



FEED THE FUTURE INNOVATION LAB FOR FISH

QUICK START RESULTS, LESSONS LEARNED, AND NEXT STEPS

The Feed the Future Innovation Lab for Fish (Fish Innovation Lab) funds research for development to generate knowledge, innovations, and technologies and to transfer information and innovations to stakeholders to achieve impacts. The overarching goal of the Fish Innovation Lab is to alleviate poverty and improve nutrition through reliable provision of fish, a nutrient-rich animal-source food for the billions of people who rely on aquaculture and capture fisheries as a dependable source of protein. To achieve this goal, the Fish Innovation Lab supports research and capacity-building activities targeting three program areas:

Advancing productivity:	Identifying and developing scalable technologies and practices that enhance opportunities for prosperity, nutrition, and resilience in aquaculture and fisheries, with the overarching objective to enhance food and nutrition security.
Reducing and mitigating risks:	Identifying and developing scalable technologies and practices that promote resilience and mitigate food security risks, especially through improved fish health and environmental stewardship.
Improving human outcomes:	Generating evidence on how to improve economic opportunity, nutrition, and resilience sustainably and equitably in aquaculture and fisheries value chains, households, and communities.

In its first and second year, the Fish Innovation Lab funded five “Quick Start” activities. These were short (12-15 month) activities designed to kick-start the Fish Innovation Lab’s research-for-development activities on the ground. The Quick Starts connected to the program areas on advancing productivity and improving human outcomes and, despite their small size, all included aspects of the following approaches:

1. **Research for development.** Increased end-user aquaculture and fisheries research results to promote sustainable, resilient intensification of production systems, enhance food safety and nutrition, increase trade and domestic market opportunities, and contribute to responsible aquatic resource management.
2. **Capacity building.** Increased capacity of local partners to independently generate and transfer fish-related knowledge, technologies, and practices to beneficiaries.
3. **Adoption of innovation and scaling.** Increased adoption of new technologies and practices as well as other innovations.

Following these three approaches, this document provides a summary of the accomplishments, lessons learned, and next steps of the five Quick Start activities.

MAJOR FINDINGS AND LESSONS FROM THE IMPLEMENTATION OF RESEARCH FOR DEVELOPMENT

The five Quick Start activities embodied the scientific rigor, awareness of local context, and building of local relationships required for successful research for development, adoption, and scaling. Connecting to two of the Fish Innovation Lab’s three program areas, below is a summary of the Quick Starts’ major findings and lessons learned:



Advancing Productivity

Nigeria Cold Chain: The study found that there is limited access to cold-chain facilities in Nigeria. To cope with this, value-chain actors keep transportation time short to maintain freshness and avoid spoilage. The average fish transport times for fresh tilapia and catfish are low (1.38 hours and 1.89 hours, respectively). A lesson learned was that postharvest losses are not pronounced and do not have a profound impact on the sector. Although both types of fish have low postharvest loss, catfish has less postharvest loss than tilapia due to the hardiness and variety of preparations of catfish. Although postharvest losses are lower than expected, the aquaculture sector in Nigeria can benefit from an overall increase in productivity that uses appropriate technology.

Zambia Feeds: The feed-trial results showed that tilapia given the piloted protein feed ingredient called DY-Pro consumed less feed to achieve the same growth as tilapia given regular fishmeal feed. This result indicates that DY-Pro is a more efficient feed ingredient, which can save producers on costs. The potential cost savings, as well as potential environmental benefits of a more sustainable feed ingredient, indicate that single-cell-protein technology is a promising alternative feed ingredient for tilapia aquaculture.

Bangladesh Rohu Sequencing: The study found that the gross margin, net margin, and benefit-cost ratio of rohu-based carp polyculture are positive, and that rohu aquaculture has potential to be profitable. However, a technical efficiency analysis found that farmers operated well below the production frontier. Interestingly, small farms were more productive than large farms, and young farmers were more productive and efficient than older farmers. The yield gap is due to inefficiency of farming practices and biotic and abiotic technical constraints. Most of the farmers preferred rohu as the main species in carp polyculture because of higher productivity and market demand, better feed conversion, and better taste and flavor. In terms of daily fish consumption by producer families, rohu alone contributed more than half to the total fish consumption and contributed significantly to daily protein requirements. The project revealed that the rohu genome was about 939.5 million base pairs (Mb) and identified 1,033,085 single nucleotide polymorphisms (SNPs) that can be correlated with physical traits to develop superior broodstock to increase productivity.

SecureFish Kenya: The study determined that gear modifications and more targeted fishing of specific species could improve livelihoods, nutrition, and ecosystems. The analysis also indicates that *tafi* (rabbitfish) are the most sustainable option for fisheries that do not negatively impact ecosystem functioning. Gear modifications and interventions should be aimed at reducing *pono* (parrotfish) and *changu* (emperor) catches while increasing the catches of *tafi*, especially adults. This could be done with increases in fishing with *malema* (traps) and installing escape gaps in these traps to allow juveniles to escape. This type of intervention has the greatest chance of success for both the local coral reef ecosystem and a diverse set of actors in the value chain, including women.

Improving Human Outcomes

Nigeria Cold Chain: The study identified opportunities for introducing technologies and practices that improve postharvest aquaculture value chains, which in turn have the potential to improve income, diets, and reduce postharvest loss. The results show that fish value chains in Nigeria are economically viable with over 80% of post-farmgate value-chain actors reporting a profit. The study also revealed that opportunities exist for greater investment in training and technical skill development among women and youth to improve the postharvest value chain in the Nigerian aquaculture production system. Constraints that preclude women's involvement in aquaculture include cultural restrictions, lack of capital and difficulty for women to access financial resources, and lack of technical knowledge that constrains women's engagement in aquaculture-related livelihood activities.

Fish4Zambia: Study results indicate that, while both men and women reported household-level hunger, women were significantly more likely than men to have reported that they or another householder had experienced all three hunger events from the Household Hunger Scale. Results also indicated significant

differences in educational attainment among men and women, with women being more likely to report non-completion of any years of school. The data highlights the importance of taking gender into account to reflect more accurately 1) how food insecurity impacts different household members, 2) the need for more data on how gender norms impact coping strategies to food shortages among fishing households, and 3) how women's lower access to education contributes to undermining women's economic development across the fish value chain. Results indicate that increasing women's participation in higher income-generating fish value-chain livelihoods as well as their decision-making input may expand women's economic resilience.

SecureFish Kenya: Study findings indicate that fish is not widely consumed by young children in the four study sites along the coast. This is particularly true among fishing households, where the team found a high prevalence of stunting (22%). Qualitative research revealed reasons for this, such as the importance of selling fish as a livelihood strategy for fishing households, the cost of purchasing fish in the market, and attitudes and beliefs about fish as an appropriate food for young children. The analysis of children's diets showed a poor-quality diet with low dietary diversity. The low dietary diversity translated to poor nutrient intake of all nutrients analyzed. The common preparation method of giving fish in soup likely leads to loss of nutrients and insufficient quantities for child nutrition. Both mothers and fathers of young children expressed receptivity to nutrition education, opening the opportunity for improving feeding behaviors and fish in children's diets. SecureFish Kenya identified women fryers (*Mama Karangas*), as being vital actors in the fisheries value chain. Fish trading, processing, and selling to consumers is the common segment in which women are engaged in the fishery, and thus, greater attention should be placed on gender equity and opportunity, including involving women in the decision-making process for management and value-chain improvements.

ACCOMPLISHMENTS RELATED TO CAPACITY BUILDING AND SUSTAINABILITY

All the Quick Start activities implemented actions targeting individual, institutional, and community-level capacity development. Capacity building highlights include:

Individual capacity building: The **Rohu Sequencing** activity trained three Bangladesh Agricultural University (BAU) master's degree students as enumerators for field data collection. Quality of survey data shows that the students were properly trained and achieved competence in survey data collection. The BAU PI acquired experience with genome data management by visiting the Institute for Genomics, Biocomputing, and Biotechnology (IGBB) at Mississippi State University and U.S. fish farming by visiting catfish farms in Mississippi. **Fish4Zambia** also engaged undergraduate and graduate students in field data collection, analysis of results, publications, and presentations at refereed international conferences.

Institutional capacity building: **Zambia Feeds** strengthened the capacity of the local vocational institution (Natural Resources Development College, NRDC). Staff and interns from NRDC gained experience in aquaculture research, which will be used during future aquaculture research, teaching, and training duties. Installing the aquaculture facility also provided practical and hands-on experience for staff and students. Under the **Rohu Sequencing** activity, the whole BAU research team acquired field-level practical knowledge on rohu-based carp polyculture through farm visits and focus group discussions, strengthening BAU as an institution.

Community-level capacity building: During community-level dissemination activities, the **SecureFish** activity shared information about the connections between fisheries management and human nutrition with fishers, caregivers, and county-level fisheries and nutrition officers. These discussions indirectly improved specific capacities related to fishery operations through recommended use of sustainable gears.

Global research community capacity building: The **Rohu Sequencing** activity has made the genome sequence of rohu available worldwide in GenBank, a publicly available database managed by the National Institutes of Health. This means that other researchers now can study the structure and functions of genes involved in growth and disease resistance and other traits of economic significance.

NEXT STEPS AND SCALE-UP STRATEGIES

While the Quick Start activities were short and focused more on research than development, lessons learned will inform and impact Fish Innovation Lab partners and new activities. Noteworthy next steps and scale-up strategies include:

Application of lean management in aquaculture in Nigeria. The cold chain study demonstrated that investments in training and technical skill development for women and youth will improve the post-harvest value chain in Nigeria. Following up on this finding, the research team has started a new project that focuses on introducing lean management production systems in aquaculture, with the goal of reducing inefficiencies across the value chain to meet customer needs and preferences. Broader impacts of any intervention in Nigeria will have ripple effects in neighboring countries, because investments in Nigeria, the largest economy on the continent, will stimulate regional growth.

Scale-up of DY-Pro feed technology via the private sector in Zambia. The Zambia Feeds activity was implemented together with private companies; hence, it has a built-in potential for adoption of the DY-Pro feed technology. Meridian Biotech donated single-cell protein ingredients for testing in feed, Aller Aqua donated feed base, and Yalelo donated fish for the experiment. Results have been disseminated to the companies for consideration of adoption.

Increasing the quality/quantity of fish benefitting nutrition and food security among children and women of reproductive age in Zambia. The Fish4Zambia activity concluded that there are multiple knowledge gaps around gender and food insecurity among small-scale fishing households in rural Zambia. For example, the results suggest a need to explore what factors make women more likely than men to report their household experienced food insecurity. A new Fish Innovation Lab activity called **FishFirst! Zambia** will build upon the Fish4Zambia results by investigating social and gender barriers to entry and/or participation in small-scale fishing value chain activities for different actors—particularly women and youth—and assessing how small pelagic fish are accessed by different consumer groups for household consumption at Lake Kariba. Following up on the finding that many households are food insecure, the FishFirst! Zambia project will develop and test nutrient-enhanced Complementary Food for Africa + dried fish powder (ComFA+Fish) products/recipes for enhanced nutrition, particularly benefiting women of reproductive age and young children in vulnerable households. FishFirst! Zambia will also explore options to scale production and dissemination of ComFA+Fish products/recipes with private- and public-sector actors, particularly women and youth entrepreneurs.

Expansion of nutrition and fisheries research and outreach in Kenya. Outreach meetings conducted as part of SecureFish found that there is a broad interest in collaboration between fisheries and nutrition sectors. County government attendees were interested in future seminars and training sessions that combine both fisheries and nutrition and felt this could be a productive way to promote problem solving that considers both sectors. The primary themes emerging from community- and county-level discussions included 1) a desire for more information about proper child nutrition and the role of fish in meeting the nutritional needs of young children, 2) fishers' desire for more support to expand their fishing operations, and 3) concerns about water, sanitation, and hygiene (WASH) and a motivation for improving sanitation to reduce the incidence and prevalence of diarrhea among young children. A new Fish Innovation Lab activity called **Samaki Salama** will expand themes when implementing a matched intervention and control study in Kilifi, Kenya. The 12-month intervention package includes: 1) a multi-tiered nutrition social marketing campaign to fishers, mothers, and health workers for sustainable fish nutrition, dietary diversity, and food safety; and 2) distribution and group training in local communities on the use of modified traps that include escape gaps to allow juveniles to escape while targeting tafi. This could be scaled across Kenya and parts of Tanzania where the fisheries are similar.

Continued sharing and dialogue to expand Rohu-based carp polyculture in Bangladesh. The Rohu Sequencing activity was designed with an effective dissemination plan of project outputs to different

stakeholders, including fish farmers, policymakers, and academics. The team has continued to connect with the government authorities responsible for developing and implementing policies to strengthen the fisheries and aquaculture sectors of Bangladesh. After completion of the Quick Start, the team organized a workshop called “Challenges, Need and Potentials of Aquaculture and Fisheries of Bangladesh,” held on December 26, 2020. The team also arranged several interactive focus group discussions across the study areas with distinguished officials from the Bangladesh Fisheries Research Institute and the Department of Fisheries along with fish farmers and hatchery owners to promote Rohu-based carp polyculture. Availability of the rohu genome and SNP markers has provided necessary tools for further research activities developing superior broodstock. In particular, the new Fish Innovation Lab activity **Advancing Aquaculture Systems Productivity Through Carp Genetic Improvement** will use the SNP results to develop a cost-effective pedigree assignment tool. Once developed and validated, this tool will allow carp families to be nursed in a common rearing environment from an early stage of development, prior to tagging. This will result in greater genetic gains through future selection of rohu carp.

Dissemination Efforts

The Quick Start activities have been highlighted in numerous USAID Agrilinks posts, Fish Innovation Lab blogs, and social media posts as well as in host-country media. Results have also been shared with local stakeholders as part of formal and informal stakeholder meetings. The teams have presented their work at multiple international, national, and university conferences and symposia and continue to submit abstracts for upcoming events. Conferences for which Quick Start abstracts have been submitted or where posters/papers have been presented include:

- 2019 Graduate Research Symposium, October 5, 2019, Mississippi State, USA (presented, **Fish4Zambia**)
- Biennial Conference of Fisheries Society of Bangladesh, December 27-28, 2019, Dhaka, Bangladesh (presented, **Rohu Sequencing**)
- Kenya Annual Fishers Forum, January 9, 2020, Diani, Kenya, (presented, **SecureFish**)
- Nutrition-Sensitive Fish Agri-Food Systems Workshop, February 24, 2020, Lusaka, Zambia, (presented, **Fish4Zambia**)
- University of California, Santa Cruz Coastal Science and Policy Seminar Series, February 24, 2020, Santa Cruz, USA (presented, **SecureFish**)
- Unlocking a Resilient Blue Economy, a workshop organized by Cordlo EA/IUCN, March 12, 2020, Mombasa, Kenya (presented, **SecureFish**)
- Society for Applied Anthropology Annual Meeting, March 18, 2020, Albuquerque, USA (abstract accepted, but conference cancelled, **Fish4Zambia**)
- 2020 Undergraduate Research Symposium, April 15, 2020, Mississippi State, USA (presented, **Fish4Zambia**)
- Global Health Works in Progress, Washington University in St. Louis Institute of Public Health, September 14, 2020, St. Louis, USA (presented, **Nigeria Cold Chain**)
- Research in Progress, Washington University in St. Louis, October 13, 2020, St. Louis, USA (presented, **Nigeria Cold Chain**)
- Washington University in St. Louis, December 3, 2020, St. Louis, USA (presented, **Nigeria Cold Chain**)
- Fourth International Conference on Global Food Security, December 7-9, 2020, Montpellier, France (presented, **Fish4Zambia**)
- Women and Gender in International Development Conference, February 23-26, 2021, Blacksburg, USA (presented, **Fish4Zambia**)
- 2021 Graduate Research Symposium, February 26-27, 2021, Mississippi State, USA (presented, **Fish4Zambia**)
- Agriculture Nutrition and Health (ANH) Academy Week, 21 June - 2 July 2021, virtual (abstract submitted, **Fish4Zambia, SecureFish**)
- Aquaculture Africa, December 11-14, 2021, Alexandria, Egypt, (abstract submitted, **Zambia Feeds**)

The Quick Start teams have also submitted multiple papers for publication in peer-reviewed journals, including:

- Expert commentary and analysis on global agriculture and food published by the Chicago Council for Global Affairs (published, **Nigeria Cold Chain**)
- “Performance Analysis of Existing Fish/Aquaculture Value Chains and Market Systems in Nigeria: Post-Farmgate Value Chain Scoping Study,” submitted to *Aquaculture Economics and Management* (revise and resubmit, **Nigeria Cold Chain**)
- Scientific paper submitted to *Animal Feed Science and Technology* (in review, **Zambia Feeds**)
- “Adapting the WEAI to explore gender equity among fishers, processors, and sellers/traders at Zambia’s Lake Bangweulu,” submitted to *World Development* (in review, **Fish4Zambia**)
- “Fish and complementary feeding practices for young children: qualitative research findings from coastal Kenya,” submitted to *PLOS One* (revise and resubmit, **SecureFish**)
- “Child nutrition differences between fishing and non-fishing households at selected sites along Coastal Kenya” to be submitted to *Maternal & Child Nutrition* (in preparation, **SecureFish**)
- Scientific paper describing the fish value chains and highlighting the role of women in the trade, processing, and sale of all types of reef fish along coastal Kenya to be submitted to *Western Indian Ocean Journal of Marine Science* (in preparation, **SecureFish**)
- “Economic assessment of freshwater carp polyculture in Bangladesh: Profit sensitivity, economies of scale and liquidity,” scientific paper submitted to *Aquaculture Journal* (in review, **Rohu Sequencing**)
- “Ensuring fish consumption and nutritional security through carp polyculture: A household level study of Bangladesh”, scientific paper to be submitted to Food Security journal (in preparation, **Rohu Sequencing**)
- “Youth involvement in carp polyculture in Bangladesh: Efficiency, yield gap and yield loss perspectives”, scientific paper to be submitted to *Aquaculture Economics and Management* journal (in preparation, **Rohu Sequencing**)

Student theses, dissertations, and papers that build on the Quick Start activities

The **Rohu Sequencing Activity** contributed to one master’s thesis: Hossain, M. E. (2019). *Economics of rohu based carp polyculture in Bangladesh: Efficiency, yield gap and nutritional perspectives* [Master’s thesis, Department of Agricultural Finance, Bangladesh Agricultural University].

The **SecureFish** project has also contributed to one master’s thesis: Cartmill, M. K. (2020). *Knowledge, skills, and attitudes regarding fish consumption in complementary feeding practices in coastal Kenya: A qualitative study* [Capstone II, Brown School, Washington University in St Louis]. Currently, a doctoral student (Yuanyuan Yang) together with an MPH student (Noah Wolthausen) are analyzing the SecureFish data for factors driving infectious disease morbidities shown to be very high [e.g., diarrhea (29%); fever (46.5%)] in the four communities studied. A PhD student at the University of Rhode Island is analyzing the value chain data and preparing a manuscript for submission.

ABOUT THE FISH INNOVATION LAB

The Fish Innovation Lab supports the United States Agency for International Development’s agricultural research and capacity building work under Feed the Future, the U.S. Government’s global hunger and food security initiative. Mississippi State University is the program’s management entity. The University of Rhode Island, Texas State University, Washington University in St. Louis, and RTI International serve as management partners.

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