Regenerative Aquatic Foods Roadmap

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Advancing Regenerative Aquatic Foods for Sustainable and Nutritious Food Systems

FOOD + PLANET

CGIAR

gain
Global Alliance for Improved Nutrition

The Rockefeller Foundation
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01
Introduction

Background and Justification of Convening

The pressure to produce more food of higher nutritional value in a sustainable fashion is mounting (Webb et al. 2020). Poor quality diets are a leading public health risk factor (Afshin et al. 2019), and more than two billion people suffer from vitamin and mineral deficiencies (Stevens et al. 2022). Our current food production system results in one-third of all greenhouse gas emissions (Crippa et al, 2021), 70% of freshwater use, and is the primary driver of biodiversity loss (Daskalova, 2020; FAO, 2019). Therefore it is critical to develop and implement strategies for sustainable food production that provide high quality diets that meet essential nutrient needs and health recommendations, yet regenerates rather than degrades the planet's ecosystems and natural resources. Diverse Regenerative Aquatic Foods (RAF) present an opportunity to promote sustainable and nutritious food systems.

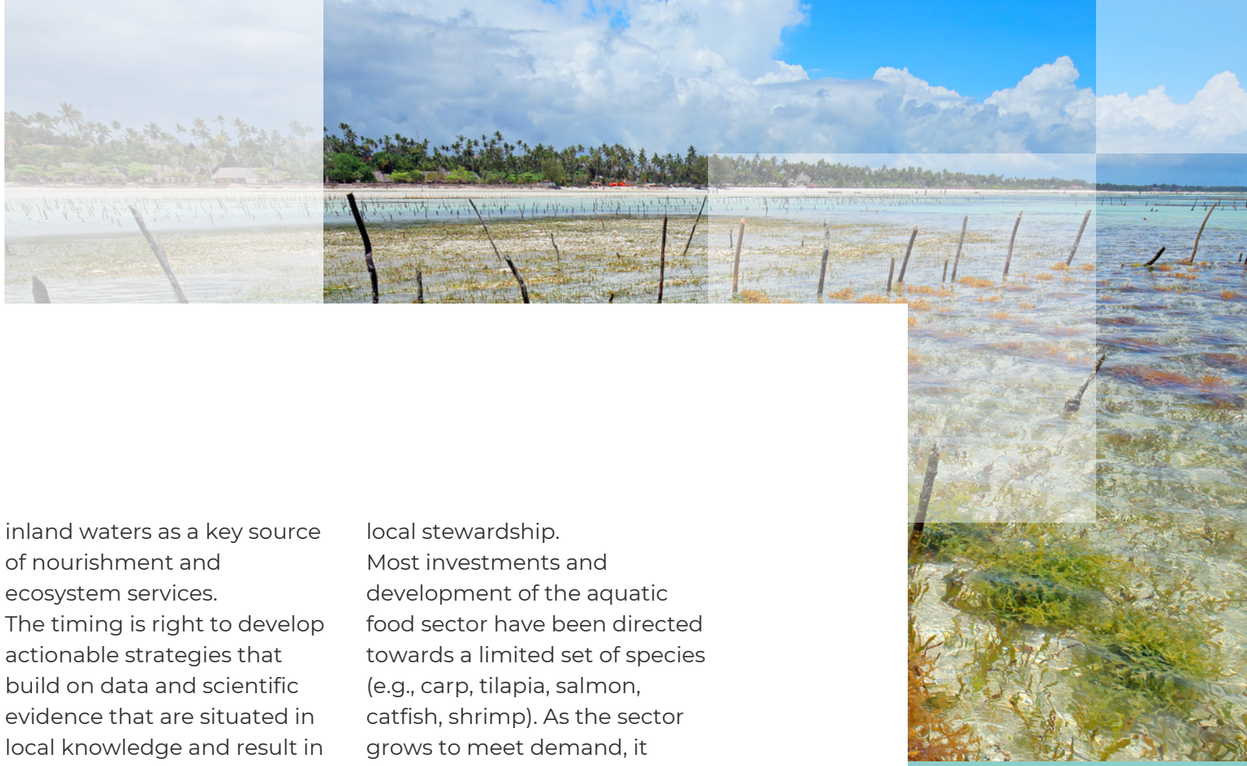
The 2021 UN Nutrition Discussion Paper on The Role of Aquatic Foods in Sustainable Healthy Diets, alongside the Blue Foods Assessment (BFA) and the widespread adoption of the 2030 Sustainable Development Goals (SDGs), mark a critical juncture for the development of actionable strategies. We are at a pivotal moment related to how we interact with our oceans and inland waters as a key source of nourishment and ecosystem services.

Oceans and inland waters already serve as crucial sources of highly-nutritious aquatic foods that are essential protein sources for more than 3 billion people (FAO, 2022). Enhancing the sustainable production of these foods offers a promising pathway toward improving both diet quality and planetary health (FAO, 2022).

The timing is right to develop actionable strategies that build on data and scientific evidence that are situated in local knowledge and result in recommendations that scale sustainable aquatic food production as part of a flourishing, resilient planet.

The Food and Agriculture Organization (FAO) anticipates significant growth in aquatic food production and consumption. However, current global trajectories in aquatic resource utilization are unsustainable and fail to ensure culturally appropriate food systems with local stewardship.

Most investments and development of the aquatic food sector have been directed towards a limited set of species (e.g., carp, tilapia, salmon, catfish, shrimp). As the sector grows to meet demand, it should do so in ways that preserve cultural traditions, local ownership, biodiversity, and global equity, especially for those populations facing food and nutrition insecurity (FAO, 2020). There is a need to avoid perpetuating historical practices of overharvest, habitat damage, and monocultural mindsets, including in emerging sectors like seaweed and bivalves (oysters, clams, mussels).



The UN Food Systems Summit held in September of 2021 harnessed multi-stakeholder energy to collectively break down "business as usual" silos to envision food system transformation pathways that lead to more equitable, sustainable, and nutritious food systems by 2030. Against this backdrop, the roadmap presented here emerged from a consultative process involving twenty global food system experts who convened in Bellagio, Italy on 3-7 July, 2023. This historic meeting provided a timely forum for generating proactive aquatic food strategies, steering clear of unsustainable practices and offering win-win solutions for both people and the planet. This roadmap is a collective output of the convening and was created to identify and advance both short and long term opportunities that elevate the responsible utilization of diverse, currently underutilized aquatic foods for sustainable and nutritious food systems.

A sustainable food system (SFS) is a food system that produces and delivers food security and nutrition for all in such a way that the economic, social and environmental foundations to generate food security and nutrition for future generations are not compromised (FAO 2018).

This means that the system: provides food and nutrition security (nutrition sustainability); has broad-based, long-term distributive social and cultural benefits for society (sociocultural sustainability) across scales; is profitable, just, and equitable (economic sustainability); and has positive impacts on the natural environment (environmental sustainability), both now and in the future.

Working definition of regenerative aquatic foods

A definition of regenerative aquatic foods has not yet been endorsed by the United Nations or any other global, standard setting body. Even within the group gathered at this convening, there was no universal consensus on a standard definition of RAF. In order to facilitate a baseline understanding for the purposes of discussing aquatic foods that benefit people and the planet, we discussed and agreed upon the following parameters:

- **The concept of a "regenerative food system" needs to embrace all four dimensions of sustainability (planetary, nutrition, economic, and sociocultural) within food systems (Figure 1).**
- **Most commercial aquaculture and fisheries are focused on generating benefits to people, such as food and economic yields (Loring, 2023). but the concept of "regenerative food production" includes restorative benefits to nature and to people's relationships with nature and one another in these systems.**
- **We referred to regenerative aquatic foods (RAF) as "coming from systems that do not withdraw more resources than can be replenished, while enhancing ecosystems'.**

Food and Planet's 4D Framework

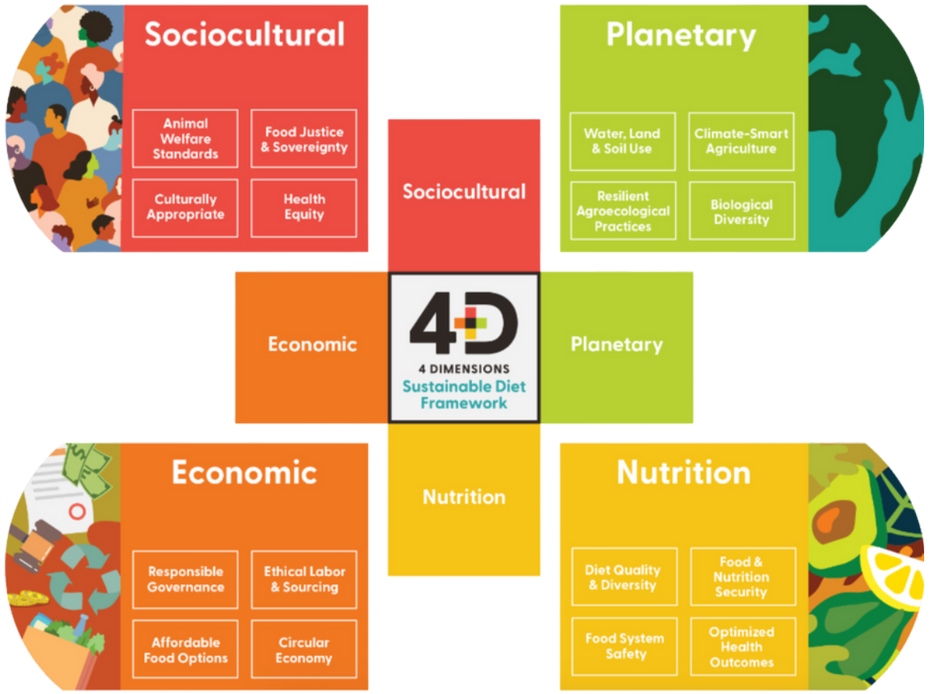


Figure 1: Four Dimensions of Sustainable Food Systems*

Rationale for a focus on specific RAF that are underutilized, understudied and undervalued

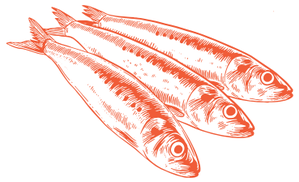
In order to accomplish our objective of advancing the potential for diverse aquatic foods that provide the best opportunities for regenerative and nutritional health outcomes, including locally-adapted and customary foods, we placed boundaries on the species under discussion during the consultation. We used seaweeds, bivalves (e.g. clams, oysters, mussels), and pelagic small fish as illustrative of the dual-purpose objectives of regenerative production that is healthy for people and the planet.

All three of these species groups have distinctive histories in terms of the amount of past research and development and degree of utilization by numerous cultural groups as food and sources of socio-economic value. However, in current food systems many of these species are understudied, underutilized, or undervalued (Costello et al., 2020). A more intentional focus on diversification using RAF could help move the needle on multiple Sustainable Development Goals.

SUSTAINABILITY

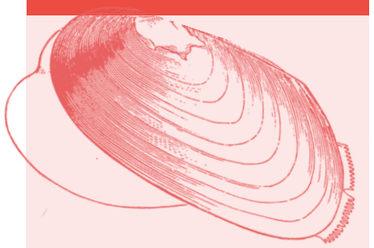
While working toward increasing the diversity of RAF species, it is important to learn from lessons of past unsustainable practices in harvesting and cultivation techniques (Lockwood and Mann, 2019), as well as the consequences of overreliance on a small number of species within complex systems.
For example, though over 10,000 types of seaweeds exist across our oceans, just a handful of edible varieties reach our plates, and only six species dominate >81% of total production (Kim et al. 2017).
However, there are models available for lower trophic aquaculture to contribute much more to the global food system if we are successful in implementing policy reforms, technological innovation, and shifting consumer demand (Costello et al. 2020). The nature of investment and the type of regenerative food production systems RAF engender matters: if global market structure remains unchanged, there is a concern that global market influences may distort the benefits away from low-income households. For example, most pelagic small fish are diverted for use in livestock, fish feed, and supplements rather than being directly utilized as food for people. If the structural attributes of the food production and distribution system stay the same, increased production as a result of increased investment in conventional production and distribution practices of small pelagic fish or other RAF could result in a similar maldistribution of benefits.
RAF provide numerous sustainability benefits, some of which are featured below. However, the global history of oyster and oyster reef devastation serves as a cautionary tale. Over harvest for economic gain led to more than 85% of oyster habitats being lost worldwide, with functional extinction in many regions. This underscores the urgent need for a sustainable approach to aquatic resource management that includes traditional and Indigenous knowledge and practices.

If we were to factor in the four dimensions of sustainable food systems (Figure 1) when assessing their value, RAF would emerge as a top priority for investment.



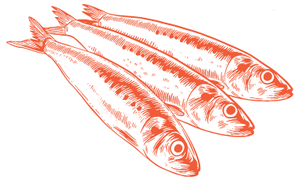
NUTRITION BENEFITS

RAF are recognized for their nutrient density and play a crucial role in supporting nutritional needs, especially among lower-income groups. RAF have traditionally provided food and nutrition security for many Indigenous Peoples and local communities.
Seaweeds, with over 10,000 types, offer over 23 essential nutrients including vitamin A, folate, omega-3 fats, iodine, iron, and magnesium (Food and Planet, 2022).
Bivalves are protein-rich, providing 15-20 grams in a 3-ounce serving. They are also abundant in omega-3 fats, with mussels containing over 700 mg of DHA + EPA per serving. Additionally, they are excellent sources of vitamin B12, zinc, choline, and selenium (Food and Planet, 2023).
Pelagic small fish are highly nutrient-dense and affordable, making them valuable nutritional resources, particularly for lower-income populations (Golden et al., 2021; Beal and Ortenzi, 2022).
Household preparation methods can help distribute their nutritional benefits equitably, benefiting all members, including women, who often eat last in many cultures (Thilsted et al., 1997).



PLANETARY BENEFITS

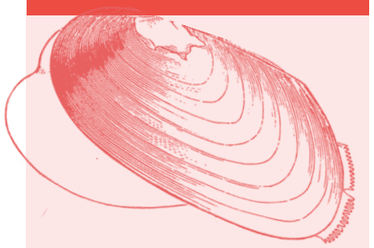
From a systems viewpoint, the health of our marine and fresh waters depend on RAF, as they are foundational to marine food webs, and they have figured prominently in the food systems of people around the world over millennia.
Seaweeds can provide essential coastal protection and take up anthropogenic nutrients, including carbon, and can support shelter for fish (Cotas et al., 2023).
Seaweed farms in China, appear to be removing about 66% of nearshore nitrogen and phosphorus inputs and nitrogen and phosphorus concentrations in seaweed farms are about half those of ambient water (Xiao et al., 2017).
Bivalves filter water, cycle nutrients, and provide habitat for fish and invertebrates (Barrett et al., 2022; Gentry et al., 2022). See the Billion Oyster Project.
Bivalve farms removed 162,000 tons of CO2 and 7,300 tons of Nitrogen, equivalent to 6% of CO2 and 9% of N discharged from all wastewater treatment plants in South Korea (Park et al., 2021).
Pelagic small fish create favorable conditions for healthy aquatic ecosystems because as food, they transfer important nutrients to a variety of larger fish, birds, and mammals. They also help maintain healthy coral reefs, generate sand, and transfer important nutrients to other ecosystems (Peck et al., 2021).



SOCIO-CULTURAL BENEFITS

RAF hold a significant place in global cultures, cherished for millennia in culinary and medicinal practices across diverse regions like Japan, Korea, and parts of Europe, and deeply embedded in the religious and cultural traditions of many Indigenous Peoples.
Seaweeds and bivalves, used globally for food and medicine for millennia, are cherished staples in Japan, Korea, China, Polynesia, and coastal communities in Scotland, Iceland, and France (Cotas et al. 2023).
Seaweeds, for many Indigenous Peoples and local communities, have significance in their cosmogony and religious and cultural arts and practices (Abbott, 1996; McDermid et al. 2022).

Seaweeds are linked with health and longevity; these species are key components of the renowned 'Blue Zone Diets' in Okinawa and the Mediterranean (Food and Planet, 2022).
Bivalves are steeped in a rich culture for many, and can be an important source of employment in rural and remote areas (Krause et al., 2019).
Bivalve shells are often used in religious ceremonies, symbolism, cultural motifs, and architecture, and in artwork and jewelry (Oliver et al., 2020).
Pelagic small fish have numerous benefits beyond their role as a food source, as they are a staple in many populations, deeply rooted in cultural foodways and traditions.



ECONOMIC BENEFIT

RAF support community livelihoods, and play a significant role in promoting place-based economies. RAF activities like harvesting, canning, and drying. can support the development of place-based economic opportunities and decrease import dependence and increase greater community self-determination.
Seaweeds can create healthier aquatic ecosystems to support place-based livelihoods, including community production, harvesting, and tourism. These shifts can restore balance to marine ecosystems, fostering sustainability and resilience. Seaweed, historically undervalued and often overlooked by producers and consumers, is now gaining recognition. There is an increasing consumer interest, with many willing to pay a premium for the ecosystem services offered by seaweed-based foods (Bolduc et al., 2023).
Bivalve production supports local economies in geographies around the world. The oyster and clam market is valued at USD $142 billion and estimated to grow to USD $204 billion over the next ten years (Global Market Insights).
Bivalves are featured on the menus of several high-end restaurants, generating revenue for many local communities. (Oliver et al., 2020).
Pelagic small fish play a vital role in local economies by providing employment and supporting community activities, notably through processes like canning and drying fish for human consumption (Isaacs, 2016).

02
Process

Guiding Principles and Desired Outcomes

We centered our convening on driving progress toward the 2030 Sustainable Development Goals (SDGs), which aim to eradicate poverty, safeguard the planet, and promote universal prosperity.

RAF, as noted by Duarte (2022) and Spillias (2022), hold substantial potential for advancing several SDGs. The following specific SDGs guided our roadmap development:

Regenerative aquatic foods, as noted by Duarte (2022) and Spillias (2022), hold substantial potential for advancing several SDGs. The following specific SDGs guided our roadmap development

Roadmap Development Process

To develop our roadmap for advancing RAF, over three working days we surfaced a wide variety of possible actions (Day 1), after which we prioritized them (Day 2), and provided context to the top five to eight actions (Day 3). These actions were organized across three primary pathways: implementation, policy, and research. We utilized the 4D Framework of Sustainable Food Systems.
(Figure 1) to ensure all four dimensions of sustainable food systems were adequately represented across each primary pathway. We utilized a 'mad lib' format to guide each pathway's development. Additionally, we collectively defined the following guiding principles to ground our thinking while designing the action areas of the roadmap:

Collectively defined ‘guiding principles’ to ground the conversation

1.

People are part of the ecosystem.

2.

Prioritize food for humans over non-food or "secondary" food uses, such as feed for farmed animals.

3.

Design using equitable and inclusive processes that ensure equitable outcomes in terms of sharing benefits and costs of intervention.

4.

Ensure just and equitable sharing of knowledge, research, and resources, giving attention to underserved geographies and populations.

5.

Ensure all research, implementation, and policy recommendations are forward-looking, conscious of climate change impacts, and in service of long-term community wellbeing.

03

Regenerative Aquatic Foods (RAF) Roadmap

Convening Outcomes

We organized the convening around three action paths: implementation, research and policy. As we discussed and engaged throughout the week, there was a desire to provide linkages between the pathways. These linkages between implementation, research, and policy pathways demonstrate how various actions and initiatives are interconnected and can support each other in advancing the utilization of diverse, underutilized RAF for sustainable and nutritious food systems.

The following five high-level thematic areas were generated by 20 global aquatic food system experts, to capture top prioritized actions to advance opportunities to elevate RAF for sustainable and nutritious food systems.

The identified five thematic areas serve as crucial guides, illuminating key connections across the three primary pathways. They are the foundation of our strategic roadmap for implementers, researchers, and policymakers to effectively activate RAF in targeted contexts and with specific stakeholders.

Five high-level thematic areas

01. Consumption

02. Community Based Practice

03. Ecosystem Services provided by RAF

04. Capital Investment

05. Technology and Innovation

01. Consumption

Stimulating consumer demand and increasing consumption of diverse RAF through implementation, research, and policy actions was a top priority surfaced by the group. The table below highlights priority actions to increase consumption of RAF and make them more affordable, accessible, desirable, convenient so that they can be prepared and consumed in diverse ways by consumers.

SUB-ACTION	RESEARCH	IMPLEMENTATION	POLICY
Consumer preferences and markets	Conduct consumer research on preferences, knowledge, preparation, affordability, taste, trust, and willingness to pay. Develop new, highly palatable products that use RAF ingredients and RAF substitutes for less sustainable ingredients.	Translate research into behavior change strategies and market them, like using seafood certifications with regenerative features. Include evidence-based data in nutrition and culinary education. Integrate RAF into institutions like school lunches and collaborate with food buyers to adopt RAF.	Include RAF as solutions in global and national policy discussions, and facilitate dialogues among diverse constituents.
Food composition and food safety	Analyze nutrient content and food safety hazards of raw, ready to eat, and processed products.	Collate information and build the evidence-base for consumers, educators, doctors, dietitians, and culinary professionals.	Incorporate information on RAF into national policy discussions and guidelines.
Dialogues		Support peer-to-peer knowledge sharing.	Facilitate spaces for dialogues on RAF among diverse sets of constituents.

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PRIORITY CONTEXT & ACTORS

This action is most urgently needed in diverse socioeconomic settings:

High, medium, and low-income communities all stand to benefit from access to sustainable and nutritious RAF

Key actors

- Culinary and food service settings, healthcare and foodservice professionals
- Researchers in universities and educational institutions
- Food safety regulators
- Dietitians and doctors
- Government and policy makers

02. Community based practices

Below are the priority actions to increase support for RAF with key stakeholders, including Indigenous and local communities. There is an urgent need to uphold rights-based frameworks that respect Indigenous self-determination and inherent sovereign relationships, such as the United Nations Declaration on the Rights of Indigenous Peoples.

SUB-ACTION	RESEARCH	IMPLEMENTATION	POLICY
Integration of Indigenous Knowledge and Practices	Promote multi-generational knowledge exchange and commit to utilizing traditional and Indigenous knowledge on par with Western scientific approaches. Develop tools for integrating traditional and Indigenous knowledge with scientific knowledge.	Foster partnerships with local and Indigenous communities, empower Indigenous knowledge holders, and safeguard access to aquatic food system benefits.	Cultivate a culture of environmental ethics, facilitate community tenure and ownership rights, and promote equitable inclusion in local policy-making.
Community Centered Approach and Empowerment	Develop models for data/knowledge ownership and advocate for benefit sharing.	Advocate for bottom-up solutions, strengthen community capacity, and assess local contexts for feasible RAF partnerships. Share traditional and Indigenous knowledge for resilient production practices, and disseminate RAF impact findings to diverse audiences.	Support a shift towards greater local self-determination and capacity on the ground, and foster inclusive and participatory dialogues.

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PRIORITY CONTEXT & ACTORS

This action is most urgently needed in

- Coastal areas with traditional ties and practices
- Communities and ecosystems under compounded climate stressors
- Indigenous peoples and local communities facing economic, racial injustices, and historical exclusion from decision-making affecting their well-being and resources

Key actors

- Indigenous Peoples and local communities
- Traditional knowledge holders
- Young peoples and women
- Land resource managers
- Researchers
- Local policy makers

03. Ecosystem services provided by RAF

There is imperative to enhance the comprehension of ecosystem services offered by RAF, incorporate the costs and benefits associated with the degradation or restoration of natural habitat into the comprehensive "true cost" of food, and translate this awareness into the execution of policies. The following actions are deemed priorities in achieving these objectives.

SUB-ACTION	RESEARCH	IMPLEMENTATION	POLICY
Contextualize Understanding	Define essential characteristics for truly regenerative systems and quantify ecosystem services in diverse settings. Document and encourage traditional and Indigenous food production as potent models for regenerative systems and resilience.	Develop context-specific rubrics with local stakeholders to assess ecosystem services and analyze local contexts for identifying feasible RAF partnerships.	Educate officials on RAF ecosystem services and translate global policy conversations to local contexts.
Support Regenerative Practices that Promote Environmental Stewardship	Document ecosystem services of RAF, develop contextualized models for multi-functional RAF systems, and conduct risk/benefit analysis for different RAF and groups.	Build area based conservation measures and community-based natural resource management.	Foster dialogues on RAF and provide recommendations to boost RAF production. Recognize area-based rights to allow Indigenous practitioners and other entities to capture ecosystem service benefits resulting from their stewardship.
Advocate for Climate-Resilient Livelihoods	Evaluate RAF trade-offs, considering equity in distribution of burdens and benefits.	Increase community awareness of benefits from RAF, including climate resilience through extension services.	Secure government and public funding for climate-resilient livelihoods, and highlight connections between AF and RAF for enhanced nutrition, environment, and equity at global conferences.

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PRIORITY CONTEXT & ACTORS

This action is most urgently needed in

- Geographies most vulnerable (environmentally and socially) to the impacts of climate change.
- Organizations that support and provide extension activities and education training

Key actors

- Fishers and farmers
- Traditional/Indigenous knowledge holders
- Researchers
- Funders
- Policymakers

04. Capital Investment

There is a need to escalate capital investment for expanded research and development in RAF production systems. The following are priority actions to advance RAF food production and consumption.

SUB-ACTION	RESEARCH	IMPLEMENTATION	POLICY
Analyze Risks and Benefits to Maximize Investment	Perform risk/benefit analysis for various RAF species and systems.	Educate investors on RAF and develop de-risking tools for farmers and investors.	Advocate for public funding as an investment case and evaluate potential certification schemes. Aid in tracking and monitoring policy commitments and assess trade-offs and potential negative consequences.
Financial Support and Blended Finance	Establish risk-tolerant capital pools and enhance consumer awareness of different capital types.	Develop guidance for blended finance models. Create incubator funds for RAF.	Secure government and public funding for climate-resilient livelihoods.

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PRIORITY CONTEXT & ACTORS

This action is most urgently needed in

- Geographies most vulnerable (environmentally and socially) to the impacts of climate change
- Lower resource contexts (LMICs)
- Female founded businesses
- In the business setting, scaling underutilized species

Key actors

- Policymakers
- Researchers
- Producers
- Private investors
- Public funders
- Accelerator programs, with a focus on women empowerment

05. Technology and Innovation

We need to harness the power of new technologies and innovations to monitor changes to the status quo in terms of benefits and costs of RAF production and innovate rapid learning cycles to promote best practices and quickly move away from practices that are harmful to people or the planet. The table below highlights priority actions.

SUB-ACTION	RESEARCH	IMPLEMENTATION	POLICY
Innovate Technologies and Sustainable Practices, while Ensuring Equitable Access	Develop cost effective tools across a range of domains (e.g. climate monitoring, water quality, food safety, selective harvesting, product development, alternative feeds). Understand the benefits and challenges of diversifying production systems with new species and innovate rapid learning loops to accentuate positive attributes and eliminate harmful practices. Build forecasting tools for equitable outcomes.	Ensure community capacity is in place to utilize new tools, track benefits or harms and develop more effective ecosystem management and product development. Ensure equitable access and training to technologies for farmers.	Advocate for RAF to improve nutrition, environment, and equity, and empower stakeholders with knowledge management tools.
Diversify Species for Sustainable Production	Develop new environmentally-friendly production practices to diversify RAF production and value chain development. Conduct research on genetics, strains, energy conversion efficiency, cultivation methods, life cycle, and propagation for a diversity of RAF species.	Optimize spatial planning to prioritize Indigenous and local species, preserving genetic diversity, and addressing water quality issues. Implement flexible permitting to foster trials of new species cultivation. Modify certification programs to credit diversification.	Advocate for policies that incentivize farmers and other value chain actors to produce RAF. Provide subsidies for research aimed at bringing more species under cultivation and improving environmental and nutritional performance and climate resilience.

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PRIORITY CONTEXT & ACTORS

This action is most urgently needed in

- Value chains which are supplying emerging markets and areas with essential nutritional needs
- Vulnerable groups (gender, resource constrained)

Key actors

- Food safety authorities
- Value chain actors, especially women and youth
- Local researchers
- Community leaders
- Indigenous peoples
- National policymakers

Conclusion

To concomitantly address malnutrition in all its forms and the unsustainable use of natural resources, we need to consume better quality foods that are produced using techniques that add value to our ecosystems. While there are many options for producing nutrient dense foods and enhancing the ecosystem functions in our food systems, this roadmap explores the solution space of RAF. RAF provide essential nutrients for people and also enrich the environment where they are produced. Examples of such species include seaweed, bivalves, and pelagic small fish. The experts gathered together for this convening prioritized actions in research, implementation, and policy for five prioritized thematic areas: **Consumption, community based practices, ecosystem services, capital investment, and technology and innovation.** We recommend actions to stimulate consumer demand, increase support to Indigenous and local communities, valorize ecosystem services as part of the true cost of food, increase investment mechanisms, and support the development and implementation of technologies and innovations to foster growth in RAF.

Implementation of actions in this roadmap come with urgency, particularly in light of climate change mitigation strategies and the 2030 timeframe for achieving the SDGs.

This document is meant to serve as an actionable roadmap to advance opportunities to identify and elevate underutilized aquatic foods for sustainable and nutritious food systems. The long-term aspiration of these efforts is to gain wide-spread community, institutional and organization support, and action on the ideas expressed in the roadmap.

Distribution opportunities identified include events hosted by the United Nations, Conference of Parties, international and regional scientific conferences, as well as embedding in organizational strategies and community-based initiatives.

Individuals and groups are encouraged to widely distribute, debate, and discuss our proposed solutions as part of local, national, and international engagements. We hope to achieve collective action through the dissemination and uptake of these ideas.

04
Credits

Bellagio Convening Participants

Listed in Alphabetical Order:
Charlotte Pederson, GAIN; Chris Vogliano, Food + Planet; Claudia Sadoff, CGIAR; Gabriella D'Cruz, The Good Ocean; Gina Kennedy, GAIN; Gracie White, Conservation International Ventures; Heidi Alleway, The Nature Conservancy; Jang Kyun Kim, Incheon National University; Johannes Pucher, German Federal Institute for Risk Assessment; Kagwiria Koome, Food Initiative, The Rockefeller Foundation; Kate Geagan, Food + Planet; Kevin Chang, Indigenous Aquaculture Collaborative and Kuaʻāina Ulu ʻAuamo; Mduduzi Mbuya, GAIN; Rashid Sumaila, University of British Columbia; Shakuntala Thilsted, CGIAR; Sharon Palmer, Food + Planet; Stineke Oenema, UN FAO; Tisungeni Zimpita, African Development Bank; Vera Agostini, UN FAO; Willow Battista, Environmental Defense Fund

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