Food and Agriculture Organization of the United Nations

AQUACULTURE TRANSFORMATION

Innovation and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region

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Bangkok, 2023

Required citation:

FAO & NACA. 2023. *Aquaculture transformation – Innovation and investment for sustainable intensification and expansion of aquaculture in Asia and the Pacific region*. Bangkok, FAO. https://doi.org/10.4060/cc4962en

PREPARATION OF THIS DOCUMENT

This White Paper was prepared by FAO Regional Office for Asia and the Pacific (FAORAP) and the Network of Aquaculture Centres in Asia-Pacific (NACA) with contributions from stakeholders across the region through a consultation process in September 2022. The draft document served as background information for discussion at the High Level Meeting on Aquaculture Transformation in Asia and the Pacific Region, 22–23 November 2022, organized by FAORAP and NACA. The draft was then revised to incorporate the main outcomes from the meeting.

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ACRONYMS AND ABBREVIATIONS

AMR	antimicrobial resistance
COFI	Committee on Fisheries
CSO	civil society organization
FAO	Food and Agriculture Organization of the United Nations
FAORAP	FAO Regional Office for Asia and the Pacific
FIFO	fish in: fish out ratio
GHG	greenhouse gas
NACA	Network of Aquaculture Centres in Asia-Pacific
PMP/AB	Progressive Management Pathway for Improving Aquaculture Biosecurity
SDGs	Sustainable Development Goals


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EXECUTIVE SUMMARY

Asia and the Pacific region is the world's largest aquaculture producer, contributing 92 percent of the world's supply of farmed fish, crustaceans, molluscs, seaweeds and other aquatic foods. Sustainable aquaculture is increasingly being recognized as an important contributor to achieving the 2030 Agenda for Sustainable Development that covers multiple goals ranging from ending hunger, improving health and nutrition, responding to climate change, wealth creation and poverty reduction, gender equality and creating decent work. FAO estimates that the global demand for aquatic food will increase by 15 percent by 2030, requiring a global aquaculture production increase of 35 percent to 40 percent, much higher than the projected production growth based on the current development trajectory.

Aquaculture can be an environmentally responsible, low carbon footprint form of food production, but, as with all forms of agricultural food production, may have environmental and social impacts that require remediation or mitigation. However, persistent and emerging challenges have the potential to impede aquaculture from meeting the projected demand for aquatic food and contributing to the broad range of Sustainable Development Goals (SDGs) in the future. Recognizing these challenges, FAO has developed a Blue Transformation Roadmap which outlines a vision for FAO's work on aquatic food systems till 2030, covering the three core components of aquaculture, capture fisheries and value chain transformation.

This White Paper is broadly aligned with the strategic goals of the Blue Transformation Roadmap and provides guidance on how to translate them into actions to support sustainable intensification and expansion of aquaculture, relevant to the context of Asia and the Pacific region. It has been prepared through a series of reviews and consultations in the region and country and regional assessments led by NACA on the innovations and investment required for the future of aquaculture in Asia and the Pacific region. It has also drawn on high-level reviews and statements, including the 2021 COFI Declaration on Sustainable Fisheries and Aquaculture, the Shanghai Declaration that emerged from the Global Conference on Aquaculture Millennium +20 and FAO's Action-Oriented Guidance for transforming aquaculture for greater contribution to achieving the SDGs.


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The White Paper provides a vision for 2030 in which aquaculture in Asia and the Pacific region is transformed into more efficient, inclusive, resilient and sustainable aquatic food systems through innovation, investment and partnerships. Transformed aquaculture harnesses the rich and diverse cultural foundations of aquaculture across the region and strengthens its contribution to world food security, improved nutrition, secure livelihoods, economic and social development and environmental recovery. The White Paper provides five strategic goals for achieving this vision: improving food and nutrition security; reducing poverty and developing economies; better environments and ecosystems; greater resilience; and more inclusion.

Recommended approaches for implementation of aquaculture transformation are also provided, emphasizing the importance of science, knowledge and data; measuring progress towards transformation; adopting a holistic food systems approach; making efficient use of existing knowledge across the diverse region; stimulating greater innovation; being people-centred and inclusive; engaging markets and consumers on the road to achieving sustainable aquaculture; grounding approaches in relevant international best practices; and encouraging continuous improvement and learning.

The objectives and expected outcomes from aquaculture transformation are provided in the White Paper, together with a series of targets and action areas for each target. There are five targets: (1) sustaining aquaculture production growth in the region by at least 3 percent average annual growth and more than 103 million tonnes of regional production by 2030; (2) improved environmental and climate resilience; (3) efficient, inclusive and resilient aquaculture value chains; (4) improved governance supporting aquaculture transformation; and (5) enhanced partnership and cooperation among governments, the private sector and civil society organizations (CSOs) to accelerate aquaculture transformation. Each target has priority Action Areas that are considered key for the sustainable intensification and expansion of aquaculture throughout the region; it is recognized that the approaches will require tailoring to specific country contexts.

The White Paper concludes with a roadmap to support implementation and monitoring by key actors, featuring four key pathways: (1) the development of national aquaculture transformation – innovation and investment plans; (2) the need for greater regional and international cooperation; (3) the need for more innovation and investment; and (4) monitoring progress and shared learning. The White Paper recognizes the important and complementary roles of public and private sectors and CSOs in aquaculture transformation and envisages a key role for FAO and NACA in mobilizing partnerships and enabling greater regional cooperation.

INTRODUCTION

Sustainable aquaculture has the potential to contribute more to achieving the 2030 Agenda for Sustainable Development across multiple goals ranging from ending hunger, improving health and nutrition, responding to climate change, wealth creation and poverty reduction, gender equality, and creating decent work. FAO estimates that the global demand for aquatic food will increase by 15 percent by 2030, requiring a global aquaculture production increase of 35 percent to 40 percent, much higher than the projected production growth based on the current development trajectory (FAO, 2022a). Well-managed aquaculture has demonstrated that it can be an environmentally responsible, low carbon footprint form of food production. It is also clear that aquaculture, as with all forms of agricultural food production, can have environmental and social impacts that require remediation or mitigation.

FAO has developed a Blue Transformation Roadmap which outlines a vision for FAO's work on aquatic food systems for the period 2022–2030, covering three core components on aquaculture, capture fisheries and value chains with their objectives (FAO, 2022b). The roadmap recognizes the importance of aquatic food systems as drivers of employment, economic growth, social development and environmental recovery, all of which underpin the SDGs. The roadmap also recognizes that achieving the 2030 Agenda requires a transformation to more efficient, inclusive, resilient and sustainable aquatic food systems for better production, better nutrition, a better environment and a better life, leaving no one behind. Blue Transformation is aligned to major global commitments to sustainable development, especially the goal of the 2030 Agenda for Sustainable Development and spans the human, environmental and economic dimensions of the SDGs, various Ocean initiatives, the United Nations Food Systems Summit, the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity (CBD).

FAO Members at the 35th Session of the Committee on Fisheries (COFI) welcomed the core objectives of Blue Transformation and their alignment with the 2021 COFI Declaration for Sustainable Fisheries and Aquaculture and the FAO Strategic Framework for 2022 to 2031 (FAO, 2022c). The Blue Transformation Roadmap

is a global strategy, requiring translation into action relevant to regional, national and local contexts and the purpose of this White Paper is to turn this into a vision and priority actions for aquaculture transformation relevant to Asia and the Pacific region by 2030.

The White Paper has been prepared through a series of reviews and consultations including a series of country assessments and a regional synthesis led by NACA on the innovations and investment required for the future of aquaculture in Asia and the Pacific region. This process has drawn on high-level reviews and statements, including the 2021 COFI Declaration on Sustainable Fisheries and Aquaculture, the Shanghai Declaration that emerged from the Global Conference on Aquaculture Millennium +20 (FAO, 2022d) and FAO's draft document on action-oriented guidance for transforming aquaculture for greater contribution to achieving the SDGs (FAO, 2022e).

This White Paper provides an overall vision and framework that is intended to accelerate aquaculture transformation in the region through innovations and investment, and provides guidance to partners from the public, private and development sectors to actively engage with Asia and the Pacific region in transforming aquaculture to provide more efficient, inclusive, resilient and sustainable food systems.

Blue Transformation and aquaculture in Asia and the Pacific region


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Blue Transformation focuses on three inter-connected objectives: sustainable aquaculture intensification and expansion, effective management of all fisheries and upgraded value chains.

Aquatic foods are a unique source of high-quality bio-available animal proteins and unique micro-nutrients such as omega-3 fatty acids, vitamins and minerals that are vital for physical and cognitive development. Aquaculture has contributed the largest supply of aquatic food available for direct human consumption since 2016 (FAO, 2020a). With 90 percent of global wild fisheries resources now fully exploited or overfished, aquaculture is expected to dominate future aquatic food supplies. Aquaculture can use energy, feed and other critical resources more efficiently than some land-based animal husbandry and can be a very effective and sustainable way of producing food important for human nutrition and health.

Asia and the Pacific region has led world aquaculture production for decades, producing 91.6 percent of globally farmed aquatic animals and algae in 2020 (FAO, 2022a). The leading global producers are in the region (China, India, Indonesia, Viet Nam and Bangladesh). It is predicted that the region will continue to play the leading role in global aquaculture development and transform the way we feed the world.

Even with the region's impressive past achievements, the future requires aquaculture in Asia and the Pacific region to grow under a broad range of challenges to provide sufficient and nutritious aquatic foods for an ever-growing population. Innovations in production technologies, value chains, social and economic inclusion and other areas will be needed to transform aquaculture in Asia and the Pacific region and contribute to the global goal of Blue Transformation.

Opportunities, challenges and needs for aquaculture transformation in the region

Asia and the Pacific region is the global leader in aquatic food production and has the highest overall rates of consumption of these foods. Aquaculture provides 70 percent of aquatic food in the region and makes important contributions to healthy and nutritious diets, livelihoods, economic development and a wide range of SDGs. The demand and consumption of aquatic food from aquaculture is projected to continue to grow in the region, driven by limitations in management and governance of capture fisheries, economic development, urbanization, the rise of the middle income group, increased demand, changing consumer preferences towards seafood, advancements in technology, fast population growth in some countries and rapid ageing in others. Aquaculture production in the region is projected to increase by 21.6 percent, from 77.6 million tonnes in 2020 to 94.3 million tonnes in 2030 (FAO, 2022a).

Asia and the Pacific region is remarkably diverse geographically with regard to, *inter alia*, its composition of flora and fauna, social and economic conditions, cultures and institutions. Aquaculture is unevenly distributed with highly diversified production systems. The consumption and utilization of farmed aquatic food also differ significantly across and within countries and territories. Many countries, particularly the lower-income countries, face great challenges in achieving their national aspirations of aquaculture development in support of national food production to feed and create jobs for their growing populations. A reduction in aquaculture areas is starting to be seen in some major producing countries such as China and Thailand. Overall aquaculture employment has also decreased in recent years, as some countries shift to greater mechanization and labour productivity (FAO, 2022a).

The trajectory of the region's aquaculture in the future will be influenced by a diverse and ever-increasing set of rapid and slow onset challenges, ranging across climate change, freshwater stress, competition for land and coastal areas, the impact of COVID-19 on supply chains, generational changes, changes in international politics and shifting globalization. There are other persistent underlying problems, some of which are legacies of earlier development, including unregulated development, unsustainable intensification, unorganized farmer bases, value chain inefficiencies, weak biosecurity and spread of aquatic diseases, inadequate governance, a lack (or unreliability) of infrastructure, resource limitations, ecological and environmental degradation and technological and skills limitations.

Aquaculture operations across Asia and the Pacific region farm hundreds of species in diverse production systems – which range in scale and intensity from small backyard family fishponds, ocean-based seaweed and mollusc operations, to highly industrialized, intensive and technologically sophisticated market-driven commercial operations. Although the region is home to an aquaculture innovation and investment theatre that is producing new world-class start-ups and companies, the reality is that many of the region's aquaculture species and production systems have received limited research and development investment. Selective breeding programmes are not yet available for many farmed species. Lack of specialized feeds, inappropriate feeding practices and poor access of small farmers to cost-effective quality feed, seed and knowledge, finance and insurance services are still major constraints in many countries. Vaccines and veterinary supervision are lacking for most aquaculture species. Antibiotics, disinfectants and various chemicals are often inappropriately used, creating food safety and antimicrobial resistance (AMR) risks. Aquatic products are highly perishable,

and the level of waste and loss is still high due to poor infrastructure and underdeveloped logistics systems in some parts of the region. Seasonal and regional oversupply in concentrated areas of aquaculture affects the industry's economic performance. Marketing and branding of aquaculture products are less developed, contributing to low competitiveness and low-profit margins.

More than anywhere else in the world, the need for aquaculture transformation in Asia and the Pacific region is considerable. A sustainable future for aquaculture in the region requires a major shift towards more secure and resilient supplies through wider adoption of sustainable intensification. There is a need to be more labour productive, to be a more efficient user of land and other resources, and for judicious expansion into areas not yet sustainably used for aquatic food production, including Small Island Developing States of the Pacific.

This White Paper provides a guiding framework with a list of targets and priority areas for innovation and investment under the proposed vision and strategic targets that are outlined in the following sections.

VISION TO 2030

Aquaculture in Asia and the Pacific region is transformed into more efficient, inclusive, resilient and sustainable aquatic food systems through innovation, investment and partnerships.

A transformed aquaculture sector is one that harnesses the rich and diverse cultural foundation of aquaculture in the region and strengthens its contribution to world food security, improved nutrition, secure livelihoods, economic and social development and environmental recovery.

Strategic goals

Aquaculture transformation will substantially and positively contribute to the SDG targets in Asia and the Pacific region, and perhaps more so than many other food systems. Five strategic goals for aquaculture transformation have been identified to guide the approach:

Improving food and nutrition security

Aquatic food production from aquaculture should contribute to the eradication of hunger, food insecurity and malnutrition, progressively ensuring a region in which people at all times have sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Reducing poverty and developing economies

Aquaculture enterprises and employment that positively contribute to the elimination of poverty and economic and social progress for all, through increased food production, enhanced rural development, safe and decent work and sustainable livelihoods.

Better environments and ecosystems

Aquaculture production and value chains that support sustainable management and utilization of natural resources, including land, water, air, climate, biodiversity and genetic resources for the benefit of present and future generations. Aquaculture should contribute more to the challenge of natural ecosystem resilience and recovery and its use of resources should become increasingly circular, reducing food loss and waste and creating a sustainable aquaculture food system.

Greater resilience

Aquaculture systems should contribute to mitigation of climate change, be climate smart and resilient and capable of withstanding the impacts of dynamic anthropogenic and non-anthropogenic processes, including a changing climate.

More inclusion

Diverse, multiscale, gender-inclusive aquaculture food systems should ensure the availability and accessibility of safe and nutritious aquatic food, through domestic supply and accessible, affordable trade, ensuring that aquatic food systems contribute to improving the rights and incomes of vulnerable communities in terms of achieving equitable livelihoods and healthy lives.

Approaches to implementation of aquaculture transformation

Implementation of aquaculture transformation in Asia and the Pacific region should be guided by the following approaches:

Science-based evidence for interventions

Aquaculture transformation interventions should be based on the best available evidence. This should come from research, data analysis, traditional, local and indigenous knowledge. The approach will switch from input-based farming to knowledge and data-based farming.

Measurable and action-oriented transformation

Aquaculture transformation should be measurable and action-oriented, with targets clearly defined and accessible to stakeholders. Priority actions need to be facilitated, aligned, prioritized, enhanced and directed towards measurable improvements in aquaculture performance throughout the value chain and with a long-term perspective.

Adoption of a food system approach

Priorities for aquaculture transformation should be identified using a food system approach, focused on actions that deliver change in the whole food system. Trade-offs and balances among different development priorities should be taken into account.

Bridging of gaps between knowledge and practice

Aquaculture is unevenly distributed and at different stages of development across Asia and the Pacific region, a situation that provides unique opportunities for regional cooperation and partners to make best use of existing aquaculture knowledge and put that knowledge into practice.

Innovation stimulation

Aquaculture transformation within Asia and the Pacific region should be enabled by a policy and investment environment that stimulates new innovations to solve problems and supports innovative businesses to apply such innovations at scale.

People-centred transformation

Aquaculture practitioners and value chain actors shall be at the centre of transformation strategies and an inclusive approach engaging small actors shall be adopted throughout the sector.

Engaging markets and consumers

Aquaculture transformation will progress positively when consumer awareness and market demand drives improvements in the efficiency and value created throughout the aquaculture value chain to stimulate sustainable production. Marketing and consumer communities should be engaged to support and reward aquaculture transformation within the region.

Proactive thinking

Aquaculture transformation strategies and investments should be proactive and take account of future trends, likely challenges and risks.

Application of international aquaculture guidelines

Aquaculture transformation in Asia and the Pacific region should aim to put into practice the best global technical and normative guidance, where relevant to national and local conditions, provided under binding and voluntary international multilateral agreements and frameworks.

Encouraging continuous improvement and learning

Aquaculture transformation should seek continuous improvement across Asia and the Pacific region, supported by a process of monitoring and analysing interventions, and sharing of learning across the region to stimulate and support overall progress towards better production, better lives and better nutrition through aquaculture.


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Objective

Sustainable aquaculture intensification and expansion in Asia and the Pacific region that satisfies demand for healthy and sustainable aquatic food and distributes benefits equitably.

Outcomes

Outcome 1

Aquaculture transformation in Asia and the Pacific region contributes to sustainable food systems and ensures affordable and safe aquatic foods for people at all income levels in the region and the world.

Outcome 2

Inclusive and responsible aquaculture value chains are well developed in Asia and the Pacific region and the benefits generated are distributed equitably across the value chains.

TARGETS AND INDICATORS

Target 1
Sustaining aquaculture production growth in the region by at least 3 percent average annual growth and more than 103 million tonnes of regional production by 2030[1]

- **Indicator 1.1**

  Annual growth of aquaculture production in the region (measured by yearly country aquaculture production data in FishStatJ).

Target 2
Improved environmental and climate resilience

- **Indicator 2.1**

  Feed use efficiency and increased use of waste stream and fish meal alternatives reduce the fish in: fish out (FIFO) ratio by 35 percent in major aquaculture systems[2] (measured by yearly country aquaculture production data, fishmeal production, export and import data in FishStatJ).

- **Indicator 2.2**

  Number of aquaculture farms certified or within programmes that support environmental performance improvement, including commitment to reducing greenhouse gas (GHG) emissions from aquaculture (measures to be developed).

[1] Aquaculture production in Asia and the Pacific region increases by 35 percent to support the 15 percent greater per capita aquatic food consumption in the region by 2030. This implies that the overall production would increase from 77 million tonnes in 2020 to 103 million tonnes in 2030 (equivalent to an average annual growth rate of 3 percent).

[2] Global fishmeal production has stagnated (FAO, 2022e). Assuming the fishmeal supply is stable (zero growth in the supply), to achieve Target 1 by sustaining at least 3 percent average annual growth (or 35 percent aquaculture production increase by 2030), the FIFO will thus be reduced by 35 percent.


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Target 3
Efficient, inclusive and resilient aquaculture value chains

- **Indicator 3.1**

  Increase > 15 percent per capita aquatic food consumption in the region by 2030 (measured by apparent consumption statistics based on Food Balance Sheets in FishStatJ).

Target 4
Improved governance supporting aquaculture transformation

- **Indicator 4.1**

  Countries and territories in Asia and the Pacific region have a National Innovation and Investment Plan for Aquaculture Transformation that has translated the strategic goals, principles and targets for aquaculture transformation into national-level enabling policies, legal and institutional frameworks and investment actions (measured by reporting to FAO and NACA).

Target 5
Enhanced partnership and cooperation among governments, the private sector and civil society organizations to accelerate aquaculture transformation

- **Indicator 5.1**

  All nations in Asia and the Pacific region develop and incorporate partnership and cooperation strategies to accelerate aquaculture transformation in the National Innovation and Investment Plan for Aquaculture Transformation.

Aquaculture transformation in Asia and the Pacific region

Vision to 2030

Aquaculture in Asia and the Pacific region is transformed into more efficient, inclusive, resilient and sustainable aquatic food systems through innovation, investment and partnerships.

Strategic goals

- Improving food and nutrition security
- Reducing poverty and developing economies
- Better environments and ecosystems
- Greater resilience
- More inclusion

Objective

Sustainable aquaculture intensification and expansion in Asia and the Pacific region that satisfies demand for healthy and sustainable aquatic food and distributes benefits equitably.

Outcomes

Outcome 1 Aquaculture transformation in Asia and the Pacific region contributes to sustainable food systems and ensures affordable and safe aquatic foods for people at all income levels in the region and the world.

Outcome 2 Inclusive and responsible aquaculture value chains are well developed in Asia and the Pacific region and the benefits generated are distributed equitably across the value chains.

Targets

Target 1 Sustaining aquaculture production growth in the region by at least 3 percent average annual growth and more than 103 million tonnes of regional production by 2030

Target 2 Improved environmental and climate resilience

Target 3 Efficient, inclusive and resilient aquaculture value chains

Target 4 Improved governance supporting aquaculture transformation

Target 5 Enhanced partnership and cooperation among governments, the private sector and civil society organizations to accelerate aquaculture transformation

Action areas for innovation and investment under the five targets

Roadmap for implementation and monitoring by key actors

Priority 1 National aquaculture transformation – innovation and investment plans

Priority 2 Regional and international cooperation

Priority 3 Innovation and investment

Priority 4 Monitoring progress and shared learning

ACTION AREAS FOR INNOVATION AND INVESTMENT UNDER TARGET 1

Action area 1.1
Increased sustainable intensification level

1.1.1 Improve productivity of aquaculture farming systems throughout the region by improving farm infrastructures, such as pond shape, size and water depth, and promoting technology adoption, such as aeration, smart feeders, renewable energy, water quality and effluent management systems.

1.1.2 Improve access to and reliable supply of high-quality seed, feed and the knowledge to manage aquaculture systems better.

1.1.3 Support aquaculture in suitable "concentrated" areas, especially major river delta areas, and develop aquaculture zones and farm clusters with essential support services. For example, those related to water management, technical assistance, energy generation, infrastructure development and so forth within specialized villages, towns and similar locations.

1.1.4 Innovate and invest in efficient and highly productive aquaculture systems, in ponds, cages and recirculating aquaculture systems that make more efficient use of land, water, energy and other resources.

1.1.5 Improve environmental performance of major commodity species that are technically suitable for intensification at scale, especially a small number of "staple" species that dominate aquaculture production.

Action area 1.2
Sustainable expansion of aquaculture production

1.2.1 Expand aquaculture in locations where feasibility indicates potential for sustainable aquaculture, and with appropriate environmental precautions, social safeguards and assessment of social and economic viability.

1.2.2 Innovate and invest in integrated aquaculture within agricultural farms and landscapes where such systems contribute positively to farm and landscape productivity, resilience and utilize or provide nutrients.

1.2.3 Explore opportunities for aquaculture to restore freshwater or degraded landscapes (including saline soils and degraded coastal areas).

1.2.4 Cautiously incorporate aquaculture in existing natural freshwater bodies where opportunities exist to enhance water productivity.

1.2.5 Ensure aquaculture expansion is responsible, i.e. it is conducted within environmental carrying capacity and does not negatively affect biodiversity or livelihoods.

1.2.6 Innovate and invest in mariculture within coastal regions and oceans through improved planning, technological development and incorporation into Ocean and Blue Economy investment strategies. In particular noting the opportunities for integrated multitrophic aquaculture, regenerative aquaculture and extractive mariculture systems such as those targeting seaweed and shellfish.

Action area 1.3
Diversification of aquaculture species, products and markets

1.3.1 Maintain diverse aquaculture species and systems and develop markets and brands for diversified species and products, including seaweed, aquatic plants and mollusc aquaculture.

1.3.2 Develop new aquaculture products and brands, such as high-value or high-yield species for local and export markets, omega-3 and micronutrient rich aquatic food products, no off-flavour aquatic food, ornamental fish and certified aquatic food.

1.3.3 Adopt farm production and management schedules that are better aligned to market requirements, such as early and delayed harvests to avoid seasonal oversupply and to obtain higher unit prices.

Action area 1.4
Accelerate innovation and investment

1.4.1 Improve research and innovation systems to stimulate investment in solutions to sustainable intensification and expansion. For example in production system efficiency; water quality improvement; resource recovery in a circular economy; advances in species domestication, genetics and selective breeding; sustainable aquafeeds and feeding strategies to improve feed conversion efficiency; disease control and biosecurity; and reducing environmental footprints.

1.4.2 Ensure national policy environments enable sustainable aquaculture businesses to grow and encourage private investment in new innovations, start-ups and business development that contribute to aquaculture transformation.

1.4.3 Increase public investment to improve infrastructure for sustainable aquaculture, including "traditional" infrastructure such as seed banks/centres, processing and market infrastructure, renewable energy, irrigation, finance, logistics and "transformative" digital infrastructure that can enhance efficiencies in production, marketing and knowledge exchange.

1.4.4 Shift aquaculture from traditional labour-intensive farming methods towards technology- and innovation-driven business, including inclusive application of digital- and data-driven approaches, mechanization and new technologies.

ACTION AREAS FOR INNOVATION AND INVESTMENT UNDER TARGET 2

Action area 2.1
Improving on-farm resource use management and production system efficiency, including use of waste streams

2.1.1 Apply an Ecosystem Approach to Aquaculture to enhance environmental performance and ensure the sustainable use and management of aquatic biodiversity.

2.1.2 Increase coverage of national and international aquaculture certification and environmental improvement schemes that enable adoption of better environmental management practices and reduce environmental footprints, including reduction of GHGs in sustainable aquaculture.

2.1.3 Seek integration and synergies with other sectors – such as agriculture, capture fisheries, forestry, tourism, renewable energy and other sectors, and agrifood systems – for increased efficiency in use of resources and greater contribution to food system resilience.

2.1.4 Innovate and invest in extractive non-fed species such as seaweeds, bivalves and nature-positive and regenerative aquaculture systems that create positive environmental and biodiversity outcomes.

2.1.5 Innovate and invest in accessible and easy-to-use technologies that can be widely adopted at scale to improve water efficiency and increase water productivity, promote on-farm recirculation and treatment of pond effluent water using physical (filtering and sedimentation), biological (filter-feeding fishes and molluscs, water plants, microorganisms) and responsible chemical (e.g. ozone disinfection) methods. Monitor and recycle waste stream or underutilized aquaculture nutrients through regenerative aquaculture systems (e.g. biofloc systems, extractive aquaculture and integrated crop systems).

2.1.6 Innovate and invest in utilization of by-products from aquatic food processing as aquafeed ingredients, encourage the use of non-traditional sources of protein from agricultural waste streams (e.g. insect meal).

Action area 2.2
Feeds and feeding for sustainable aquaculture

2.2.1 Reduce the GHG and environmental footprints of aquaculture feeds through better ingredients, better formulation and manufacture of the aquaculture feeds, and better management and precision-use of aquaculture feeds on farm. Feed formulas should be nutritionally balanced and precisely designed to the requirements of farmed species based on age, genotype, environmental and immune status.

2.2.2 Reduce dependency on wild-caught fish as sources for aquaculture feeds through use of alternative and sustainable ingredients and shift from feeding trash fish to adoption of formulated feeds and better feeding practices.

2.2.3 Increase innovation and investment in development and adoption of alternatives at scale, such as agricultural by-products, microbial sources and insects.

Action area 2.3
Promoting conservation, sustainable use and development of aquatic biodiversity and genetic resources

2.3.1 Implement the Global Plan of Action for Aquatic Genetic Resources (FAO, 2022f) within Asia and the Pacific region.

2.3.2 Strengthen national institutions and create legislation to manage aquatic biodiversity and genetic resources, improve production permit licensing, seed quarantine regulations, and explore intellectual property protection systems aligned with the Nagoya Protocol.

2.3.3 Implement risk assessment and better safeguards as well as protection of natural environments from the adverse impacts of aquaculture escapees and deliberate or accidental release to open waters.

2.3.4 Innovate in genetics and breeding biotechnologies to improve aquaculture efficiency, improve production and system resilience, while applying risk assessment before upscaling and dissemination.

2.3.5 Improve the infrastructure for conservation of wild relatives and farmed types of cultured species, breeding and propagation as well as strengthening of broodstock and seed production and distribution systems. Promote the appropriate development (with a focus on selective breeding), commercialization, extension and application of improved farmed types.

Action area 2.4
Enhancing aquaculture biosecurity capacity

2.4.1 Implement the Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB) (FAO, 2020b) through application of PMP/AB tools (e.g. biosecurity plans, biosecurity risk assessments along the aquaculture value chain, emergency preparedness and contingency planning, surveillance and reporting, diagnostics, health economics and farm-level biosecurity).

2.4.2 Encourage FAO and NACA members to develop and implement a National Strategy for Aquatic Organism Health within the PMP/AB, a broad yet comprehensive strategy to build and enhance capacity for the management of national aquatic biosecurity and aquatic plant and animal health.

2.4.3 Encourage FAO and NACA members to implement the FAO Action Plan on Antimicrobial Resistance (2021–2025) (FAO, 2021) within the One Health goals and in particular the development of country National Action Plans on AMR. Under the One Health approach, it is essential to make progress in the prevention and control of diseases that spread between animals and humans, tackle AMR, and ensure food safety and healthy production of farmed aquatic species.

2.4.4 Improve implementation of international standards on animal health and sanitary and phytosanitary measures (e.g. World Organization for Animal Health Aquatic Code; The 1995 World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures) and other regional and national instruments that will encourage adoption of best practices; assist in reducing the risk of disease transfer and other adverse impacts on wild and cultured stocks and promote responsible movement of live aquatic animals.

Action area 2.5
Coping with climate change and other trauma

2.5.1 Ensure that states, territories and major aquaculture industries are prepared for climate change impacts on all aquaculture production systems and value chains.

2.5.2 Implement risk reduction strategies, including advanced planning, early warning and risk assessment, insurance products, as well as emergency response systems and contingency planning for droughts, floods, disease outbreaks and other climate-related risks.

2.5.3 Invest in climate- and disaster-resilient aquaculture infrastructure.

2.5.4 Develop aquaculture farmed types with greater resilience and tolerance to higher temperature, salinity variation and other climate stressors.

2.5.5 Reduce the GHG emissions from aquaculture systems and value chains at all levels through technologies, policies and investments, making substantive progress towards a net-zero aquaculture food system in the region.

ACTION AREAS FOR INNOVATION AND INVESTMENT UNDER TARGET 3

Action area 3.1
Contributing to healthy and nutritious diets through aquaculture

3.1.1 Invest in policy and business solutions that promote aquatic food consumption as part of a sustainable healthy diet within national food, diet and health policies and guidelines.

3.1.2 Implement aquatic food safety regulations and standards throughout the aquaculture value chain to ensure safe and healthy food from aquaculture is accessible to all.

3.1.3 Improve communication to consumers of the benefits of aquatic foods in healthy and sustainable diets and conduct campaigns that improve the image of aquaculture. Reward better practices and highlight the benefits of sustainable aquaculture, including its vital role in healthy and sustainable diets, livelihoods and economic growth, as well as its capacity to reduce the impacts of climate change.

3.1.4 Eliminate spoilage, food loss and waste in aquaculture value chains by improving practices during harvesting, storage and transport. Innovate and invest in new products from the conversion of parts of aquatic species of low value into sustainable, tasty and safe products of high nutritional value, low cost and with a high level of acceptability.

3.1.5 Ensure the availability and accessibility of safe and nutritious aquatic food by innovating and investing in better infrastructure and marketing systems.

3.1.6 Integrate aquatic foods in an environmentally, economically and socially sustainable manner into food, health and nutrition strategies, programmes and policies, including school feeding programmes and public procurement programmes for feeding children and nutritionally vulnerable populations.

Action area 3.2
Innovating and improving aquaculture value chains

3.2.1 Invest in upstream and downstream businesses that contribute to aquaculture intensification, generate more value for aquatic products and provide more employment opportunities (e.g. in sustainable aquaculture feed ingredients, processing and capture of food loss and waste, digital marketing infrastructure and improved machinery).

3.2.2 Encourage the industry to innovate and invest in value chain improvements that enhance efficiency and access of consumers to safe and healthy aquaculture products. This should occur across the spectrum of aquatic food trading systems, intermediaries, specialized export, wholesale and retail markets. Improve quality and food safety control through wider adoption of traceability, certification, ecolabelling, branding, digital applications and effective marketing for the whole aquaculture value chain. Promote regional trade of farmed aquatic products in Asia and the Pacific region.

3.2.3 Promote aquaculture-related research and innovation on value chain improvement in the seed, feed, farming machinery, processing, marketing and branding domains.

Action area 3.3
Empowering value chain actors

3.3.1 Invest in capacity-building activities that build skills and knowledge in aquaculture transformation among private and public extension agents, government official and financial institutions.

3.3.2 Innovate and invest in digital- and data-driven approaches to optimize value chains, enhance market competitiveness and shift value chain organization towards improved environmental and social outcomes.

3.3.3 Ensure that equitable access to resources and services delivers new and secure existing aquaculture-based livelihoods, particularly inclusivity of all small actors.

3.3.4 Support formation, engagement and involvement with aquaculture organizations.

Action area 3.4
Promoting equity

3.4.1 Empower small producers, women, youth and Indigenous Peoples to receive equal opportunities for access to training, information, technology and markets.

3.4.2 Remove all forms of discrimination against gender in laws and regulations, mainstreaming gender targets in all aquaculture certification, accreditation, and labour policies and practices, as well as in toolkits and guidance on aquaculture development.

3.4.3 Encourage more opportunities and market access for small-scale and artisanal aquaculture through value chain improvements and marketing.

Action area 3.5
Decent work and social protection in aquaculture

3.5.1 Adopt FAO Guidance on Social Responsibility in Fisheries and Aquaculture Value Chains to increase social responsibility in aquaculture value chains and to promote human and labour rights, including decent work and social protection in the sector.

3.5.2 Promote access to accident, life and health insurance, social insurance, and financial services for aquaculture practitioners, especially in developing countries.

ACTION AREAS FOR INNOVATION AND INVESTMENT UNDER TARGET 4

Action area 4.1
Prioritizing aquaculture in national development strategies

4.1.1 Raise awareness of the connections of aquaculture to SDG progress. Mobilize policymakers, the private sector and CSOs to translate the vision of aquaculture transformation into action.

4.1.2 Ensure aquaculture and aquaculture products are integrated within national food and nutritional security, health and climate policies and action plans.

4.1.3 Ensure consumption of diverse aquatic foods is provided as a key component in countries' food-based dietary guidelines and public health nutrition policies.

Action area 4.2
Improving aquaculture governance

4.2.1 Prepare feasible policies, plans, legal and institutional frameworks that are aligned with the national priority actions for aquaculture transformation, using the White Paper as a guide.

4.2.2 Ensure public investment for creating national science, technology and innovation systems that are required to stimulate innovation and investment into growing innovative aquaculture businesses and business models that transform at the scale needed.

4.2.3 Prepare national and regional investment plans and strategies aligned with White Paper targets to ensure national policy environments and incentives that are attractive to public and private investors and financial institutions.

4.2.4 Ensure the goals for aquaculture transformation – improved environmental performance, climate resilience and social inclusion – are integrated within aquaculture policies and planning and national aquaculture development programmes.

Action area 4.3
Develop monitoring and reporting systems for tracking the implementation of the investment plans and evaluating the impacts from the investment

4.3.1 Improve national-level statistical data collection systems by building institutional, financial, technological and digital capacities.

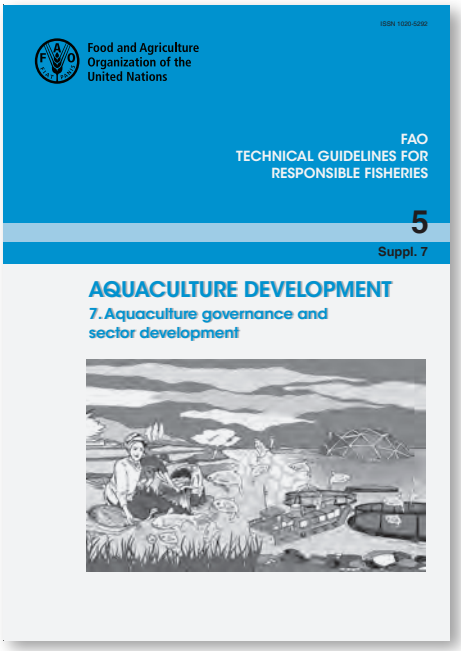
4.3.2 Develop monitoring and reporting systems for aquaculture in all countries and territories that are capable of evaluating the growth and ecological, social and economic performance of aquaculture.

4.3.3 Develop indicators, monitoring and reporting systems to support the assessment of performance.

Action area 4.4
Establishing and promoting transparency, certification and improvement systems

4.4.1 Promote public and private, national and international certification to be more widely adopted and applied to aquaculture transformation within Asia and the Pacific region, such as through better management practices, good aquaculture practices and aquaculture improvement project schemes.

4.4.2 Give special attention to the empowerment of small farmers and value chain actors in certification and aquaculture improvement schemes, including through better farmer and stakeholder organizations that enable better access to knowledge, services, markets and certification.



ACTION AREAS FOR INNOVATION AND INVESTMENT UNDER TARGET 5

Action area 5.1
Develop knowledge transfer and exchange platforms

5.1.1 Strengthen aquaculture knowledge transfer platforms, public and private partnerships and innovation systems within the region, making best use of digital approaches, to promote collaboration in innovating new technologies and wider exchange and uptake and investment in better practices and new innovations.

Action area 5.2
Strengthening partnerships for innovation, technology transfer and exchange

5.2.1 Strengthen partnerships for knowledge exchange – public and private extension and aquaculture education systems – to enhance aquaculture technology and knowledge transfer among stakeholders and economies.

5.2.2 Make best use of the opportunities of digital- and data-driven approaches to strengthen knowledge and capabilities among the aquaculture community for better decision-making, and education and extension activities that strengthen cooperation and networking.

5.2.3 Strengthen national and regional partnerships between public and private sectors to prioritize areas for action; stimulate "precompetitive" collaboration of topics of common concern and invest in innovation for aquaculture transformation.

5.2.4 Support industry associations and dialogues for industry-led collaboration that encourage problem-solving, innovation and scaling of aquaculture transformation solutions.

ROADMAP FOR IMPLEMENTATION AND MONITORING BY KEY ACTORS

This White Paper provides a guiding framework with priority targets and action areas for innovation and investment in terms of aquaculture transformation in Asia and the Pacific region. National-level plans, cooperation and partnerships, and mobilization of investments from governments and the private sector are needed to implement the actions provided in the White Paper.

A monitoring and learning system is also needed to follow the progress in aquaculture transformation within the region, and to stimulate and share learning. The roadmap suggests four priorities to monitor the implementation of this White Paper.

Priority 1
National aquaculture transformation – innovation and investment plans

A National Innovation and Investment Plan for Aquaculture Transformation is recommended as the foundation for aquaculture transformation at the national level. A systems approach should be used to identify policy and investment priorities in aquaculture transformation that are feasible and tailored to national contexts of aquaculture industry structure and status, social and economic conditions, natural resources endowment, climate risks and comparative advantages. These plans should identify suitable and feasible targets, aquaculture farming systems and species, and investments and innovations needed to enable national aquaculture transformation. They should encourage aquaculture to evolve from lower to higher stages of sustainable intensification through innovation, commercialization, expansion, intensification and industrialization. Economic, policy and life-cycle analytical tools and stakeholder consultations can be used to explore scenarios and options to identify investment priorities.

Priority 2
Regional and international cooperation

Regional and international cooperation is required to support aquaculture transformation in the region. Cooperation among national and local governments, private sector actors and their representatives and other stakeholders and development partners can accelerate progress by finding and sharing solutions and stimulating innovation and investment.

FAO can play an important role in enabling NACA, and other international and regional organizations, to disseminate and support adoption of this White Paper by developing key platforms, multistakeholder forums, guidelines and tools as well as supporting and strengthening collaborations and knowledge transfer for aquaculture transformation.

Guidelines and training for preparing national aquaculture transformation plans are needed and can be developed and organized by NACA. Aquaculture industry associations and organizations representative of the aquaculture industry can also play important roles in stimulating industry leadership in finding solutions to common problems and mobilizing progressive action towards innovation, investment and aquaculture transformation.

Priority 3
Innovation and investment

Public and private investment is needed at a significant scale to achieve the targets required for aquaculture transformation. Aquaculture transformation represents an opportunity for bringing new innovations and investment into the region.

Innovating and investing in, *inter alia*, new collaboration, innovation systems, capacity-building tools, climate-proofing infrastructure, feed mills, hatcheries, aquaculture technologies, processing facilities, innovation systems, digital infrastructure and new services will be essential for sustainable aquaculture intensification and expansion. NACA Members, public sector institutions and development banks and private financing institutions should all be engaged, collectively and individually, in stimulating and accessing the finance needed for aquaculture transformation within the region.

Financial investments and innovative financing solutions should be integrated into national aquaculture transformation plans. Innovation and investment should give special attention to inclusion – encouraging innovation that includes smallholders, women, youth and Indigenous Peoples.

Priority 4
Monitoring progress and shared learning

FAO and NACA need to build an institutional monitoring system to monitor, measure and review the progress and results in aquaculture transformation, using a set of indicators, including aquaculture's contribution to food and nutrition security and social outcomes and environmental impacts. Indicators should be developed according to regional contexts and aligned with the 2030 Agenda for Sustainable Development.

Monitoring of progress and lessons learned can be shared with stakeholders by using multiple mechanisms such as annual progress reports, websites, workshops and symposiums. A guideline on monitoring results and learning for aquaculture transformation, taking account of FAO statistics, NACA and regional data infrastructure, will be prepared during 2023 to guide progress.

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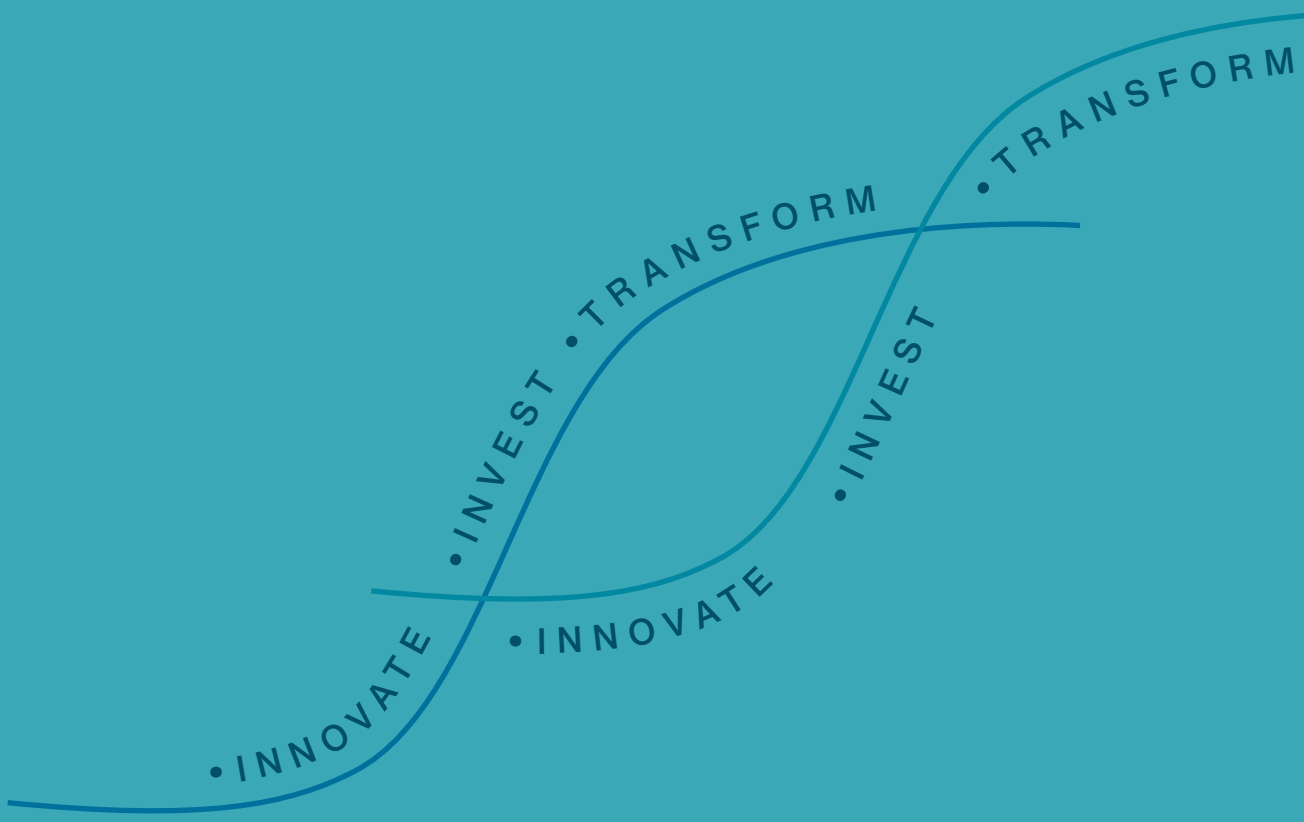

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