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The fishmeal and fish oil industry: a perspective on sustainability, justice, and food security

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Aquatic food systems—as a critical nutritional component of the larger food system—must be rooted in justice to promote global nutrition and planetary health goals. Here we examine the global fishmeal and fish oil (FMFO) industry, which annually consumes around 15–20 million tons of wild-caught fish, through four dimensions of justice—distributional, recognitional, institutional, and environmental. Drawing on examples from South America, West Africa, and South Asia, we explore how FMFO production generates and exacerbates inequities in food access, environmental harm, and governance failures. Addressing these justice gaps requires reforms in corporate and State governance to realign FMFO production with human rights and environmental sustainability objectives.

KEYWORDS

blue justice, farmed salmon, fed aquaculture, fish oil, fishmeal, food security

Introduction

Food systems must be rooted in justice, equitable distribution of resources, and meaningful agency for producers and consumers (Baudish et al., 2024; Pereira et al., 2024). While equity considerations have gained traction in terrestrial agriculture (Méndez et al., 2013; IPCC, 2019; Tribaldos and Kortetmäki, 2022; Onyeaka et al., 2024; La Vía Campesina, 2025), they remain underexamined in aquatic food systems, particularly in the fishmeal and fish oil (FMFO) sector.

Worldwide, 15–20 million tons of wild fish are reduced into FMFO annually (FAO, 2024b), with production concentrated in Peru, Chile, Vietnam, China, and India, which together account for 46% of total volume of 6.6 million tons, although Peru and Mauritania have the largest number of FMFO factories (Shea et al., 2025).

Although by-products comprise an increasing share of raw material (34% of fishmeal and 53% of fish oil in 2022), whole food-grade pelagic fish still dominate inputs, especially in West Africa and South America (Cashion et al., 2017; Liu et al., 2025; Shea et al., 2025). Rapid expansion into West Africa and Southeast Asia following the surge in the demand of FMFO for growing fed aquaculture has raised significant concerns, as these regions depend heavily on small pelagic fish for nutrition, livelihoods, and cultural identity

(Fabinyi et al., 2022; Robinson et al., 2022; Surathkal et al., 2023; Bara Dème and Failler, 2024; Bunting et al., 2024; Quezada-Escalona et al., 2025).

Most fishmeal is consumed in China and other Asian countries for farmed shrimp and freshwater fish, while fish oil flows primarily to Europe and Chile for salmon aquaculture (EUMOFA, 2025). Although aquaculture is promoted as a sustainable alternative to wild fisheries (World Bank, 2014; Belton et al., 2020; HLPE, 2025) and is the world's fastest growing animal-food sector (Mair et al., 2023; FAO, 2024b), carnivorous aquaculture increasingly depends on FMFO (FAO, 2024b; Majluf et al., 2024) derived largely from forage fisheries in lower- and middle-income countries (FAO, 2024b; Shea et al., 2025), while its products are mostly destined for high-value markets in North America, Europe, Japan, and China (Sumaila et al., 2022).

Drawing on four justice dimensions: distributional, recognitional, institutional, and environmental (Bennett et al., 2021; Rockström et al., 2025), we argue that the FMFO industry represents a structural justice challenge within global blue food systems, one that is insufficiently addressed by existing food-vs.-feed or technical efficiency debates. This Perspective draws on a structured, purposive engagement with peer-reviewed literature (Web of Science, Scopus, Google Scholar) and authoritative institutional reports to synthesize evidence on FMFO, food security, and justice. While many examples derive from regions where justice gaps are acute (South America, West Africa, South Asia), our analysis highlights global inequities in how burdens and benefits are allocated.

Distributional justice

Distributional justice addresses the fair distribution of key resources, opportunities, or capabilities (e.g., healthy and affordable food), and the fair allocation of benefits and burdens (Rockström et al., 2025).

Since the 2010s, the rapid expansion of FMFO production in West Africa to keep up with global demand has increasingly diverted small pelagic fisheries away from local food systems (Greenpeace, 2020; Changing Markets Foundation, 2021). Mauritania is the region's leading exporter, producing over 110,000 tons of fishmeal (18% exported to the European Union), and nearly 35,000 tons of fish oil (over 70% destined for EU markets) (Changing Markets Foundation, 2021) and, until January 2026, had the second largest number of FMFO plant in the world, surpassed only by Peru (Shea et al., 2025). The small pelagic fish stocks used in the Mauritanian FMFO factories are transboundary stocks shared with neighboring countries such as Senegal and The Gambia (Palomares et al., 2020; Dème et al., 2023). In The Gambia and Senegal, in particular, FMFO factories now acquire a significant share of the total small-pelagic fisheries production, displacing local processors—primarily women—and compromising national food security (Deme et al., 2022; Thiao and Bunting, 2022; FAO, 2024a; Sall and Sow, 2025). This extraction thus reduces access to essential nutrition from some of the most food-insecure populations in the world (Cashion et al., 2017; Hicks et al., 2019; Pauly, 2019; Golden et al., 2021). For instance, per capita availability of small

pelagic fish fell from 18 to 6 kg in Senegal (2009–2022) and from 15 to 7 kg in The Gambia (2017–2020), dropping below the recommended annual intake of 10 kg and reflecting the costs of the expanding global FMFO industry (Deme et al., 2021, 2022; Troell et al., 2019).

The FMFO industry raises significant distributional justice concerns by reallocating nutritionally critical fish away from food-insecure populations toward export-oriented value chains. In 2020 alone, Norway's salmon industry sourced over 22,000 tons of fish oil from West Africa, requiring up to 144,000 tons of small pelagic fish—species that could have met the annual nutritional needs of 2.5–4 million people in the region (Foodrise, 2024).

This diversion is particularly consequential in West Africa, where fish provides a major share of dietary protein (e.g., 72% in Sierra Leone and 55% in Ghana, (Isaacs, 2016), yet 51% of women of reproductive age suffer from anemia (FAO, 2021). Redirecting small pelagic fish from reduction to direct human consumption could substantially improve nutrition and health outcomes (Isaacs, 2016).

At the same time, FMFO benefits are highly concentrated: in Peru, the world's largest FMFO producer, 98% of production is exported (Quispe Cacho et al., 2024), but only seven companies control 80% of FMFO exports (i.e., fishing, processing, and distribution) and their benefits (Hurtado, 2023), while local communities bear environmental and health burdens. For example, in Chimbote, Peru, the leading FMFO producing hub in the world, emissions from FMFO factories have been associated with ocular, skin, and upper respiratory tract irritation in children (Hansman et al., 2019). Similar pollution and environmental impacts are also documented in India's FMFO industry (Changing Markets Foundation, 2019). These patterns in some of the main FMFO producing countries indicate stark inequities in how benefits and harms are distributed across regions and populations.

Recognitional justice

Recognitional justice requires a society that recognizes the diversity of intersecting identities, knowledge systems, and lived experiences and understands how these are shaped by cultural, legal, historical, and spatial contexts (Bennett et al., 2021; Hicks et al., 2022; Rockström et al., 2025).

In many countries, small pelagic fish are central to both food security and cultural identity (Konar et al., 2019; Deme et al., 2022; Robinson et al., 2022; Basurto et al., 2025; Novilla and Fabinyi, 2025; Sall and Sow, 2025). In West Africa, in particular, local and regional fish trade is a well-structured part of the socio-economic fabric (Sall and Sow, 2025). This structure entails commercial relations as well as cultural links, and the local artisanal fishing activities are connected to other social and trade activities on land (Randin, 2024). However, in some regions of the Global South, FMFO factories monopolize access to key fish species by driving up fish prices (Fréron et al., 2014; Shea et al., 2025; Surathkal et al., 2023; Thiao and Bunting, 2022), ignoring or threatening customary fishing practices, tenure arrangements, and

culturally embedded foodways, with disproportionate impacts on already marginalized groups.

For instance, women working in post-harvest processing and local trade in West Africa and South Asia are often displaced from traditional smoking or processing sites, excluded from formal employment, and exposed to pollution and health risks from nearby factories (Thiao and Bunting, 2022; Ramappa et al., 2023; Wabnitz and Harper, 2023; Foodrise, 2024; Jyotishi et al., 2024). In Gunjur, The Gambia, women processors were evicted from land over which they held usufruct rights and that was traditionally used for fish smoking and vegetable farming, and replaced by FMFO factories that now pollute nearby farms and waters (Amnesty International, 2023). In South America, the expansion of FMFO production is a key driver for the erosion of the traditional custom of eating small pelagic fish. Anchoveta in Peru is the world's largest monospecific fishery, and almost all of the catch is reduced to FMFO. In this country, these fish were once one of the leading sources of protein for coastal communities (López de la Lama et al., 2021) but anchoveta has lost its status as a culturally important food in the region, partly driven by the higher prices the FMFO industry pays for the fish (Fréon et al., 2014; Majluf et al., 2017).

Although FMFO factories are often justified based on providing jobs to the local communities, their overall contribution to the labor market is minimal relative to the systems they displace. For example, in Senegal, one of the main FMFO producers in West Africa, FMFO factories employed 129 permanent and 264 temporary workers in 2018 (FAO, 2022), whereas the domestic fisheries sector employs around 2 million people (Changing Markets Foundation, 2021). The lack of job opportunities for fishers that face the consequences of an increasingly overexploited stock (Bara Dème and Failler, 2024) has been suggested to be linked with the surge of migrant from Senegal toward Europe in the last decade (Chen-Zion, 2022; Shryock, 2020). Further, many formal positions go to foreign workers, while women are relegated to low-paid, informal tasks such as fish carrying or sorting (Thiao and Bunting, 2022). In Peru, FMFO factories process over 80% of the national catch, but are only responsible for 21% of total fisheries-related revenue, and 5% of total employment across the fisheries value chain (Christensen et al., 2014).

Together, these dynamics suggest a failure of recognition of justice in FMFO production systems, whereby culturally significant food, customary rights, and gender-specific livelihoods are systematically overlooked by national governments in favor of industrial and export-oriented priorities.

Institutional justice

Institutional justice requires formal and fair decision-making processes (Rockström et al., 2025), and, for the purpose of this perspective, it includes the contextual, management, and procedural elements of social justice (Bennett et al., 2021).

A key institutional challenge is that governance often fails to encompass the full scope of the FMFO supply chain—from raw material inputs to aqua feed manufacturing. Most fisheries governance systems remain focused on harvest activities, ignoring the downstream decisions that affect how fish are processed, where

factories are located, and how trade routes are structured. In The Gambia and Senegal, governance structures have facilitated the establishment of FMFO factories on land traditionally used by artisanal fish processors, ignoring the impacts on local people throughout the value chain (i.e., nutrition, livelihoods, revenue). For example, women in these countries have traditionally occupied the strategic niches of fish processing, using traditional techniques, and trading in local markets, building their own financial capital that can be used to finance small-scale fishing (Sall, 2024).

Equitable and legitimate governance frameworks, such as the FAO's Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries, call for inclusive and participatory decision-making, with particular attention to marginalized groups such as women and Indigenous peoples (FAO, 2015). Yet implementation of these policies remains limited. Many FMFO factories operate in regions with low regulatory oversight and scarce institutional transparency. In countries like Senegal, local reports on active factories often conflict with available public data on production and even number of factories, underscoring the opacity of FMFO-related governance (Gorez, 2021). Without traceable and accessible information on ownership, sourcing, trade flows, and subsidies across the value chain, meaningful oversight is virtually impossible (Basurto et al., 2020; Allegretti and Hicks, 2023; Sumaila, 2024).

Compounding these issues is the misalignment of policy incentives. The lack of global aquaculture subsidy transparency means that many countries support practices that increase third-party harm to ecosystems and communities without accountability (Sumaila, 2024; Pauly et al., 2025). Researchers have even framed increased fish prices caused by FMFO demand as a form of involuntary subsidy paid by low-income consumers to industrial aquafeed companies (Neori and Agami, 2024). Together, these dynamics reveal institutional failures, where opaque policies and misaligned incentives privilege industrial actors while externalizing social and environmental costs to vulnerable communities.

Environmental justice

Environmental justice highlights the ecological harm borne by vulnerable communities. FMFO production is frequently associated with overfishing (Pikitch et al., 2014; Froehlich et al., 2018; Longo and York, 2024; Shea et al., 2025), localized pollution (Ertör, 2021; Gorez and Saine, 2021; Thiao and Bunting, 2022), environmental degradation (Changing Markets Foundation, 2019; Ertör, 2021; Gorez and Saine, 2021), and high greenhouse gas (GHG) emissions (Johansen et al., 2022; Ziegler and Hilborn, 2023)—costs that are often borne by local coastal communities with limited agency to influence these outcomes.

In terms of overfishing, for example, over 85% of sardinellas caught in Mauritania were processed into FMFO in some years, contributing to stock declines (Greenpeace International, 2019; Bara Dème and Failler, 2024; Braham et al., 2024). Adding to this problem is the fact that many of these stocks in West Africa span multiple countries; hence, what happens in one country (e.g., Mauritania) could affect food security in another country (e.g., Senegal) unless these stocks are managed under agreed objectives (Corten et al., 2017; Bara Dème and Failler, 2024;

Braham et al., 2024). Similarly, in South and Southeast Asia, the use of low market value “trash fish” (many of which are juveniles) for aquaculture feed has amplified declines in fish stocks (FAO, 2009; Mahesh et al., 2019; Fabinyi et al., 2022; Eswaran et al., 2023).

On land and in nearshore areas, FMFO factories are a major source of local air and water pollution. Facilities in countries like The Gambia, Senegal, Peru, Mauritania, India, and Vietnam, among others, have been linked to untreated wastewater discharge, particulate emissions, foul odors (which may be toxic), and ecosystem degradation (Changing Markets Foundation, 2019; Ertör, 2021; Gorez and Saine, 2021). In Chimbote, Peru—a hub of FMFO production—the seafloor has been so heavily contaminated by decades of industrial activity that scientists estimate it may take up to 70 years to recover, assuming all pollution ceases (Global Atlas of Environmental Justice, 2023; García Nolasco et al., 2025). In The Gambia, FMFO effluent has damaged nearby farmland and reduced vegetable yields, affecting both environmental and food system resilience, and factories have polluted mangroves, harmed tourism, and caused respiratory illnesses among women processors (Jobe, 2022; Amnesty International, 2023). In South Asia, similar findings have been reported in the vicinity of FMFO factories (Changing Markets Foundation, 2019).

In addition, the FMFO supply chain contributes substantially to global GHG emissions. At scale, reduction fisheries and the associated transport and processing networks collectively emit millions of tons of CO₂ annually (Ziegler and Hilborn, 2023). These emissions compare unfavorably to wild fish harvested and consumed locally, reinforcing concerns about the climate inefficiency of current aquaculture models (Johansen et al., 2022). The environmental impacts of FMFO extend to biodiversity as well: feed production in Southeast Asia has been documented to include bycatch of juvenile fish and threatened species like turtles and sharks (Leadbitter, 2019). Environmental impacts of FMFO are an additional dimension of how local communities are bearing the costs instead of aquaculture beneficiaries.

Discussion

Fishmeal and fish oil expansion places industrial aquaculture in direct competition with small-scale fishers and coastal communities, reinforcing neocolonial patterns that undermine human rights in Peru, Senegal, The Gambia, India, and other Global South regions (Randin, 2024). With this Perspective, rather than offering a new empirical assessment, we reframe existing evidence to argue that, across the four dimensions of justice, FMFO expansion intensifies inequality, environmental degradation, and food insecurity.

Distributionally, FMFO production exacerbates inequality by prioritizing an export-oriented commodity over domestic food security, especially in low-income countries where these species represent a critical source of affordable animal protein and micronutrients. While higher-income countries are increasingly expected to transition toward plant-based diets, fish remains an essential and often irreplaceable source of protein and micronutrients in lower-income contexts (Rasmussen et al., 2021; Deng et al., 2025; Voinea et al., 2025). Yet, current FMFO supply

chains serve carnivorous aquaculture aimed at high-value seafood markets (Budhathoki et al., 2025), undermining local food systems and exacerbating global nutritional inequalities (Cojocaru et al., 2022). This distribution of resources is not only unjust but inefficient: studies show that reallocating even just a third of food-grade wild fish to direct human consumption could significantly improve global nutrition (Christensen et al., 2014; Majluf et al., 2017).

Protecting small-scale fishers' access to land, sea, and markets, as well as their human rights, is crucial for both equity and sustainability (FAO, 2015). Given the multiple threats with cumulative impacts some coastal communities face (Gill et al., 2023), the FMFO industry risks further marginalizing vulnerable groups while benefiting powerful transnational aquaculture actors. This “recognition gap” manifests in a failure to acknowledge the importance of tenure rights, traditional livelihoods, gendered labor, and customary foodways, particularly in regions where small-scale fisheries are vital to local economies and nutrition (GRAIN, 2024; Basurto et al., 2025). Recognition needs to come hand in hand with participation and accountability mechanisms.

Further, the decline in small pelagic fish availability for artisanal fishers and processors in West Africa, where most of the main stocks are overexploited (FAO, 2024a), and the displacement of coastal communities from their places of work are driving thousands of people to migrate (Pauly et al., 2025). In 2024, around 50,000 people from Senegal and other West African countries reached the Canary Islands (Spain), and another 10,000 went missing in the Atlantic Ocean during the 1,500-km journey (Macias, 2025). This illustrates a human rights issue driven by unsustainable, industrial fishing, and processing practices that should be urgently addressed.

Institutional failures—including poor transparency in ownership, subsidies, and trade flows—undermine accountability and participatory governance, especially in countries with weak regulatory oversight. The FMFO industry is marked by opaque governance, limited transparency in ownership and corporate structure, and barriers to local participation (Sumaila, 2024; Caveen et al., 2025; Pauly et al., 2025). Institutional justice in FMFO requires a structural shift in fisheries policies toward inclusive governance, localized control, and systems that empower coastal communities (Illycky, 2007; Jobe, 2022).

governments are the primary duty-bearers responsible for protecting, respecting, and fulfilling the rights of their citizens, FMFO corporations, like all businesses, are nonetheless morally, and in many cases also legally, obligated to avoid causing or contributing to human rights violations and, if harm occurs, companies must provide, or cooperate in providing, effective remedy and fair compensation to those affected (United Nations, 2011; Bennett et al., 2024).

Toward a just and sustainable future

Aquaculture can contribute meaningfully to sustainable and equitable food systems, particularly through low-impact production such as seaweed, bivalves, and fish species that require little or no wild fish as food such as carps, tilapia, and catfishes (Gephart et al., 2021; Naylor et al., 2021; FAO, 2025).

However, the FMFO industry, as currently structured, undermines food security, perpetuates inequities, and threatens ecological sustainability. The “justice gap” emphasizes the need for nuanced, context-specific approaches to dietary recommendations that consider both global sustainability goals and local realities (e.g., Budhathoki et al., 2025; Deng et al., 2025).

While some improvements have been made in traceability and by-product use, the industry remains structured around an inequitable flow of marine resources from low-income producing regions to affluent consumers. Reform must begin with recognizing fish as critical food, not feed. The FAO Code of Conduct for Responsible Fisheries advises minimizing the use of food-grade fish in FMFO production. Policies should prioritize direct human consumption of small pelagic fish, support small-scale fisheries, and ensure equitable access to aquatic resources. Greater transparency, reduced reliance on wild-caught fish, support for direct human consumption, stronger corporate accountability and community governance, and anti-colonial approaches are essential to overcome the injustices currently associated with the FMFO industry.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

DC: Data curation, Project administration, Validation, Formal analysis, Methodology, Investigation, Writing – original draft, Supervision, Conceptualization, Resources, Writing – review & editing. SC: Investigation, Writing – review & editing, Validation. SdlP: Writing – review & editing, Investigation, Validation. RL: Investigation, Writing – review & editing, Validation. MM: Writing – review & editing, Investigation, Validation. GM: Data curation, Formal analysis, Validation, Writing – review & editing, Writing – original draft, Methodology, Investigation. MP: Writing – original draft, Methodology, Formal analysis, Data curation, Investigation, Validation, Writing – review & editing. DS: Data curation, Writing – review & editing, Investigation, Validation. TG: Data curation, Methodology, Validation, Writing – review & editing, Investigation, Formal analysis, Writing – original draft, Conceptualization, Resources, Supervision.

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The author(s) declared that generative AI was used in the creation of this manuscript. The manuscript was written and developed entirely by the author(s). We used Microsoft Copilot (MS Pilot) only on a limited basis to reword and shorten a small number of individual sentences that were overly long, with the sole purpose of improving clarity and complying with the 3,000-word limit for Perspective articles. All such revisions were manually reviewed and edited by the author(s), and each sentence was checked to ensure accuracy, consistency with the manuscript's style, and alignment with the author(s)' intended meaning. No AI tool was used to generate original content, develop arguments, or synthesize literature.

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