Photo credit: Habibul Haque/WorldFish

CGIAR Research Program on Fish Agri-Food Systems:
A synthesis

Led by

WorldFish

In partnership with

IWMI
International Water
Management Institute

JAMES COOK
UNIVERSITY
AUSTRALIA

UNIVERSITY of
GREENWICH

WAGENINGEN
UNIVERSITY & RESEARCH

CGIAR Research Program on Fish Agri-Food Systems: A synthesis

Authors

Michael Phillips,[1] Nisha Marwaha,[1] Malcolm C. M. Beveridge,[1] John Benzie,[1] Philippa J. Cohen,[1] Jérôme Delamare-Deboutteville,[1] Mark Dubois,[1] Matthew McCartney,[3] Cynthia McDougall,[1] Essam Mohammed,[1] Chadag Vishnumurthy Mohan,[1] Nigel Preston,[2] Cristiano Rossignoli,[1] Sonali Senaratna Sellamuttu,[3] Fiona Simmance,[1] Alex Tilley,[1] Marc Verdegem[4] and Rodrigue Yossa.[1]

Affiliations

[1] WorldFish
[2] Chair, FISH Independent Steering Commitee
[3] International Water Management Institute (IWMI)
[4] Wageningen University & Research (WUR)

Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: fish@cgiar.org
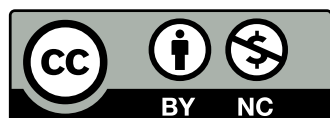
Photo credits

Front cover, Habibul Haque/WorldFish; page 3, Michael Akester/WorldFish; page 9, A.w.m Anisuzzaman/WorldFish; page 10, Kate Bevitt/WorldFish; page 13, Chosa Mweemba/WorldFish; page 14, Noor Alam/WorldFish.

Table of contents

1. Background

The fish agri-food system connects supplies of fish and other aquatic foods through multiple pathways and scales to diverse consumers across the planet and is a key component of global agri-food systems. Fish and other aquatic foods contribute to the livelihoods of 800 million people and provide 20 percent of daily animal protein, as well as key micronutrients and essential fatty acids, for more than 3.1 billion people. A diverse array of fish and aquatic foods from ocean to inland waters contributes to many national economies and diets, particularly in low-income food-deficit countries, providing one of the most accessible and often most sustainable animal-source foods. With nutrient deficits high and growing in many regions and as global demand for fish and other aquatic foods grow, so does the challenge of improving and sustaining the fish agri-food system to deliver healthy and nutritious food and positive social, economic and environmental outcomes, including those represented in the UN Sustainable Development Goals.

The CGIAR Research Program on Fish Agri-Food Systems (FISH) was launched in 2017. It was led by WorldFish together with its managing partners, the International Water Management Institute (IWMI), the Aquaculture and Fisheries Group at Wageningen University & Research (WUR), the Australian Research Council Centre of Excellence in Coral Reef Studies at James Cook University (JCU) and the Natural Resources Institute at the University of Greenwich. FISH was designed as the main programmatic vehicle for WorldFish to achieve its 2017–2021 organizational strategy objectives, specifically to identify innovative solutions to contemporary food and nutrition challenges and to contribute to more sustainable and resilient fish agri-food systems. FISH developed and adopted a theory of change and an integrated approach that addressed challenges for developing and managing sustainable aquaculture and small-scale fisheries in inland and coastal waters, with cross-cutting themes of nutrition, gender, youth, capacity development, climate change and, as later emerged, COVID-19.

Research was undertaken from community to global levels with multiple partners and investment from a blend of CGIAR and bilateral projects spanning 20 countries in Africa, Asia and the Pacific. FISH focused in depth on seven countries, namely Egypt, Nigeria, Zambia, Bangladesh, Cambodia, Myanmar and Solomon Islands. New knowledge and innovations were shared widely within countries and beyond through extensive networks and investments in capacity to influence policy, stimulate investment and generate wider impact.

This brief synthesizes outputs, outcomes and learnings from FISH. Further details on the specific research areas of FISH can be found within the 11 strategic briefs (Section 6). All supporting documentation and evidence of FISH's contributions to the CGIAR System Level Outcomes and Sustainable Development Goals can be found on the CGIAR Results Dashboard.
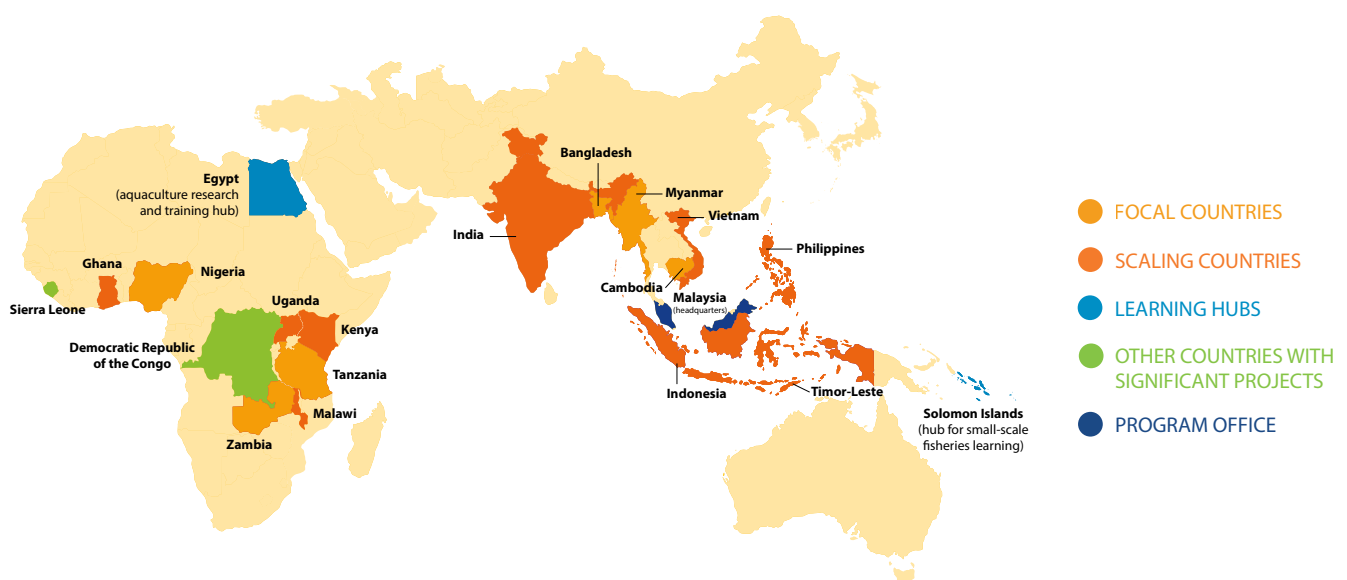
Highlights

During its five years of operation, FISH helped improve food and nutrition security, reduce poverty, enhance sustainability, build resilience to climate change and develop a new foundation of research and innovations for fish agri-food systems. New, compelling evidence was provided on the critical role fish and other aquatic foods play in nutritious diets and the diverse values fish agri-food systems bring to sustainable livelihoods and responses to the global climate crisis. FISH championed the more significant and central role that fish and other aquatic foods can and must play in securing sustainable, healthy and resilient food systems. Concurrently, FISH helped position small-scale fishers, fish farmers and value chain actors, their well-being and the goods and services they provide as central to sustainable and inclusive food system transformation and building forward better post-COVID-19.

Nutrition, health and food security – FISH developed new evidence and knowledge products on the nutritional values of fish and other aquatic foods, particularly their global importance in healthy, nutritious diets and ending malnutrition, including their critical role in diets in the first 1000 days. These contributions can be enhanced by securing sustainable and diverse supplies, integrating aquatic foods within food and nutrition policies, reorienting fisheries and aquaculture policies toward nutrition-sensitive approaches, and enhancing access in vulnerable geographies and social groups. The integration of fish and aquatic foods within social protection and emergency responses, such as school feeding programs, is a critical pathway to improve nutrition of the most vulnerable and provide lifelong benefits, including educational potential, especially for girls. FISH researchers and partners contributed to an influential UN Nutrition Discussion Paper and the UN Food Systems Summit and related policy processes that have led to increased recognition at the highest levels of fish and aquatic foods and the small-scale actors that steward fish agri-food systems.

Poverty reduction, livelihoods and jobs – Small-scale actors are crucial stewards of aquatic resources and play critical roles in shepherding fish and other aquatic foods through food systems to consumers. Securing or improving these roles—by sustaining access to productive small-scale fisheries, small-scale aquaculture or investing in women in value chains—provides multiple opportunities for poverty reduction, better livelihoods and new jobs. Small-scale actors make up more than 70 percent of those engaged in fisheries and aquaculture but are often "hidden" in data and governance structures, with voices and experiences rarely heard. FISH has helped quantify these opportunities and shown that greater attention in policy and investment to small-scale actors provides a highly significant but often overlooked opportunity to advance equity, nutrition, livelihood and resilience outcomes from fish agri-food systems.

Gender equality, youth and social inclusion – FISH delivered new knowledge and innovation that pushes the frontier of gender equality and social equity in agri-food systems. FISH and partners addressed the most fundamental case of exclusion—the persistent underrepresentation of women and their labor in data—illuminating, for example, that at least 44 million women worldwide contribute labor in pre-harvest, harvest and post-harvest roles in small-scale fisheries. However, the essential roles women play, like in processing and trading fish in Africa, are poorly supported by policy and investment, a situation made worse during COVID-19. Systemic inequities and barriers based on gender, age, wealth, ability or other social identities must be addressed and vulnerable groups empowered if fish agri-food systems are to help achieve food and nutrition security, decent livelihoods and poverty reduction. FISH has created new approaches and tools for gender equality in fish agri-food systems, such as a gender-transformative approach that address systemic, yet invisible, barriers to equity.

Climate adaptation and greenhouse gas reduction – Climate change is impacting fisheries and aquaculture. Yet fish and other aquatic foods also provide pathways to improve the resilience of food, land and water systems, including as a supply of nutritious food that can help reduce greenhouse gas emissions in the fish agri-food system. FISH research has provided new tools and frameworks for inclusive and holistic climate adaptation in coastal communities and worked with partners to apply new climate information tools to mitigate risks. The management and technology approaches in fisheries and aquaculture have helped highlight low carbon opportunities for mitigation, such as the work on tilapia farming systems in Egypt through adoption of new tilapia strains and better management practices.

Environmental health and biodiversity – Small-scale fisheries and aquaculture are commonly missing from policies and investments for water and land management. This often leads to unintended negative impacts on fisheries productivity and the nutrition and livelihoods of people dependent on them. FISH has shown positive social, economic and environmental outcomes when small-scale fisheries and aquaculture are provided with operating space and enabling conditions in multifunctional water and landscape policies and investments. Achievements were made in the development of innovations, guidance and tools to integrate fisheries into modern irrigation systems and rice-dominated landscapes. New tools for assessing aquaculture futures also provided policy advice on the design of new pathways for sustainable aquaculture growth and the application of FISH innovations to improvements in environmental health and biodiversity.

Pathways to impact in fish agri-food systems – FISH has made progress in translating research and innovation to impact through four key pathways: (i) using research evidence and partnerships to influence policies, institutions and investments, (ii) creating global public good innovations and enabling adoption and dissemination of validated innovations, (iii) building partnerships across the research-to-impact pathway with public, private and civil society agencies and communities, and (iv) supporting partners in diverse ways to put research into use. A key learning from FISH is that a firm focus on such change mechanisms is necessary for sustained uptake of fish agri-food system research and innovation as the foundation for longer-term impacts. The approach has already provided benefits as noted in the 2020 independent evaluation: *"Management and governance have helped translate research results into meaningful impact"* and *"Hundreds of thousands of individuals in low-income countries have had their income, empowerment and nutrition enhanced."*

Buying fish from roadside sellers in the Ayeyarwady Region, Myanmar.

2. Research, innovations and impacts

Research and innovations provide the basis for impact. FISH researchers reported over 100 innovations between 2017 and 2021, underpinned by over 700 research products in sustainable aquaculture, small-scale fisheries, nutrition, gender, youth, climate change and capacity development. FISH innovations are at various stages of development and application, from discovery and proof of concept to uptake by end users, contributing to the goal of *reducing poverty and improving food and nutrition security through fisheries and aquaculture, while enhancing environmental sustainability*.

Sustainable aquaculture

Sustainable aquaculture research was directed at improving tilapia and carp farming systems, two widely cultured species that constitute over 27 percent of global aquaculture production. Research focused on fish breeds and genetics, fish health, nutrition and feeds, and aquaculture systems, with an overall objective of *"enabling sustainable increases in, and gender- and socially equitable livelihood returns from, aquaculture production without creating adverse socioeconomic or environmental impacts."*

- **Fish genetics as a foundation for enhancing productivity, profitability and sustainability of small-scale fish farms**. FISH built on genetic improvement research that began in 1987 to develop new generations of genetically improved farmed tilapia (GIFT), expand dissemination of existing strains, assess on-farm performance and apply learnings from the GIFT program to other strains and species. Additionally, new research on preferences of women and men is helping guide future genetic selection investments to address the needs of poor and nutrition-insecure consumers.

- **Faster growing tilapia for improved profitability and sustainability**. FISH supported dissemination and assessment of GIFT in four countries in Asia—Bangladesh, India, Myanmar and Timor-Leste—with increases in growth rate in selection programs translating to superior productivity,

profitability and sustainability for farmers. The increasing penetration of GIFT into national aquaculture programs has become significant. In Bangladesh, impact assessments show that over 50 percent of the country's tilapia stocks are derived from GIFT, with associated flow on benefits to farmers via improved farm productivity and profitability.

- **New genetic improvement programs for rohu, catla and silver carps**. FISH researchers and partners in Bangladesh made substantial progress in developing selection programs for rohu carp (*Labeo rohita*), catla carp (*Catla catla*) and silver carp (*Hypophthalmichthys molitrix*). The improved rohu strain was released to farmers in 2021, with early on-farm trials indicating 30 percent faster growth. The expectation is that these improved strains will be "game changers" as the foundation for major contributions to future carp supplies in the country.

- **New resilience traits characterized in tilapia**. A consortium of advanced research institutes developed novel genetic tools to characterize traits in GIFT that promise better performance under a changing climate, including tolerance of low dissolved oxygen conditions, resistance to tilapia lake virus and improved feed efficiency. A strategy was prepared by FISH and partners to integrate these new traits into future tilapia breeding programs.

- **New molecular genetic tools**. A single nucleotide polymorphism array, reference genomes, linkage maps and genetic markers for host disease resistance were also developed through FISH to accelerate development of resilient fish strains and support sustainable management of aquatic genetic resources, providing a foundation for future genetic selection.

- **Closer collaboration for improved aquatic genetic resources management**. Field-level experiences from FISH contributed new policies for improved management of aquatic

genetic resources, including global policies and guidelines from the Food and Agriculture Organization (FAO) and regional policies of the Southern African Development Community and East African Community. An in-depth assessment highlighted the significance of access and benefit sharing policies for attention in movements of genetically improved fish and aquatic genetic resources in line with the Nagoya Protocol. Technical assistance was provided through FISH to assist stakeholders with development of genetic improvement programs, including the governments of Zambia and Malawi for three-spotted tilapia (*Oreochromis andersonii*) and chambo (*Oreochromis shiranus*), respectively.

- **Making the most of genetic improvement with better health, feed and management systems**. Genetically improved strains of tilapia perform better than non-improved strains in a range of fish farming systems. However, evidence from comparisons of various strains and feeds in Kenya support the fact that the better the farm environment, the better the performance of genetically improved strains. As such, FISH applied an integrated approach, developing new health and feed innovations to complement genetic improvement, as well as ensuring that dissemination programs for genetically improved strains are accompanied by accessible advice to farmers on better fish health, feeds and pond management.

- **Making better use of local ingredients to formulate fish feeds**. Small-scale farms require access to affordable fish feeds, but commercial feeds often contain expensive or imported ingredients that may compete with direct human use, like fishmeal, fish oil or soy. FISH and partners worked to identify local, underused feed ingredients in Africa and Asia and made ingredient data widely available to feed millers and farmers through the FeedCalculator application. The app is now available worldwide and used in FISH training activities in Africa and Asia, with regional language versions to follow shortly.

- **Innovation to nourish the fish and the pond**. FISH partners at WUR developed the "nutritious pond" concept to exploit the inherent capacity of the pond ecosystem to

mineralize wastes, nourish the pond food web and produce natural fish feeds. This fish feed innovation provides important advantages for intensification of pond fish farming due to the ability to use local ingredients, recycle wastes and increase fish production in a healthy pond environment. FISH successfully tested the approach in Bangladesh, Egypt and Zambia with public and private partners. The approach of "feeding the pond" for productive and environmentally efficient tilapia production systems, instead of just "feeding the fish," is increasingly being applied for tilapia farming in Asia and Africa.

- **Improving health management and reducing disease risks for small-scale fish farmers**. Infectious fish diseases are a major risk to small-scale fish farmers. Fish health researchers working with FISH improved disease detection, management and prevention measures for tilapia and carp farmers. New epidemiology and health economics tools were developed and used in Bangladesh and Egypt, informing improvements in national aquatic animal health policies. National partners in Ghana, Kenya and Nigeria are now being trained to apply the tools in formulating new national fish disease control policies.

- **Rapid fish disease diagnostic tools for fish hatchery operators and farmers**. Portable technologies have immense potential application for early detection of fish pathogens. The lab-in-a-backpack was developed to rapidly and accurately identify fish pathogens and management actions. It contains tools for (i) bacteria sampling from diseased fish, (ii) sequencing of bacterial DNA, and (iii) uploading DNA sequences to an online portal where they are compared to a growing database of reference genomes for bacterial fish pathogens, so that (iv) sampled bacterial pathogens are identified and management actions defined. Such new innovations are now helping farmers manage risks and are contributing to new data pipelines that provide the foundation for better management and preventative responses to fish disease risks.

- **Better approaches to tilapia management**. FISH translated the key management recommendations arising from research into a

set of better management practices for tilapia farming that have been widely disseminated in multiple languages and used extensively for practical training in 10 countries. These management practices cover tilapia hatcheries and farming, capturing key dimensions of productivity and profitability, environmental sustainability, social equity, and management of disease-related risks. A special collaboration with the CGIAR Antimicrobial Resistance Hub helped integrate these better management practices into One Health policies and practices to address the global challenge of antimicrobial resistance.

- **Assessing aquaculture system performance and innovations for sustainable intensification**. FISH made major advances in providing practical, open-access tools and approaches for assessing and benchmarking aquaculture system performance. Using these tools, FISH analyzed tilapia, carp and catfish aquaculture system performance in terms of productivity, profitability and other social, economic and environmental factors across focal and scaling countries in Africa and Asia. The performance assessments of genetically improved tilapia and carp farming provide unique insights into a diversity of aquaculture systems. These include benchmarks for tilapia feed performance in Zambia, "Ecopond" polyculture systems in Bangladesh, GIFT performance in Bangladesh, Nigerian fish futures, GIFT dissemination in India and environmental impacts of Egyptian aquaculture. Partner training has been conducted to help put tools into wider use in several countries, including a suite of digital applications linking farmers and extension agents to knowledge, markets and finance.

- **Fish seed dissemination systems**. FISH and partners developed methods for assessing the dissemination of genetically improved fish seed. Standardized approaches and tools were used to identify barriers, constraints and "lock ins" that prevent dissemination and identify better policy and practices. The recommendations have been incorporated into national GIFT dissemination systems and public-private partnerships in Bangladesh, India, Myanmar and Timor-Leste as well as

in the development of fish seed systems in Ghana, Malawi and Nigeria.

- **Business, finance and entrepreneurial models for inclusive investment**. FISH developed and tested inclusive, gender-sensitive and women-targeted business, finance and entrepreneurial models. An analysis of inclusive business models provided the foundation for further development and scaling of updated fisheries science curriculum and training tools in Zambia, the local service provider model in Bangladesh, empowerment methods for fish retailers in Egypt and collective farming by women self-help groups India. The research, tools and approaches developed by FISH provide a promising foundation for further private and public sector investment for widespread scaling and impact.

Sustaining small-scale fisheries

Small-scale fisheries are critical sources of food and livelihoods, including where formal markets and value chains function poorly, but they are increasingly threatened by pressures like overfishing, climate change and geopolitics. FISH research on resilient coastal fisheries, fish in multifunctional landscapes (water systems, rice-dominated landscapes) and fish in regional food systems worked at multiple scales to illuminate and sustain the values of small-scale fisheries, with the objective of *"securing and enhancing the contribution of sustainable small-scale fisheries to gender-equitable poverty reduction and food security in priority geographies."*

- **Building inclusivity and efficacy of co-management**. Building on earlier evidence, FISH found that fishery co-management contributes to a range of social, economic and ecological objectives, but evidence and outcomes toward gender equity, food and nutrition security, and medium-term ecological or productivity gains were lacking. FISH focused on addressing these weaknesses and developed a bundle of innovations toward a more inclusive and effective model of co-management. New ecological and biological knowledge was generated and used to adjust management. This led to lead gains in productivity or resilience in Bangladesh and recommendations for management for

communities in the Pacific and Island Asia. Additionally, FISH and partners developed a gender-inclusive guide for community-based marine resource management, a framework and methodology for assessing inclusion in co-management, and handbooks for gender and social inclusion in coastal fisheries management and community engagement. Through action learning with communities, FISH applied, refined and translated these insights into a national forum and policy.

- **New digital innovations focus on small-scale fisheries**. FISH researchers engaged with government and private partners and the CGIAR Big Data Platform to identify novel digital approaches for managing small-scale fisheries. As a result, Timor-Leste now has one of the most sophisticated data collection systems for small-scale fisheries monitoring and analytics in the world, based on PeskAAS. The system allows catch data from community-based enumerators to be placed quickly in the hands of fisheries officers, fishers, researchers and local stakeholders. The new tool provides analyses of fisheries catches, fishing boat tracking and the contribution of fish and fisheries to local livelihoods and food security. PeskAAS is open-source and designed to be highly adaptable to new geographies and fisheries contexts. It shows promise in bringing new understanding to small-scale fisheries globally in support of greater awareness of the sector and improved management.

- **Making space for fish and aquatic foods in water management and irrigation modernization**. Inland capture fisheries are the primary source of livelihoods and food and nutrition security in many low- and middle-income countries but have often been adversely impacted by irrigation infrastructure. New guidelines developed with FAO provide practical guidance for integrating fisheries within irrigation systems, a nature-based approach that can reposition irrigation infrastructure as multifunctional systems that improve sustainability, livelihoods and food and nutrition security. The guidelines support those involved in water resources planning and management, detailing the benefits of integrating fisheries into the planning, design,

construction, operation and management of irrigation systems. They also describe the potential negative effects of water control infrastructure on aquatic ecosystems, including fisheries, and outline technical, management and governance measures to mitigate negative impacts and enhance fisheries for local people.

- **New promise for rice-fish systems**. FISH research on multifunctional landscapes addressed the challenges of sustaining the multiple contributions of inland fisheries in the face of land-use changes, hydropower development and climate change. In the rice-dominated landscapes of the Mekong Delta in Cambodia and the Ayeyarwady Delta in Myanmar, research focused on assessing and enabling rice-fish innovations that deliver multiple positive benefits. Community fish refuges scaled across 140 sites in Cambodia led to improvements in fish productivity and diversity, fish consumption, access to water and community capacity to manage fish habitats and climate change risks. The management improvements have been incorporated into Cambodia's 2020–2029 Strategic Plan for Fisheries Conservation and Management. Integrated rice-fish culture in Myanmar shows equal promise, with performance data indicating widespread benefits in suitable areas across the Ayeyarwady Delta. A FISH Decision Support System was developed to assist participatory processes of rice-fish implementation to enable evidence-based application and uptake of the findings. With rice grown in more than half the countries in the world across 158 million ha, of which about 80 million ha are irrigated lowland rice, such integrated rice-fish systems innovations hold great promise.

- **Illuminating the hidden values of small-scale fisheries**. FISH was a partner and funder of Illuminating Hidden Harvests, a global initiative led together with FAO and Duke University, to generate new knowledge on the diverse and often overlooked contributions of small-scale fisheries to sustainable development. The initiative drew together over 800 research, government and industry experts to deliver 52 country case studies from a novel standardized method—an innovation

in itself that can form the basis of new capacity and data systems at national levels. Small-scale fisheries were found to support average annual first sale revenues of USD 77.1 billion, employment for 60 million people and subsistence livelihoods for an additional 53 million women and men. New data and analysis were also provided in Malawi, Nigeria and Zambia. The global data represents the most comprehensive assessment the value of small-scale fisheries across environmental, economic, nutrition, governance and social dimensions, and establishes a series of priority actions to protect and optimize these values as pathways toward the Sustainable Development Goals.

- **Fish and aquatic foods within regional food systems**. The food system is a powerful concept for understanding and responding to nutrition and sustainability challenges. Yet FISH found that prior to 2019, fisheries and aquaculture research had only lightly engaged with the food system concept. FISH established the different pathways through which fish and other aquatic foods could generate positive outcomes in distinct regions of the Pacific Islands, the Ayeyarwady and Mekong deltas, and the Great Lakes of Africa. For example, in the Pacific, FISH identified that high national averages of fish consumption mask underconsumption and nutrition in the first 1000 days and of women of reproductive age, and as a response developed novel nutrition awareness alongside co-management. In the deltas, FISH focused on the integration of fisheries and culture techniques in agriculturally adjusted landscapes as a primary way to increase supplies. In the Great Lakes Region, FISH developed new knowledge on the uses, potential and losses of small nutrient-rich fish for human nutrition.

- **New analytical and decision-making tools for nutrition-sensitive fisheries**. To support interventions that account for the diverse nutritional values of fish and other aquatic foods, but recognizing the prohibitive expense of nutrient analysis, FISH and partners developed FishNutrients, a database and predictive model of nutrient composition of over 5000 fish species. The data and model have been integrated into FishBase—the most

frequented database for the sector. The novel data has enabled global, regional and national analyses that illuminate where nutrient potential can be directed more effectively toward human nutrient deficiencies.

Nutrition

Throughout FISH, the nutritional values of fish as part of a diverse diet became increasingly apparent. FISH focused on the sustainable supply of fish from aquaculture and small-scale fisheries but worked extensively on the pathways and mechanisms for securing nutrition outcomes. Outcome and impact assessments of a diverse set of innovations provide unique insights into the pathways for delivering nutrition outcomes.

Although fish and aquatic foods are nutrient-rich components of a diverse diet, they remain poorly represented in agri-food system research, policy and investments. FISH researchers and partners championed the value of fish in healthy, sustainable agri-food systems and worked extensively on pathways and mechanisms for securing nutrition outcomes. These include, but are not limited to, expanding production of small indigenous fish species, improving the sustainability and productivity of fisheries and aquaculture, and reducing loss and waste in fish value chains. A toolbox of five key actions to strengthen the contributions of aquatic foods to agri-food systems was also developed, with an emphasis on Zambia.

Gender

FISH research on gender highlighted the multiple, critical values of gender inclusivity in fish agri-food systems. FISH generated new evidence on systemic inequities and barriers based on gender, age, wealth, ability or another social identity, and how they can be addressed so that fish agri-food systems equitably contribute to food and nutrition security, livelihoods and poverty reduction. Shifts toward inclusive governance and practice require a range of strategies, but perhaps the most fundamental for research is to overcome sexist data systems that perpetuate the cycle of invisibility and inequality for women in the sector. In overcoming these, for example, the Illuminating Hidden Harvest Initiative revealed the pre-harvest, harvest and post-harvest labor of at least 44 million women worldwide.

With a diverse set of partners, FISH identified and progressed four pathways to accelerate gender inclusivity in fish agri-food systems: (i) adopting gender-inclusive and gender-responsive approaches to innovation, (ii) securing inclusive livelihoods and wealth generation for women's economic empowerment, (iii) prioritizing inclusive governance as the foundation of equitable and resilient fish agri-food systems, and (iv) use of gender-transformative approaches to overcome invisible barriers to gender equality. These four pathways connect to gender and social justice themes of voice and choice, women's economic empowerment, gender equality, equity and human rights, and food systems transformation.

Strategic gender-focused research was complemented with a gender-integrated approach to sustainable aquaculture and small-scale fisheries research. The innovations, tools, capacity and policies that have delivered results include gender-disaggregated preferences of fish traits for genetic investments, ways to improve gender inclusivity in small-scale fisheries and a gender-transformative approach for advancing gender equality in fisheries management. These results are all widely shared with partners, with relevant capacity building to enable their adoption and application at the scale.

Youths

FISH's research on youths and their contributions to fish agri-food systems was led by managing partner IWMI. An assessment of youth participation in fish agri-food systems drew on the voices of youths in Bangladesh, Cambodia, Egypt, Myanmar, Nigeria, Solomon Islands, Tanzania and Zambia and was complemented by empirical studies in Myanmar and Nigeria. Opportunities and challenges for youth participation in fish agri-food systems were identified and used to support multiple interventions, including policy guidance in Myanmar and Nigeria, youth empowerment in aquaculture as part of the Technologies for African Agriculture Transformation initiative, and a youth-oriented capacity development initiative on aquaculture vocational and entrepreneurship training in Zambia. FISH researchers also joined the team that prepared the UN High Level Panel of Experts on Food Security and Nutrition report on promoting youth engagement and employment in agriculture and food systems.

Climate change

In close cooperation with the CGIAR Research Program on Climate Change, Agriculture and Food Security, FISH provided evidence and innovations to help build the resilience of fish agri-food systems. FISH and partners' landmark analysis on key climate risks for fish agri-food systems has prompted the development of new approaches focused on two pathways: climate adaptation and mitigation.

First, FISH managing partner JCU led development of an innovative framework for assessing and enhancing adaptive capacity. This was further refined to integrate social organization and networks for both adaptive and transformative actions in communities experiencing climate change impacts and was used to inform policy in select countries in Asia and the Pacific.

Second, climate mitigation work included quantification of greenhouse gas emissions from aquaculture, development of FishScores, a digital tool for monitoring environmental impacts of aquaculture systems, and recommendations for more sustainable management and integrated or alternative livelihood opportunities.

A substantial component of the climate change research involved assessing and supporting the integration of fish and aquatic foods in climate

Celebrating International Women's Day 2019 in Jessore, Bangladesh.

policy agendas. Three regional dialogues were held with 157 stakeholders to identify key priorities for future policies and investments, with results published in a report launched at the Climate Adaptation Summit and major participation in the 2021 UN Climate Change Conference.

Capacity development

Capacity development is a key mechanism for ensuring research quality and enabling impact. FISH pursued several pathways with diverse projects and partners to enhance capacities of key stakeholders. Short-term training activities were supported in multiple ways, often through partners and bilateral project investments, with over 600,000 participants in 40 countries from 2017 to 2021, of which 75 percent were women. Trainees, including small-scale fishers, fish farmers and other value chain actors, were supported with practical training on many topics, like production, business and nutrition-sensitive aquaculture. Partners in intermediary organizations, government research and extension agencies, vocational training institutions, civil society, and private sector organizations also received training on the application of key research findings. Training tools on gender-transformative approaches, better management practices for aquaculture, fish health management and integrated production systems, among others, were widely shared to support sustained local and national capacity.

In some cases, new digital channels were also used to extend the reach of training programs, such as vocational aquaculture training in Zambia supported by the Norwegian Agency for Development Cooperation and digital tools for extension and marketing support. FISH also invested in translation and handover of many products to 22 vocational level training partners in Africa, Asia and the Pacific, helping to build longer-term capacity.

Longer-term training focused on young researchers from developing countries and advanced research institute partners engaged in internships, masters and doctoral programs. Forty young researchers involved in PhD and related long-term educational programs represent the forefront of research capacity growth in Africa, Asia and the Pacific.

COVID-19

FISH and partners faced significant challenges due to the COVID-19 pandemic, which started in 2020. This required changes in operations and management to secure core lines of research and pivoting FISH research and innovations to support partners with arising challenges. Early in the pandemic, FISH invested in monthly fisheries and aquaculture value chain assessments in Bangladesh, Egypt, India, Myanmar and Nigeria to track knowledge of COVID-19 impacts and formulate appropriate responses. Partners employed methods and principles developed by FISH to also bring insights from Kenya and Papua New Guinea. These insights were complemented by *ad hoc* demand-led research on fisheries, aquaculture and community responses as well as methodological guidance, using largely bilateral funded projects. A dedicated COVID-19 portal was established to rapidly share content and disseminate relevant policy guidance, with a strong emphasis on assisting national partners and providing rapid feedback on results to users. Cooperation was established with the CGIAR COVID-19 Hub and the CGIAR GENDER Platform to prepare a landmark participatory assessment of COVID-19 impacts on women fish processors and traders in Africa, which provides a compelling case and directive for intervention to secure and improve fish agri-food system livelihoods for women.

Photo credit: Kate Bevitt/WorldFish

Members of the Beacou Women's Group preparing to make fish powder, Timor-Leste.
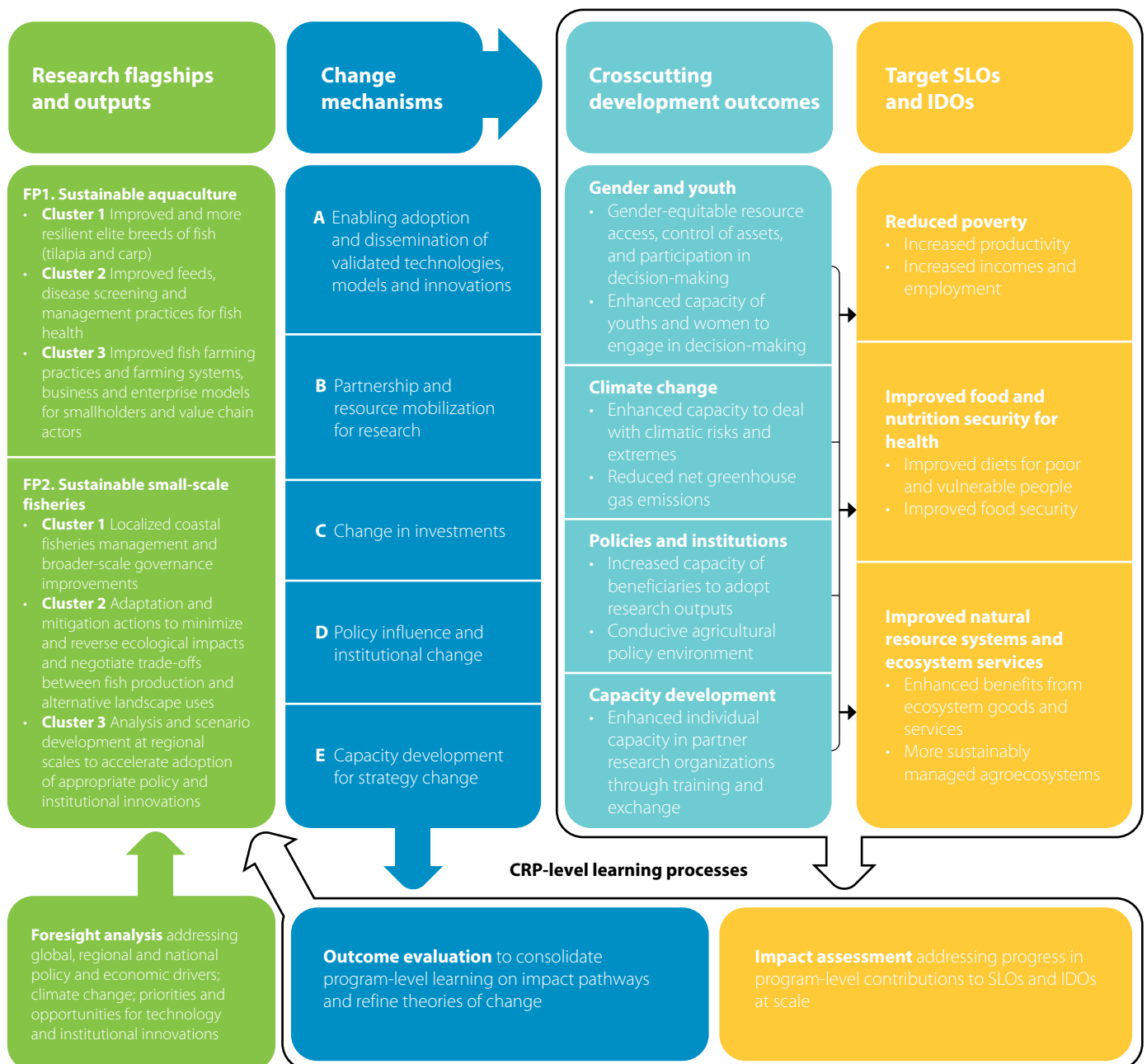
3. Program organization and learning

FISH brought together multidisciplinary partners across multiple countries and scales to identify and deliver innovations and impact across the fish agri-food system. The FISH approach provides many lessons for how a large program can be organized to deliver research and innovation and achieve impact. Key lessons are highlighted below.

Theory of change approach, and monitoring, evaluation and learning

FISH applied a theory of change approach to program design and implementation, supported by a monitoring, evaluation and learning system, to monitor progress and capture learning. This enabled FISH to apply a systematic approach to identify intervention priorities and develop pathways between activities and change mechanisms for impact. The theory of change was used at various levels within FISH with a nested approach from program to country levels and research teams to partners. Multistakeholder participatory workshops were held in several countries to develop country-level theories of change, interventions and progress assessments.

Research flagships and outputs

FP1. Sustainable aquaculture
- **Cluster 1** Improved and more resilient elite breeds of fish (tilapia and carp)
- **Cluster 2** Improved feeds, disease screening and management practices for fish health
- **Cluster 3** Improved fish farming practices and farming systems, business and enterprise models for smallholders and value chain actors

FP2. Sustainable small-scale fisheries
- **Cluster 1** Localized coastal fisheries management and broader-scale governance improvements
- **Cluster 2** Adaptation and mitigation actions to minimize and reverse ecological impacts and negotiate trade-offs between fish production and alternative landscape uses
- **Cluster 3** Analysis and scenario development at regional scales to accelerate adoption of appropriate policy and institutional innovations

Change mechanisms

A Enabling adoption and dissemination of validated technologies, models and innovations

B Partnership and resource mobilization for research

C Change in investments

D Policy influence and institutional change

E Capacity development for strategy change

Crosscutting development outcomes

Gender and youth
- Gender-equitable resource access, control of assets, and participation in decision-making
- Enhanced capacity of youths and women to engage in decision-making

Climate change
- Enhanced capacity to deal with climatic risks and extremes
- Reduced net greenhouse gas emissions

Policies and institutions
- Increased capacity of beneficiaries to adopt research outputs
- Conducive agricultural policy environment

Capacity development
- Enhanced individual capacity in partner research organizations through training and exchange

Target SLOs and IDOs

Reduced poverty
- Increased productivity
- Increased incomes and employment

Improved food and nutrition security for health
- Improved diets for poor and vulnerable people
- Improved food security

Improved natural resource systems and ecosystem services
- Enhanced benefits from ecosystem goods and services
- More sustainably managed agroecosystems

CRP-level learning processes

Foresight analysis addressing global, regional and national policy and economic drivers; climate change; priorities and opportunities for technology and institutional innovations

Outcome evaluation to consolidate program-level learning on impact pathways and refine theories of change

Impact assessment addressing progress in program-level contributions to SLOs and IDOs at scale

FISH joined the MEL consortium with other CGIAR Research Programs and CGIAR Centers. The MEL system helped provide a structured review of the theory of change and facilitate reporting to CGIAR. Foresight analysis, outcome evaluations and impact assessments were also regularly conducted to assess impacts of interventions along the theory of change and understand future scenarios, the latter in partnership with the CGIAR Research Program on Policies, Institutions and Markets. The MEL approach adopted by FISH was commended as the only CGIAR Research Program to report system-level outcomes in the recent CGIAR synthesis of learning from a decade of CGIAR Research Programs.

Blended financial resources

FISH planned for and received finance from various mechanisms, including CGIAR W1/W2 funds (approximately 20 percent) and bilateral resources (approximately 80 percent). Bilateral projects were proactively mobilized to complement CGIAR funds, supporting both research and development outcomes. This blended funding approach expanded the outputs and outcomes of FISH, though it required significant commitment to coordination and monitoring.

Research products

FISH innovations were underpinned by over 700 peer-reviewed publications, briefs, manuals, reports and other documents from researchers and partners. These were tailored to a diverse user group and provided a unique and important insight into fish agri-food systems.[1] Many leading science publications have set global agendas and a foundation for the future. A total of 310 peer-reviewed International Scientific Indexing journal articles were published during FISH, of which around 70 percent were open access and 16 with Altmetric Attention Scores greater than 100.[2] The highest Altmetric score (820) was achieved by a *Nature* article entitled *"Harnessing global fisheries to tackle micronutrient deficiencies,"* which quantifies the potential of fisheries to address malnutrition.[3] High Altmetric scores were also achieved by "Escaping the perfect storm of simultaneous climate change impacts on agriculture and marine fisheries," "Environmental performance of blue foods," "Securing a just place for small-scale fisheries in the blue economy" and "Building adaptive capacity to climate change in tropical coastal communities." Research quality was underpinned by the CGIAR Quality of Research for Development guidelines. Training, resources and ongoing mentoring were provided to ensure early career researchers were enabled to contribute high quality research outputs.

Partnerships

Partnerships enabled successful implementation of FISH. This included a unique and diverse set of over 400 partners and a range of partnership mechanisms engaged to harness emerging science in fish agri-food systems, codevelop and share innovations, and enhance development outcomes at scale. Academic and research organizations accounted for 30 percent of partners, while partnerships with the private sector, national agriculture research organizations, governments and civil society groups grew significantly after 2019 as greater emphasis was given to collaboration to improve responsiveness of research to stakeholder needs and accelerate scaling of research and innovations.

Program management and governance

FISH established a governance and management structure that included an independent steering committee and a management committee, both reflecting a diversity of disciplinary expertise and institutional perspectives. The independent steering committee was responsible for the overall strategic direction of FISH, science quality and priorities, risk management, budget allocation and identification of new investment, and developing partnerships to grow the program and enhance impact. Membership consisted of scientists, practitioners and representatives from end-user bodies that represent a balance of disciplinary expertise, gender and national diversity.

The management committee was responsible for timely and effective planning, budgeting and reporting. The committee was composed of representatives of the five managing partner institutions and the flagship coordinators, chaired by the FISH director. The committee reviewed annual work plans and budgets developed at regional and global levels to ensure consistency, integration and appropriate budget allocation across the program. The work of the two committees was supported by a program management team and financial, administrative, communications and other supportive functions based in WorldFish.

Results of the 2020 independent evaluation

An independent review of FISH was commissioned in 2020 by the CGIAR Advisory Services as part of the review of the CGIAR Research Program portfolio. The review of FISH assessed quality of science, effectiveness and future orientation. The reviewers posed three questions: (i) To what extent does FISH deliver quality science? (ii) What outputs and outcomes have been achieved and what is the importance of those identified results? and (iii) What evidence exists for future effectiveness within the life of the program?

The reviewers commended FISH as having a high quality, extremely hard-working, dedicated scientific team with an array of skills, experience and training. The research is enhanced by strong multidisciplinary approaches. The reviewers praised FISH germplasm outputs and, for example, noted that GIFT show at least 8 percent faster growth per generation. They also highlighted the high-quality, award-winning tools and technologies. High quality science, capacity building and policy contributions have helped FISH make significant progress along the theory of change. It was concluded that FISH has helped improve income, empowerment and nutrition for hundreds of thousands of individuals in low- and middle-income countries. Key lessons highlighted by the reviewers from FISH included the following:

- Involving communities in fisheries management can be highly effective in sustaining and increasing a natural resource that ultimately impacts the income and nutrition of low-income communities.

- Partnering and involvement of medium and large enterprises in technology transfer to the poor can increase the likelihood of successful dissemination of innovations with benefits to the entire value chain.

- Facilitating communication between men and women can break down barriers, resulting in greater empowerment and participation of women while increasing their income and self-efficacy.

- Retention of knowledge and performance of outputs and tools must be measured.

The reviewers concluded that FISH can provide a sound foundation and starting point to the future One CGIAR. The flagships, clusters and crosscutting themes were considered highly impactful and should be continued to derive full benefit from the strong foundation that has been laid. This includes work in genetics, fish diseases, aquaculture feeds and the nutritious pond concept, nutrition, small-scale fisheries, rice-fish refuges, policy contributions and gender and youth. In the CGIAR Review of CGIAR Research Programs, it was further noted that *"among the CGIAR Research Programs reviewed, only FISH explicitly determined success in terms of achievements along the theory of change pathways to system-level outcomes."*

Hidden gems

This synthesis highlights some major FISH innovations. However, researchers and partners have also identified several areas of innovation that show substantial promise for further development and application beyond the timeframe of FISH. These hidden gems include the newly emerging genetic map of GIFT, the FishNutrients model and tool, and the comprehensive methodological and practice innovations around gender and inclusion, among others.

Photo credit: Chosa Mweemba/WorldFish

Improving the production of quality fingerlings, Zambia.

4. Follow-up actions

Despite various challenges, FISH and partners have made progress on new and important areas of research, innovation and impact. Specific focus on fish genetics, health and feeds, resilient coastal fisheries, fish in multifunctional landscapes and fish in regional food systems generated positive nutrition, gender and social equity, livelihood and environmental outcomes. Progress has been made in increasing the evidence and visibility of small-scale actors and the benefits of their meaningful participation in research prioritization, design, implementation and scaling. These efforts provide a solid foundation for future One CGIAR efforts to strengthen the resilience of fish agri-food systems and evidence that fish agri-food systems—or aquatic food systems—can contribute to broader agri-food system transformation under a changing climate. Moving forward requires

- One CGIAR to continue recognizing the role of fish agri-food systems in the wider agri-food system and foster adoption of technical and social innovations at scale as a contribution to achieving overall system transformation;

- public agencies to ensure sufficient attention to fish agri-food systems within policies and investments, in both the "traditional" fisheries

and aquaculture sector and the food, health, water and related "non-fish" sectors;

- recognizing that the fish agri-food system involves large numbers of vulnerable people—particularly women, the poor and those threatened by loss of natural resources, severe climate change impacts and malnutrition—and ensuring they are given greater focus and attention;

- improving assessment, evidence and metrics related to fish agri-food systems, particularly for vulnerable populations, and continuing to support evidence-based decision-making in the process of food, land and water system transformation.

FISH has provided a strong foundation of research, innovations and partnerships that have and continue to make contributions to the Sustainable Development Goals. The integration of promising innovations into the future One CGIAR initiatives represents one pathway to accelerate innovations to greater impact, but stakeholders beyond One CGIAR are encouraged to assess and innovate from the many opportunities for impact developed by FISH.

Chachra Fingerlings Market in Jashore, Bangladesh.

Photo credit: Noor Alam/WorldFish

5. Key resources

Below is an inventory of key resources as they align to key research areas of FISH, including a set of strategic briefs that illustrate program logic, outcomes and learnings.

Sustainable aquaculture

Genetics
https://hdl.handle.net/20.500.12348/5009

Diseases
https://hdl.handle.net/20.500.12348/4833

Feeds
https://hdl.handle.net/20.500.12348/4754

Aquaculture systems
https://hdl.handle.net/20.500.12348/5061

Sustaining small-scale fisheries

Coastal fisheries
https://hdl.handle.net/20.500.12348/5017

Integrated fish-water systems
https://hdl.handle.net/20.500.12348/4847

Fish-rice systems
https://hdl.handle.net/20.500.12348/4910

Food systems
https://hdl.handle.net/20.500.12348/4947

Crosscutting themes

Gender
https://hdl.handle.net/20.500.12348/4875

Youth
https://hdl.handle.net/20.500.12348/4752

Climate
https://hdl.handle.net/20.500.12348/4921

Capacity development (in press)

Fish agri-food system impact and Sustainable Development Goals

Nutrition and health
https://hdl.handle.net/20.500.12348/4827

Small-scale actors, livelihoods and poverty reduction
https://doi.org/10.1038/s43016-021-00363-0

Climate resilience
https://doi.org/10.1038/s43016-021-00368-9

Tools and methodological innovations

Theory of change (in press)

Digital tools (in press)

Gender-transformative approaches (in press)

Notes

[1]   Accessed on November 30, 2021.

[2]   Accessed on December 14, 2021.

[3]   Accessed on November 16, 2021.

About FISH

The CGIAR Research Program on Fish Agri-Food Systems (FISH) is a multidisciplinary research program. Designed in collaboration with research partners, beneficiaries and stakeholders, FISH develops and implements research innovations that optimize the individual and joint contributions of aquaculture and small-scale fisheries to reducing poverty, improving food and nutrition security and sustaining the underlying natural resources and ecosystems services upon which both depend. The program is led by WorldFish, a member of the CGIAR Consortium. CGIAR is a global research partnership for a food secure future.

For more information, please visit fish.cgiar.org