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Evaluation of IDEA Project in Bangladesh

A baseline report

October 2022

Working Paper 53

Agriculture and forestry

3ie International Initiative for Impact Evaluation

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This paper, *Evaluation of IDEA Project in Bangladesh,* has findings of a baseline survey conducted for the evaluation of a WorldFish project on aquaculture. This paper has not been edited by 3ie, it is being made available as submitted by the authors. The content of this paper is the sole responsibility of the authors and does not represent the opinions of 3ie, its donors or its board of commissioners. Any errors and omissions are also the sole responsibility of the authors. All affiliations of the authors listed in the title page are those that were in effect at the time the paper was accepted. Please direct any comments or queries to Pooja Sengupta at psengupta@3ieimpact.org

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Evaluation of IDEA Project in Bangladesh: a baseline report

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Summary

This report presents the findings from the baseline of the impact evaluation of the WorldFish project, Aquaculture: increasing income, diversifying diets, and empowering women in Bangladesh (IDEA). The project was launched in 2019 with support from the Bill & Melinda Gates Foundation to improve incomes, nutrition and women's empowerment in Rajshahi and Rangpur divisions in northwest Bangladesh. The project is operating in five districts of Rajshahi division (Rajshahi, Bogra, Naogaon, Natore and Pabna) and two districts of Rangpur division (Rangpur and Gaibandha). It includes interventions that:

a) Enhance aquaculture productivity
b) Increase the value of marketed fish
c) Enhance the quality, reach, efficiency, and sustainability of extension services
d) Improve access to nutrient-rich foods, and
e) Empower women

Stimulating the local private sector and building a cadre of private extension workers is an important component of the project. For this, WorldFish is identifying and training extension workers or local service providers in some areas. In other areas, extension workers are being identified and trained by NGO partners.

The impact evaluation aims to answer the following research question: *What are the impacts of the aquaculture investments in the WorldFish project, Aquaculture: increasing income, diversifying diets, and empowering women in Bangladesh on primary outcomes? The outcomes are:*

1. *Smallholder aquaculture productivity; smallholder income (with delineation of income from fish and fish-based products).*
2. *Dietary diversity; the nutritional outcomes of women and children, e.g., height/weight of women (BMI, short stature), height/weight of children (HAZ/LAZ, WAZ, WHZ/WLZ), MUAC for pregnant women; food security.*
3. *Women's participation and time use in different nodes of the aquaculture value chain; women's empowerment and say in aquaculture-related and other household decision making.*

The evaluation is designed as a cluster randomized trial where 176 unions were assigned to three experimental arms: control, private Local Service Provider (Treatment 1 or T1) and NGO (Treatment 2 or T2). The project will not be implemented in the control unions. In T1, WorldFish is recruiting, training and building a network of aquaculture extension agents or Local Service Providers In T2, the agent network is being formed in partnership with two large, local NGOs.

Using questionnaires administered to men and women of the same household, the evaluation will form a panel with three rounds of data collection: baseline, endline 1 and endline 2. In addition, one round of process evaluation will seek to explain reasons for achievement or under-achievement, and both granular and more pronounced differences in the performance of T1 and T2 delivery models.

This report shares the findings and implications of the baseline data collection. The men's questionnaire includes questions on household aquaculture income, investments,

productivity and practices. Additionally, one woman in every household is administered a questionnaire to understand pre-program levels of women's empowerment in aquaculture and nutrition related outcomes. Similar questions are fielded to her husband allowing a comparison of the couple's engagement in aquaculture and say within different spheres of household decision-making.

Data collection for the baseline was delayed because of the first wave of the Covid-19 pandemic in 2020. This report is based on data collected in February to April 2021, almost a year into the project. The reference period for all aquaculture related questions was for the previous pre-Covid-19 cycle of 2019-20. The baseline data collection had to be cut short in April 2021 due to the second wave of Covid-19 when this had been completed for 159 unions. As WorldFish had started some of the planned activities by this time, we also conducted a phone-based survey of 42 extension workers (local service providers) recruited till the completion of the baseline survey.

Our final baseline sample covers 3,716 households in 551 villages which has some implications for the power of our study. We are now powered to detect 5-9% change in consumption expenditure against the original expectation of 3-7%, and a change in dietary diversity score of 0.69 against that of 0.55 (the mean dietary diversity score is 4). The reduction in sample size makes it essential to ensure high tracking rates of households and women in endline 1 and endline 2 so that adequate statistical power is maintained.

Despite the many challenges encountered, our analysis shows that baseline variable balance, which is important for credible comparability of the experimental arms, was achieved in most cases. Analysis of the baseline data presents many interesting findings that shed light both on the context in which this project is being implemented and on the validity of key assumptions in the project theory of change. Some of the key findings are summarized below:

1. Knowledge of the usefulness of recommended aquacultural best practices is high among both men and women. However, the actual application of these best practices varies. While some practices are not taken up for lack of resources, others are adopted less frequently than prescribed.
2. Self-reported ability to access credit is reported to be very high among women and men throughout the study area with numbers in the upper 90 per cent range for both. High perceived availability of credit does not mean that credit terms are attractive for aquaculture or other investment purposes.
3. Nutritional knowledge among households, particularly about the benefits of consuming small indigenous fish varieties, was low, with around 1/3 of women recognizing these as particularly nutrient-rich.
4. Almost 50 per cent of the households are still dependent on local traders for fish seed.
5. We noted important differences in the extension workers recruited in T1 and T2. Extension workers in T2 unions were more likely to focus on nutritional messaging than T1 extension workers.

Implications for program: Since some of the main interventions of the project aim to enhance knowledge of aquaculture production and promote best practices, our findings suggest that the scope for raising aquaculture productivity through this specific route will

be dependent on the constraints that inhibit the application of the practice. Interventions to alleviate credit constraints must be designed keeping in mind the presence of other forms of credit available to farmers and at terms that address the existing gaps in the credit market. Given that nutritional knowledge about the value of fish consumption among women is limited in some key respects, the nutrition messaging components of the intervention could be effectively utilized to improve specific nutrition outcomes. Similarly, addressing gaps in access to high quality commercial fish seed can be effective in improving productivity and fish value.

Implications for evaluation: While baseline balance was achieved in most demographic and project outcome indicators, we observe differences in the pond productivity of T1 and the other arms. We will control for baseline pond-productivity in our endline analysis. We will include a qualitative component to examine the translation of aquaculture best practices knowledge to actual practice and the usefulness of credit provision. Additionally, we will collect data on quality of project implementation at endline and examine difference in project impacts.

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1. Introduction

1.1 Context and rationale for evaluation

Described as a 'quiet revolution', farmed fish production in Bangladesh grew more than 15-fold — from 124,000 tons to 1.96 million tons — between 1984 and 2014, making it the fifth largest aquaculture producer in the world (Hernandez et al 2018, Hussain 2016). By 2014, aquaculture accounted for 55% of total fish consumption in the country (Hernandez et al 2018). Fish is a source of vital micronutrients including iron, zinc, calcium and vitamin A and accounts for roughly 60% of animal protein consumption among Bangladeshis.

With per capita fish consumption projected to rise from 18kg in 2010 to 30kg in 2030 (WorldFish 2018), WorldFish is implementing the 50-month project Aquaculture: Increasing Income, Diversifying Diets, and Empowering Women in Bangladesh. The project, which covers Rajshahi and Rangpur divisions in the northwest of the country, aims to exploit untapped aquaculture potential with estimates suggesting that the productivity of homestead pond aquaculture in Rajshahi and Rangpur may be as low as one third of the national average (Jahan et al 2016). Rajshahi and Rangpur also have high poverty and undernutrition rates, especially among women and children.

Overall, Bangladesh has extremely high rates of undernutrition with 'very high' levels of stunting (36%) and 'high' levels of wasting (11%) among children under five years of age. Women are more likely to be undernourished, with 36% of adolescent women and 16% of women of reproductive age having low BMI (JPGSPH 2015, de Onis et al 2019). Diets typically consist of rice, which accounts for approximately 62% of the per capita calorie consumption at the national level (Tetens et al 1998). Though Bangladesh achieved self-sufficiency in rice production in 2012, access to and consumption of other components of a healthy, diverse diet such as fish and vegetables, is still a concern.

In a study by Belton and colleagues (2014), fish was one of the most frequent consumption categories (following non-leafy vegetables, cereals, and oil). Across household wealth quartiles, 78 to 92 per cent had consumed fish at least once during the last three days. Despite this, only a third of women were reported to consume an adequately diverse diet. Similarly, 37 per cent of children aged 0-24 months attain minimum dietary diversity thresholds, with the prevalence increasing with age (10, 28, and 64% for 6, 12, and 24-month-olds, respectively) (JPGSPH 2015). Dietary diversity reduces further within poor households: even households in the upper quintile of total household expenditure consumed meat, legumes, fruits, and eggs less than twice during the previous 7 days. Nationally, a third of women are estimated to have achieved minimum dietary diversity with slightly lower numbers in Rangpur (28 per cent) and Rajshahi (31 per cent) (JPGSPH 2016).

In their recent review of nutrition-sensitive agriculture, Ruel, Quisumbing and Balagamwala (2018) conclude that agricultural projects that include communication to promote healthy diets and child feeding practices, and modules to improve women's status and empowerment in agriculture, are consistently associated with improved diets and nutritional outcomes for women and children.

To increase aquaculture productivity among smallholder farmers and reap the pro-poor benefits of aquaculture accomplished in other parts of the country (Rashid and Zhang 2019), the project draws on the accumulated knowledge from WorldFish's longstanding work in Bangladesh to promote improved and sustainable aquaculture technology and management practices. The former include carp polyculture with micronutrient-rich small indigenous fish species (SIS), high quality carp, and improved tilapia seed. The recommended improved management practices include removal of black soil from pond, pre-stocking liming and the identification of quality seed for stocking.

The project includes training provided by intermediaries (see below) and tailored for smallholders, to bolster knowledge and raise awareness about better feeding practices, strategies for management of fish disease risks and optimization of seasonal food production aligned with market and consumer demands. In addition, the project seeks to improve women's and children's dietary quality and diversity through nutrition counselling with special emphasis on the importance of fish consumption along with the improving access to nutritious fish species.

To empower rural women, the project aims to support female entrepreneurship, enhance women's aquaculture and nutritional knowledge and work to expand women's participation in different nodes of the aquaculture value chain, especially in downstream activities such as marketing and trading of fish where women's participation has been limited (Krujjsen, McDougall and van Asseldonk 2018). Another important objective is to enhance women's intrahousehold say in aquaculture and other decision-making domains.

An innovative feature of the WorldFish project is the split between two alternative and indirect models of delivery: (a) A Local Service Provider (LSP) or pure private sector model and (b) a Hybrid model (also called the NGO model). According to WorldFish, 'the LSP model is a decentralized extension model where local actors (farmers, business owners, breeders, etc.) provide extension services (knowledge, technology transfer, products, etc.) to farmers. LSPs are expected to sustain themselves as small businesses through a commission on sales of products or by charging for the provision of a variety of services to farmers. A novel (and challenging) added responsibility of LSPs – after receiving capacity building and training – is to also deliver the nutritional and gender transformative modules of the project.

In the Hybrid or NGO model, two large and well established NGOs, BRAC and Thengamara Mohila Sabuj Sangha (TMSS), have been contracted to select LSPs and build their capacity. Both NGOs have a strong track record of livelihood promotion among smallholder (and women) farmers and have established programs for credit linkage and aquaculture extension services and inputs. The NGOs have agreed to follow WorldFish's LSP selection guidelines and train LSPs using training materials provided by WorldFish.[1]

[1] Even so, there could be differences in BRAC's and TMSS's approaches, including in (i) the content and priorities of LSP training due to variation in their respective experience with delivering training in the study area, (ii) ground presence, (iii) human resources and so forth. Our process evaluation will help [continued…] pin down differences in the content, intensity and thematic foci and priorities of the LSP training provided by BRAC and TMSS, differences in the characteristics of LSPs selected in the three arms and so forth. The process evaluation will also pay careful attention to the quality of the LSP delivery of different project modules.

In this model, WorldFish provides raining of Trainers to the two NGOs, following which, the NGOs build capacities of the LSPs they mobilize. The LSPs in turn train smallholder farmers. Leveraging their existing network of community health and nutrition workers, TMSS and BRAC will also train the grassroots extension workers to deliver key nutrition and health messages to smallholder farmers under the intervention.[2]

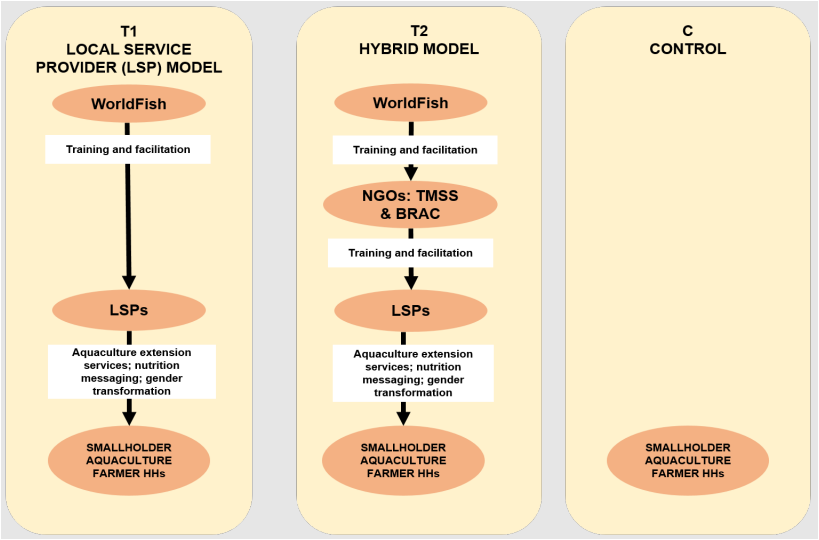
3ie, with support of the Natural Resources Institute (NRI) and Potsdam Institute for Climate Impact Research (PIK), is the evaluation partner of this program, and is designing and conducting —to the best of our knowledge — the first of its kind rigorous evaluation of WorldFish's large-scale aquaculture intervention, using counterfactuals to address attribution.

The evaluation of WorldFish's IDEA Project in Bangladesh is a clustered, multi-armed randomized controlled trial that uses a theory-based, mixed methods impact evaluation approach. The evaluation has been designed to identify the extent to which the project achieves intended impacts on aquaculture practices, productivity, smallholder income, nutrition and women's empowerment and whether impacts are more pronounced for some sub-groups. In addition, the trial has been designed to provide in-depth comparisons of the performance of the two delivery models.

Constructive dialogue and information sharing between WorldFish and 3ie has helped the evaluation team to secure agreement about the unions where LSP model (T1) and the Hybrid or NGO model (T2) will operate and where there will be no intervention (control). BRAC and TMSS have also committed to the roll-out plan and evaluation design.

The three-arm trial, portrayed in Figure 1, is complemented by a multi-round process evaluation that will seek to explain reasons for achievement or under-achievement, and both granular and more pronounced differences in how the two delivery models perform. Aquaculture extension services are being delivered by LSPs whose area of operation may increase with project duration and expand into control areas. This points to a genuine risk of control area contamination. Delineating the extent and nature of such spillovers will be an important objective of the process evaluation.

Figure 1: The three-arm trial



[2] These community and health workers are not present in the private sector LSPs model.

In this report, we discuss the data collection for the baseline, present descriptive statistics and baseline values for the sample with respect to the broad aquaculture productivity, nutritional and women's empowerment variables touched upon above. We also report on balance tests to examine randomization performance and whether there are systematic differences (if any) across the control and treatment arms.

The baseline data collection, which was slated to commence during the first quarter of 2020, did ultimately have to be postponed until the first quarter of 2021 due to the outbreak of Covid-19 in March 2020 and the ensuing delays in implementation of the program because of strict social distancing norms, travel and other restrictions.

The pandemic-induced circumstances in the study area also required an additional ethical clearance of the field protocol by the Internal Review Board at the University of Greenwich (UoG) followed by the IRB of the Department of Health Economics, University of Dhaka, which was received in December 2020. The subsequent rounds of data collection for endline 1 and endline 2 are now expected to take place in 2023 and 2024, respectively.

1.2 Objectives of the evaluation

The evaluation will examine the impacts of the WorldFish project on stated project outcomes. It will also attempt to answer what factors and mechanisms led to impacts — or the lack of impacts — and how these factors influence outcomes.

The three overall research questions are:

A: What are the impacts of the aquaculture investments in WorldFish's IDEA project, on the following primary outcomes:[3]
   1. Smallholder aquaculture productivity; smallholder income (with delineation of income from fish and fish-based products).
   2. Dietary diversity; the nutritional outcomes of women and children, e.g., height/weight of women (BMI, short stature), height/weight of children (HAZ/LAZ, WAZ, WHZ/WLZ), MUAC for pregnant women; food security.
   3. Women's participation and time use in different nodes of aquaculture value chain; women's empowerment and say in aquaculture-related and other household decision making.

B: If there are impacts for 1), 2) or 3), what are the effect sizes?

C: If some but not all of the expected impacts materialize, which failed and what may explain the failure?

1.3 Scope of the evaluation

1.3.1 Geographical area

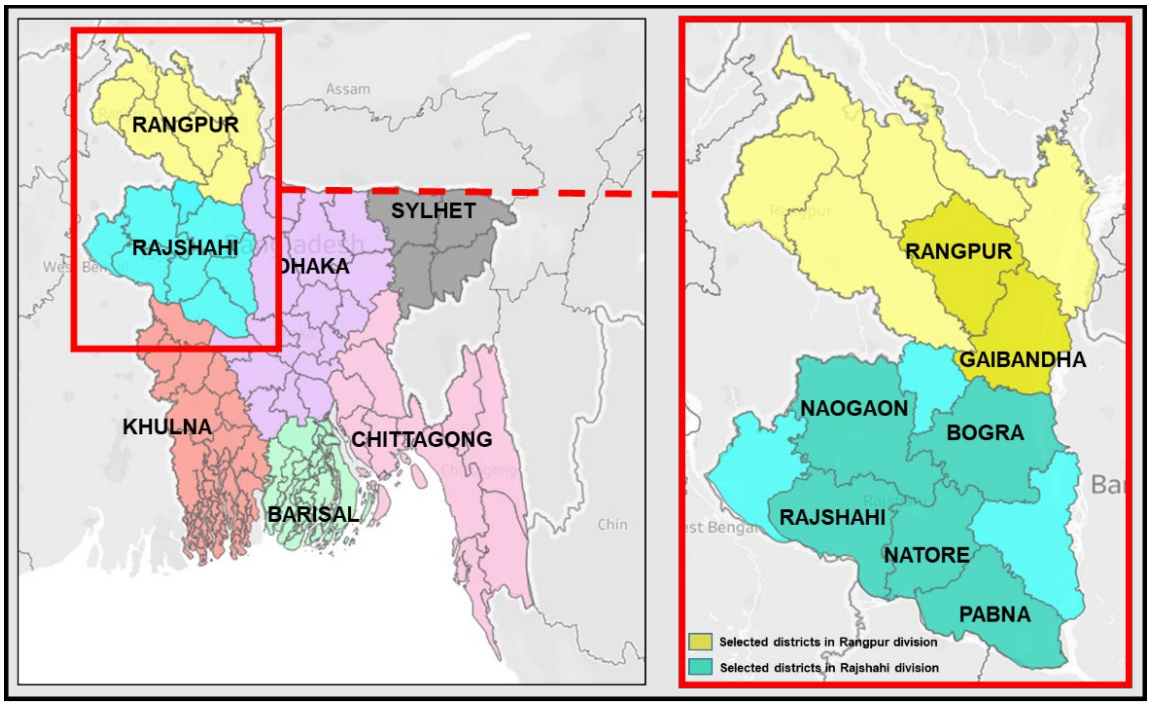
Rajshahi and Rangpur divisions account for 24 per cent of Bangladesh's population and have agro-ecological conditions conducive to substantive aquaculture productivity improvements. In contrast to the southwest, with its mix of marine, brackish and freshwater systems, Rajshahi and Rangpur depend on freshwater sources from major rivers, rainfall and groundwater (WorldFish 2018). A variety of fish production systems,

[3] The indicators and variables that will capture each of these primary outcomes have been listed in Table 1.

including homestead ponds, commercial ponds and rice field ponds, can be operated by smallholder farmers, depending on elevation, soil type, access to water and susceptibility to flash floods (ibid.). However, these rainfed systems are not perennial and require sustainable approaches for their development There is already a growing fish trading and buying network within the two divisions, involving smallholders, fish traders, small and medium enterprises and large-scale fish buying businesses, facilitated by good road connections.

WorldFish initially rolled out the project in five districts in Rajshahi division (Rajshahi, Bogra, Naogaon, Natore and Pabna) and two districts in Rangpur division (Rangpur and Gaibhanda) as shown in Figure 2 (map). This trial covers the same seven districts.

Figure 2: Rajshahi and Rangpur divisions with study districts



Source: Authors using Bangladesh GIS administrative map

1.3.2 Target population

The main participants and intended beneficiaries of the project are rural, smallholder agriculture and fish-farming households. While Hernandez et al. (2018) define small and medium aquaculture producers in Bangladesh as those with less than 0.2 hectare and 0.8 hectare of pond area, respectively, WorldFish has developed a three-step process to define a smallholder for the purposes of this project (Online appendix A). A household is a fish-farming "smallholder" if the household holds a maximum of 2 hectare of arable land (including pond area) or if the volume of aquaculture production is less than 4 million tonnes per hectare, or if at least 50 per cent of own farmed fish production is for family consumption.[4]

[4] One insight from our piloting of this three-step process is the need for precision about the handling of jointly owned ponds.

1.3.3 The WorldFish project interventions

Our evaluation questions and questionnaire protocols were designed based on the following key interventions that the WordFish project aimed to implement across five fish agri-food system domains.

1. *Productivity-enhancing interventions*

The project aims to enhance smallholder access to quality fish seed and broodstock, improved fish feed and pond inputs. LSPs provide a conduit for smallholders to access quality inputs such as seed (tilapia, carp species) from certified fish hatcheries and nurseries, including those arising from WorldFish genetic improvement investments, and from private businesses supplying better-quality fish feed, fertilizer and management solutions. The project aimed to mobilize activity and credit groups of farmers to access formal and intra-group credit. These interventions focus on introducing knowledge and access to technologies, management practices and a business-oriented approach. The activities are to be complemented by actions to improve fisheries policy, regulation and investment relating to input quality and safety.

2. *Interventions to increase value of marketed fish*

To strengthen farmers' market linkages and increase the value of fish sales, the project supports the creation and strengthening of small-scale farmer organizations, including women's groups, and develop farmers' market knowledge, market strategies and business skills. Studies of demand for fish and fish products, prices and affordability for low-income groups and consumer dynamics are to inform the development of market strategies. The project builds market linkages and business relationships between farmer groups and private sector market actors like LSPs and small and medium enterprises engaged in processing and fish product development, as well as buying fish and fish-based products. Sustainable business models and agreements are to be developed between farmer groups and processers, wholesalers and retailers. Relevant information is disseminated through digital platforms and promotional materials.

3. *Enhancing quality, reach, efficiency and sustainability of extension services*

In addition to input provision, LSPs are the means for delivery of the farmer training and capacity development. The two different models of delivery outlined above both involve capacity strengthening. WorldFish prepares training materials and delivers training of trainers sessions. In the decentralized, private sector model, WorldFish selects, trains and mentors LSPs, while for the Hybrid or NGO model, WorldFish trains the two contracted NGOs (TMSS and BRAC), who in turn select and train their LSPs using guidelines and training materials from WorldFish. The main topics on which the LSPs are to be trained are:

- The basics of aquaculture extension work and farmer-level participatory training approaches.
- Importance of aquaculture and the present aquaculture scenario in Bangladesh.
- Aquaculture practices and activities associated with each phase of the aquaculture production process.
- The role of women in aquaculture.
- Dietary diversity and household nutrition: Use of Social Behavior Change Communication (SBCC) approach in providing nutrition advice.
- Potential benefits of intervention for LSPs and local fish farmers.

- Cultivation of nutritious vegetables and leafy greens through homestead farming and dike cultivation.
- Intervention monitoring methods and creation of LSP work plans.

Smallholder farmer training is to be supported by the development of digital, gender-responsive training content by a private sector digital partner. The training is to be customized for local contexts and users.

The LSPs working in the private sector model and in the Hybrid or NGO model are to both carry out the same range of interventions (group formation, training of farmers groups, input supply, credit and financial products, market linkages, nutritional messaging and women's empowerment). The LSPs are expected to behave like entrepreneurs, charging a commission for their services.

4. *Interventions to improve access to nutrient-rich foods*
The project seeks to improve the quality and quantity of fish consumption among smallholder farmers through social behavior change communication and nutritional messaging, as well as the increased production and availability of nutrient-rich fish. There is special focus on young mothers, pregnant women and children. The nutritional outreach at union level is undertaken by the LSPs, both in the private sector model and in the Hybrid or NGO model. In addition, a wider range of consumers are reached with nutritional messages through mass media and digital messaging. Building on the findings of WorldFish research on consumer preferences and fish value chains for poor consumers in Dhaka, the project also targets fish and fish-based products to the growing urban markets.[5]

5. *Women's empowerment interventions*
The project aims to increase the empowerment of women in aquaculture production and fish value chains. The project develops gender integration strategies based on an understanding of gender dynamics and barriers, and opportunities for women in aquaculture and men's involvement in the aquaculture value chain. Selected training partners are trained as trainers on gender integration. Training of trainers and LSPs includes gender transformative approaches, which they are expected to utilize when training farmer groups. The project forms gender-inclusive farmer activity groups, savings and credit groups, as well as women-only fish farm groups/associations. The objective is to increase women's knowledge in aquaculture production and value chain activities. The project plans to select women into LSP cadres, providing training on entrepreneurship, value chain activities and financial management. The communication and scaling strategy aim to promote gender inclusivity and socially responsible investments in smallholder aquaculture and value chain development.

1.3.4 Theory of Change
The theory of change or ToC is a visual depiction of the causal pathways which are intended to lead from program activities, through to changes in knowledge and practice, leading to early outcomes and then to intermediate and longer-term outcomes. Mapping out these pathways can highlight critical relationships to be investigated in monitoring

[5] These policy and higher level project objectives and activities are beyond the remit of the cluster randomized trial.

and evaluation. It also identifies where the causal relationships rely on assumptions or expectations, which require evidencing over the period of the project. Assumptions can relate to the project design and problem analysis, to implementation conditions, to capacity and behavior change and to targeting and reach.

The program theory of change in Figure 3 was constructed in 2019 by the evaluation team, based on project documents, including the results framework, WorldFish's diagram of the project impact pathways and the work plan.[6] The colored columns represent the five intervention domains outlined above. The numbers in the narrative below refer to the numbered text boxes in the theory of change and are based on the outcome areas in the results framework.

The **productivity enhancing interventions** of improved supply and access to high quality fish seed, feed, credit and extension services (1.2, 1.3, 1.4) are expected to lead to the adoption of improved fish and vegetable farming practices by men and women smallholder farmers (1.1). Supportive policies, strategies, regulations and investments developed with the participation of partners and stakeholders, support women-oriented, nutrition-sensitive and inclusive growth of aquaculture (1.5), resulting in higher productivity and diversity of homestead fish production systems (1). The main assumptions are that men and women smallholders find credit, feed and seed input provision accessible, acceptable and affordable, and take them up; that productivity gains and volumes of fish produced are realized as anticipated, and that there is sufficient stakeholder support to influence policies towards nutrition sensitive aquaculture. A related assumption is that the current levels of farmers' knowledge and adoption of improved management practices are the main factors limiting productivity. Hence, the baseline study includes questions on farmer knowledge and practice to establish the initial status against which improvements can be measured.

Efforts to enhance **quality, reach, efficiency and sustainability of extension services**[7] start with the two different implementation models of engagement with input suppliers and service providers, existing and new. These extension agents or LSPs (private sector and NGO) play a crucial role in the delivery of services to smallholder aquaculture farmers. Training and capacity building improves knowledge and competitiveness of LSPs and their effectiveness in providing access for smallholders to seed, feed and credit, contributing to higher productivity. The specific ways in which the Hybrid or NGO model of farmer training and engagement differs from the private sector model will be carefully tracked by the evaluation team. The project promotes professional development, sustainability, competitiveness and knowledge of new and existing LSPs (3.2) and improves organizational structures of LSPs/private sector/input suppliers and enhances their capacity to provide services (3.1). These LSPs are identified from local small entrepreneurs working in the farm and fisheries sector, including women farmers. These interventions lead to an improvement in the quality, reach, efficiency and sustainability of extension services (3). An important assumption in the original design is that private sector service providers are willing to engage in gender sensitive service

6 A subsequent version of a theory of change was produced by Worldfish in January 2020, which provided further detail at the activity level and modified some of the impact pathways; however, as no change was made to the results framework or workplan structure, the original ToC is retained.
7 This is the third project outcome, but it is presented next to outcome 1 in the theory of change diagram, for ease of mapping inter connections.

delivery to Self-Help Groups (SHGs) and that the volume of demand and profitability is adequate to justify their effort. Their effectiveness is also influenced by favorable policies and investment (1.5).

The pathway to increasing **the total value of fish and fish products sold** by smallholder farmers starts with increasing membership of women and men in existing and new farmers groups and developing their business and marketing skills and linking them to input and output markets (2.1), developing gender responsive market strategies to capture a larger share of market margins (2.3) and increasing the total value of aquaculture products sold under sustainable market linkages (2.2), which together lead to an increase in the incomes of smallholder farmers from the sale of fish and fish-based products (2). This assumes that effective arrangements for male and female smallholder marketing can be implemented and that their market strategies result in them securing a greater share of market margins. It is supported by responsible investment and business standards (1.5), by the quality and reach of extension services (3) and the productivity increases achieved (1). The gender inclusiveness of farmer group formation is supported by strategies for gender integration (5.1).

Increasing **access to nutrient-rich foods** starts with social behavior change communications (though LSPs and digital) to increase the knowledge of farming and non-farming households about the benefit of nutrient rich food groups and dietary diversity in addressing malnutrition, the importance of fish in their daily diet and to influence attitudes and practices (4.1 and 4.3). At the broader policy level, WorldFish engages with key stakeholders such as the public health and nutrition departments to include fish and fish-based products in food assistance, health and nutrition programs (4.2) with particular attention to maternal and child health supported by information for policy change (4.5).[8] These leads to higher demand for and availability of fish in rural and urban markets (4.4 and 2.2) and increased consumption of nutrient rich foods, including fish and fish-products, by farming and non-farming households (4). Improved consumption of fish can also lead directly from increased availability of home-produced fish. The main assumptions are that nutritional SBCC strategies and mechanisms, including digital and mass media, have the required reach and are effective and that they are appropriately targeted at the intra-household level. Economic incentives are sufficient for processors to develop fish products and price relationships remain favorable to support increased the consumption of fish and other nutritious food. A further assumption is that an increase in commercialization with greater market integration and stronger price incentives, does not have a negative effect on home fish consumption by reducing its volume compared with the marketed proportion, or by substituting higher value species for more nutritious but lower value species.

The envisaged changes leading to **women's empowerment** are guided by strategies for gender integration in partner programs and activities of LSPs and informed by studies of gender dynamics and women's position in aquaculture (5.1). Inclusion of women in farmers' groups and women groups (5.4 and 2.1) is expected to be supported by these strategies. Gender transformative strategies and training are intended to positively influence women's decision-making power over productive assets (5.2) and their

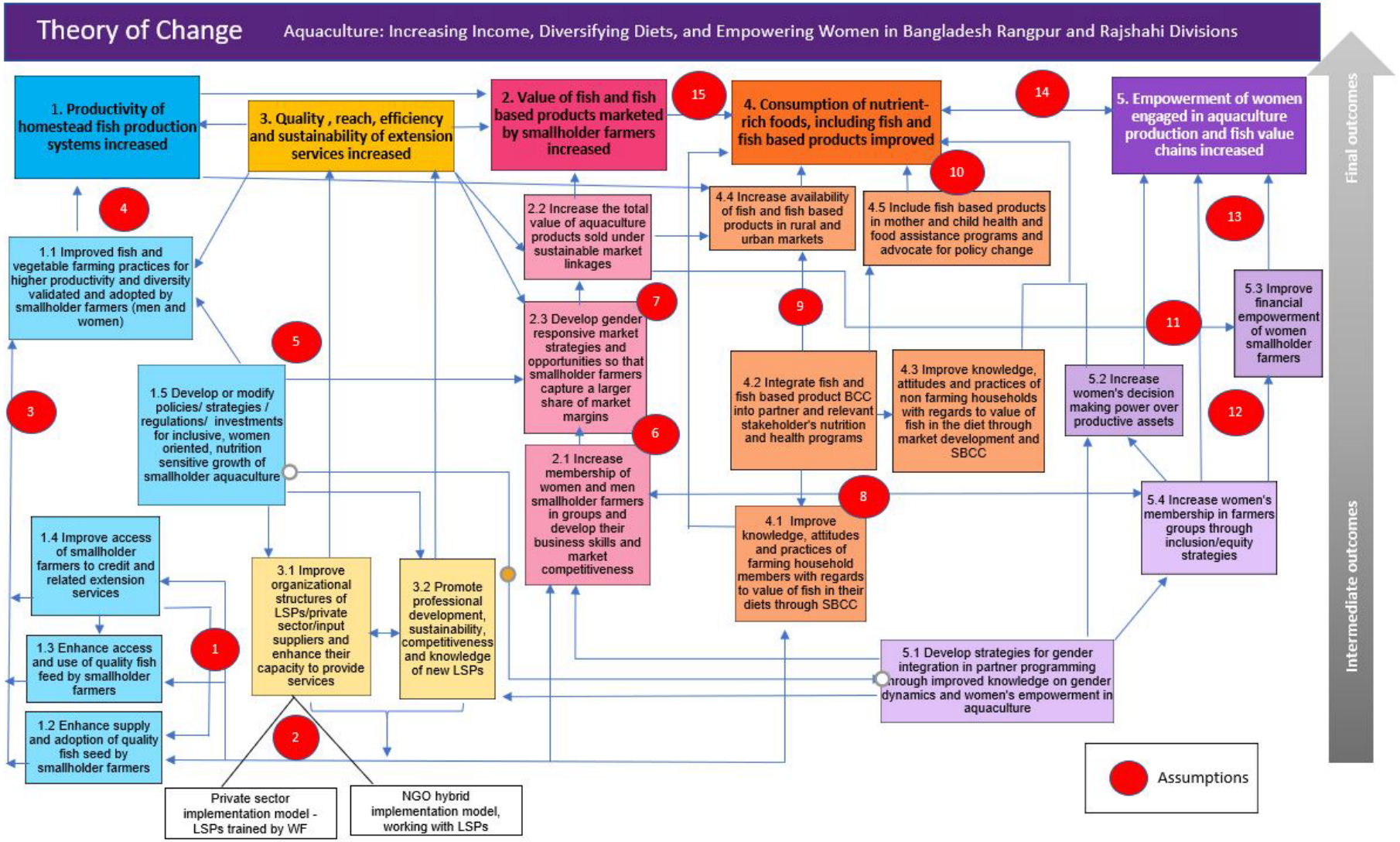
[8] These are, again, beyond the remit of the cluster randomized trial but may, if successful, reduce the impacts of the farm-level interventions.

financial status (5.3), contributing to the empowerment of women engaged in aquaculture and fish value chains (5) as well as strengthening women's participation and influence as purchasers and consumers of fish (4). Several important assumptions are necessary to the realization of these outcomes: women's participation in groups and fish related activities does not increase their work burden to the detriment of their health and well-being; transformative strategies are able to influence and change gender norms to support women's increased decision making control over assets; income earned by women through participation in fish production and marketing remains within their control; and women's empowerment in aquaculture positively influences their choice and consumption of nutrient rich foods.

Our theory of change diagram shows how the interventions interact with each other in complex ways to lead intermediate and final outcomes. The assumptions (depicted by the red circles) at each important node are summarized below:

1. Men and women smallholders find credit, feed and seed provision acceptable and affordable, and take them up.
2. Private sector service providers are willing to engage in gender inclusive service delivery and BCC messaging to SHFs; group mechanisms function and volume of demand and profitability is adequate to justify effort.
3. Significant gaps in farmers' knowledge of improved management practices and access to inputs exist and filling these gaps will enhance productivity.
4. Productivity gains and volumes of fish produced are realized as anticipated.
5. There is sufficient stakeholder support and engagement to influence policies towards nutrition sensitive aquaculture.
6. Effective arrangements for smallholder (male and female) marketing can be implemented.
7. Market strategies result in a greater share of market margins for smallholder producers and responsible investment and business standards are in operation.
8. SBCC strategies and mechanisms, including digital, are appropriately targeted at the intra-household level, have the required reach and are effective.
9. There are sufficient economic incentives for processors to develop fish products and for traders to increase fish supply.
10. Price relationships remain favorable to support increased fish consumption.
11. Transformative strategies are able to influence and change gender norms to support women's increased decision-making control over assets and enhanced participation and bargaining power.
12. Women's participation in groups and fish related activities does not increase their work burdens to the detriment of their health and well-being.
13. Income earned by women through participation in fish production and marketing remains within their control.
14. Women's empowerment in aquaculture will influence positively their choice of and consumption of nutrient rich foods.
15. An increase in commercialization does not reduce the volume or nutritional value of home fish consumption.

Figure 3: Theory of Change



2. Evaluation questions

To understand and discern the mechanisms of impact (or failure), we will answer the following secondary research questions:

For smallholder aquaculture productivity:

Did the project improve/change:

a) *the quality of outreach of extension services, with respect to aquaculture inputs and credit?*
b) *the management and other aquaculture knowledge of male and female fish farming household members?*
c) *the management and other aquaculture production practices of the same households?*
d) *the fish variety production mix towards varieties that are e.g. higher value and more nutritious or, perhaps, higher value and less nutritious?*

Did the project increase:

e) *the quantity and percentage of fish produced in smallholder households that is sold in the market?*

Did the project affect:

f) *to whom and through what channels (e.g. local, regional and national markets) fish is sold?*
g) *the prices smallholders receive?*

Additionally, what are the time trajectories for new aquaculture technology uptake and for production practice changes among intended beneficiary households?

For nutritional outcomes:

Did the project improve:

a) *the quality and outreach of nutrition-related extension?*
b) *the nutritional knowledge of women responsible for food preparation?*
c) *dietary intake and the consumption of nutrient-rich fish and other foods?*

For women's empowerment:

Did the project impact:

a) *women's access to and their decision-making power over credit?*
b) *women's decision-making power over pond use?*
c) *women's decision-making power over other production related decisions (inputs, fish species mix)?*
d) *how income from aquaculture should be spent?*
e) *the time women and others spend in activities at different aquaculture value chain nodes?*
f) *women's self-esteem and self-efficacy as well as other aspects of women's psychosocial well-being and their aspirations for sons and daughters?*
g) *women's participation in SHGs and in public life?*

Overall:

Are there differential impacts of the program by mechanism of delivery i.e., the LSP model and the Hybrid or NGO model?

3. Identified outcomes and key indicators

Table 1: EAB theory of change intermediate / final outcomes and measured indicators

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
1. Productivity of homestead fish production systems increased					
1.1 Improved fish and vegetable farming practices for higher productivity and diversity validated and adopted by smallholder farmers (men and women)	Costs of aquaculture inputs	BL, EL1, EL2	Each survey round	3.2 Source and purchase of fingerlings	Data on expenditure on fingerlings not collected at baseline
				3.3 Cost of inputs: pond equipment	
				3.4 Cost of inputs: services availed	
				3.5 Cost of inputs: Lime, feed, fertilizers, medicines, and fuel	
	Knowledge and application of aquaculture practices	BL, EL1, EL2	Each survey round	7.1.6 / 7.2.6 Knowledge about aquaculture practices	
	Number of commercial ponds operated	BL, EL1, EL2	Each survey round	(E) Household Pond Information	Data on which ponds are commercial not collected at baseline
	Number and type of fish cultivated for consumption and sale	BL, EL1, EL2	Each survey round	3.1 Pond usage	

[9] While all these indicators were part of earlier versions of the questionnaire prior to the pandemic, cuts had to be made as they were thought necessary to avoid overburdening respondents during circumstances likely to enhance their vulnerability.

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
1.2 Enhance supply and adoption of quality fish seed by smallholder farmers	Quantity of fish harvested in kgs per hectare of operable pond (past aquaculture season)	BL, EL1, EL2	Each survey round	3.1 Pond usage	
	Source of fingerlings, expenditure on fingerlings	BL, EL1, EL2	Each survey round	3.2 Source and purchase of fingerlings	Data on expenditure on fingerlings not collected at baseline
1.3 Enhance access and use of quality fish feed by smallholder farmers	Source of fish feed, variety of fish feed used, expenditure on fish feed	BL, EL1, EL2	Each survey round	3.5 Cost of inputs: Lime, feed, fertilizers, medicines, and fuel	
1.4 Improve access of smallholder farmers to credit and related extension services	Awareness about credit and related extension services	BL, EL1, EL2	Each survey round	7.1.2/ 7.2.2 Awareness about aquaculture support programs	
	Use of extension services and inputs, access to formal credit, reduced dependence on money lenders	BL, EL1, EL2	Each survey round	7.1.2/ 7.2.2 Awareness about aquaculture support programs	
				5. Debts: outstanding loans	
				Module G3(B): Access to financial services	
				Module G5: Group Membership	
2. Value of fish and fish-based products marketed by smallholder farmers increased	Volume of sale of fish in kg (past aquaculture season)	BL, EL1, EL2	Each survey round	3.7 Fish / fingerling sale and marketing	
	Value from sale of fingerlings (past aquaculture season)	EL1, EL2	Each survey round	3.7 Fish / fingerling sale and marketing	Data on sale of fingerlings not collected at baseline

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
2.1 Increase membership of women and men smallholder farmers in groups and develop their business skills and market competitiveness *2.2 Increase the total value of aquaculture products sold under sustainable market linkages*	Value from sale of fish-based products (past aquaculture season)	EL1, EL2	Each survey round	3.7 Fish / fingerling sale and marketing	Data on sale of fish based products not collected at baseline
	Group membership	BL, EL1, EL7	Each survey round	Module G5: Group Membership	
	Membership in influential groups	BL, EL1, EL8	Each survey round	Module G5: Group Membership	
	Purchase and sale in formal markets, prices received in these, reduction in costs of linkages	EL1, EL8	Each survey round	3.7 Fish/fingerling sale and marketing	Data on prices only collected in village survey, not at the HH level
3. Quality, reach, efficiency and sustainability of extension services increased					
4. Consumption of nutrient-rich foods, including fish and fish-based products improved	Dietary diversity (individual: adult and child)	BL, EL1, EL2	Each survey round	8.1.2/ 8.2.3 Dietary diversity: Individual	
				8.2.4 Infant and Young Child Feeding (IYCF)	
	Household dietary quality	EL1, EL2	Each survey round	12.3 Food consumption score nutritional quality analysis (protein, iron, vitamin A)	Data was not collected on this indicator at baseline
	Household food security	BL, EL1, EL2	Each survey round	8.1.1/ 8.2.1 Food security	
				8.2.1 Food security	

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
		BL, EL1, EL2	Each survey round	12.3 Food consumption score	Data was not collected on this indicator at baseline
	Fish consumption (% consuming / types consumed) by women and children; HH food consumption expenditure			8.2.2 Fish Consumption	
				8.2.4 IYCF	
				2. Expenditure	
	Introduction of fish / fish-based products to children	BL, EL1, EL2	Each survey round	8.2.4 IYCF	
				8.2.4 IYCF	
	Nutritional status of women and children (0-59m)	BL, EL1, EL2	Each survey round	12.7 Anthropometry (woman and 0-59m child)	Anthropometry data was not collected at baseline
4.1 Improve knowledge, attitudes and practices of farming household members with regards to value of fish in their diets through SBCC	Knowledge of nutrition messages	BL, EL1, EL2	Each survey round	8.1.4/ 8.2.6 Knowledge and practice questions	
	Sources of nutrition information	BL, EL1, EL2	Each survey round	8.1.6/ 8.2.8 Nutrition information acquisition	
4.3 Improve knowledge, attitudes and practices of non-farming households with regards to value of fish in the diet through market development and SBCC	-	-	-	-	
4.4 Increase availability of fish and fish-based products in rural and urban markets	Fish purchased for consumption, especially by small pond owners	BL, EL1, EL2	Each survey round	8.2.2 Fish Consumption	
				8.2.2 Fish Consumption	

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
				8.2.2 Fish Consumption	
5. Empowerment of women engaged in aquaculture production and fish value chains increased	Mobility - visiting important locations	BL, EL1, EL6	Each survey round	MODULE G6. PHYSICAL MOBILITY	
	Time use in aquaculture value chain	BL, EL1, EL9	Each survey round	7.1.3/ 7.2.3 Time allocation in aquaculture	
	Knowledge about aquaculture technologies and management practices	BL, EL1, EL10	Each survey round	7.1.6/ 7.2.6 Knowledge about aquaculture practices	
	Life satisfaction	BL, EL1, EL11	Each survey round	11. Aquaculture-adjusted Women's empowerment in Agriculture Index (WEAI) module	Data was not collected on this indicator at baseline
	Self-esteem	BL, EL1, EL12	Each survey round	11. Aquaculture-adjusted WEAI module	Data was not collected on this indicator at baseline
5.2 Increase women's decision-making power over productive assets	Input into productive decisions expanded for aquaculture	BL, EL1, EL2	Each survey round	7.1.5/ 7.2.5 Role in household decision-making about aquaculture production decisions	
5.3 Improve financial empowerment of women smallholder farmers	Ownership of land and other assets	BL, EL1, EL3	Each survey round	2. Household land ownership; MODULE G3 (A1): Access to productive capital/ MODULE G3 (A2): Consumption assets / durable consumer	

Intermediate and final outcomes	Indicator	Data collection round	Data collection frequency	Baseline questionnaire module	Note[9]
				goods/ MODULE G3 (A3): Livestock assets	
	Access to and decisions on financial services	BL, EL1, EL4	Each survey round	MODULE G3(B): Access to financial services	
	Control over use of income	BL, EL1, EL5	Each survey round	MODULE G2: Role in household decision-making around production and income	
5.4 Increase women's membership in farmers groups through inclusion / equity strategies	Group membership	BL, EL1, EL7	Each survey round	MODULE G5: Group membership	
	Membership in influential groups	BL, EL1, EL8	Each survey round	MODULE G5: Group membership	
BL: Baseline survey (2021)					
EL1: Endline survey 1 (2023)					
EL2: Endline survey 2 (2024)					
IYCF: WHO infant and young child feeding indicators					

4. Research Design

4.1 Evaluation design

There are three administrative tiers below the division level in Bangladesh: district, upazila and union. Rajshahi division has eight districts, 67 upazilas and 564 unions. Rangpur division has eight districts, 58 upazilas and 536 unions.

The evaluation design is a cluster randomized trial with union as the unit of randomization. We chose to randomize at the union level since an LSP's initial area of operation (and commercial outreach) is likely to be the area where the service provider resides with easy and established access to a customer base and market.[10] A typical union in Rajshahi and Rangpur comprises of 15 to 20 villages that vary in size. Randomization at the union level reduces but does not eliminate the risk of control group contamination since there are many circumstances where a subset of or all the commercial operations of an LSP may transcend union boundaries. Our randomization procedure was therefore designed and implemented to build in adequate geographical buffers between unions allocated to the three trial arms as discussed in more detail below.[11]

For the randomization, our sampling frame is the list of unions for the seven Rajshahi and Rangpur districts from the 2011 Bangladesh Census. Randomization at the union level was implemented in a centralized computer with a control (C), LSP model (T1) and NGO (T2) treatment arms. To reduce the risk of situations where an LSP located near a union boundary may operate in a neighboring union, we first oversampled with 90 unions assigned to the control and each of the treatment arms as shown in Table 2.[12]

Table 2: Number of unions selected for treatment and control arms

	Total unions randomized	Total unions selected
C- No WorldFish project	90	58
T1- LSP model	90	57
T2- NGO-led model	90	61

To minimize the likelihood of control group contamination and other spillovers, we dropped contiguous unions if one had been assigned as control and others assigned either to the LSP or the NGO model.[13]

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[10] Randomization at the village level was considered in our proposal to Bill & Melinda Gates Foundation but eventually ruled out as an option since control group contamination would be inevitable.

11 Another option was to randomize at the upazila level. However, the number of upazilas in the seven study districts is insufficient for an adequately powered study.

12 Sample size considerations, including the number of clusters (unions) and number of households in each cluster, are based on the power calculations in the 3ie proposal to the Gates Foundation, allowing for up to 20% attrition.

[13] While this reduces spillover and control group contamination risk, it does not eliminate the risk. An important empirical question – which our process evaluation will be able to answer – include the prevalence of LSPs with commercial operations beyond their union boundaries, the share of their revenue from outside the union boundaries, whether all or a subset of their commercial operations cross union boundaries and whether the nature and extent of these spillovers change

We proceeded in the following stepwise manner:

1. *We first selected all T1 unions that were isolated (no neighboring union was T2 or C).*
2. *We next selected T1 unions which shared boundaries with T2 unions.*
3. *The last step was to select T1 unions with short boundaries with control unions.*

We next selected the control unions:

1. *We first selected isolated control unions which were either truly isolated or shared a boundary with another control (or a non-selected T1 union).*
2. *We then marked all controls sharing boundaries with T2 unions, giving preference to those with short boundaries.*
3. *We finally selected controls sharing short boundaries with T1 unions.*

We finally selected the T2 unions:

1. *All T2 unions sharing boundaries with non-selected controls and with T1 unions.*
2. *The rest were chosen randomly.*

4.2 Sampling

4.2.1 Selection of villages

By the time village sampling was about to commence, Covid-19 restrictions had been put in place across Bangladesh. Following the initial and collective paralysis that put field based data collection across the world on hold, the evaluation team proceeded to explore remote means of village selection. The initial plan had been to select two villages from each union. Given that a total of 12 aquaculture households from each village would be sampled according to the WorldFish criteria, the survey team first reached out remotely to union level government officials (e.g. Upazila chairman, Union chairman/secretaries and the Department of Fisheries officials) asking for a list of villages with high pond density and aquaculture activities in each union. At least two villages were then selected from each union at random from the lists provided by union level officials. To reduce the risk of spillovers, villages located close to the union boundary were not included in the village sampling frame.[14] A total of 551 villages were finally selected for the baseline survey. A village questionnaire to collect information on basic infrastructure, local aquaculture markets and prices was developed by the evaluation team.

4.2.2 Selection of households for interview

Following the WorldFish three criteria definition of a fish-farming smallholder (see Online appendix A), we selected households with ponds who either have up to 2 hectares of land suitable for agriculture and aquaculture OR have fish yields of less than the equivalent of 4 million tons per hectare OR consume 50 per cent or more of the fish they produce. Of the 12 households in each village, one third were chosen from households with less than 1.25 hectare, one third from households with 1.25 to 2 hectares of land and one third from households with more than 2 hectares of land but with yields below 4 million tons per hectare or who consume more than 50 per cent of the fish they produce.

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over time and as businesses expand. This will also enable us to capture spillovers beyond the buffer unions and into control area unions.

14 The only exception was in cases where no other villages were available for sampling households within the union, except villages in close proximity to the union boundary.

As noted, the evaluation team had initially targeted 12 households from two villages in each union. However, given Covid-19 restrictions and the limited number of villages in some unions, it was occasionally difficult for the field team to find 24 households from each union that met the three WordFish criteria. As a result, the sampling plan was revised to target 24 households from each union, failing which, the remaining of the 24 households would be collected from villages of other unions from the same study arm.

4.2.3 Selection of household members for interview

Household members for the baseline were selected for interviews as follows:

- The main household questionnaire was administered to household members most actively engaged in aquaculture and/or knowledgeable about household affairs. This included both male and female respondents.
- The aquaculture-adjusted project level Women's Empowerment in Agriculture Index (pro-WEAI) instrument: If the respondent for the household questionnaire was a married man, the male aquaculture-adjusted pro-WEAI instrument was administered to him and the female aquaculture-adjusted pro-WEAI instrument was administered to his wife (vice-versa if the respondent for the household questionnaire is a married woman).
- If the respondent to the main questionnaire was male and unmarried, another woman above 18 was interviewed for the aquaculture-adjusted pro-WEAI. As is well known and in general, the WEAI seeks to capture inequality between the primary adult male and female in each household. While these usually will be husband and wife, they can also be the primary male and female decisionmaker regardless of their relationship to each other.[15] We were also interested in capturing absolute improvements for other categories of women. If the respondent to the main questionnaire was a woman and unmarried (or widowed) or if her husband was away on migration, she was interviewed for the aquaculture-adjusted pro-WEAI and if a non-spouse male counterpart was found in the HH who was engaged in aquaculture, he too was interviewed.
- The nutrition module questions consist of household food security, individual food intake, and nutrition knowledge: these were administered to the person in the household with most knowledge about what is being consumed.
- Infant and young child feeding indicators (0-24m), dietary diversity (0-59m), antenatal care (0-24m) data was collected for one child in the respondent household. In the case that the women interviewed for the pro-WEAI had a biological child in the desired age range (0-59m), data for this child was collected. Otherwise, one randomly chosen child (0-59m) in the household was selected.

4.3 Data collection

The household questionnaire is divided into four main sections: Household characteristics, aquaculture information, women empowerment & nutrition module. It includes information on household demographic characteristics, housing, income, savings, debt, economic shocks and participation in social safety net programmes. Since increasing aquaculture productivity is a key outcome for the project, we have included several sections on extent of household involvement in aquaculture, expenditure on and

[15] If the household is polygamous, the wife interviewed was to be chosen randomly.

income from aquaculture and aquaculture sales. In the women empowerment sections, information was collected on men and women's role in household decision-making about aquaculture production decisions, role in household decision-making about production and income, awareness about good aquaculture practices, access to productive capital, livestock assets, financial resources and consumption assets, mobility, attitudes towards women's involvement in aquaculture, awareness about aquaculture support programs, time allocation in aquaculture, group membership and self-efficacy.

The nutrition section includes information on food insecurity, dietary diversity, food related decision making, sources of nutrition information acquisition, nutrition related knowledge and practices and how Covid-19 has affected food decision making of both male and female respondents. We also collect information on Infant and Young Child Feeding (IYCF) and fish consumption from the female respondent. The survey was conducted with two respondents per household: one male and one female. The sections administered to both respondents have been highlighted below:

Table 3: Questionnaire sections administered to male and female respondent

Male Respondent	Female Respondent
1. HOUSEHOLD ROSTER	1. HOUSING
1.A. Demographic Details	
1.B. Group membership	
1.C. Occupation of household members	
1.D. Education of household members	
1.E. Migration of Household Members	
1.F. Remittance in	
2. HOUSEHOLD LAND OWNERSHIP	2. HOUSEHOLD EXPENDITURE (including household food consumption expenditure)
3. INCOME SOURCE: AQUACULTURE	3. ECONOMIC EVENTS/SHOCKS
3.1. Pond usage	3.1 Negative shocks
3.2. Source of purchase of fingerlings	3.2 Participation in social safety net programs
3.3. Cost of inputs: Pond equipment	
3.4. Cost of inputs: Service availed	
3.5. Cost of inputs: Lime, feed, fertilizers, medicines and fuel	
3.6. Hired Labor: Aquaculture	
3.7. Fish/fingerling Sale and Marketing	
4. Other Income Sources	
5. Debts	
6. Savings	
7. WOMEN EMPOWERMENT MODULE	7. WOMEN EMPOWERMENT MODULE
7.1. Women Empowerment Module: Male Respondent	7.2. Women Empowerment Module: Female Respondent
7.1.1. Respondent details	7.2.1 Respondent details
7.1.2 Awareness about aquaculture support Programs	7.2.2 Awareness about aquaculture support Programs
7.1.3 Time Allocation in aquaculture (for	7.2.3 Time Allocation in aquaculture (for the

Male Respondent	Female Respondent
the last aquaculture season, from April 2019 to March 2020)	last aquaculture season, from April 2019 to March 2020)
7.1.4 Role in household decision-making about participation in aquaculture production (for the last aquaculture season, from April 2019 to March 2020)	7.2.4 Role in household decision-making about participation in aquaculture production (for the last aquaculture season, from April 2019 to March 2020)
7.1.5 Role in household decision-making about aquaculture production decisions (for the last aquaculture season, from April 2019 to March 2020)	7.2.5 Role in household decision-making about aquaculture production decisions (for the last aquaculture season, from April 2019 to March 2020)
Module g2: role in household decision-making about production and income	Module g2: role in household decision-making about production and income
7.1.6. Knowledge about aquaculture practices	7.2.6. Knowledge about aquaculture practices
	7.2.7. Social Capital and Market Links
Module g3 (a1): access to productive capital	Module g3 (a1): access to productive capital
Module g3 (a2) consumption assets / durable consumer goods	Module g3 (a2) consumption assets / durable consumer goods
Module g3 (a3) livestock assets	Module g3 (a3) livestock assets
Module g3 (b): access to financial services	Module g3 (b): access to financial services
Module g5: group membership	module g5: group membership
Module g6. physical mobility	Module g6. physical mobility
7.1.8. Attitudes towards women's involvement in aquaculture	7.2.8. Attitudes towards women's involvement in aquaculture
7.1.9. Self-efficacy	7.2.9. Self-efficacy
8. NUTRITION MODULE	8. NUTRITION MODULE
8.1.1 Food Security	8.2.1 Food Security
8.1.2. Dietary diversity: individual	. 8.2.2 Fish Consumption
8.1.3 Food decision-making and purchasing	8.2.3 Dietary diversity: individual
8.1.4 Knowledge and practice questions	8.2.4. Infant and Young Child Feeding
8.1.5 Covid-19-related questions	8.2.5 Food decision-making and purchasing
8.1.6 Nutrition information acquisition	8.2.6 Knowledge and practice questions
	8.2.7 Covid-19-related questions
	8.2.8. Nutrition information acquisition

WordFish had started implementation of some activities in some treatment unions before the first lockdown. Identification of LSPs and their training activities had commenced by October 2019. Thirty five LSPs from 33 evaluation unions were a part of WorldFish's training activities. The evaluation team was therefore alert to the need for a clean baseline and following much internal discussion we opted for a reference period of April 2019 to March 2020 aquaculture season preceding the lockdown for data in general and aquaculture production in particular. Since this represented the last normal pre-pandemic year, we felt that recall challenges would be less pronounced.

Part of our survey (mid-March-survey end) was conducted during the less severe lean season (Monga) which could indicate potentially higher food insecurity when compared to non-lean season. However, studies have differed in reporting dietary diversity changes in times of increased food insecurity. Na et al (2016) reported decreasing dietary diversity with worsening household food insecurity in Rangpur, Bangladesh. Hillbruner and colleagues (2008) reported increases in dietary diversity in the more food insecure months of the monsoon (as compared to dry season) in Dinajpur, Bangladesh. One possible explanation being that during food insecure times, less preferred foods are consumed, which may be more diverse.

As mentioned earlier, three types of questionnaires were used to collect the baseline data: village questionnaire, household questionnaire with main questions to the main respondent and questions on women's empowerment and nutrition with mostly common but also some separate content administered to individual women and men. Multiple versions of the village, household and individual questionnaires were shared with the Bill & Melinda Gates Foundation and WorldFish, and were carefully piloted twice to test clarity, comprehension and the time required for completion. The drafts underwent numerous rounds of pre-pandemic revisions to incorporate stakeholder feedback. The entry into CAPI and translation into Bengali underwent a series of checks by evaluation team members.

The individual questionnaires incorporated components of the WEAI modules which have been used in at-least 86 organizations in 53 countries across the world till 2019 (Malapit et al. 2019). Standard nutrition indicators of dietary diversity (FAO and FHI 360, 2016), food insecurity (Cafiero et al, 2018, Bilinsky & Swindale, 2010), and infant and young child feeding (WHO, 2021) were implemented. In addition, we asked questions about existing nutrition knowledge and practice, in particular targeting messages that would be emphasized by WorldFish programming, as well as questions about sources of new nutrition knowledge, with the idea to explore if WorldFish activities had reached the household via individual outreach, social media, or other means.

Questions on food decision-making and purchasing were introduced to enable greater understanding of which household members played a key role in which foods entered the household. Finally, as the Covid-19 pandemic had been ongoing for some time, we asked the respondents about changes that they had made (e.g., diet, market access, hygiene) during the pandemic to get a sense of how the pandemic may have changed the current situation, as dietary intake was not measured pre-pandemic.

Because of the pandemic, initial objectives had to be revised: our plan to collect anthropometric data was abandoned: the survey modules were also shortened to avoid overburdening respondents at times and under circumstances of potentially considerable additional stress. As discussed in detail below, adequate social distancing and other Covid-19 protocol was developed and observed by the field team throughout. There were no Covid-19 infections reported among the field teams during the entire duration of data collection.

As the sense of some normalcy returned, fieldwork planning resumed, and a listing exercise was first conducted between December 2020 and February 2021 to develop a roster of 4,574 households across 176 evaluation unions. The baseline survey

commenced in February 2021 but had to be stopped two weeks before the planned end of the data collection exercise in April 2021 because of new strict lockdowns in Bangladesh related to a resurgence in Covid-19 cases. The survey team was able to collect data from 3,716 out of the 4,574 households (or 81% of listed households) across 159 study unions and 551 villages, spread across 7 districts and 57 upazilas (see Table 4). Considering that these 3,716 households were equally spread across the control and treatment arms and delaying the survey any further would push back the reference period to two aquaculture seasons prior to the survey year, the evaluation team decided to stop the survey and re-work the power calculations.

Out of the 3,716 households surveyed, data was collected from all 3,716 male respondents in the households. However, there were non-responses from 216 female respondents and hence we were able to collect data from 3,500 female respondents out of the 3,716 households. Although our sample consists of 551 villages, the village questionnaire could be administered in 279 of these. This was due to the low number of eligible households in some unions. The original plan was to collect data from 4,574 households across two villages in a union. However, in some unions, we could not identify the requisite number of eligible households across two villages. To meet this shortfall, households in a third village had to be included. Our budget did not permit fielding the village questionnaires in these additional villages and we have village information for around half of the villages in our sample. We will therefore supplement this with information from the village level census data of 2011, if needed.

Table 4: Households surveyed across treatment and control unions

Treatment	Unions covered	Villages surveyed	Households surveyed	Women surveyed
Control	52	171	1,220	1,157
T1 (LSP/Private sector)	52	189	1,253	1,180
T2 (NGO)	55	191	1,243	1,163
Total	**159**	**551**	**3,716**	**3,500**

4.4 Implementation of the baseline survey

Following a public tender and interviews by a shortlist of three bidders, Innovations for Poverty Action (IPA), Bangladesh was contracted to implement the baseline survey. IPA, Bangladesh is headquartered in Dhaka and has significant and relevant expertise in undertaking surveys for RCTs and covering a variety of development-related themes. The first set of draft questionnaires for the baseline survey were tested by members of the evaluation team and IPA twice after incorporating feedback from the program implementation organization and the donors. After finalization of the paper-based baseline questionnaires, the survey firm programmed the questionnaires in Computer-Assisted Personal Interviews (CAPI) using SurveyCTO. The CAPI tools were bench-tested multiple times to ensure coherent flow of questions, accurate skip patterns and translations. Detailed survey manuals were designed prior to IPA's training of enumerators and field supervisors.

Because of the pandemic, the ethical approval process has been more complex than usual and has mainly been handled by NRI. Ethics approval was initially sought and

obtained from the UoG Internal Review Board. Our survey partner, Innovations for Poverty Action, have their own IRB and a reliance agreement, assigning the ethics responsibility to UoG, was signed by UoG and IPA (30 Oct 2019). IPA, together with the World Bank, USAID and others were at the global frontier of discussions of Covid-19 secure field protocol, including e.g. outdoor interviews, social distancing, and how to mitigate local transport and other risks. Our initial plan was to send a small and highly competent team into the field and then - and if deemed feasible and safe - gradually scale up. IPA drafted the field protocol and the evaluation team fed back and commented: given the circumstances, it became necessary to ask for UoG's approval of the field protocol (10 Nov 2020) and also to obtain ethical clearance from the Department of Health Economics, University of Dhaka (6 Dec 2020). Staff and survey respondent's safety even in the post-Covid-19 lockdown period has also been a prime concern for 3ie.

Keeping in mind Covid-19 safety protocols for the protection of survey respondents during data collection, the informed consent that was read out to respondents was revised to incorporate sections on the requirement of social distancing and mask-wearing by both the enumerator and the respondent. Respondents were informed prior to the survey that enumerators had taken all government mandated precautions for the prevention of Covid-19 infection like regular hand sanitization, wearing of masks and frequent disinfection of surfaces. Respondents were requested to strictly follow social distancing rules and to permit the interview in an open/well ventilated and uncrowded space where they are comfortable while maintaining a safe distance from the enumerator during the course of the interview. Respondents were also urged to wear a mask during the interview.

Following the safety protocol, the baseline questionnaire underwent considerable revision to reduce risks and limit the exposure of respondents and enumerators. We also adapted the questionnaire to capture Covid-19-related information that would be of interest for the evaluation. We also undertook multiple rounds of streamlining the questionnaires to reduce the time required for interviews. Important adjustments that were made included (i) dropping anthropometric data collection because of the elevated risks, (ii) excluding households with pregnant women (iii) adding some new questions on Covid-19 knowledge, practices, and adaptation. With Covid-19-related restrictions slowly being eased in Bangladesh towards the end of 2020, with ethics approvals in place and after receiving nods from IPAs regional and global offices, training for the baseline survey commenced on 19th January 2021.

IPA has a large network of field personnel with survey data collection experience across Bangladesh. From this pool, 56 male enumerators, 34 female enumerators, 10 male supervisors and 2 training facilitators were selected for training. The training of enumerators and supervisors continued for three weeks. During this time, enumerators were trained on paper-based questionnaires, CAPI-tools and Covid-19 safety protocols that were to be practiced in the field. IPA also conducted mock sessions with enumerators before testing their knowledge of the questionnaire, delivery, time management and rapport building. Based on these mock sessions and tests a total of 50 male and 30 female enumerators were selected for the baseline survey.

Since the baseline represents the first of a three-round panel, facilitating tracking of the households interviewed at baseline for follow up interviews in endline 1 is crucial. To

minimize attrition, we collected information about neighbors and networks likely to have information and knowledge about household members' whereabouts if a household relocates between baseline and endline 1.

We used the SurveyCTO mobile data collection platform, which contains several features and design options to facilitate collection of high-quality data with less effort.[16] This section outlines the steps taken for data quality-assurance, and the particular SurveyCTO features used to monitor and ensure high-quality data collection.

4.5 Data validation

An important requirement is that accurate survey data is recorded during the interview and that mistakes can be corrected efficiently during the interview itself. The response fields on the survey form were designed to prevent enumerators from entering data that are obviously incorrect, invalid, or inconsistent. The form disallowed answers that are clearly impossible, or those that contradict earlier responses, while still allowing unusual (but sometimes correct) values.

4.5.1 Monitoring and auditing of surveys

To assure quality in data-collection, survey supervisors randomly accompanied enumerators with re-visits to a sample of surveyed individuals to perform back-checks. To complement this manual quality assurance, SurveyCTO offers a text auditing option that allowed us to monitor the quality of survey administration. IPA consistently checked SurveyCTO meta-data about the survey administration, including how much time each enumerator spent on each question in the survey form and the sequence with which he or she progressed through the survey. Further and elaborated below, this also provides the opportunity – especially during the early days of implementation – to detect and take action to correct entered response patterns suggesting systematic misunderstandings on the part of a numerator or a group of enumerators.

4.5.2 Monitoring Incoming Data

As well as the checks on data collection in the field, IPA configured automated quality checks to monitor the overall quality of our incoming data using an in-house developed high-frequency check application called "ipacheck". For example:

1. Individual field values that are too low or too high.
2. Individual field values that are outliers. SurveyCTO uses statistics to warn when field values are unusually high or low.
3. Individual field values that are too frequent or too infrequent, allowing monitoring of the frequency of certain response values.
4. Field means that are too low or too high, giving a warning when overall mean or average of a field is above or below a certain threshold.
5. Mean values that differ from one sub-group to another, for example checking that average values for a particular field do not differ significantly depending on the interviewer.
6. Response distributions that differ from one sub-group to another. checking to see if the distribution of responses differs across sub-groups which might indicate enumerator effects in the reported response.

[16] https://docs.surveycto.com/

SurveyCTO gives warnings whenever submission values, frequencies, means, or distributions in our data cause configured quality checks to fail. This allowed for a rapid response to any issues that arose.

In addition to the data quality checks being administered by IPA, the evaluation team conducted statistical checks by computing means, standard deviations and histograms of important variables on a regular basis to ensure there were no data discrepancies. Large outliers in the data where identified were communicated to the survey firm, who conducted field checks to ensure accuracy. The first round of data post commencement of data collection was expected at the latest within 10 days of start of the survey, however, due to some initial challenges in the field, this data arrived later than expected and delayed our discovery of systematic weaknesses for time-use data: once discovered, corrective action was taken: it was nevertheless necessary to redo interviews for the time-use section for a subset of households remotely.

5. Data Analysis

The sample of households selected at baseline will be revisited in January 2023 with a follow up questionnaire administered to the same respondents. The households will be visited again one year after the World Fish project is finalized. Three rounds of data will therefore be available for the panel households (0=baseline, 1= follow up and 2=end of treatment).

Our simplest proposed Intention-to-Treat estimator is given by the following regression equation:

$$Y_{iut} = \alpha + \beta_1 T1u + +\beta_2 T2u + \tau_t + D_u + Y_{iu0} + \varepsilon_{iut}, \quad t \in \{1,2\}$$

Where Y_{iut} is the outcome variable for household i in union u in time t = (1,2). T1 and T2 are dummy variables which take the value 1 if a union u is assigned to treatment 1 or 2, respectively. The omitted variable represents control unions. We will include year (τ_t) and district-fixed effects (D_u) as well as controls for baseline values of Y_i. In more restricted versions of the Intention-to-treat estimator, we will control for some village characteristics that may influence impacts such as (i) distance to markets, (ii) the female literacy rate, (iii) the presence of other NGOs and government interventions. $\square_{iut}$ is the residual which we cluster at the union level. The coefficients on T1 and T2 capture the impact of the two individual arms relative to the control.

We randomized unions before the roll-out of the baseline household survey. We also explore heterogeneous impacts of the program on different sub-samples of the population. The table below lists selected outcome indicators for which we compare heterogeneous effects.

Table 5: Outcome wise heterogeneous effects

Outcome	Indicator	Heterogeneous effects
Productivity	1. Number of ponds operated 2. Quantity of fish harvested by household 3. Quantity of fish sold by household 4. Total household income from aquaculture (sale of fish, fingerlings and associated businesses) 5. Total household expenditure on aquaculture 6. Share of income from aquaculture in total household income	1. Farmers with less than 1.25 hectare of land and farmers with land between 1.25 to 2 hectares 2. Education of primary decision maker on aquaculture 3. Household membership in groups
Nutrition	1. Dietary diversity score for women and men 2. Total food consumption expenditure 3. Household food insecurity 4. Household fish consumption (e.g., days consumed, types consumed)	1. Education level of male/female respondent 2. Baseline income of household
Women's empowerment	1. Time spent by women and men in aquaculture and different aquaculture activities 3. Number of women who are active members of farmer groups 4.Pro-WEAI Index on adequate participation into production decisions in aquaculture 5. Pro-WEAI Index on ownership of land and other assets	1. Education of woman 3. Age of woman 4. Baseline income of household

6. Registration of pre-analysis plan

The pre-analysis plan was registered with RIDIE (RIDIE-STUDY-ID-5ee9e80c34a39) on 17 June 2020 and can be accessed here.

7. Internal validity of the evaluation

We present here selected results from the full list of balance tests (Online appendix C) run across the private sector arm, Hybrid or NGO arm and the control arm to test for statistically significant differences with respect to the outcome variables discussed in Table 1. We have presented results from the balance tests on household level characteristics, aquaculture outcomes related to the program, women empowerment outcomes and nutrition outcomes. For the women empowerment and nutrition outcomes we have used several indices like mobility index, self-efficacy index, progressive attitude towards women in aquaculture index, good aquaculture practices awareness index, standard Pro-WEAI indicators and nutrition indices like Minimum Dietary Diversity and Food Insecurity Experience Scale (FIES). These indices have been described in Online appendix B. We have also presented revised power calculations since we were able to survey 3,716 out of the targeted 4,574 households.

7.1 Balance Tests

Household characteristics across the sample were found to be comparable with no major variations across Control (C), LSP (T1) and NGO (T2) areas. We found statistically non-significant differences across T1, T2 and C for years of education among males (7.9, 7.7, 7.3) and females (6.6, 6.5, 6.5) within the sample households and percentage of households with children under 5 years of age (31%, 34%, 32%). Thirty three per cent of sample households across T1, T2 and C had more than 2 hectares of operable land and pond area combined. In terms of operable decimals of pond area, too, there were non-significant differences across T1, T2 and C (115, 111, 115). There was a slight variation across the 3 arms for income from non-aquaculture sources of income during the reference period, however, the difference was not found to be significant.

There was statistical balance across majority of the aquaculture outcomes calculated for the study. There was no variation in number of fish varieties (SIS and non-SIS) cultivated by households across T1, T2 and C (12.44, 12.55, 12.9). Households of LSP areas fared slightly better in terms of both, SIS and non-SIS varieties of fish harvested, consumed and sold but these differences were not significant. LSP union households also spent more on aquaculture inputs and had higher incomes from fish farming (T1-BDT 214000, T2-BDT-175,000, C-BDT 150,000) but these differences were not statistically significant, either.

Overall, commercialization seems to be slightly ahead in T1. The observations here could easily be driven by the presence of a few very large producers which we will check for in later rounds. For only two indicators, pond productivity (kilograms per hectare) (T1-2848, T2-2556 C-2546) and per centof households that used commercial fish feed (T1-67%, T2-66% and C-60%,) the difference was statistically significant between C, T2 and T1.

To understand the differences in fish productivity (kilogram per hectare operable pond), variations in cultivation of major fish species (cultivated by at least 10 per centof the households) were investigated (Figure C15). No major differences were found. We will look into reasons of possible commercialization in T1 through the process evaluation. We will also control for these indicators in the endline reports.

The household questionnaire asked respondents if anyone in their household was a part of a Facebook group that promotes aquaculture and the name of the Facebook group. A total of 37 households reported that members of their household were a part of an aquaculture-promoting Facebook group. Only 5 out of these 37 households report that this was Facebook group promoted by WorldFish or The Right Fish. Out of these 5 households, 3 were in the LSP arm and 2 in the NGO arm.

As part of our process evaluation, we also conducted a remote phone survey with a total of the 42 LSPs spread across control, T1 and T2 areas in 2020 and in 2021. The survey provided us with an opportunity to understand the characteristics of the LSPs across treatment and control unions and to explore any differences in characteristics and delivery quality of their trainings.

Some crucial differences observed between T1 and T2 LSPs are that NGO-led LSPs report greater ease of entry and low risk in establishing aquaculture businesses. In terms of aquaculture themes covered in training, NGO-led LSPs focused more on nutritional importance of fish in diets and the importance of women in aquaculture compared to

private sector model LSPs. NGO-led LSPs were also able to expand aquaculture services to women without facing as many challenges compared to private sector model LSPs.

7.2 Revised power calculations

As discussed earlier, we were able to conduct baseline data collection from 3,716 households in 159 unions out of the targeted 4,574 household in 176 unions. We present the power calculations using similar assumptions as in our proposal.

Table 6: Power calculations

Outcome	Mean	SD	Number of clusters	Number of villages per cluster	ICC	Targeted MDD	Revised MDD
Dietary Diversity Score	4	1.7	52	2	0.07	0.55	0.69
Household consumption expenditure	10822	1000-2000	52	2	0.5	3-7%	5-9%

8. Other findings

In this section, we present other key findings that relate to the project design and theory of change and to balance on nutritional outcomes and women's empowerment. An important driver of expected productivity improvements in aquaculture production is the adoption of seven different production practices advocated by WorldFish. Table C3 of Online appendix C reports the baseline awareness levels about the usefulness of these practices. We find that there is already widespread awareness among men and women in respondent households across treatment and control arms. For a maximum awareness score of 7, the average score for men across T1, T2 and C were, respectively, 6.36, 6.30 and 6.27, while the corresponding scores for women were slightly lower, but still high and at 5.5, 5.6 and 5.6. This suggests that the scope for raising aquaculture productivity through this specific knowledge enhancement route may be much more limited than expected.

Online appendix C also reports on the credit constraints facing households in the study area. Sixty per cent of the households had outstanding loans till the end of the reference period (March 2020) (Figure 4). Among these households with outstanding loans, 73 per cent reported to have taken these loans during the reference period (April 2019 to March 2020) (Figure C1). The main loan providers were Microfinance Institutions (56%), commercial banks (30%), relatives (15%) and neighbours (10%) (Figure C2). The average size of outstanding loans was USD 2,363 as of March 2020. Figure C6 shows that more than 99 per cent of men report that they can access multiple sources of credit: while the corresponding number among female respondents is slightly lower and at 97%, 97% and 96% in T1, T2 and C, these are still very high numbers suggesting that any credit-provision related route to enhancing aquaculture productivity may – again – either be less promising than expected or be able to provide credit terms that are more attractive to smallholder aquaculture households or individuals within these than what is currently available in the market.

For T1, T2 and C, the main sources for purchase of fingerlings were local fish traders (or patiwalas who travel from village to village to sell small quantities of fingerlings from hatcheries/nurseries) (50%, 50%, 50%), fish nurseries (30%, 40%, 40%) and hatcheries (20%, 20%, 30%). As WorldFish is also seeking to enhance aquaculture productivity through provision of improved fish seed and feed, considering that almost 50 per centof the households are still dependent on local traders for fish seed, there may be scope to create impact through the marketing route. Sixty four per centof the households purchased commercial fish feed (T1, T2, C - 67%, 66%, 60%), while 80 per cent used home-made fish feed (82%, 77%, 81%) in their ponds, so there is slight scope to impact outcomes by enhancing provision of better feed by WorldFish.

Another important finding suggestive of more promising scope for impacts is awareness about the nutritional value of small indigenous fish species. Around a third of women specifically identified small indigenous species as nutrient rich (35%, 32%, 38% in T1, T2, and C, respectively) which suggests that awareness raising can contribute to child and other nutritional dividends through knowledge-induced behavioral change that results in increased consumption of SIS-varieties.

Less than 1% of male and female respondents said that consuming fish was not important for pregnant/lactating women or young children (see Online appendix C, Table C8). Most reported that eating fish was good for health and that fish were high in vitamin/mineral content. Thus, we expect that overall perceptions of fish as healthy will likely not change (as most already hold this belief) but focus on the SIS-varieties may still lead to greater valuing and increased consumption of these species.

However, increasing fish consumption in general appears less likely, as more than 75 per cent of men and women reported eating fish the previous day: however, this was expected as other regional surveys have found similarly high fish consumption prevalence. Adequate dietary diversity overall was achieved by around two-thirds of male and female respondents. Sixty-four per cent of children 6 to 23 months of age attained a minimum adequate diet with half of children 12 to 23 months consuming fish the previous day. Thus, increasing fish intake among adults may not improve dietary diversity (as fish consumption is already high.) However, we will be able to detect shifts in fish consumption towards more nutritious types and these changes may be reflected in overall child diet metrics.

Regarding relevant nutrition related outcomes of concern, there was very little variation in dietary diversity scores of infants between 12 to 23 months (4.94, 4.76, 4.97), adult men (5.17, 5.07, 5.07) and women (5.17, 5.05, 5.06) across T1, T2 and C. On food insecurity, the moderate to severe food insecurity scores for male respondents across T1, T2 and C are, respectively, 0.11, 0.14 and 0.13 with the corresponding numbers for women being 0.09, 0.095 and 0.13. The scores for severe food insecurity among males are 0.003, 0.004 and 0.003, and thus very low: for females the scores are only marginally different: 0.005, 0.003 and 0.007: while the latter is more than double the incidence for males in C, this is from a very low initial base.

For assessing women empowerment outcomes, we constructed standard Pro-WEAI indicators (See Online appendix B) for input in aquaculture productive decisions, land and asset ownership, mobility, self-efficacy, group membership and access to financial

services for both men and women. It is encouraging to register that for the women's empowerment outcomes that relate to role in household decision-making about participation in aquaculture production, there are no significant differences across T1, T2 and C: there are also no significant differences in women's participation in aquaculture production decision-making across the three trial arms. Finally, there are no differences in female economic and non-economic mobility scores, in the surprisingly high female self-efficacy score or in women's progressive attitude score about the appropriateness of women's involvement in aquaculture across T1, T2 and C.

On women's participation in decision-making by type of aquaculture activity, it is encouraging to note that participation is particularly high where this would be expected: whether harvested fish should be consumed by the household or sold in the market where 85%, 85% and 86% of women in T1, T2 and C report participating in the decision. For examples of other decisions in this domain, 65%, 69% and 67% of women report participating in decisions about which fish species to cultivate while lower numbers, respectively, while 50%, 58% and 56% participate in deciding from where to purchase fingerlings and fish feed. There are, again, no statistically significant differences across the trial arms.

We next present a comparison of T1 and T2 with the control areas using equation (1). Thus, we include district fixed effects, thereby controlling for time-invariant district variations, in this analysis. The results are presented in Online appendix D. The coefficients on the variables 'T1' and 'T2' provide an estimate of difference in average values of the outcome of interest in T1 and T2 compared to the Control unions. We also present results for selected outcome indicators (mentioned in Table 1) for which we compare heterogeneous effects (See Online appendix E).

Table D1 in Online appendix D presents the results of estimating equation (1) for outcomes related to aquaculture productivity and income of households. We find that across all outcomes there is no significant difference in baseline outcomes between T1, T2 and Control. Pond productivity, investments and incomes are statistical comparable for all three experimental groups. Table D2 and D3 present indicators of men and women's engagement in aquaculture, their attitudes towards this type of work and different dimensions of empowerment. For most indicators, we find no statistical difference in the coefficients of T1 and T2.

However, men in T1 and T2 were involved in decision making for a higher number of aquaculture activities for which decision-making can be done at home such as deciding which fish feed to use, which fish species to harvest and when and which species to sell, compared to control. We observe significant differences in women's group membership across the arms as well. Fewer women were part of economic and social groups in T1 and T2 than in control.

Looking at some indicators of food security and nutrition (Tables D4, D5 and D6), we see that households in T1 consumed more large fish than small fish (as indicated by the number of days each fish type was consumed). Both T1 and T2 reported significantly lower moderate food insecurity for women than control. Overall, we are confident that households in the three experimental arms demonstrated comparable project relevant outcomes at baseline. However, the significant and consistent differences observed in

women's group membership may influence impacts. We will control for this difference in initial level of group-membership among women in our Intention-to-treat estimation.

Sub-section 1 of Online appendix E analyses the heterogeneity in aquaculture income, investment and productivity by the size of landholding. As expected, the quantity of fish harvested increases with land size. Smaller land holdings are associated with lower income and expenditure. The average income from aquaculture for farmers who own less than 1.25 hectare of land (subsistence farmers) is BDT 78380 while expenses are BDT 42058. This income and similarly expenditure more than doubles and then quadruples for small (1-2 hectare) and pre-commercial (2+ hectare) farmers. The contribution of aquaculture to household income is also lower for subsistence farmers (20% for subsistence compared to 27% and 30% for small farmer and pre-commercial farmers).

Given the ubiquity of microfinance groups in Bangladesh, we next explore the how membership in credit and livelihood groups may be correlated with aquaculture income and pond productivity. Pond ownership is comparable across households with group membership and those without (~2 ponds). However, group members report higher quantity of fish harvested, sold and income earned than non-members. While the average quantity of fish sold by non-members is around 1000 kilos per annum, this is 1300 kilo per annum for group members. Income from aquaculture for group members is around BDT 2 lakh while for non-members this is BDT 1.7 lakhs.

We next examine heterogeneity of nutrition indicators by women's education. The average years of education of women in our sample is 6.5 years. We group women into two categories- those who have completed 6.5 or fewer years of education (low education) and those who have more than 6.5 years (high education). We find that the less educated women spend more time in aquaculture compared to women in the high education group. Despite women's time contribution, such households report a comparable number of days in which fish is consumed (4.6 compared to 4.9 by households of more educated women) and no difference in the variety of fish consumed. Households with less educated women report lower dietary diversity than the high education group. A similar pattern is observed for men's education as well. Since better educated women (and men) are likely to be belong to economically better-off households, this difference in dietary diversity may well be determined by household income rather than woman's education. Overall, we do not find consistent patterns of correlation between women's education and household nutrition.

9. Ethics

As discussed above, the evaluation has formal ethics approval from the University of Greenwich with commitment to adhere to the Belmont Report principles for the conduct of research with human participants. An ethics reliance agreement between University of Greenwich and the survey organization, Innovations for Poverty Action (IPA), has been entered into and signed. In addition to University of Greenwich, the evaluation has also received a second ethics approval from the Institute of Health Economics, University of Dhaka in December 2020, owing to changing field circumstances due to the Covid-19 pandemic.

Our aims are to: (i) generate and disseminate high-quality, policy-relevant evidence about what works in aquaculture, for whom, how, why, and at what cost,[17] and (ii) strengthen the "culture of evidence" in Bangladesh by engaging key stakeholders—including policymakers, beneficiaries and downstream partners—throughout the project, with representatives serving in an advisory role in the interpretation and use of high-quality evidence for making policy and programming decisions. In addition to ethics, we have and will adhere to high standards of quality assurance and research transparency.

10. Major challenges and lessons learned

The major challenge faced by our team at baseline was the Covid-19 pandemic and the resulting lockdown measures taken by the government as well as preventative actions taken by our team and the survey agency. In coordination with IPA, we modified the data collector protocols incorporating reduced use of public transport, minimum distance between respondents and interviewers, obligatory wearing of masks, and reductions to the baseline survey to avoid contact with respondents (e.g., removing measures of anthropometry). These challenges were additionally compounded by the lack of Covid-19 testing availability in most of the country (outside of Dhaka), which meant that respondents and data collectors could not easily be tested for Covid-19 for prevention nor diagnosis. In addition, to minimize time in the field because of the pandemic, village selection was done remotely, and through calls to union level government officials.

With regard to data quality, the Covid-19 pandemic will have changed many parameters that we were measuring including aquaculture activity, sale, and dietary measures. To minimize this in our data, we changed the recall period to the last aquaculture season before the lockdown measures were in place. This could not be credibly done for some measures, such as dietary diversity, but for most of the indicators, piloting indicated that respondents were able to recall back to this time period.

Another challenge was the survey length, survey piloting showed that the survey was much longer than expected and the 3ie team went through several rounds of revisions to shorten each section. First, this was done to minimize respondent burden. Later rounds of more drastic reductions were done as the Covid-19 situation called for reduced inter-personal interactions.

Finally, as the baseline roll out was delayed, WorldFish had already begun implementation activities in October 2019 with the identification of LSPs and the start of training activities. Outreach to farmer groups started as early as November 2019. To measure any potential contact with our survey respondents, we asked if any new nutrition related information had been acquired since this time in order to monitor already implemented training and touch points. Our process evaluation interviews reveal, that despite commencement of implementation in 2019, the majority of project activities had to be delayed or stalled in 2020 due to severe Covid-19 restrictions in Bangladesh. Given this, we are confident that we have a cleaner baseline than expected.

[17] Scholars from University of Washington are working in parallel and will collect data from WorldFish to conduct a cost-effectiveness analysis (CEA) of the WorldFish intervention. We have held several discussions with the UoW team. Combined with the effect sizes identified by our impact evaluation, direct and indirect cost estimates will help determine the cost per unit change in key indicators (using the best available guidance to apportion costs to multiple outcomes).

Our findings suggest that there may be possible variations in the usefulness of the different project interventions. To understand the implications of these differences, we will collect data on project reach and quality from respondents in the endline. We will then analyze differences in project impacts based on implementation quality.

11. Conclusion

The baseline has been successfully completed after a wide range of challenges necessitated multiple adjustments to data collection plans and data collection instruments. While this also involved some cuts to WEAI and other modules, the descriptive statistics, figures and results in the Appendixes provide rich insights about decision-making around and participation in aquaculture activities.

A few key findings that relate to the project design and theory of change are worth reiterating. To start with and as suggested in the preceding discussion, the WorldFish project is seeking to enhance aquaculture productivity by improving the knowledge and practices of smallholder aquaculture households. These practice improvements include seven different practices. We collected data on the awareness around these practices and actual application of these practices by male and female respondents (or anyone in their household) if they were aware about them. If these practices were not implemented by the household, we also asked follow-up questions on the reasons for not implementing these practices if they knew about them.

We find that knowledge of the usefulness of these practices (Figure C4) and actual application (Figure C5) are fairly high among both men and women. Among those who reported that they did not implement these practices, lack of proper knowledge about the practices as explanation was cited by a small minority (Figures C6 to C13). The reasons cited for not engaging in best practices provide interesting insights into the constraints faced by farmers in implementing these practices.

For example, the main reasons cited for not engaging in construction or repair of pond dikes during the previous aquaculture season were good condition of the current dike (71%) and lack of financial resources for construction or repair (22%). Similarly, reasons cited for not engaging in removal of black soil were difficulty in drying pond (50%) and of lack of financial resources for construction or repair (31%). These reasons suggest that apart from lack of proper knowledge, several constraints inhibit the application of some of these practices. Thus, the scope for raising aquaculture productivity through knowledge enhancement route if done without addressing the supply side constraints may be more limited than expected. Provision of improved seed may be a more promising approach for improvement of aquaculture productivity as 50 per centof the households still depend on local fish traders for fingerlings.

Credit constraints also appear to be less binding for households in the area with a very high percentage of men and women reporting that they can access credit from multiple sources. This suggests that a credit provision related route to enhancing aquaculture productivity – unless it significantly improves on credit terms compared to existing offerings – may again be less promising than expected. Our findings point to potential for nutritional behavior change communication strategies, as women's nutritional knowledge about the nutritional value-added of especially small indigenous fish species is lower than expected, with only about one in three being aware of such dividends.

Overall, we find that our randomization process achieved balance for most baseline variables. Household characteristics such as educational attainment of men and women, land ownership and pond size are comparable across the three experimental arms. Looking at our primary outcomes of interest, namely productivity, income, women's empowerment and nutritional outcomes, we find some differences in means that are worth taking note of. Pond productivity is higher in the LSP areas, although these differences disappear once we include district level controls. Some differences are observed in women's membership in groups as well, with women in LSP areas less likely to be part of influential groups. This suggests that including sensitivity analysis to understand how these differences at baseline may influence impacts at endline 1 and endline 2 will be critical to substantiate any impact estimates.

Online appendixes

Online appendix A: WordFish small-holder aquaculture household selection criteria

https://3ieimpact.org/sites/default/files/2022-10/WP53-Aquaculture-Baseline-Report-Online-appendix-A.pdf

Online appendix B: Description of scores used in report

https://3ieimpact.org/sites/default/files/2022-10/WP53-Aquaculture-Baseline-Report-Online-appendix-B.pdf

Online appendix C: Balance tests

https://3ieimpact.org/sites/default/files/2022-10/WP53-Aquaculture-Baseline-Report-Online-appendix-C.pdf

Appendix D: Fixed effect regressions of main outcomes at baseline

https://3ieimpact.org/sites/default/files/2022-10/WP53-Aquaculture-Baseline-Report-Online-appendix-D.pdf

Online appendix E: Heterogeneous effects

https://3ieimpact.org/sites/default/files/2022-10/WP53-Aquaculture-Baseline-Report-Online-appendix-E.pdf

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