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Editorial: Sustainable aquaculture production for improved food security

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Editorial on the Research Topic
Sustainable aquaculture production for improved food security

Food security has been persistently recognized in global discourse as one of the world's main challenges. Despite some progress toward ensuring access to safe, nutritious, and sufficient food for all people year-round (SDG Target 2.1) or eradicating all forms of malnutrition (SDG Target 2.2), FAO et al. (2024) estimated that between 713 to 757 million individuals (8.9%−9.4% of the worldwide population) experienced undernourishment in 2023. Based on the mid-range figure of 733 million, about 152 million additional people may have faced hunger in 2023 compared to 2019. With outputs from capture fisheries stagnating over the past few decades, aquaculture holds the potential to play crucial roles in achieving food security (FAO, 2020). Global demands for fish are expected to increase in future decades to meet the needs and preferences of a growing human population (Jennings et al., 2016). With global populations projected to increase to over 9.7 billion by 2050 (United Nations, 2024), seafood in general and fish in particular will continue to play an important role in providing nutrition and food security globally, especially in developing countries (Cojocaru et al., 2022; Bjørndal et al., 2024).

Two separate but interconnected sectors contribute to global fish supply: capture or wild-caught fisheries and aquaculture or farmed fish. In fact, as capture fisheries have leveled off, continued increases in production from aquaculture will be required in order to maintain or increase per capita fish consumption (FAO, 2020). According to the FAO (2022), aquaculture has for several decades, been the fastest growing animal production sector in the world, contributing to 49% of total aquatic production (FAO, 2022). This rate of growth and the sector's contribution to global food security, however, appear to be much lesser than estimated when seaweeds (algal autotrophs) are excluded from the production statistics and comparisons to terrestrial livestock productions are made based on only edible yields (Edwards et al., 2019). This, notwithstanding, the sector still holds the potential to make important contributions to sustainable food futures although its rapid expansion has consequences relating to environmental sustainability. Additionally, the sector faces challenges relating to the high cost of aquafeeds for finfish and shellfish, post-harvest losses, and pathogen-induced mortalities.

The article submissions to this Research Topic make contributions to solving some of the problems the aquaculture sector faces through perspectives, reviews, and original research works focusing on various aspects of aquaculture, including sustainable production (Chen et al.; Shen et al.; Mizuta; N'Souvi et al.), aquaculture nutrition (Akter et al.; Andam et al.), postharvest processing technologies (Barros et al.), production systems (Rossignoli et al.), fish health and welfare (Stentiford et al.; Zornu, Tavornpanich, Brun, et al.; Zornu, Tavornpanich, Shimaa, et al.), and aquaculture finance (Munguti et al.). The primary data for the articles published under this Research Topic were sourced from 13 countries spread across three continents (Figure 1) and broadly fall under the three pillars of sustainability: environmental sustainability (production technologies that optimize fish production and/or minimize significant environmental disruptions or impacts), economic sustainability (private-public sector partnerships and multinational donor investments), and social and community sustainability (social dimensions of aquaculture, especially in developing countries).

The development of aquaculture hinges largely on the formulation and production of low-cost, but nutritionally balanced aquafeeds for finfish and shellfish culture, but aquafeed remains prohibitively expensive for many small-scale farmers. The aquafeed industry has long depended on fishmeal as a chief protein source, but unstable supplies and erratic price fluctuations have called for partial or total replacements with more sustainable raw materials (Roques et al., 2020). The studies by Akter et al. and Andam et al. thus highlight the advancements in aquaculture nutrition over the last two decades through continuous innovations in feed formulation to improve feed efficiency and sustainability. The replacement of fishmeal with mysid meal up to 65% in diets for the Pacific white shrimp (*Penaeus vannamei*) without negatively impacting growth performance, feed utilization efficiency, and body composition (Andam et al.) represents a cost-saving strategy that can increase the profitability of shrimp culture. The successful inclusions of mustard oil cake, soybean meal, and rice bran as fishmeal replacers in diets for *Labeo rohita* (Akter et al.) highlight the possibility of using these unconventional ingredients as dietary protein sources to minimize fish production costs and positively contribute to increased food security, particularly in developing countries.

Due to significant pathogen-induced mortalities, aquaculture, which provides half of the world's aquatic protein, faces difficulties in providing a safe and sustainable fish supply. Investigating the causes of fish mortalities (Zornu, Tavornpanich, Brun, et al.), extending the interpretations of diseases beyond the identification of disease agents to address host, environmental, and human factors (Stentiford et al.), and bridging knowledge gaps in fish health management through education and research (Zornu, Tavornpanich, Shimaa, et al.) can enhance aquatic animal health and foster a resilient and sustainable aquaculture industry. Sustainability in aquaculture development is further gaining prominence due to environmental issues like water pollution. Reducing the impacts of aquaculture production on the environment should be a key focus if the sector, which paradoxically is largely dependent on clean water, is to sustainably contribute to global food and nutrition security. The implementations of resource-efficient and environmentally-friendly approaches such as green total factor productivity (the efficiency of aquaculture production considering environmental sustainability) (Shen et al.) and the adoption of emerging green production technologies in production (Chen et al.) are key ways to ensure this.

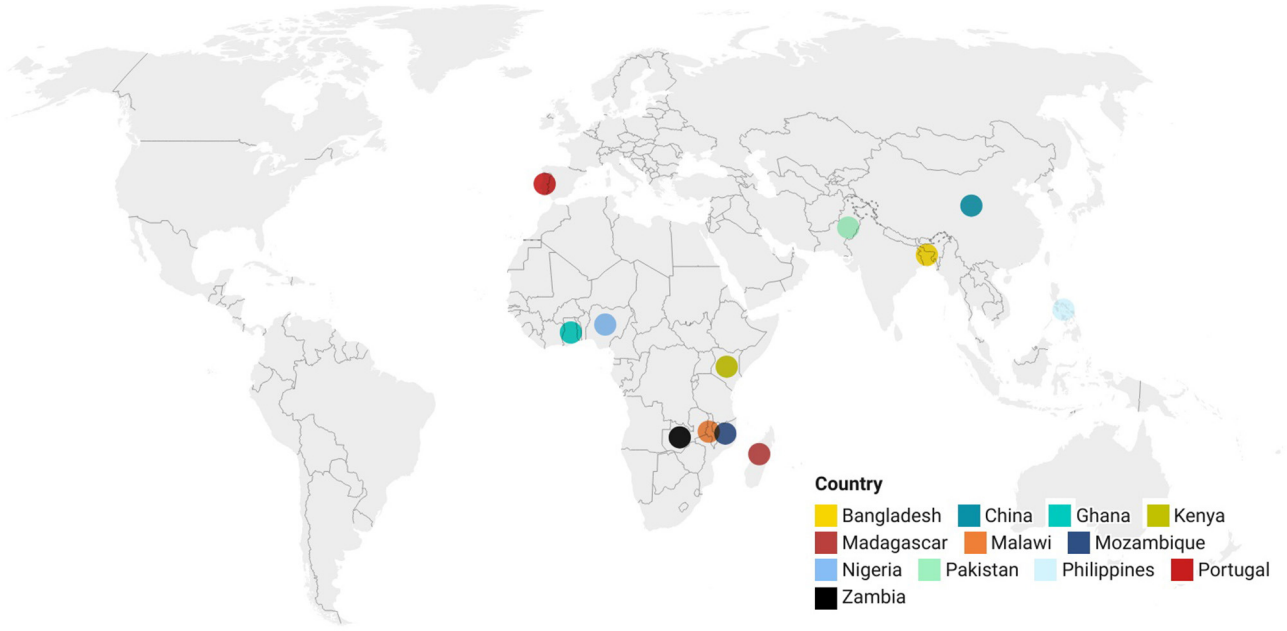

FIGURE 1
Geographic distribution of the countries from which primary data was sourced for the articles in this Research Topic.

To build resilience and sustain production in the face of climate change and environmental degradation, aquaculture producers must adapt to short-term available options such as shading ponds and aeration or make long-term adjustments to production practices, including diversifying production systems and areas (Maulu et al., 2021). By expanding the areas available for aquaculture production, the industry can increase its production capacity to meet the rising human demands for fish and other aquatic products. Aquaculture production in inland saline environments, also known as "desert aquaculture" in some jurisdictions, offers the potential to increase production of euryhaline and marine species. While commercial aquaculture production using saline groundwater is well-developed in countries such as the USA, Israel, India, and Australia (Allan et al., 2009), it remains underdeveloped in some developing countries such as Pakistan (Rossignoli et al.). Inland saline waters provide key resources for producing fish and other aquaculture products by employing otherwise unproductive resources while minimizing reliance on freshwater resources, which otherwise serve as potable water sources for humans. The study by Rossignoli et al. serves as key baseline data to address some of the information gaps crucial for the sustainable development of saline aquaculture in developing countries. There is the need to strengthen technical skills in saline aquaculture in tandem with the establishment of hatcheries for salt-tolerant species, aiming to reduce dependence on freshwater species in saline pond environments.

With several projections highlighting the vulnerability of the entire aquaculture value chain to climate change and environmental degradation, there are valid concerns about whether the sector is growing sustainably and fast enough to meet future demands, further exacerbated by the rapidly growing human population. The present shifts in human dietary patterns toward sustainable foods may further cause the demand for seafood to rise sharply over the next 10 years, necessitating further research on innovative aquafeeds in all areas of sustainability. Prioritizing research on low-cost and complementary ingredients in aquafeeds, especially for species in low-trophic production systems, will be an innovative way to stimulate the development of the sector. Additionally, there is the need to adopt innovative production methods, prioritize disease prevention measures, and minimize the environmental impacts to optimize the economic, social, and environmental efficiency of the aquaculture sector.

Author contributions

KO: Writing – original draft, Conceptualization. KQ: Writing – review & editing. JK: Writing – review & editing. MV: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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