue foods within the food system and, regardless of the system studied, how they used the HLPE framework (i.e. to position the impact or value of the work, to characterize elements of the food system, to analyze data, or only as a superficial reference or cited for other elements of the report beyond the food systems framework) and which elements of the food system they studied. Our analysis revealed that, despite being intended for universal application, the HLPE food system framework is rarely applied in practice to examine blue foods. While 44% of articles recognized blue foods as part of food systems (meaning, at least one mention of blue foods), only 6% ($N = 8$) explicitly focused on blue foods. Across all systems, most articles (69%) cited the HLPE report superficially, often with a single citation in the introduction or conclusion. Among the 31% ($N = 40$) of articles that were more substantively engaged with the HLPE's SFS framework, most used it to position the contributions of their work (i.e. as framing in the introduction or conclusions) or to characterize their study system. In comparison, only 8% ($N = 10$) of articles utilized the framework for analysis, including three papers focused on blue food, which used the framework to scope literature reviews and identify existing knowledge gaps and entry points for action (Simmance

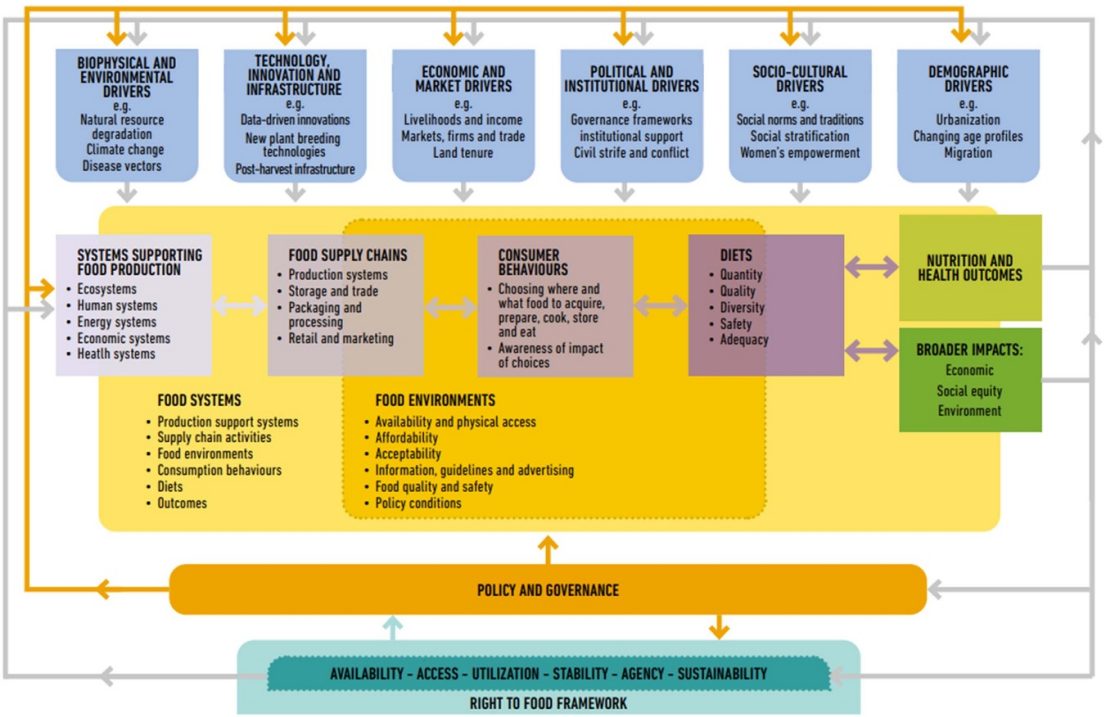

Figure 1. The updated sustainable food systems (SFS) framework from the HLPE (2020). Reproduced with permission.

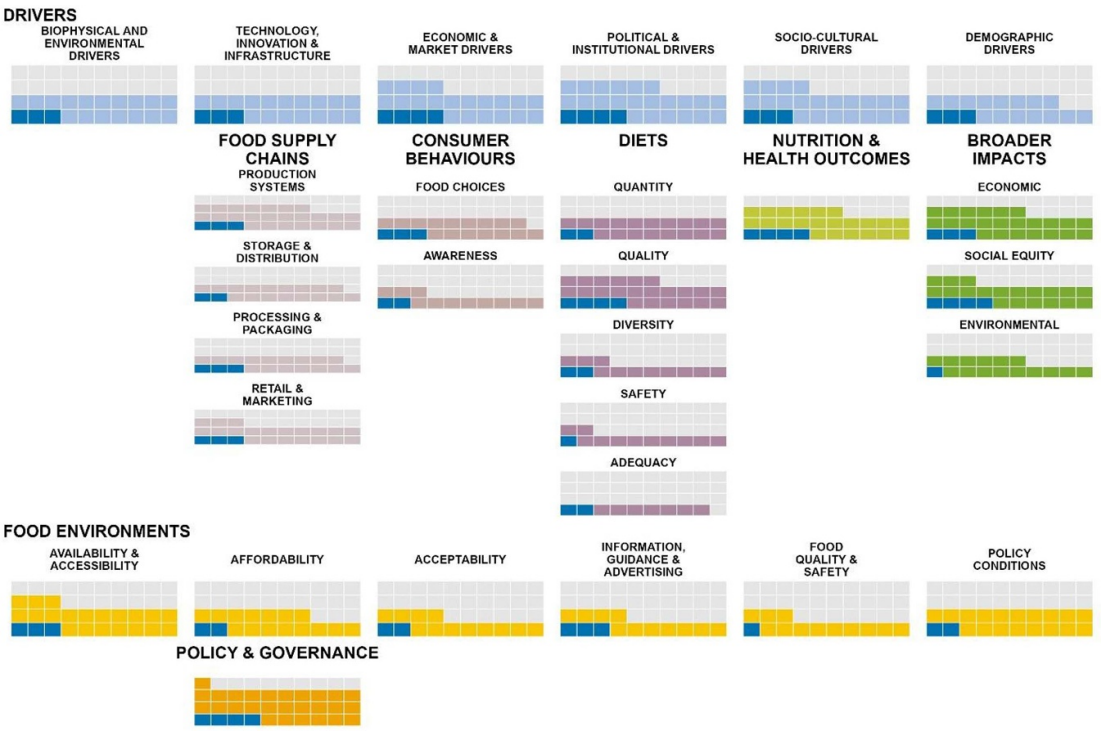

Figure 2. Different elements of the HLPE's SFS framework that were substantively engaged with in the 40 papers identified through our literature search and coding (each tile representing one paper that cited either the 2017 or 2020 report, regardless of the system studied). The tile colors correspond to those of the 2020 framework with blue foods-focused papers emphasized in blue.

et al 2021, Ahern *et al* 2021, de Bruyn *et al* 2021). The most studied elements of the framework across all systems included food system drivers (primarily political and institutional, economic, and sociocultural drivers), food supply chain activities (mainly production activities), food environments (including availability, access, and policy conditions), and the policy and governance context (see figure 2).

2.2. Positionality of the HLPE food systems framework's creators

We also examined the backgrounds of the HLPE report authors to assess their positionality in the development of the frameworks. Of the 2017 and 2020 HLPE expert authors, only 8% and 11%, respectively, had experience with aquatic food systems (i.e. a degree or related work, such as a published report, talk, or peer-reviewed article on fisheries or aquaculture). This limited representation across both expert groups may help explain why blue food system dynamics are underrepresented in the HLPE food systems framework, which is particularly concerning given projections about the increasing importance of blue foods for meeting global food security (Allegretti and Hicks 2022). The values foregrounded by the HLPE SFS framework center on diets, nutrition, and health outcomes of food systems (HLPE 2017). The overall objective of the original report and framework is to contribute to the progressive realization of the right to food (HLPE 2017). These values reflect the framework's origins in the CFS, particularly its goal of ensuring food security and nutrition for all. While the framework acknowledges the complexity of drivers, inter-relationships, and multiple outcomes of food systems, its creation was motivated by the values of food security and nutrition, as evidenced by the context provided in the 2017 and 2020 reports. Further, analysis by Brouwer *et al* (2020) on the focus in different food systems reports and studies affirms the HLPE's (e.g., 2017 report's) emphasis as being on 'demand-oriented or consumption activities and outcomes' (e.g., consumer behavior, food environments, and diets and nutrition).

2.3. Missing blue food elements of the HLPE SFS framework

While the current HLPE SFS framework captures many important elements and relationships of the food system, we argue that essential aspects of blue foods are missing, revealing important factors relevant to many food systems.

(1) **The production dynamics of blue foods are not reflected.** Wild capture fisheries and aquaculture target a great diversity of species and aquatic environments, which often have distinct socio-economic, political, and ecological factors relating to mobility, space, boundaries, and property. For example, the mobility of resource units (e.g., fish stocks) creates transboundary resource issues. Meanwhile, the presence of distant-water fishing fleets and the interplay between wild-capture and aquaculture production in shared, public waters can result in fundamental differences from conventionally studied terrestrial food systems in spatial conflicts, organizational structures, and relationships (Halpern *et al* 2019, Gephart *et al* 2021). Property rights in a blue foods context (e.g., common-pool resources with overlapping property rights regimes that mediate access, use, and management rights) create complex tenure and access issues and potential externalities from production activities. Greater attention to these characteristics would extend the framework's applicability beyond blue foods to encompass the diversity of other, less conventionally studied food systems as well (e.g., wild foods, subsistence foods, etc).

(2) **Food loss and waste (FLW) are not recognized**. Though not unique to blue foods, their highly perishable nature incurs specific behaviors, technologies, risks, and institutional arrangements to reduce food loss and waste, with the most comprehensive estimates at 35% in blue food systems (FAO 2011). Monetization of fish bycatch and byproducts may incentivize the diversion of blue foods into non-food systems, such as targeted landings into the fish meal and oil industry (Lobo *et al* 2010). Moreover, there are several non-physical losses, including nutrient and quality (Kruijssen *et al* 2020), which have implications for nutrition security and food safety.

(3) **The forces of corporate food system consolidation and concentration are not adequately captured**. Consolidation among large corporations that dominate our food system, leading to the concentration of supply chain activities and services within fewer, more powerful actors, is widespread (Clapp *et al* 2025). This process can exacerbate inequalities to which blue food systems are susceptible and marginalize small-scale producers and post-harvest workers (Silver and Stoll 2022, FAO *et al* 2024, Clapp *et al* 2025). The shift towards globalized, vertically integrated distribution of blue foods can negatively impact economic access and social equity (Gephart and Pace 2015, Barbesgaard 2018, Campling and Havice 2018). These trends impact all food systems, shaping markets, access to inputs and technologies, innovation agendas, and policy and governance (Clapp *et al* 2025), yet are inadequately reflected in current frameworks.

(4) **Guidance to operationalize the framework is lacking.** This limits its value for diagnosing and acting within food systems. The framework needs clear recommendations for mapping potential interventions, as well as facilitating cross-sectoral interactions crucial for addressing complex, interconnected blue food system challenges (Crona *et al* 2023). Examples applying the framework to

diverse food systems, including blue food systems, are needed. For instance, the FAO's recent (2025) guide on translating a food systems approach provides practical guidance and examples but is not explicitly linked to the SFS or any other food systems framework.

3. Progress areas for integrating blue foods into broader food system analyses and frameworks

A food systems approach holds the potential for a holistic and interdisciplinary way of 'thinking and doing' food research and policy development (FAO 2018). This approach intends to broaden the framing and analysis of challenges and potential solutions beyond the longstanding focus on food production activities and output in isolation.

Important progress towards this goal has been made over the last few decades, including through the creation of food system frameworks that illustrate the complexity and diversity of actors, activities, and outcomes that animate our food system (Ericksen 2008, Ingram 2011, HLPE 2017, 2020). Furthermore, interdisciplinary food system science is now well-accepted, encompassing various types of social science knowledge and governance contributions. However, more progress is needed to integrate and secure sustainable blue food futures as part of wider food system transformations. We conclude by highlighting four initial areas for progress to update food systems approaches, ensuring they reflect diverse contexts and support effective integration of blue foods into food systems research, policy, and action.

First, for researchers, policymakers, and practitioners working with blue foods, we *recommend using food systems frameworks to examine and act within blue food systems*. Our analysis highlights that the popular HLPE SFS framework is not yet widely applied to examine aquatic food systems or blue foods, despite growing calls for integrating a food systems approach in fisheries and aquaculture research (Simmance *et al* 2021). While we acknowledge some shortcomings in the framework for blue foods (which can be improved, as noted below), we encourage engagement with this or similar food systems frameworks. Specifically, examining case studies with the SFS would allow for comparisons across different cases and systems, such as terrestrial and aquatic environments.

Second, for agri-food system researchers, policymakers, and practitioners, *recognize blue foods within wider food systems and further utilize food systems frameworks to analyze diverse food systems*. Our review suggests that the current use of the HLPE SFS framework is largely superficial, missing opportunities to apply it to analyze interactions, trade-offs, and entry points to affect change, and to identify relevant stakeholders, including through case studies and analysis that integrate 'green and blue' food systems. Currently, some elements of the framework are better understood than others, indicating areas in need of future research (e.g., post-harvest activities, environmental outcomes, dietary outcomes beyond quantity and quality, aspects of food environments beyond physical availability).

Third, we call on the CFS and HLPE to *update the framework to reflect missing dynamics, particularly those relevant to blue foods and other diverse food systems* (e.g., the dynamics of wild capture fisheries and aquaculture in production, issues of food loss and waste, overlapping tenure rights, forces of corporate control and consolidation impacting access). The upcoming CFS HLPE focus on Fisheries and Aquaculture in 2027 presents an opportunity to update the framework to accommodate blue foods and utilize it to discuss the complexity of blue food systems.

Fourth, we call on the CFS and HLPE to *provide guidance and examples on how to operationalize the framework*. The updated 2020 framework, in particular, lacks an explanation of key terms, and neither report provides guidance on applying the framework in practice. While the SFS framework is widely cited, its use in structuring food systems analysis is limited by a lack of practical guidance and, particularly in the case of blue foods, case study examples. Future iterations of the framework should include actionable steps for applying it, as well as illustrative examples, to encourage researchers, decision-makers, and other stakeholders to utilize the framework in structuring empirical inquiry and action within food systems.

Data availability statement

The data that supports the findings of this study are openly available in the supplementary files of this article.

Supplementary data 1 available at: https://doi.org/10.1088/2976-601X/ae659b/data1.

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