

Aquatic Food Systems: The Next Frontier



ANNUAL REPORT 2023

Welcome to the
2023 WorldFish
Annual Report

Our Value Proposition

Big Splashes in 2023

Amping Up
Aquaculture Gains
with Genetic Insights

Advances in Disease
Diagnostics Drive
Aquaculture
Sustainability

Evidence to
Turn the Tide for
Small-Scale Fisheries

Strengthening
Climate Resilience
through Information
Sharing

The Data Revolution
in Small-Scale
Fisheries
Management

A Gender Lens for
Better Nutrition and
Resilient Livelihoods

Responsive Value
Chains to Accelerate
Africa's Blue
Economy

Modeling Aquatic
Food Systems of the
Future

Asia–Africa
BlueTech
Superhighway

Moving toward
NextGen
Partnerships for
Greater Impact

Emerging
Breakthroughs
in Aquatic Food
Systems

Meet the
Authors

Finances

Our Donors

Citation

This publication should be cited as: WorldFish. 2024. WorldFish 2023 Annual Report. Penang, Malaysia: WorldFish. Annual Report: 2024-27.

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For more information, please visit www.worldfishcenter.org.



about

WorldFish

WorldFish is a leading international research organization working to improve food security, nutrition, and livelihoods through aquatic food systems that are sustainable, equitable, and inclusive. It collaborates with international, regional, and national partners to enable the delivery of transformative innovations, tools, and practices to advance aquatic food systems through its cutting-edge research, evidence for policymaking, and knowledge co-creation. With a global presence in 27 countries across Asia, Africa, and the Pacific, and growing, WorldFish has established itself as a global leader in research and innovation in the realm of sustainable aquaculture and fisheries.

Our Vision

An inclusive world of healthy, well-nourished people and a sustainable blue planet, now and in the future.

Our Mission

To end hunger and advance sustainable development by 2030 through science and innovation to transform food, land and water systems with aquatic foods for healthier people and planet.

Table of Contents

6

Welcome to the 2023 WorldFish Annual Report

14

Evidence to Turn the Tide for Small-Scale Fisheries

8

Our Value Proposition

16

Strengthening Climate Resilience through Information Sharing

9

Big Splashes in 2023

18

The Data Revolution in Small-Scale Fisheries Management

10

Amping Up Aquaculture Gains with Genetic Insights

12

Advances in Disease Diagnostics Drive Aquaculture Sustainability



20

A Gender Lens for
Better Nutrition and
Resilient Livelihoods

24

Modeling Aquatic
Food Systems of the
Future

30

Emerging
Breakthroughs in
Aquatic Food Systems

22

Responsive Value
Chains to Accelerate
Africa's Blue Economy

26

Asia–Africa BlueTech
Superhighway

32

Meet the Authors

28

Moving toward
NextGen
Partnerships for
Greater Impact

36

Finances

37

Our Donors

Welcome to the 2023 WorldFish Annual Report

The year 2023 was a pivotal one for environmental action and sustainability. Despite being the hottest year on record, it brought food systems into the global spotlight, with 159 countries signing the Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action. This commitment, alongside the Global Stocktake and the Global Goal on Adaptation, provides the much-needed boost for WorldFish and other likeminded organizations to leverage increased commitments for transforming our food systems at scale.

For aquatic foods, one of the main highlights of 2023 was the surge in global acceptance of the World Trade Organization (WTO) Agreement on Fisheries Subsidies—a monumental step toward responsible fisheries management. This agreement brought us closer to its full implementation, reinforcing our commitment to sustainable and fair practices and conserving biodiversity.

Furthermore, the historic agreement to establish a legally binding instrument for the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (the BBNJ Agreement) was a key milestone reached in June 2023, preserving biodiversity in the high seas.

For our part, WorldFish has been working right at the forefront, ready to support the implementation of these decisions.

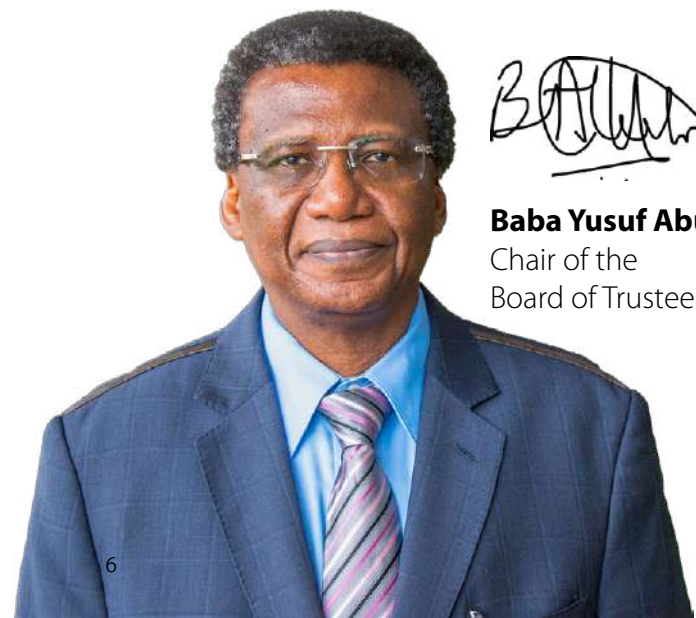
With a suite of proven scientific innovations, transformative digital tools, and evidence to inform policy, we are at a turning point where we can unlock the full potential of aquatic food systems to address global challenges—from strengthening nutrition security and alleviating poverty to adapting to climate change and restoring biodiversity.

In this report, WorldFish scientists share their contributions to scientific advances and pioneering research that lay a new vision for food systems to ensure a healthy and sustainable future for people and the planet.

Our work in 2023 underscores the tremendous promise of genetic advancements in aquaculture in meeting the rising demand for aquatic foods while supporting local economies and nutritional goals. The dissemination of the genetically superior Generation 3 (G3) rohu strain to Bangladesh and the ongoing improvements in Genetically Improved Farmed Tilapia (GIFT) demonstrate how targeted genetic enhancements can revolutionize aquaculture efficiency and productivity.

Our advancements in disease diagnostics and management are setting new standards for aquaculture sustainability while contributing to One Health. Through digital farm-level diagnostic tools and tailored treatments, we are empowering small-scale fish farmers to protect their stocks and reduce losses.

We also made significant strides in fisheries management. The Illuminating Hidden Harvests publication, a comprehensive study jointly conducted with The Food and Agriculture Organization of the United Nations (FAO) and Duke University highlighted that small-scale fisheries account for 40 per cent of the global



A handwritten signature in black ink, appearing to read 'B. Abubakar', written over a light blue background.

Baba Yusuf Abubakar
Chair of the
Board of Trustees

catch and support nearly 500 million people. We also published a co-management guidebook with the Wildlife Conservation Society and James Cook University, offering best practice for localized management. Additionally, we piloted co-management systems in Timor-Leste and Indonesia, focusing on enhanced nutrition outcomes and optimized fishing methods for sustainable and equitable fisheries.

In 2023, we also unveiled new insights to ensure gender-sensitive research and interventions that can empower women and marginalized communities. In doing so, we can ensure advances in aquatic foods systems are inclusive and equitable.

WorldFish's impact is evident in the numbers: 393,765 people, including 192,362 women and marginalized groups improved their livelihoods and incomes through our research and innovations in 2023. We developed 17 new policy influence and investment cases, established 418 active partnerships, and produced and published 355 new knowledge products.

Looking ahead, the integration of advanced modeling and foresight tools will be essential for informed decision-making. Our economic models and integrated assessment frameworks provide valuable insights into future scenarios, helping policymakers anticipate challenges and opportunities to make informed decisions conducive to economically and environmentally beneficial aquatic food systems.

As we navigate the complexities of climate change, overfishing, habitat degradation, and pervasive malnutrition, the advancements highlighted in this annual report demonstrate the potential of scientific innovation for transformative impact.

We could not achieve these milestones without the unwavering support of our partners, host countries and donors. Collaboration and "next generation" partnerships lie at the heart of our work. Together, we have pushed the boundaries of what is possible, driving forward innovations that make a tangible difference in the lives of millions.

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We want to take this opportunity to thank all our partners, stakeholders, staff, and communities for joining us in this vital journey. Together, we are unlocking the full potential of aquatic food systems, ensuring they continue to nourish and sustain the world's population while preserving the health of our planet.



Essam Yassin Mohammed
Director General WorldFish



Our Value Proposition

Why Invest in Aquatic Foods

Aquatic food systems have a large and distinct sphere of impact

Provides **food, nutrition, and livelihoods**



3.3 billion

People receiving their micronutrients from aquatic foods globally



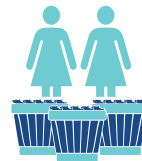
90 percent

The percentage of small-scale fishers living in low- and middle-income countries



600 million

People dependent on fisheries and aquaculture for their livelihoods



1 in every 2

Workers being a woman in fisheries and aquaculture sector

Is an engine for **economic growth**



USD 424 billion

The value of aquatic food production in 2020



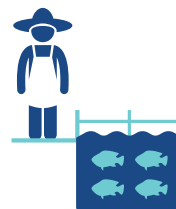
200 percent

The increase in production trade value since international standards for fisheries set in 1995



44 percent

The portion of global catch in economic value coming from small-scale fisheries



22 percent

An estimated increase in aquaculture production by 2030 from 2020 levels

Lowers carbon footprint

For producing healthful nutrient-dense foods compared to land-produced crops and livestock

- **36 percent lower** environmental impact from WorldFish's selectively-bred Abbassa Nile Tilapia
- **Lower environmental stressors** from small fish and bivalve aquaculture than chicken, the most efficient major terrestrial animal-source food



Big Splashes in 2023

Contributions and Achievements Globally

Global Public Goods for Sustainable Aquatic Food Systems Produced



54

journal articles published



355

new knowledge products produced and published in 2023



70

innovations in aquatic food systems

Improved Nutrition and Food Security



62,601

people received adequate nutrition with aquatic foods integrated in their diets

Greenhouse Gas Emissions Reduced in Food Systems



436,600 MT

of farmed fish were produced with reduced CO₂ emissions

Environmental Health and Biodiversity Improved



339,418 hectares

brought under sustainable/improved management

Improved Livelihoods and Resilience



393,765

people have improved their livelihoods and incomes thanks to WorldFish research and innovations



192,362

women and marginalized groups have improved their livelihoods and incomes thanks to WorldFish research and innovations



118,835

people trained to enhance their capacity in fisheries and aquaculture

Capacity of Value Chain Actors Strengthened



118,810

actors upskilled in both long and short term programs



55 percent

trainees who were women

Strengthening Collaboration and Policy Influence



418

active partnerships established



17

new policy influence and investment cases established

Amping Up Aquaculture Gains with Genetic Insights



John Benzie
Principal Scientist

Around 600 million people depend on fishing and aquaculture for their livelihoods. Yet the global catch is declining from overfishing, habitat degradation and warming oceans. As such, the stakes are high in the quest for quality fish breeds. Add to that, the demand for aquatic foods is set to double by 2050. With targeted genetic enhancements in fish, we can ensure aquaculture not only meets these demands, but is also the backbone of local economies and nutrition goals in vulnerable countries.

Breeding fish that grow quickly and are hardy against diseases can significantly reduce the risks associated with securing food and nutrition and making a living. As the climate changes, however, fish breeds that can withstand environmental shifts are becoming increasingly critical.

Pioneering Sustainable Aquaculture with G3 Rohu

In 2023, the transfer of WorldFish's G3 Rohu to the Bangladesh Fisheries Research Institute marked a significant milestone for the country. This genetically enhanced strain matures 37 percent faster than traditional rohu, a globally significant species, promising a revolution in aquaculture efficiency.

The transfer was the culmination of over 11 years of research under the WorldFish Carp Genetic Improvement Program (CGIP) set up with the support of the United States Agency for international Development (USAID), Bill & Melinda Gates Foundation, International Fund for Agricultural Development, EU and CGIAR to improve the productivity and profitability of carp aquaculture systems in Bangladesh through fast-growing carp strains.

Rohu is a staple in Bangladesh's aquaculture, accounting for more than 78 percent of total pond production along with catla, mrigal carp and silver carp. As such, the introduction of G3 Rohu is poised to dramatically boost production and act as a safeguard against the effects of climate change, ensuring a consistent and cost-effective supply of essential proteins and livelihoods to millions of people.

With the program also undertaking genetic improvement of catla and silver carp, the research is tackling the pressing issues of food security and economic reliance on fisheries head-on.



Spreading and Securing GIFT

WorldFish's GIFT, a project that started in 1988, has demonstrated the success of a food systems approach to improving nutrition and livelihoods. Countries such as Timor-Leste, which is now on to the 14th generation of GIFT, have increased incomes and stimulated hatchery and feed businesses. In 2023, specifically, these countries were able to nourish the diets of kids through school meals program with now easily accessible and affordable fish.

It is estimated that more than 50 percent of global tilapia production is from GIFT and GIFT-derived strains. Advanced genetic technologies are, therefore, paramount to shed light on the genetic factors influencing growth, feed efficiency and additional traits that will be crucial to produce resilient fish that will maintain production of this important fish breed in the face of environmental change.

In partnership with the Earlham Institute, we published the first high-quality assembly of the GIFT genome, increasing our understanding of Nile tilapia genomes. We discovered substantial and unique genetic variation in farmed strains of tilapia, highlighting the need to use this strain-specific resource to inform future breeding programs.

This new, more accurate genome sequence will make it easier to identify genes influencing disease susceptibility, growth rate and feed conversion (the measure of how efficiently a

fish converts feed into body mass). It will also allow us to tailor our breeding programs to improve these important traits for efficient food production and adaptation to climate change.

Tailoring Genetic Innovations to Communities

To promote social equity, it is critical to ensure that our genetic programs and innovations, like GIFT, are tailored to empower women so that the benefits of aquaculture are equitably distributed.

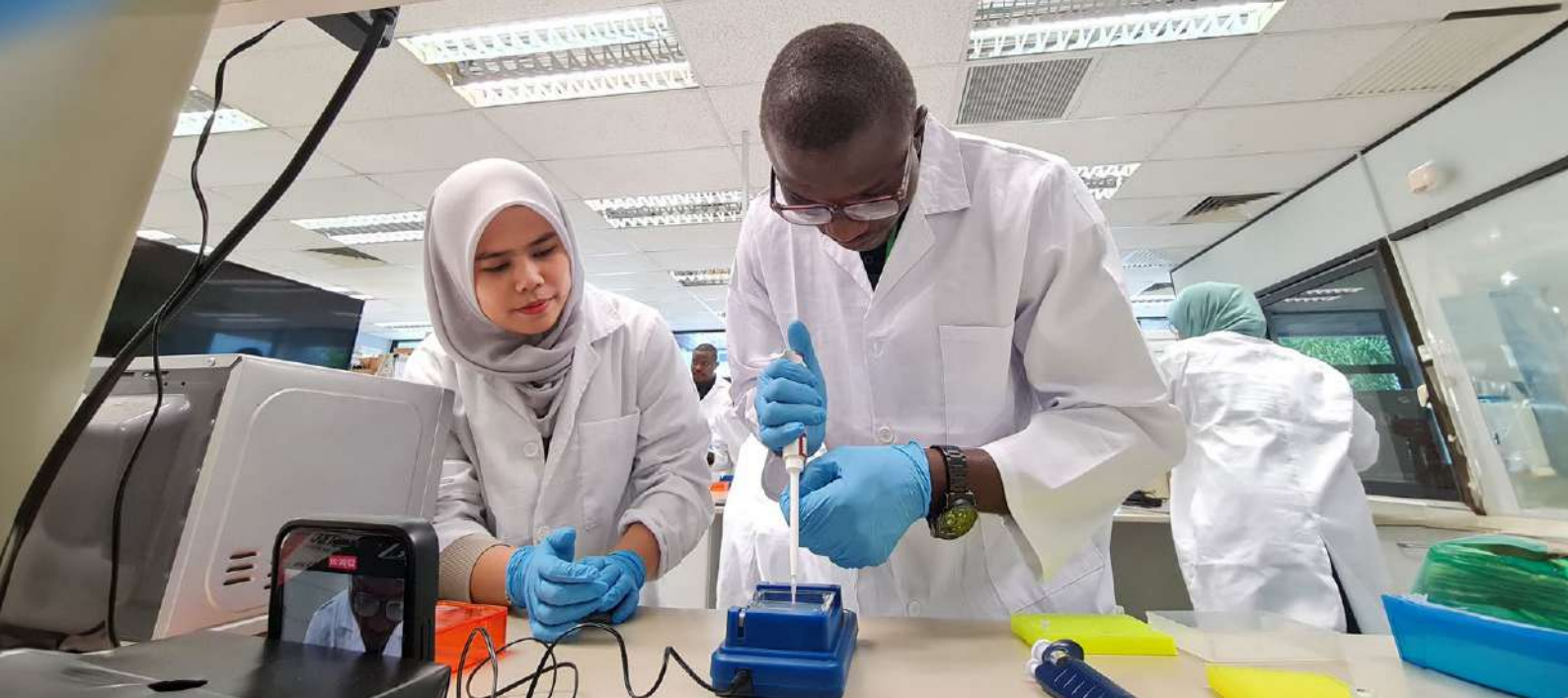
In 2023, we published a paper on the preferences of male and female tilapia farmers in the districts of Jessore and Mymensingh in Bangladesh. The study reinforced the importance of integrating gender perspectives into breeding programs. It showed that, while some preferences were shared by both men and women, in some cases, preferences differed because of a division in roles and responsibilities. Women, who are usually the primary food preparers in the house, valued characteristics that refer to eating quality, like taste and freshness. Men, on the other hand, tended to prefer traits that enhance growth rate, feed efficiency and profitability.

These findings on gender-disaggregated trait preferences will help embed social equity and community well-being into the design of our breeding programs and genetics research.

The Work being Done Today is Vital to Tomorrow

These advances in aquatic animal genetic research are not just increasing production but are transforming how we can sustainably harness aquatic food systems to nourish the world amid climate change. By focusing on the most widely consumed and hardy fish species, such as tilapia and carp, for genetic improvements and understanding the human element in genetics research, we are setting the stage for resilient aquatic food systems that support both ecological balance and community needs. Our aim is make aquatic foods a sustainable and resilient part of our global food system that contributes to the health of people and the planet and shared prosperity.





Advances in Disease Diagnostics Drive Aquaculture Sustainability



Jérôme Delamare-Deboutteville
Scientist



Laura Khor
Research Fellow



David Verner-Jeffreys
Senior Scientist



Rodrigue Yossa
Director, Aquatic Food Biosciences



Mohan Chadag
Principal Scientist

According to the latest data, almost half of the world's fish, shellfish and other aquatic foods are farmed rather than caught, and this is forecast to grow in the years ahead.

Managing health of farmed fish is, therefore, increasingly important as disease outbreaks on fish farms reduce productivity and profitability. Globally, disease-related losses in the aquaculture sector were estimated to exceed USD 6 billion in 2017.

Aquatic animal diseases not only undermine food and nutrition security by reducing supply, but they can also cause foodborne illness in people. This warrants the need for a One Health approach, which treats the health of animals, people and environment as interconnected.

To date, investments into developing diagnostic technologies to help manage the health of aquatic animals have disproportionately focused on globally high-value species such as shrimp and salmon.

At WorldFish, we harness advances in aquatic biosciences to reduce the cost and losses of disease outbreaks to small-scale fishers, who typically rely on lower value and indigenous species, such as carp, catfish and tilapia.

Cracking the Genetic Code of Fish Pathogens

Using new diagnostic tools, we have been able to genetically characterize common disease-causing pathogens that limit aquaculture production in developing countries. This allows for more targeted treatments to prevent or reduce the spread of disease and, therefore, control financial loss.

For example, in 2023 our team sequenced for the first time the complete genome of several tilapia lake virus (TiLV) samples using nanopore technology. TiLV can cause up to 90 percent mortality in affected farms, jeopardizing the

present global production of more than 6 million metric tons of tilapia annually. The disease has been reported in more than 18 countries, including Bangladesh, Colombia, India and the Philippines.

Nanopore sequencing is a simple, accurate, inexpensive and portable system that uses flow cells containing tiny holes or nanopores to measure electric current, which is then decoded to determine the DNA or RNA sequence in real time.

With the complete genomes of viruses isolated from a range of locations, we are better able to understand the genetic variations of the virus, track the emergence of new strains and develop custom vaccines that protect fish from specific disease threats. All of this helps increase the ability to protect tilapia and reduce the economic cost of TiLV to fish farmers.

Protecting Animal and Human Health

We also used nanopore sequencing to track drug-resistant strains of *E. coli* and *Salmonella* in tilapia and shrimp products in wet markets in Bangladesh. These zoonotic pathogens pose a significant risk to human health with growing levels of drug resistance making the diseases they cause increasingly untreatable. Findings on the level and nature of antimicrobial resistant bacteria found in fish and seafood sold in wet markets indicated a need for better hygiene measures within food markets and along the value chain.

Rapid Diagnostics for Healthier Fish and Fisheries

We further leveraged the portability and cost-efficacy of nanopore technology to develop monitoring and diagnostic tools for specific strains of aquatic pathogens. For example, Lab in a Backpack equips specialist end-users with simple and remote methods for sampling, processing, sequencing and quickly identifying disease-causing agents affecting their fishstock. The tool accelerates the ability to treat fish more effectively, develop vaccines and prevent outbreaks from spreading through better biosecurity.

Scaling out the Lab in a Backpack tool can empower developing countries to prevent and manage common disease outbreaks, which means more, healthier fish reaching the market and a better return for small-scale farmers. Rapid and accurate diagnostic data can also inform policymakers, health agencies and industry about emerging food safety issues and encourage investment in improved sanitation practices along the entire value chain.

In 2023, we also worked to build national capacities for managing aquatic animal diseases by introducing nanopore sequencing technology to aquaculture researchers from five different countries through a 6-day training program.

A Fish Health Digital Tool: Reducing Losses for Nigeria's Aquaculturists

To help reduce disease-related losses of catfish in Nigeria, one of Africa's leading aquaculture producers, WorldFish developed the Fish Epidemiology and Health Economics digital survey tool.

Using common smartphones and mobile tablets, this tool enabled the remote collection and auto-compilation of information on different farming systems, practices, inputs and losses to disease across 220 farms in two Nigerian states.

The results provided insights into the risk factors associated with disease spread, which were then used to develop a set of best management practices to improve biosecurity. The data was also used to support national aquatic health strategies to help farmers mitigate losses to disease. These strategies were then shared with businesses, veterinarians, government agencies and academic institutions.



Evidence to Turn the Tide for Small-Scale Fisheries



David Mills

Country Lead, Timor-Leste

Small-scale fisheries (SSF) account for at least 40 percent of the global catch from capture fisheries and are relied upon, at least in part, by almost 500 million people for their livelihoods. The first sale of the catch generates an estimated USD 77 billion in annual revenue.

Yet the socioeconomic and environmental contributions of this vast subsector, which ranges from individuals fishing on foot to those on semi-industrial vessels, have historically been underreported and underestimated. As a result, there is a lack of adequate support at national and local levels for small-scale fishers, so their potential to improve food and nutrition security, gender equity and local economies has stayed untapped.

In 2023, WorldFish played a key role in closing the information gap through landmark research publications that are guiding global communities toward unlocking the full potential of small-scale fisheries.

Illuminating Hidden Harvests

Illuminating Hidden Harvests (IHH) is the most comprehensive, systematic research effort to date to reveal diverse contributions from SSF. Jointly researched and published by WorldFish, the UN's Food and Agriculture Organization (FAO) and Duke University, it contains contributions from more than 800 authors across the globe and is based on 58 country case studies.



Patrick Smallhorn-West

Postdoctoral Research Fellow

The first international instrument dedicated to leveraging the benefits of SSF study was the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines) in 2014. As the follow-up to the SSF Guidelines, IHH provides a comprehensive, global understanding of the contributions of small-scale fisheries to sustainable development.

Leading the research on nutrition for the study, WorldFish team found that the fish currently landed by SSF globally represent half of the recommended nutrient intake of omega 3 fatty acids for 987 million women. The healthy fats that fish provide contribute to women's health, healthy pregnancies and infant development. Small-scale fish production also represents more than 20 percent of the recommended intake of calcium, selenium and zinc for 477 million women.

However, to sustain or sustainably increase these and other substantial benefits, there is an urgent need to effectively manage SSF in the face of increased environmental and fishing pressure. The IHH study calls for greater recognition of the role of SSF and for this recognition to be reflected in supportive policies that allow for improved productivity, sustainability and equity.



Hampus Eriksson

Senior Scientist

Devising Small-Scale Fisheries Co-Management Strategies

Two key findings of the IHH report were that (1) fishers and fish workers see themselves as critical contributors to the outcomes of the SSF Guidelines, and (2) co-management, while central to a sustainable future for SSF, is likely implemented for only about 20 percent of the catch from SSF.

In response, in 2023 we published a co-management guidebook, in conjunction with the Wildlife Conservation Society and James Cook University, to support small-scale fishers and other fishery managers to develop best practices in localized settings.

The guidebook compiles emerging research and evidence that, if adopted, would substantially improve outcomes across both ecological and social dimensions, which is largely missing currently. Through a series of infographics, it summarizes a substantial body of research covering varied aspects of co-management, including human rights, gender equality, ecology and life-history, management strategies, human behavior, monitoring, and impact evaluation.

The guide is being used as a key training resource in capacity building programs under development by the partner institutions, including in Timor-Leste.

Co-Management in Practice

Building on three decades of WorldFish and partner research on co-management in the Pacific, our team worked with partners in six small-scale fishery communities in Timor-Leste and Indonesia in 2023 to pilot co-management systems approaches. This involved building systems that improve fisheries and environmental outcomes, with an additional focus on nutrition outcomes.

The pilot focused on two different fisheries: (1) gleaning fisheries, carried out mostly by women who collect invertebrates, seaweeds and small fish at low tide, and (2) fisheries conducted by men in boats around floating rafts or fish aggregation devices that attract fish to make them more accessible to fishers.

Comparative analysis of the nutrient content of catch from these and other important fisheries showed that, while all fish were highly nutritious, fisheries

using devices support the catch of fish with higher overall nutrient value than adjacent reef fisheries. Gleaning fisheries are also important and, at times, fill gaps in household nutrient requirements when other sources of food are seasonally scarce.

The project is working through co-management committees with these communities to test a range of interventions targeted at optimizing the benefits from such fisheries, including improving fishing methods, processing and preservation, and business skills. A special focus is education on the nutritional benefits of fish, particularly for pregnant and breastfeeding women as well as children in the first 1000 days of life.

With support from the Australian Centre for International Agricultural Research, the project is also developing a regional community of practice to further develop and apply these tools.

Developing co-management strategies that allow for full and equal participation in decision-making processes for fishers is essential for addressing the unique needs of each ecosystem. This growing knowledge base, on which to further develop and scale SSF co-management systems, will be key to harnessing the potential of SSF for global food, nutrition and economic security.

Artemia4Bangladesh: Enhancing Agricultural and Food Systems in Cox's Bazar

The Artemia4Bangladesh project, funded by the European Union, aims to enhance agricultural and food systems in the Cox's Bazar area of Bangladesh.

In 2023, significant achievements were made:

- **219 Artemia and aquaculture demonstrations** were set up with improved technologies, leading to the production of 51 kg of Artemia cysts and 3300 kg of biomass. Additionally, 122 metric tons (MT) of shrimp, 233 MT of fish, and 19 MT of crab were produced across 709 hectares through technological improvements.
- **83 capacity development events** were organized, with 2608 participants. Annual incomes of demonstration farmers increased by **85-212%**, depending on the technology adopted, such as Artemia pond culture, shrimp production, improved traditional aquaculture, and homestead pond aquaculture. Trained farmers saw their annual income rise by 66% with the adoption of at least one new technology.

Strengthening Climate Resilience through Information Sharing



Michelle Tigchelaar
Scientist and Climate Impact Area Lead



Edward Allison
Principal Scientist



Peerzadi Rumana Hossain
Scientist

Many of the most climate-vulnerable countries are also heavily dependent on aquatic food systems for nutrition and livelihoods. This leaves them doubly exposed to the impact of climate change on aquatic ecosystems.

Not only are countries like Bangladesh, Cambodia, Malawi and Zambia more likely to face climate hazards, such as flooding, drought and shifting fishstocks, but these hazards are more likely to have a disproportionate effect on food security because of a high reliance on fish and other aquatic foods.

Climate risks to aquatic food systems in low-income countries are often compounded by a lack of information and advisory services for fishers and fish farmers, limiting their ability to effectively pre-empt and adapt to evolving climate-related challenges.

In 2023, WorldFish helped close this information gap by working with governments and partners to develop digital climate information and advisory services and to adapt aquatic food systems to climate change.

Climate Information at the Touch of a Button

For small-scale fish farmers facing increasingly unpredictable conditions, knowledge is power. With advanced warning, farmers can adapt and protect their fishstocks to reduce losses and safeguard their food and economic security. In addition, long-term planning for climate-smart systems, like integrated aquaculture and agriculture (IAA), can ensure the climate resilience of aquatic foods and the benefits they deliver.

Our teams across several countries worked to develop and advance climate-related digital services for fish farmers to help put them on the front foot against climate change.

In Bangladesh, we developed a policy brief alongside the Ministry of Fisheries to help develop the first digital climate information and advisory service for aquaculture in the Bengal Delta as part of the revision process of the national fisheries policy.



At the same time, WorldFish scientists produced the first economic evaluation of climate information services for aquaculture in Bangladesh. The assessment 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.

Meanwhile, in Zambia, one of the most vulnerable countries to climate change, we developed an early warning system for extreme temperatures to help protect farmed tilapia and ensure that farmers can maintain ponds at optimal temperatures for growth and productivity. Temperatures above 40°C (104°F) can be lethal for tilapia, while reproduction is limited below 20°C (68°F).

We developed an algorithm that forecasts water temperature based on air temperature trends. It feeds into a dashboard and generates color-coded alarms to trigger specific actions whenever the pond becomes too cold or too hot.

Traditional Practices for Today's Challenges

Throughout 2023, we also helped fish farmers implement climate-resilient IAA systems. Many such practices have been used across the world for many years, but they can be scaled up for greater impact with technical support for best practices.

In India, we promoted integrated rice and fish farming in flood-affected low-lying areas in Assam to use resources more

sustainably, diversify the food production system and improve income and nutrition. By growing rice and fish together, farmers are less exposed to the negative impacts of extreme rainfall and flooding on paddy fields, as fish offer an alternative source of food and incomes.

The five-year Assam Agribusiness and Rural Transformation Project (APART), supported by the World Bank, promoted rice–fish systems on 500 ha, reaching more than 800 beneficiaries, and was extended by a year in 2023 to build on these successes.

Meanwhile, in Bangladesh, through WorldFish's genetics program, we provided farmers with improved seed for IAA systems, such as the fast-maturing G3 Rohu and small indigenous fish species, which are better adapted to local environments and climate challenges.

The G3 Rohu can grow up to 30 percent faster than conventional breeds with the same inputs, which allows farmers to get a better return. These improved breeds also

contribute to more resilient integrated systems that include growing sweet potato, fruits and vegetables on pond dikes. This helps increase overall productivity as well as dietary diversity.

Through research and evidence-based innovations, WorldFish continues to work to empower fishers and fish farmers to thrive in a changing climate. With record-breaking global temperatures in 2023, those on the frontline of aquatic food systems in the most climate-vulnerable countries increasingly need tools that enable short-term adaptation while building resilience in the long-term.

"WorldFish is one of the long-trusted partners of the Department of Fisheries (DoF) actively supporting in the promotion of Aquaculture and Fisheries sector in Bangladesh to have major impacts in increasing production, income, and livelihoods of millions of people - the smallholder fish farmers, fishers, value chain actors"

**– Syed Md. Alamgir,
Director General,
Department of Fisheries,
Bangladesh**

Embedding Aquatic Foods in National Climate Strategies

As part of an initiative with Stanford University, WorldFish is developing guidelines for integrating aquatic foods into Nationally Determined Contributions (NDCs), the country-level climate strategies submitted under the Paris Agreement.

This effort is part of the growing wave of momentum for food and oceans in global climate negotiations, including the COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action. Almost 160 countries signed the declaration and committed to scaling up adaptation and resilience for farmers and fishers. It also recognized the importance of promoting aquatic foods as part of sustainable food systems.

The NDC guidelines will offer entry points for governments to include fisheries and aquaculture in national plans for climate mitigation and adaptation. This includes implementing sustainable fisheries management, promoting the use of sustainable feeds, reducing food loss and waste, and protecting blue carbon ecosystems.

The Data Revolution in Small-Scale Fisheries Management



Alex Tilley
Senior Scientist



Cristiano Rossignoli
Monitoring, Evaluation and Learning and Impact Assessment Research Leader

The digitalization of fisheries management holds much promise for productive, sustainable and inclusive aquatic food systems. However, the realization of these benefits depends on the availability of reliable and easily accessible data. This is particularly true in many parts of the developing world, which are plagued by significant data gaps.

A change is coming, though. A data revolution in SSF is already well underway in Timor-Leste, one of the newest, smallest and economically weakest countries in the world. Back in 2016, there was almost no reliable information about where coastal fishers went and what they caught. Less of a data gap and more of a gaping chasm, it meant the country's policymakers had no evidence upon which to develop a fisheries strategy to improve food security, incomes and resilience to climate change.

The Peskas system changed that. Developed by scientists at WorldFish, in partnership with the country's Ministry of Agriculture and Fisheries, it uses GPS trackers mounted on the boats of artisanal fishers to capture data about where they go, how often and for how long. Data collectors from the local community meet fishers as they come to shore, documenting their catch. The data is then uploaded to a publicly accessible online dashboard, providing a near real-time view of SSF in the country.

This kind of data can help policymakers decide where some fishing areas may need to be managed more sustainably, or where to deploy fish aggregating devices to improve catches. Peskas is now the official fisheries monitoring system in Timor-Leste and has been used to develop its latest National Fisheries Strategy.

Timor-Leste is now being hailed as an example of how Peskas can work in SSF in Kenya, Tanzania and Mozambique, as part of the WorldFish-led Asia–Africa BlueTech Superhighway (AABS) project, which started in 2023.

Bridging the Aquaculture Data Gap

But data gaps plague fish farming too. For example, until recently there was no baseline data to assess the performance of aquaculture systems, nor a standardized way of gathering it. This made it difficult to make recommendations for introducing or improving aquaculture technologies and practices—a huge challenge given its potential to provide nutrition in remote communities, particularly if agricultural crops fail.

To address this, under the CGIAR Initiative on Aquatic Foods, the WorldFish team undertook smartphone surveys in Nigeria,



Egypt, Bangladesh and India involving thousands of fish farmers. These tracked productivity, profitability, input use and more. The results serve as benchmark data that can be used to show the benefits of different aquaculture approaches, from feeding regimens to the use of genetically improved carp and tilapia. Data from carp polyculture systems has already supported policymaking in Bangladesh and India.

Identifying data gaps in aquatic food systems requires comprehensive access to existing data. However, there is currently no organized integrated platform for scientists to do this. Nevertheless, a good place to start is FishBase, a free online database on marine fish distribution, traits, habitats and more. Due to the historical need for information to manage fisheries, FishBase is skewed toward commercially important marine fish species, so including a wider range of fish, especially those used in aquaculture, could strengthen the database.

Ensuring FAIR Data Standards

Although dealing with data gaps is essential, it is part of a bigger challenge facing scientists, and it is not just about the data. The real revolution hinges on the way data is presented and managed. Adhering to the FAIR principles—Findable, Accessible, Interoperable and Reusable—is essential for maximizing the usefulness of data.

Noise exists partly because of semantics and partly due to a lack of consistent standards in the way data is collected and managed. For example, a fish species can have many names in many languages, with researchers collecting information about it differently. This causes mismatches when scientists, or language-based artificial intelligence (AI) models like Chat GPT, try to compare catch data. One study might call it a “harvest” while another refers to “landings.” It means the data must be manually checked, which is a laborious task.

To tackle this, the Aquadata team is developing an ontology of SSF and aquaculture. This defines maps and categorizes the relations between different fish-related words and concepts to help clean up datasets. It is a simple housekeeping exercise for fish-related language, but one that will supercharge the data by making it FAIR and, therefore, ready for meaningful use by human and AI alike.

All in all, the data revolution in aquatic food systems is well on its way. With these foundations coming into place, fishers and fish farmers in some of the world’s poorest countries may soon benefit from the insights and opportunities the data revolution has always promised.

In some places, they already are.



A Gender Lens for Better Nutrition and Resilient Livelihoods



Rahma Adam
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Senior Scientist and Nutrition Impact Area Lead

Aquatic foods play a significant role in the diets and nutrition of women, especially women and girls of reproductive age, providing a rich source of affordable protein, vitamins, minerals and healthy fats. These nutrients are particularly important for healthy pregnancies and infant development.

At the same time, women play an equally significant role in SSF and aquaculture. Almost half of the 600 million fish workers are women. They work across the entire fish supply and distribution chain and often assume responsibility for adding value to the catch through drying, smoking and marketing.

In 2023, our teams helped increase scientific understanding of the links between gender, nutrition and livelihoods within aquatic food systems. This generated insights that led to high-impact interventions and resulted in tangible improvements in gender equality.

Building Climate Resilience of Women

Part of our work on reducing postharvest fish losses involved applying a gender lens to understand how climate change was impacting women, men and youths and their livelihoods within the fish value chain.

To do this, we conducted a scoping study that assessed the impact of climate change on the livelihoods of fisher communities, with a strong gender lens in the Lake Victoria Zone region of Kenya, to identify key challenges and needs.

Among our findings was the fact that meteorological data (1981–2022) demonstrated a significant upward trend for minimum and maximum temperatures and rainfall. These changes have resulted in declining fishstocks,

destroyed infrastructure, increased conflicts and disease, and reduced incomes, leading to higher poverty levels. The rainfall and extreme temperatures also contributed to postharvest losses because of a lack of fish handling and processing facilities. These losses tend to impact women more than men as they lack access to fish handling facilities and are more involved in small-scale trading.

This insight ultimately led to the delivery of equipment, including solar powered freezers, solar tent driers and smoking kilns. With this equipment, women are able to store and process the fish before it is damaged or lost by the elements, thus improving their opportunities to make a living. Studies indicate up to 60 percent of fish is lost along Kenya's value chain, the equivalent of feeding more than 21 million people.

Women in the region have since started to use the freezers to generate additional income by charging per kilogram to store surplus fish. Many have used the income to pay for their children school fees, among other benefits.

Understanding and Serving Women's Dietary Choices

We also made an important breakthrough in understanding fish consumption patterns in India, which helps inform gender- and nutrition-sensitive decision-making in fisheries management.

In a first of its kind study, carried out in collaboration with the Indian Council of Agriculture Research and completed in 2023, we found higher fish consumption than previously reported in India, a country traditionally associated with vegetarian diets.

Analysis of consumption levels between 2005 and 2021 found that India's fish-eating population increased by a third, the greatest increase of non-vegetarian food after eggs. We also found that men had a higher fish consumption rate (78 percent) than women (65 percent).

This research highlights the need to ensure the responsible management of fisheries and sustainable aquaculture growth to meet current and future demand. But it also identifies opportunities to invest in the fish value chain to benefit women, both in terms of improved nutrition and livelihoods, to close the gender gap.

Understanding the diverse behavior and preferences of fish consumers, including women, throughout India would be the first step toward adopting effective fish production, marketing and policy strategies. A consumer-centric approach to production would help direct investment and innovation toward priority subsectors or species based on demand, ensuring the viability and sustainability of the sector.

Meanwhile, empowering women within aquatic food systems would also support improved nutrition for households and families, including children. For example, mothers committees were among those involved in training sessions on the importance of small fish powder for children as part of a supplementary nutrition program in Assam. As part of the project, more than 3000 children consumed locally produced small fish powder three times per week, while community organizations and women's groups were trained in the nutritional benefits to help support childhood development. Demand

for such fish powder in turn generates income opportunities for women working in fish processing.

Aquatic food systems make vital contributions to the nutrition and livelihoods of women around the world. As we continue to understand these links, we can provide increasingly rigorous scientific recommendations for evidence-based policies and interventions that target gender equality and social inclusion through sustainable fisheries and aquaculture.

A Gender-Transformative Approach Tested in India

In 2023, WorldFish was part of a multilateral partnership involving MicroSave Consulting and the government of Bihar, India, to support the economic empowerment of women.

The partners worked with a group of 101 women who were introduced to aquaculture by Bihar state's rural livelihood mission, JEEVIKA. They were supported with technical guidance and training to restore and make use of a community pond to farm fish.

In just one year, and with no prior experience of fish farming, the women produced 1250 kg of fish and turned a profit of INR 140,000 (USD 1681). Gender equality and social inclusion experts from WorldFish visited the group in October 2023 to incorporate their learnings and insights into gender-transformative approaches that address the root causes of gender inequality, including imbalanced power dynamics and rigid gender norms.

Gender-based and social inclusion tools developed as part of the partnership will be taken forward with support from the Bill & Melinda Gates Foundation.



Responsive Value Chains to Accelerate Africa's Blue Economy



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Despite an abundance of lakes, rivers, oceans, seas and mangrove ecosystems, Africa remains a net importer of fish, which cost the continent USD 4.8 billion in 2014.

With Africa's population expected to reach 2.4 billion people by 2050, demand for fish and seafood will only continue to rise, alongside the need for sustainable forms of employment for a growing number of young people.

Given this, artisanal fisheries and SSF, which already employ some 13 million people, represent significant untapped potential within Africa's blue economy to simultaneously improve food security, diets, livelihoods and economic outlook, contributing to greater shared prosperity.

WorldFish has been working hand in hand with African countries on their ambitious plans to overcome the challenges holding back the sector and to optimize opportunities to grow the blue economy.

A Market-Driven Approach

In 2023, WorldFish supported these goals in several African countries, adopting a systems approach for maximum benefit across the entire value chain, from improved feed and other inputs to market access and sales.

For example, with funding from the German Corporation for International Development (GIZ) and the Norwegian Agency for Development Cooperation (Norad), WorldFish was able to connect communities in rural Zambia and Malawi with high quality feed and fingerlings, as well as extension services, to help increase their household income, food and nutritional security. At the same

time, WorldFish has partnered with Rhodes University of South Africa to pilot a digital app, BUNA. The university developed the app to collect data from aquaculture farmers and deploy advisory services, including market information, to farmers in real-time.

The pilot was undertaken in Malawi and Zambia and generated valuable feedback from the Departments of Fisheries in the two countries, which helped adapt the app to localized needs. GIZ has since adopted the app in one of its projects in northern Zambia.

Meanwhile, agrodealers, cooperatives and aquaculture-based small entrepreneurs in the project areas were also trained in better management practices for aquaculture. As a result of the support they are now receiving and the proximity of necessary inputs, smallholder farmers improved their production and are now able to consider aquaculture as a business and not just a means to livelihood.

Transcending Boundaries for Shared Prosperity

Regionally, through the Programme for Improving Fisheries Governance and Blue Economy Trade Corridors (PROFISHBLUE) in the Southern African Development Community (SADC), funded by the African Development Bank, WorldFish is also working with the SADC Secretariat to build the business acumen of small and medium enterprises (SMEs) in Tanzania and Zambia. This includes outreach around the various mechanisms to attracting financing for their businesses and facilitate their participation in intraregional trade.

To improve the environmental sustainability of aquatic food systems, WorldFish has enabled aquapreneurs in Zambia to insulate their enterprises from climate-related shocks as part of the World Bank-funded Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) project. This involved using a combination of climate information services, agroadvisory services and the adoption of IAA systems in farming where aquaculture is integrated with small livestock and horticulture.

Another challenge to overcome is the slow growth of indigenous fish species in aquaculture. To this end, the Zambian government, working with WorldFish, prioritized the genetic improvement of the three spotted tilapia, with support from the Zambia Aquaculture Enterprise Development Project, funded by the Government of the Republic of Zambia and the African Development Bank.

The main objective of the three spotted tilapia genetic improvement program is to improve the growth performance of the species, targeting harvest weight as a key trait for selection. In 2022, the project produced a genetically diverse base population upon which the program is anchored. Since then, the program has produced the first improved generation of three spotted tilapia, and the best candidates have now been identified to produce the next improved generation that is better performing and resilient.

To build on these foundations, WorldFish is now scoping opportunities to work with governments, donors and the private sector, including commercial banks and insurance companies, to create innovative financing to catalyze the growth of the blue economy.

Aquatic food systems are already a critical part of Africa's economy. However, with sustained investment and development, a thriving blue economy can have a multiplier effect that improves health, equality, environment and community well-being for future generations.

In 2023, Abbassa successfully hosted a total of 15 in-person and 3 hybrid capacity building programs. These programs were carried out with partners such as the U.S. Soybean Export Council (USSEC), the Norwegian Agency for Development Cooperation (Norad), the International Fund for Agriculture Development (IFAD), the Food and Agriculture Organization (FAO), Assam University, the Egyptian International Centre for Agriculture (EICA), Japan International Cooperation Agency (JICA), Fisheries Research Institutions (ICAR), and universities in Algeria (El Tarf and Souk Ahras).

Additionally, the Soy Excellence Center (SEC), in collaboration with USSEC and the U.S. Soybean Board (USB), facilitated 8 virtual training programs. These programs covered areas such as nano-technology in fish production, quality assurance, value addition measures, processing and post-harvesting techniques, water efficiency, fish trade, fish health, sustainability, best management practices, and aquaponic and hydroponic IAA systems.

1127 participants, **705** male and **422** female attendees participated at these programs from 20 countries, including 17 African nations, as well as countries in the MENA region, and Asia. Countries represented included Malawi, Zambia, Uganda, Kenya, Ghana, Mali, Nigeria, Cameroon, Sierra Leone, Tanzania, Guinea, Ethiopia, Eritrea, Benin, Burundi, the Democratic Republic of the Congo, Cote d'Ivoire, Congo, Algeria, Morocco, Egypt, India, Malaysia, and Thailand.

Abbassa facilitated 6 visits for 137 visitors from public universities and the private sector. Three internship programs were introduced for fresh graduates from Faculties of Fish Resources of Kafr El Sheik and Suez universities. In addition, a 3-week summer training was offered to two students from Faculty of Agriculture in Zagazig and Faculty of Science of Arish University, North Sinai.



Modeling Aquatic Food Systems of the Future



Chin Yee Chan
Scientist



Nhung Tran
Senior Scientist

With the increased recognition of its nutritional benefits, demand for aquatic foods has been increasing. According to recent research, it is expected to double by 2050. However, anticipating where and how demand will grow, and what factors might impact aquatic food systems, will determine whether this demand is sustainably met.

This is why foresight and modeling are so important. Projecting various scenarios can give policymakers a glimpse into the future, allowing them to act pre-emptively to avoid issues such as food shortages, price hikes and environmental degradation.

In recent years, aquatic foods have become more integrated into the foresight models of the broader agriculture and land-use sectors, which have developed systems for

anticipating future scenarios related to food production, consumption, trade and prices.

Developments in modeling tools, as well as increased data from developing countries dependent on aquatic foods offers the potential to also assess the future challenges, needs and opportunities on the horizon for aquatic food systems.

Going for Better than Business-as-Usual

In 2023, our team used AsiaFish, a partial economic equilibrium model, to analyze future scenarios for fish supply and demand in Bangladesh. Such modeling, which projects the impact of specific policy actions on relevant markets, can help inform effective policies to meet the nutrition and livelihood needs of the population.



Research compared business-as-usual aquatic food production to four alternative scenarios: (1) increased productivity of farmed tilapia, pangasius and rohu carp, (2) improvements in feed quality, (3) disease outbreaks in farmed shrimps and prawns, and (3) the impact of climate change.

We found that while production was expected to double by 2040 with business as usual, stronger results were associated with increased productivity of tilapia, pangasius and rohu, which are among the most commonly farmed species in Bangladesh. Productivity gains in these species would contribute to lower prices, making an important source of micronutrients more affordable, which is especially important for reducing hunger and malnutrition.

These findings indicate that policies geared toward accelerating the sustainable growth of aquaculture, combined with a nutrition-sensitive approach, will help tackle malnutrition in the country. Also, the findings informed the annual work plan for the Bangladesh Agricultural Research Council, under the Ministry of Agriculture.

Forward Planning for Nature

Foresight and economic modeling research can also anticipate the relationship between increased demand and supply, and subsequent environmental impact and sustainability.

We contributed to a novel integrated assessment framework, published in 2023. The first of its kind, the framework provides a tool to assess the impacts of growing demand for animal-sourced food on the local environment. We achieved this by linking a model of the global agricultural and food system, a landscape-level environmental impact assessment model and an ecosystem services simulation model.

The framework was initially applied to land-based animal-source foods in Tanzania. However, the findings demonstrated how food security gains from increased production could be set against the impact on natural ecosystems. This kind of assessment can help policymakers and decision-makers navigate trade-offs and identify sustainable best practices that deliver the best outcomes for people and the environment.

Preparing for a Changing World

Foresight modeling can also provide crosscutting insights into future scenarios of climate change, population growth, diets and policy shifts. These insights inform government decisions on how best to balance the needs of a growing population with increasingly limited natural resources.

Our recent modeling on fish and rice showed that demand for both commodities was expected to grow across Asia to 2050. This evidence supports the case for adopting integrated rice and fish farming systems to meet this rising demand while also improving the sustainability of both through a mutually beneficial production system.

We also found an expected increase in the consumption of other animal-source foods, pointing toward the Westernization of Asian diets. This valuable foresight helps anticipate the nutritional needs of a population and position aquatic foods as part of a healthy diet. These findings informed the discourse at the 2023 International Rice Congress.

Climate-Smart Aquaculture

Our forthcoming research includes focusing on how we can transition to a low-emission food system by assessing the future supply and demand for fish against socioeconomic and environmental impacts using the International Model for Policy Analysis of Agriculture Commodities and Trade (IMPACT) fish module. The insights will help determine changes to aquatic food production that can maximize the benefits for farmers and consumers.

Ongoing research will also use a revised AsiaFish modeling approach to investigate the implications of climate change impact on fisheries and aquaculture in Egypt, Africa's largest producer of aquatic foods.

Better data and modeling about various aspects of aquatic food systems can better inform decision-making about investments and policies to drive improved nutrition, livelihoods and climate action.



Asia–Africa BlueTech Superhighway

Delivering a Triple Win for Nature, People and Climate

Through WorldFish’s AABS project, a pioneering South-South collaboration platform is being developed between Asia and Africa. The aim is to adapt and scale proven aquatic food systems technologies through knowledge sharing and co-learning across the two continents.

In 2023, AABS brought together research, conservation, development and policy experts from the small-scale coastal fisheries and aquaculture sector in Bangladesh, Nigeria, Kenya, Tanzania, Zanzibar and Mozambique for its inception workshop, held on October 9–12 in Penang, Malaysia.

Many coastal communities in the global South earn a living from diverse but low-yielding SSF and aquaculture. These livelihoods are jeopardized by overfishing, degradation of marine ecosystems, and the impacts of climate change on oceanic waters.

The AABS, a 7-year project funded by the UK Government, seeks to address these challenges through four interconnected work packages:



Work Package 1 (WP1)

Digital Coasts



Work Package 2 (WP2)

Integrated Multitrophic Aquaculture



Work Package 3 (WP3)

Climate-Smart Technologies for Reducing Aquatic Food Loss and Waste



Work Package 4 (WP4)

Incentives for Coastal Conservation and Fisheries Management



The inception workshop and the ensuing rollout of theory of change workshops in countries are convening all actors—from fishers to local associations and government officials. Together, they are mapping out insights, challenges and a way forward, designing AABS from the ground up to tailor solutions to local contexts over the two phases of the project.

Over the course of the project, AABS aims to establish a robust knowledge exchange forum by connecting coastal communities in Asia and Africa to scale out nature-positive solutions for SSF and aquaculture that will help alleviate poverty and restore coastal ecosystems.

“We are very pleased with the work WorldFish is delivering under COAST (2023–2030), which provides an opportunity to expand the evidence base and South-South learning to enable scaling up action on small-scale fisheries, regenerative aquaculture and incentives for coastal conservation in Africa and Asia”.

—Dr Ina Porras, FCDO/AABS Lead



Moving toward NextGen Partnerships for Greater Impact



Ann Fleming
Director, Programs and Impact



Today, WorldFish researchers are tackling socio-ecological problems that pose far more complexity and uncertainty than when WorldFish was first established, nearly 50 years ago. Food systems in our partner countries are under stress and the livelihoods of women and men fishers, farmers and traders face uncertain futures.

At the same time, the research and leadership strengths of our country partners have grown, and they increasingly aspire to engage with us on a 'level playing field' in terms of research prioritization, design and implementation.

WorldFish recognises the role that more collaborative and equal partnering plays in greater accountability to our partners and beneficiaries in delivering sustained societal benefits.

Most of all, this shift in partnership model is bound to lead to more widespread adoption of co-developed science and innovations.

Embracing Collaborative Approaches

Since the mid-1990s development organizations have shifted from service delivery to a human rights-based approach to enhance accountability to beneficiaries and effectively address poverty. Donors are becoming more conscious of their negative influence on achieving development outcomes by favouring upward accountability that prioritize short-term outputs over long-term goals aimed at pro-poor social development.

Both donors and development organizations have recognized the need for enhanced downward accountability and legitimacy. Donors now seek national endorsement of investment priorities, and evidence of sustained benefits to the lives of the poor. WorldFish sees exciting opportunities for greater alignment of our mission. We see our maturing partnering arrangements as a key mechanism to achieve this alignment and better deliver on our mission.

Effective partnering requires crossing organizational boundaries and engaging differently, setting a framework that respects the socio-political context and emphasizes the collaborative process over the technical outputs - focusing more on 'how' we work together, rather than 'what' we work on or the technical skills we bring.

Next Generation Partnerships in Action

WorldFish is actively refining its approach to managing and monitoring the health of our country partnerships, emphasizing shifting power balances to enhance leadership in research prioritization, and program design by local policymakers and researchers.

This involves building competencies among WorldFish researchers for collaborative research identification and knowledge creation with in-country counterparts, signalling a transition to what we call 'Next Generation' partnerships.

WorldFish's NextGen Partnerships focus on research behaviours and attitudes that support equality in our research and engagement practices.

A prime example is our program in the Solomon Islands, where, over the past decade or so, our partnership approach has shifted to a more equitable collaboration involving the integration of staff within the national fisheries agency to inform and support program design and implementation. This approach facilitates the co-creation of knowledge and scaling of research innovations, establishing research legitimacy as a precursor to effectiveness.

Our nearly 40-year engagement in Pacific small island states has influenced national development agendas, reflecting a deep consideration of the role of research in achieving sustainable change. We prioritize research legitimacy and local ownership to enhance the effectiveness of our initiatives.

Looking forward, WorldFish aims to establish similar frameworks across our maturing partnerships. We recognize that empowering local knowledge holders in decision making processes leads to more sustainable societal changes, especially in the lives of those women and men dependent on aquatic resources for their livelihoods.

Emerging Breakthroughs in Aquatic Food Systems

WorldFish scientists are working at the cutting edge of research into aquatic food science with several breakthrough innovations.



Seaweed: A Sustainable Superfood

Seaweed production has surged nearly 75 percent over the past decade. This growth raises the question: Can seaweed be the next major crop to help sustainably meet the nutritional needs of a growing population while combating climate change?

In 2023, a paper published by WorldFish scientists and Tufts University in *Global Food Security* investigated the farming and commercialization of seaweed in these regions. The study reviews seaweed's efficiency as a resource, its role in mitigating greenhouse gas emissions, and its nutrient-rich properties. It also highlights significant data gaps that need addressing to understand its impact on food insecurity and the carbon footprint of food systems.

In 2023, WorldFish initiated the AABS project. Under its work package on integrated multitrophic aquaculture, it is investigating innovative farming methods in saltwater environments, including seaweed cultivation. This work is designed to expand food production opportunities and enhance livelihoods in coastal regions.



Digitising Diagnostics for Better Fish Health

New technologies are making it easier and more cost-effective to sequence, diagnose and treat fish diseases. As such, WorldFish scientists are looking to leverage the potential for even earlier interventions to protect the health of farmed fish.

Scientists are currently working on new tools and large datasets to form the basis of a platform that can identify microbial markers or microbiomes that could signal a precursor to disease. This would be set alongside targets in aquatic animals and their production systems for improving aquaculture-related traits to minimize the risk of disease and strengthen productivity.

Creating a new web-based aquaculture pathogen identification tool needs ongoing investment in skilled data analysts and developers as well as IT infrastructure. The aim is to centrally connect systems in different countries to a cloud server to allow data scientists to perform bioinformatics analyses and report back to users in a timely manner.



Algorithms for Aquaculture

WorldFish scientists have developed a first-of-its-kind climate information system for fishers in Zambia.

It features an algorithm that uses air and water temperature to predict whether a pond is too warm or too cool for optimal fish breeding and growth. With this system, scientists have created a tool that helps guide fishers on early interventions to protect their stocks and reduce losses.

The algorithm is linked to a data hub that provides fishers with a decision tree based on forecasted pond temperature. It outlines the steps to take if the pond temperature is likely to fall below 12°C or above 41°C. By using deep learning and AI, the system can issue advisories 24 hours in advance, giving farmers a head-start in dealing with extreme temperatures. With ongoing improvements, WorldFish hopes to refine the system to offer advisories up to 7 days in advance.



Challenging Gender Norms to Improve Livelihoods

The gender-transformative approach is an emerging model for building the economic resilience of women within fisheries and aquaculture through greater gender inclusion.

WorldFish’s HER+ program studied how gender norms, such as the perception that it is inappropriate for women to go fishing, were holding back climate-resilient livelihoods in Tanzania. By limiting women to processing and marketing roles that relied on the safe storage of caught fish, their livelihoods were more exposed to climate hazards such as flooding.

WorldFish scientists are addressing this by working with both men and women to promote women’s engagement and roles within aquatic food systems, as well as empowering women with tools and training. This includes installing purpose-built fish drying racks to reduce women’s reliance on makeshift wooden racks that are more exposed to extreme weather. The initiative has also promoted greater engagement within aquatic food bodies and committees, such as beach management units.



Preserving Nutrition Value through Hot Smoking

Innovative food preservation methods are vital to enhancing food security, particularly in regions reliant on fisheries for economic stability and nutrition. A study published in 2023 explored the impacts of hot smoking on various fish species from Lake Nasser in Egypt. This research, spearheaded by WorldFish and the Egyptian National Institute of Oceanography and Fisheries, highlighted this method as a way to prolong shelf life and to enhance the nutritional profile of fish.

The study looked at six fish species to show that these species, when raw, contained a lot of moisture and significant levels of protein and lipids, which are essential for human health. The hot smoking process induced notable changes in these components, typically reducing moisture content while increasing protein and lipid concentrations. The result was a concentrated nutritional value per gram of smoked fish.

A remarkable aspect of this method was its effect on microbial load and safety markers. After hot smoking, the fish showed decreased microbial load and maintained quality within international safety standards, with no detection of harmful pathogens like *E. coli* and *Salmonella*. This not only ensures the safety of the smoked fish but also extends its marketability and reduces waste from spoilage.

The study’s findings highlight the potential for broader application of hot smoking techniques to safeguard nutritional intake in vulnerable regions and also to boost economic gains by lengthening the shelf life of fish products and their marketability.



Island Food Systems, a New Approach

Island Food Systems is a nascent field, pioneered by WorldFish, that responds to a largely neglected geography. This emerging research area harnesses historical insights and modern aquacultural practices to uniquely address the distinctive characteristics of food systems within small island states.

Aquatic foods are central to these food systems and crucial for the diet and economy of island communities. The WorldFish research program on island food systems develops and promotes this approach through briefings and “tok story” sessions—informal discussions that integrate local knowledge with scientific research. These methods have proven effective in blending cultural heritage with innovative practices to enhance food security and sustainability.

Initially targeted at the Pacific, the success of this approach has captured the attention of other parts of the world, including the Caribbean and the Indian Ocean region, highlighting its broad applicability and potential for global impact. This framework offers a promising model for addressing the unique challenges that island communities face worldwide.

Meet the Authors



Dr. John Benzie leads the genetics group at WorldFish, bringing over 40 years of global research experience in applying genetics to natural resource management and aquaculture.

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Dr. Jérôme Delamare-Deboutteville focuses on aquatic animal health for tilapia, carp, and catfish, specializing in fish epidemiology, biosecurity and novel molecular tools for pathogen genomics, rapid diagnostics and microbiome profiling. Before 2018, he worked on vaccine projects in Australia and completed his PhD at the University of Queensland on emerging bacterial diseases.



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Dr. Rodrigue Yossa is an Aquaculture Scientist with research and development experience across Africa, Asia, Europe, and North America, focusing on sustainable fish feeds and nutrition. He is also an Adjunct Professor at the University of Moncton, a certified Project Management Professional, and the Editor-in-Chief of the Journal of Applied Aquaculture, with a Ph.D. in animal sciences from Université Laval and an M.Sc. in aquaculture from Ghent University.

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Laura Khor, with an MSc in Aquaculture from Universiti Malaysia Sabah, focuses on novel approaches to monitoring and mitigating aquaculture disease outbreaks. She is developing virtual courses and online tools to help aquatic food farmers in low- and middle-income countries, aiming to bridge the gap between researchers and rural farmers.



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Dr. David Verner-Jeffreys is an aquatic animal health microbiologist, earned his PhD in Infection and Immunity from the University of Glasgow, focusing on farmed Atlantic halibut bacteriology. He previously led the UK FAO Reference Centre for Antimicrobial Resistance at Cefas and worked at the Oceanic Institute in Hawaii on rearing programs for tropical marine finfish and shrimp.

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Dr. David Mills leads WorldFish’s research in Timor-Leste, focusing on coastal fisheries and inland aquaculture. With over 30 year’s experience in fisheries sustainability research experience in Australia, he specializes in sustainable coastal livelihoods and fisheries governance.



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Dr. Patrick Smallhorn-West is a marine scientist at James Cook University, working in collaboration with WorldFish and Wildlife Conservation Society. His work focuses on marine management in the South Pacific, balancing conservation and sustainable use.

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Dr. Hampus Eriksson focuses on supporting small-scale fisheries through applied research, analyzing management institutions’ impact on marine resource sustainability. He studies how Asian seafood market institutions influence small-scale fisheries and leads project monitoring, evaluation, and development programming to enhance local livelihoods.



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Dr. Michelle Tigchelaar is a climate scientist focused on assessing climate risks, scaling adaptation and mitigation solutions, and integrating aquatic foods into climate strategies.

Michelle Tigchelaar
Scientist and Climate Impact Area Lead

Prof. Eddie H. Allison, an expert in fisheries and aquaculture with over 30 years of experience, has significant global influence in livelihoods and food systems. Repeatedly recognized as one of the top 0.1% most cited cross-disciplinary researchers worldwide, and has advised the High-Level Panel for a Sustainable Ocean Economy and Oceana. He holds an honorary professorship at Lancaster University and is on the editorial boards of the journals “Frontiers in Sustainable Food Systems” and “npj Ocean Sustainability”.



Edward Allison
Principal Scientist

Dr. Peerzadi Rumana Hossain is a Climate Change Research Scientist leading on climate risk management for farmers and fishers in Asia and Africa.



Peerzadi Rumana Hossain
Scientist



Dr. Alex Tilley specializes in the improvement of visualisation and management of food systems through digital transformation, AI and automated analytics.

Alex Tilley
Senior Scientist

Dr. Cristiano Rossignoli specializes in Impact Assessment and M&E, enhancing livelihoods, nutrition, and food security.



Cristiano Rossignoli
Monitoring, Evaluation and Learning and Impact Assessment Research Leader



Dr. Rahma Adam is Scientist and Gender Impact Area Lead at WorldFish. She has worked as a Gender and Development Specialist at International Maize and Wheat Improvement Center, a World Bank Group Fellow, a Researcher for the Mo Ibrahim Index of African Governance at Harvard University.

Rahma Adam
Scientist and Gender Impact Area Lead

Dr. Wanjiku Gichohi is a Public Health Nutritionist and Food Systems Researcher with over 15 years of experience in industry, academia, and NGOs.



Wanjiku Gichohi
Senior Scientist and Nutrition Impact Area Lead



Dr. Victor Siamudaala is WorldFish's Country Director for Zambia and Southern Africa. With 28 years of experience in Southern Africa, he leads a multidisciplinary team delivering innovations in Aquatic Food Systems, focusing on climate resilience, social inclusion, and public health. Victor supports SMEs, fosters regional trade, and collaborates with financial institutions to create investment ecosystems for aquaculture and fisheries.

Victor Siamudaala
Country Director, Zambia and Southern Africa

Dr. Rose Komugisha Basiita is a Senior Scientist specializing in aquaculture and fish genetics. Based in Zambia, her research advances sustainable aquaculture in Southern and East Africa. She holds a Ph.D. in Aquaculture Genetics from James Cook University.



Rose Komugisha
Senior Scientist



Dr. Netsayi Noris Mudege, is a Senior Researcher managing donor-funded projects, including those from USAID, NORAD, and GIZ. She specializes in agrifood systems, rural development, and gender mainstreaming. Previously, she coordinated gender research at the International Potato Center and served as a Gender Advisor at the Royal Tropical Institute.

Netsayi Mudege
Senior Researcher

Dr. Sunil Siriwardena has 45 years of experience in aquaculture and inland fisheries research. He holds a PhD from the University of Stirling. Previously, he led FAO projects in several countries and worked with organizations like NARA, UNDP, NACA and Institute of Aquaculture across various countries.



Sunil Siriwardena
Country Lead, Nigeria



Dr. Essam Yassin Mohammed is the Director General of WorldFish and CGIAR's Senior Director of Aquatic Food Systems. With over 19 years of international experience, he has advised governments on environmental and fisheries policies, specializing in economic valuation, fiscal reforms, and sustainable ocean-based economies. He is a member of various UN advisory bodies focusing on the marine environment.

Essam Yassin Mohammed
Director General and CGIAR Senior Director of Aquatic Food Systems

Chin Yee Chan, specializes in fish foresight modeling, assessing fish production, consumption, and trade patterns. Her work aids decision-makers in aligning investments and policies with CGIAR objectives and Sustainable Development Goals.



Chin Yee Chan
Scientist



Dr. Nhuong Tran is a Senior Scientist (Applied Economist) specializing in foresight modeling, value chain assessment, and climate change mitigation in fisheries and aquaculture. Nhuong holds multiple advanced degrees and has extensive experience with international research projects in Africa and Asia.

Nhuong Tran
Senior Scientist

Dr. Ann Fleming holds a PhD in Aquaculture from the University of Melbourne and is pursuing a Masters in International Development at RMIT University. She has managed research projects at ACIAR, focusing on fisheries livelihoods in Southeast Asia and the Pacific, and served as Manager of Aquaculture in the Northern Territory Government.



Ann Fleming
Director, Programs and Impact

Finances

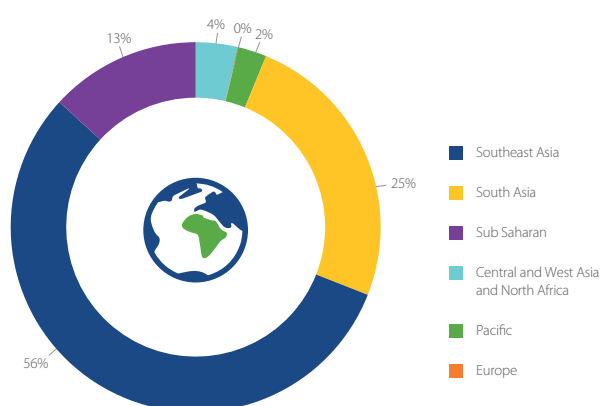
Statement of Financial Position (USD '000)

	As of December 31, 2023	As of December 31, 2022
Assets		
Cash and cash equivalents	11,008	12,254
Accounts receivable	4352	5726
Other current assets	266	251
Non-current assets	675	739
Total assets	16,301	18,970
Liabilities		
Accounts payable	6,308	8965
Accruals and provisions	1,695	1821
Other current liabilities	297	196
Non-current liabilities	672	794
Total liabilities	11,776	11,776
Net assets	7329	7194
Total liabilities and net assets	16,301	18,970

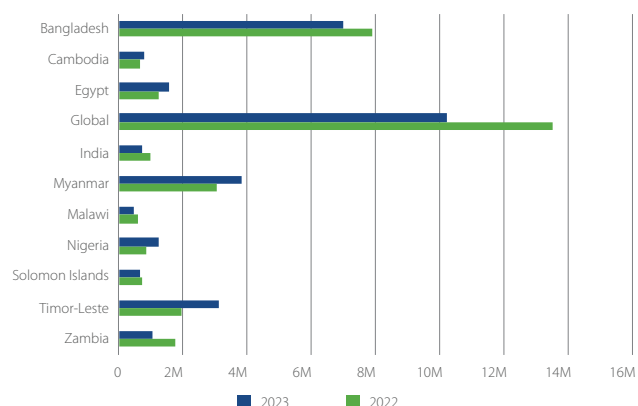
Statement of Operating Activities (USD '000)

	For the years ended December 31	
	2023	2022
Revenue		
Grants	30,586	33,137
Other income	1181	1016
Total revenue	31,767	34,153
Expenses		
Research	26,556	28,375
Administration, support and other	5081	5734
Total expenses	31,637	34,109
Net deficit	130	44

Expenditure by Region 2023



Funding by Country (thousands USD)



Our Donors

We are deeply grateful to our donors for their support and partnership with WorldFish in together advancing sustainable development in countries by investing in sustainable aquatic food systems.

Academic or Research Institute

- Mississippi State University
- University of Wollongong
- Synergos Institute
- Rajiv Gandhi Center for Aquaculture
- Lilongwe University of Agriculture and Natural Resources

CGIAR Center

- International Center for Tropical Agriculture
- International Institute of Tropical Agriculture
- International Rice Research Institute
- International Potato Center

Foundation

- Bill & Melinda Gates Foundation
- Minderoo Foundation
- Margaret A. Cargill Philanthropies

Financial Institutions

- African Development Bank
- International Fund for Agricultural Development
- Livelihoods and Food Security Fund

Private Sector

- MSC India Consulting Private Limited
- COFREPECHE
- De Heus Limited Liability Company
- Skretting Egypt
- US Soybean Export Council

Others

- Institute of Food Technologists

Government Institution

- United States Agency for International Development
- Norwegian Agency for Development Cooperation
- European Commission
- New Zealand Ministry of Foreign Affairs and Trade
- Foreign, Commonwealth and Development Office
- Deutsche Gesellschaft für Internationale Zusammenarbeit
- Australian Centre for International Agricultural Research
- Ministry of Agriculture and Food Security Malawi
- Ministry of Foreign Affairs Norway
- Ministry of Agriculture and Farmers Welfare India
- Indian Council for Agricultural Research and Min. of Agriculture Department of Agricultural Research and Education
- Assam Rural Infrastructure & Agricultural Services Society
- West Africa Trade and Investment Hub
- Ministry of Agriculture and Fisheries Timor-Leste
- Department of Mission Shakti, Government of Odisha
- Fisheries and Animal Resources Development Department, Odisha
- International Development Research Centre
- Bangladesh Local Government Engineering Department

International and Regional Organizations

- CGIAR System Organization
- Livelihoods and Food Security Trust Fund Manager's Office
- Food and Agriculture Organization
- The Pacific Community (SPC)
- Save the Children
- World Bank
- Southern African Development Community

