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Quo Vadimus

Charting a science course for the sustainable transformation of aquatic food systems

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Abstract

Aquatic foods hold a unique potential to contribute to a much-needed transformation of food systems thanks to their high nutritional value, cultural significance, and relatively low environmental impact. However, realizing this potential requires a transformative approach to help overcome two grand challenges: sustainably increasing the production of nutritious aquatic foods and ensuring equitable access to these resources. This paper highlights the key recommendations from the White Paper on Challenge 3 ('Sustainably nourish the global population') of the United Nations Decade of Ocean Science for Sustainable Development (hereafter, the Ocean Decade), developed by a group of experts under the Vision 2030 process, on the science needed to support a 'Blue Transformation'. A holistic, interdisciplinary science agenda is proposed, emphasizing strengthened institutional and public–private partnerships, prioritizing the inclusion of small-scale actors, women, and youth, and focusing on delivering science targeted to solve specific challenges. The Ocean Decade provides a platform to catalyse these efforts, fostering a paradigm shift towards inclusive, co-created science. Achieving these goals will enable aquatic food systems to contribute significantly to global food security and the Sustainable Development Goals by 2030.

Keywords: aquatic food systems; sustainable production; equitable access; aquatic food systems transformation; knowledge co-creation; Blue Transformation

Introduction

The high and growing prevalence of hunger and malnutrition (FAO et al. 2024) underscores that global food systems are failing to provide equitable access to safe, nutritious, sustainable, affordable, and culturally preferred food. This is further exacerbated by a growing population, increased geopolitical conflicts, and rising impacts of climate and environmental change (IPCC 2022, FAO et al. 2024). Consequently, a transformation of food systems is needed, as highlighted by the 2030 Agenda for Sustainable Development and the 2021 United Nations Food Systems Summit.

Albeit widely undervalued (Bennett et al. 2021), aquatic foods hold great potential to contribute to this transformation given their high nutritional value (Blue Food Assessment 2021, Golden et al. 2021, UN Nutrition 2021, Crona et al. 2023, FAO, Duke University, and WorldFish 2023, FAO 2024), importance to livelihoods and culture (Thilsted et al. 2016, Cojocaru et al. 2022, Tigchelaar et al. 2022, FAO, Duke University, and WorldFish 2023, FAO 2024), ability to improve production and equity (Costello et al. 2020), and often lower environmental footprint compared to other animal food production systems (Hallström et al. 2019, Gephart et al. 2021).

A 'Blue Transformation' is required to realize the potential of aquatic foods, and maximize their contribution to equitably and sustainably nourishing the global population (FAO 2022a, 2024). The 'Blue Transformation' is a vision to expand aquatic food systems and increase the contribution of capture fisheries, aquaculture, and value chains to nutritious and affordable healthy diets for the most vulnerable, while fostering equitable growth. Importantly, it recognizes the limited opportunity for increased production in capture fisheries,

Figure 1. An integrated aquatic food systems approach, illustrating the whole value chain from sustainable capture fisheries and aquaculture [including small-scale capture fisheries and aquaculture (SSFA)] through processing, transport, and marketing, all the way to nutritious meals for consumers.

while simultaneously acknowledging the potential for growth in aquaculture (FAO 2022a).

For this, two 'grand challenges' must be overcome: (i) *sustainably producing more nutritious aquatic foods* and (ii) *ensuring equitable access to aquatic foods* (with 'access' referring to the process of accessing food physically and economically). While numerous international initiatives have focused on policy and practice solutions to these challenges (Costello et al. 2020, Farmery et al. 2021, Farmery et al. 2022, Tigchelaar et al. 2022, FAO 2022a, Crona et al. 2023, FAO, Duke University, and WorldFish 2023), we argue that each of these proposed solutions has specific science needs to be overcome. To contribute to this debate, this paper outlines the science needed to address these challenges and ultimately deliver a 'Blue Transformation.'

The science we need

The UN Decade of Ocean Science for Sustainable Development (hereafter, Ocean Decade) Vision 2030 process outlined the science, knowledge, and innovation needs required to optimize the ocean's role in nourishing the world amid changing environmental, social, and climate conditions, while taking into account the diverse needs of stakeholders and rights-holders. This paper summarizes several key recommendations that emerged from this process and are presented in broader detail in the Challenge 3 White Paper (Agostini et al. 2024).

Implement a holistic and interdisciplinary approach well connected to solution pathways

Fully addressing barriers in aquatic food systems requires a science agenda that spans capture fisheries, aquaculture, and value chains, and is centred around an integrated food systems approach that transparently addresses trade-offs (Fig. 1). The complexity of solution pathways demands that all relevant disciplines are leveraged, integrating production systems science (e.g. capture fisheries, aquaculture, oceanography, and limnology) with social, economic, behavioural, and policy sciences (e.g. resource governance, consumer behaviour and education, and practical knowledges of food systems actors, including traditional farmers, fishers, and Indigenous Peoples). A focus on linkages between different types of aquatic environments, interactions across the land/sea interface, opportunities for a circular economy, and promoting nutrition-sensitive approaches is also critical. Most importantly, we recommend science be designed with a clear vision for how it will support specific solution pathways.

Evaluate and develop science programmes against clear objectives

Investments in and planning of aquatic food systems science programmes need to be guided by clear, high-level objectives (Fig. 2). These are vital for assessing the required science and knowledge, identifying gaps or imbalances, and clarifying how, where, and by whom it could be used. Ultimately, these objectives will help adjudicate which scientific investments deliver the largest benefits for sustainable, equitable, and nutritious aquatic food systems.

Support partnerships

Aquatic food systems interact with other systems such as trade, energy, and health, and involve actors with differing priorities (FAO 2018), necessitating science that leverages diverse participants and partnerships. Aquatic food systems are closely linked to business and industry, making private–public partnerships critical. We also suggest that a special emphasis be placed on partnerships led by and involving low- and middle-income countries. These partnerships would help ensure equitable ownership and advance effective governance.

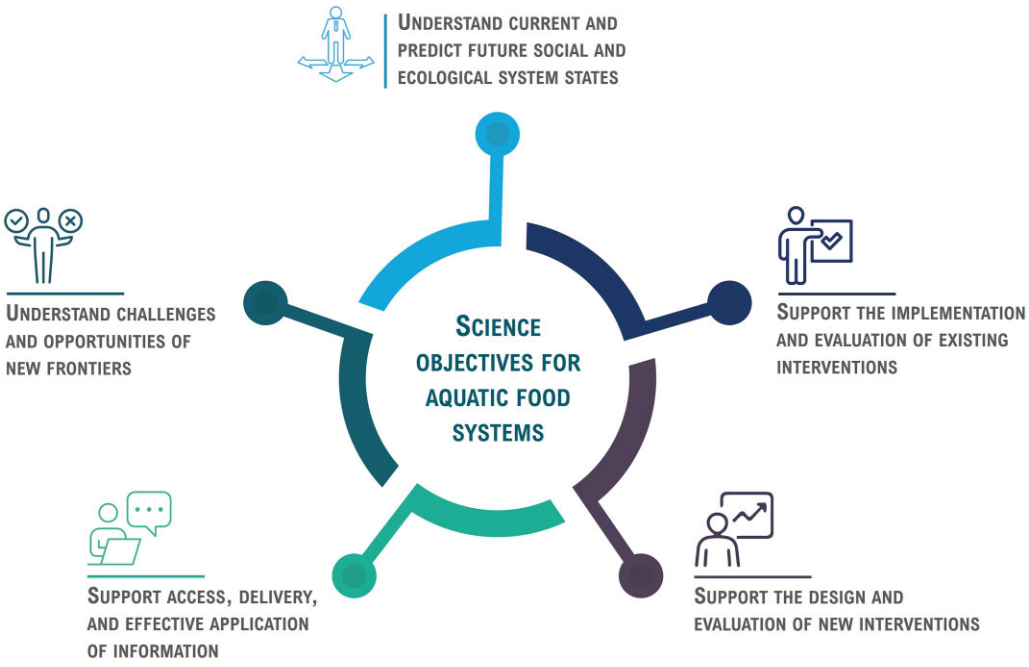

Figure 2. Five science objectives for sustainable, nutritious, and equitable aquatic food systems (source: Agostini et al. 2024).

Furthermore, diversifying and increasing financial investments to support partnerships among stakeholders is an important priority.

Enhance the focus on small-scale actors, women, and youth

We recommend that science and knowledge be developed to understand and address the specific and diverse needs of SSFA actors, as well as women, given their important role in aquatic food systems, existing inequalities in access to aquatic foods, and their crucial contribution to achieving hunger and malnutrition targets (Viana et al. 2019, Short et al. 2021, FAO 2024). Youth are also critical to ensuring the long-term future sustainability, and equity of the sector. Critical science gaps for these groups include understanding barriers to participation and representation resulting from power imbalances and institutionalized structures (Hicks et al. 2022), market dynamics, and the allocation of burdens and benefits (Cojocaru et al. 2022).

Facilitate co-creation

We recommend prioritizing where appropriate inclusive, proactive, and co-created science, knowledge, and innovation, which leverages diverse knowledge systems and knowledge broker (Fig. 3). Doing so will help enhance connections between all users of aquatic food systems, thereby reinforcing integration across aquatic food systems, as well as address the challenges of a rapidly changing world.

Conclusion

Successfully addressing the grand challenges of aquatic food systems by 2030 will require a paradigm shift in why and how we do science, and what science we do. Creating science through interdisciplinary, multi-stakeholder collaborations helps deliver more creative, inclusive, and durable solutions. We recommend that our collective efforts focus on science that is tied directly to promising solution pathways. Substantial science and knowledge on aquatic food systems have primarily focused on natural sciences and key species, actors, and regions. Although this has yielded some outcomes, such as the recovery of several overfished stocks (Hillborn et al. 2020, FAO 2022b), these have been limited by a siloed approach that neglects the multiple dimensions of aquatic food systems and the value of diverse types of knowledge.

It is therefore essential to develop science and knowledge to support work across capture fisheries, aquaculture, and value chains, and implement a shift towards a nutrition-sensitive approach, while respecting ecological boundaries, traditions, and livelihoods. Science will also need to be forward-looking. Addressing topics such as alternative aquatic food sources (e.g. plant-based) and technological innovation for production (e.g. opportunities and risks of algal biotechnology and genetically engineered aquatic food organisms) will help address emerging obstacles.

The large-scale transformation of our terrestrial food systems was achieved through concerted, coordinated, long-term strategic efforts and partnerships between governments, research institutions, and the private sector (Moberg et al. 2021). A similar reshaping of aquatic food systems is possible, which the ‘Blue Transformation’ (FAO 2022a, 2024) is well poised to catalyse. Strategic and targeted science and knowledge programmes are needed to support this transformation. The Ocean Decade provides an excellent platform to enhance connectivity between aquatic food systems science and broader ocean users and governance. Fostering, supporting, and carefully evaluating new and existing Ocean Decade programmes and ensuring connections to solution pathways will be critical to bridging the science–policy gap. This will enable aquatic food systems to significantly

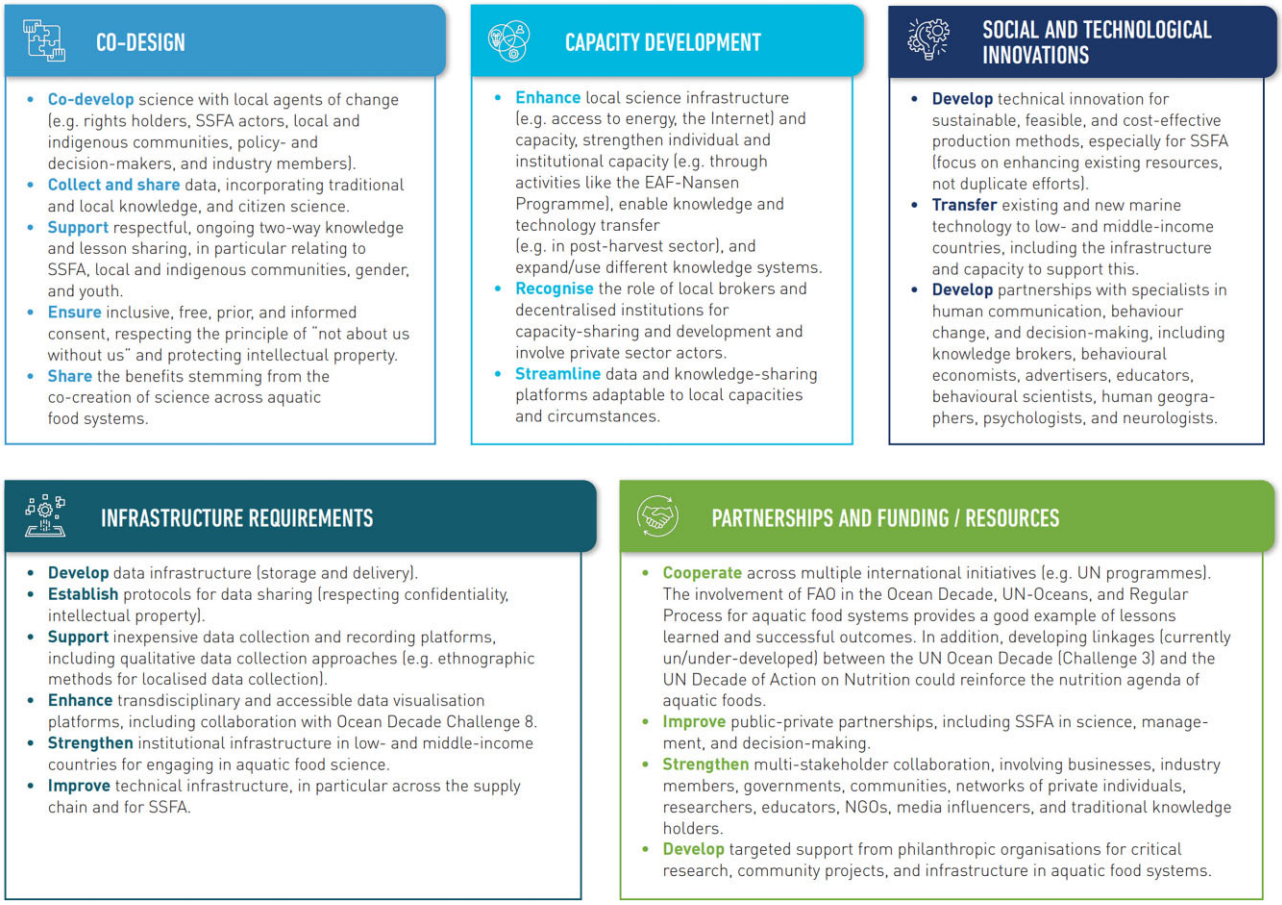

Figure 3. Five dimensions of how to improve and facilitate the co-creation of knowledge for sustainable, nutritious, and equitable aquatic food systems (source: Agostini et al. 2024).

contribute to achieving multiple Sustainable Development Goals.

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Author contributions

V.N.A., E.O., C.T., E.H.A., A.-L.C., C.C. M.J.D., M.F., E.A.F., S.G., K.E.M., F.E.M., S.H.T., M.T.: conceptualization, design, and methodology, formal analysis of the findings, writing—original draft, and writing—review & editing.

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Data availability

No new data were generated or analysed in support of this research.

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