Integrating blue foods into national climate strategies

Enhancing nationally determined contributions and strengthening climate action

Contents

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Abbreviations

Aquatic/blue foods Foods that are wild-caught or farmed from oceans, rivers, and lakes

COP Conference of the Parties (to the UNFCCC)
FAO Food and Agriculture Organization of the United Nations
FCR feed conversion ratio
FLW food loss and waste
GHG greenhouse gas
IMO International Maritime Organization
IPCC Intergovernmental Panel on Climate Change
LIFE low-impact, fuel-efficient practices
MRV measurement, reporting, and verification
MtCO2e million tonnes of carbon dioxide equivalent or metric tons of carbon dioxide equivalent
NAP National Adaptation Plan
NDC nationally determined contribution
R&D research and development
REDD+ Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
TgC teragrams of carbon
UNFCCC United Nations Framework Convention on Climate Change
WTO World Trade Organization

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Executive summary

Blue or aquatic foods—foods that are wild-caught or farmed from oceans, rivers, and lakes—are an important part of global food systems. They are increasingly recognized as a priority for climate action, yet they are often overlooked in climate discussions and underfunded in mitigation and adaptation financing. Addressing climate impacts on aquatic food systems and leveraging their potential for climate action requires their integration into national climate strategies and UNFCCC processes. Climate decision-makers have an opportunity to use growing momentum and insights on blue foods to develop concrete policy strategies that can support a thriving blue food sector in the face of climate change.

These guidelines are designed for audiences working on nationally determined contributions (NDCs) and other climate strategies. They offer diverse entry points for employing blue foods in climate solutions and are intended to be a starting point for setting targets and developing policies related to blue foods in climate action, offering a framework rather than an exhaustive list of actions. Policymakers can adapt these policy options to NDCs as well as consider their relevance in other areas of climate planning, including water and waste management, energy, nutrition, and economic development.

The policy options outlined in these guidelines are organized into five intervention areas. In addition, we offer four enabling measures that can strengthen the implementation and monitoring of aquatic food climate solutions.

Guidelines for incorporating blue foods in NDCs

Capture fisheries production

Global fishing activities are estimated to emit about 180 MtCO2e annually, accounting for approximately 4 percent of the global food system's production emissions. Marine and freshwater fisheries, which support the livelihoods of millions of people worldwide, are also highly vulnerable to climate change impacts.

Policy option 1 Develop sustainable and climate-adaptive fisheries management

Policy option 2 Reduce emissions from fishing

Policy option 3 Support climate-adaptive livelihoods and practices for fishers and fishing communities

Aquaculture production

In 2022, aquaculture production surpassed capture fisheries in aquatic animal production for the first time, representing 51 percent of the world's total. As aquaculture expands, strategic planning, investment, and resilience-building measures are essential to reduce emissions as well as aquaculture's vulnerability to climate change.

Policy option 1 Improve aquaculture feed and feeding management to reduce greenhouse emissions

Policy option 2 Transition aquaculture energy inputs to renewables and reduce energy use

Policy option 3 Promote expansion of low-input, integrated, and/or non-fed aquaculture systems

Policy option 4 Support climate-adaptive technologies and practices to increase aquaculture's resilience to climate change

Blue food supply chains

Aquatic foods are the most traded food products globally, providing higher net revenues for developing countries than all other agricultural commodities combined. Along highly diverse supply chains, the world lost around 23.8 million tonnes of edible aquatic food in 2021, representing 14.8 percent of total production. Transport emissions, particularly for fresh products, can be as high or higher than those from production.

Policy option 1 Reduce loss and waste and enhance circularity in blue food supply chains

Policy option 2 Reduce emissions from energy use and operations such as storage, processing, and transport of blue foods

Consumption and diets

Blue foods are rich in key nutrients like vitamin B12 and omega-3 fatty acids and can help address micronutrient deficiencies and reduce the incidence of non-communicable diseases. Responsibly produced blue foods can therefore be part of low-emission development pathways and diets, but transparency about sustainability, nutrient content, and carbon footprint needs to be improved.

Policy option 1 Integrate sustainable, low-carbon blue foods into food procurement, planning, and assistance programs

Policy option 2 Help consumers shift to sustainably produced, low-footprint blue foods

Blue foods and coastal blue carbon habitats

Blue carbon ecosystems, including mangroves, salt marshes, and seagrasses, are important carbon sinks that collectively store over 30,000 teragrams of carbon across approximately 185 million hectares. These ecosystems also act as fish nursery habitats and offer ecosystem services such as storm surge and flood protection.

Policy option 1 Reduce impact of aquaculture and fisheries on blue carbon habitats

Policy option 2 Implement blue carbon habitat management and restoration for carbon storage and adaptation

Enabling policy measures to address cross-cutting challenges

Across intervention areas, policy measures are needed to ensure that climate actions are integrated rather than siloed. These can help reduce uncertainties, verify effectiveness, and enhance equity and inclusiveness.

Enabling measure 1 Research and development

Enabling measure 2 Develop and maintain robust data collection, monitoring, and prediction systems

Enabling measure 3 Improve equitable access to financial services, knowledge, government support, and resources

Enabling measure 4 Ensure collaborative and inclusive management, planning, and decision-making

Integrating blue foods into national climate strategies presents a practical pathway to reduce emissions and foster resilience across food, oceans, and water, with significant potential for co-benefits with biodiversity and sustainable development. The options outlined in these guidelines can serve as a foundation for developing effective blue food climate actions.

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Introduction

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Why include blue foods in nationally determined contributions?

Blue or aquatic foods[1] are an important part of global food systems (Blue Food Assessment). They are increasingly recognized as a priority for climate action. Blue foods are mentioned in the COP28 Presidency's Emirates Declaration on Food and Agriculture, which currently has 160 signatories (COP28 United Arab Emirates, 2023). The UNFCCC High Level Champions included resilient aquatic food systems as a 2030 Breakthrough as part of the Marrakech Partnership (Climate Champions, 2023). The 2023 Ocean and Climate Dialogues featured "Fisheries and food security" as one of its two topics, chosen in consultation with parties and observers (UNFCCC, 2023). These developments underscore the urgency of integrating aquatic food sectors into national climate strategies and nationally determined contributions (NDCs).

Blue foods play a critical role in global food security. More than 40 percent of the world's population depends on aquatic foods for at least 20 percent of their animal protein intake (FAO, 2024b). For hundreds of millions of people, these foods are their primary source of protein and provide essential micronutrients such as calcium, iron, vitamin A, vitamin B12, and omega-3 fatty acids. In many places, these micronutrients cannot be easily replaced by land-based alternatives (Golden et al., 2021). Blue foods are particularly important for developing countries and vulnerable communities. Globally, around 600 million people depend, at least partially, on the aquatic food sector for their livelihoods, with nearly 500 million involved in small-scale fisheries and aquaculture supply chains (FAO, 2022a). Women play key roles in these systems, comprising 24 percent of fishers and fish farmers and 62 percent of processing workers around the world in 2022, where sex-disaggregated data are available (FAO, 2024b).

Climate change poses severe challenges to blue food systems. Rising atmospheric greenhouse gas (GHG) concentrations affect marine and freshwater production capacities, aquaculture feed supply, and post-production processes. For example, pelagic fisheries face shifts in species distributions, while coral reef fisheries and bivalve production suffer from ocean acidification. Inland fisheries contend with changes in freshwater quality and availability, and fed aquaculture is impacted by terrestrial crop losses affecting feed supply. Small-scale actors, women, Indigenous communities, and other marginalized groups are particularly vulnerable to these climate impacts, especially those communities that rely on aquatic food for sustenance and economic stability (FAO, 2020a; FAO, 2024c; Cooley et al., 2022). Ensuring these groups are represented in environmental decision-making is important for enhancing the resilience of aquatic food systems and supporting food and nutrition security.

Blue foods can also play roles in reducing GHG emissions from food systems. They generally have a lower carbon footprint than terrestrial animal-source foods, with some, such as bivalves and seaweed, having minimal or neutral GHG emissions (Gephart et al., 2021). Sustainable management of aquatic food systems offers significant potential for reducing emissions in existing systems, for example by more effectively managing capture fisheries. There is an even bigger opportunity for emission reduction by shifting from high-emission species and practices to lower ones (FAO, 2024b). There is considerable variation in GHG emissions across different species, geographical regions, and farming practices (Gephart et al., 2021). For instance, the CO2 emissions from small pelagics are one-eighth those from flatfish, while bivalves emit, on average, one-ninth the CO2 of farmed shrimp (Gephart et al., 2021). Targeted investments in sustainable and low-carbon aquatic foods can support low-emission development strategies, addressing both poverty and food and nutrition insecurity.

Addressing climate impacts on aquatic food systems and leveraging their potential for climate action requires their integration into national climate strategies and UNFCCC processes (UNFCCC, 2023). This integration is crucial for unlocking climate finance and creating targeted funding opportunities that align aquatic food systems with broader climate goals. These foods often have been overlooked in climate planning, yet they hold immense potential to drive sustainable and equitable growth. Climate decision-makers have an opportunity to use growing momentum and insights on blue foods to develop concrete policy strategies that can support a thriving blue food sector in the face of climate change.

[1] *Note: The terms "blue foods" and "aquatic foods" are used interchangeably in this publication.*

Current state of blue foods in NDCs

Despite their potential for contributing to both climate mitigation and adaptation efforts, blue foods are underrepresented in NDCs. There is often a stronger focus on land-based ecosystems than aquatic ecosystems in current NDCs (Rochette et al., 2024). We analyzed the level of inclusion of blue foods in the most recent NDCs submitted in 2020 (Figure 1). Each NDC was scored on its level of inclusion of keywords related to blue foods (e.g., fisheries, seafood, aquaculture): “No mention” when blue food keywords were not included, “Low” when blue foods were mentioned only in passing, and “High” for NDCs that include blue foods in specific adaptation or mitigation objectives or specifically target the sector through a policy action.

Based on this analysis of 2020 NDCs, 73 countries have High inclusion, 37 countries have Low inclusion, and 84 countries did not mention blue foods at all. Inclusion is notably higher in Africa, Southeast Asia, and Oceania, with lower levels in the Americas and Europe. European Union Member States submitted a single NDC, which did not include blue food keywords.

Many of the NDCs that include blue foods reference them vaguely or alongside other sectors. For instance, in South Africa’s NDC, under the goal of implementing adaptation interventions, fisheries are mentioned as a priority alongside transport, agriculture, energy, health, and other sectors (Republic of South Africa, 2021). Of the NDCs that mention blue foods, 31 percent – primarily in the Caribbean, West Africa, and Southeast Asia – reference them in relation to both adaptation and mitigation. Another 35 percent reference them only in adaptation context, 6 percent only in mitigation context, and 25 percent mention them without targeted strategies (Koehn, Schutter et al., in progress).

It is important to note that blue foods can also be incorporated into other climate policies at national or regional levels, even if not explicitly included in NDCs. For example, several countries with strong fisheries and climate policies were found to have little to no inclusion of blue foods in their NDCs. This highlights the importance of aligning NDCs with other climate policies to align climate action across sectors and levels of government.

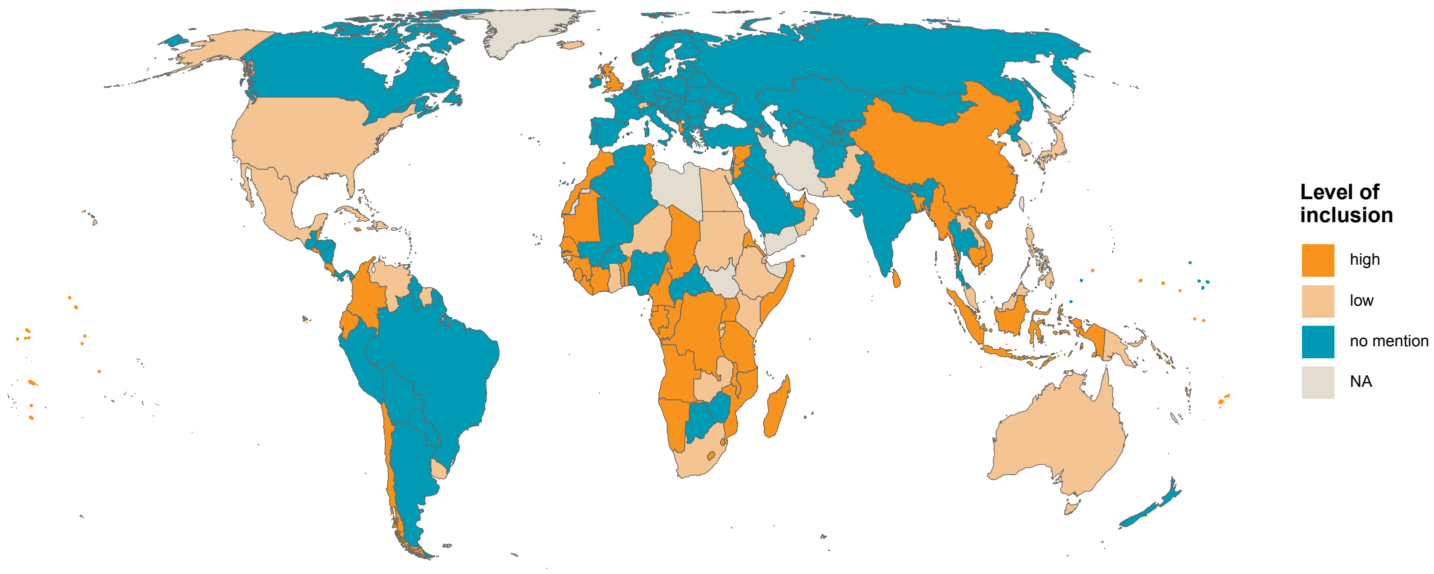

Figure 1: Level of inclusion of blue food keywords in 2020 NDCs. (Koehn, Schutter et al., in progress).

Objectives of these guidelines

These guidelines are designed for audiences working on NDCs and other climate strategies. This includes national planners, UNFCCC focal points, national designated authorities of the Green Climate Fund, and aquatic food sector experts involved in NDC formulation and implementation. They also address global climate change experts from the United Nations, bilateral donors, and financing institutions such as the Green Climate Fund and Global Environment Facility. Finally, they aim to assist nonspecialists in understanding the sector's unique challenges and opportunities.

These guidelines offer diverse entry points for employing blue foods in climate solutions. They are designed to help integrate blue foods into NDCs and other climate strategies. They emphasize gender-responsive and nutrition-sensitive analyses and solutions and provide options across the entire value chain. The guidance complements existing NDC guidelines outlined in the Paris Agreement and **Katowice climate package**, aligning with resources such as the IPCC Wetlands Supplement, FAO's fisheries and aquaculture knowledge products and guidance, and the recent Food Forward NDCs tool.

These guidelines are intended to be a starting point for setting targets and developing policies related to blue foods in climate action, offering a framework rather than an exhaustive list of actions. Policies and targets should be tailored to each country's needs. Policymakers can adapt these policy options to NDCs as well as consider their relevance in other areas of climate planning, including water and waste management, energy, nutrition, and economic development.

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Guidelines for incorporating blue foods in NDCs

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Blue food climate solutions range from the aquatic environments where these foods are produced to the meals they ultimately provide. The policy options outlined in these guidelines are organized into five intervention areas: capture fisheries production, aquaculture production, blue food supply chains, consumption and diets, and blue foods and coastal blue carbon habitats.

For each policy option, we provide a brief description, offer potential concrete measures and example targets, and assess co-benefits and trade-offs between adaptation and mitigation, as well as other sustainable development outcomes. We also share practical examples of these policy options in action. Each intervention area is supplemented with tools and resources to support planning, decision-making, implementation, and progress evaluation. In addition, we offer four enabling measures that can strengthen the implementation and monitoring of aquatic food climate solutions.

Capture fisheries production

Global capture fisheries have long played a key role in the world's food systems, with production levels fluctuating between 86 and 94 million tonnes annually since the late 1980s. In 2022, this sector reached a total output of 92.3 million tonnes, contributing an estimated value of USD 159 billion to the global economy. This included 91 million tonnes of aquatic animals and 1.3 million tonnes of algae. Of aquatic animal production, marine fisheries accounted for the bulk of production at 79.7 million tonnes (43 percent of global aquatic animal production), while inland waters contributed 11.3 million tonnes (FAO, 2024b). Globally, an estimated 492 million people derive their livelihoods from small-scale fisheries (FAO, Duke University, and WorldFish, 2023).

The sustainability of capture fisheries is increasingly under threat. In 2021, 37.7 percent of marine stocks were below biologically sustainable levels, an increase from 35.4 percent in 2019. Despite this, when weighted by production volume, an estimated 76.9 percent of landings in 2021 were sourced from stocks that FAO has classified as "sustainable," underscoring the variable nature of fisheries management due to different pressures on specific species and ecosystems (FAO, 2024b).

The main source of GHG emissions from capture fisheries is fuel use by vessels. Global fishing activities are estimated to emit 179 million tonnes of carbon dioxide equivalent (MtCO2e) annually, accounting for approximately 4 percent of the global food system's production emissions (Parker et al., 2018). On average, capture fisheries emit 2.2 kg CO2e per kilogram of landed fish and shellfish, compared to 36 kg CO2e per kilogram of beef and 10 kg CO2e per kilogram of chicken (Ritchie, 2020b).

Marine and freshwater fisheries are highly vulnerable to climate change impacts. Warming waters, ocean acidification, sea level rise, storms, and shifting rainfall patterns threaten fish stocks and degrade coastal and freshwater habitats (FAO, 2019; Tigchelaar et al., 2021; Cao et al., 2023). To address these vulnerabilities, policymakers can prioritize three key areas. First, developing sustainable and climate-adaptive fisheries management will help maintain fish stocks and ecosystems in the face of changing environmental conditions. Second, reducing emissions from fishing activities can mitigate the sector's contribution to climate change while enhancing efficiency. Third, supporting climate-adaptive livelihoods and practices for fishers and fishing communities will build resilience against the immediate and long-term impacts of climate change.

A woman harvests fish from her inland homestead pond using a lift net in Rangpur, Bangladesh.

Image credit: Holly Holmes/WorldFish

43%

of global aquatic animal production comes from marine capture fisheries (FAO, 2024b)

179 metric tons

of carbon dioxide equivalent (MtCO2e) are emitted annually by global fishing activities

4%

of the global food system's production emissions (Parker et al., 2018)

Box 1: Inland capture fisheries

Inland capture fisheries occur in ponds, streams, rivers, lakes, and artificial or modified habitats such as reservoirs, canals, and rice fields. These fisheries produce more than 12 percent of the world's wild-caught fish – 11.3 million tonnes in 2021 – from less than 1 percent of available (liquid) water (Mittermeier et al., 2010). More than 50 million people rely on these fisheries for food and income, with nearly all the fish consumed by people, providing a vital and affordable source of nutrition. This is especially important in landlocked countries with high malnutrition rates or in regions or populations facing a limited selection of affordable, nutritious foods. However, many of these regions are highly vulnerable to climate change. Increasing water temperatures and shifting rainfall patterns can reduce the productivity of capture fisheries. The extent of these impacts depends on the geographic context and is often worsened by other stressors, such as habitat degradation and competition for water resources from urbanization, increased pressure from increasing populations, and agriculture (Barange et al., 2018).

Many inland capture fisheries are valuable due to their accessibility. Their proximity to communities means many fishers can work close to home or their other livelihood activities. They can also use low-cost fishing gear and share or sell their catch locally. These fisheries also offer safety nets against natural disasters, such as floods that disrupt agriculture, that might otherwise impoverish nearby communities. Post-harvest activities also provide valuable opportunities for women and contribute relatively little to GHG emissions. Local knowledge informs fishing practices, such as seasonal gear use and adapting to fish abundance and distribution. These practices also include efforts to sustain productivity, for example creating fish refuges and improving water, crop, and riparian management. Such strategies can inform national fisheries management priorities and strengthen adaptive capacity in the face of climate change.

National mitigation and adaptation strategies must prioritize an integrated response to climate change. Inland fisheries are not a marginal or last resort activity; they are a fundamental pillar of local livelihoods, economies, and food systems. Overlooking inland fisheries in climate adaptation strategies can undermine these roles and the contributions of inland fisheries and could marginalize those who depend on them. Furthermore, from a positive perspective, it is important to recognize the potential adaptive capacities of inland fisheries and how viable inland fisheries can contribute to adaptation strategies and to food security, nutrition, and poverty reduction, especially where alternatives are limited (e.g., Barange et al., 2018).

Policy option 1

Develop sustainable and climate-adaptive fisheries management

Overview

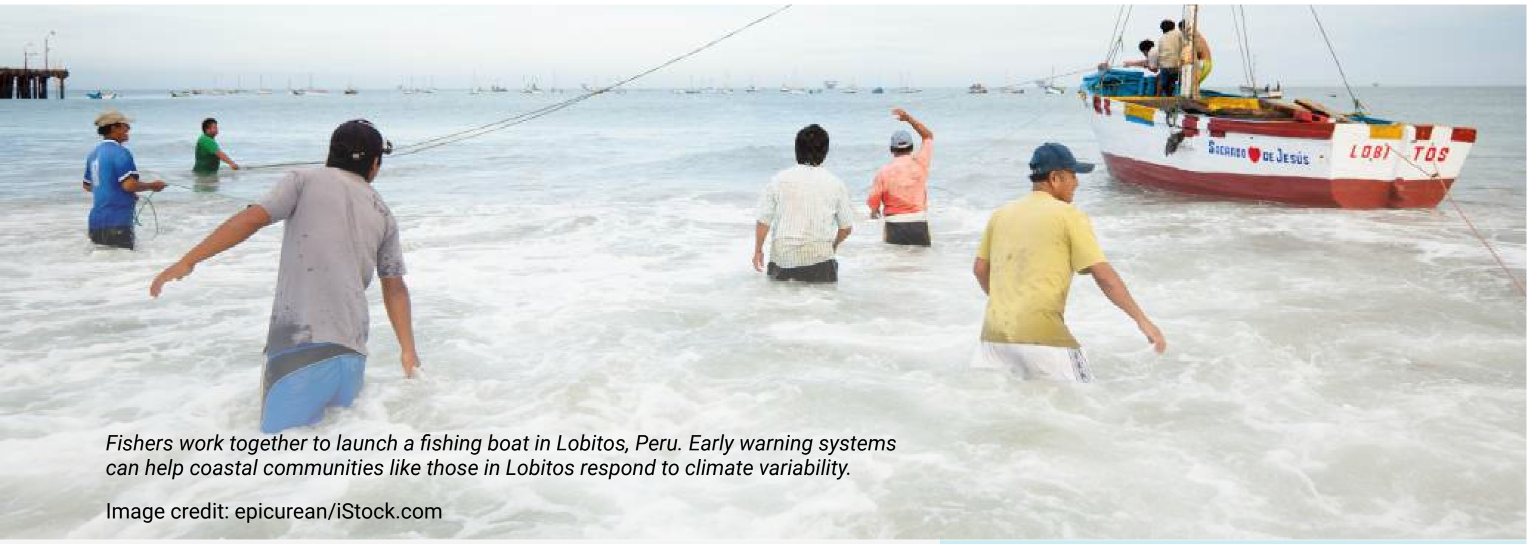
Primary benefit	Spatial scale	Applicable countries/regions
Mitigation and adaptation	Subnational to international	Countries that operate wild-capture fisheries

Global climate models underscore the urgency of sustainable fisheries management. Under a high-emissions scenario, extractive marine fish species are projected to decline by more than 10 percent in many regions by 2050, with some regions being impacted more than others. However, limiting global warming to 1.5-2°C under a low-emission scenario could stabilize these changes, with declines limited to 10 percent or less. This highlights the urgent need for climate-adaptive management to reduce the severe impacts on fisheries, especially for countries heavily reliant on aquatic foods for protein, such as the Solomon Islands and Portugal, or countries that have major marine fisheries, such as China and Peru (Blanchard & Novaglio, eds., 2024).

The foundation for adaptation is sustainable management of fisheries to ensure the health of fish stocks and the ecosystems that support them. Healthier fish stocks lead to higher catch per unit effort, meaning fishing vessels will require less fuel for the same amount of catch. This increase in efficiency could lead to a reduction in GHG emissions by 81 $MtCO_2e$ per year, nearly half of current fishing emissions (Hoegh-Guldberg et al., 2019). However, sustainable management alone is not enough; fisheries management must also adapt to climate change by adjusting management mechanisms to changes in species productivity and location. Certain stocks may take a long time to recover from unsustainable practices or climate impacts, requiring nuanced measures that account for species variability. These adaptive strategies can help communities continue to benefit from fisheries in a changing climate.

Concrete measures

- Conduct baseline assessments to evaluate the current status of fisheries, including social considerations such as the roles of women in fisheries, and assess the potential impacts of climate change on livelihoods, habitats, and species. Employ data-limited assessment tools where information is scarce.
- Integrate environmental variables and climate risks into fisheries assessment models, particularly in data-rich systems, to enhance stock management accuracy.
- Establish comprehensive community-based monitoring programs that engage local fishers and marginalized groups, such as women, in data collection and reporting.
- Introduce flexible management tools such as dynamic fishing seasons, tradable fishing rights, and adaptive plans that allow for real-time responses to climate-driven events and shifting harvest limits.
- Implement multispecies quota systems to ensure sustainable harvest levels, reduce bycatch, and adapt to shifting species distributions.
- Implement measures to protect and restore critical habitats, habitat connectivity, and keystone species to maintain ecosystem health.
- Strengthen collaboration with neighboring countries through diplomatic channels and regional fishery bodies (including regional fisheries management organizations and advisory bodies) to manage the transboundary movement of fish stocks across national waters.
- Apply marine spatial planning and integrated coastal and water resource management to balance sustainable fisheries production with other activities, such as renewable energy production in coastal areas.
- Enact a precautionary pause, or at minimum require environmental impact assessments, on developing commercial fisheries targeting mesopelagic zone (200-1,000 m depth) species for human consumption or fishmeal and fish oil until the ecological and carbon sequestration roles of these organisms are fully understood (Saba et al., 2021).



Fishers work together to launch a fishing boat in Lobitos, Peru. Early warning systems can help coastal communities like those in Lobitos respond to climate variability.

Image credit: epicurean/iStock.com

Example targets

- X percent of wild-caught fish stocks in [Party] will have sustainable and climate-adaptive management plans adopted and implemented by [Year].
- [Party] will reduce annual fuel emissions from wild-capture fisheries production by at least X percent by [Year] following adoption of sustainable management policies.
- To protect keystone species and critical habitats, [Party] will make X percent of its exclusive economic zone marine protected areas or under other effective area-based conservation measures by [Year].
- [Party] will have X percent of fishing communities engaged in monitoring programs by [Year] and early warning systems covering X percent of coastal fishing communities by [Year].
- [Party] will have developed and implemented transboundary management agreements with X of its neighboring exclusive economic zones by [Year].

Co-benefits and trade-offs

Sustainable and climate-adaptive fisheries management can support both climate mitigation and adaptation. Ensuring well-managed fisheries can secure long-term food and nutrition security, reducing the need to seek alternative food sources, which may have a higher carbon footprint. Enhancing transboundary cooperation in fisheries management can also foster regional stability and promote more sustainable practices across borders.

However, these benefits come with trade-offs. Top-down implementation of fisheries management may inadvertently exclude inland and coastal communities from resources they depend on for food and income, leading to social and economic challenges. Successful climate-adaptive management can be undermined by developments in other sectors, such as coastal infrastructure projects, changes in agriculture and land use practices, or energy production. Additionally, restricting access to overfished stocks, while needed for recovery, could disproportionately affect small-scale fishers who may lack the resources to adapt to new regulations or technologies, potentially exacerbating inequalities within the sector.

Examples in practice

Sistema de Alerta, Predicción y Observación (S.A.P.O.) | Chile, Peru, Ecuador

Chile, Peru, and Ecuador are collaboratively developing S.A.P.O., a joint oceanographic monitoring and early warning system designed to support climate-resilient fisheries in South America. S.A.P.O. 2.0, a mobile app, empowers fishers by providing real-time predictions of species availability, enabling them to adapt their practices and negotiate more effectively with buyers. This tool enhances the ability of coastal communities to respond to climate variability, supporting sustainable fisheries practices and markets in the region.

The Alaska Climate Integrated Modeling project (ACLIM) | United States of America

ACLIM is an effort led by the U.S. National Marine Fisheries Service, in collaboration with more than 50 scientists, to assess the impacts of climate change on the Bering Sea ecosystem. This project links global climate and socioeconomic projections to regional circulation, climate-enhanced biological models, and socioeconomic and harvest scenarios. By integrating diverse research disciplines, ACLIM provides managers with insights into the risks that climate change poses to fish and fisheries, while also evaluating a range of adaptation strategies. The project's findings inform regional models and management plans, offering a comprehensive approach to climate-adaptive fisheries management in Alaska.

Policy option 2

Reduce emissions from fishing

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Fishery to international	All countries that have fisheries with motorized vessels or those that are in the process of motorizing their fleet

Fuel use in wild-capture fisheries is the sector's largest source of GHG emissions, with fishing fleets emitting between 73 to 159 million tons of CO2 annually from 2012-2016 (United Nations Conference on Trade and Development, 2024). While recent data are scarce, in the year 2000, fishing fleets accounted for about 1.2 percent of global fuel consumption (Tyedmers, Watson, and Pauly, 2005). These emissions represent 0.1 percent to 0.5 percent of global carbon emissions and approximately 4 percent of food production emissions, though these figures are likely underestimated due to inconsistent GHG reporting (United Nations Conference on Trade and Development, 2024). Home to the largest fishing fleet, Asia produces the most CO2 emissions, followed by Europe and Africa (United Nations Conference on Trade and Development, 2024).

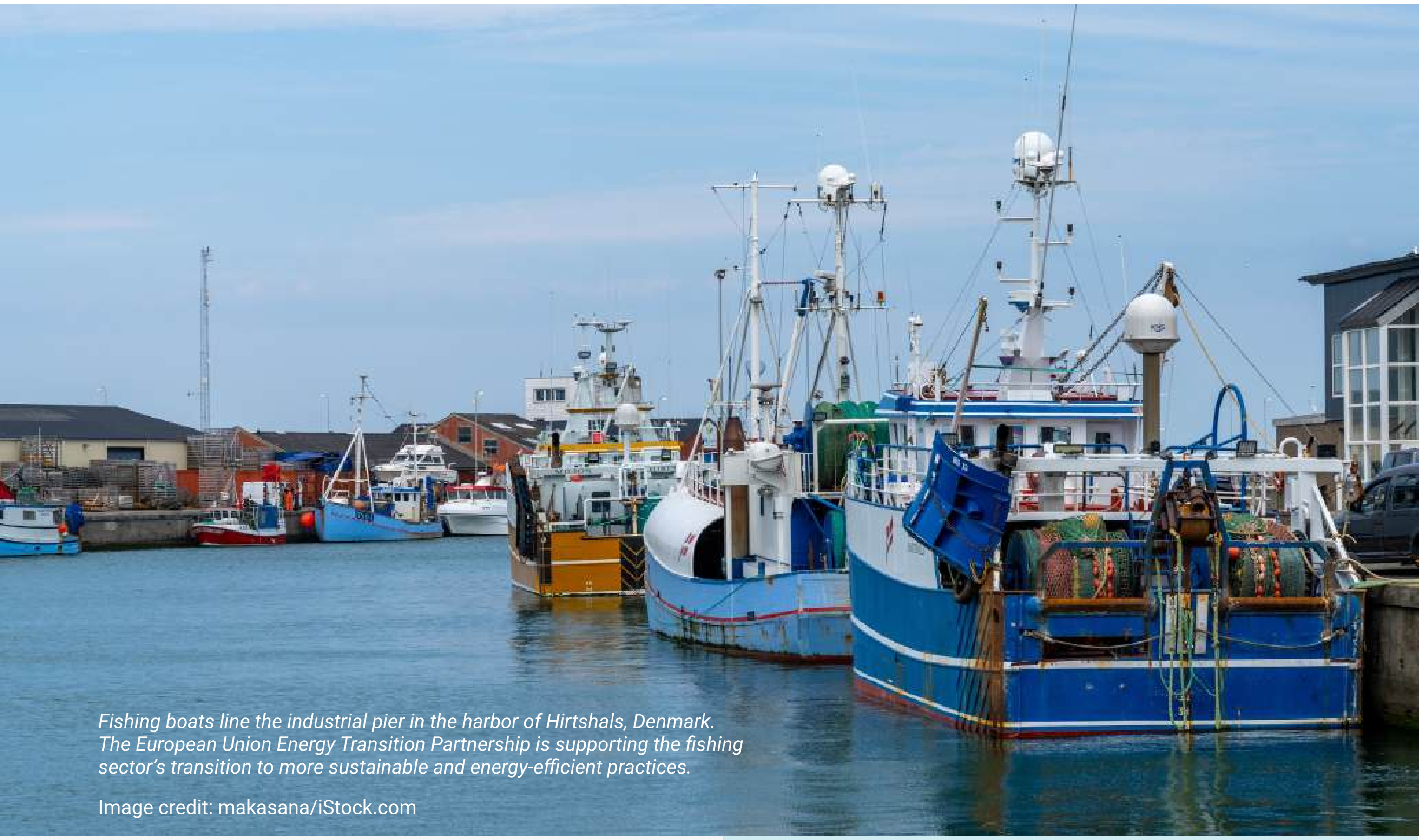
Reducing emissions requires adopting low-fuel gear within each fishery, which could lower GHG emissions by 4 percent to 61 percent, depending on the species (Gephart et al., 2021). Transitioning to low-impact, fuel-efficient (LIFE) practices, such as optimizing vessel hull shape or propulsion efficiency, can further improve the efficiency of fishing operations. Changing to hybrid or fully electric vessels can also cut emissions. The International Maritime Organization (IMO) recently revised its GHG strategy for global shipping, aiming for net-zero GHG emissions from international shipping by 2050 and a commitment to ensure the uptake of alternative and near-zero GHG fuels by 2030 (IMO, 2023). While this strategy does not target fishing fleets, it is likely to accelerate the deployment of low- and zero-emissions technologies and fuels in the fisheries sector, along with necessary infrastructure (United Nations Conference on Trade and Development, 2024).

Concrete measures

- Support the World Trade Organization (WTO) Agreement on Fisheries Subsidies to eliminate harmful fossil fuel subsidies and promote sustainable fishing practices.
- Establish and enforce mandatory emission standards or bans on high-emission fishing gear, and promote the adoption of low-impact, low-emission alternatives.
- Provide incentives for retrofitting existing fishing vessels with low-emission technologies and support the development of "green" shipbuilding.
- Invest in research and development of alternative energy sources for fishing vessels, such as green methanol, biogas, green hydrogen, and wind propulsion. This includes retrofitting vessels, adopting new engine designs, and upgrading port infrastructure.
- Improve the energy efficiency of port infrastructure and support the transition to renewable energy sources in port operations.
- Develop a global system for data collection, monitoring, and reporting of fishing fleet emissions, tailored for small-scale and artisanal fisheries, building on the experiences of the IMO and FAO.

Example targets

- To improve the efficiency of fishing techniques, [Party] will have X percent of vessels converted to LIFE practices and gear by [Year].
- [Party] will reduce fossil fuel subsidies by X percent by [Year] and reallocate $X annually to support low-emission energy alternatives by [Year].
- [Party] will ban high-emission fishing gear and ensure that X percent of fishing fleets adopt low-emission alternatives by [Year].
- [Party] will invest $X in research and development for alternative energy sources by [Year].
- [Party] will retrofit X major ports with renewable energy infrastructure by [Year] and achieve an X percent reduction in port energy use by [Year].
- [Party] will aim to reduce greenhouse gas emissions from the commercial fishing sector by [X MtCO2e per year/X percent] by [Year].



Fishing boats line the industrial pier in the harbor of Hirtshals, Denmark. The European Union Energy Transition Partnership is supporting the fishing sector's transition to more sustainable and energy-efficient practices.

Image credit: makasana/iStock.com

Co-benefits and trade-offs

The primary benefit of transitioning to renewable energy in fisheries is the mitigation of GHG emissions. While there are no clear adaptation co-benefits, this transition offers several advantages. Cleaner energy sources improve air and water quality, benefiting public health and the environment. Renewable energy can also reduce fuel costs over time, leading to lower operational costs and enhancing energy security by decreasing dependence on fossil fuels.

However, there are trade-offs to consider. The initial capital required for transitioning to renewable energy technologies and retrofitting vessels can be substantial, which may be a barrier for businesses. There are knowledge gaps regarding how to ensure an effective, equitable, and just transition to renewables in different contexts. Charging batteries for electric motors may also depend on fossil fuel energy supply. If cheaper fuel and technology costs lead to increased fishing effort, this could inadvertently exacerbate overfishing if not managed properly.

Examples in practice

EU Energy Transition Partnership (ETP) | European Union

The EU Energy Transition Partnership is a multi-stakeholder platform designed to improve collaboration and knowledge sharing among private and public sectors to accelerate the energy transition in fisheries and aquaculture. Established as part of the European Commission's "fisheries and oceans"' package, which includes an action plan for decarbonizing EU fisheries and aquaculture, the ETP aims to reduce fossil fuel intensity by at least 15% from 2019 to 2030. The ultimate goal of the partnership is to achieve a CO2-neutral footprint for EU fisheries by 2050. By fostering dialogue and collaboration, the ETP supports the sector's transition to more sustainable and energy-efficient practices.

WTO Agreement on Fisheries Subsidies | Global

Adopted at the 12th WTO Ministerial Conference (MC12) in June 2002, the WTO Agreement on Fisheries Subsidies is the first legally binding multilateral agreement addressing marine resources. The agreement regulates the provision of fisheries subsidies and targets subsidies, such as fossil fuel, that can adversely impact the sustainability of marine natural resources and overall fossil fuel usage.

Policy option 3

Support climate-adaptive livelihoods and practices for fishers and fishing communities

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Adaptation	Local to national	All climate-vulnerable countries where the fisheries sector contributes to food and nutrition security and the economy

Fisheries are among the most climate-vulnerable sectors in the world. Regions heavily reliant on blue foods – such as Africa, South and Southeast Asia, and the Indo-Pacific – are particularly at risk. By 2050, under a high-emissions scenario, more than 50 countries heavily dependent on blue foods will face high climate hazards yet have limited capacity to adapt (Tigchelaar et al., 2021).

To reduce these risks, in addition to adopting climate-adaptive fisheries management (Policy option #1), it is important to implement measures that enhance the resilience of both fisheries and the communities dependent on them. These include improvements in preparedness for extreme events, such as storms or ocean heat waves, through early warning systems and climate information services. Strengthening disaster response, offering alternative livelihoods, and addressing socioeconomic vulnerabilities through insurance, social protection, and gender-sensitive approaches can further support community resilience.

Concrete measures

- Establish early warning systems and enhance disaster preparedness to protect fishers and fishing communities from extreme weather events.
- Fund local climate projections, extension services, and data-limited assessment and monitoring systems to provide essential climate information and services to fishers and their communities to support adaptive decision-making.
- Engage fishers and especially marginalized voices, such as those of women and Indigenous Peoples, in the fisheries value chain to identify local adaptation initiatives through participatory planning processes, and create financial instruments to support these projects.
- Invest in capacity building and knowledge sharing among fisheries managers, scientists, and local communities, including regional networks and platforms for exchanging best practices, adaptation options, and innovative management approaches.
- Strengthen social protection systems and safety nets for fishers and communities to manage climate-related shocks, including insurance options, disaster relief funds, and unemployment benefits. Recognize that fisheries can also serve as safety nets and support local adaptation strategies.
- Improve women's access to affordable and accessible credit, tenure rights, and labor-saving technologies to boost uptake of adaptation measures, increase incomes and intrahousehold decision-making, and reduce gender-related climate vulnerability.
- Support the relocation or adaptation of landing and processing facilities to align with shifting fish populations and environmental conditions.
- Create policy frameworks for marine spatial planning that support livelihood diversification in fishing communities – including aquaculture, tourism, and small-scale manufacturing – to enhance climate resilience.

Fishers carrying nets wade into the water off the coast of Zanzibar, Tanzania. Including fishers, especially marginalized voices such as those of women, can strengthen local adaptation initiatives and disaster response.

Image credit: vladk213/Stock.adobe.com

A fisherman checks his net in Santey Village in Cambodia. Community fish refuges in the village are designed to enhance productivity in rice field fisheries.

Image credit: Finn Thilsted/WorldFish

Example targets

- [Party] will improve the resilience of fishing infrastructure by retrofitting or upgrading X percent of coastal facilities to withstand extreme weather events, and ensure that X percent of fishers use durable and climate-resilient fishing gear by [Year].
- By [Year], [Party] will establish a disaster relief fund of $X, with the goal of reducing disaster emergency costs by X percent through proactive infrastructure improvements and early warning systems.
- [Party] will provide fishers with access to enhanced climate information services and social protection mechanisms, such as insurance and access to extension programs, with a goal to reach X fishers by [Year].
- By [Year], [Party] will introduce X new policies or initiatives that explicitly reference coastal livelihood diversification or climate risk reduction in fisheries, with regular (e.g., annual) reviews to assess effectiveness and inclusivity.
- [Party] will establish or enhance X regional learning networks or knowledge-sharing platforms, involving at least X percent of fishing communities, to facilitate the exchange of best practices, climate adaptation strategies, and technological innovations.
- [Party] will support the development of new fisheries and seafood products, aiming to diversify by X percent by [Year].

Co-benefits and trade-offs

The primary benefit of introducing climate-adaptive livelihoods and practices for fishers and fishing communities is adaptation, with limited or no direct mitigation co-benefits. Adaptive measures can enhance income stability by diversifying income sources. They can also support food and nutrition security. Integrated responses that recognize links to other productive sectors can help strengthen overall food system resilience to change, while early warning systems benefit both fishers and coastal ecosystems. Gender-sensitive adaptation measures can support women's roles in fisheries. Infrastructure investment and capacity building can promote poverty reduction.

There are trade-offs to consider for this policy option. Risk reduction measures, such as infrastructure improvements or financial assistance, may not be equitably accessible to all community members. Financial aid measures, such as subsidies for fishing gear, or insurance mechanisms might inadvertently encourage unsustainable fishing practices or increase dependency. In addition, diversifying away from traditional fisheries could also erode cultural identity and traditional practices.

Examples in practice

Caribbean Ocean and Aquaculture Sustainability Facility (COAST) | Grenada and Saint Lucia

COAST is the first-ever parametric insurance developed for the fisheries sector, designed to enhance resilience against the impacts of climate-related disasters. With financial support from the U.S. Department of State, the World Bank, the Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company, and the Caribbean Regional Fisheries Mechanism, COAST provides rapid payouts to fisherfolk affected by "bad weather," with the intention to be inclusive of all those in the fisheries sector, including crew members, captains and/or boat owners, and fish vendors and processors, the latter group being made up mostly of women. COAST was launched as a pilot in Grenada and Saint Lucia, and payouts are channeled through Ministries of Finance followed by a rapid transfer to beneficiaries.

Community Fish Refuges | Kingdom of Cambodia

Community fish refuges are a fish conservation and adaptation measure designed to enhance productivity in rice field fisheries. These refuges, which leverage local ecological knowledge, create sanctuaries for brood fish during the dry season. Proof-of-concept projects have demonstrated a 71 percent increase in annual average fish catch among the poorest 20 percent of households. The government of the Kingdom of Cambodia officially recognizes and supports the widespread adoption of community fish refuges as part of its food and water security strategy.

Tools and resources

EDF Climate-Resilient Fisheries Planning Tool: A decision-support tool for stakeholders and communities to identify actions for building greater resilience to climate change.

EDF Framework for Integrated Stock and Habitat Evaluation (FISHE): A step-by-step process for providing scientific guidance for sustainable, climate-resilient management of data-limited fisheries.

FAO Adaptive Management of Fisheries in Response to Climate Change: A set of 15 good practices for climate-adaptive fisheries management that have proven success and can be adapted to different contexts.

FAO Ecosystem Approach to Fisheries Toolbox: Practical steps and tools for fisheries management planning and implementation that can be applied in the circumstances of anticipating climate change and integrating adaptive responses into fisheries management.

FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication: Voluntary guidelines that represent a global consensus on principles and guidance for small-scale fisheries governance and development.

United Nations Conference on Trade and Development Energy Transition of Fishing Fleets: A set of key economic, technological, trade, environmental, and social considerations to support a just energy transition for fishing fleets, particularly in developing countries.

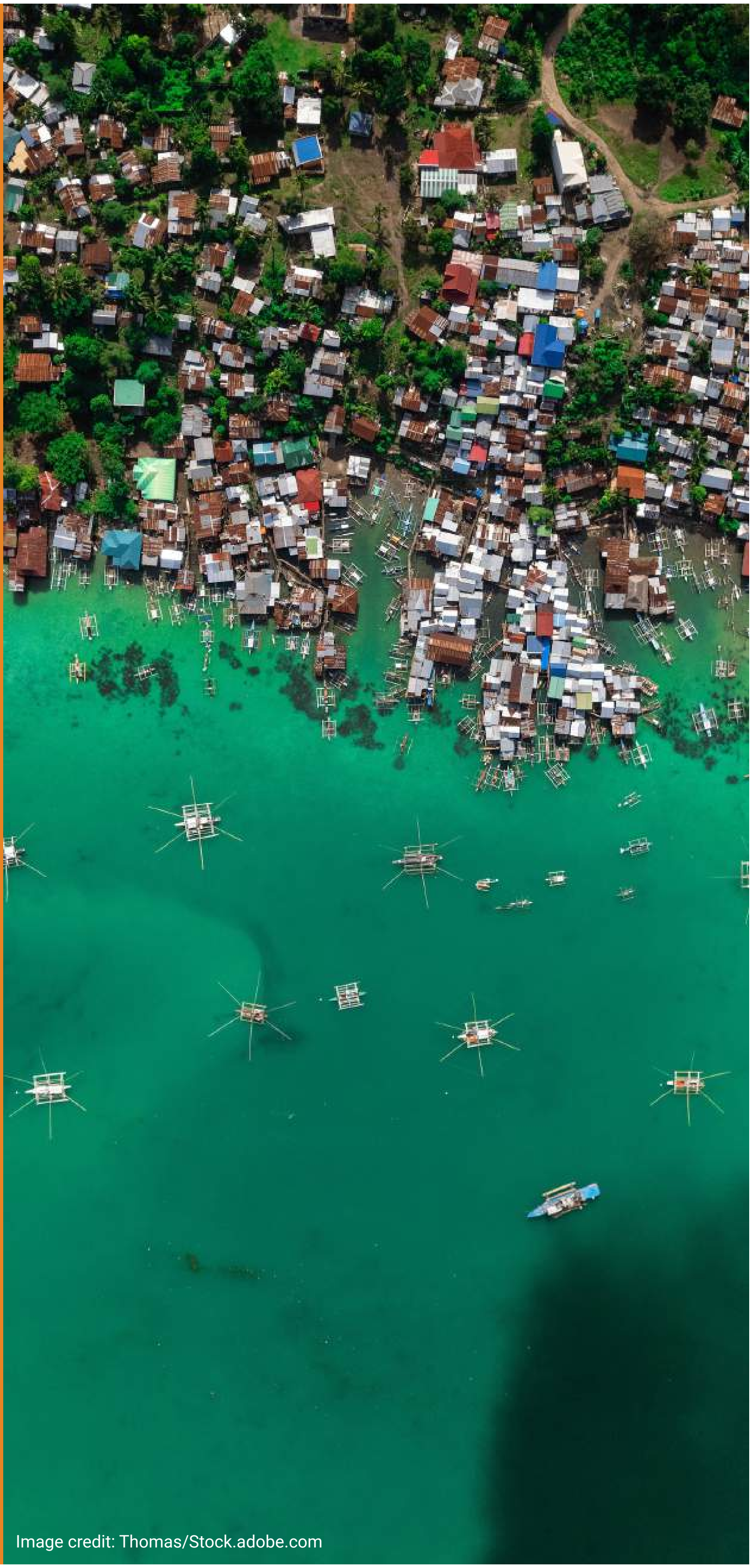


Image credit: Thomas/Stock.adobe.com

Aquaculture production

Aquaculture has become a cornerstone of blue food production. In 2022, global aquaculture production reached 130.9 million tonnes, valued at USD 312.8 billion. Aquaculture now accounts for 59 percent of global blue food output[2], with inland aquaculture contributing 62.6 percent and marine and coastal aquaculture 37.4 percent of the total global blue food output. For the first time, aquaculture production surpassed capture fisheries in aquatic animal production, representing 51 percent of the world total (FAO, 2024b). Aquaculture's importance is underscored by the production of accessible and affordable species, such as tilapia, African catfish, and pangasius. Globally, out of some 730 species items, 17 staple species represent about 60 percent of global aquaculture production, though a diversity of species is important at local levels (FAO, 2024b). The sector's growth is largely driven by Asian countries, especially China, which in 2022 produced 70 percent of the total output of aquatic animals.

With aquaculture's growth, GHG emissions from the sector are also increasing. In 2017, aquaculture activities were estimated to be responsible for 263 MtCO2e, or 0.49 percent of global GHG emissions, primarily from feed production, energy use, land use changes, and mangrove deforestation (Macleod et al., 2020) – although uncertainties around this estimate are high. There is a wide range of GHG emissions among different species and systems (Gephart et al., 2021). This offers opportunities both for improving practices and for shifting to more sustainable systems.

As aquaculture expands, strategic planning, investment, and resilience-building measures are essential to reduce emissions as well as aquaculture's vulnerability to climate change. Policymakers can prioritize measures in four key areas: First, improving aquaculture feed and feeding management can reduce GHG emissions. Second, transitioning energy inputs to renewables and reducing energy use will lower the sector's carbon footprint. Third, promoting the expansion of low-input, integrated, or non-fed aquaculture systems can be a key solution to enhance environmental sustainability. And fourth, supporting adoption of climate-adaptive technologies and practices will increase aquaculture's long-term resilience to climate impacts.

59%

of global blue food output comes from aquaculture. (FAO, 2024b)

130.9 million tonnes

global aquaculture production in 2022. (FAO, 2024b)

As the aquaculture industry grows, strategic measures are essential to reduce emissions as well as support aquaculture's resilience to climate change.

Image credit: Auremar/Stock.adobe.com

[2] *Note: These values are calculated using wet weight rather than edible weight. This may overemphasize the volume produced for products that are especially moisture rich (e.g., seaweeds) or have higher proportions of inedible parts (oysters) compared to edible weight.*

Policy option 1

Improve aquaculture feed and feeding management to reduce GHG emissions

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Farm to national	Countries that operate aquaculture or that are looking to start their production

In 2022, fed aquaculture – of species such as salmon, tilapia, and catfish that use aquafeeds – accounted for about two-thirds of global aquaculture production (FAO, 2012b; FAO, 2024b). Feed is the most expensive input for aquaculture. It also accounts for up to 90 percent of the environmental impacts and carbon footprint of farmed fish production (Little et al., 2018; Gephart et al., 2021). Emissions from aquafeed production primarily stem from raw materials, land use changes, fertilizer use, and the energy-intensive processes of feed transport, processing, and distribution (MacLeod et al., 2020).

Reducing feed-related emissions in aquaculture can be achieved by improving feed conversion ratios (FCR) (the amount of feed divided by animal weight gain), selecting lower-emission feed ingredients, or shifting to species with lower feed demand. Emissions from feed production vary significantly depending on the species and the production system, with FCR playing an important role considering the predominance of feed-related emissions in aquaculture (MacLeod et al., 2020). However, feed composition is also important; emissions can be reduced by choosing feed ingredients with a lower GHG footprint and optimizing feed management practices (Gephart et al., 2021).

Concrete measures:

- Invest in research, development, and use of low-carbon feed ingredients, such as bacteria, yeast, earthworms, krill, insects, algae, and single-celled proteins, ensuring they meet nutritional, environmental, and ethical standards.
- Incentivize the adoption of precision feeding techniques and efficient species to optimize nutrient intake, reduce feed waste, and improve FCR.
- Develop and implement training programs for farmers on advanced feeding management, precision feeding, and alternative feed ingredients to reduce GHG emissions.
- Invest in infrastructure to facilitate the use of fish processing by-products as substitutes for fishmeal and oils.
- Invest in hatchery and distribution infrastructure and establish local and regional distribution networks to ensure small-scale farmers have reliable access to high-quality feeds and seeds.
- Establish comprehensive monitoring and reporting systems for key performance indicators, including feed use, to improve feeding management practices and reduce GHG emissions.

A farmer feeds fish in a commercial fish farm along the Mekong River in Thailand. Feed accounts for a large portion of aquaculture's carbon footprint, which can be reduced through precision feeding techniques and other measures.

Image credit: Thirawatana Phaisalratana/iStock.com

Fish farmers tend to a tilapia hatchery in Leohitu, Timor-Leste. The government has supported increasing access to sustainable seed, feed, and grow-out technologies in alignment with its National Aquaculture Development Strategy.

Image credit: Kate Bevitt/WorldFish

Example targets

- [Party] targets an X percent improvement in FCR across the sector and for key aquaculture species by [Year].
- [Party] aims to reduce GHG from aquafeed use by X percent by [Year] through the adoption of low-carbon feed ingredients and/or raw materials.
- [Party] will invest $X annually over the next X years to promote research and innovation in aquafeed formulations and feeding management.

Co-benefits and trade-offs

Better feed and feeding management in aquaculture primarily offers mitigation benefits, yet breeding, feed management practices, and infrastructure development can also provide adaptation co-benefits. Improved FCR and optimized feeding techniques reduce GHG emissions while lowering feed costs for farmers, leading to savings and improved productivity. Precision feeding further enhances nutrient utilization, leading to healthier fish.

However, proper management of aquafeed ingredients (e.g., crop and wild-caught fish) is necessary to avoid conflicts with human consumption (FAO, 2024b). Lowering FCR through the inclusion of higher-quality feed ingredients may also result in greater GHG emissions. Therefore, it's important to carefully select aquafeed ingredients by considering their nutritional value, cost, availability, and environmental and social impacts.

Examples in practice

Guidelines for Feed Use in Carp and Trout Production Systems | Central Asia and Eastern Europe

In aquaculture, providing high-quality aquafeeds that meet the nutritional needs of farmed species is essential for improving yields, reducing costs, and improving economic returns for farmers. These guidelines on fish nutrition focus on the dietary requirements of commercially cultivated species, such as carp and trout, covering different feed types (live, supplementary, farm-made, and commercial), their composition, and their use. Governments can facilitate training and capacity-building programs for fish farmers to develop more effective feed management practices, including determining proper storage, calculating feed rations, determining feeding frequency, and monitoring appetite and the feeding responses, to optimize feed consumption and production efficiency.

Partnership for Aquaculture Development | Timor-Leste

The government of Timor-Leste in Southeast Asia is developing its fisheries and aquaculture to improve food and nutrition security while creating income opportunities for coastal and inland farming communities. In its NDC, Timor-Leste highlights an ongoing financing program, IKAN Adapt. This development program strengthens the adaptive capacity and resilience of fishery- and aquaculture-dependent communities while also protecting biodiversity. Aligning with its National Aquaculture Development Strategy (2012-2030), Timor-Leste is also working to sustainably scale the production of genetically improved farmed tilapia, with concentrated efforts on increasing access to sustainable seed, feed, and grow-out technologies.

Policy option 2

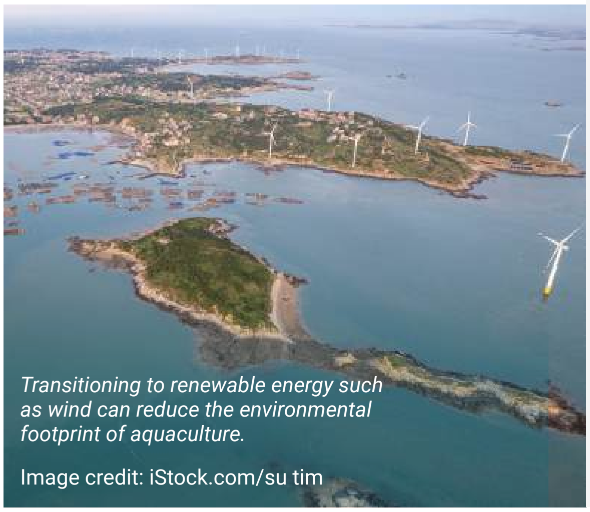
Transition aquaculture energy inputs to renewables and reduce energy use

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Farm to national	Countries that operate aquaculture or that are looking to start their production

Energy use is the second largest source of GHG emissions in aquaculture, after feed production and use. The energy demands of aquaculture vary based on production intensity, including needs for feed processing, storage, transportation, and equipment such as aerators and automatic feeders (Gephart et al., 2021). As aquaculture grows, it is important to optimize energy use in both feed production and farm operations to minimize emissions and improve overall efficiency.

Transitioning to renewable energy sources – solar, wind, bioenergy, hydro, and geothermal – can reduce the environmental footprint of aquaculture. For example, switching from diesel oil to natural gas in fed finfish mariculture has cut nitrous oxide emissions from farmed salmon by 85 percent and CO2 emissions by 20 percent (Ellingsen and Aanondsen, 2006; Jones et al., 2022). Improving energy efficiency – particularly in high-energy activities such as water exchange and treatment, handling systems, and feed production – is essential for keeping aquaculture on a low-emissions pathway (FAO, 2012a).



Transitioning to renewable energy such as wind can reduce the environmental footprint of aquaculture.

Image credit: iStock.com/su tim

Concrete measures

- Provide targeted incentives and subsidies to help farms, feed production, and transportation upgrade to energy-efficient equipment and renewable energy systems, such as efficient pumps, temperature control systems, solar panels, and electric vehicles.
- Establish and enforce energy efficiency standards for aquaculture operations to optimize and reduce energy use.
- Facilitate subsidized energy audits to help farms identify opportunities for energy savings and transition to renewable energy.
- Implement demand response programs that incentivize energy-intensive equipment use during off-peak hours.
- Create trainings and platforms for farmers, researchers, and industry experts to share technology and knowledge on energy management and emissions reduction.
- Include aquaculture in national climate policies and energy priorities, connecting it to other sectors for comprehensive support of energy transitions.
- Promote public-private partnerships to drive renewable energy adoption in aquaculture.

Example targets

- [Party] will provide $X in low-interest loans to aquaculture farms for the adoption of energy-efficient technologies and renewable energy systems, such as solar panels and energy-efficient water pumps, with a goal of reaching X farms by [Year].
- By [Year], [Party] aims to achieve an X percent reduction in grid energy use by the aquaculture sector based on improving energy efficiency and transitioning to renewable energy sources.
- [Party] will facilitate subsidized energy audits for X percent of aquaculture farms by [Year] to identify opportunities for improving energy efficiency transitions to renewable energy sources.
- [Party] will allocate $X in funding for research and development projects focused on energy efficiency and renewable energy technologies in aquaculture over the next X years.

An aerial view reveals shrimp farms in Indonesia

Image credit: Nasrul Ma Arif/Stock.adobe.com

Co-benefits and trade-offs

Transitioning aquaculture energy inputs to renewables and reducing energy use offers mitigation benefits with potential adaptation co-benefits. Renewable energy and energy-efficient systems can help farms adapt to climate impacts by ensuring reliable energy operations for adaptive practices, such as using paddles to counter deoxygenation or cooling hatcheries during heat waves. Reducing fossil fuel use lowers GHG emissions while minimizing the risk of water pollution from fuel spills or leakage, which improves water quality and ecosystem health. Renewable energy systems can also lead to long-term cost savings on energy bills, improving the financial stability of aquaculture farms. These practices can promote better resource management, including water conservation, and excess energy can be sold to provide additional revenue for farms (FAO, 2012a).

There are trade-offs to consider for this policy option. The upfront investment required for energy-efficient technologies and renewable systems could potentially be a financial burden for smaller operations, and the return on investment may take time to materialize. New systems often require specialized maintenance and training, which may pose challenges for farms with limited technical expertise. Integrating new energy technologies with existing infrastructure may also be technically challenging, and the spatial planning for renewable installations, such as solar panels or wind turbines, should consider equitable access to land or water areas needed for aquaculture operations.

Examples in practice

Fisheries and Aquaculture Clean Technology Adoption Program | Canada

Iceland's source of geothermal energy, due to its location on the Mid-Atlantic Ridge, has enabled the government to increasingly focus on using renewable energy sources for power generation, direct uses, and the transportation sector (Ragnarsson, Steingrímsson & Thorhallsson, 2020). Aquaculture pond and raceway heating are among the most common applications of geothermal energy, enabling operations in colder climates or areas where alternative heating sources are not economical. In Iceland, this renewable energy is used to farm species like Arctic char, turbot, tilapia, and Atlantic halibut, supporting more sustainable aquaculture in the region.

Supporting Renewable Geothermal Energy | Iceland

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Policy option 3

Promote expansion of low-input, integrated, and/or non-fed aquaculture systems

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Farm to national	Countries that operate aquaculture or that are looking to start their production

Non-fed aquaculture – usually extractive animal and plant species – makes up about one-third of global aquaculture production (FAO, 2024b). These systems can offer climate benefits because seaweeds, bivalves, and filter-feeding finfish generally produce lower GHG emissions compared to many fed production systems (of aquatic and land animal systems) (Troell et al., 2022; Jones et al., 2022). Practices such as 3D ocean farming, which combines seaweed and shellfish cultivation, require minimal inputs because seaweeds absorb naturally occurring dissolved nutrients from the water (Chopin et al., 2024). Bivalve farming is among the most sustainable forms of farming on the planet, offering a climate-friendly, high-protein food source.

A group of people gather seaweed from the water. Seaweed farming requires minimal inputs because seaweeds absorb naturally occurring dissolved nutrients from the water.

Image credit: Degimages/stock.adobe.com

Concrete measures

- Promote the development and proper management of low-trophic, low-input systems, such as filter-feeding finfish, seaweeds, and bivalves, that provide nutrition with minimal environmental impact.
- Offer financial incentives and technical assistance to develop functional and beneficial integrated multispecies aquaculture, tailored to national and regional characteristics, such as cage fish farming combined with seaweed and bivalve cultivation.
- Invest in the necessary infrastructure, such as water management systems, processing facilities, and transportation networks, to support and scale low-input aquaculture practices.
- Support the development of supply chains and improve market access for non-fed aquaculture products through certification programs and promotional campaigns to raise consumer awareness and demand.
- Implement capacity-building programs for aquaculture operators, providing them with the skills and knowledge needed to adopt and maintain sustainable, low-input, and integrated farming practices.
- Support data collection and spatial assessments, including life-cycle assessments and ecological evaluations, to guide the expansion of low-input and integrated aquaculture systems with minimal environmental impact.

Example targets

- [Party] will establish a $X fund by [Year] to provide grants, subsidies, and low-interest loans for developing non-fed/low-input production systems.
- [Party] will invest $X in processing, storage, and transportation infrastructure for low-input aquaculture by [Year].
- [Party] will aim to have an increased production of non-fed aquaculture systems by X percent by [Year].
- By [Year], [Party] will implement capacity-building programs for X aquaculture operators, enhancing their skills and knowledge for sustainable, low-input, and integrated farming practices.
- [Party] will allocate $X in R&D funding by [Year] for the development and improvement of integrated farming systems and enhance extension services to reach X percent of aquaculture farmers with best practices.

A farmer stands by his integrated rice and fish farm in Laos. Such farming systems support low-trophic fish species.

Image credit: Jharendu Pant/WorldFish

Co-benefits and trade-offs

The adoption of low-input and integrated aquaculture systems offers mitigation benefits with adaptation co-benefits. These systems have the potential to increase production with lower environmental impacts and provide resilience to environmental shocks. Low-input and non-fed systems have smaller environmental footprints, reducing nutrient pollution and habitat destruction. These systems may cause less negative impact on biodiversity, and in some cases even promote biodiversity. Integrated farming systems, which combine multiple species, tend to be less vulnerable to disruptions, ensuring a more resilient supply chain for aquatic food products. Aquaculture can also provide socioeconomic benefits, such as enhancing food security, generating additional income, and creating alternative employment opportunities (Bhosle et al., 2021).

However, managing integrated, multispecies systems can be more complex than traditional aquaculture, requiring advanced knowledge and management practices. In addition, there are knowledge gaps about what is needed to develop markets, infrastructure, and integrated farming systems that can scale to larger operations. Financial incentives and support programs may not be equally accessible, potentially leaving small-scale farmers at a disadvantage compared to larger operations. While algae can be a supplementary component in aquaculture, its development as a core component faces challenges, even in regions such as Asia, where more investment is needed. Low-carbon practices, such as bivalve farming in open coastal systems, can also be vulnerable to environmental stressors such as pollution and toxic algae blooms (Cao et al., 2023).

Examples in practice

Integrated Agriculture-Aquaculture Pilots | Laos

Over the past decade, the Department of Livestock and Fisheries in Laos has successfully piloted integrated agriculture-aquaculture through farmer promotion trials, a participatory approach to sustainable aquaculture farming. These trials introduced aquaculture into rice-based farming systems, supporting low-trophic fish species. The initiative aligns with FAO's Guidelines for Sustainable Aquaculture and will contribute to the development of Laos' National Action Plan for Sustainable Food Systems.

Philippine Seaweed Industry Roadmap 2022-2026 |The Philippines

In the Philippines, seaweed production accounts for 60 percent of total aquaculture production, valued at more than 12.1 billion Philippine pesos (USD 212 million) annually (CARE, 2021). With around 12,000 farmers involved in the sector, the Department of Agriculture introduced a five-year roadmap in 2022 to position the country as the global leader in seaweed and carrageenan. The government has also partnered with organizations such as CARE Philippines to support seaweed farmers' associations. These associations receive training in cultivation, disease prevention, and processing for market consumption.

Policy option 4

Support climate-adaptive technologies and practices to increase aquaculture's resilience to climate change

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Adaptation	Farm to regional	Countries looking to enhance resilience of existing aquaculture sector or looking to develop the sector

Like other farming systems, aquaculture is highly vulnerable to climate change. Climate change poses challenges to aquaculture productivity, sustainability, and profitability (FAO, 2024c). Climate change–driven higher water temperatures, ocean acidification, lower oxygen levels, increased pests and diseases, salinity changes, harmful algal blooms, droughts, and floods can all negatively impact aquaculture systems. Extreme weather events resulting from climate change can also damage aquaculture infrastructure and assets (Tigchelaar et al., 2021).

Strategic interventions are needed to sustain aquaculture in the face of climate threats. Addressing aquaculture's vulnerabilities requires both technological solutions and a holistic approach that reduces the sector's exposure to hazards and increases the adaptive capacity of aquaculture systems. Identifying and implementing short-, medium-, and long-term actions can improve aquaculture's overall resilience to climate change (Henriksson et al., 2021).

Concrete measures

- Strengthen capacity for climate-informed decision-making by identifying and predicting key climate change hazards, such as extreme weather events and water quality issues, and supporting aquaculture farmers with early warning systems, data collection, and regional knowledge sharing on climate risks and management practices.
- Invest in genetic enhancement programs to develop farmed types (e.g., strains and varieties) more resilient to changing conditions such as temperature and salinity, with a focus on locally adapted species.
- Incorporate climate risk assessments into aquaculture spatial planning, considering climate impacts in site selection, farm layout, and stocking and harvesting schedules.
- Identify and implement climate-resilient infrastructure, such as climate-controlled facilities, advanced water management systems, and protective barriers against flooding and storms.
- Support R&D initiatives to explore cost-effective new technologies, including energy-efficient systems, integrated farming approaches, closed recirculating aquaculture systems, feed alternatives, and climate-resilient breeding programs.
- Encourage climate-resilient management practices, such as adaptive stock density and water management, biosecurity protocols to prevent disease, and advanced monitoring techniques such as sensors, automated control systems, and water treatment technologies.
- Subsidize adoption of climate-smart aquaculture practices and systems by women to improve income and employment gains and reduce inequality.

Women harvest water lilies in Vietnam.

Image credit: Quang/Stock.adobe.com

A fish farmer spreads feed in her fish pond in Goaldhanga, Jashore, Bangladesh.

Image credit: Noor Alam/WorldFish

Example targets

- [Party] will implement comprehensive training programs on climate risks, innovative solutions, and climate adaptation strategies, reaching at least X percent of aquaculture farmers and technicians by [Year].
- [Party] will invest at least $X each year to support research projects focused on the identification of technological and innovative solutions to reduce aquaculture's vulnerability to climate change.
- [Party] will integrate temperature and precipitation prediction or measurement systems into national and regional aquaculture management plans, covering X percent of aquaculture areas by [Year].
- [Party] will establish a national system for evaluating and reporting the impacts of climate change on aquaculture, with annual reports published starting in [Year].
- [Party] will develop at least X regional platforms for technology and knowledge sharing, with active participation from X actors, by [Year].

Co-benefits and trade-offs

While the primary benefit of technological and innovative solutions in aquaculture is adaptation, certain strategies such as integrated farming, breeding, and farm management solutions offer mitigation co-benefits. These approaches can improve aquaculture's resistance and resilience to climate change while simultaneously increasing productivity and efficiency. The adoption of advanced technologies can boost overall yields and profitability while contributing to the reduction of GHG emissions.

Still, there are trade-offs to consider. Implementing these advanced technologies and infrastructure improvements often requires substantial upfront investment, which can be a financial challenge, especially for small-scale farmers. Some technologies, such as recirculating aquaculture systems, may have high energy demands, potentially leading to increased GHG emissions unless the systems are coupled with renewable energy sources. Adopting climate-resilient aquaculture practices also requires technological expertise, underscoring the need for technical assistance and training for small-scale farmers to support equitable implementation.

Examples in practice

Strengthening Climate Resilience Through Information Sharing | Bangladesh

In Bangladesh, the government has been
In the People's Republic of Bangladesh, the government has been working to develop digital climate information and advisory services and to adapt aquatic food systems to climate change. As part of the revision process of the national fisheries policy, the Ministry of Fisheries worked with WorldFish to develop a policy brief to help develop the first digital climate information and advisory service for aquaculture in the Bengal Delta. WorldFish researchers produced the first economic evaluation of climate information services for aquaculture in the People's Republic of Bangladesh, which found that these services could represent economic value of up to USD 14 million a year in losses averted thanks to the ability to anticipate and mitigate climate hazards.

Advancing Climate Smart Aquaculture Technologies (ACLISAT) | Egypt, Eritrea, and Ethiopia

This project aims to improve rural livelihoods and resilience in Egypt, Eritrea, and Ethiopia by promoting water-efficient aquaculture technologies. ACLISAT is developing and adopting systems such as the improved pond raceway system and enhancing post-harvest practices, while increasing the capacity of national aquaculture research institutions and extension agencies. By addressing water scarcity challenges due to climate change, the project supports sustainable aquaculture development in arid and semiarid regions, strengthening climate resilience.

Tools and resources

FAO Fuel and Energy Use in the Fisheries Sector: A publication addressing the utilization of fuel energy by the global fisheries industry along the entire supply chain from aquatic raw materials to consumption, including aquaculture.

FAO Guidelines for Sustainable Aquaculture: A set of shared principles and practices that countries can use to make their aquaculture sectors synonymous with food security and nutrition, equitable livelihoods, restored ecosystems, and climate resilience.

FAO Seaweeds and Microalgae: An Overview for Unlocking their Potential in Global Aquaculture Development: An overview of the algae sector with a focus on its contribution to global aquaculture development.

World Economic Forum The Global Sustainable Aquaculture Roadmap: Pathways for Systemic Change: A guide for transformative action across aquaculture value chains and the sector overall. It is grounded in a systems-change approach, offering four pathways with recommendations to scale the sector within nature's limits while achieving greater social, economic, and environmental benefits.

Image credit: Michel/Stock.adobe.com

Blue food supply chains

Blue food supply chains play a key role in global food supply, with 89 percent of aquatic animal production in 2022 – equivalent to 185.4 million tonnes – consumed by humans.[3] This translates to 20.7 kg per capita. Aquatic foods are distributed in various forms, with live, fresh, or chilled products making up the largest share (43 percent), followed by frozen (35 percent), prepared and preserved (12 percent), and cured (10 percent) (FAO, 2024b).

Aquatic foods are the most traded food products globally, providing higher net revenues for developing countries than those provided by all other agricultural commodities combined (Gephart and Pace, 2015; Sumaila et al., 2016; FAO, 2020c). The sector is highly diverse, with more than 2,500 species or species groups that are wild-caught or cultivated and numerous actors and markets ranging from small-scale subsistence mosquito-net fishers in Mozambique to lobster-fishing cooperatives in Mexico catering to high-end markets. However, this diversity and the opacity of global supply chains make it difficult for buyers to trace the environmental impacts of production (LeBaron, 2021). Policymakers can address this challenge to help create more transparent and sustainable supply chains. We identify two main options for addressing climate change through blue food supply chains. First, reducing loss and waste and enhancing circularity can improve resource efficiency and minimize environmental impacts. Second, reducing emissions from energy use and operations is crucial for reducing the carbon footprint of blue food production.

Aquatic foods are the most traded food products globally, providing higher net revenues for developing countries than all other agricultural commodities combined.

(Gephart and Pace, 2015; Sumaila et al., 2016; FAO, 2018)

A man purchases fish at a market in Cairo, Egypt. From fishers to consumers, there are opportunities to reduce loss, waste, and emissions from operations across blue food supply chains.

Image credit: Michel/Stock.adobe.com

[3] *Note: These consumption values reflect the estimated amount of blue foods that are consumed in country from national statistics. They are calculated as the sum of domestic production and import/reimport minus export.*

Policy option 1

Reduce loss and waste and enhance circularity in blue food supply chains

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation and adaptation	Local to international	All major aquatic food producers. The magnitude and drivers vary greatly across different geographies, which means interventions will vary.

Reducing loss and waste in blue food supply chains can help tackle global food waste, which accounts for approximately 6 percent of total GHG emissions (Ritchie, 2020a). In 2021, the world lost around 23.8 million tonnes of edible aquatic food, representing 14.8 percent of total production. Processing on land and wild-capture fisheries discards were the main contributors to this, responsible for 39.1 percent and 35.4 percent of aquatic food loss and waste (FLW), respectively (World Economic Forum, 2024). These figures are likely conservative, as they exclude waste from at-sea processing, aquaculture, and small-scale fisheries due to limited data.

Aquatic FLW distribution varies across regions. Asia leads with 37 percent of total edible loss, followed by Europe (31.81 percent), North America (12.37 percent), Africa (10.41 percent), South America (6.46 percent), and Oceania (1.95 percent) (World Economic Forum, 2024). Despite these challenges, the use of by-products traditionally discarded as waste has increased. In 2022, by-products accounted for 34 percent of fishmeal and 53 percent of fish oil production (FAO, 2024b). Addressing FLW is important for achieving Sustainable Development Goal 12.3, which aims to halve per capita global food waste by 2030 and reduce losses along production and supply chains (United Nations, 2015). An estimated 62 percent of fish processing workers are women (FAO, 2024b), tying progress on SDG 12.3 closely to progress on SDG 5: Gender Equality. Enhancing circularity in aquatic food systems through the better use of by-products and waste reduction therefore supports broader global sustainable development.

23.8
million tonnes

of edible aquatic food were lost in 2021, representing 14.8 percent of the world total production.

Concrete measures

- Support existing processing practices and supply chains where these enable access to nutritious and culturally appropriate foods at low cost, such as drying and fermentation in inland fisheries.
- Invest in cold-chain infrastructure, including refrigeration and transportation technologies, to minimize spoilage and loss of blue foods. This includes portside storage, solar-powered ice makers, and coolers to improve product quality and reduce waste.
- Ensure policy interventions promote equal access to technologies, markets, and skills, especially for women and other marginalized value chain actors.
- Upgrade public infrastructure that supports blue food supply chains, such as reliable renewable energy, water supply systems, fish landing sites, post-harvest handling and processing facilities, food storage systems, and wholesale and retail market facilities.
- Promote the conversion of aquatic food by-products into value-added products such as fish powder, dietary supplements, cosmetics, fertilizers, and other applications.
- Grow markets for shelf-stable canned and dried products that can be stored without refrigeration and, depending on species, may be available to consumers at low cost.
- Facilitate the recovery and redistribution of surplus or unsold blue foods to food banks and charities, ensuring food safety and nutritional standards are met.
- Strengthen data collection systems, particularly for small-scale operations, and encourage interdisciplinary collaboration to support evidence-based decision-making on FLW.
- Promote and implement the Voluntary Code of Conduct for Food Loss and Waste Reduction to guide effective strategies in reducing FLW (FAO, 2022b).

Usipa fish, a small pelagic species harvested in large volumes for food and bait, dry on racks on the banks of Lake Malawi.

Image credit: Alex Bramwell/Alamy Stock Photo

Example targets

- [Party] will measure the total amount of waste generated and total amount diverted across the blue food supply chain annually, aiming for an X percent reduction in waste and an X percent diversion rate by [Year].
- [Party] will monitor the percentage of total catch discarded at sea, aiming to reduce discard levels by X percent by [Year].
- [Party] will invest $X in public infrastructure improvements – such as renewable energy installations; port, road, and market facilities upgrades; and technology enhancements – with a target of X new projects by [Year].
- [Party] will invest $X annually to support small-scale fishers and farmers adopting more sustainable practices.
- [Party] will measure the adoption of advanced processing techniques, such as efficient drying methods, with a target of adoption in X percent of processing facilities by [Year].

Co-benefits and trade-offs

Reducing FLW and enhancing circularity in blue food supply chains offers both mitigation and adaptation benefits. Improving preservation and processing techniques helps buffer against environmental conditions and climate-induced production losses while promoting more equitable livelihoods, especially for small-scale producers and women fish processors. Effective preservation techniques extend the shelf life of aquatic foods, sometimes increasing their nutritional value. Reducing waste also lowers operational costs for producers, improving sustainability and profitability, while converting by-products into valuable products such as fish powder or fertilizers creates additional revenue streams and supports industry growth. Efficient resource use helps build a more stable supply of aquatic food and makes supply chains more resilient to disruptions caused by market fluctuations or environmental events.

Reducing FLW in capture fisheries can involve complex trade-offs, such as balancing bycatch reduction with economic viability. While many interventions have focused on small-scale operations, these may not fully address the complexities of large-scale production. On-vessel processing, for instance, requires balancing between reducing losses and maximizing the value of high-quality parts of catch. Advanced waste reduction measures can be expensive, particularly for smaller businesses, and technologies used for by-product conversion can be energy-intensive or environmentally damaging. Some preservation techniques may also increase energy use or packaging, or compromise food safety, highlighting the need to balance between effective preservation and environmental and safety standards. There is also a risk that interventions to modernize processing methods could displace traditional practices, which may be culturally significant and tied to community livelihoods, particularly for women.

Examples in practice

Enhancing Circularity In Blue Food Supply Chains | Barbados

In Barbados, fish filleting produces by-products such as heads, guts, bones, and skin, which account for up to 70 percent of the fish's weight. These are being transformed into valuable products such as fish silage – fermented fish by-products – for animal feed and fertilizers. Thanks to awareness-raising and capacity-building initiatives, a national fish silage community has been created, and the 2022-2030 Fisheries Policy now incorporates fish waste utilization. The potential for fish silage has attracted private investment, and there is considerable interest from fisherwomen and young farmers to produce fish silage. Related to these efforts, FAO provides the women-led Central Fish Processors Association with equipment and training to engage with this new fish silage community (adopted from FAO, 2024b).

Sustainable Management of usipa | Malawi

The Malawi Department of Fisheries has developed a management plan for usipa, a small pelagic fish species harvested in large volumes from Lake Malawi. This plan recognizes usipa's importance to Malawi's food and nutrition security and prioritizes sustainable resource management as well as research on post-harvest dynamics to reduce loss and improve handling and storage. Innovations such as improved processing methods, the introduction of solar dryers, and increased access to basic education have the potential to reduce post-harvest quantity and quality losses by 54 percent (Torell et al., 2020; Nagoli et al., 2017). The plan is supported by Malawi's National Agriculture Investment Plan, aligning fisheries policy with broader food systems goals, including climate change, gender, food safety, and strategic investment (Tigchelaar et al., 2022).

Policy option 2

Reduce emissions from energy use and operations such as storage, processing, and transport of blue foods

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Local to national	All major aquatic food producers, processors, and exporters

Energy is essential for storage, processing, and transportation, especially given the highly perishable nature of fish. At the processing stage, energy is required for canning, drying, and smoking, often relying on fossil fuels as the main source of energy (Puri et al., 2023). The challenge therefore is to improve energy access while reducing GHG emissions. A main consideration is that emissions estimates often focus on blue food production, overlooking the considerable climate impact of post-harvest activities. Transport emissions, particularly for fresh products, can be as high or higher than those from production. For instance, transport by ship, rail, or road increased the climate impact of maricultured seaweed in Tamil Nadu, India, by 14 percent, 51 percent, and 139 percent, respectively, compared with the product's emissions footprint before leaving the farm (Ghosh et al., 2015). Air transport, commonly used for high-value products such as tuna and salmon, produces three to five times the emissions of road freight and 31 times more than sea freight, posing a growing challenge as global seafood markets expand (Buchspies et al., 2011; Max et al., 2020). To reduce these emissions, it is important to transition to renewable energy sources, shorten supply chains, and promote more sustainable modes of transportation. Localizing processing and developing regional markets can reduce transportation-related emissions, countering the recent trend of distant processing and re-exporting (Asche et al., 2022). Together, these approaches will be essential for minimizing emissions and building more sustainable post-harvest systems.

Concrete measures

- Create incentives for investment in renewable energy–powered equipment, for instance by offering targeted subsidies and facilitating access to commercial financing for decentralized solar energy and similar infrastructure.
- Conduct demonstration projects to showcase renewable energy technologies among small-scale processors and raise awareness of their benefits and challenges.
- Promote the electrification of vessels and transport vehicles with tax breaks and subsidies for electric or hybrid models to reduce fossil fuel dependency.
- Establish and enforce energy efficiency standards for blue food facilities and equipment, including refrigeration, processing machinery, and transport vehicles.
- Invest in domestic processing to lower emissions from transporting seafood for processing abroad, including grants or low-interest loans for local hubs and domestic processing plants near production sites.
- Develop regional trade agreements for nearby countries to exchange blue foods that are typically air-freighted and support local distribution channels to meet regional demand.

Example targets

- [Party] will target X percent of blue food storage, processing, and transport operations to be powered by renewable energy sources by [Year].
- [Party] will ensure that X percent of transport vehicles and vessels in the blue food supply chain are electric or hybrid by [Year].
- [Party] will implement mandatory energy efficiency standards for X percent of new blue food facilities and equipment by [Year], with an aim to achieve an X percent improvement in energy efficiency across the blue food sector by [Year].
- [Party] will aim to train X fish processors in energy-efficient fish processing techniques and equip X fish processing units with energy-efficient technologies by [Year].
- [Party] will aim to invest $X in domestic processing, such as local hubs and domestic processing plants, by [Year].

A fishing boat idles alongside the dock at Los Cristianos Seaport in Tenerife, Spain. Ports can lead sustainability efforts like renewable energy development.

Image credit: iStock.com/Felipe Rodriguez

Co-benefits and trade-offs

The primary benefit of this policy option is mitigation, but reducing emissions from energy use and operations can also benefit adaptation by increasing resilience to shocks. Lower reliance on fossil fuels decreases operational costs for producers, processors, and distributors, improving their profitability and financial resilience. Investment in renewable energy technologies can stimulate job creation, especially in the installation, maintenance, and operation of these systems. Locally produced and processed aquatic foods also build more resilient supply chains, reducing vulnerability to energy price fluctuations and global market shocks, and enhancing food security in regions dependent on distant suppliers. Efficient energy management systems can further reduce food loss, contamination, and spoilage, leading to more reliable food availability and improved nutrition security.

While there are emissions benefits, there are also trade-offs to consider with a shift to renewable energy in aquatic food supply chains. Transitioning vessels and vehicles to electric or hybrid models requires significant investments in charging infrastructure and long-term maintenance, which could place financial strain on small-scale operators or developing countries. Small-scale operators may need subsidies or financial support to make these transitions viable, further complicating the implementation of large-scale renewable energy adoption.

Examples in practice

FAO Blue Ports Initiative | Argentina, Cabo Verde, China, Colombia, Ecuador, Indonesia, India, Kenya, Korea, Mauritius, Morocco, Mozambique, Namibia, Peru, Philippines, Spain, Thailand, Viet Nam

The FAO Blue Ports Initiative is an example of how blue fishing ports can serve as hubs for sustainable development at local, national, and regional levels. This initiative focuses on integrating environmental, social, and economic dimensions into port operations, aiming to enhance sustainability across these areas. This includes a working group dedicated to promoting renewable energy and developing projects centered around blue energy. Capacity-building activities have been conducted on topics such as decarbonization and blue energy. Through sustainable principles, the initiative supports the transition to greener energy solutions and fosters broader environmental and socioeconomic benefits in coastal regions.

The FAO-Thiaroye Processing Technique (FTT) | Senegal

The FAO-Thiaroye Processing Technique (FTT) is an innovative approach for fish smoking and drying, designed to enhance both food safety and sustainability in small-scale fisheries. Developed in response to international food safety concerns about polycyclic aromatic hydrocarbons in traditionally smoked fish, the FTT significantly reduces polycyclic aromatic hydrocarbon levels while improving energy efficiency. Its dual smoking and drying system has been adopted in 16 countries, benefiting small-scale fish processors, particularly women, by improving their livelihoods. For successful integration of FTT into national strategies, policymakers should establish supportive policy and regulatory frameworks that promote safe food production and aligns with international standards.

Tools and resources

FAO Food Loss and Waste in Fish Value Chains: A repository with resources and other information about FAO's efforts to reduce food loss and waste in fish value chains.

FAO Small-Scale Fisheries and Energy Nexus: A publication introducing the current situation and proposing a way forward with regard to the use of renewable energy in small-scale fisheries. It provides general guidance for decision-makers and development specialists on the choices, benefits and challenges related to renewable energy use and uptake in small-scale fisheries.

FAO Voluntary Code of Conduct for Food Loss and Waste Reduction: A generic framework of actions and guiding principles to reduce FLW, while supporting the transformation of agrifood systems to be more efficient, more inclusive, more resilient, and more sustainable.

Food Loss and Waste Protocol: An accounting and reporting standard that enables companies, countries, cities, and others to quantify and report on food loss and waste so they can develop targeted reduction strategies and realize the benefits from tackling this inefficiency.

World Economic Forum Investigating Global Aquatic Food Loss and Waste: Updated estimates of global aquatic FLW across different nodes of the value chain, offering a comprehensive breakdown across species groups, product types, and continents. The report also outlines targeted calls to action for distinct stakeholder groups including policymakers, industry, and civil society.

Image credit: Hien Phung/Stock.adobe.com

Consumption and diets

Global consumption of aquatic animal foods reached an estimated 165 million tonnes in 2022, with an annual growth rate nearly double that of the world population since 1961. Per capita consumption has risen significantly over this period, from 9.1 kg in 1961 to 20.7 kg in 2022, with projections of 21.3 kg by 2032. This is driven by rising incomes, urbanization, improved post-harvest practices, and dietary trends. However, in Africa – particularly sub-Saharan Africa – per capita consumption is expected to decrease amidst rapid population growth, which is alarming given the region's reliance on blue foods for essential protein and nutrients (FAO, 2024b).

Blue foods are rich in key nutrients such as vitamin B12 and omega-3 fatty acids and can help address micronutrient deficiencies, especially for vulnerable groups such as children, pregnant women, and the elderly. If aquatic foods replace consumption of less healthy red and processed meats – or avert the transition to diets that contain large quantities of such foods – they can also help reduce the incidence of noncommunicable diseases such as heart disease and cancer (Golden et al., 2021). Many aquatic foods, such as farmed bivalves, also offer high nutritional benefits with a relatively low environmental footprint. For instance, oyster and mussel production have low GHG emissions and also require limited freshwater and land resources while providing 76 times more vitamin B12 and five times more iron than chicken (Gephart et al., 2021). Shifting to lower-impact species therefore presents a key opportunity to align both nutrition and environmental goals.

Policymakers can support measures related to consumption and diets. First, integrating sustainable, low-carbon blue foods into food procurement, planning, and assistance programs can help improve public health and promote environmental sustainability. Second, supporting consumers in shifting toward sustainably produced, low-footprint blue foods can align nutritional benefits with lower environmental impacts.

Blue foods are rich in key nutrients such as vitamin B12 and omega-3 fatty acids and can help address micronutrient deficiencies.

Image credit: Avel Chuklanov/Unsplash

Policy option 1

Integrate sustainable, low-carbon blue foods into food procurement, planning, and assistance programs

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	Local to national	All countries, particularly those with residents who have nutrient deficiencies such as vitamin B12 and omega-3, as well as countries with a high prevalence of cardiovascular disease[4]

This policy option presents an opportunity to enhance food and nutrition security through low-emission development. Integrating sustainable blue foods into diets through public programs, such as school meals, infant feeding programs, and humanitarian aid, can significantly improve nutritional outcomes. For example, a 2021 modeling study estimated that an 8 percent increase in sustainable production of species consumed today could prevent 166 million micronutrient deficiencies by 2030 (Golden et al., 2021).

Integrating low-carbon blue food options into food programs can also reduce the carbon emissions associated with diets by replacing high-emission foods with more sustainable, low-emission alternatives. A 2023 study found that for 82 percent of countries dealing with high cardiovascular disease risk, promoting blue foods over red (particularly ruminant) meat overconsumption would simultaneously address health and environmental concerns (Crona et al., 2023).

Governments can contribute to both public health and environmental sustainability by prioritizing locally produced small pelagic fish and non-fed/low-input farmed species in food procurement, food system planning and guidelines, and food assistance programs (Gephart et al., 2021; FAO, 2024b).

Concrete measures

- Revise national dietary guidelines to include recommendations for the consumption of sustainable, nutrient-dense blue foods, highlighting their environmental and health benefits, especially for children, the elderly, and pregnant women.
- Incorporate sustainable, low-carbon blue foods in national food assistance programs, such as food banks, food purchase assistance programs, and school meals, to improve nutrition and support sustainable systems.
- Encourage schools to integrate local fish production and consumption into school meals, including underutilized small fish and fish powders made from by-products, to enhance local food security and livelihoods.
- Establish a national system to monitor and report on the integration of aquatic foods in procurement and assistance programs, ensuring transparency and accountability.
- Increase capacity for data collection and analysis on aquatic food consumption, nutrient composition, and environmental impacts to inform policy decisions and improve food systems.

Example targets

- [Party] will update national dietary guidelines by [Year] to include recommendations for the consumption of diverse, sustainable, low-carbon blue foods, including recommendations for children and pregnant women.
- [Party] will establish a target for public institutions such as hospitals, schools, and government facilities to source at least X percent of their seafood from sustainable, low-carbon blue food producers by [Year].
- [Party] will ensure that X percent of the animal-sourced protein provided through national food assistance programs, such as school meal programs or food banks, consists of sustainable, low-carbon blue foods by [Year].
- [Party] will establish a national monitoring and reporting system by [Year] to track integration progress, with annual public reports on key metrics and areas for improvement.

[4] *Crona et al., 2023, maps countries where nutrition and environment policy objectives for blue foods are relevant.* https://gedb.shinyapps.io/BFA_synthesis/

Fish like the nutritious Peruvian anchoveta shown here can augment local school feeding programs.

Image credit: Mark Bowler/Alamy Stock Photo

Co-benefits and trade-offs

The primary benefits of integrating sustainable aquatic foods into food procurement, planning, and assistance programs are mitigation and low-emission development, but some of the measures have adaptation co-benefits. Integrating blue foods into these programs can improve nutrition and health, and locally sourcing these foods can support local livelihoods and stimulate economic growth. Inclusive food assistance programs can reduce nutritional inequities for women and girls and can act as a social safety net against climate and economic shocks.

It is important, however, to ensure aquatic foods come from sustainably managed sources, because increased demand could place additional pressure on fish stocks. Food procurement and assistance programs would require consistent supply and quality of blue foods, and program implementation would need to address logistical challenges such as transportation and food safety. Some regions may have limited access to aquatic foods, making integration into procurement and meal programs more difficult. Sustainable blue foods may also be more expensive than other protein sources, potentially straining the budgets of food assistance programs, particularly in low-income areas. Cultural preferences for food should also be considered when introducing diverse or unfamiliar blue food options.

Examples in practice

Fish In Home-Grown School Feeding Programs | Angola, Honduras, Peru

The governments of Angola, Honduras, and Peru, in collaboration with FAO, have developed national strategies to diversify school feeding programs by incorporating fish products. These strategies aim to improve the nutritional quality of meals provided to schoolchildren through "home-grown" school feeding programs. By combining school feeding programs with the procurement of nutritious and locally produced foods, these programs support both the health of students and the livelihoods of local fishers and food producers. This approach diversifies school meals and also promotes sustainable and low-carbon blue foods.

Reducing Food Waste and Supporting Food Banks | United States of America

SeaShare, a nationwide nonprofit, helps to divert waste in the blue food sector by directing donated fish harvested in the North Pacific to food banks across the United States. Through partnerships with major seafood companies in the Pacific Northwest and the nation's largest food bank network, Feeding America, SeaShare ensures that high-quality seafood reaches communities in need. This initiative and company donations are enabled by federal tax incentives (Koehn et al., 2020).

Policy option 2

Help consumers shift to sustainably produced, low-footprint blue foods

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation	National to international	Countries with high demand for healthy and sustainable food options

The high diversity of aquatic foods – including finfish, shellfish, and seaweeds – means they vary in their impacts on climate and biodiversity and their potential for providing nutritional value. However, these sustainability and nutrition dimensions are often not transparent to consumers and supply chain actors. Increasing consumer awareness of sustainable blue food options can support both sustainable practices and local production. By raising awareness of locally available and sustainable species and their carbon footprint, demand can shift toward more sustainable and low-carbon options. This sends a positive signal to producers and encourages upstream actors to prioritize sourcing from local, sustainable, low-carbon producers and systems.

Concrete measures

- Launch national campaigns to raise public awareness about the nutritional, sustainability, and climate benefits of blue foods, with a focus on promoting more sustainable and/or underutilized low-carbon species to expand consumer choices.
- Integrate aquatic foods and their nutritional and environmental benefits into school curricula to educate students from an early age.
- Implement certification, labeling, rating, and other programs to guide consumers toward sustainable, low-carbon blue food options, boosting market demand.
- Invest in technical infrastructure and promote international cooperation for traceability systems that allow consumers to track the origin, carbon footprint, and sustainability of blue foods.
- Invest in and promote the use of digital tracking tools and platforms that provide consumers with real-time information on the origin, carbon footprint, and sustainability of aquatic foods.

Example targets

- [Party] will reach X percent of national population with blue food awareness campaigns that particularly emphasize diverse blue food species by [Year], increasing recognition of sustainable and locally available blue food options by X percent.
- [Party] will allocate $X by [Year] to develop and implement digital tracking tools and other technological infrastructure for blue food traceability.

Mackerel caught in the Eastern English Channel received a certification from the Marine Stewardship Council

Image credit: Nick Hanna/Alamy Stock Photo

A fisherman casts his bait net on Mismaloya Bay in Mexico. The Mexican Council for the Promotion of Fisheries and Aquaculture Products promotes the consumption of locally sourced, sustainable seafood in Mexico.

Image credit: InStock/ iStock.com

Co-benefits and trade-offs

Increasing consumer awareness of blue foods primarily offers mitigation benefits. Promoting greater blue food diversity to consumers can help shift demand. If awareness programs emphasize sustainability, they can incentivize producers to adopt more sustainable practices. This shift can open new markets, supporting the livelihoods of fishers and farmers. Increased collaboration on sustainability policies and initiatives can emerge, driving broader industry improvements. Greater transparency and traceability in supply chains can also benefit other sustainability dimensions, such as fair labor practices and ethical sourcing.

However, there is a risk of "greenwashing," where unsustainable products are marketed as sustainable options, misleading consumers and undermining genuine efforts. Meeting certification and export requirements may increase costs and operational burdens for producers, especially small-scale operators, limiting their ability to compete. Promoting premium sustainable products also raises concerns about market access and affordability, potentially excluding lower-income consumers from benefiting from aquatic food options.

Examples in practice

Taste the Ocean | European Union

"Taste the Ocean" is a European Union campaign launched in 2021 to encourage consumers to buy, cook, and enjoy sustainable fish and seafood. In collaboration with 27 "Sustainable Seafood Ambassador" chefs, the campaign shares recipes using sustainable seafood options as well as resources about seafood sustainability. These include information about seasonality, less consumed species, and seafood labeling.

The Mexican Council for the Promotion of Fisheries and Aquaculture Products (COMEPESCA) | Mexico

COMEPESCA is a civil association established in 2003, comprising entrepreneurs from Mexico's fishing and aquaculture industry. COMEPESCA's mission is to promote the consumption of Mexican aquatic foods through targeted campaigns that highlight the health benefits of seafood and the importance of sustainable fishing and aquaculture practices. COMEPESCA aims to strengthen the market for locally sourced, sustainable seafood in Mexico, benefiting both consumers and the environment.

Tools and resources

Aquaculture Stewardship Council (ASC) and **Marine Stewardship Council (MSC):** Certification programs with science-based standards for sustainable and responsible seafood. The MSC's focus is sustainable capture of wild seafood, and the ASC sets standards for responsible aquaculture.

Monterey Bay Aquarium Seafood Watch: A program of the Monterey Bay Aquarium that empowers consumers and businesses to make choices for healthy oceans, helping support diverse marine ecosystems for the future. Using science-based peer review methods, Seafood Watch assesses how fisheries and farmed seafood impact the environment and provides ratings indicating which items are best choices, certified, good alternatives, or best to avoid.

FAO Public Food Procurement for Sustainable Food Systems and Healthy Diets: Evidence on how public food procurement can be used as a development tool and can deliver multiple benefits for multiple beneficiaries.

School Meals and Food Systems: Rethinking the Consequences for Climate, Environment, Biodiversity, and Food Sovereignty: White paper prepared by the Research Consortium for School Health and Nutrition, an initiative of the School Meals Coalition, a multilateral coalition of more than 95 countries aiming to improve and expand national school meal programs for all children. The white paper explains how implementing planet-friendly school meal programs, including with aquatic foods, can provide far reaching co-benefits for public health and human capital.

UN Nutrition The Role of Aquatic Foods in Sustainable Healthy Diets: Evidence to inform and steer policy, investments, and research to leverage the vast potential of aquatic foods in delivering sustainable healthy diets and in meeting the U.N. Sustainable Development Goals.

Image credit: Songkhla Studio/Stock.adobe.com

Blue foods and coastal blue carbon habitats

Blue carbon ecosystems, including mangroves, salt marshes, and seagrasses, are important carbon sinks that collectively store more than 30,000 teragrams of carbon (TgC) across approximately 185 million hectares. They play a vital role in climate mitigation by preventing up to 304 TgCO2e of potential emissions annually (Macreadie et al., 2021). Restoration of degraded blue carbon habitats offers significant potential for carbon sequestration. Large-scale restoration efforts by 2030 could store an additional 841 TgCO2e annually, equivalent to roughly 3 percent of global emissions (Macreadie et al., 2021).

Beyond carbon storage, blue carbon measures are multifunctional. Mangroves, seagrasses, and tidal marshes act as fish nursery habitats, offering protection for juvenile aquatic species and constituting feeding grounds for adults (Siikamäki et al., 2013). These ecosystems also offer ecosystem services, such as storm surge and flooding protection, nutrient cycling, pollution buffering, and biodiversity conservation, while supporting coastal communities through cultural and recreational uses (Vierros, 2017). In inland areas, peatlands and flooded forests serve as important links between forests, water, and fish. However, unsustainable fisheries and aquaculture practices can harm blue carbon ecosystems, underscoring the importance of sustainable management to protect these habitats and, in turn, blue food production.

Overall, countries can harness blue food and coastal blue carbon measures that provide benefits beyond carbon sequestration and storage. First, reducing the impact of aquaculture and fisheries on blue carbon habitats can reduce blue food emissions while protecting fish nurseries and ecosystem services. Second, implementing blue carbon habitat management and restoration for carbon storage and climate adaptation can support climate mitigation, biodiversity, and coastal communities.

A shoal of small baitfish take shelter in the mangrove roots off Bimini, Bahamas.
Mangroves are a type of coastal blue carbon ecosystem, along with seagrasses and wetlands.

Image credit: Matt Potenski/iStock.com

Policy option 1

Reduce impact of aquaculture and fisheries on blue carbon habitats

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation and adaptation	Subnational to national	Countries with mangroves, salt marsh, and/or seagrass ecosystems

Certain fisheries and aquaculture practices can harm blue carbon habitats. Destructive fishing practices such as bottom trawling or anchor damage can release large amounts of carbon into the atmosphere, worsening global warming (O'Connor et al., 2020). When mangroves are cleared, for example to create shrimp ponds, up to 92 percent of their original carbon stocks can be released (Cifuentes-Jara et al., 2015; Kauffman et al., 2020). The rapid expansion of shrimp farming in the 1980s and 1990s led to the loss of about 1.89 million hectares of mangroves globally, with additional damage from effluent discharges from intensive farms (Valiela et al., 2001; Ahmed et al., 2017). To address this, integrated approaches to shrimp farming have been promoted that develop farms within mangrove habitats to protect their critical ecological function, along with their roles as carbon sinks and buffers against climate hazards. While the ponds likely reduce full functioning due to habitat fragmentation, they are preferred to complete mangrove deforestation (Jonell and Henriksson, 2015).

Addressing the impacts of aquatic food production on blue carbon habitats can help preserve these ecosystems and their role in combating climate change. Strategies that combine coastal ecosystem management with more sustainable fisheries and aquaculture practices can foster greater ecosystem and food system resilience.

Concrete measures

- Enforce sustainable fishing practices, such as selective gear, seasonal closures, catch quotas, and no-take zones, that minimize habitat destruction and bycatch.
- Implement zoning regulations to ensure aquaculture sites are located away from sensitive blue carbon habitats and follow best environmental practices.
- Establish monitoring programs to detect and manage in blue carbon habitats invasive species that can be introduced through aquaculture.
- Implement measures such as buffer zones and better waste management processes to reduce nutrient pollution from aquaculture and land-based activities.
- Ban or mitigate impacts of bottom trawling in sensitive benthic habitats that store carbon.

Example targets

- [Party] will implement zoning regulations for aquaculture production by [Year], with periodic reviews and updates every X years to adapt to climate change impacts.
- [Party] will achieve an X percent reduction in habitat destruction by [Year] through the mandatory use of selective gear types, implementation of seasonal closures, adoption of catch quotas, and establishment of no-take zones covering at least X percent of national marine areas.
- [Party] will ban trawling in X percent of identified sensitive blue carbon habitats by [Year], with a complete phase-out in all other areas by [Year], supported by monitoring and enforcement mechanisms.
- [Party] will establish invasive species monitoring programs in X percent of blue carbon ecosystems by [Year], aiming to reduce the presence of invasive species by X percent by [Year].

Mangrove restoration efforts include planting mangrove seedlings in shallow water to serve as fish nursery habitats.

Image credit: Fokasu Art/Stock.adobe.com

An aerial view reveals coastal shrimp farms in Giao Thuy, Namdinh, Vietnam.

Image credit: hcongthanh/iStock.com

Co-benefits and trade-offs

Reducing the impact of aquaculture and fisheries on blue carbon habitats can be a mitigation strategy to strengthen carbon sinks as well as an adaptation strategy for ecosystem resilience. This includes reducing coastal erosion, storm surge, and coastal flooding; enhancing water quality; and providing habitat for commercially and locally important species. More resilient blue carbon habitats can also support biodiversity and strengthen coastal fish production.

Implementing measures to reduce impacts of blue food production on blue carbon habitats may involve trade-offs related to productivity and income, particularly for communities dependent on fisheries and aquaculture resources. Restricting activities in blue carbon habitats may shift fishing efforts to other areas, potentially leading to overfishing or habitat degradation elsewhere. The adoption of certain fishing-gear technologies that are less harmful to blue carbon habitats may also be more energy-intensive, creating a climate-biodiversity trade-off.

Examples in practice

Mangroves and Markets Project | Viet Nam

This project developed a sustainable shrimp aquaculture sector in Viet Nam that simultaneously protects and enhances mangrove forests. By training 5,500 farmers in organic shrimp farming practices and achieving organic certifications for 3,200 farms, the project has increased farmer incomes while protecting 12,600 hectares of mangroves and replanting an additional 80 hectares. These efforts have led to reduced GHG emissions and improved coastal protection from impacts of climate change and have established a financially viable model for sustainable shrimp farming, demonstrating the benefits of integrating environmental conservation with aquaculture practices.

Building with Nature Indonesia Consortium | Indonesia

This consortium addresses coastal erosion and aquaculture sustainability by implementing Associated Mangrove Aquaculture systems in Demak, Central Java. These innovative systems combine mangrove restoration with aquaculture, boosting local incomes and productivity while enhancing coastal resilience. The program trained 277 farmers in sustainable aquaculture practices, resulting in tripled shrimp yields and improved economic returns. Financial support enabled farmers to convert their ponds, leading to active community engagement in mangrove recovery and protection.

Policy option 2

Implement blue carbon habitat management and restoration for carbon storage and adaptation

Overview

Primary benefit	Spatial scale	Applicable countries/regions
Mitigation and adaptation	Subnational to national	Countries with large current or historical blue carbon habitats and coral reef ecosystems

Blue carbon habitats are highly effective at sequestering and storing carbon, capturing CO2 in their biomass and carbon-rich soils. At the same time, blue carbon and other coastal ecosystems are essential nursery habitats for fish and shellfish species, contributing to the productivity and resilience of marine food systems. In addition to mangroves, salt marshes, and seagrasses, coral reefs are important habitats that facilitate the carbon function of linked coastal systems. However, these habitats are among the most threatened ecosystems on Earth. An estimated 340,000 to 980,000 hectares of blue carbon habitats are lost annually. Over the past 50 years, up to 50 percent of mangroves, 50 percent of tidal marshes, and 30 percent of seagrass meadows have been lost globally (International Partnership for Blue Carbon, 2020). Between 2009 and 2018 there was a progressive loss of about 14 percent of the coral from the world's coral reefs primarily from recurring, large-scale bleaching events (Souter et al., eds., 2021). These losses have implications for both climate regulation as well as the health of blue food systems that rely on these habitats for fish nursery functions and ecosystem services.

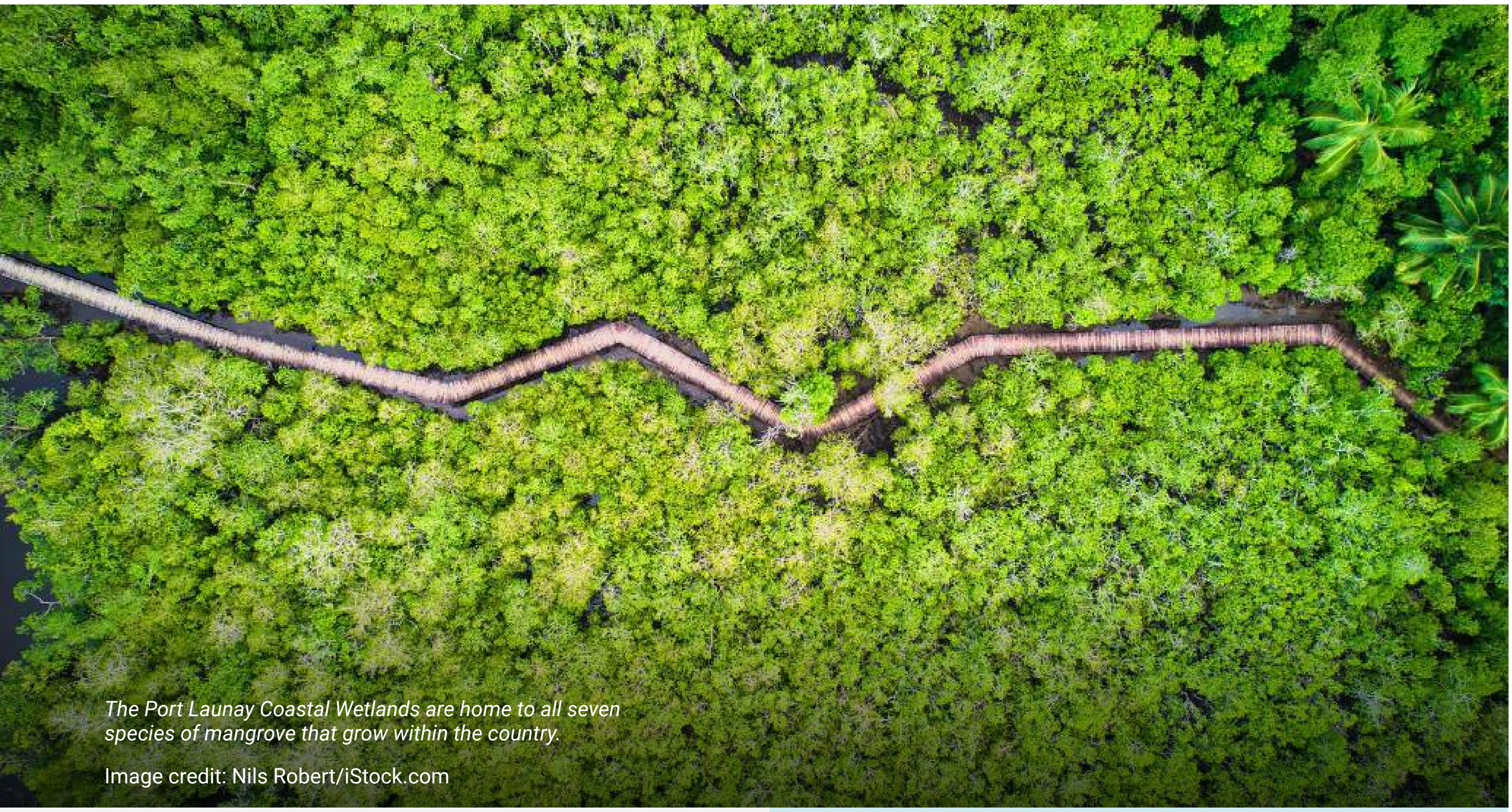
Despite these challenges, there are opportunities to better integrate blue foods into blue carbon planning. Effective management, protection, and restoration of blue carbon habitats can help mitigate climate change, enhance biodiversity, and strengthen community resilience. Including blue food management strategies in blue carbon planning can optimize these benefits, ensuring that efforts to mitigate climate change are aligned with those that support sustainable and resilient aquatic food systems.

Concrete measures

- Establish comprehensive management plans for blue carbon habitats in blue food strategies, incorporating adaptive management principles and community input.
- Invest in research and long-term monitoring programs to evaluate the health of coastal ecosystems, carbon storage and sequestration potential, and ability of ecosystems to reduce the impacts of cyclones, storm surges, and coastal flooding.
- Strengthen blue carbon accounting methodologies, including monitoring, verification, and reporting systems, that provide science-based information on the sequestration and release of blue carbon in mangrove, seagrass, and coastal wetland ecosystems and reflect them in national GHG inventories.
- Include blue carbon and other coastal habitats in broader climate change and adaptation plans, recognizing their role in buffering storm surges and coastal flooding.
- Develop plans and programs to restore previously removed or degraded coastal ecosystems.

Example targets

- [Party] will conserve existing coastal wetlands through the establishment of X hectares of marine protected areas by [Year] (adopted from Blue Carbon Initiative, 2023).
- [Party] will restore X hectares of previously removed or degraded mangrove forests by [Year], which is expected to generate X TgCO2e. in reduced and/or newly sequestered emissions (adopted from Blue Carbon Initiative, 2023).
- [Party] will formulate and implement a national blue carbon strategy by [Year], with specific goals to protect X percent of existing blue carbon habitats and restore X percent of degraded habitats by [Year].
- [Party] will allocate $X annually for research and long-term monitoring programs to assess blue carbon habitats, producing a comprehensive national blue carbon ecosystem carbon stock assessment by [Year].
- [Party] will incorporate blue carbon habitats into national and regional adaptation plans by [Year], aiming to protect $X of infrastructure by [Year].



The Port Launay Coastal Wetlands are home to all seven species of mangrove that grow within the country.

Image credit: Nils Robert/iStock.com

Co-benefits and trade-offs

Blue carbon habitats offer both mitigation and adaptation benefits. These include climate benefits, such as carbon sequestration and storage and protecting coastal areas from erosion, storm surges, and flooding. Beyond these benefits, the protection and restoration of blue carbon habitats can bolster fisheries, enhance food security, and improve coastal protection, all of which are essential for the livelihoods and well-being of coastal communities. These ecosystems also offer socioeconomic benefits, including reducing economic costs associated with flood and storm damage by acting as natural barriers. Healthy blue carbon habitats support healthy fish stocks and align with indicators for the Convention on Biological Diversity Framework, demonstrating synergies across multiple environmental and conservation goals.

Despite their benefits, measures to manage and restore blue carbon habitats may conflict with local livelihood activities, such as by restricting access to coastal areas for fishing or firewood collection. Effective management requires long-term monitoring and maintenance, which could impose a financial cost on coastal resource managers. Additionally, there is a need to avoid methodological errors in carbon credit programs, such as those encountered with REDD+ (Haya et al., 2023), to ensure that carbon accounting and reporting are accurate and reliable.

Examples in practice

Belize 2021 Updated NDC | Belize

In its 2021 updated NDC, Belize has committed to ambitious blue carbon habitat management and restoration goals, aiming to protect an additional 6,000 hectares of mangroves by 2025, with another 6,000 hectares under protection by 2030. This effort builds on the existing 12,827 hectares already protected. To achieve these targets, Belize is developing and implementing fisheries and mangrove conservation and management plans. By 2030, these initiatives to protect and restore mangrove and seagrass ecosystems are expected to remove a cumulative total of 381 KtCO2e. .

Seychelles 2021 Updated NDC | RSeychelles

In its 2021 updated NDC, Seychelles has set a target to protect at least 50 percent of its seagrass and mangrove ecosystems by 2025, with 100 percent protection of these ecosystems by 2030. To support this goal, the country plans to map the full extent of its blue carbon ecosystems and measure their carbon stock values. By 2025, Seychelles aims to establish a long-term monitoring program for these ecosystems and incorporate their GHG sink into the national GHG inventory. Additionally, Seychelles is developing and implementing sustainable, license-based fisheries management plans that integrate climate change adaptation, ensuring the sustainable use of resources to avoid overexploitation.

Tools and resources

Blue Carbon Initiative Blue Carbon and Nationally Determined Contributions: A guide on how countries may include blue carbon in their NDCs.

High-Quality Blue Carbon Principles and Guidance: A Triple-Benefit Investment for People, Nature, and Climate: Principles and guidance that have been developed to align stakeholders around a shared vision for high-quality blue carbon projects and credits.

IDDRI Integrating the Ocean into the Climate Regime: Progress Report and Future Prospects: Issue brief and supporting note that aim to assess the efforts made in recent years to integrate the ocean into the climate regime, and to identify ways of accelerating action.

International Partnership for Blue Carbon Coastal Blue Carbon: An Introduction for Policymakers: Report on some of the challenges and opportunities in developing policies and undertaking projects to protect and restore coastal blue carbon ecosystems. This report also highlights work already underway.

UNFCCC Ocean and Climate Change Dialogue 2023 Summary Report: A summary of the discussions that took place on two topics during the Ocean and Climate Change Dialogue 2023-2024: first, coastal ecosystem restoration, including blue carbon, and second, fisheries and food security.

Image credit: James White/Danita Delimont/Stock.adobe.com

Enabling policy measures to address cross-cutting challenges

Across intervention areas, policy measures are needed to ensure that climate actions are integrated rather than siloed. These measures can address multiple sectors and challenges simultaneously, leading to more effective and long-lasting outcomes. They may not be specific to climate change, but rather support measures to reduce emissions or enhance climate resilience. By addressing cross-cutting issues, countries can in a more structured way try and maximize the co-benefits of climate actions, reduce GHG emissions and impacts of climate change, and better align their NDCs with global frameworks such as the Sustainable Development Goals and the Global Biodiversity Framework.

Collaboration and inclusive approaches are key to ensuring that diverse perspectives and knowledge are integrated into NDC implementation, building a broad base of support for climate policies. In this section, we discuss four enabling measures: research and development; data collection, monitoring, and prediction systems; equitable access to financial services, knowledge, government support, and resources; and collaborative and inclusive management, planning, and decision-making. For each of these enabling measures, we provide specific examples related to the intervention areas previously discussed, illustrating how they can be applied to support comprehensive and effective climate action.

A fisherman cleans cod onboard his boat in the fishing village of La Poile, Canada.

Image credit: shaunl/iStock.com

Enabling measure 1

Research and development

Research and development (R&D) is needed to reduce the uncertainties and knowledge gaps associated with each of the intervention areas. Continued investment in R&D is essential to test the effectiveness of different policy measures and technological innovations in varying geographic and socioeconomic contexts. This can tailor climate solutions to local and regional needs, ensuring that interventions reduce GHG emissions while improving efficiency and sustainability. Beyond R&D on immediate climate solutions, research can also identify emerging challenges and potential risks. Countries can adapt more effectively by staying ahead of these challenges, reducing vulnerabilities in blue food systems.

Examples for intervention areas 1-5:

Intervention area	Example
1. Capture fisheries production	• Research fishing vessel GHG emissions reduction technologies and implementation. • Research social and equity outcomes for fisheries carbon management and adaptation measures. • Leverage remote sensing and AI to predict changes in fish populations and enhance stock assessments. • Develop adaptive management frameworks that incorporate new scientific knowledge as well as Indigenous and local knowledge into fisheries policies. • Evaluate how advancements in innovation, technology, and infrastructure to sustainably increase aquatic food production interact with efforts to promote equitable access to aquatic foods and identify governance tools to manage trade-offs. • Establish collaborative research networks that incorporate knowledge on the water.
2. Aquaculture production	• Invest in R&D to accelerate the development and dissemination of sustainable aquaculture technologies, such as sustainable feed ingredients, disease management tools, and effective breeding programs. • Develop cost-effective tools and methodologies for measuring CH4, N2O, and CO2 emissions from aquaculture ponds. • Research environmental outcomes of novel aquaculture systems. • Research the trade-offs to support managing conflicts in ocean spaces, for example spatial analysis of siting of aquaculture farms and exploring synergies between fisheries and aquaculture (Agostini et al., 2024).
3. Blue food supply chains	• Invest in research on blockchain and other digital technologies to enhance supply chain traceability. • Conduct research on the socioeconomic impacts of blue food supply chains, including livelihoods, gender equity, and labor rights. • Invest in R&D on energy-efficient cold chain technologies to reduce post-harvest losses and carbon footprints in blue food supply chains.
4. Consumption and diets	• Research the nutritional benefits of aquatic foods and their role in addressing malnutrition and diet-related diseases. • Support R&D on alternative aquatic food products that cater to diverse dietary needs and preferences. • Incorporate traditional knowledge and cultural practices into research on blue food consumption patterns. • Research how to shift consumer preferences toward diverse sustainable blue food options.
5. Blue foods and coastal blue carbon habitats	• Research and quantify blue carbon habitat storage potential to more effectively set targets for protection. • Develop models that predict the impacts of blue food production on carbon sequestration and ecosystem health. • Research the extent to which gender plays a role in managing blue carbon ecosystems.

Enabling measure 2

Develop and maintain robust data collection, monitoring, and prediction systems

Data collection, monitoring, and prediction systems provide accurate, often real-time, information to inform decision-making, allowing policymakers to create climate policies tailored to current and projected environmental and socioeconomic conditions. These data-driven approaches can help lower the costs of implementing interventions and improve their long-term success by reducing uncertainties. Transparent data collection and reporting systems can also foster public trust by demonstrating progress and accountability.

Monitoring, reporting, and verification (MRV) forms a basis for tracking progress against NDC targets and validating carbon credits. This helps countries unlock climate finance as well as demonstrate alignment with global climate goals under the Paris Agreement (World Bank Group, 2022). Consistent and comprehensive data collection across countries strengthens international cooperation, enabling collective progress toward shared climate objectives.

Examples for intervention areas 1-5:

Intervention area	Example
1. Capture fisheries production	• Establish early warning systems that enable sustainable management and risk reduction. • Develop and implement systems for real-time monitoring of GHG emissions from fishing vessels, including fuel consumption and operational efficiency. • Develop credible estimates for volumes of bycatch and illegal, unreported, and unregulated catch. • Provide technical assistance to support the adoption of low-cost monitoring technologies in small-scale fisheries. • Establish standardized data collection protocols for metrics such as fish stocks, catch sizes, fishing effort, and environmental conditions.
2. Aquaculture production	• Encourage integration of GHG accounting into farm management software to provide emissions and/or sequestration data. • Facilitate data sharing among aquaculture producers, researchers, and regulators to create comprehensive GHG inventories for the sector. • Develop life cycle assessment tools, standardized methodologies, and databases for comparison. • Establish early warning systems and biosecurity protocols for aquaculture farms.
3. Blue food supply chains	• Develop tools to track and report GHG emissions across the entire blue food supply chain, from harvesting to processing, transportation, and retail. • Implement monitoring systems to optimize cold chain operations, reducing energy use and associated GHG emissions. • Measure transport emissions from the aquatic food sector from production to plate and include this in GHG footprint estimates. • Collect sex-disaggregated data regarding supply chain actors, including roles, distribution of benefits, governance, and vulnerability to climate risks.
4. Consumption and diets	• Develop databases that combine nutritional information with environmental impact data, including GHG emissions and pollutants, to guide public health and sustainability policies. • Collect aquatic food consumption data that are disaggregated by species or species group.
5. Blue foods and coastal blue carbon habitats	• Develop monitoring systems to track the carbon sequestration potential of coastal blue carbon habitats. • Establish an MRV process for the quality and durability of carbon stored in blue carbon ecosystems. • Create predictive models to assess how different blue food production practices affect the health and carbon sequestration capacity of coastal ecosystems.

Enabling measure 3

Improve equitable access to financial services, knowledge, government support, and resources

Social inequality – including gender inequality – is one of the root causes of climate vulnerability. Previous studies found that for countries facing high climate risk to their blue food sectors, reducing societal vulnerabilities can lower climate risk by margins similar to meeting Paris Agreement mitigation targets (Tigchelaar et al., 2021). As part of this, improving equitable access to financial resources, knowledge, and government support builds resilience in blue food supply chains and helps communities adapt to climate change. When financial resources and knowledge are more accessible, fishers and farmers can more easily invest in sustainable practices, strengthen local economies, and reduce inequalities across the sector. Access to this support empowers businesses and communities to implement resilience-building measures, supporting long-term sustainability in the face of environmental challenges.

Examples for intervention areas 1-5:

Intervention area	Example
1. Capture fisheries production	• Support the development of social protection options such as insurance mechanisms, collective entities such as fisheries cooperatives, and tailored loans as climate resilience–enhancing measures. • Implement training programs that enhance financial literacy among fishers, enabling them to better manage loans, savings, and investments. • Implement measures to reduce bureaucratic barriers that often prevent small-scale fishers from accessing government resources. • Support learning networks/hubs or other venues for small-scale fishers to share knowledge and resources.
2. Aquaculture production	• Provide government-sponsored extension services that offer technical advice on sustainable aquaculture practices, disease management, and farm management. • Ensure that government support programs, such as grants or subsidies, prioritize the most climate-vulnerable farmers, adapted to their scale of operation, geographic location, and gender. • Support learning networks/hubs or other venues for farmers to share knowledge and resources and foster innovation.
3. Blue food supply chains	• Provide training for small-scale suppliers, processors, and retailers on best practices in supply chain management within the context of climate change, quality control, and value addition. • Develop gender-sensitive policies that promote equal access to technologies, markets, and other blue food benefits, especially for women and other marginalized value chain actors. • Invest in infrastructure that supports small-scale actors in blue food supply chains, such as cold storage, transport, and processing facilities.
4. Consumption and diets	• Develop policies that subsidize the cost of sustainably produced blue foods to make them more affordable for low-income consumers. • Promote the integration of blue foods into local food policies and urban planning to enhance food security and sustainability.
5. Blue foods and coastal blue carbon habitats	• Provide training and resources to local communities to strengthen their role in managing and protecting coastal ecosystems. • Ensure that coastal communities have equitable access to government programs aimed at habitat restoration, such as grants, technical assistance, and capacity-building initiatives.

Enabling measure 4

Ensure collaborative and inclusive management, planning, and decision-making

Collaborative and inclusive management, planning, and decision-making can help address complex challenges in aquatic food systems. Small-scale fisheries and aquaculture producers, Indigenous Peoples, and women have all been marginalized in dialogues about sustainable and equitable food system transformation, despite being central to it in many contexts (Bennett et al., 2021; Cohen et al., 2019). Inclusion of these actors in decision-making is essential to enable more adaptive governance mechanisms and policies that build on the strengths of the diversity of small-scale actors, acknowledge the cultural importance and specific roles of blue foods and steer food systems toward a more equitable distribution of blue food benefits. By incorporating diverse perspectives, including local and Indigenous knowledge, governments can develop more comprehensive and effective solutions tailored to specific geographic, cultural, and socioeconomic contexts. Such approaches also promote equity in climate actions and widespread community buy-in.

Examples for intervention areas 1-5:

Intervention area	Example
1. Capture fisheries production	• Promote the establishment of comanagement arrangements where fishers, local communities, and governments jointly manage fishery resources, ensuring local voices are heard. • Require the inclusion of marginalized groups, such as women and Indigenous Peoples, in fisheries management committees and decision-making processes. • Ensure more coherence and coordination of fisheries issues into broader strategies and processes, including National Biodiversity Strategies and Action Plans. • Ensure cross-sectoral planning, including related to inland fisheries and impacts of mitigation strategies on the entire fisheries sector.
2. Aquaculture production	• Engage local communities, including small-scale farmers, in the planning and zoning of aquaculture areas to balance environmental protection with production needs. • Establish research partnerships among aquaculture producers, local communities, and academic institutions to codevelop sustainable farming practices. • Support farmer cooperatives for resource sharing and joint environmental management.
3. Blue food supply chains	• Establish value chain governance structures that include representatives from all segments of the supply chain, from producers to retailers, ensuring fair representation, including of marginalized people of all genders. • Ensure that certification programs for sustainable blue foods are developed through inclusive processes that involve all stakeholders, particularly small-scale producers.
4. Consumption and diets	• Support community-led initiatives that promote the consumption of sustainable aquatic foods, ensuring that programs are culturally appropriate and locally driven. • Involve local leaders and community organizations in the planning and implementation of public health and nutrition programs related to blue foods.
5. Blue foods and coastal blue carbon habitats	• Promote the comanagement of coastal blue carbon habitats, involving local communities, marginalized people of all genders, Indigenous communities, governments, NGOs, and the private sector in decision-making processes. • Develop conflict resolution mechanisms in management decision-making that address disputes over resource use in coastal areas.

Additional resources

Climate adaptation and mitigation in fisheries and aquaculture

Strategy, guidelines, and guidance

- FAO Addressing Fisheries and Aquaculture in National Adaptation Plans: These guidelines provide practical steps and entry points for integrating fisheries and aquaculture into the formulation and implementation of NAPs. It aims to draw the attention of policymakers and government officers responsible for NAP planning and processes generally, as well as fisheries and aquaculture officers at country level, specifically.
- FAO Blue Transformation Roadmap 2022-2030: Blue Transformation is a critical part of the FAO Strategic Framework for 2022-2030 approved by its 194 Member States. It consists of three components (capture fisheries, aquaculture, and value chains) with respective measurable climate-resilient objectives.
- FAO Building Resilience to Climate Change and Disaster Risks for Small-Scale Fisheries Communities: This document provides guidance on the integration of human rights standards and laws into disaster risk reduction and climate action in small-scale fisheries.
- FAO Impacts of Climate Change on Fisheries and Aquaculture: The report provides a compilation of more than 90 adaptation options available in the aquatic food sector based on a literature review.
- FAO The Fisheries and Aquaculture Sector in National Adaptation Programmes of Action: Importance, Vulnerabilities and Priorities: The main purpose of this review is to support least-developed countries, development partners, and donors in planning and implementing climate change adaptation actions for the fisheries and aquaculture sector.
- IFAD Guidelines for Integrating Climate Change Adaptation into Fisheries and Aquaculture Projects: This study describes a range of multiple-benefit options for integrating climate change adaptation and mitigation into IFAD interventions in the fisheries and aquaculture sectors, based on a review of relevant literature on climate change, the fisheries and aquaculture sectors, and related activities of other international organizations.

Data and knowledge bases

- FAO Climate Change Adaptation in Fisheries and Aquaculture: Compilation of Initial Examples: This circular contains a selection of current and recent climate change adaptation activities and measures in the fisheries and aquaculture sector. These examples provide an overview of the types of adaptation activities and programs rather than a comprehensive review of adaptation activities addressing fisheries and/or aquaculture.
- FAO The Fisheries and Aquaculture Adaptation Finance Gap and UNEP Adaptation Gap Report 2023: The adaptation finance gap for fisheries and aquaculture is estimated at approximately USD 4.5 billion per year for developing countries.

Capacity building and training

- FAO Climate Change Adaptation and Mitigation in Fisheries and Aquaculture: This e-learning course provides an overview of adaptation and mitigation strategies that can be implemented in response to climate change impacts on the aquatic food sector.
- FAO Climate-Smart Fisheries and Aquaculture: This e-learning course has been designed to support the inclusion of climate-smart agriculture approaches in the fisheries and aquaculture sector. It provides technical knowledge on these concepts and examines how implementation of climate-smart agriculture practices can enhance mitigation and adaptation to climate change in the sector.


Image credit: Parilov/Stock.adobe.com

General climate mitigation and adaptation resources

Tools

- Climate Policy Radar Global Stocktake Explorer: This pilot tool allows users use AI tools to search through the text of all UNFCCC Global Stocktake documents.
- GAFF Untapped Opportunities for Climate Action: An Assessment of Food Systems in Nationally Determined Contributions: The Global Alliance for the Future of Food comprehensively assesses how 14 countries have incorporated food systems into their NDCs to date. It is designed as a toolkit for policymakers and other interested stakeholders, with assessments, country case studies, a framework, and a summary report.
- ICAT Knowledge Hub: The Knowledge Hub includes knowledge, lessons learned, and best practices that result from the work of ICAT partner countries, regional hubs, and implementing partners.
- NDC Partnership Climate Toolbox and Knowledge Portal: The Climate Toolbox database contains a catalog of useful guidance, frameworks, tools, and other resources related to NDC planning and implementation and is part of the online Knowledge Portal.
- WWF and Climate Focus Food Forward NDCs: A guidance tool to support the enhancement and implementation of NDC ambitions for agriculture and food systems transformation. It helps countries strengthen their NDCs by identifying policy measures and providing accessible information about their climate change mitigation, adaptation, and sustainable development benefits.

Strategy, guidelines, and guidance

- Climate Focus, EAT, UNEP, and WWF Enhancing NDCs for Food Systems: Recommendations for Decision-Makers: This tool seeks to provide guidance and recommendations for policymakers to increase ambition in NDCs, building upon the climate change mitigation and adaptation potential of a transition to sustainable food systems.
- COP28 Agriculture, Food and Climate National Action Toolkit: Under the COP28 Food Systems and Agriculture Agenda, the UAE Presidency convened a group of key partners supporting NDC and NAP planning and implementation. These partners consolidated existing experiences, lessons, and resources to accelerate ambitious climate action in food and agriculture systems for a global audience.
- FAO Climate-Related Development Finance to Agrifood Systems: This publication addresses the persistent knowledge gap related to climate finance to agrifood systems, providing data and information to support countries making informed decisions toward agrifood systems transformation. The analysis brings to light the evolution of climate finance in agrifood systems over the past two decades.
- NAP Global Network Building Resilience with Nature: Ecosystem-Based Adaptation in National Adaptation Plan Processes: This analysis highlights the extent of integration and identification of ecosystems and ecosystem-based adaptation (EbA) into NAPs, trends in how EbA was incorporated, and opportunities to strengthen the profile and quality of EbA.
- NDC Partnership Climate Action Enhancement Package: Lessons in Developing Implementation Ready NDCs:The NDC Partnership's Climate Action Enhancement Package was launched in 2019 to help countries enhance their NDCs and fast-track their implementation.
- NDC Partnership Global Call for NDCs 3.0 & LT-LEDS: The Global Call facilitates access to expertise and dedicated resources for countries to align, update, and enhance NDCs and Long-Term Low Emissions Development Strategies in line with the Paris Agreement.
- NDC Partnership NDC Investment Planning Guide and Checklist: This document provides step-by-step guidance for countries to develop and strengthen their climate commitments into actions through the preparation of climate investment plans based on current best practices collected by the NDC Partnership.
- UNDP and WRI NDC Enhancement: Opportunities in Agriculture: This tool helps countries think through the process of more ambitious inclusion of agriculture in enhanced NDCs. It presents the necessary foundation and then actions that have demonstrated technical potential to reduce emissions in the agricultural sector and increase global food production while emphasizing the need to tailor enhancement approaches to suit a country's unique set of circumstances.
- WRI and UNDP Enhancing NDCs by 2020: Resources for Strengthening National Climate Action: This report proposes an overarching framework that countries can use to think through the process of, and options for, updating their NDCs. This overarching guidance is supplemented by sector- and issue-specific guidance that provides additional insights.

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