

# Measuring impact of innovations on aquaculture system performance

Aquaculture plays an important role in supporting job creation and economic growth and improving well-being and food and nutrition security.<sup>1,2</sup> Research and innovation can lead to significant productivity and sustainability gains in aquaculture but must be supported by an effective and inclusive dissemination system.

Reliable, consistent and comparable data on social, economic and environmental performance of aquaculture systems<sup>3</sup> across different contexts is essential, but lacking, for better understanding of associated fish agri-food system outcomes. This baseline data would enable holistic performance assessments of aquaculture research and innovations in practice, which can inform more effective interventions for uptake and scaling.<sup>4,5</sup> Additionally, the ability of small-scale value chain actors to benefit from research and innovation in, for example, fish genetics, health and feeds, can be hindered by many factors, including access to resources, structural barriers and legal frameworks.

The purpose of aquaculture systems research within the CGIAR Research Program on Fish Agri-Food Systems (FISH) was to assess the performance of research and innovation in practice and develop sustainable, inclusive dissemination systems for scaling. Research was conducted across diverse aquaculture systems in Asia and Africa, with emphasis on genetically improved fish seed, health, feeds and better management practices. Research was structured around developing four products:

1. performance assessment of aquaculture systems
2. sustainable and inclusive dissemination systems for improved fish seed, health and feeds

## Key messages

- A consistent approach to benchmarking and performance assessments enables standard evaluations of aquaculture systems and the benefits associated with uptake of research and innovation, which is key to sound research, policy and investment decisions.
  - Dissemination systems for aquaculture research and innovation must account for context-specific opportunities and constraints that affect adoption, with specific focus on enablers for adoption by vulnerable groups and long-term sustainability.
  - Inclusive business models, such as the local service provider model or collective farming, offer important opportunities for women, youth and other small-scale value chain actors, but require greater support from public and private sectors.
  - Open access tools and standard methods for data generation can contribute to a data ecosystem to support development and implementation of evidence-based interventions at national, regional and global scales.
3. inclusive business, finance and entrepreneurial models for small-scale value chain actors
  4. tools, methods, data and analytical capacity to support assessment and adoption of aquaculture research and innovation.





## Performance assessments provide evidence for uptake of research and innovation

Research and innovation must deliver measurable, positive impacts in practice if they are to contribute to improved social, economic and environmental outcomes. To assess impact from FISH aquaculture innovations, researchers put together a [set of tools and methods](#) to assess the performance of tilapia and carp aquaculture systems that are widely applicable to diverse contexts.

Due to the lack of consistent baseline data across aquaculture systems, the first step required collecting and standardizing country-level aquaculture data in Bangladesh, [Cambodia](#), [Egypt](#), [India](#), [Myanmar](#), [Nigeria](#), [Timor-Leste](#) and [Zambia](#). This data provides a holistic view of system performance and enables comparisons across geographic, agroecological, socioeconomic and cultural contexts, which are the [foundation for understanding the real contributions](#) of aquaculture research and innovation.

After this, on-farm performance of genetically improved fish strains, including Genetically Improved Farmed Tilapia (GIFT) in [Bangladesh](#), [Cambodia](#), [India](#) and [Myanmar](#), the Abbassa strain in [Egypt](#), and other improved or local strains in [Kenya](#) and [Zambia](#), was assessed in terms of productivity, profitability, gendered employment, food security and dietary diversity, and climate change adaptation. Results from Bangladesh, for example, showed that GIFT was mainly farmed by small-scale farmers operating less than 1 ha of ponds with fewer assets than farmers with non-GIFT strains. However, GIFT grew about 30 percent faster and yielded almost 2 metric tons per ha more than non-GIFT strains in monoculture and polyculture systems. In efforts to improve consistency, comparability and effectiveness of research and data delivered around on-farm performance of aquaculture systems, FISH developed a [digital tool for on-farm performance assessment](#) and shared it with public and private sector stakeholders across Asia and Africa.

Aquaculture system performance assessments are now being used to inform policy and investment decisions, and contribute to scaling of improved aquaculture system

models. In [Timor-Leste](#), governmental [endorsement](#) and [investment](#) in GIFT for achieving nutrition and livelihood goals are now reflected in the [National Aquaculture Development Strategy](#). In [Bangladesh](#) and [India](#), evidence of benefits from carp polyculture systems have led to their integration into nutrition policy and investments.

## Sustainable and inclusive dissemination systems for improved fish seed, health and feeds

FISH researchers and partners investigated [dissemination and adoption patterns](#) of aquaculture innovations to identify successful strategies and common barriers that could inform program, policy and investment recommendations, with a focus on enablers for adoption by target groups like women and youth. For example, dialogues with stakeholders about dissemination of improved fish seed highlighted the importance of (i) strengthening institutional capacity to monitor and enforce quality control, (ii) increasing advocacy and knowledge transfer about benefits and sources of elite broodstock, (iii) promoting adoption of better management practices by hatcheries and farmers as an integrated package, including adaptation to weather shocks, (iv) leveraging partnerships with local service providers as intermediaries, and (v) using social networks for information diffusion among farmers. From this, FISH researchers developed recommendations for improved dissemination of GIFT seed in [Africa](#), [Bangladesh](#), [Cambodia](#), [India](#), [Myanmar](#), [Timor-Leste](#), as well as of [genetically improved carp seed in Bangladesh](#). This work was also integrated into the CGIAR [Seed Systems Strategy](#), which traditionally has not included fish seed.

These participatory processes were widely used to inform development of fish seed systems, and are being applied to scale innovations in fish health and feeds. For example, FISH findings have informed [private sector investment decisions](#) on strategic and appropriate feed production in Egypt. In [Zambia](#), [performance assessments of tilapia feeding approaches](#) are informing government policies and extension advice on strain selection and better management practices.





## Inclusive business models for small-scale value chain actors

FISH's [analysis of inclusive business models](#) provided the basis for further development of inclusive and women-targeted business, finance and entrepreneurial models along fish value chains, especially given the large number of women involved in post-harvest roles. A set of cases was documented to help shape policy and investment environments in several countries, particularly suitable for private sector investment. FISH was able to support the development and scaling of (i) improved fish processing technologies with gender-transformative approaches in [Malawi](#), (ii) updated fisheries science curriculum and training tools in [Zambia](#), (iii) aquaculture assessments in [Sierra Leone](#), (iv) the local service provider model in [Bangladesh](#), and (v) collective farming by women self-help groups in [India](#). Additionally, an analysis of the [Egyptian aquaculture value chain](#) showed the growing sector has [employment opportunities for resource-poor people](#), including [post-harvest opportunities for women](#).

FISH's contributions to assessment and design of policy interventions can be seen in [India](#), where small-scale value chain actors have ready access to research and innovations. Further scaling will require an improved regulatory environment, better understanding of market requirements and increased private sector support for inclusive business models.

## Tools, methods, data and analytical capacity for assessment and adoption of research and innovation

FISH and partners made major progress in consistent generation of aquaculture data. To do this, FISH developed a set of open-access digital tools and standard methods for assessing aquaculture system performance, including (i) an [on-farm performance tool](#), (ii) a characterization tool for aquaculture systems, and (iii) [FishScores](#), a life-cycle assessment tool. Partners have been trained to help put tools into wider use, including in [Bangladesh](#), [Egypt](#), [Myanmar](#) and [Nigeria](#).

Adoption of these survey tools and methods by local and international stakeholders is contributing to generation of consolidated and comparable data on aquaculture production at farm and system level. The resulting data ecosystem can support development and implementation of evidence-based interventions for aquaculture development. For example, FISH's environmental benchmarking can provide standardized estimates of greenhouse gas emissions and nutrient leaching for improved evaluation of the production of diverse aquatic foods.

A set of context-specific digital tools was also developed with partners and disseminated to connect farmers with extension services, markets and finance. Key tools include (i) a [virtual aquaculture extension](#) mobile app in Myanmar with local weather forecasts, input sourcing information, market prices and trends, and climate risks, (ii) [Shwe Ngar \(Golden Fish\)](#), a mobile app in Myanmar with extension advice that connects farmers to suppliers, traders and buyers, (iii) a [formal financial package facilitated by digital financial service channels](#) in Bangladesh to improve access to credit for farmers as well as small and medium enterprises, (iv) [Rupali](#), a mobile app for aquaculture and input sourcing advice in Bangladesh, and (v) [Digital MachHaat](#), a digital marketplace to connect small-scale farmers with buyers across Bangladesh. These tools have been used in Bangladesh, Myanmar and Egypt, and to date incorporate data from over 12,000 farms.

FISH also continued development of foresight tools, in partnership with the International Food Policy Research Institute and the CGIAR Research Program on Policies, Institutions and Markets. Foresight modeling of the aquaculture sector in [Indonesia](#), [Nigeria](#), [Tanzania](#) and [Zambia](#) has shown implications for food and nutrition security, decent livelihoods and gender equality at national and [regional](#) levels.

## Next steps

### Policy and investment recommendations

The consistent and coherent generation and analysis of data can improve the efficacy and inclusivity of policy and investments for sustainable aquaculture development. The transformation of fish agri-food systems will require a reliable, integrated, [findable, accessible, interoperable and reusable \(FAIR\)](#) evidence base that helps generate actionable insights. Key areas for future policy and investment include

- promoting wider adoption of benchmarking and performance assessment tools to build a coherent, global approach to aquaculture performance assessment;
- building inclusive participatory processes to strengthen local ownership, legitimacy and sustainability of research and innovation, with emphasis on vulnerable groups;



- developing close partnerships with regional and international organizations to shape locally appropriate and inclusive capacity building opportunities and embed learning in global policies for statistics and data collection;
  - promoting activities that encourage equitable use of digital tools to support real-time business models and decision-making;
  - reinforcing foresight modeling to support analysis of policy frameworks and the projected social, economic and environmental outcomes of aquatic food system transformation.
- collaboration with private sector stakeholders to develop investments in real-time data monitoring and analysis tools for long-term sustainability.

## Notes

- <sup>1</sup> Béné C, Arthur R, Norbury H, Allison EH, Beveridge MCM, Bush S, Campling L, Leschen W, Little D, Squires D et al. 2016. Contribution of fisheries and aquaculture to food security and poverty reduction: Assessing the current evidence. *World Development* 79:177–96. doi: [10.1016/j.worlddev.2015.11.007](https://doi.org/10.1016/j.worlddev.2015.11.007)
- <sup>2</sup> Filipski M and Belton B. 2018. Give a man a fishpond: Modeling the impacts of aquaculture in the rural economy. *World Development* 110:205–23. doi: [10.1016/j.worlddev.2018.05.023](https://doi.org/10.1016/j.worlddev.2018.05.023)
- <sup>3</sup> The term “aquaculture systems” refers to the diverse collection of fish farming systems and the wider social, economic and environmental boundaries within which they operate.
- <sup>4</sup> Bush SR, Pauwelussen A, Badia P, Kruk S, Little D, Luong LT, Newton R, Nhan DT, Rahman MM, Sorgeloos P et al. 2021. Implementing aquaculture technology and innovation platforms in Asia. *Aquaculture* 530:735882. doi: [10.1016/j.aquaculture.2020.735822](https://doi.org/10.1016/j.aquaculture.2020.735822)
- <sup>5</sup> Lasner T, Brinker A, Nielsen R and Rad F. 2017. Establishing a benchmarking for fish farming – Profitability, productivity and energy efficiency of German, Danish and Turkish rainbow trout grow-out systems. *Aquaculture Research* 48(6):3134–48. doi: [10.1111/are.13144](https://doi.org/10.1111/are.13144)

## Future research

Future research must continue developing data ecosystems to address data gaps that create barriers to the longer-term sustainable development of aquaculture. Research priorities include

- further development of open-access innovations for data collection, in accordance with FAIR principles;
- scaling benchmarking of aquaculture systems with standardized tools and methods;
- testing performance tools and models to integrate production with socioeconomic, climate and environmental data;
- continued action research for designing and testing digital systems, remote sensing, analytics and artificial intelligence that help stakeholders identify actions for transforming fish agri-food systems;

## Authors

Cristiano Rossignoli, Michael Phillips, Malcolm C. M. Beveridge and Nisha Marwaha.

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