CGIAR

RESEARCH PROGRAM ON Fish

Led by WorldFish

More sustainable, productive and inclusive fish agri-food systems

2020 ANNUAL REPORT

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FISH at a glance

The CGIAR Research Program on Fish Agri-Food Systems (FISH) is a multidisciplinary research program led by WorldFish, in partnership with the International Water Management Institute (IWMI), James Cook University, the University of Greenwich and Wageningen University & Research. A fish agri-food system is an interconnected and interdependent system involving components of fish production, through to processing, marketing and consumption. FISH, in collaboration with our research and development partners and a diversity of stakeholders, develops and implements research innovations that enhance the role of aquaculture and small-scale fisheries to reduce poverty, improve food and nutrition security, and sustain natural resources and ecosystem services upon which people and the fish agri-food system ultimately depend.

Our vision

Resilient fish agri-food systems that deliver sustainable increases in socially and gender-inclusive production and equitable distribution of nutritious fish to those most in need.

Our mission

To deliver evidence-based solutions that address the complex challenges and opportunities in fish agri-food systems in the developing world.

Our beneficiaries

FISH works to reduce poverty and improve food and nutrition security for fish-dependent households and communities as well as the processors, traders and consumers of the fish they produce.

Our research primarily targets the needs of small-scale fishers and fish farmers in low-income, food-deficit countries in Africa, Asia and the Pacific. We focus particularly on developing the capacity of women and youth to participate in decision-making around aquaculture technologies and small-scale fisheries management, as a key enabler of impact.

As fisheries and aquaculture adapt to changing ecological challenges and opportunities, our work on climate-smart technologies and production systems and mitigation strategies is building adaptive capacity and resilience to external shocks for fishers, farmers and other stakeholders in fish value chains, and a better response to the COVID-19 pandemic.

Message from the Chair of the Independent Steering Committee

Those of us fortunate enough to have access to a wide variety of plant and animal foods have many ways to meet our nutritional needs. However, for millions of people with scant food sources, the availability of even small amounts of nutrition-dense foods can be critical to health and wellbeing, particularly for young children and pregnant women. Fish is among the most nutritious of all food types, which is why FISH is striving to increase the sustainable production of, and access to, fish as vital inputs to community diets and livelihoods. And according to a recent review, FISH is achieving that goal with global impacts on improving the income, empowerment and nutrition of hundreds of thousands of individuals in low-income countries.

An independent external review organized by the CGIAR Advisory Services looked at FISH's past and current accomplishments, resources, inputs, networks and collaborations and concluded that FISH has delivered high quality science and effectiveness. The lessons learned from FISH provide the foundations for future investment and impact in aquatic foods within One CGIAR.

A theme that came out in the review is how the FISH program has achieved integration within and across the research domains. In sustainable aquaculture, integration has enhanced the combined effects of improved tilapia and carp breeds, fish disease detection mitigation, access to and use of aquafeeds ingredients, feed management systems and tools and digital tools.

In small-scale fisheries integration has improved the management of, and benefits from, fisheries from community to regional levels. Water management innovations in multifunctional rice-dominated landscapes, and improvements in policies are enabling more productive and equitable management of inland and coastal fisheries and highlighting the often-hidden role of small-scale fisheries in income and nutrition.

The external review highlighted two examples of significant positive impacts: improvements to the hilsha fisheries in Bangladesh and the nutritional benefits of rice field fisheries. Overall, the research is having a profound effect on raising global awareness of the benefits of small-scale fisheries.

The external review also noted that the cross-cutting themes are operating very effectively. FISH's work on gender transformative approaches research has significantly increased the participation of women in fisheries and aquaculture. The research on youth is demonstrating the critical need for greater engagement and support for youth participation in fish agri-food systems. This is also emphasized by the success that the FISH capacity building team is having in supporting both short-term and longer-term youth training. The Monitoring Evaluation and Learning team is having a huge impact in delivering rigorous analysis of the outputs and impacts of FISH.

The reviewers concluded that FISH can provide a sound foundation and starting point to future work in the One CGIAR. The review highlighted how the current flagships, clusters and cross-cutting themes are highly impactful and should be continued in order to derive full benefit from the strong foundation that has been laid. One CGIAR now offers a response to the central challenge of a "world food plate." We can now look at the interactive benefits of the cereals and some protein, whether that's animal protein or fish protein, and see a plate of food focused on nutrition and not just individual commodities.

On behalf of the ISC, I would like to congratulate the FISH leadership team and all participants on another year of outstanding outputs and impacts. On a personal note, it has been a pleasure and honor to serve as ISC Chair and I look forward to a successful completion of the program and continued momentum into the future based on the strong foundation that has been built.

Nigel Preston
Chair, Independent Steering Committee

Message from the Director

I am pleased to present this FISH Annual Report which highlights major FISH innovations. These innovations – or "golden eggs" – represent the key areas of research and innovation that FISH teams and partners have developed through the program. In 2020, these golden eggs are now showing real potential for impact. With further nurturing, the golden eggs will thrive beyond FISH and provide the foundation for long-term impact.

The FISH innovation package on gender transformative approaches is re-shaping the way that gender issues are approached in fish agri-food systems. The report highlights examples from the Barotse Floodplain of Zambia and the Barisal region of southwest Bangladesh where short-term fixes to gender issues are being replaced by a shift to addressing underlying gender barriers that perpetuate inequalities.

Recognizing the importance for aquaculture productivity and integration of genetics with better feed, health and management, a further FISH innovation package was developed around better management practices (BMPs). The report highlights BMP packages for enhanced productivity, disease management and feed efficiency improvements in aquaculture systems that result from their adoption.

Selective breeders in the terrestrial agricultural realm are happy with gains of a few percentage points per generation. Our genetic improvement innovations in tilapia and carp are achieving gains anywhere from 8% and higher. The report highlights the progress made up to 2020, and the foundation of improved strains of tilapia and carp that will remain useful, valuable and available for many years to come.

The nutritional benefits of fish are being well documented, but fish products can be expensive or inaccessible to those who most need that nutrition. In this report, we tell how FISH has worked on developing accessible new products for consumers in Odisha, helping a group of women in Timor-Leste make and sell a fish-based powder, promoting dried small fish species powder in Myanmar, and reducing waste through use of a fish solar tent dryer in Malawi.

FISH has also helped develop a suite of digital tools and approaches for aquaculture and small-scale fisheries that improve management and policy decisions across fish agri-food systems. Our innovation package includes a variety of tools that are increasingly being put into use to inform and connect farmers and other value chain actors, as well as advise government entities in real time for decision making.

As the climate and biodiversity crises become increasingly challenging, we need to look at more nature-positive climate resilient approaches that secure food and nutrition security. Our work in rice landscapes builds on 2,000-year-old traditions with innovations that combine productivity and nutrition outcomes, whilst also building resilience and enhancing biodiversity. The report highlights that securing fish harvests within rice fish systems through a suite of innovations can maintain rice productivity and almost double profitability of the landscape.

Lastly in this year's annual report, we tell the story of our fisheries co-management golden egg. This innovation package highlights our work with communities to engage in local economic development and governance activities and encourages community conservation through mutual stewardship of natural resources.

Eggs need to be nurtured if they are to hatch and thrive. Over the past four years, FISH has strongly focused on capacity building. Our Young Scientists program will ensure that not only will these golden eggs be nurtured but that there will be many more to come.

Finally, I take this opportunity to highlight the hard work and enthusiasm of our partners and donors. FISH is indebted to them and I feel this annual report is a testament to their commitment.

Michael Phillips
Director, CGIAR Research Program on Fish Agri-Food Systems

FISH in numbers

487,973 vulnerable women, children and men have increased fish consumption and dietary diversification due to aquatic foods interventions.

1,765,984 hectares of water were brought under improved fisheries co-management and aquaculture management.

291 active partnerships: 60 new for 2020.

28 improved policies and investment decisions at various levels.

301,401 households adopted improved fish breeds, aquaculture or fisheries management practices.

85 private sector partnerships: 37% increase from 2019.

516,000 people were assisted to exit poverty.

406,104 received short term training and 32 long-term training (PhD & Internships)

FISH Independent Evaluation: key messages

The outcomes from FISH are looking very positive. An independent review commissioned in 2020 by the CGIAR Advisory Services looked at our past and current accomplishments, resources, inputs, networks and collaborations and concluded that we will continue to deliver a high quality of science and effectiveness for the duration of the program and that the experience will provide the foundations for future work within One CGIAR.

The review of FISH was conducted in late 2020 to assess our quality of science, effectiveness and future orientation. The reviewers posed three questions: 1) To what extent does FISH deliver quality of science? 2) What outputs and outcomes have been achieved and what is the importance of those identified results? 3) What evidence exists for future effectiveness within the life of the program?

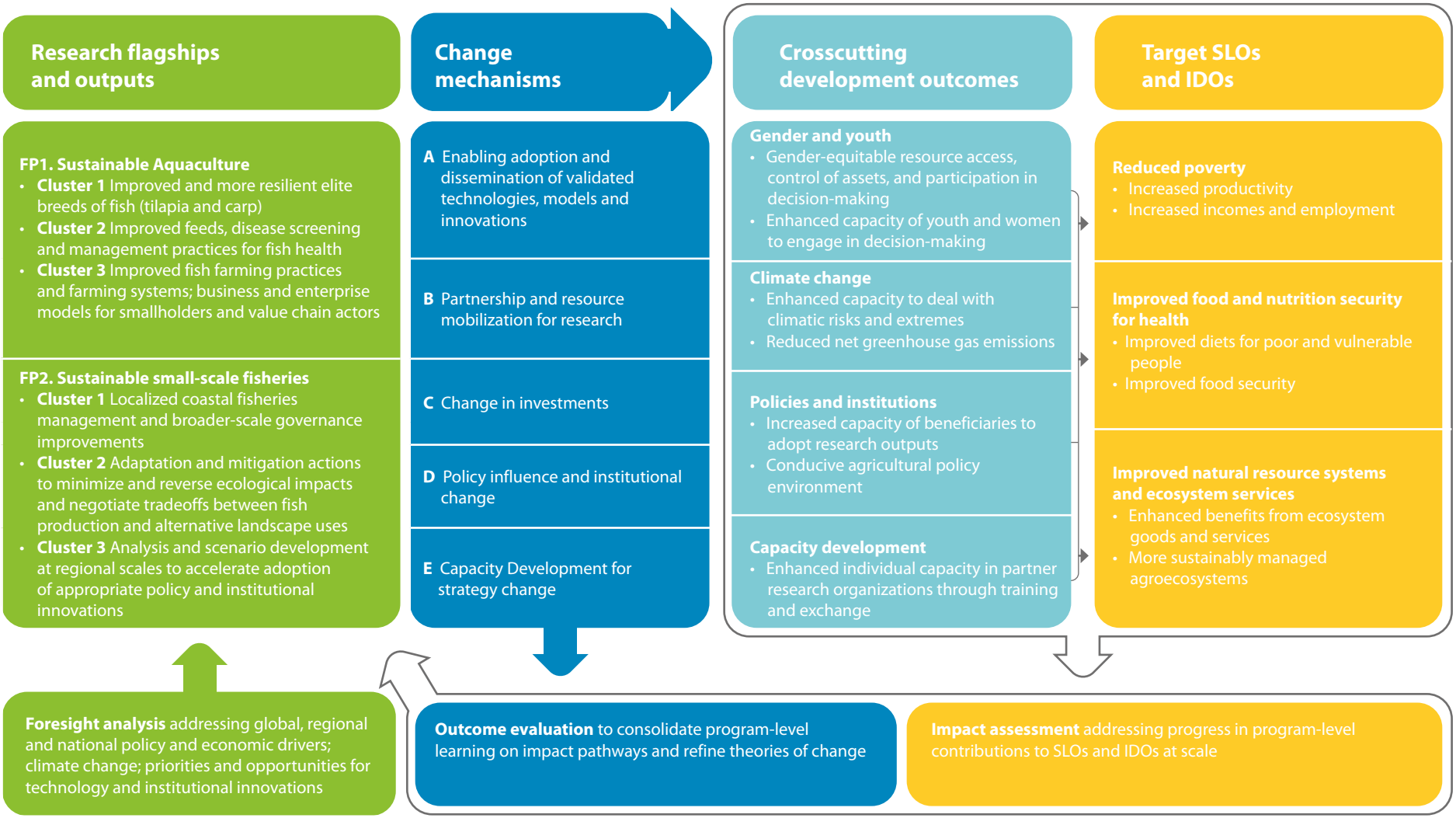
According to the reviewers, FISH has a high quality, extremely hard-working, dedicated scientific team with a mixture of skills, experience and training. The research is enhanced by strong multi-disciplinary approaches. The reviewers praised FISH germplasm outputs and, for example, noted that GIFT tilapia are gaining 8% faster growth or more per generation. They also highlighted the high-quality, award-winning tools and technologies. High quality science, and capacity building and policy contributions have helped FISH make significant progress along the Theory of Change (ToC). FISH work has helped improve income, empowerment and nutrition for hundreds of thousands of individuals in low-income countries.

The reviewers were able to extract some lessons learned from FISH, which can no doubt be applied to future work:

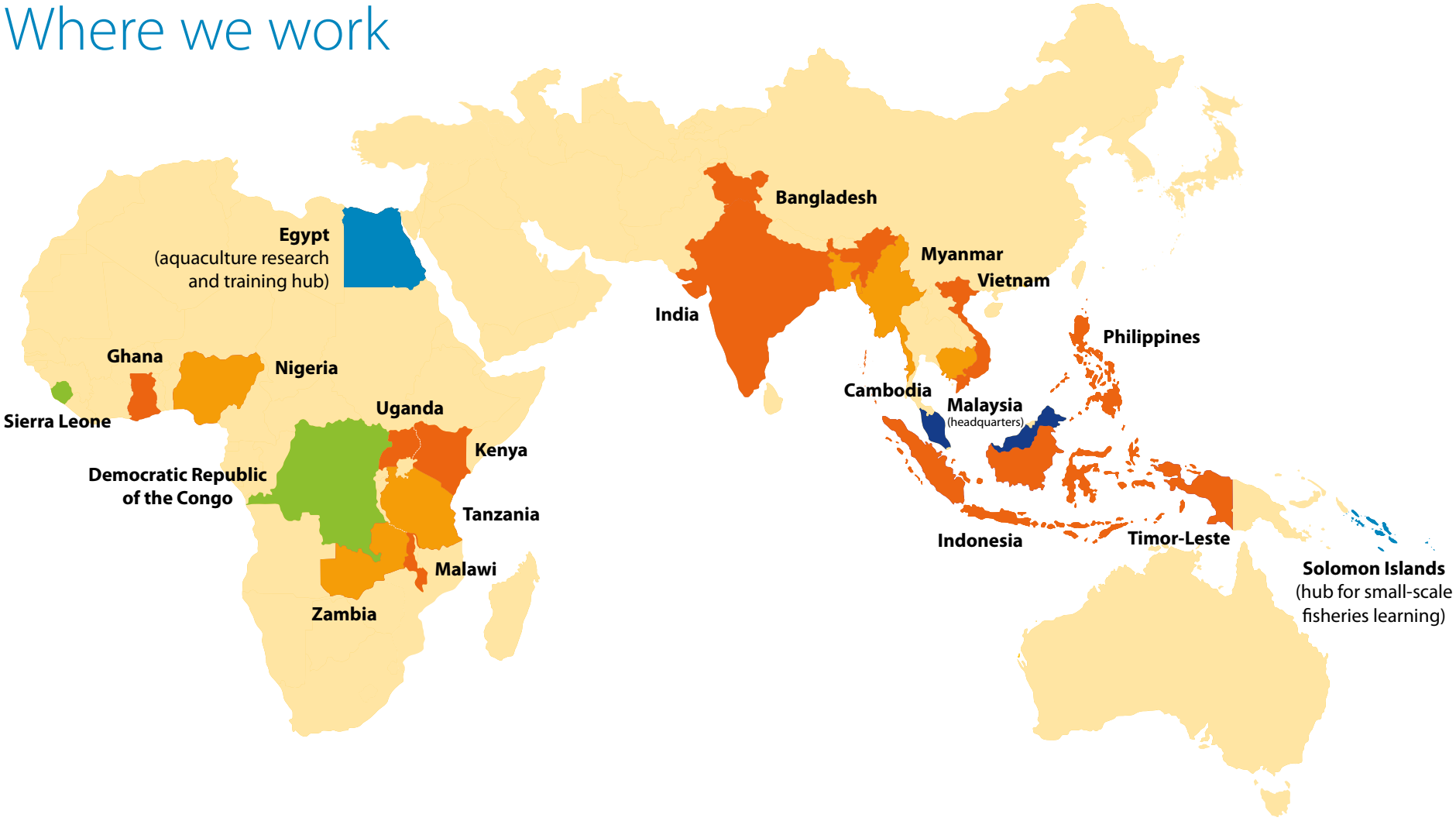
- Involving communities in fisheries management can be highly effective in sustaining and increasing a natural resource that ultimately impacts the income and nutrition of low-income communities.
- Partnering and involvement of medium and large enterprises in technology transfer to the poor can increase 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-satisfaction.
- 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. Most of the flagships, clusters and cross-cutting themes are highly impactful and should be continued to derive full benefit from the strong foundation that has been laid. This includes our work in genetics, aquaculture feeds, fish diseases, nutritious ponds, micronutrients, small-scale fisheries, rice-fish refuges, policy contributions, and gender and youth.

FISH impact pathways and theory of change



Where we work



- FOCAL COUNTRIES
- SCALING COUNTRIES
- LEARNING HUBS
- OTHER COUNTRIES WITH SIGNIFICANT PROJECTS
- PROGRAM OFFICE

FISH pursues an integrated body of research in six focal countries. Three are in Asia (Bangladesh, Cambodia and Myanmar) and three are in Africa (Nigeria, Tanzania and Zambia). In addition, the Program focuses on Egypt as a research hub and training center for our aquaculture capacity development in Africa, and Solomon Islands as a hub for our learning networks on small-scale fisheries governance in the Pacific.

FISH innovations and impact

With this annual report, FISH presents seven innovation packages, which we have affectionately called "golden eggs." The CGIAR has adopted the term "golden eggs" to describe innovation packages since the term captures the fragility of the innovations in a change process but also highlights the notion of continued life with appropriate nurturing.

The seven golden eggs of this report represent the key areas of research and innovation that FISH has focused on since the start of the program in 2017. The eggs package innovations from FISH's two research areas – sustainable aquaculture and resilient small-scale fisheries – and its three cross-cutting themes – gender, climate change and youth. In 2020, these golden eggs are being hatched and we can now start seeing some of the impact from these areas of innovation in the countries we work in. With appropriate nurturing we hope that these golden eggs will thrive in the long term as an integral initiative of One CGIAR.

Gender transformative approaches address root causes of gender inequality

Gender transformative approaches complement and go beyond traditional gender approaches. While traditional approaches work around gender barriers, transformative approaches shift underlying social norms that perpetuate inequalities. GTA can contribute to more potent and longer-term gender outcomes.

Research for development projects have implemented strategies to engage, benefit, and at times, empower women for more than half a century. These efforts have been tremendously valuable, but they often fall short. They haven't levelled the playing field between men and women for the long term. Women directly involved in the projects may benefit during the lifespan of a project but as soon as the project winds up the positive effects may recoil.

The **Global Gender Gap Report** suggests that on the current trajectory it will take 136 years to achieve gender equality. We must take different and deeper approaches to gender barriers in order to transform food systems towards equality rather than tinker at the edges. Gender transformative approaches (GTA) present such an opportunity to engage with the root causes of gender inequality.

GTA complement and go beyond the more traditional gender accommodative approaches. While traditional approaches work around gender barriers, transformative approaches seek to shift underlying gender barriers that perpetuate inequalities. Moreover, while it is common to focus gender efforts only on women, GTA engage both women and men together in understanding and co-creating locally developed strategies. This takes the burden of change off women and recognizes that gender equality is the responsibility of everyone. Emerging findings indicate that this transformative approach may contribute to more potent and longer-term gender outcomes.

FISH has been at the forefront and a champion of developing GTA. But it hasn't always been easy going. Initially, there was minimal experience regarding how to implement GTA in food systems. There was also a lack of empirical evidence on its specific outcomes and a dearth of understanding and tools for monitoring outcomes.

Reducing post-harvest fish losses in Zambia

To overcome these challenges, **FISH continued earlier work of the CGIAR Research Program on Aquatic Agricultural Systems (AAS)** to test GTA within a fish post-harvest project to reduce post-harvest fish losses. In the Barotse Floodplain of Zambia, men generally tend to be the primary fishers, women are the primary processors of fish, and a mix of women and men do the trading. Gender norms and dynamics in this context mean that women carry high unpaid care and domestic burdens, while at the same time having lower decision-making power and ownership of assets. The study found that these dynamics are not only gender inequitable, but they also contribute to higher fish losses.

To implement GTA in this study, the team facilitated discussions with the community and within the

participatory action research groups that tested and developed the technologies over time. A communication tool comprised of drama skits on gender-related issues facilitated the discussion with the community. The main topics for the skits included reflecting on local patterns of division of care and paid work between men and women, power, support and working together, and gendered decision-making. The skits were developed to transmit the serious and sensitive subject matter in a relatively fun and humorous way. Facilitators asked thought-provoking questions to participants after the entire skit was acted out.

The research, not only helped meet the challenge of "how" to carry out GTA, but also provided empirical evidence. Results indicate that GTA led to significant changes in gender equal attitudes and women's empowerment outcomes compared to only using a gender accommodative approach.

Gillnets in Bangladesh

Cultural norms vary across the world, so FISH worked not only in Africa but also Asia to develop GTA. In the Barisal region of southwest Bangladesh, men generally harvest fish from backyard ponds. Families face criticism or ridicule if women take on this role. Harvesting typically requires entering the pond, so women are often reluctant to do because it would mean their clothing would stay wet all day.

To address these challenges, an integrated technical and social strategy was prepared. On the technical side, **FISH developed a low-cost gillnet** that women could use from the bank rather than entering the pond. On the cultural side, the team developed and conducted gender consciousness-raising exercises. For these sessions, the project included not only women training participants but also members of the women's households, in particular spouses and more powerful household members. Facilitators sought to create a safe environment for participants to engage candidly and without fear of repercussions. These sessions sparked reflection and dialogue between household members about current gender dynamics, how these affect family members and outcomes, and possibilities for shifting dynamics.

Measuring outcomes of GTA

To help measure outcomes of GTA, FISH developed and tested the Women's Empowerment in Fisheries Index (pro-WEFI). The pro-WEFI was inspired by the **Women's Empowerment in Agriculture Index (WEAI)** developed by IFPRI. FISH adapted WEAI to work with GTA by including mixed methods, enabling before and after measure of change, incorporating measurements of change in gender attitudes, and assessing "power within" as a dimension of empowerment.

After the successful pilots in Bangladesh and Zambia, FISH has partnered with other actors in CGIAR to develop GTA projects, including IMWI and the CGIAR GENDER Platform. FISH has contributed to GTA being taken up by international agencies such as the Food and Agricultural Organization, International Fund for Agricultural Development and World Food Programme. FISH also supported GTA's inclusion in the United Nations Food Systems Summit. Building on this rich history, these partners will continue to develop and test the next generation of innovative, scalable strategies, methods and tools for catalyzing and assessing gender-transformative change and women's empowerment.

Re-integrating fish into multi-functional rice landscapes

FISH has been adapting rice-fish production practices first used 2,000 years ago to bring fish back into the rice fields. Rice and fish can be integrated using a variety of innovations that can make efficient use of increasingly scarce water and land. The innovations not only address environmental and nutrition concerns but can also improve the livelihoods of rural farmers.

Integrating fish with rice production in the same place is hardly an innovation. Designs on ancient Chinese pottery show us that the practice is at least 2,000 years old. But with the advent of modern agriculture, rice production and fisheries have become less integrated. Rice has become a monoculture and as its production rises wild fish production declines due to habitat loss and fragmentation, alteration of hydrological flows, and harmful use of agro-chemicals. FISH has been active to adapt rice-fish production practices to bring fish back into the rice fields, to address environmental and nutrition concerns and improve the livelihoods of rural farmers.

Throughout Asia, most lowland rice is grown in standing water … water that can be used by fish for feeding and spawning. Rice and fish can be integrated using a variety of innovations, ranging from systems involving capturing wild fish in rice fields to intensive rice-fish culture systems. For example, in one type of rice-fish production practice, farmers cultivate rice during the dry season and stock, grow and harvest fish from the flooded rice fields during the wet season.

Integrated rice-fish systems can make efficient use of increasingly scarce water and land. When natural rice field flooding occurs, wild fish and other aquatic animals use these spaces. The animals fertilize the rice leading to gains in rice yield and help to control pests thus reducing the use of chemicals in rice production. Recognizing these natural species and adapting rice paddy land to allow for an integration of fish with rice-dominated landscapes can improve nutrition, increase income and lessen environmental impact, particularly when using targeted varieties of rice and species of fish.

In 2017, work through FISH began towards increasing understanding and information surrounding fish agri-food systems. FISH has focused on Myanmar and Cambodia to develop solutions to integrate fish within rice-based farming systems. Both countries could benefit from improvements in rice and fish integration at the landscape level.

In Myanmar, rice farming covers approximately eight million hectares and involves more than five million households. Within the Ayeyarwady Delta, fishing is a priority because of the connected rivers and water bodies that connect to floodplain fisheries. Fish, particularly small, wild fish species, have been identified as a good source of micronutrients, as well as fatty acids and animal protein. Estimates suggest that poor families consume 7 kilograms/per person/per year, compared to up to 50 kilograms/per person/per year for the richest families.

Most people in Cambodia live in rural areas and diversified livelihoods are prevalent, where households undertake fishing and other activities in addition to rice farming. Around 80% of Cambodia's rice farmland is rainfed, and most of this area contains diverse rice field fisheries.

Rice-fish farming in Myanmar

Trials conducted by FISH in Myanmar's Ayeyarwady Delta show that growing fish in rice fields and using best management practices can maintain rice productivity and almost double profitability due to the fish production. **Research in Myanmar demonstrates** that even if the area of rice cultivation is reduced by 13% to accommodate a fish refuge, rice yield increases by 6%, with a net profit increase of 132% due to the harvest of fish. The rice-fish systems encourage better management practices for rice and thereby increase rice yield, profitability, employment options for youth and women, and family nutrition.

More than 45% of land in the Ayeyarwady Delta is considered suitable for rice-fish farming. **Converting just 10% of this land area to rice-fish farming** would produce 100,000 tons of edible fish and associated micronutrients and create USD 100 million more income per dry season when compared to traditional rice farming in neighboring areas.

Integrated rice-fish systems can make efficient use of increasingly scarce water and land.

Community fish refuges in Cambodia

Community fish refuges (CFRs) are the heart of FISH and Feed the Future USAID activities on rice-fish systems in Cambodia. CFRs are communal ponds within a village's rice growing area. Fish and other aquatic animals can take refuge and survive extended dry periods in these refuges before returning to adjacent rice fields via connecting channels when water levels rise. A CFR acts as a seasonal refuge for fish and other aquatic animals to survive, grow and reproduce. By 2020, CFRs in Cambodia had led to three times as many households making small fish species an integral part of their diet than in 2017. This work also had significant success in encouraging nutrition and child-friendly preparations of small fish.

FISH has supported the development of a **Decision Support System,** which is a bundle of tools for the planning and management of rice-fish systems. The tools help ensure the needs and aspirations of stakeholders are reflected when tailoring investments for specific social, economic and environmental contexts. The bundle includes training modules and a comprehensive database of physical, social, and climate variables that feed into a spatial rice-fish suitability model.

Given the success of its work in Asia, FISH is now sharing these experiences with AfricaRice in West Africa under European Commission and World Bank funding, for adaptation and scaling within countries with significant rice-based diets.

Digital tools for decision making and investment in fish agri-food systems

Digital tools and innovations can help record fishing activities, improve access to aquaculture finance and markets, improve efficiency of management and conservation planning, and identify fish pathogens.

Actors involved in aquaculture and small-scale fisheries need to be able to anticipate and respond to changes in systems quickly and appropriately. Innovations in technology and new digital tools help to generate more structured and powerful data ecosystems that now allow these actors to work toward improving fisheries and sustainable aquaculture.

FISH has supported the development of a suite of digital tools and innovations to assist multiple actors to improve management, investment and policy decisions in fish agri-food systems.

Fisheries monitoring

Fisheries in Timor-Leste are small-scale, and most fishers are gleaning on foot or use paddle canoes to access narrow fringing reefs and other nearshore habitats. Currently, coastal waters in Timor-Leste have healthy fish stocks and while there is great potential to develop small-scale fisheries, there is also a danger that certain species could be overfished.

With the support of FISH and partners, Timor-Leste now has one of the most sophisticated data collection systems for small-scale fisheries in the world. PeskAAS is a web portal displaying data and insights on the fisheries of Timor-Leste. PeskAAS relies on a team of community-based enumerators collecting catch data from fishers around the country. Catch data are matched with location data from solar-powered vessel trackers to show fishing trends over time and space. This system puts small-scale fisheries data in the hands of fisheries officers, researchers and local stakeholders and enables a better understanding of the contribution of fish and fisheries to local livelihoods and food security. PeskAAS was built with the objectives of being low cost, open source, open access and near-real time, and has now achieved national level uptake and financial backing by the Government of Timor-Leste.

The USAID-funded project Enhanced Coastal Fisheries in Bangladesh piloted an innovative approach of engaging trained boat skippers as citizen scientists who use smartphones to generate reliable fisheries data. The novel catch monitoring system has been introduced to five sanctuaries and 60 citizen scientists are engaged to generate reliable fisheries data with real-time, species-wise catch data.

Financing and marketplaces

Aquaculture market actors in Bangladesh struggle to gain access to financing. Small operators are taking loans from relatives, neighbors, and informal sources, and operating capital has largely shifted to cash transactions due to low harvests and market prices.

The USAID-funded **Feed the Future Nutrition Activity Bangladesh** (BANA) has helped improve access to aquaculture finance and markets. An innovative formal financial package provides digital channels that have improved access to credit for small aquaculture farmers in the country. This innovation uses digital approaches to access microloans directly from banks. Digital channels have been created for fish retailers, hatcheries and other small- and medium-sized enterprises to directly access credit from a bank by creating a digital transaction history. The digital payment systems for trading among farmers, input retailers and other stakeholders are showing great promise.

The BANA project has also helped access to markets via the **Digital MachHaat app**. This digital marketplace connects smallholder fish farmers with buyers throughout Bangladesh, creating sales opportunities for smallholder fish producers to hard-to-reach buyers through a smartphone app.

Regional data in the Coral Triangle

The Coral Triangle is an area encompassing ocean and coastal waters in Southeast Asia and the Pacific, including Indonesia, Malaysia, Papua New Guinea, the Philippines, Timor-Leste, and the Solomon Islands. Data on fisheries, biodiversity, natural resources, and socioeconomics have been collected for decades by scientists and managers working in different parts of the Coral Triangle region. However, to date, little of this information has been aggregated into region-wide layers to provide an overview and support management planning and decision-making at a regional level.

FISH researchers have partnered with the Coral Triangle Initiative to upgrade the **Coral Triangle Atlas.** The Atlas is an online GIS database, providing governments, NGOs and researchers with spatial data across the region. The Atlas is intended to improve the efficiency of management and conservation planning in the region by giving researchers and managers access to spatial data while providing a platform to share data and visualize and plug data gaps.

Lab in a backpack

Aquaculture farmers face challenges regarding the control of fish diseases. Early detection of pathogens and their genetic variations are critical for determining the origin and spread of disease outbreaks. Genome sequencing that could identify diseases in fish is not only costly but requires time and coordination between specialist labs. FISH brought together partners to create a **"lab-in-a-backpack,"** equipped with a portable DNA-extraction system, a hand-held DNA sequencer and a battery-operated minicomputer that can identify fish pathogens from water samples and infected tissues by users who don't have expertise in molecular biology or bioinformatics. A cloud-based database is being developed to track fish disease outbreaks, which can be accessed by a smartphone, informing management actions for farmers and extension agents, as well as informing business on investments required.

New generation co-management approaches

FISH has supported a bundle of innovations to improve outcomes of co-management, including innovations that increase equity and inclusion in co-management establishment, implementation and review

Fisheries co-management is widely adopted globally as the preferred approach to govern small-scale fisheries. Co-management refers to a collaborative relationship to share management responsibilities and authority between resource-user groups (e.g. local fishers or communities) and other entities (e.g. principally a government agency, but in some contexts a non-government organization). Those who are affected by management (e.g. fishers and other resource users) are involved in determining management objectives and rules – in doing so improving the legitimacy and fit of management arrangements. Whilst these co-management processes perform well for participation broadly, research shows that some sectors of society can become increasingly marginalized, or 'conversely' empowered in these processes – widening existing inequalities. Whilst there is evidence co-management has delivered benefits to sustainability, in some contexts and for some fisheries configurations (multi-species fisheries) data and evidence are sparse. FISH has developed and piloted a number of innovations across several countries, seeking opportunities to improve the model of co-management that will be applied more widely.

Empowering local fishers to monitor their own fishery area has been shown to improve enforcement capacity along with compliance to fishery regulations.

The management of small-scale fisheries in Lake Nasser of Upper Egypt is well suited to a co-management approach. Lake Nasser is a critical fishery where stocks are overfished and catches have been declining. WorldFish in cooperation with Egypt's General Authority for Fish Resources Development and other stakeholders carried out a baseline study and an ecological risk assessment. Stakeholders, including fishers, managers and nongovernmental organizations, were convened to design and formalize an ecosystem-based, co-management approach to manage and rebuild the fishery. In addition to technical and biological aspects, the plan covers the social, economic and institutional aspects related to the Lake Nasser fishery.

In Solomon Islands, declining coastal fishery resources and environmental degradation are increasingly putting livelihoods and food and nutrition security at risk. Hundreds of communities have implemented community-based resource management (CBRM) strategies for managing these coastal resources. The CBRM approaches used can be quite intensive and long term and therefore engagement can be slow and expensive and have

limited reach. FISH and partners have adopted a "lite-touch approach" as an efficient and cost-effective way to establish and spread CBRM. The lite-touch approach relies on a local volunteer who acts as a community champion and leads community activities and on "look and learn" trips. This method was successfully tested in the village of Mararo, where it was effective in raising awareness and sharing experiences and knowledge with surrounding communities as well as motivating them to take management action themselves. To support more inclusive facilitation of CBRM in Solomon Islands and the Pacific more broadly, FISH developed a suite of facilitation strategies – published as an addendum and improvement to a facilitators guide that has been taken up and influential throughout the region for the last decade.

The hilsa shad fishery in Bangladesh has also benefited from co-management, improved through the USAID Ecofish project. Hilsa is a herring-like fish that spawns upriver and matures at sea. In Bangladesh, the catch had been declining since the early 2000s, but recent bans to control fishing have led to increased catches and fisher incomes for some, but for other families reliant on fishing alone the bans have caused financial distress. The views of hilsa fishers about policy were not being heard. Co-management approaches have been used to engage fishers in the decision-making in the Andharmanik River area and has resulted in fishery improvements.

Empowering local fishers to monitor their own fishery area has been shown to improves enforcement capacity along with compliance to fishery regulations. Enforcement agencies in Bangladesh have insufficient manpower, funds, equipment and transport. To provide the necessary support in patrolling the fish sanctuaries during the juvenile and brood hilsa ban periods, we worked with local entities and introduced Community Fish Guards (CFGs). The CFG initiative is a co-management process that offers community members an opportunity to engage in local economic development and governance activities and encourages community conservation through stewardship of natural resources.

In Cambodia, co-management approaches were used to enhance the effectiveness and legitimacy of community fish refuges (CFRs). A CFR is a sanctuary for brood fish that is protected from fishing year-round and is especially important as fish habitat during the dry season in seasonally inundated rice fields. They are a form of stock enhancement or fish conservation measure to improve the productivity of rice-field fisheries. Each CFR is managed by a trained committee. In 2019, the Cambodian Government chose to include co-management of CFRs in its 10-year Strategic Plan for Fisheries Conservation and Management.

The hilsa shad fishery in Bangladesh has also benefited from co-management, improved through the USAID Ecofish project.

Faster-growing and more resilient tilapia and carp

Pioneering selective breeding techniques in fish have helped enable aquaculture to now provide half of the global fish supply. Genetically improved farmed tilapia are now in their 17th generation and grow 100% faster than they did before the breeding program started.

In the early 1980s, less than 10% of the fish consumed globally were sourced from aquaculture. But the demand for fish has been growing and now 40 years later aquaculture is the fastest-growing food production sector in the world, providing almost half of the global fish supply.

Early efforts at aquaculture simply didn't pay off. The strains of fish used didn't grow fast and were susceptible to disease. Scientists recognized that if aquaculture was to meet the growing demands for food there would have to be a readily available supply of seed of improved fish. Research started focusing on improving the production traits of commercially important fish through selective breeding.

Selective breeding isn't a new technique. Genetic improvement through selective breeding has been used for millennia on crops and livestock, but in 1980s it hadn't been used for farmed fish. WorldFish began implementing pioneering selective breeding techniques in 1988 based on prior experiences in Norway with trout and salmon.

Selective breeding is based on a "pick of the litter" technique. The techniques developed by WorldFish begin by rearing families of fish in small, separate enclosures until they are big enough to be tagged with a microchip and moved into a communal pond. The tags allow researchers to identify individual fish and assign them a breeding value. The offspring with the highest breeding values become the parents of the next generation. This process of choosing the parents of the next generation results in improved performance for certain traits considered important during production and marketing. These genetic gains are cumulative and permanent.

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From the onset, scientists recognized that the Nile tilapia (*Oreochromis niloticus*) has unique characteristics that make it an ideal candidate for genetic improvement through selective breeding. Tilapia can be grown in diverse farming systems and are omnivorous, requiring minimal fish meal in its feed. They have a naturally high tolerance to variable water quality and can grow in both freshwater and more saline environments. Because tilapia are hardy and have good disease resistance, they are inexpensive and easy for small-scale farmers to grow for food, nutrition and income.

Tilapia start breeding when they are four to six months old and that means genetic improvements can be made in a short time. Tilapia are easy to breed, so you can produce the next generation of offspring in a short period – less than a year.

WorldFish and partners created an improved strain of tilapia called the genetically improved farmed tilapia (GIFT). FISH has continued this process, with the GIFT strain now in its 17th generation and growing

100% faster than the fish used at the beginning of the breeding program, contributing to increases in productivity and income for fish farmers throughout many developing countries in Asia. GIFT strains have been disseminated from WorldFish to 16 countries.

FISH hasn't limited its genetics work to tilapia. Carp species are among the most important and widely used fish species in polyculture systems. Genetic improvement programs for the main carp species (rohu, catla and silver carp) in Bangladesh are now starting to improve access of farmers to better quality improved carp seeds, with potential for a significant future impact on fish supply in the country.

FISH is moving beyond the classical methods of selective breeding and is now using DNA-based approaches and genomic tools in its breeding program. For example, a genotyping-by-sequencing platform known as DArTseq will give insights into the genetic makeup of fish populations. Researchers have used DArTseq to identify genetic markers in **catla** and **rohu carp** and establish family relationships. The relationships have been used in genetic analyses of the breeding populations to improve the accuracy of the breeding value estimates, which will be used in future parental selection and mate allocation to avoid inbreeding in the short and long term. Other genomic techniques can make it possible to measure characteristics that are not easy to see in a fish like whether certain fish are resistant to disease.

Faster-growing, hardier and more disease-resistant fish will have many benefits for small-scale farmers and resource-poor consumers. They allow farmers a greater return on their investment, and in some countries will lead to lower prices for consumers. FISH's commitment to improving tilapia and carp through selective breeding provides a foundation from which improved strains will remain useful, valuable and available to farmers in the future.

Sustainable aquaculture growth through better management practices

FISH has packaged the most promising innovations into an integrated set of better management practices (BMPs) for aquaculture, to increase profitability, reduce negative environmental impacts and enhance social benefits. BMPs involve replacing less efficient production systems by implementing technical innovations to facilitate continuous improvement in aquaculture practices.

Aquaculture is the fastest-growing sector in agricultural production globally, but it still falls short of meeting the growing demand of aquatic foods. If we are to achieve sustainable aquaculture intensification and growth, improvements in management are required.

FISH has developed a package of aquaculture innovations called better management practices (BMPs) to bring together in an integrated way the management practices for sustainable aquaculture intensification, including optimizing the benefits from improved genetics. The BMPs are a set of standardized management guidelines prepared with inputs from both local and international actors. The innovations arising from FISH and its partners have developed BMPs covering fish nutrition and feeding regimes, genetics and breeding programs, fish health management, farming systems, pond management, water quality management and gender integration.

BMPs are being made widely available in multiple languages in FISH focal and scaling countries, through partners, with adoption contributing to small farmers' incomes by increasing productivity and efficient use of inputs, and thus reducing negative environmental impacts. They are proving to be especially important to support capacity building among public and private extension agencies.

BMPs for enhanced productivity

In Myanmar, for example, fish farming in the small canals running alongside rice fields owned by farmers is a great opportunity. BMP innovations have focused on two types of water bodies: "garden-irrigation systems" and "water and fish," so-called WISH ponds. To support the fish farmer in their activities, BMP manuals have been published to provide guidelines for tilapia breeding and all-male fry production to support sustainable intensification of tilapia production systems.

In India, a wide set of BMPs have been developed, including a cooperation with the Assam Department of Fisheries to BMPs for *beel* – a type of wetland – fisheries. The BMPs focus on improving the productivity of *beels* by restoring habitat and demonstrating culture-cum-capture fisheries technology demonstration.

BMPs to manage disease

Aquatic animal diseases are an important cause of economic losses. Enhanced BMPs related to disease management and prevention can help to increase productivity.

Bacterial and viral infections are known to be the most important source of disease problems in aquaculture. One of the most severe diseases affecting freshwater fish species worldwide is columnaris, which is caused by the bacteria *Flavobacterium columnare*. Existing methods to detect the pathogen were too complex. FISH help

develop a simpler, on-field applicable technique to detect the bacteria which is proving to be very accurate. The robust performance of the test reflects its potential use, especially in environments with limited resources.

To best combat diseases we need to understand how they develop and how they are transmitted. Special attention was given to the tilapia lake virus (TiLV) that causes significant losses globally. FISH researchers discovered the virus enters the reproductive organs of the fish and can then be passed on to the fertilized eggs. This research indicates, for the first time, that TiLV can be transmitted from parents to offspring and provides the foundation for management recommendations to manage risks in tilapia hatchery operations.

The common method to treat or prevent disease and increase productivity in fish is to use antimicrobials, such as antibiotics. But the intensification of aquaculture production is likely to drive indiscriminate use of medicines while the pathogens might also develop resistance. In low and middle-income countries, regulations and monitoring regarding antimicrobial usage are often insufficient and inefficient. FISH researchers have developed and applied a typology analysis in Vietnam, Bangladesh and Egypt to identify hotspots for antimicrobial resistance emergence and human exposure.

BMPs for fish feed

Among BMPs in aquaculture, there are those related to fish feed. Considering that feed often represents the most considerable operating cost item, the improvement of feed efficiency leads to reduced production costs, contributing to achieving higher sustainability for the aquaculture industry.

There is a lack of quality feed ingredients in low and middle-income countries, especially fishmeal and fish oil. This leads to a dependency on imported feed resources, increasing production costs, particularly for smallholder farmers. To make better use of local ingredients, we have collaborated to create an inventory of local feed ingredients to assist fish feed manufacturers and farmers make better use of available resources.

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Knowledge on fish feed formation is assisting fish farmers in several countries. In DR Congo, a tilapia feed was developed using locally produced feed ingredients. The combination of soybean, maize and cassava flour as local ingredients, together with fish meal, mineral and vitamin premix, and dried cow blood has provide fish farmers with a noticeably improved productivity in tilapia and catfish farming systems.

Feed ingredient data from FISH research are being integrated into databases on the nutritional composition of locally available ingredients, which can be used by feed manufacturers to formulate low-cost, sustainable aquafeeds in Africa and Asia.

Nutrition-sensitive approaches to fish agri-food systems transformation

FISH has been addressing micronutrient deficiency by expanding production of small indigenous fish species, increasing productivity and reducing waste and loss in fish value chains and developing improved feeds to enhance the nutritional value of fish.

The nutritional value of fish is increasingly well known. Fish are a highly nutritious food that contribute a wide range of micronutrients essential to human health. But the people who could benefit most from that nutrition often don't have access to fish. FISH has been working on a set of innovations for production and processing of fish to meet nutritional needs, with an emphasis on vulnerable children and women.

Promoting ready-to-cook fish products

One area of innovation is in ready-to-cook or ready-to-serve fish products. The people of Odisha love rohu. It's a carp and one of the most commercially important freshwater fish in India that grows well in aquaculture. We worked with local partners and developed a standardized processing method to prepare boneless rohu as well as rohu with soft bones. A manual to promote the production and delivery of products from rohu provides a helpful tool for women's self-help groups, fish farmers, entrepreneurs, hotel industries and consumers. As a result, consumers are benefiting from the nutritional qualities of rohu and a new line of business that employs many rural people has been created.

Selling fish-based powder

In some circumstances, fish can be so close, yet so far. Timor-Leste is surrounded by water. And yet, fish are often inaccessible and too expensive for many Timorese. In the coastal village of Beacou, FISH researchers supported a group of women who came up with an idea to make and sell fish-based powder consisting of fish and numerous seasonings. The powder is easily incorporated into children's meals and scattered over popular dishes like rice porridge, soups and noodles to increase their nutritional value. The activity not only makes fish more accessible and affordable but also enables the women in the group to improve their livelihoods.

As a way to encourage the people of Timor-Leste to eat fish and seafood as a part of a healthy diet, Agustinha Duarte, a WorldFish research analyst,

recorded recipes and stories from the women and men involved in aquatic food production. The result of her three-year-long voyage is her book, Cooking Fish and Seafood in Timor-Leste, which takes readers on a journey to discover the diverse people and diets of current and past generations. The recipes provide a helpful and valuable guide for families, households, and restaurants and inspire all Timorese, especially the younger generation, to healthier diets that include more fish and seafood.

Small yet nutritious fish

Bigger isn't always better, particularly in terms of nutrition from fish. Small fish, in particular when eaten whole, are widely available, renewable and versatile resource. They are rich in micronutrients, including calcium, iron and zinc, which is vital for the growth and development of young children. In Myanmar, only four out of 10 households have access to nutritious diets. For poor households, fish is not affordable, and this can lead to micronutrient deficiencies. We have been promoting dried small fish species powder in Myanmar and several countries in Africa and Asia. The Myanmar Sustainable Aquaculture Programme (MYSAP) introduced a fish powder as complimentary food in Myanmar, targeting infants over six months of age and young children. Small indigenous fish species are dried using a dehydrator and then ground to a fine powder and mixed with other food ingredients to make the mixtures. These mixtures can be incorporated in products such as rice porridge, soups and noodles, thereby making them much more nutritious.

The nutrition-sensitive approach has also been promoted through the implementation

In Myanmar, only four out of 10 households have access to nutritious diets.

of innovative processing and transformation technologies. In Malawi, we have supported the development of a fish solar tent dryer. The fish solar tent dryer is a greenhouse-like structure made of a wooden frame and wrapped in a plastic sheet. Using fish solar tent dryers helps to reduce losses in waste, value and quality when fish are processed and transported. Ultimately, that means more Malawians have access to more, and better quality, fish products.

Communications and knowledge sharing

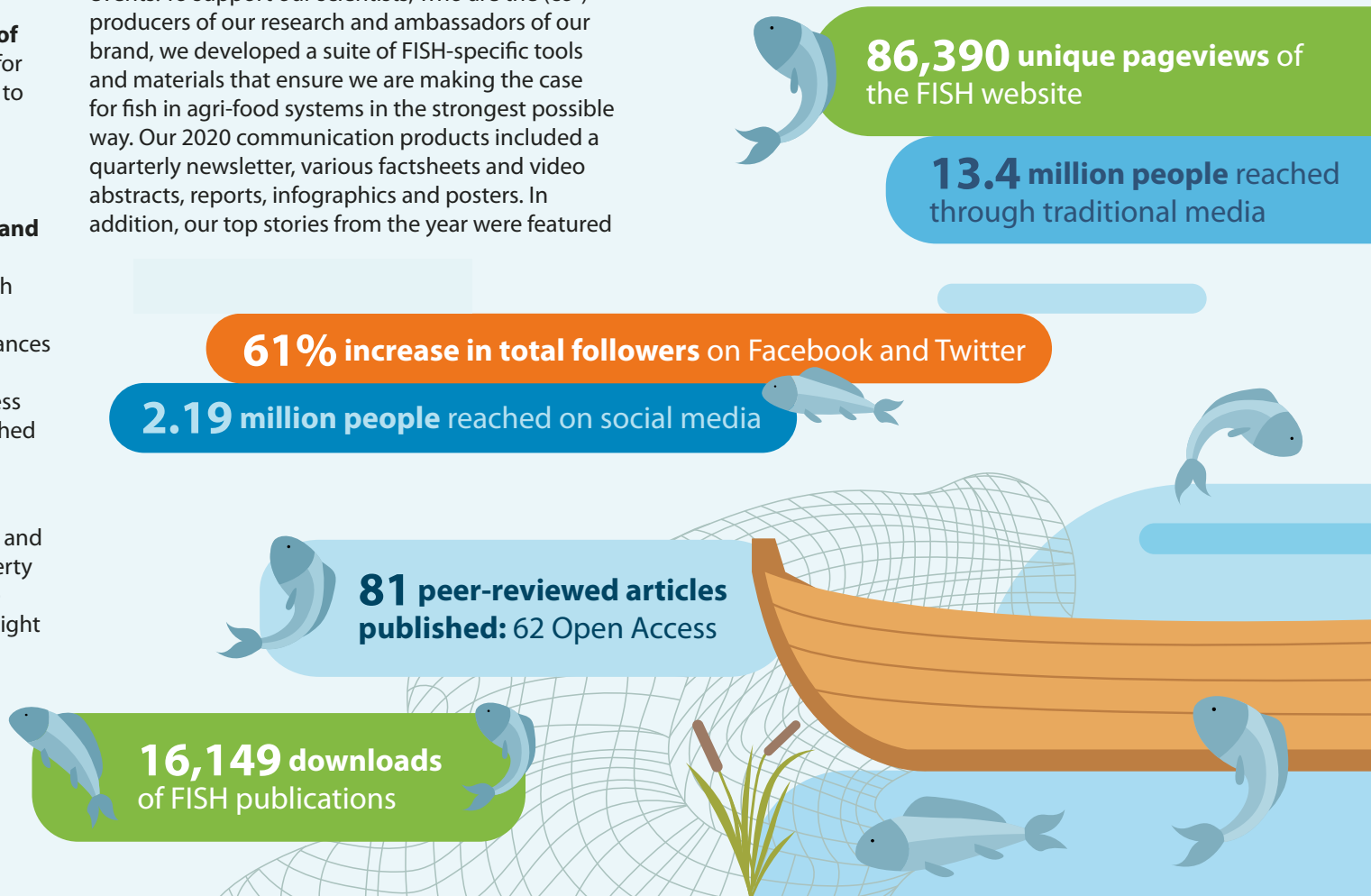
Communication is a way for us to share knowledge and deliver research evidence to a variety of audiences, including fishers, farmers and traders, policymakers, extension agents and the scientific community.

We focus on three areas, with the aim of enabling others to translate our science into action:

1. **Practitioner guidance to enable adoption of technologies and management practices**, for example on improved fish feeds or measures to reduce loss and waste in the value chain.
2. **Evidence, learning and exchange on technologies and innovations shared via peer-reviewed literature, outcome stories and evidence-based narratives** focused on FISH generated science. For peer reviewed research publications, we encourage our scientists to publish in open access journals. In those instances where publishing in fee-paying journals is preferred, FISH endeavors to cover open access costs. Of the 78 peer-reviewed articles published in 2020, 59 were open access.
3. **Policy dialogue** demonstrating the value of fisheries and aquaculture to address national and regional food and nutrition security and poverty reduction goals, and evidence to support the analysis of policy alternatives, including foresight modeling and scenario analysis.

Supporting quality science dissemination

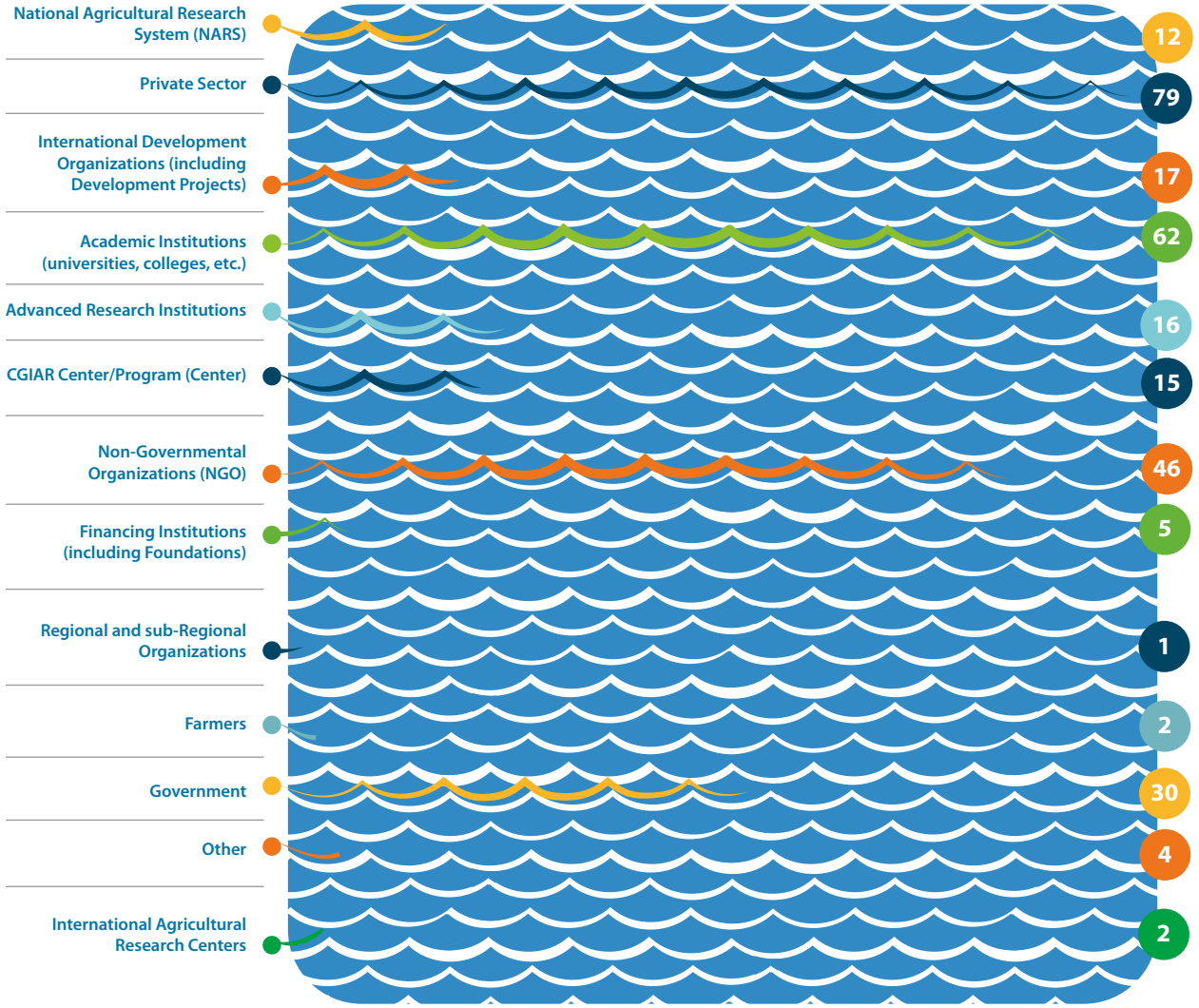
We regularly share our knowledge and research evidence at scientific conferences and other strategic events. To support our scientists, who are the (co-) producers of our research and ambassadors of our brand, we developed a suite of FISH-specific tools and materials that ensure we are making the case for fish in agri-food systems in the strongest possible way. Our 2020 communication products included a quarterly newsletter, various factsheets and video abstracts, reports, infographics and posters. In addition, our top stories from the year were featured in the news media such as the *Scientific American* reaching 3.3 million people and published in blogs and press releases. In total, 234 media outlets carried FISH stories, reaching 232 million people, garnering over 11,000 likes, shares, comments, and retweets on social media.



Partners

We work with an extensive network of partners, including international, national, regional and local governmental institutions, universities, private sector organizations and NGOs, who share our commitment to creating positive change for the millions who depend on fish in the developing world.

In 2020, FISH was engaged in 291 active external partnerships, 60 of which were new. A substantial percentage of these were with academic and research organizations (19%). However, there was significant growth in partnerships with the private sector (29%), and national agriculture research systems and governments (15%), which reflects greater attention to delivering innovations and outcomes with partners at scale through policy contributions, commercialization and capacity building partners.



Investors and financial summary

The 2020 financial plan provided USD 5.56 million of W1/W2 funding, which combined with a 2019 carryover provided FISH with USD 6.21 million of W1/W2 funding for the year. The expenditure of W1/W2 funds for 2020 was USD 6.04 million (97%), and the W3/bilateral expenditure was USD 18.22 million. A total of USD 170,466 W1/W2 funds were carried over to 2020. The sourcing of bilateral funds increased in 2020, providing a planned budget of USD 23.10 million, of which about 79% was spent during the year. The allocation of bilateral funding represents an increase beyond that predicted in the FISH proposal. A significant proportion of these bilateral funds were oriented toward "development" investment, allowing in particular enhanced investment in outcomes and impacts across FISH.

Actual expenditure 2020**	W1/W2	W3/bilateral	Total
FP1 (Sustainable Aquaculture)	2,411,200	14,525,197	16,936,397
FP2 (Sustaining Small-Scale Fisheries)	1,130,831	3,693,443	4,824,274
Cross-program investments	1,891,268		1,891,268
Carry over and contingency funding	-		-
CRP management and support cost	608,321		608,321
CRP total	**6,041,620**	**18,218,640**	**24,260,260**

**Source: Audited lead and participating center financial report.

Governance and Management

Independent Steering Committee

The Independent Steering Committee (ISC) is responsible for the overall strategic direction of the FISH Program. This includes science quality and priorities, risk management, budget allocation and identification of new investment, partnering and funding opportunities to grow and sustain the Program and enhance impact. Membership consists of scientists, practitioners and representatives from end-user bodies that represent a balance of disciplinary expertise, gender and national diversity.

Management Committee

The Management Committee is responsible for timely and effective planning, budgeting and reporting of FISH. The committee is composed of representatives of the five managing partner institutions and the flagship coordinators and is chaired by the FISH Director. The committee reviews the annual work plans and budgets developed at regional and global levels to ensure consistency, integration and appropriate budget allocation across the Program. Once cleared by the FISH Management Committee, work plans, budgets, strategies and other program implementation documents are submitted to the ISC for approval.

FISH people

Independent Steering Committee (ISC)

- Nigel Preston, ISC Chair, University of Queensland, Australia
- Editrudith Lukanga, Environmental Management and Economic Development Organization, Tanzania
- Gareth Johnstone, WorldFish, Malaysia
- Ian Cowx, University of Hull, United Kingdom
- M.A. Sattar Mandal, Bangladesh Agricultural University, Bangladesh
- Marian Kjellevold, Institute of Marine Research, Norway
- Mark Smith, International Water Management Institute, Sri Lanka
- Cristina Rumbaitis del Rio, WorldFish Board of Trustees

Management Committee (MC)

- Michael Phillips, MC Chair, Director, CGIAR Research Program on Fish Agri-Food Systems and Aquaculture and Fisheries, Sciences, WorldFish
- Cristiano Rossignoli, Monitoring and Evaluation Leader, WorldFish
- Cynthia McDougall, Gender Research Leader, WorldFish
- Essam Yassin Mohammed, Climate Change Research Program Leader, WorldFish
- Johan Verreth, retired Head of the Chair Group Aquaculture and Fisheries, Wageningen University & Research
- John Benzie, Sustainable Aquaculture Program Leader, WorldFish
- John Linton, Commercial Director, Natural Resources Institute of the University of Greenwich
- Marion Barriskell, Director of Finance and IT, WorldFish
- Michael Akester, Country Director, Myanmar, WorldFish
- Philippa Cohen, Resilient Small-Scale Fisheries Program Leader, WorldFish
- Shakuntala Thilsted, Value Chains and Nutrition Program Leader, WorldFish
- Sonali S. Sellamuttu, Head of Southeast Asia Office, International Water Management Institute
- Tana Lala-Pritchard, Director of Communications and Marketing, WorldFish
- Terry Hughes, Director, ARC Centre of Excellence for Coral Reef Studies

Managing Partner Institutions

- WorldFish
- International Water Management Institute
- James Cook University
- University of Greenwich
- Wageningen University & Research

Acronyms

BANA	Feed the Future Nutrition Activity Bangladesh
BMP	better management practice
Ecofish	Enhanced Coastal Fisheries
FAO	Food and Agriculture Organization of the United Nations
FISH	CGIAR Research Program on Fish Agri-Food Systems
CBRM	community-based resource management
CFG	community fish guards
CFR	community fish refuge
DArTseq	Diversity Arrays Technology sequencing
GIFT	genetically improved farmed tilapia
GTA	gender transformative approaches
IFPRI	International Food Policy Research Institute
IDO	intermediate development outcomes
ISC	Independent Steering Committee
IWMI	International Water Management Institute
MC	Management Committee
MEL	Monitoring, Evaluation and Learning Platform
MYSAP	Myanmar Sustainable Aquaculture Programme
NGO	non-governmental organization
PeskAAS	*peskas* Automated Analytics System
SDG	Sustainable Development Goal
SLO	system level outcomes
TiLV	tilapia lake virus
ToC	theory of change
WEAI	Women's Empowerment in Agriculture Index
WEFI	Women's Empowerment in Fisheries Index

About FISH

The CGIAR Research Program on Fish Agri-Food Systems (FISH) brings together a unique set of multistakeholder partnerships to harness emerging science in aquaculture and fisheries to deliver development outcomes at scale. The program partners closely with governments, NGOs, the private sector and research organizations to influence national, regional and global policy and development practice.

For more information, please visit fish.cgiar.org