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Evaluation of IDEA

An aquaculture project in Bangladesh

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Evaluation of IDEA: An aquaculture project in Bangladesh

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Executive summary

Bangladesh's aquaculture sector has grown rapidly in recent decades, becoming one of the largest in the world. Yet, northwest Bangladesh has lagged other regions in productivity, women's participation, and nutrition outcomes. In 2019, WorldFish launched the *Increasing Income, Diversifying Diets, and Empowering Women in Aquaculture (IDEA)* project in Bangladesh's Rajshahi and Rangpur divisions, characterized by high poverty, limited aquaculture development, and persistent undernutrition, particularly among women and children. The project aimed to harness the untapped aquaculture potential of these regions by improving aquaculture productivity and women's empowerment, and nutritional outcomes through training, improved access to inputs and services, and gender-transformative and nutrition sensitive approaches.

The IDEA project was implemented through two modes of implementation. In the first, WorldFish worked directly with private Local Service Providers (LSPs) as extension agents. In the second, a hybrid model was implemented through national NGOs, TMSS and BRAC, which trained and supported their own LSPs. Both models emphasized trainings and knowledge dissemination; access to quality seed, feed, and pond inputs; improved market and credit linkages and complementary activities to enhance women's participation in aquaculture and household decision-making.

The evaluation used a cluster randomized trail design, where 176 unions were assigned to three experimental arms: control, LSP-led implementation and NGO-led implementation. The project was not implemented in the control unions. Baseline data were collected in early 2021 and endline data in mid-2023, covering more than 3,600 households across 550 villages. The household panel data were complemented by qualitative research, surveys of LSPs, and satellite imagery to capture changes in aquaculture practices and land use.

Across all study areas, including control unions, fish production, harvest, sales, and pond productivity rose substantially between 2020 and 2023. Fish production rose by 21.1% in LSP area and 13 percent in NGO areas while control areas experienced even larger growth of 29 percent. Sales followed a similar trend with increase of 23.3 percent, 14 percent and 30 percent in LSP, NGO and control areas. Pond productivity improved across all arms, accompanied by shifts toward more commercial practices, including a marked decline in home-made feed use and increased adoption of commercial feed. Farmers increasingly shifted toward higher-value species such as carp, tilapia, and pangas, despite IDEA's emphasis on small indigenous species (SIS) for nutrition.

However, the evaluation finds **no statistically significant differences between project and control areas** on any of the primary production, income, or productivity outcomes. Both delivery models generated minimal incremental impacts beyond changes observed in control areas.

These results indicate that several of the project's core assumptions, particularly regarding low baseline knowledge and limited adoption of improved aquaculture practices were overly conservative. At baseline, most farmers already demonstrated strong knowledge of recommended aquaculture practices, leaving limited scope for further gains through training alone. Knowledge levels increased only marginally by endline. While COVID-19 disruptions delayed implementation and compressed timelines,

nearly 69 percent of training sessions were delivered in 2022. These challenges alone cannot explain the absence of impacts, given the strong and widespread growth observed across all study areas.

A key explanation lies in the **rapid commercialization of aquaculture during the evaluation period**. Private hatcheries, feed suppliers, and dealers expanded rapidly, offering embedded services, branded feeds, and technical advice that overlapped substantially with project activities. In this context, IDEA project struggled to demonstrate additional value. Descriptive evidence shows that government aquaculture program coverage declined more sharply in treatment areas than in control areas over the study period, suggesting a potential crowding-out effect. These patterns indicate that broader market forces and private-sector dynamics played a dominant role in shaping outcomes, overshadowing project-level interventions.

The evaluation also finds **limited impacts on women's empowerment**. While overall participation in aquaculture decision-making did not change, women's input in production decisions increased in NGO areas, and input into sales decisions rose slightly in LSP areas, among those already participating. Women's time use and control over aquaculture income remained largely unchanged. Notably, attitudes toward women's full-time involvement in aquaculture worsened among women over the study period, particularly in LSP areas, while men's attitudes changed little. These patterns suggest that commercialization may have reinforced existing gender roles, as men were more likely to access training, markets, and technology, while women's participation remained peripheral.

Nutritional outcomes followed a similar pattern. While overall fish consumption and dietary diversity were high across all groups, there were no significant improvements attributed to the project. Women's dietary diversity increased modestly in intervention areas, but these gains were not driven by increased fish or SIS consumption. Instead, changes reflected higher intake of meat, dark green leafy vegetables, and vitamin A–rich foods. Very few respondents reported receiving nutrition-related information through IDEA activities, and changes in SIS production and consumption were negligible.

Overall, the evaluation finds **limited to no incremental impact of the IDEA project on production, women's empowerment, or nutrition outcomes**. Rather than reflecting implementation failure alone, these results point to a more fundamental issue that in a rapidly commercializing and market-driven sector, interventions centered on basic training, knowledge dissemination, and small-scale service provision are unlikely to generate additional impacts when private markets and broader structural forces are already driving change. The findings suggest that future development efforts in similarly dynamic contexts should move beyond stand-alone training and extension models. Future development efforts in similarly dynamic settings must go beyond basic training and address structural constraints related to innovation, institutional linkages, access to finance, while ensuring that both men and women share the benefits of sectoral growth.

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List of acronyms

IDEA Aquaculture: Increasing Income, Diversifying Diets, and Empowering Women project

LSP Local service provider

NDVI Normalized Difference Vegetation Index

NDWI Normalized Difference Water Index

RCT Randomized controlled trial

SIS Small indigenous species

1. Introduction

Like the country's more well-known garment sector, aquaculture in Bangladesh has witnessed rapid and unprecedented growth in recent decades. Described as a "quiet revolution," farmed fish production grew more than 15-fold—from 124,000 tons to 2.3 million tons—between 1984 and 2022, making Bangladesh the fifth-largest aquaculture producer in the world (FAO 2024).

Garment sector growth has been similarly impressive, with employment increasing from 40,000 in 1983 to 4 million by 2013 (Ibid), and garments accounting for 79 percent of Bangladesh's export earnings by 2008–2009. In a strongly conservative society in which women did not traditionally work outside of the home, the garment sector transformed women's employment, with estimates suggesting that they now comprise up to 80 percent of the garment sector workforce (Heath and Mobarak 2015). The aquaculture sector, despite its growth performance, has a lower share of female employment; however, this is growing, with women holding 1.4 million of the 17.8 million jobs in the sector in 2016 (Choudhury, McDougall, and Rajaratnam 2017).

In 2019, WorldFish launched a new initiative targeting Rajshahi and Rangpur divisions in northwest Bangladesh, where the aquaculture sector had yet to take off, women's participation in economic activities was limited, and levels of malnutrition were comparatively high. The Aquaculture: Increasing Income, Diversifying Diets, and Empowering Women (IDEA) project combined insights from WorldFish's global experience with lessons from the organization's long-term engagement with aquaculture in other areas of Bangladesh.

The project's broad, overall objectives fit the description of a nutrition-sensitive rural intervention, which would usually focus on agriculture, but in this case had an aquaculture entry point. IDEA's overall objectives were to: (1) enhance aquaculture productivity; (2) strengthen women's empowerment and expand female participation in aquaculture (including downstream value chain nodes); and (3) reduce food insecurity and nutritional deprivation and improve dietary diversity through improved nutritional knowledge, as well as indirectly through women's empowerment.

At the outset, IDEA had two stand-out features. First and foremost were the two implementation models: private sector-based through local service providers (LSPs), and a "hybrid" model through reputed Bangladeshi NGOs, their private enterprises, and other networks. The second feature was a gender-transformative aspiration for rural settings, with experiences from the garment sector indicating that such transformations could be achievable.

For the implementation models, plausible assumptions were that NGO actors might prioritize "soft" project objectives (e.g., women's empowerment, nutrition), while small LSPs might focus on productivity and related facets with more obvious commercial potential. Against the backdrop of the garment sector's transformation of women's culturally sensitive employment outside of the home, what were the prospects for enhancing women's participation in aquaculture in general, and expanding their involvement in different nodes of the aquaculture value chain, in particular?

2. The IDEA project

Furthermore, access to credit, extension services, and market linkages have been identified as key enablers of the transition from subsistence to commercial aquaculture, especially for homestead farmers (Jahan, Ahmed, and Belton 2010).

Despite strong commercialization trends, key constraints remain, like low seed and feed quality control, especially among small-scale producers. Lack of cold-chain and disease-management infrastructure, and low participation of women and limited access to finance, are other key challenges affecting this sector (Samanta and Roy 2023).

2.1 Background: The WorldFish project intervention

The IDEA project was launched by WorldFish in Rajshahi and Rangpur divisions in northwest Bangladesh in 2019. The project covered five districts of Rajshahi division (Rajshahi, Bogra, Naogaon, Natore, and Pabna) and two districts of Rangpur division (Rangpur and Gaibandha).

Key planned interventions under IDEA included:

1. **Enhancing productivity** by improving smallholder access to quality fish seed and breed stock, improved fish feed, and pond inputs. LSPs were to provide a conduit for smallholders to access quality inputs such as seed (tilapia, carp species) from certified fish hatcheries, nurseries, and WorldFish genetic improvement investments. This would be supplemented by better-quality fish feed, fertilizer and management solutions from private businesses. Farmer activity and credit groups were to be mobilized or created to access formal and intra-group credit.

   These interventions focused on access to technologies, improved aquaculture knowledge and practices, and a more business-oriented approach. The LSPs are small private enterprises and expected to charge a commission for their services. These activities were to be complemented by actions to improve fisheries policy, regulation, and investment relating to input quality and safety.
2. **Establishing market linkages** to increase the value of sales by supporting the creation and strengthening of farmer groups (including women's groups) and promoting business relationships—between farmer groups and private sector market actors engaged in processing and fish product development, on the one hand, and buyers of fish and fish-based products, on the other. Relevant information would be disseminated through digital platforms and promotional materials.
3. **Strengthening capacity of LSPs** through two different models of delivery. WorldFish would prepare training materials and deliver "training of trainers" sessions. In the decentralized, private-sector model, WorldFish would select, train and mentor LSPs; in the hybrid model, WorldFish would train the two contracted NGOs (Thengamara Mohila Sabuj Sangha [TMSS] and BRAC), who in turn would select and train their own LSPs using guidelines and training materials from WorldFish.
4. **Using nutritional behavior change communications** and nutritional messaging to increase consumption of fish and other nutrient-rich foods, with a special focus on young mothers, pregnant women, and children. At the union level, nutritional outreach was expected to be undertaken by the LSPs, both in the private sector

model and in the hybrid model. In addition, a wider range of consumers would be reached with nutritional messages through mass media and digital messaging.

5. **Framing women's empowerment interventions** as gender-transformative—though they were subsequently adjusted to gender integration strategies based on an understanding of gender dynamics and barriers, and opportunities for enhancing women's entrepreneurship and involvement in aquaculture value chains. Trainings for trainers and LSPs were also meant to retain some gender-transformative approaches, which were expected to be presented when training farmer groups. Gender-inclusive farmer activity groups and savings and credit groups were to be formed alongside women-only fish farm groups/associations.

2.2 Theory of change

The theory of change is a visual depiction of the causal pathways which are intended to lead from program activities to changes in knowledge and practice, early outcomes, and then intermediate and longer-term outcomes. Mapping these pathways can highlight critical relationships to be investigated in monitoring and evaluation. It also identifies where the causal relationships rely on assumptions or expectations, which require evidencing over the project period. Assumptions can relate to the project design and problem analysis, implementation conditions, capacity and behavior change, and targeting and reach.

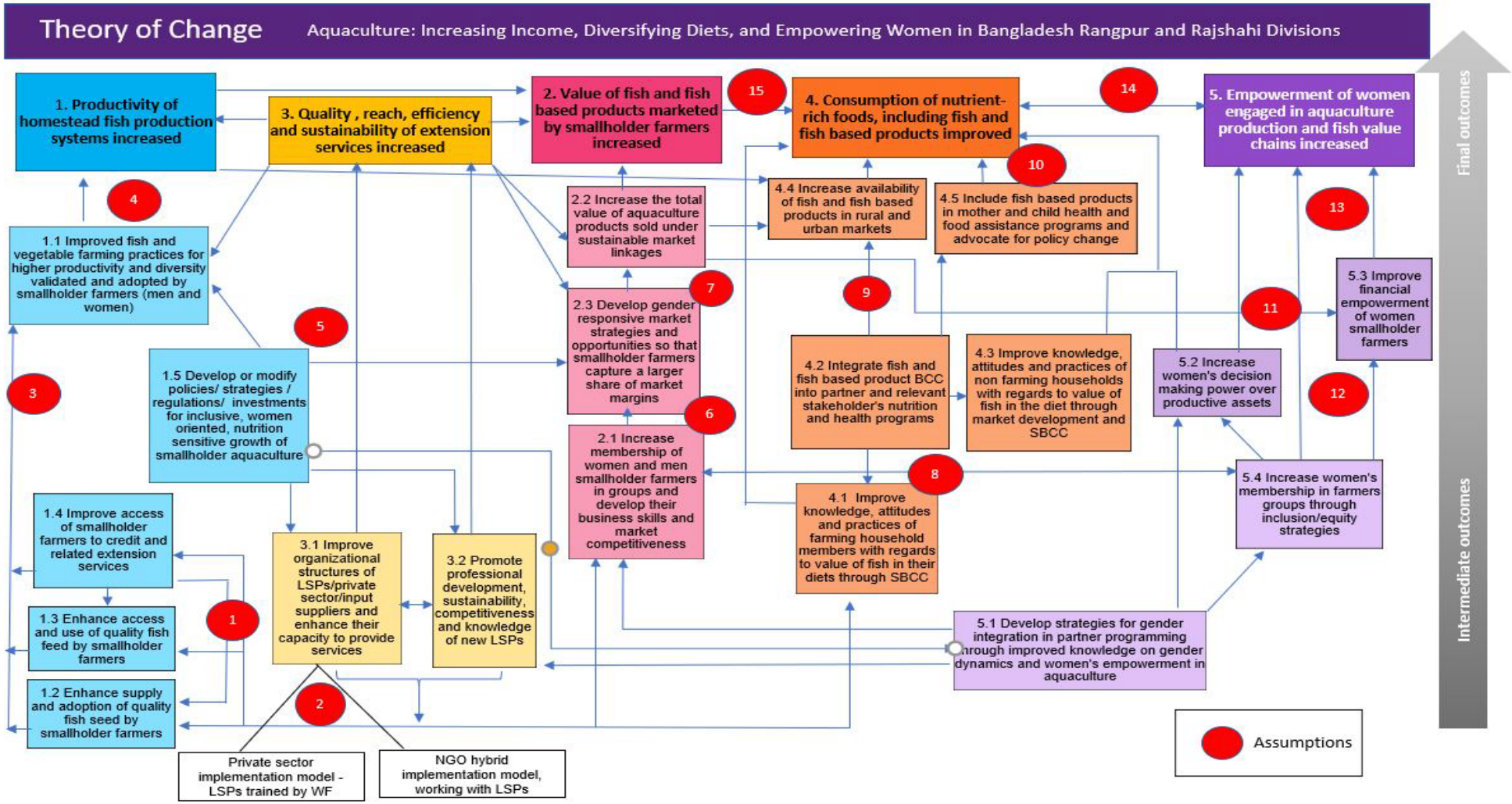
The program theory of change was constructed in 2019 by the evaluation team, based on project documents including the results framework, WorldFish's diagram of the project impact pathways, and the work plan.[1] The theory of change is presented in Figure 1. The colored columns represent the five intervention 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 will be developed with the participation of partners and stakeholders, which 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. Therefore, the baseline study included questions on farmer knowledge and practice to establish the initial status against which improvements can be measured.

[1] 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 theory of change was retained.

Figure 1: Theory of change (developed by evaluation team [2019])



Note: BCC = behavior change communication; SBCC = social and behavior change communication; WF = WorldFish.

Efforts to enhance **quality, reach, efficiency, and sustainability of extension services**[2] 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) will play a crucial role in the delivery of services to smallholder aquaculture farmers. They will be the subject of training and capacity building to improve their knowledge, competitiveness, and effectiveness in providing smallholders with access to seed, feed, and credit, thereby contributing to higher productivity.

The evaluation team will carefully track the specific ways in which the hybrid model of farmer training and engagement differs from the private sector model. The project will promote professional development, sustainability, competitiveness and knowledge of new and existing LSPs (3.2) and improve organizational structures of LSPs/private sector/input suppliers and enhance their capacity to provide services (3.1). These LSPs will be identified among local small entrepreneurs working in the farm and fisheries sector, including women farmers.

These interventions will 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 delivery to self-help groups, 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 the membership of women and men in existing and new farmers groups, 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). Together these lead to an increase in small-holder farmers' income 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), 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** will start with social behavior change communication (though LSPs and digital information) to increase the knowledge among farming and non-farming households about the benefit of nutrient-rich food groups and dietary diversity in addressing malnutrition and 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 will engage with key stakeholders, such as the departments of public health and nutrition, to include fish and fish-based products in food

[2] This is the third project outcome; however, it is presented alongside Outcome 1 in the theory of change diagram, for ease of mapping connections.

assistance, and health and nutrition programs (4.2), with particular attention paid to maternal and child health supported by information for policy change (4.5).[3] These will lead 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-based products, by both farming and non-farming households (4).

Improved consumption of fish can also be a direct result of increased availability of home-produced fish. The main assumptions are that nutritional social and behavior change communication strategies and mechanisms (including digital and mass media) have the required reach and are effective and 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 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 LSP activities, and informed by studies of gender dynamics and women's position in aquaculture (5.1). Inclusion of women in farmers' groups and women's groups (5.4 and 2.1) will 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 financial status (5.3), contributing to the empowerment of women engaged in aquaculture and fish value chains (5) and strengthening women's participation and influence as purchasers and consumers of fish (4).

Several important assumptions are necessary for the realization of these outcomes, including: women's participation in groups and fish-related activities does not increase their work burdens 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 and women's income earned through participation in fish production and marketing remains within their control; and women's empowerment in aquaculture will positively influence their choices and consumption of nutrient-rich foods.

Our theory of change diagram shows how the interventions interact with each other in complex ways to produce 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 behavior change communication messaging to smallholder farmers; group mechanisms function and the volume of demand and profitability is adequate to justify the effort.

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

3. There are significant gaps in farmers' knowledge of improved management practices and access to inputs, 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. Social and behavior change communication 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 positively influence their choices around, and consumption of, nutrient-rich foods.
15. An increase in commercialization does not reduce the volume or nutritional value of home fish consumption.

3. The impact evaluation design, sampling, and data

3.1 Evaluation design and sampling

A clustered and multi-armed randomized controlled trial (RCT) was designed and implemented to evaluate the IDEA project. This is a large RCT with two treatments and one control arm in what was initially intended to be a three-round rural household panel with a baseline, an end-of-project endline, and an additional endline one year after the project's conclusion. The second endline was justified by an assumption that some important outcome variables (e.g., relating to new technology uptake and women's empowerment) would likely undergo delays and thus be slow-moving. As in many agricultural research for development interventions led by the Consultative Group on International Agricultural Research, impacts might therefore take time to manifest.

This second endline was subsequently dropped due to COVID-related resource constraints and a change in priorities. Funds were therefore repurposed to study implementation processes, seasonal variation in nutritional intakes, and changes in gender-regressive social norms. We therefore have a two-round panel covering approximately 3,500 rural households with male and female members from the core

marital unit of each household interviewed in both rounds.[4] The household panel data are supplemented by data from two rounds of surveys of LSPs, a separate periodic nutrition survey and panel, and experimental data on gender-related attitudes and norms.

The aim of the RCT was to causally identify the impacts of the project on: aquaculture practices and productivity; the income of smallholders and other rural households involved in aquaculture; women's empowerment and participation in aquaculture-related activities; and dietary diversity and other nutritional outcomes, and to determine whether impacts were more pronounced for some subgroups than for others.

Randomization was clustered at the union level, which is the smallest administrative unit above a village.[5] We chose to randomize at this level as an LSP's initial area of operation (and thus its commercial outreach) was likely to be in the proximity of the service provider's residence, and thus rely on a customer base and market with which the service provider had already become established, or had comparatively easy access. A typical union in Rajshahi and Rangpur comprises 15 to 20 villages, which vary in size.

Randomization at the union level reduces but does not eliminate the risk of control-group contamination, as there are many circumstances in which a subset of or all commercial operations of an LSP may transcend union boundaries. Our randomization procedure therefore built in geographical buffers between unions allocated to the three trial arms, as discussed in more detail below.

For the randomization, our sampling frame was 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 control (C), LSP model (T1), and hybrid model (T2) treatment arms.

To reduce the risk of situations in which LSPs located near a union boundary 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 1.

Table 1: Number of unions selected for treatment and control arms

	Total unions randomized	Total unions selected
C- No WorldFish project	90	59
T1- LSP model	90	57
T2- Hybrid model	90	61

[4] With COVID-19 introducing significant uncertainty (resulting in delays and multiple rounds of time-consuming and costly revisions of plans), the quality of the endline data would be affected. We had also come to realize the considerable value added by the LSP survey, the seasonal nutrition survey, and the gender experiments.

[5] There are three administrative tiers below the division level in Bangladesh: district, upazila, and union. Rajshahi division has 8 districts, 67 upazilas, and 564 unions. Rangpur division has 8 districts, 58 upazilas, and 536 unions.

To minimize the likelihood of control group contamination and other spillovers, we dropped contiguous unions if one had been assigned to control and others assigned either to the LSP or the hybrid model. 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.
3. The last step was to select T1 unions with short boundaries with control unions.

We next selected the control unions:

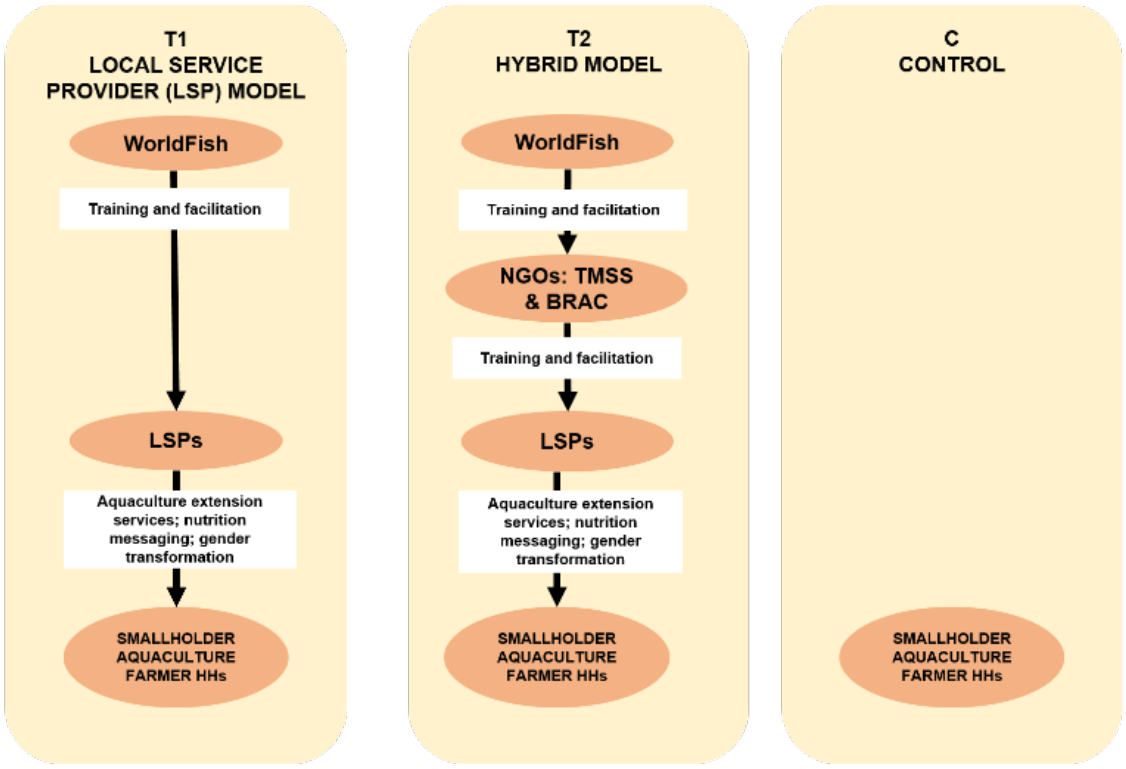
1. We first selected isolated control unions which were either truly isolated or that shared a boundary with another control (or a non-selected T1).
2. We then marked all controls sharing boundaries with T2, giving preference to those with short boundaries.
3. We finally selected controls sharing short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

We finally selected the T2s:

1. All T2s sharing boundaries with non-selected controls and with T1.
2. The rest were chosen randomly.

Figure 2 shows the trial design distinguishing between the two treatment arms that comprise the LSP delivery model (T1) and the hybrid model (T2).

Figure 2: The three-armed trial



Note: HH = household.

While rich food security and nutrition data were collected in the household panel data survey, a separate and smaller sample nutrition survey was implemented to gain a better understanding of seasonal variation. This survey was initially intended to cover the six main seasons in Bangladesh: summer, monsoon, autumn, late autumn, winter, and spring (Table 2). However, due to political unrest in the region, the sixth round could not be completed; therefore, only five rounds of data are presented in this report. Surveys

were conducted telephonically to reduce travel costs, enabling a random subsample that did not require adjustments for geographical or logistical constraints.

Table 2: Seasons in Bangladesh[6]

Months	Six seasons	Three seasons
15 April – 14 May	Summer	Pre-monsoon hot
15 May – 14 June		Rainy monsoon
15 June – 14 July	Monsoon	
15 July – 14 August		
15 August – 14 September	Autumn	
15 September – 14 October		
15 October – 14 November	Late autumn	Cool dry winter
15 November – 14 December		
15 December – 14 January	Winter	
15 January – 14 February		
15 February – 14 March	Spring	
15 March – 14 April		Pre-monsoon hot

3.2 Data

A typical aquaculture season in Bangladesh begins in April and ends in March the following year.[7] The study uses two rounds of survey data collected from February to April 2021 (baseline) and June to September 2023 (endline).[8] COVID-19 postponed the original baseline, with a new time window falling between the start of the project and the start of the baseline data collection (February 2021), with a genuine risk of project-induced changes distorting baseline values.

To avoid this issue, we employed a longer-than-usual recall period, using April 2019–March 2020 as the reference aquaculture season. As the last “normal” aquaculture season prior to the full onset of the COVID-19 pandemic, this is consistent with findings of recall as more reliable when referring to events or circumstances that are salient or unusual. This ensured that we were able to capture information for two complete aquaculture seasons: one before project roll-out began, and another after its official end date (Smith and Thomas 2003).

[6] Stevens B, Watt K, Brimbecombe J, Clough A, Judd J, Lindsay D. The role of seasonality on the diet and household food security of pregnant women living in rural Bangladesh: a cross-sectional study. Public Health Nutr. 2017 Jan;20(1):121-129. doi: 10.1017/S136898001600183X. Epub 2016 Aug 30. PMID: 27573667; PMCID: PMC10261298.

[7] Fish are stocked in pre-monsoon months (April–June), grow rapidly during the monsoon (June–September), and are harvested in the dry winter (October–March), avoiding overlap with peak paddy harvests. Common species like rohu, catla, pangas, and tilapia require 6–9 months to reach market size, making seasonal alignment crucial. The aquaculture season avoids overlap with peak paddy harvesting seasons (e.g., Aman in November–December, Boro in April–May), ensuring labor availability and scheduling integrated farming.

[8] For the baseline, the reference period is the aquaculture season of 2019–2020 since aquaculture activities were strongly affected by the 2020 onset and spread of the pandemic.

To select sample villages, the survey team first reached out remotely to union-level government officials (e.g., upazila chairmen, union chairmen/secretaries and Department of Fisheries officials) asking for a list of villages with high pond-density and aquaculture activities in each union. At least two of these villages were then selected at random from each union. To reduce the risk of spillovers,[9] villages located close to the union boundary were not included in the village sampling frame. A total of 551 villages were finally selected for the baseline survey.

Following the WorldFish three-criteria definition of a fish-farming smallholder (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 tons per hectare, OR consume 50 per cent or more of the fish they produce. Of the 12 households selected in each village, we chose: one third from households with less than 1.25 hectares; one third from households with 1.25–2 hectares of land; and one third from households with more than 2 hectares of land but with yields below 4 tons per hectare, or who consume more than 50 per cent of the fish they produce.

A listing exercise was 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. The endline survey was conducted between May and July 2023—a few months after the program ended. The months of March and April 2023 were avoided for the endline survey due to Ramadan and the resultant differing food consumption patterns. The cohort of households were followed from the baseline. We covered 3,654 households at endline, with an attrition rate of 1.7 percent.

Three types of questionnaires were used to collect data at the village and household levels, including separate questionnaires for women and men (typically the household's core marital unit). The village questionnaire included information on basic village infrastructure, local aquaculture markets, and existing aquaculture support programs. The main household questionnaire included a roster covering demographic characteristics, educational attainment, occupational status, migration experience, group membership, land, pond and other asset ownership, sources of income, and aquaculture-related information.

Since increasing aquaculture productivity was a major objective of the project, care was taken to appropriately measure the extent of male and female knowledge about and involvement in aquaculture, and their expenditure on and income from aquaculture and aquaculture sales. In the women empowerment sections of the questionnaires, which were administered separately to women and men, information was collected on men's and women's roles in household decision-making regarding: aquaculture production, other production and income, awareness of good aquaculture practices, access to assets, mobility, awareness of aquaculture support programs, time allocation in aquaculture, group membership, and self-efficacy.

Sections on household decision-making and access to assets unrelated to aquaculture were adapted from the Project-level Women's Empowerment in Agriculture Index tool,

[9] To minimize the risk of control-group contamination, we introduced "buffer" unions in the sampling strategy. The main concern here was that small LSPs might expand their business operations beyond the union boundaries of their base. In our LSP survey, we collected data on the geographical coverage of LSP business operations.

with additional modules included to solicit detailed information on aquaculture involvement, practices, and decision-making (Malapit et al. 2019).[10] In the nutrition sections of the household survey, which were administered to female respondents, topics included food insecurity, dietary diversity, food-related decision-making, sources of nutrition information, and nutrition-related knowledge and practices.

The five rounds of high-frequency nutrition panel surveys reviewed food consumption questions from the baseline and endline surveys to gain an understanding of seasonal food consumption, with a particular focus on fish and small indigenous species (SIS) intake. Sampling for the nutrition panel surveys is detailed in Appendix D. Indicators of dietary diversity in infant and young child feeding were also included in the survey (FAO and FHI 360 2016; WHO and UNICEF 2021). We leveraged satellite imagery data to measure visible changes in fishponds as a means of examining possible changes in the momentum and pace of the aquaculture sector.

Additionally, two rounds of LSP surveys were conducted in 2021 and 2024 to gather insights into LSP business operations, including: geographical outreach, challenges and constraints (and whether these align with the constraints the IDEA program sought to address), training received, involvement in the organization of groups, and training they provided to local farmers.

The surveys also explored the participation of women in aquaculture, the perceived effectiveness of aquaculture programs, and LSP perceptions of changes in the aquaculture sector and in aquaculture practices and outcomes during the project period (previous three years). The LSP list was acquired from WorldFish and showed that LSP training was primarily concentrated in T1.

We also have two sources of data for studying changes in gender attitudes and gender norms. The first is data from the panel concerning female and male attitudes to women's involvement in aquaculture-related household decision-making, asset ownership, and participation in economic activities. This is supplemented by data from behavioral experiments focusing on gender norms, which, together with a post-experiment survey, covered approximately 900 couples across 50 villages (18 aquaculture-based households per village), chosen randomly from the two treatment and control areas of the impact evaluation.

Households covered within a village included a subset from the baseline–endline panel and an additional fresh set of households new to the study. A listing exercise was conducted to identify additional households involved in aquaculture, from which the required number of non-panel households were selected at random. The detailed listing of the sample size at village level is provided in Appendix B.
In both the panel and the experiments, we use a five-point Likert scale, asking respondents their view about women's or their own participation across different thematic spheres. In the experiments, we followed Krupka and Weber's (2013) coordination game approach for norm elicitation.

[10] The initial plan to cover the full Project-level Women's Empowerment in Agriculture Index modules had to be adjusted due to field protocol and interview time changes necessitated by COVID-19.

3.3 Empirical approach

Our proposed intention-to-treat estimator is given by the following regression equation:

$$Y_i u_1 = \alpha + \beta_1 T1_u + \beta_2 T2_u + Y_i u_0 + \epsilon_u$$

where Y is the outcome variable for household *i* in union u at endline. 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 as control the baseline values of *Yi*. ϵ_u is the residual which we cluster at the union level. The coefficients on T1 and T2 capture the impact of the two individual treatment arms relative to the control.

We first examine the internal validity of our randomization. Table 3 presents baseline balance tests for household characteristics and aquaculture-related characteristics and outcomes across the control and two treatment arms. We see that in most cases, differences between T1, T2, and control are not statistically different, despite mean differences sometimes being large (e.g., fish harvested, fish sold). We also observe that aquaculture productivity, aquaculture income, and aquaculture expenditure are all higher in LSP areas than control areas at baseline.

Table 3: Baseline individual and household characteristics

	Control	LSP	NGO	Diff (LSP-C)	Diff (NGO - C)
Women's characteristics (respondent): Age	38.1	38.3	38.07	0.21	-0.03
	(10.63)	(11.42)	(10.92)	(0.56)	(0.58)
Educational attainment (years of schooling)	9.7	9.37	9.59	-0.34	-0.11
	(4.42)	(4.22)	(4.54)	(0.33)	(0.39)
Men's characteristics (respondent): Age	45.89	46.05	46.01	0.16	0.12
	(12.23)	(12.91)	(12.73)	(0.69)	(0.74)
Educational attainment	10.11	10.27	9.92	0.17	-0.19
	(4.52)	(4.44)	(4.67)	(0.29)	(0.32)
Household characteristics: Household size	4.84	4.81	4.82	-0.03	-0.02
	(1.97)	(1.90)	(2.01)	(0.09)	(0.10)
Muslims	0.95	0.94	0.94	-0.01	-0.01
	(0.21)	(0.24)	(0.23)	(0.02)	(0.02)
Bangali (tribe)	0.99	1	0.99	0.01	0
	(0.09)	(0.06)	(0.08)	-	(0.01)
Fish harvested (kg)	1,454.03	2,005.56	1,821.91	551.53	367.88
	(3,915.17)	(6,834.49)	(5,977.03)	(431.26)	(463.47)
Fish sold (kg)	1,324.37	1,865.91	1,665.20	541.54	340.83
	(3,871.92)	(6,795.97)	(5,871.08)	(427.72)	(449.00)
Fish consumed (kg)	90.14	93.79	85.95	3.66	-4.18
	(64.18)	(69.63)	(64.38)	(4.03)	(3.57)

	Control	LSP	NGO	Diff (LSP-C)	Diff (NGO - C)
SIS productivity (kg/decimal[11])	0.79	0.79	0.78	0.00	0.00
	(1.63)	(1.41)	(1.62)	(0.10)	(0.11)
Non-SIS productivity	10.58	12.91	10.75	2.33*	0.18
(kg/decimal)	(20.39)	(28.64)	(15.92)	(1.36)	(1.18)
Total productivity (kg/decimal)	11.27	13.66	11.52	2.40*	0.26
	(20.87)	(29.77)	(16.24)	(1.42)	(1.20)
Equipment expenditure	121.45	113.22	126.32	-8.23	4.87
per decimal (takas)	(216.59)	(193.00)	(232.37)	(12.09)	(13.04)
Service expenditure	57.55	73.37	59.18	15.82**	1.63
per decimal (takas)	(96.22)	(133.99)	(93.78)	(7.19)	(6.34)
Input expenditure	430.66	590.31	507.13	159.65**	76.47
per decimal (takas)	(744.06)	(1,006.57)	(916.52)	(74.05)	(85.56)
Labor expenditure	68.85	72.70	77.83	3.85	8.98
per decimal (takas)	(171.44)	(156.73)	(169.34)	(9.13)	(9.99)
Total aqua expenditure	678.51	849.59	770.46	171.08**	91.95
per decimal(takas)	(970.50)	(1,196.35)	(1,069.52)	(85.28)	(93.08)
Aqua income	1,139.44	1,519.10	1,205.68	379.66*	66.23
per decimal (takas)	(1659.40)	(2819.47)	(1852.82)	(200.98)	(167.31)
Household income ('000 takas)	567.97	690.84	614.46	122.87	46.49
	(1,013.75)	(1,475.23)	(1,037.63)	(95.76)	(78.37)

*Note: *p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01. Standard deviations in parentheses for first three columns and standard errors clustered at the union level.*

4. Summary statistics

4.1 Aquaculture outcomes

We organize the discussion of summary statistics around the three main categories of outcomes that align with IDEA priorities and the project theory of change: aquaculture productivity and income; women's empowerment; and nutrition.

The theory of change of how aquaculture productivity increases were to be achieved focused on enhanced knowledge, the use of better inputs (e.g., fingerlings and fish feed), and the uptake of WorldFish-recommended (and tailored for the Rajshahi/Rangpur context) aquaculture best practices.[12] WorldFish also sought to strengthen linkages and access to both input and output markets, and to make local aquaculture more knowledge-intensive, modern (with regard to input use), market-oriented, and commercial.

We first provide descriptive comparisons in order to document the substantive changes observed between baseline and endline in the control and T1 (LSP) and T2 (NGO) treatment areas covered by the IDEA project.

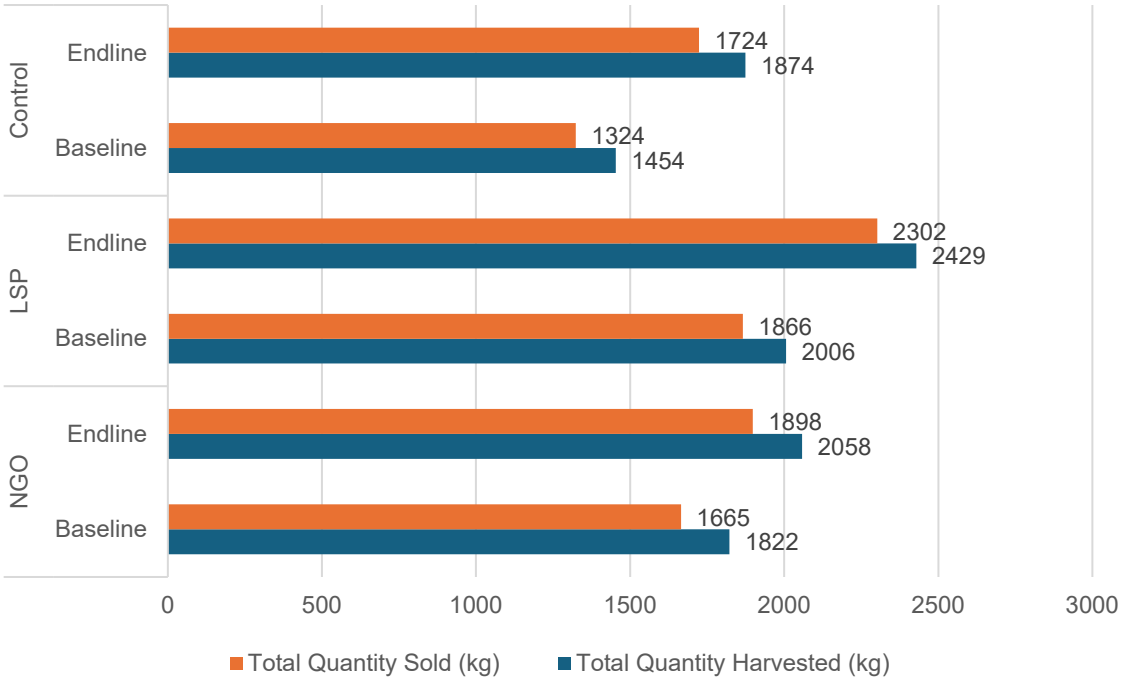
Two key indicators of the commercial shift in aquaculture between baseline and endline

[11] A decimal is 1/100 of an acre, or about 40m^2.

[12] A significant early observation (reported in the baseline report) was that several of the recommended "best practices" were already well-known in the treatment areas (slightly more so among male than among female respondents). After follow-up discussions with WorldFish, more practices were added and included in the endline questionnaire.

are the substantive increases in aquacultural production and sales (Figure 3). Among LSP and NGO area households, total fish production increased by 21.1% and 13%, while fish sales increased by 23.3% and 14%, respectively. Compared to the baseline, this marks a clear uptick in both production and sales. Consistent with prior expectations, we also observe a more substantial increase in LSP areas than in NGO areas. However, even more pronounced gains were seen in control areas, where production rose by 29% and sales by 30%.

Figure 3: Changes in production and sales in control and treatment arms (kgs)



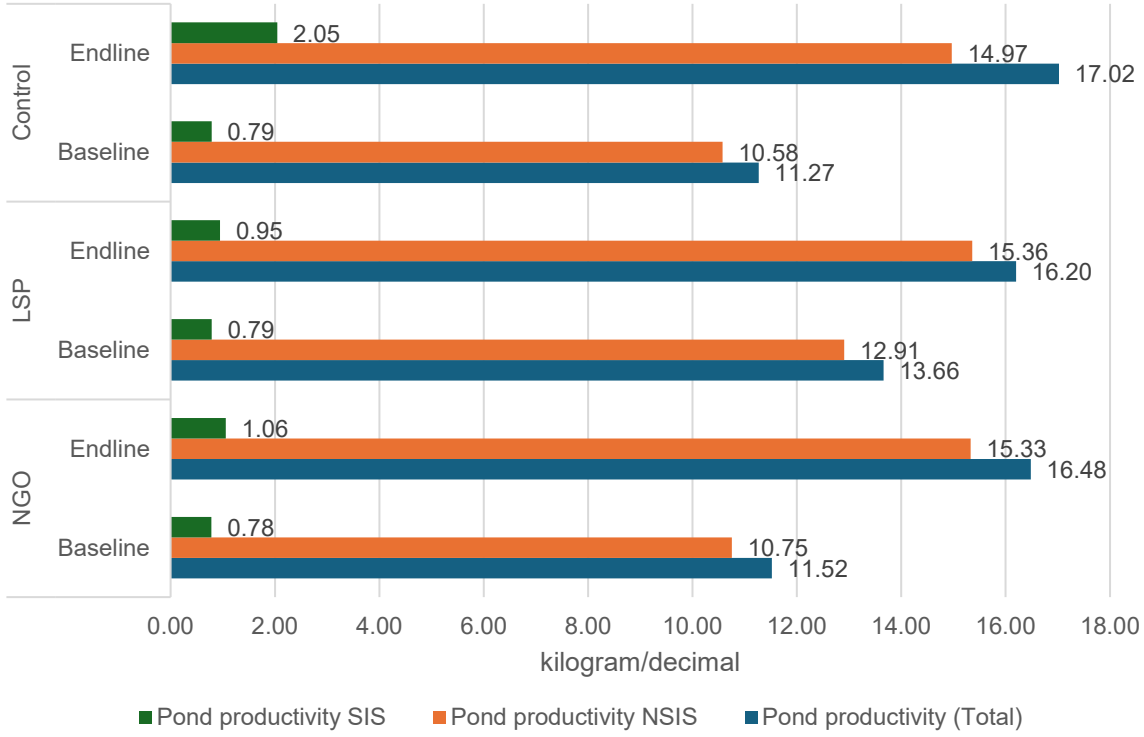
A possible explanation for these production and sales increases could be the expansion in smallholder pond areas used for fish cultivation. While we do observe average increases in smallholder pond areas under cultivation (Appendix C, Figure 26), these are too small to account for the gains in production and sales. What we do observe, and what helps to explain these changes, are notable increases in aquaculture productivity, as shown in Figure 4.

Our qualitative findings provide other insights into the increasing commercialization of aquaculture. The availability of cars with water storage capacity has significantly increased the ease of transporting live fish which, in turn, increased market access. We found that this has become the preferred and most common way of selling fish.

4.2 Changes in productivity

In LSP and NGO areas, we observe overall pond productivity increases of 18.6 percent (from higher baseline levels) and 43 percent, respectively. While there were productivity gaps between LSP and NGO areas at baseline, these narrowed and effectively disappeared by endline. Seen in isolation and over the period in question, these are dramatic aquaculture productivity improvements. As for production and sales, these improvements have not been restricted to treatment areas: in the control areas, the corresponding increase was 51 percent.

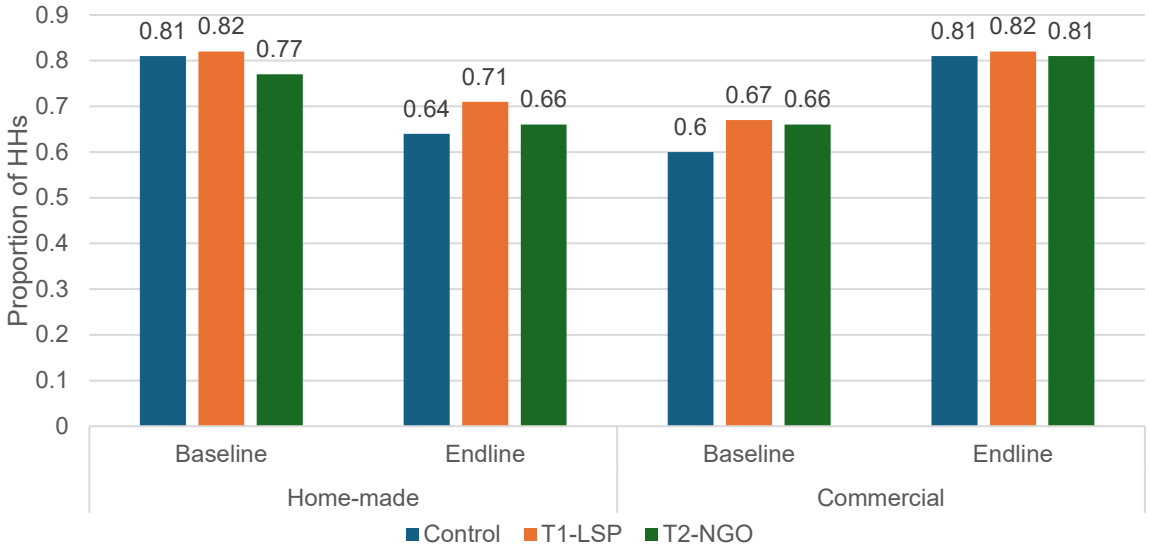
Figure 4: Pond productivity changes (kg per decimal)



4.3 Changes in input use and practices

We next consider changes in input use, comparing baseline and endline data and starting with fish feed—a key IDEA project recommendation was a shift towards more commercial feed use. Figure 5 shows a notable increase in the share of LSP- and NGO-area households using commercial fish feed along with a decline in the share using home-made fish feed. We observe similar changes in the control areas, with a decline in the share of households using home-made fish feed and an increase in the share of households using commercial fish feed.

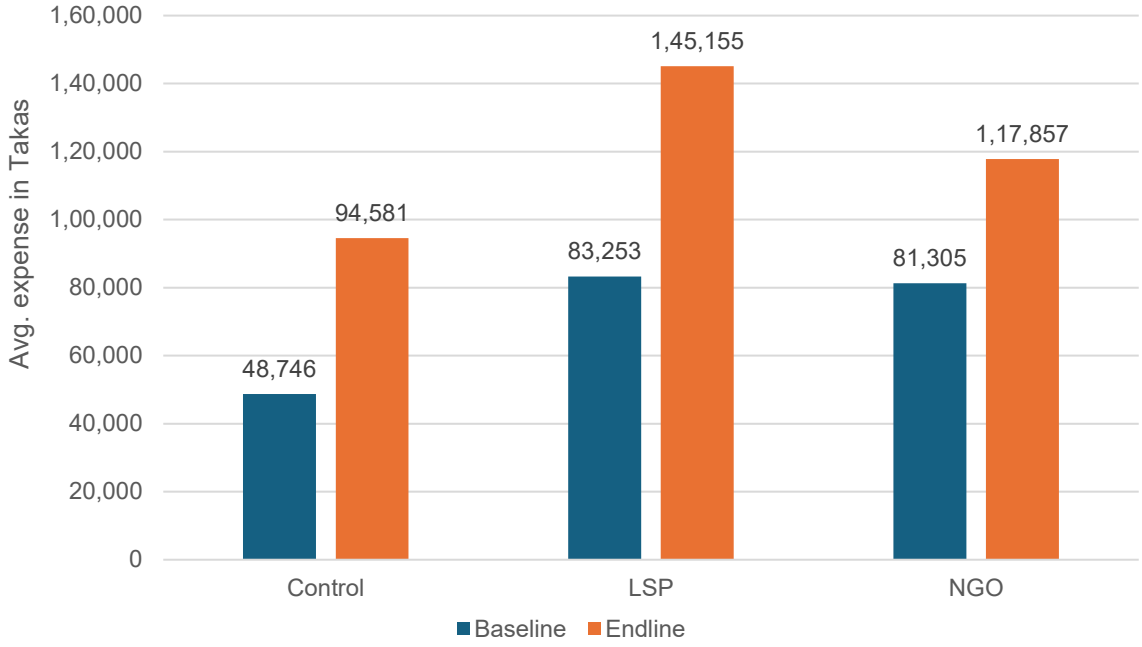
Figure 5: Changes in shares of households using home-made and commercial feed



For both LSP (T1) and NGO (T2) area households, we observe declines and increases of 11 and 15 percentage points, respectively. For control area households, the magnitude is even bigger, with a decline of 17 percentage points for home-made fish feed and an increase of 21 percentage points for commercial fish feed. Next, and in Figure 6, we report on the changes, in real (inflation-adjusted) terms, in expenditures on commercial feed and fertilizer.

While real expenses at baseline were at a similar average level for LSP and NGO areas, Figure 6 shows notable increases in LSP, NGO, and control area households. In control areas, the increase is significantly more pronounced at 94%, with 74.3% in the LSP area and a corresponding NGO area increase of 44.9%. We observe similar inflation-adjusted increases among LSP- and NGO-area households for expenses on aquaculture-related capital and other investments (see Figure 27 in Appendix C).

Figure 6: Changes in real expenditures on fertilizer and commercial fish-feed



4.4 Changes in fish portfolio composition

A key objective of the IDEA project was to promote fish portfolios that included the production of SIS, due to their rich nutritional content, which could improve feeding and nutritional outcomes for young children. An important assumption in the project's theory of change was that combined production was technically feasible and commercially attractive. However, when comparing baseline and endline portfolios, it is evident that the diversity of fish portfolios declined slightly, and most notably for SIS varieties (Figure 7). In Figure 8, we observe a notable shift away from SIS cultivation and towards larger varieties, including different carp species, tilapia and, to a lesser extent, pangas. Qualitative interviews gathered during field visits suggest that better prices of non-SIS varieties compared to SIS varieties could be a contributing factor.

Figure 7: Fish portfolio diversity changes

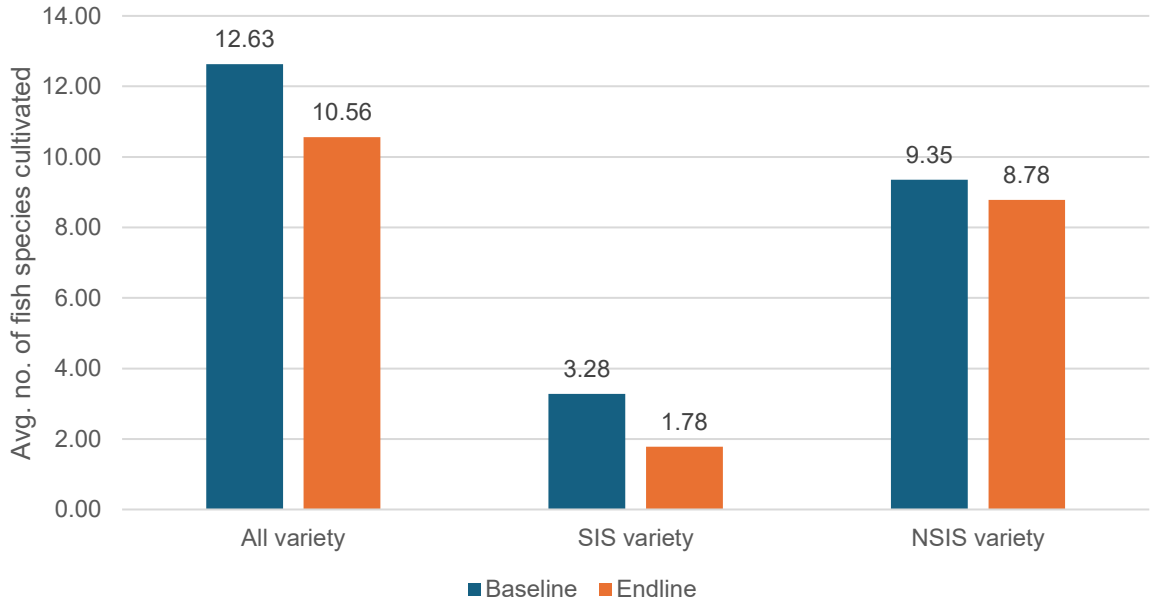
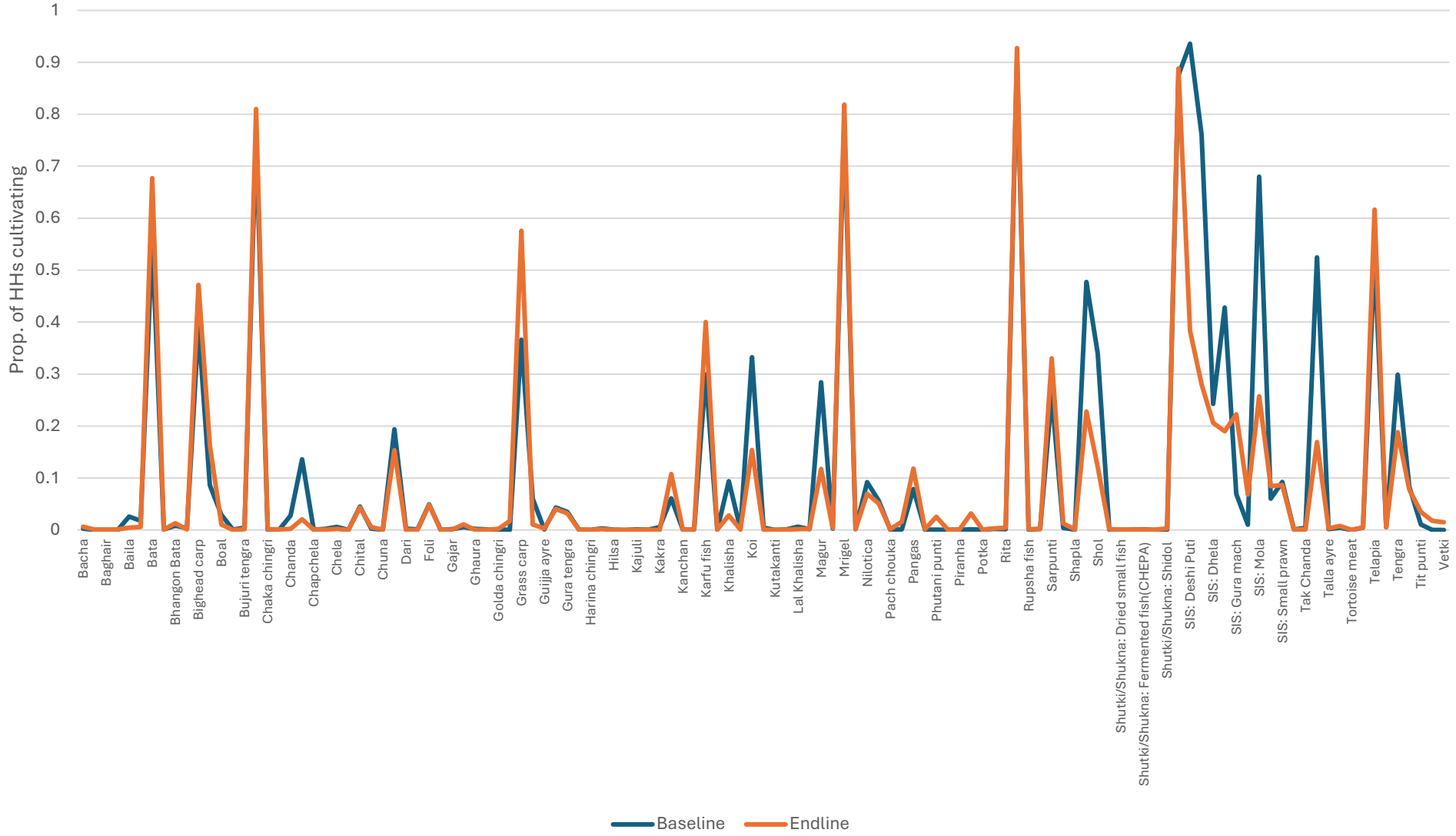


Figure 8: Fish portfolio changes



In summary, we observe dramatic changes in aquaculture in the LSP and NGO areas during the project period. In isolation, simple before-and-after comparisons suggest considerable IDEA project impacts on aquaculture production and sales, practices, fish portfolio priorities and productivity, indicating a shift towards more commercialized aquaculture.

However, in a well-known and much-cited case study of a World Bank-funded nutrition initiative in Bangladesh, White (2007)[13] highlights a before-and-after comparison wherein all the main outcomes of interest appeared to be moving in the right direction. This impression of success and progress changed once a credible counterfactual, using propensity score matching, was introduced. Our case is an RCT with a credible control area counterfactual: crucially, here, we observe similar secular trends across both treatment and control areas (Figures 3–6).

5. Empirical results: aquaculture impact estimates

Looking at fish productivity and sales in Table 4, the coefficients on LSP and NGO are negative and statistically insignificant, suggesting no impact of either of the two models of IDEA project delivery. The findings on productivity are similar. Against the backdrop of the descriptive statistics in Figures 3–6, it is not surprising that neither of the two models led to higher total or aquaculture income compared to the control group.

Table 4: Impact on productivity and income

	Productivity SIS (1)	Productivity non-SIS (2)	Productivity total (3)	Quantity sold (4)	Aquaculture income (5)	Household income (6)
LSP	-1.092	0.148	-1.354	-0.213	142.5	28,404
	(1.13)	(1.05)	(1.58)	(1.07)	(188.22)	(55,017.00)
NGO	-0.987	0.364	-0.527	0.054	-34.79	-4,424
	(1.13)	(1.32)	(1.78)	(1.35)	(191.86)	(61,786.00)
Baseline	0.240***	0.111*	0.129*	0.127	0.292***	0.449***
	(0.06)	(0.06)	(0.08)	(0.08)	(0.07)	(0.08)
Constant	1.856	13.788***	15.592***	11.080***	1,811.53***	375,935***
	(1.12)	(0.86)	(1.53)	(0.96)	(120.99)	(56,420.00)
N	3,229	3,437	3,204	3,203	3,423	3,654

Note: This table presents the impacts on the productivity of SIS varieties, non-SIS varieties, total productivity, quantity sold, income from aquaculture, and household income. Standard errors in parentheses clustered at the union level. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Overall, and as noted in Section 4, we find that the IDEA project was operating in the context of rapid productivity gains and commercialization of aquaculture. Sharp increases in production, sales, productivity, use of inputs, and incomes are observed between baseline and endline across all three arms (Table 23 in Appendix C). The incremental impact of the LSP and NGO models of delivery compared to the control is limited to expenses on aquaculture inputs (Table 5).

[13] White, H., & Masset, E. (2007). "Assessing interventions to improve child nutrition: a theory-based impact evaluation of the Bangladesh Integrated Nutrition Project." *Journal of International Development*, 19(5), 627-652.

Table 5: Impact on different expenditure categories

	Regular equipments expenditure (1)	Capital equipments expenditure (2)	Total equipments expenditure (3)	Input expenditure (4)	Service expenditure (5)	Labor expenditure (6)	Total aqua expenditure (7)
LSP	-0.05	-0.064	0.018	0.197*	0.240*	-0.072	0.141*
	(0.09)	(0.11)	(0.09)	(0.08)	(0.11)	(0.09)	(0.07)
NGO	-0.057	-0.272**	-0.139	-0.039	-0.019	0.132	-0.062
	(0.09)	(0.10)	(0.08)	(0.08)	(0.13)	(0.09)	(0.07)
Baseline	0.167***	0.234***	0.196***	0.404***	0.275***	0.257***	0.368***
	(0.02)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)
Constant	3.229***	3.289***	3.740***	3.658***	2.689***	3.010***	4.187***
	(0.09)	(0.13)	(0.11)	(0.15)	(0.15)	(0.12)	(0.15)
N	2,587	1,930	2,994	3,332	1,551	1,733	3,420

Note: This table presents the impacts on different kinds of expenditure, such as regular equipment, capital equipment, total equipment, inputs, services, labor costs, and total expenditure incurred on aquaculture. Standard errors in parentheses clustered at the union level. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Put differently, the growth in outcomes in IDEA project areas is not different from non-project (control) areas. This lack of project impact suggests that WorldFish and other observers underestimated the momentum and pace of development of the aquaculture sector in Rajshahi and Rangpur. From the vast literature on development, there are few, if any, accounts about the possible pitfalls of seeking to implement development interventions in a dynamic rural economy, where the challenge becomes one of outdoing the market.

In such a context, any development assistance that attempts to add value and make a difference must be cutting edge, and thus on the knowledge or technology frontier. This is dramatically different from the requirements in the more static rural settings where development interventions are usually implemented. At the same time, other factors may have contributed to this absence of program impact. We next consider three such factors, namely: (1) the underestimation of local knowledge at baseline; (2) the disruption and scale-down of implementation caused by the COVID-19 pandemic; (3) the LSP point; and (4) crowding out of other support programs in treatment areas. We consider each of these in turn, below.

5.1 Mechanisms and explanations for the lack of impact

5.1.1 Underestimation of local knowledge at baseline

Assumptions about baseline local knowledge and familiarity with WorldFish's aquaculture best practices recommendations turned out to be inaccurate. At baseline, while most female and male respondents were familiar with the seven main recommended practices (and many had already implemented them), those who didn't typically had good explanations for this. These baseline values, for women and men, are shown in Tables 6 and 7. Although we observe some improvements in knowledge for some practices, these changes are generally marginal and unlikely to have contributed significantly to productivity improvements.

Table 6: Knowledge among men about best aquaculture practices

	Baseline		Endline		Difference	
Practice	Mean	(sd)	Mean	(sd)	Difference of Means	(se)
Construction of pond dikes	0.97	(0.17)	0.98	(0.14)	0.01*	(0.00)
Black soil removal	0.83	(0.38)	0.90	(0.29)	0.08***	(0.01)
Pre-stocking liming	0.98	(0.15)	0.96	(0.20)	-0.02***	(0.00)
Quality fish feed	0.86	(0.35)	0.88	(0.32)	0.02***	(0.01)
Home-made feed	0.88	(0.32)	0.93	(0.26)	0.05***	(0.01)
Commercial feed	0.92	(0.27)	0.96	(0.19)	0.04***	(0.01)
Nutrition rich SIS varieties	0.87	(0.33)	0.84	(0.37)	-0.04***	(0.01)
Observations	3,716		3,608			

Note: This table shows the proportion of men aware of key aquaculture practices at baseline and endline and the mean differences between the two. Standard deviations (sd) and standard errors (se) are reported separately. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Table 7:Knowledge among women about best aquaculture practices

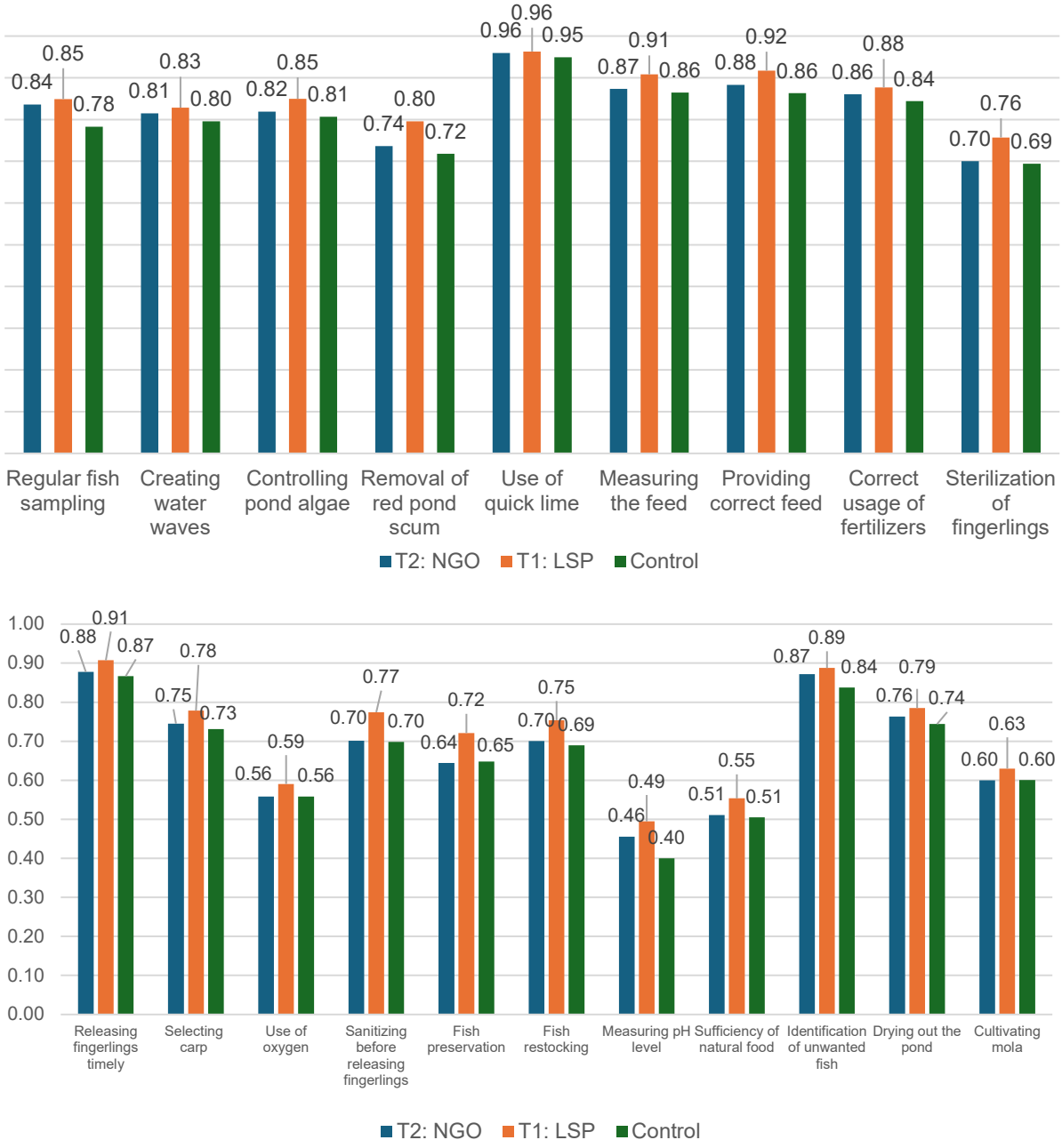
	Baseline		Endline		Difference	
Practice	Mean	(sd)	Mean	(sd)	Difference of Means	(se)
Construction of pond dikes	0.89	(0.32)	0.81	(0.39)	-0.08***	(0.01)
Black soil removal	0.72	(0.45)	0.75	(0.43)	0.03***	(0.01)
Pre-stocking liming	0.94	(0.25)	0.83	(0.38)	-0.11***	(0.01)
Quality fish feed	0.65	(0.48)	0.70	(0.46)	0.05***	(0.01)
Home-made feed	0.80	(0.4)	0.82	(0.38)	0.02**	(0.01)
Commercial feed	0.84	(0.37)	0.80	(0.4)	-0.04***	(0.01)
Nutrition rich SIS varieties	0.76	(0.43)	0.72	(0.45)	-0.04***	(0.01)
Observations	3,500		3,542			

Note: This table shows the proportion of women who were aware of key aquaculture practices at baseline and endline and the mean differences between the two. Standard deviations (sd) and standard errors (se) are in parentheses. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

When further disaggregating and bringing in a set of additional practices promoted by WorldFish recorded only at endline, Figure 9 shows that this knowledge is almost always more pronounced among LSP area households—while for most topics, the knowledge of control and T2 groups is similar. The difference between LSP and control is also often statistically significant, but the overall difference sizes are small.

Overall, knowledge of general pond management is strong, while knowledge of fish health and pond ecosystem management practices (e.g., oxygen use, measuring pH levels, sufficiency of natural feeds) is more limited. Knowledge around cultivating SIS varieties also remains low across all groups. The uptake of new practices at endline, promoted by WorldFish, is illustrated in Figure 9; uptake is higher in LSP areas, but this is not statistically significant.

Figure 9: Additional recommended best practices introduced by WorldFish



5.1.2 The disruption and scale-down of implementation caused by the COVID-19 pandemic

Are there other possible explanations for the limited impact of the IDEA project? To answer this question, we examine the project's implementation. While the project design included a number of components, there were deviations. The WorldFish implementation report details how the IDEA project was expected to employ a market-systems approach to promote gender- and nutrition-sensitive aquaculture among over 469,000 smallholder households. Central to this strategy was the development and training of more than 2,120 LSPs. The project also aimed to foster strong private-sector partnerships—with hatcheries, feed companies, and firms—helping smallholders to access formal value chains, including processing, packaging, and urban markets.

The promotion of improved technologies, such as the genetically improved rohu strain, and training on good aquaculture practices, aimed to raise productivity and profitability. Digital tools, particularly Facebook-based platforms and live sessions, were expected to play a supporting role in facilitating outreach and marketing. Overall, the project targeted a 50 percent increase in productivity and a 17 percent increase in profitability, with more farmers accessing credit and formal markets.

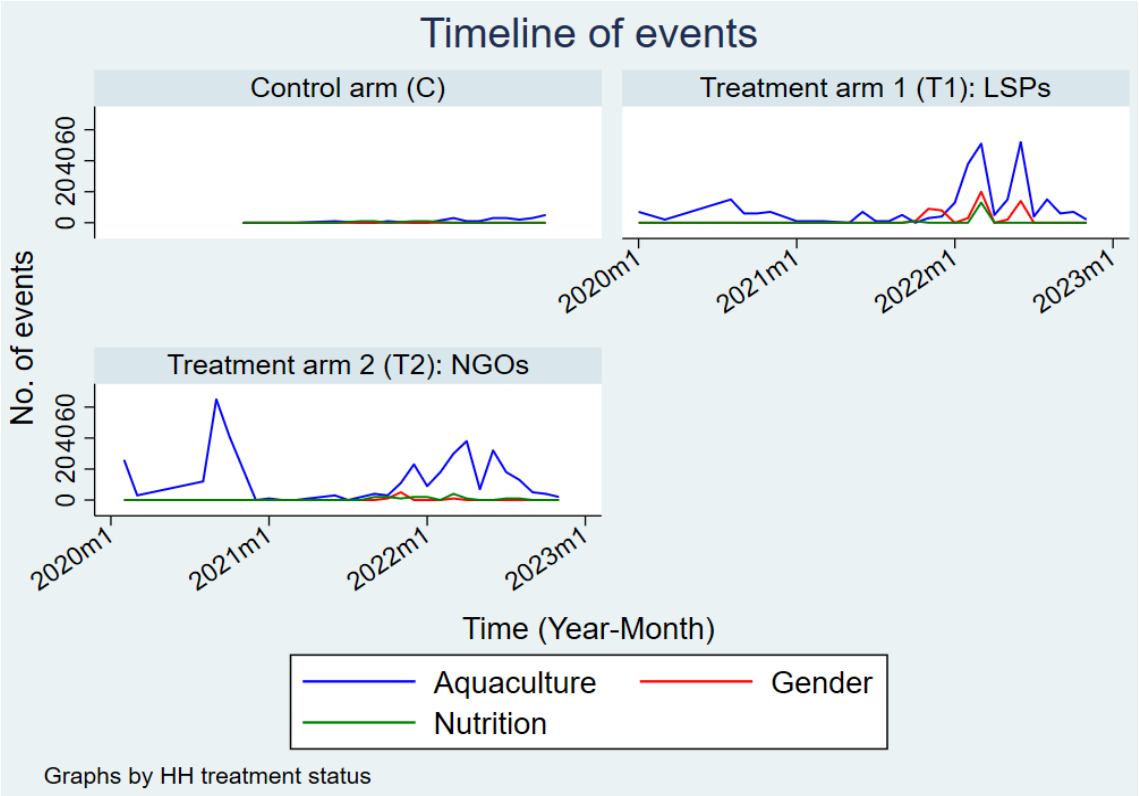
WorldFish had begun implementation of some activities in few treatment unions before the first COVID-19 lockdown. Identification of LSPs and their training activities had commenced by October 2019; however, most group formation and training occurred in 2022 due to pandemic-related disruptions in 2020 and 2021, which delayed capacity-building and field implementation. A total of 1,731 farmer groups (40% men's farmer groups, 3% women-only groups, and 57% mixed groups) were formed under the project. Among these groups, 1,386 (81%) were formed only in 2022. COVID-19 constraints delayed group formation as the selection process required close collaboration between farmers, LSPs, and project employees.

Due to many nationwide lockdowns during COVID-19, farmers' training activities in 2020 and 2021 were postponed. Approximately 69 percent (1,656) of the training sessions were organized in 2022. In addition to pandemic-related delays, the project encountered several other barriers. Low digital literacy and limited smartphone ownership (only 24%) among farmers posed challenges for digital extension strategies. Restrictive gender norms hindered women's participation, prompting the project to deploy tailored social and behavior change communication, such as couple-based business training and community theatre, to foster inclusion.

Operationally, the project also faced a series of internal and implementation-related challenges. One major issue was staff recruitment and turnover. Post contract signing WorldFish took nearly a year to fully staff the team, and NGOs faced similar recruitment delays. High-performing staff were often lost to better-paying roles in a competitive development job market. This issue was particularly acute in the final year of the project, as contract-linked staff began seeking new opportunities. NGOs also faced constraints in scaling activities during the second phase, especially as more integration with their core programs was expected. For instance, during COVID-19, BRAC's involvement in public health response diverted focus away from project-specific tasks.

Private-sector partners were generally supportive but had to adapt by assigning internal staff or hiring consultants to meet ambitious targets. The digital partner, The Right Kind, faced specific challenges as it was brought in mid-project to replace a non-performing firm. With limited field staff and budget, it struggled to provide adequate follow-up, managing only a single household visit to onboard users to the platform—despite the need for repeated engagement to ensure adoption.

Figure 10: Timeline of events



These delays are corroborated by WorldFish's implementation data. While some activities commenced in late 2019, they were not implemented at scale. Project implementation accelerated from late 2021 and continued to the end of 2022. Some aquaculture-related activities and training were conducted in early 2020 in the NGO areas (T2). However, in T1 these were primarily conducted in late 2021 and 2022. Gender-related training did not pick up until late 2021 (Figure 10).[14]

When analyzing the project management information system data, we find that a total of 126 LSPs were trained in the LSP sample area, of which only one was female. In the NGO area, 106 LSPs were trained, including six female LSPs. We also find that the most common type of training was in basic aquaculture, which consisted of informing farmers about aquaculture best practices, but there was not enough training on market linkages and there was even less focus on gender training (Table 8). While some form of nutritional messaging had begun even before COVID-19, IDEA was not the main source of nutrition information reported by respondents.

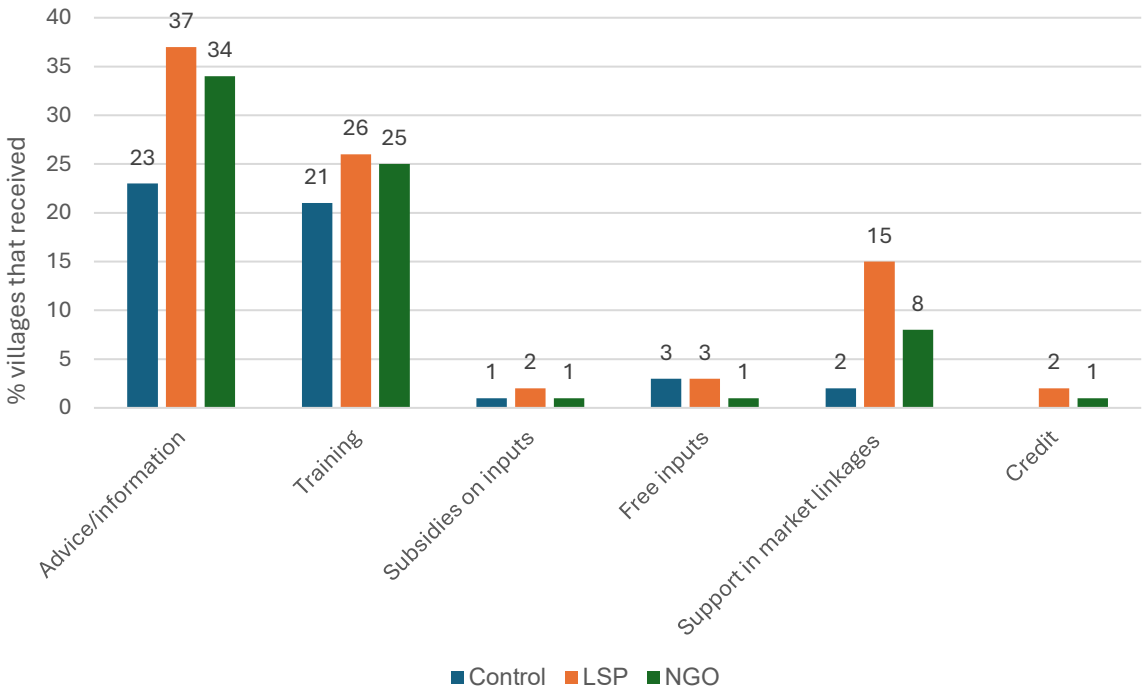
[14] Given that the project's pathway was through knowledge, and primarily through organic diffusion of knowledge through peer-learning, its realization of outcomes and impact were impeded by reduced intensity and a delayed timeframe. Fewer LSPs trained meant fewer personnel for trainings of farmers. This resulted in the delivery of basic trainings and not much beyond this.

Table 8: Number of IDEA events organised by treatment areas

Event	Control	LSP	NGO
Awareness meeting on dike cropping	0	0	3
Awareness meeting on quality seed	0	9	2
Cooking demonstration	0	9	3
Digital technology training	3	26	34
Farmer training (basic)	15	163	187
Farmer training (post-stocking management)	0	22	58
Farmer training (pre-stocking management)	0	25	37
Farmer training (stocking management)	0	18	51
Farmer training (stocking)	0	6	2
Financial literacy training	16	25	21
Fish fair	0	2	0
Forum theatre	0	21	7
Gender training	0	7	0
Linkage meeting	0	13	1
Market actor training	1	6	9
Nutrition training	4	5	10
Training of trainers, LSP	2	4	13
Video show	5	54	7
Workshop/seminar	0	0	1

Our village-level survey data shows the support provided to villages, as depicted in Figure 11.

Figure 11: Villages receiving support from aquaculture programs (endline village survey)



5.1.3 The project scale and quality were not as per expectations

We provide supportive evidence that LSPs were unable to deliver at the scale the project had envisioned. The LSP survey was conducted via telephone amongst a sample of 101 LSPs from September to October 2024, with an initial response rate of approximately 60 percent. Unreachable LSPs were then interviewed in person. The LSP survey provides interesting insights into the scale and quality of project implementation, as well as the changing aquaculture landscape in Bangladesh.

LSPs reported a high rate of participation in aquaculture-related training, with 70.3% having attended at least one such session since July 2021. In total, 64.8% of LSPs reported receiving training from WorldFish, though, this was not the only training received during that period: 53.5% of these LSPs reported receiving training from the Department of Fisheries and 15.5% received training from private companies.

The most frequently cited benefit of these trainings was increased knowledge, reported by 86.1% of LSPs. A smaller share also felt that such trainings contributed to improvements in income from their businesses (41.6%), enhanced social and business networks (28.7%), and income increases specifically from service provision (16.8%).

However, LSPs faced several challenges in expanding their aquaculture-related work, even after receiving training. The most prominent barriers included exposure to unexpected weather events (e.g., floods and droughts) (71.3%), market fluctuations (60.4%), and poor access to credit (47.5%).

Limited technical knowledge (46.5%) and inadequate infrastructure (32.7%) also posed significant hurdles, despite the training initiatives. These challenges suggest that while trainings contributed to knowledge gains, systemic and environmental barriers continued to constrain business expansion.

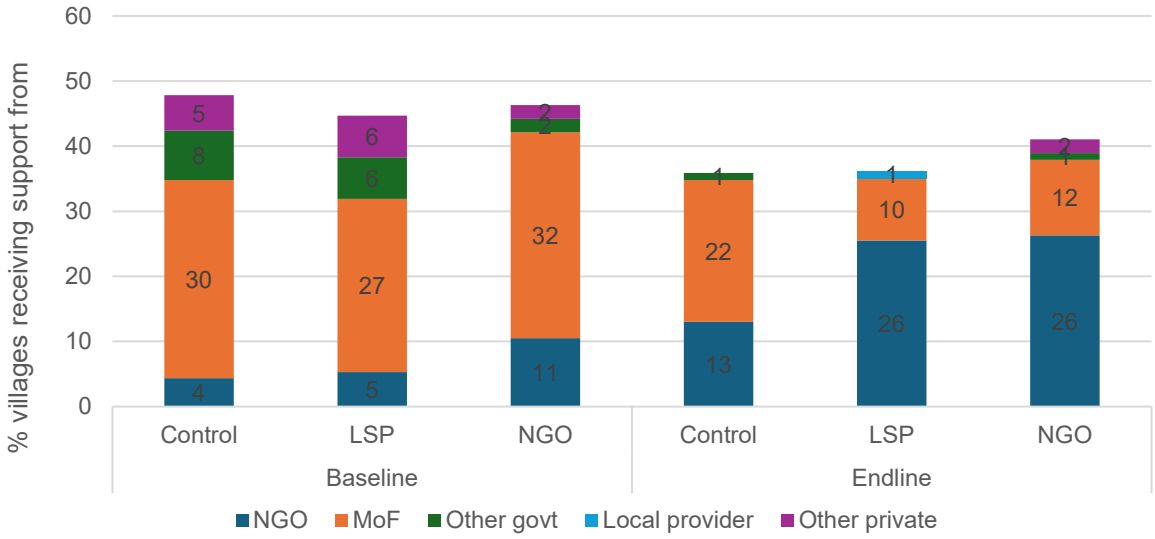
A subset of LSPs saw a direct increase in income as a result of their involvement in trainings or the program, either through business activities (41.6%) or service provision (16.8%). This implies that while trainings were useful for capacity-building, not all LSPs were able to translate the acquired knowledge into financial gains. Additionally, support in the form of credit access or improved market linkages—both essential for translating training into income—was relatively limited, highlighting gaps in the broader support ecosystem surrounding LSP operations.

5.1.4 Crowding out of other support programs in treatment areas

Another possibility, which has also received limited attention in the impact evaluation literature, is a crowding-out effect, wherein other development actors adjust in response to the introduction of a new project such as IDEA. When exploring this more carefully, we find some evidence of adjustments.

For a subsample of 281 villages, the village-level data on access to aquaculture programs was collected at baseline and endline. We find that the percentage of villages receiving aquaculture programs from the government at baseline was 38% in control areas and 33% and 34% in LSP and NGO areas, respectively. At endline, the corresponding numbers were 23% in control areas and 10% and 13% in LSP and NGO areas, respectively. The major providers of aquaculture programs, and their distribution across the treatment arms at baseline and endline, are illustrated in Figure 12.

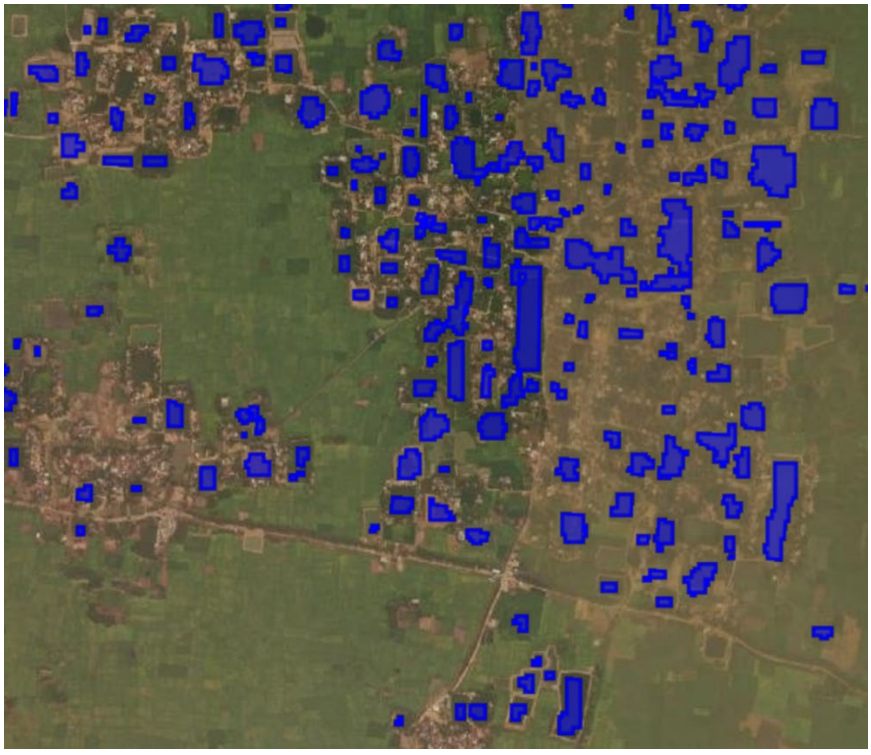
Figure 12: Sources of aquaculture programs and support received by villages



5.1.5 Using satellite imagery to support the survey findings of an increasingly dynamic aquaculture sector

Using a methodology adapted from Yu et al. (2020) and Ferriby et al. (2021), we provide other evidence to support the findings from the survey data analysis of an increasingly dynamic aquaculture sector in the study areas. The method employs imagery from the Sentinel 2A and 2B satellites and indices such as the Normalized Difference Water Index (NDWI), the Modified Normalized Difference Water Index, and the Automated Water Extraction Index to detect water bodies in Bangladesh, filtering by size, and then using a logistic regression on the detected polygon shape features to identify aquaculture ponds. Figure 13 provides examples of machine learning-detected fishponds.

Figure 13: Satellite imagery used to map aquaculture ponds in study areas



We test whether the total area under fishponds, as well as the total number of fishponds, has changed differentially across treatment and control units. In Table 9, we use 153 unions as our unit of analysis. Column 1 estimates the effect of treatment on the total area under fishponds. We find that, conditional on baseline values, there is no detectable change in total area under fishponds in treatment units attributable to IDEA.

Similarly, Column 2 estimates the effect of treatment on the total number of fishponds. We observe no detectable difference in fishpond count in treatment units compared to control. In contrast, we find that the area under fishponds in 2019 is a strong and significant predictor of the area under fishponds in 2023.

Put simply, a 10 percent increase in fishpond area in 2019 is associated with an approximately 8.9 percent increase in 2023. This suggests a secular trend of expansion in fishpond area that predates the intervention. Similarly, the number of fishponds in 2019 is a significant predictor of the number in 2023. On average, each additional fishpond present in 2019 is associated with about 1.25 additional fishponds by 2023.

Table 9: Fishpond area and count regressions

	Log total area under fishponds (2023) (1)	Total fishpond count (2023) (2)
Intercept	1.553***	14.313***
T	(0.542)	(5.487)
Total fishpond count (2019)	0.038	1.366
Log total area under fishponds (2019)	(0.063)	(5.077)
		1.253***
		(0.056)
	0.892***	
	(0.047)	
Observations	153	153
R^2	0.858	0.799
Adjusted R^2	0.856	0.797
Residual Std. Error	0.381 (df = 150)	32.895 (df = 150)
F Statistic	194.949*** (df = 2; 150)	248.772*** (df = 2; 150)
Note: * p < 0.1; ** p < 0.05; *** p < 0.01		

Next, we test whether farmlands have been converted into aquaculture ponds by measuring changes in vegetation and water using satellite imagery. We use the Normalized Difference Vegetation Index (NDVI) to measure green vegetation and the NDWI to measure water content of water bodies. For the NDVI, the value ranges from –1.0 to 1.0, with higher values indicating denser and healthier vegetation.

The NDWI also ranges from −1.0 to 1.0, and values above 0.5 and close to 1.0 indicate areas with high water content or water bodies, while values below zero and closer to −1.0 indicate drought or non-aqueous surfaces. Built-up features and vegetation have small positive values of NDWI. We hypothesize that if there is a shift from farmland to fishponds, there should be a fall in NDVI and an increase in NDWI over time. We test whether this change is differential across treatment and control areas.

In Table 10, we use 19,601 fishponds across all unions as our unit of analysis. Column 1 estimates the effect of treatment on NDVI, and Column 2 estimates the effect of treatment on NDWI. We see that, conditional on baseline values, there is no detectable difference in NDVI and NDWI values between treatment and control. This might lead us to conclude that there has not been a differential change from farmland to fishpond in our study region. However, we then look at NDVI and NDWI to test whether there has been an overall shift over time.

Table 10: NDVI and NDWI regressions

	Mean NDVI (2023)	**Mean NDWI (2023)**
	(1)	**(2)**
Intercept	0.128***	-0.036***
T	(0.006)	(0.004)
Mean NDVI (2019)	-0.003	0.002
Mean NDWI (2019)	(0.005)	(0.005)
	0.274***	0.353***
	(0.017)	(0.017)
Observations	19,601	19,601
R^2	0.197	0.300
Adjusted R^2	0.197	0.300
Residual Std. Error	0.057 (df = 19598)	0.057 (df = 19598)
F Statistic	129.224*** (df = 2;19598)	223.339*** (df = 2;19598)
Note: *p<0.1; **p<0.05; ***p<0.01		

Table 11: Changes in NDVI and NDWI over time in the study region

	Dependent variable: value	
	NDVI	**NDWI**
	(1)	**(2)**
Intercept	0.252***	-0.141***
2021	(0.001)	(0.001)
2023	-0.015***	0.010***
	(0.001)	(0.001)
	-0.057***	0.056***
	(0.001)	(0.001)
Observations	58,803	58,803
R^2	0.065	0.066
Adjusted R^2	0.065	0.066
Residual Std. Error	0.091 (df = 58800)	0.093 (df = 58800)
F Statistic	2684.050*** (df = 2;58800)	2624.268*** (df = 2;58800)
Note: * p < 0.1; ** p < 0.05; *** p < 0.01		

Table 11 shows the change in NDVI and NDWI over time in our study region, with the unit of analysis being a fishpond-year. We see that the average NDVI has been falling, and the average NDWI has been increasing (2019–2023). A NDVI decrease of 0.015–0.057 suggests a 3–6% reduction in greenness, and a 0.01–0.056 increase in NDWI suggests a 5–10% increase in aqueous areas, which can interpreted as fishponds in our

context. This substantiates our hypothesis that there has been a secular shift from agriculture to aquaculture in this region.

5.1.6 Other evidence of study area aquaculture commercialization

Overall, aquaculture in Bangladesh has rapidly transitioned from subsistence-level production to a commercially driven, market-oriented sector. Multiple studies confirm this shift as manifested by the emergence of a dense network of private hatcheries, nurseries, and feed dealers. The use of branded commercial feeds, embedded services by feed companies, and brokered seed distribution illustrates a growing private sector-led input supply chain.

At the national level, aquaculture now contributes over 57 percent of total fish production, with over 1,000 hatcheries, over 200 feed companies, and 133 processing plants—most serving domestic markets and some integrated into export chains, particularly for shrimp and prawn (Larive International and LightCastle Partners 2021; Samanta and Roy 2023). Nearly 99.5 percent of seed production is private-sector controlled, reflecting strong profit orientation (Larive International and LightCastle Partners 2021).

Between 2018–2019 and 2022–2023, pond-based fish production recorded substantial growth in both Rangpur and Rajshahi divisions. In Rangpur, production increased from 177,026 metric tons to 222,494 metric tons, reflecting a 26 percent rise. Similarly, Rajshahi saw production climb from 320,543 metric tons to 408,961 metric tons, representing a 28 percent rise (Yearbook of Fisheries Statistics of Bangladesh, 2018–2019, 2022–2023).

FAO’s aquaculture factsheet (2024) underscores that aquaculture production quadrupled between 2000 and 2021, now supplying 98.9 percent of national fish consumption and contributing over 2 percent of global aquaculture output. This points to a well-commercialized, efficient domestic sector with export potential. The sector's growth is not only supply-driven but also supported by growing domestic demand, with per capita fish consumption doubling between 1999 and 2019 (Cai, Zhou, and Baroi 2024).

Consumer behavior also supports this trend. In Rangpur, the dominant species consumed (rui, pangas, and tilapia) are farmed, not wild-caught, indicating a shift to aquaculture-sourced diets. At the same time, price sensitivity and access remain barriers, particularly for lower-income consumers (Rahman and Islam 2020).

6. Women’s empowerment outcomes

6.1 Women’s empowerment: household aquaculture decision-making and aquaculture-related work and time use

Given the gender transformative aspirations of the IDEA project, we are well placed to evaluate the impacts of an ambitious, but otherwise fairly standard approach on a moderate scale. While the objectives were to enhance women’s participation in aquaculture decision-making within their households, to increase their involvement in different nodes of the aquaculture value chain, and to bolster female entrepreneurship, it is not obvious that a dynamic and rapidly growing sector with substantive productivity gains will deliver the type of demand boost for (female) labor that was observed in the garment sector. In fact, the shift towards greater reliance on commercial inputs and on

improving productivity through more knowledge-intensive aquaculture practices could have the effect of making technical knowledge and more specialized effort a potentially more critical input in aquaculture production.

Further, and as pre-IDEA project research by WorldFish colleagues has demonstrated, a shift towards more commercialization may reduce women's aquaculture involvement (Jahan KM, Belton B, Ali H, Dhar GC and Ara I. 2015). This, we suggest, is more likely to occur if men remain the main recipients of the aquaculture-related training and capacity-building that form a pillar of the IDEA project. As shown in Section 5.1.1, WorldFish's initial best aquaculture practices recommendations (seven in total) underestimated local aquaculture knowledge both among women and men at baseline.

In this section, we first report on IDEA-induced changes in women's involvement in aquaculture decision-making within their households and then turn to IDEA project impacts on women's involvement and time use in various everyday, household-related, and other aquaculture activities.

6.2 Women's involvement in aquaculture-related decision-making within the household

With regard to earlier impact evaluation results, Table 12 reports changes in women's involvement in aquaculture-related decision-making within their households in the LSP and NGO-treatment arms. Such decisions include who should undertake and participate in different aquaculture-related activities (e.g., pond preparation and management, purchase of inputs, harvesting) and matters related to production and sales (e.g., which fish feed to use, which fish varieties to cultivate, where to sell and to whom).

Although their participation in aquaculture-related decision-making has not changed overall, female participants in the NGO arm have increased their input into decision-making related to aquaculture production. Similarly, while there has been a change in women's participation in aquaculture sales-related decision-making, those participating in the LSP arm have shown a weak increase in decision-making input.

Table 12: Changes in women's decision-making capacity

Variables	Aquaculture participation (1)	Aqua prod. participation (2)	Aqua prod. input (3)	Aqua sales participation (4)	Aqua sales input (5)	HH income (6)	Social linkage (7)
LSP	0.235	0.103	0.215	0.146	0.590*	-0.013	0.035
	(0.24)	(0.13)	(0.16)	(0.17)	(0.32)	(0.19)	(0.23)
NGO	0.168	0.061	0.536***	0.033	0.421	-0.172	-0.227
	(0.26)	(0.14)	(0.20)	(0.17)	(0.32)	(0.20)	(0.19)
Baseline	0.147***	0.155***	0.022	0.135***	0.150***	0.224***	0.008
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.08)	(0.03)
Constant	1.663***	0.896***	4.931***	1.032***	4.717***	4.804***	0.969***
	(0.18)	(0.10)	(0.16)	(0.12)	(0.28)	(0.22)	(0.15)
N	3,450	3,450	1,574	3,450	1,673	3,439	3,450

Note: The table shows the participation and input of women in decision making. The dependent variables are proportions of women who are able to participate/give input about aquaculture participation, aquaculture production participation, aquaculture input, aqua sales participation, aqua sales input, household income/production, and social linkage.
Standard errors in parentheses are clustered at the union level.p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Rather than observing a relative increase in women's involvement in these dimensions of aquaculture-related decision-making covered by Women's Empowerment in Agriculture Index-type questions and responses, none of the LSP and NGO arm coefficients covering participation in aquaculture-related decision-making in Table 12 are statistically significant. This signifies that women's participation in the treatment arms did not increase compared to the control group.

6.3 Changes in women's involvement in aquaculture-related activities and time use

We next report descriptive statistics for changes between the baseline and endline in women's time use and involvement in different aquaculture-related activities. Table 13 shows the average number of working days spent on each activity during the relevant aquaculture season at baseline and endline. The average total number of working days in aquaculture among female respondents amounts to 17.51 days at baseline and 18.29 days at endline. The activities for which we observe the most notable changes are fish feed preparation (negative), fish feeding (positive), and pond monitoring (negative).

Table 13: Women's time use in aquaculture: descriptives

	Baseline		Endline		Difference	
Practice	Mean	(sd)	Mean	(sd)	Difference of Means	(se)
Pond preparation	0.31	(1.18)	0.42	(1.64)	0.11***	(0.03)
Purchase of fish feed	0.05	(0.50)	0.19	(2.25)	0.14***	(0.04)
Purchase of fingerlings	0.06	(0.30)	0.08	(0.88)	0.02	(0.02)
Preparation of fish feed	4.27	(10.41)	3.32	(7.47)	-0.95***	(0.22)
Feeding of fish	2.24	(5.52)	4.92	(8.22)	2.68***	(0.17)
Maintenance of pond	0.02	(1.20)	0.27	(1.63)	0.07**	(0.03)
Harvesting of mola or other SIS	0.52	(1.95)	0.27	(1.20)	-0.25***	(0.04)
Harvesting of main fish species	0.52	(2.38)	0.32	(1.28)	-0.20***	(0.05)
Sales of fish to neighbors	0.08	(0.43)	0.21	(0.72)	0.13***	(0.01)
Sales of fish in local markets	0.01	(0.20)	0.07	(0.86)	0.06***	(0.01)
Pond monitoring	9.09	(18.74)	7.78	(14.13)	-1.31***	(0.40)
Other time use	0.16	(1.07)	0.44	(2.67)	0.27***	(0.05)
Observations	3,500		3,541			

Note: This table shows time allocation for female respondents (person days of work). Standard deviations for the means and standard errors for the differences are shown in parentheses. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

When estimating the impacts of the IDEA project on women's involvement in aquaculture activities, with results reported in Table 14, there are two marginally significant coefficients: positive for fish feed preparation in LSP areas and negative for pond maintenance in NGO areas.

Table 14: Impact of IDEA project on time allocation in aquaculture among women

	Pond prep (1)	Feed purchase (2)	Fingerlings purchase (3)	Feed prep (4)	Fish feeding (5)	Pond maintenance (6)
LSP	-0.083	-0.095	0.017	0.966*	0.616	0.048
	(0.09)	(0.10)	(0.02)	(0.46)	(0.63)	(0.11)
NGO	-0.101	-0.102	0.038	0.71	0.74	-0.112*
	(0.10)	(0.11)	(0.03)	(0.74)	(0.71)	(0.06)
Baseline	0.042*	-0.018	0.043	0.103***	0.228***	-0.004
	(0.02)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)
Constant	0.466***	0.256**	0.058***	2.355***	3.950***	0.292***
	(0.08)	(0.09)	(0.01)	(0.26)	(0.37)	(0.04)
N	3,116	3,136	3,131	3,249	3,257	3,315

Note: This table shows the impact of the IDEA project on time allocated to different aquaculture activities for women. Standard errors in parentheses clustered at the union level.p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Table 15: Impact of IDEA project on time allocation in aquaculture among women-continued

	Harvesting SIS varieties (1)	Harvesting main (2)	Sale nearby (3)	Sale market (4)	Pond monitoring (5)	Other time (6)	Total time (7)
LSP	0.042	0.095	-0.015	-0.044	2.091	-0.002	3.475
	(0.07)	(0.08)	(0.05)	(0.06)	(1.20)	(0.15)	(1.94)
NGO	-0.051	-0.001	0.006	0	2.248	-0.099	2.18
	(0.08)	(0.08)	(0.05)	(0.06)	(1.32)	(0.18)	(2.25)
Baseline	0.016*	0.007	0.086*	-0.022**	0.159***	0.035	0.194***
	(0.01)	(0.01)	(0.03)	(0.01)	(0.03)	(0.04)	(0.04)
Constant	0.266***	0.277***	0.233***	0.090*	4.823***	0.480***	12.877***
	(0.05)	(0.05)	(0.03)	(0.05)	(0.72)	(0.09)	(1.26)
N	3,302	3,301	3,325	3,340	3,240	3,327	3,342

Note: This table is the continuation of the previous table, which shows the impact of the IDEA project on time allocated to remaining aquaculture activities like harvesting mola or other SIS varieties, main fish species, sale to neighbors and nearby houses, sale in regional markets, pond monitoring, other time use, and total time for women. Standard errors in parentheses clustered at the union level. p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Table 15 shows women's time allocation for the production and sale of fish. In contrast to the key outcomes reported earlier, where we observed dramatic changes between baseline and endline, the changes for women's involvement in household-related aquaculture activities due to the IDEA project are marginal. The coefficients on T1 and T2 are insignificant, suggesting that there are no changes attributable to the IDEA project.

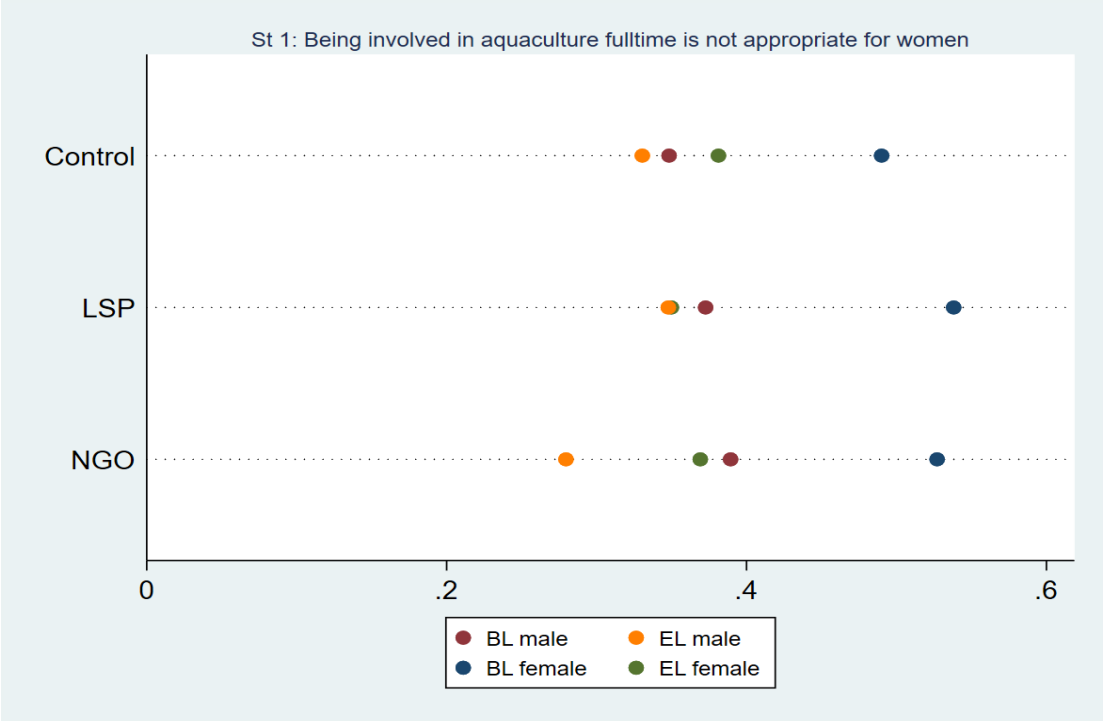
6.4 Gender attitudes amongst men and women

Notwithstanding the minimal change in women's involvement in aquaculture-related activities, we observe rich, dynamic, and quite unexpected changes in male and female attitudes. These observations challenge notions of norm-related attitudinal changes as

slow-moving and women's empowerment as unidirectional and free from contradictions. Below, we report such changes between baseline and endline in male and female respondents' attitudes to women's fulltime work in aquaculture, to women's co-ownership and self-ownership of ponds, and to women selling fish in markets.

We begin with attitudes toward women's fulltime involvement in aquaculture and report on the share of male and female respondents in the two treatment and control arms who have a liberal attitude and disagree or strongly disagree with the statement that "being involved in aquaculture fulltime is not appropriate for women" (Figure 14).

Figure 14: Changes in attitudes toward women's fulltime involvement in aquaculture



Note: BL = baseline; EL = endline.

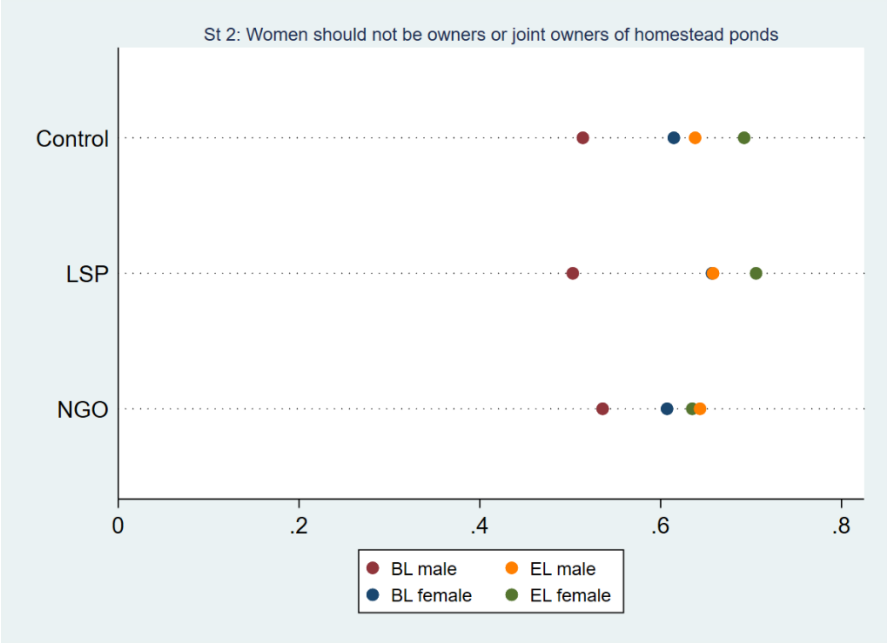
At baseline, close to 50 percent of women in each trial arm report a liberal attitude towards (and thus support for) women's fulltime involvement in aquaculture: notice that male support is in the 35–40% range (Figure 12). Among both women and men, we observe a notable backlash between baseline and endline. The backlash among women is most pronounced in LSP areas, lower in NGO areas, and least pronounced in control areas. Among men (and from a lower initial base) there are also backlashes, but these are marginal in LSP and control areas and more pronounced in NGO areas.

With notable male–female differences, and women being significantly more progressive at baseline, we observe convergence between the two groups: women's attitudes become more similar to the attitudes of men. One possible explanation relates to how commercialization—including in this case a shift towards more technical knowledge-intensive aquaculture production—may push women out and reduce their involvement in aquaculture. Furthermore, if men are the main beneficiaries of aquaculture knowledge upgrading through training, women's skillsets become less fit for purpose, which can generate the type of backlash observed here.

While women's land and other rural asset ownership rights tend to be sensitive and controversial issues, a clear majority of women in all three trial arms have a liberal attitude toward women's joint- or self-ownership of homestead aquaculture ponds. Here, the baseline gender gap in attitudes is more pronounced: men's liberal attitudes represent between 50–54%, which are clear minority positions in each of the three arms. We now observe notable progressive shifts—from a liberal to a solid liberal majority in men's attitudes to women's joint- or self-ownership of homestead ponds across LSP, NGO, and control areas.

Among women, we also observe progressive but less-pronounced shifts, with a strong consolidation of the liberal majority view. Drawing on Deshpande and Kabeer's (2023) analysis of cultural practices that correlate with progressive views, we find that liberal female attitudes to women's joint- and self-ownership of ponds correlate with their level of education but not with much else. Crucially, this otherwise quite surprising finding is even more pronounced in the experimental data.

Figure 15: Changing attitudes toward women's joint- or self-ownership of homestead ponds



Note: BL = baseline; EL = endline.

As above, the order of magnitude of the shifts is quite consistent across LSP, NGO, and treatment areas, and once more there is a notable convergence between the two groups. This time, however, it is men's attitudes that converge towards and become more similar to the attitudes of women.

We next consider attitudes toward responsibility for selling fish in the market. This intersects with and reflects the (strong) social norms regulating women's movements, mobility, and taking up work outside the home in the study areas. Figure 16 illustrates changes in the shares of female and male respondents who disagree or strongly disagree with the statement that men should mainly be responsible for selling fish in the market. Here, liberal views represent a small minority position—on average, 6 percent among women and 2.6 percent among men at baseline.

While progressive shifts are observed among men across the board, and especially in LSP areas (also notably in control areas), we observe small backlashes, also across the board, among women. We observe a slightly higher prevalence of liberal attitudes (still representing small minorities) in the experimental data. Two factors—household agricultural land size and having a migrant household member—correlate negatively with liberal attitudes to this particular form of female work outside the home.

Figure 16: Changing attitudes toward responsibility for selling fish in the market



Note: BL = baseline; EL = endline.

An immediate insight from the simple summaries in Figures 14–16 is the challenges posed to existing notions of norm-related views as static, stable, or slow-moving, and of women's empowerment as a unidirectional, monotonic, and contradiction-free "journey" that unfolds consistently across thematic spheres. What we observe, instead, is a more intricate combination of progress and backlashes with uneven orders of magnitude, where female and male gaps in views may converge or diverge, and where convergence may be towards more liberal or more conservative views. In general, these sometimes rapid changes are unconnected to the gender-related WorldFish interventions, and occur against the backdrop of a highly dynamic and rapidly evolving local aquaculture sector.

7. Nutritional outcomes

This section details the IDEA project's impacts on various areas, including: dietary diversity for both women and men, household fish consumption with an emphasis on SIS, food security among women and men, women's anthropometric measurements, and sources of new nutrition information cited by women and men. We also use data from the nutrition survey to explore seasonal variation in dietary diversity, consumption patterns, and other nutritional outcomes.

7.1 Dietary diversity

Overall, at endline, 77 percent of women and 80 percent of men consumed an adequately diverse diet. For both women and men, the most consumed food groups were starchy staples, meat (mostly fish), vitamin A-rich foods, and other fruits (Figures 17 and 18).

Women in both intervention groups were less likely to have an inadequately diverse diet (defined as fewer than five food groups consumed in the previous day) when controlling for baseline levels (Table 16). Both groups consumed approximately 0.18 more food groups than the control group (LSP: 0.172, NS; NGO: 0.188, $p < 0.1$). However, this increase was not driven by higher consumption of SIS or overall fish intake. Instead, in the LSP group, the dietary changes included increased consumption of meat, dark green leafy vegetables, vitamin A-rich foods, and a decreased likelihood of consuming “other vegetables” (Table 27 in Appendix D).

Women in the NGO group were more likely to consume starchy staples, dairy, and meat, and less likely to consume nuts. The increase in meat consumption in the LSP group primarily came from flesh foods or small animal proteins (not fish), although there was a slight increase in large fish consumption (0.049; $p < 0.1$). The NGO group also had small, non-statistically significant increases in flesh foods/small animal proteins and large fish consumption.

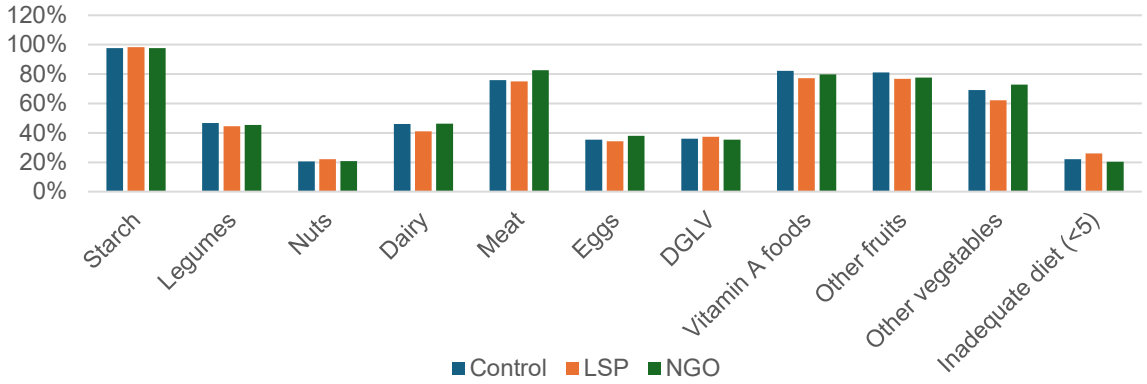
Men's dietary diversity did not vary between the intervention and control groups (Figure 18). The only significant difference observed was that men in the NGO group consumed more dairy and vitamin A-rich foods.

Table 16: Dietary diversity and food group intake among women and men, adjusting for baseline values

	Women				Men			
	LSP		NGO		LSP		NGO	
	Beta coef.	SE	Beta coef.	SE	Beta coef.	SE	Beta coef.	SE
Starch	0.01	(0.01)	0.018**	(0.01)	0.003	(0.01)	-0.002	(0.01)
Legumes	0.013	(0.03)	-0.003	(0.02)	0.013	(0.02)	-0.012	(0.02)
Nuts	-0.006	(0.02)	-0.036**	(0.02)	0.012	(0.02)	0.036*	(0.02)
Dairy	0.015	(0.03)	0.058**	(0.03)	0.046*	(0.03)	0.060***	(0.02)
Meat	0.065***	(0.02)	0.053***	(0.02)	-0.002	(0.02)	0.017	(0.02)
Eggs	0.006	(0.03)	0.034	(0.03)	-0.036	(0.02)	-0.03	(0.02)
DGLV	0.050**	(0.02)	0.008	(0.02)	-0.007	(0.02)	-0.005	(0.02)
Vitamin A foods	0.041*	(0.02)	0.036	(0.02)	0.002	(0.02)	0.044**	(0.02)
Other fruits	0.024	(0.03)	0.035	(0.02)	0.016	(0.02)	0.027	(0.02)
Other vegetables	-0.044**	(0.02)	-0.017	(0.02)	-0.01	(0.03)	0.006	(0.02)
Number of food groups	0.172	(0.12)	0.188*	(0.11)	0.026	(0.08)	0.133	(0.09)
Inadequate diet	-0.048**	(0.02)	-0.050**	(0.02)	0.009	(0.02)	-0.016	(0.02)
N	3,439				3,608			

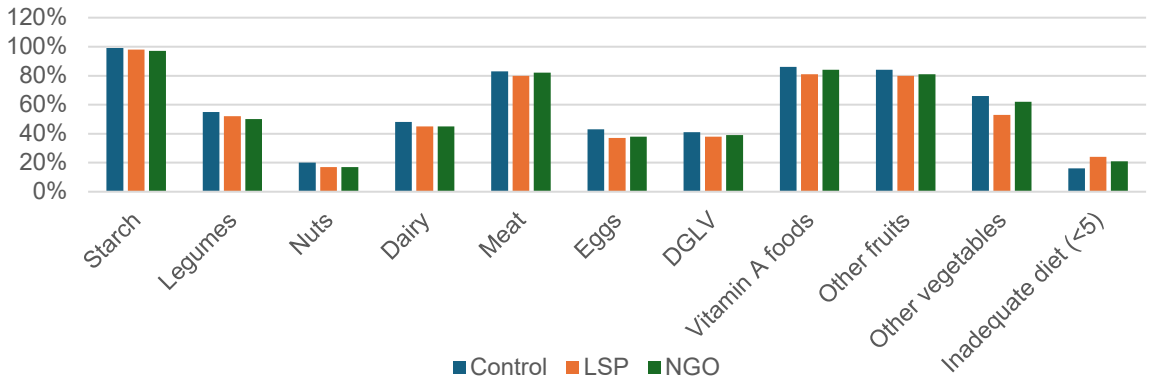
Note: Inadequate diet defined as consuming fewer than 5 of 10 food groups. DGLV = dark, green, leafy vegetables; Other vegetables = vegetables that were not included in the DGLV or vitamin A-rich food categories; Other fruits = fruits that were not included in the vitamin A-rich food category; Inadequate diet = defined as consuming fewer than five food groups in the previous day. * p<0.10, ** p<0.05, *** p<0.010

Figure 17: Women's endline food group consumption and dietary diversity



Note: DGLV = dark, green, leafy vegetables; Other vegetables = vegetables that were not included in the DGLV or vitamin A-rich food categories; Other fruits = fruits that were not included in the vitamin A-rich food category; Inadequate diet = defined as consuming fewer than five food groups in the previous day.

Figure 18: Men's endline food group consumption and dietary diversity



Note: DGLV = dark, green, leafy vegetables; Other vegetables = vegetables that were not included in the DGLV or vitamin A-rich food categories; Other fruits = fruits that were not included in the vitamin A-rich food category; Inadequate diet = defined as consuming fewer than five food groups in the previous day.

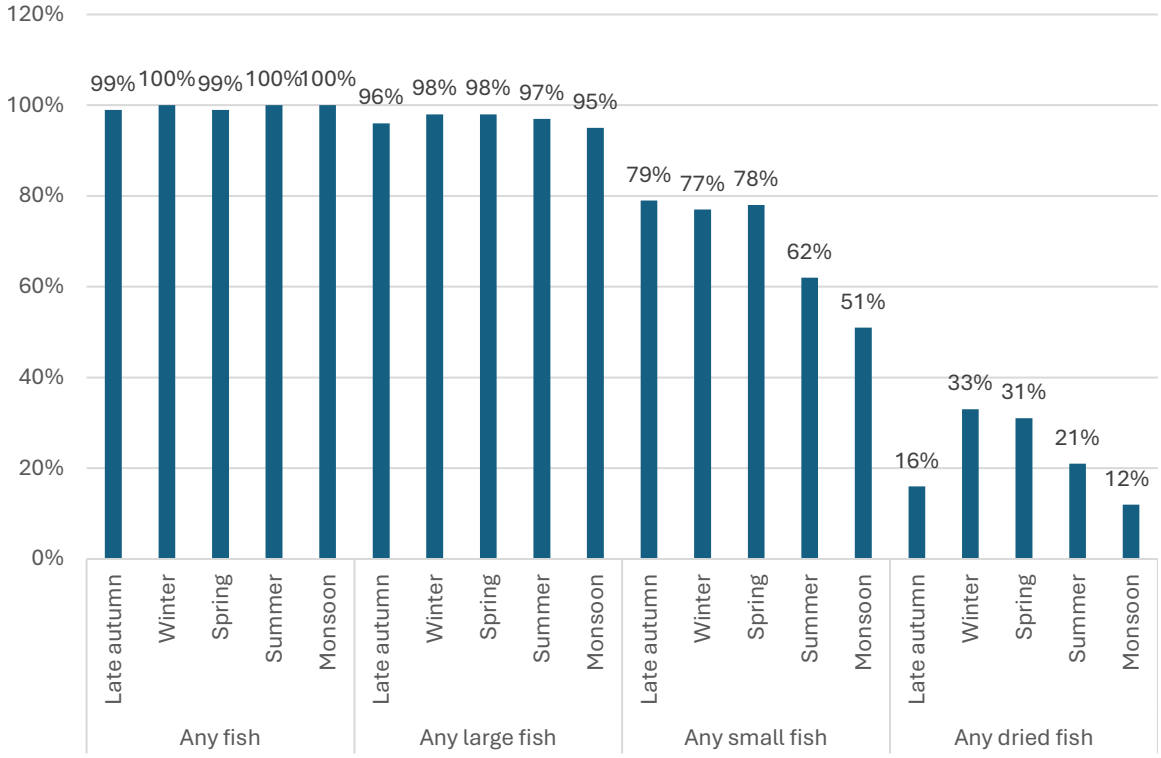
7.2 Fish consumption

As baseline and endline evaluations were conducted in different seasons, qualitative data were first collected to assess seasonal variation in fish consumption and home production. In response to these results, we collected additional data through nutrition survey rounds to understand how seasonality influenced consumption of different types and sources of fish to add context to these indicators.

Focus groups conducted among farmers reported increased consumption of small fish both from home production and purchase from monsoon until late autumn (July–December). For large fish, an increase in consumption from home production was seen during this time and replaced by a rise in large fish consumption by purchase during the other months of the year. This aligned with farmer reports of aquaculture activity timings wherein mid-June through February consisted of feeding, pond management, and rounds of harvesting and restocking (Table 26 in Appendix D). These results led us to conduct further quantitative surveys during the Bangladeshi seasons to further evaluate household fish consumption.

Seasonal nutrition surveys showed that overall fish consumption was very high in this population. All households (99–100%) consumed fish in the previous week (approximately four of the last seven days) over all seasons (Figure 19 and Table 17). For almost all households (95–98%) this included large fish of some kind (on average three days in the previous week). Some seasonal variation was seen in small fish consumption (almost 80% from late autumn to spring and dropping to 50–60% during summer and monsoon season). For dried fish, we see a peak (30%) from winter to spring, with lower values in the rest of the time points measured.

Figure 19: Seasonal fish consumption among households in Rajshahi and Rangpur, Bangladesh[15]



[15] Self-reported fish consumption in the previous week, with small fish defined as species consumed whole, and dried fish defined as consumed dried or fermented.

Table 17: Frequency of fish consumption in the previous week in Rajshahi and Rangpur, Bangladesh

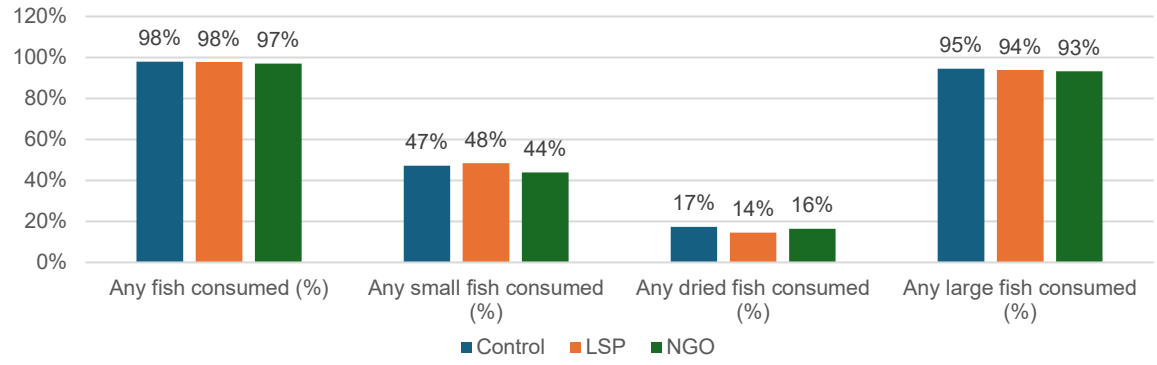
	N	Mean	SD	Min	Max
Days in last week any fish consumed					
Late autumn	409	4.9	1.5	1	7
Winter	398	4.8	1.5	1	7
Spring	398	4.8	1.4	2	7
Summer	401	3.9	1.5	1	7
Monsoon	400	3.1	1.3	1	7
Days in last week any large fish consumed					
Late autumn	399	3.1	1.3	1	7
Winter	392	3.1	1.3	1	7
Spring	394	3.3	1.3	1	7
Summer	389	2.9	1.2	1	7
Monsoon	380	2.4	1.1	1	7
Days in last week any small fish consumed					
Late autumn	328	2.1	1.1	1	7
Winter	306	1.9	0.9	1	7
Spring	313	1.9	0.9	1	7
Summer	249	1.6	0.8	1	6
Monsoon	205	1.5	0.7	1	5
Days in last week any dried fish consumed					
Late autumn	68	1.2	0.4	1	2
Winter	131	1.4	0.6	1	5
Spring	124	1.4	0.7	1	5
Summer	84	1.1	0.4	1	3
Monsoon	50	1.2	0.4	1	2

Mean days in the previous week that fish from each category was eaten among those who consumed the mentioned fish type in the last week.

Comparing endline and baseline data, fish consumption was assessed at the household level for the week preceding the survey. At the endline, nearly all households consumed fish in the previous week (98%), with a particularly high consumption of large fish (94%) (Figure 20). Almost half of the households consumed small fish (47%), and a sixth consumed dried fish (16%). The LSP group was less likely to consume small fish (–0.048; $p < 0.01$) and those that did consume any fish on fewer days (–0.25; $p < 0.01$) as compared to the other two groups (Table 27 in Appendix D).

Examining these relationships with the nutrition data rounds, we found weak evidence that the LSP group was more likely to consume any fish, and in particular large fish (Table 28 in Appendix D). The NGO group was more likely to consume dried fish compared to control households. In terms of seasonality, households were more likely to consume large fish in winter, dried fish in winter and spring, and were less likely to consume small fish in summer and monsoon seasons as compared to late autumn.

Figure 20: Household fish consumption at endline[16]

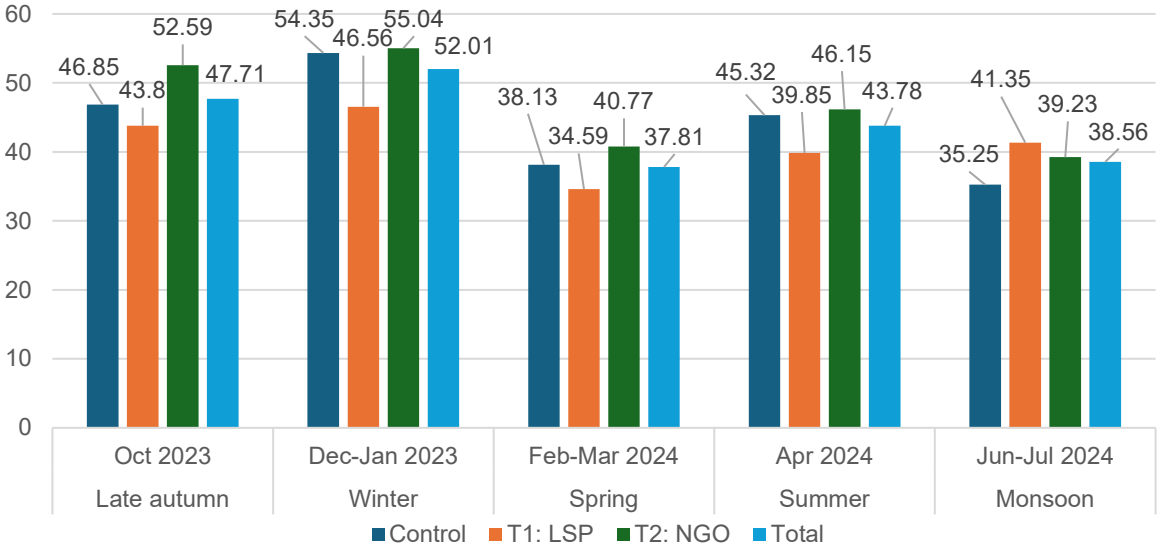


7.3 SIS consumption

To examine SIS consumption, we utilized data from the seasonal nutrition survey rounds, conducted from October 2023 to July 2024. This was due to some data issues which we identified in the endline survey. Specifically, the consumption of SIS was underrepresented due to inadequate probing by the interviewers on sources of fish consumed, across all treatment arms. As the nutrition rounds more consistently represent SIS consumption and consider seasonality, we will use this data for the SIS consumption interpretation. The nutrition survey was conducted on a subsample of approximately 400 households.

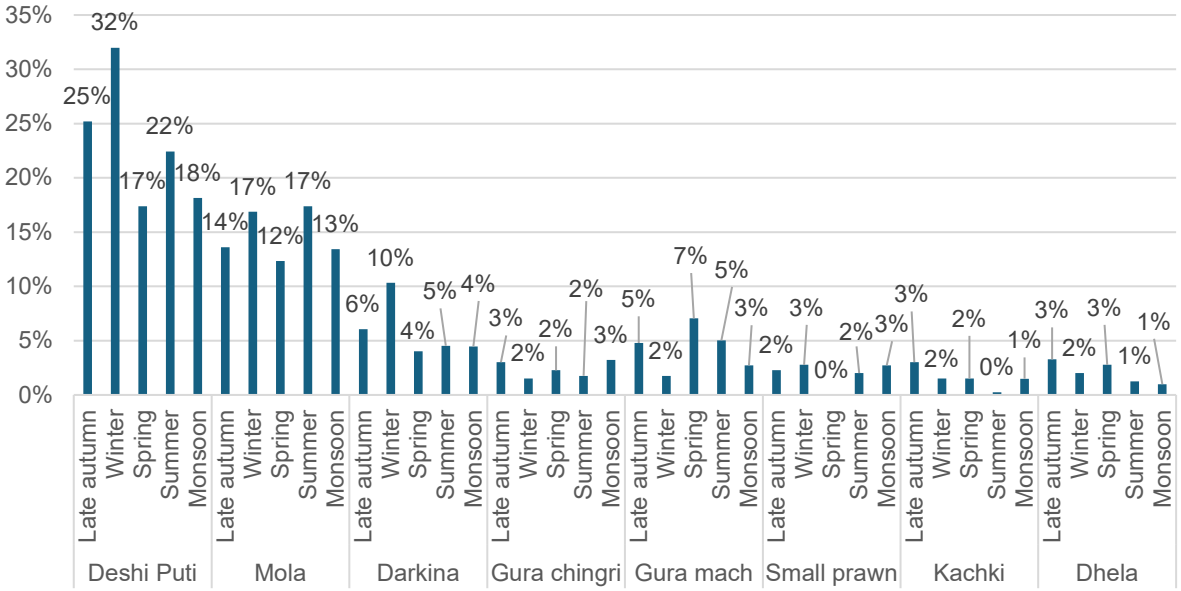
Seasonal data from the nutrition surveys indicate no significant difference between treatment arms at the 0.05 level (Table 28 in Appendix D). SIS were less likely to be consumed in spring and monsoon compared to late autumn (Figure 21, and Table 28 in Appendix D). Individual SIS consumption was also analyzed over the five nutrition survey rounds (Figure 22). Deshi puti and mola were the most consumed SIS, with consumption varying across seasons.

Figure 21: Overall SIS consumption across nutrition survey rounds



[16] Small fish were defined as species that are often consumed whole.

Figure 22: Percentage of households consuming individual small indigenous fish in Rajshahi and Rangpur, Bangladesh



Note: Deshi puti: puntius puntio; mola: amblypharyngodon mola; darkina: esomus danricus; gura chingri: palaemon styliferus; gura mach: corica soborna; small prawn ; kachki: corica soborna; dhela: osteobrama cotio.

7.4 Food security

Overall, food insecurity levels were very low (Figures 23 and 24). At endline, 1% of women and men were classified as having a probability of severe food insecurity; 3% of women and 5% of men had a probability of moderate to severe food insecurity. There were no differences between treatment groups. Men reported being more food insecure than women on most food security indicators, particularly the less severe indicators (e.g., worrying about having enough food [11% versus 6%] and consuming fewer kinds of foods due to lack of money or other resources [11% versus 7%].

Figure 23: Women's food insecurity at endline

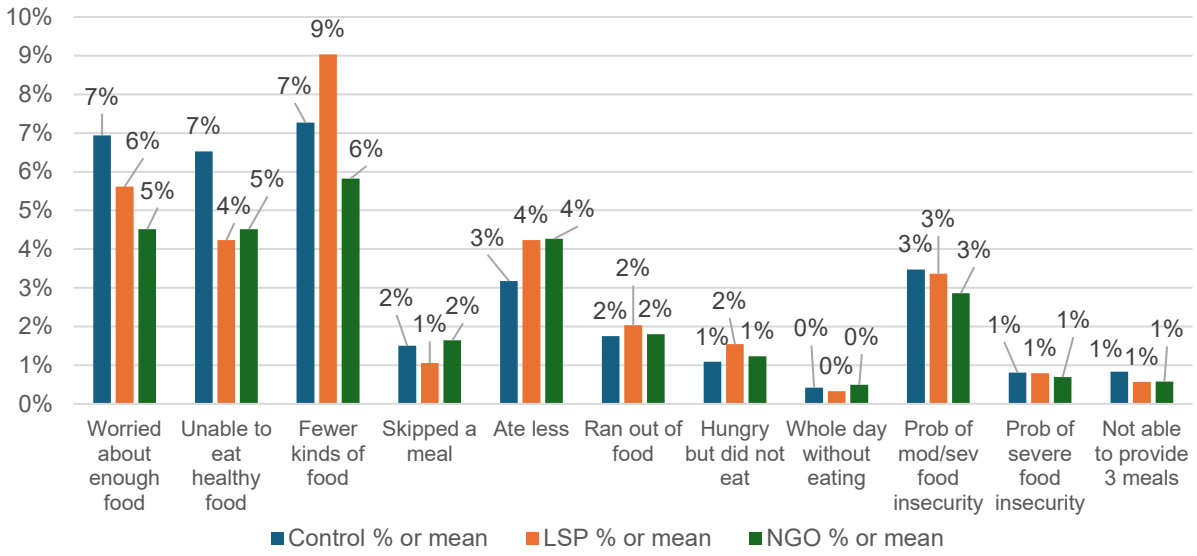
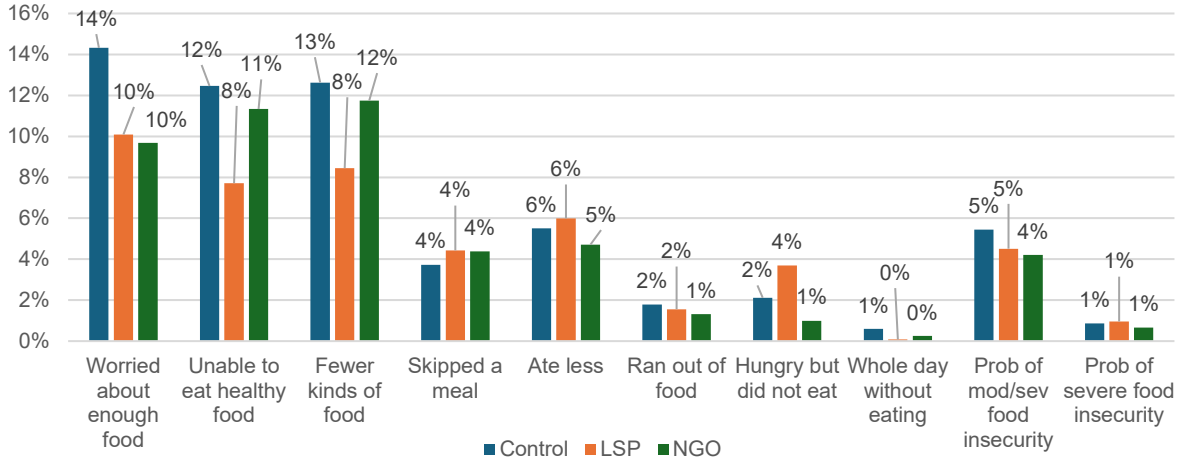


Figure 24: Men's food insecurity at endline



7.5 Women's anthropometry

There were no differences in women's body mass index between treatment groups at endline (Table 18). Overall, around 10 percent of women were underweight and about half were overweight or obese. Their average body mass index was 23.5.

9: BMI category of women at endline using Asian cut-offs

	Control	LSP	NGO	Total
BMI category				
Underweight	9%	9%	10%	9%
Healthy	40%	41%	39%	40%
Overweight	31%	33%	31%	32%
Obese	19%	18%	20%	19%
BMI score	23.4	23.4	23.6	23.5

Note: BMI = body mass index.

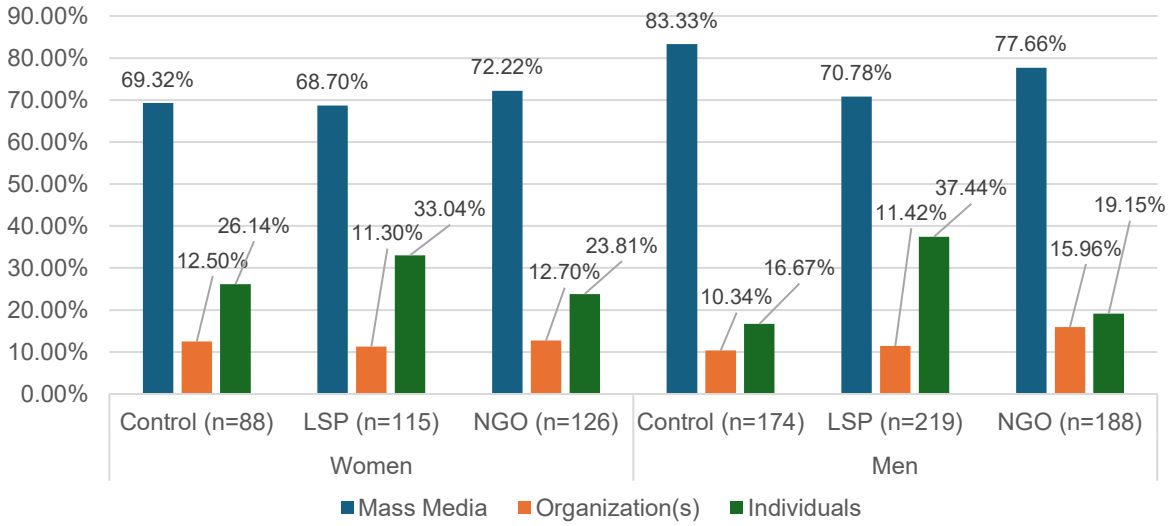
7.6 Nutrition information sources

Overall, 9 percent of women and 16 percent of men reported learning new nutrition information since April 2021. Although slightly more women and men in both intervention groups reported gaining new knowledge, this difference was not statistically significant after adjusting for the union and upazila.

Among women, most reported learning from television and mobile phones, with five citing "The Right Fish" Facebook group. In total, 16 women mentioned learning from WorldFish (n = 3), BRAC (n = 12), or TMSS (n = 1). When learning from individuals, most women cited government health workers or female household members or relatives.

Men primarily obtained nutrition information from mass media sources such as television, newspapers/magazines, and mobile phones (Figure 25), with four mentioning "The Right Fish" Facebook group. Men less frequently mentioned learning from groups. In total, 38 cited groups led by WorldFish, BRAC, or TMSS as sources of new nutrition information. For individual sources, men most often mentioned female household members or government health workers.

Figure 25: Sources of new nutritional information, as reported by women and men



7.7 Knowledge and practice about nutrition and fish consumption

No differences were detected between the treatment groups concerning knowledge and practices related to nutrition and fish consumption (Tables 19 and 20). When asked who in the household decides which food is nutritionally beneficial, women almost always mentioned at least one woman and about two-thirds mentioned a man, with an average of 1.9 people involved in the decision.

Men reported a slightly lower percentage of women and a higher percentage of men involved, with an average of two people. Both groups provided, on average, about 3.5 reasons as to why consuming fish is important for pregnant women, lactating women, and young children. Very few respondents said they did not know or that fish was not important for these groups.

Table 18: Knowledge and practice questions about nutrition and the importance of fish consumption among women

	Control	LSP	NGO
Who decides what will be nutritionally beneficial to the family			
≥1 woman mentioned	92%	94%	95%
≥1 man mentioned	65%	71%	68%
# household members	1.9	1.9	1.9
Importance of nutrition to influence what is consumed			
Rank score*	4.3	4.2	4.2
Why consuming fish is important for pregnant women			
# of answers given	3.5	3.4	3.5
Don't know	1%	1%	2%
Not important	0%	0%	0%
Why consuming fish is important for lactating women			
# of answers given	3.5	3.3	3.5
Don't know	1%	1%	1%
Not important	0%	0%	0%
Why consuming fish is important for young children			

	Control	LSP	NGO
# of answers given	3.5	3.4	3.6
Don't know	1%	1%	2%
Not important	0%	0%	0%

Note: * Rank score calculated: 5 pts for 1st rank, 4 pts for 2nd rank, etc.

Table 19: Knowledge and practice questions about nutrition and importance of fish consumption among men

	Control	LSP	NGO
Who decides what will be nutritionally beneficial to the family			
≥1 woman mentioned	81%	81%	79%
≥1 man mentioned	83%	83%	82%
# household members	2	2	2
Importance of nutrition to influence what is consumed			
nutrition selected*	0.83	0.79	0.78
Why consuming fish is important for pregnant women			
# of answers given	3.2	3.6	3.3
don't know	1%	1%	1%
not important	0%	0%	0%
Why consuming fish is important for lactating women			
# of answers given	3.2	3.6	3.3
don't know	2%	1%	2%
not important	0%	0%	0%
Why consuming fish is important for young children			
# of answers given	3.3	3.7	3.4
don't know	1%	1%	1%
not important	0%	0%	0%

Note: * If nutrition was selected as a factor

8. Conclusions

This report sets out the findings of a rigorous evaluation of the impacts of a nutrition-sensitive aquaculture intervention implemented by WorldFish in two divisions of northwest Bangladesh between 2020 and 2023. A three-arm RCT is used to identify causal impacts of the project by comparing unions where the project was implemented with those in which it was not implemented.

Fifty-seven unions were assigned to a treatment arm, in which the IDEA project was implemented by LSPs directly trained under the project. Sixty-one unions were assigned to an arm in which the project was implemented by LSPs trained by two prominent local NGOs, while a set of 58 control unions continued with business as usual. A qualitative process evaluation was conducted to examine project relevance and implementation.

We find that between 2020 and 2023 there was a tremendous increase in fish production, harvest, sales, and pond productivity across the areas covered; we also find a sharp rise in the use of commercial inputs and a switch towards non-SIS fish varieties that are more suitable for cultivation for sale. As a result, household incomes and income from aquaculture have increased.

However, when we compare the changes in each of these key outcomes across the two treatment arms and the control arm, we find that smallholder aquaculture households in IDEA implementation areas did not do better than households in control group areas. This suggests that the incremental impact of the IDEA project was negligible.

We test for, and find support for, some possible explanations for these muted project impacts. First, project implementation was disrupted and delayed by two waves of COVID-19. Second, as the theory of change shows, a key assumption was that aquaculture productivity would be significantly enhanced by introducing smallholder aquaculture producers to new best practices through training. However, and as this report shows, knowledge of best practices initially introduced by WorldFish were very high among both men and women respondents at baseline.

In response to this finding, which was communicated to WorldFish early on, the set of recommended best practices was expanded: this has led to knowledge differences between LSP and other areas without yet affecting productivity. Additionally, project components such as establishing market and credit linkages had not taken off at the time of the evaluation endline.

Finally, an important and unprecedented observation entailed some evidence of an unexpected response in the form of government support for aquaculture withdrawal in the intervention arms, while aquaculture smallholders in the control arm continued to receive incentives and support. On average, this may also have contributed to the dilution of the overall project impacts.

While the WorldFish project—perhaps inspired by the rise in female employment in the garment sector—had gender-transformative aspirations, and sought to significantly increase women's input into aquaculture-related decision-making in their households and participation in household aquaculture production and other nodes of the aquaculture value chain, we find that project impacts on both have been very limited. While this is partly attributable to the reduction in gender-related intervention efforts, another possible explanation is that the rapid expansion of a more commercial and knowledge-intensive aquaculture sector (where new knowledge is mainly acquired by men) can have the effect of pushing women out, as opposed to strengthening their involvement in aquaculture-related activities.

When exploring changes in local men's and women's attitudes to women's fulltime involvement in aquaculture, ownership of assets, and selling fish in local markets, Figures 14–16 highlight challenges to notions of norm-related views as static, stable or slow-moving, and of women's empowerment as unidirectional and monotonic and unfolding consistently across thematic spheres.

What we observe, instead, is a combination of progress and backlashes of uneven orders of magnitude, where female and male gaps in views may converge or diverge and where convergence may be towards more liberal or more conservative views. While we observe notable progressive shifts relating to women's co-ownership or self-ownership of aquaculture ponds, there is a backlash on women's fulltime involvement in aquaculture.

Nutrition and behavior change interventions were important components of the IDEA project. Apart from a slight increase in dietary diversity for both intervention groups, very

little movement was observed on most nutrition indicators among both women and men. Household fish consumption was nearly universal, with little change over time. There was little evidence to support a change in SIS consumption, apart from a slight trend in the LSP group to consume less SIS, which persisted over various seasons. Food security levels were generally very low, with no differences seen between treatment arms.

Finally, only a small proportion of both women and men reported learning new nutritional information since the start of the project. Those that did report learning new information primarily cited mass media and health workers as sources.

Our study provides some sharp insights for future program and policy design and efforts:

- We are accustomed to thinking about impacts and added value of development interventions in quite stagnant rural contexts. The two divisions of northwest Bangladesh that were targeted by the IDEA project showed credible signs of lagging behind other geographical areas with regard to aquaculture productivity, nutrition, and women's empowerment and economic participation.
- However, during project implementation, the local aquaculture sector became more dynamic, with important private sector actors offering services that competed with the IDEA project.
- This new dynamic made impacts harder to achieve since productivity-enhancement interventions had to be cutting edge in order to outperform the market. The IDEA project implemented critical productivity-enhancing interventions (such as the provision of high-quality fish and feed, digital platforms, credit and market linkages) too late in the project cycle and too limited in scale. Thus, the project unwittingly became a training and capacity enhancement project. This may not be enough to achieve the conceptualized impacts. While we find evidence of additional best-practices knowledge achieving this, these gains appear to have been too small to achieve measurable productivity impacts.
- A key insight regarding development settings with potentially dynamic private sector agents is to be much clearer about the contribution of the development intervention over and above what the market and the private sector will be able to achieve.
- While a development intervention may work on gender attitudes to enhance women's entrepreneurship and involvement (and we have seen transformative effects on women's work outside of the home in other sectors of the Bangladesh economy), our findings provide evidence that commercialization in aquaculture did not increase women's participation and decision-making in aquaculture.
- Our evaluation further highlights the need to carefully consider how an external NGO-led project may interact with existing public programs. In our context, the Department of Fisheries played an important role in providing critical support to fish farmers at baseline. By endline, the role of the Department declined for all areas, but more steeply for those in which the IDEA project was implemented. This suggests that external programs may have the effect of "crowding out" local institutions, a point that requires further examination and critical thinking in the development literature.

Appendix A: WorldFish small-holder aquaculture household selection criteria

Smallholder farmer selection guideline

Income, Diets and Empowerment through Aquaculture (IDEA) project

1. Smallholder farm household

The IDEA project aims to work with smallholder fish farmers in Bangladesh. *A fish farming household is defined as a "smallholder" by the IDEA project if it has a maximum of 2ha of arable land (including pond area)* ***or*** *if the volume of aquaculture production is less than 4MT/ha,* ***or*** *if at least 50 percent of its own production is for family consumption.* The farm household is considered a smallholder if it satisfies at least one of the three criteria. The household does not have to formally own the land or water area; it can be either leased or owned.

The target farmer must be above 18 years of age with sound physical and mental health, and must be associated with fish culture and/or other related activities (e.g., table fish producers [in pond/rice field], nursery operators, fingerling bankers [who rear/nurture over winter fingerling]). Priority should be given to women farmers in case of household selection, especially for homestead ponds.

2. Farmer selection process

The IDEA project has adopted two business models, namely: (1) an LSP-led business model; and (2) a hybrid NGO-led business model, to disseminate technologies to the farmers at scale. In both models, LSPs are the primary responsible bodies to carry out the farmer selection process. In the LSP-led business model, they are solely responsible for farmer selection.

However, in the NGO-led model, the LSPs will lead the selection process with assistance from NGOs. The NGOs already have ongoing programs in some of the IDEA project areas. Therefore, in many cases they will be able to provide the LSPs with lists of potential fish farmers for selection. The training and extension team of the IDEA project will explain the conditions and process of farmer selection to LSPs/NGO staff during training of trainers. Based on the definition of smallholders (see above), the LSPs should follow the following steps to ensure that farmer selection is accurate, appropriate, and uniform:

Step1: Respective LSPs will take necessary steps to inform the villagers regarding farmer selection in advance. The LSPs will organize 1–2 focus group discussions with villagers and local influential personnel in each village. These meetings will also inform the villagers about the objectives of IDEA project and the conditions and process for client selection. The LSPs will also prepare a list of fish farmers of the village through these meetings.

Step2: Respective LSPs or their representatives will visit pond households at the village level and prepare a priority list on the basis of the three criteria mentioned in the definition of the smallholder farmer (questions to be asked are mentioned in Table 21). Before selecting women farmers, LSPs must gain permission from powerful family members (e.g., spouse, mother-in-law) and build rapport with them.

Step3: Respective LSPs will organize a gathering of villagers to present the list of potential farmers who are preliminarily selected as participants. In the meeting, LSPs will also elaborate on the criteria they followed for potential farmer selection.

Step4: The LSPs will commence one-to-one discussions with potential fish farmers based on willingness and motivation towards the IDEA project approach. From these discussions, the LSPs will prepare a final list of smallholder fish farmers from each village, which will be shared with the IDEA project office.

Table 20: Criteria for the selection of smallholder farm households in the IDEA project

Criteria	**Explanation**
Question1: How much is your total arable land area in decimal?	**Land area:** Total arable land area at the time of interview. Total arable land = land owned + rented/leased in – rented/leased out
Decision rule: If the arable land area is equivalent to 494 decimal (2ha) or less, the farm household is a smallholder according to the first criterion. S/he can be selected as a potential farmer. The LSP does not need to ask Question 2. If the arable land area is more than 494 decimal, the LSP should ask him\her Question2.	
Question2: What is your pond productivity in kg per decimal?	**Pond productivity:** Total fish production (kg) from pond in the last production year divided by total pond water area (decimal)
Decision rule: If pond productivity is less than 16 kg per decimal (4MT/ha), the farm household is a smallholder according to the second criterion. S/he can be selected as a potential farmer. The LSP does not need to ask Question 3. If the pond productivity is more than 16 kg per decimal, the LSP should ask him\her Question3.	
Question3: How much is the contribution of fish production from your own pond to family consumption in percentage?	**Contribution of fishpond to family consumption:** Total household consumption in kg from own pond in the last production year divided by total pond fish production multiplied by 100
Decision rule: **If at least 50 percent of self-production is for family consumption, s/he can be selected as a potential farmer.** **If the farm household does not match the third criterion, s/he is not a smallholder farmer.**	

Appendix B: Gender norms survey experiment sample frame

Table 21: Gender norms survey experiment sample frame

Serial	District	Union	Village	Treatment Status	Panel HHs	Non-Panel HHs	Total
1	Bogra	Gunahar	Amjhupi	Control	13	5	18
2	Bogra	Champapur	Boro/Chotto Zhakur (Jhakar)	NGO	17	1	18
3	Bogra	Erulia	Erulia	NGO	7	11	18
4	Bogra	Nandigram	Ghushon	LSP	10	8	18
5	Bogra	Madhupur	Hasrat/Dasi Hasrat	Control	17	1	18
6	Bogra	Adam Dighi	Mondop pur	LSP	15	3	18
7	Bogra	Gosainbari	Niz Natabari/ParNapabari	LSP	10	8	18
8	Bogra	Paikar	Paikar sadar	NGO	13	5	18
9	Bogra	Durgapur	Protab pur	Control	15	3	18
10	Bogra	Chaukibari	Rudrobariya	Control	14	4	18
11	Gaibandha	Dhapherhat	Ali nagar	Control	12	6	18
12	Gaibandha	Jamalpur	Boro Jamal pur	Control	14	4	18
13	Gaibandha	Kuptala	Durga pur	LSP	10	8	18
14	Gaibandha	Mohadipur	Durgapur	LSP	9	9	18
15	Gaibandha	Darbasta	Gopinathpur	Control	11	7	18
16	Gaibandha	Kumar Para	Kismat paksi	LSP	16	2	18
17	Gaibandha	Kamardaha	Rosulpur	LSP	10	8	18
18	Gaibandha	Shibpur	Sribari	NGO	6	12	18
19	Gaibandha	Sreepur	Utter sree pur	NGO	10	8	18
20	Naogaon	Banagram	Utter/Dokkhim Manduya	NGO	13	5	18
21	Naogaon	Niamatpur	Banila	LSP	16	2	18
22	Naogaon	Tentulia	Barinda	LSP	16	2	18
23	Naogaon	Bharsio	Bharsio	LSP	10	8	18
24	Naogaon	Aranagar	Bolla	Control	10	8	18
25	Naogaon	Chandas	Chandas	NGO	9	9	18
26	Naogaon	Tilna	Chanduria	Control	9	9	18
27	Naogaon	Bhabicha	Gobay	Control	12	6	18
28	Naogaon	Bilasbari	Holud bihar	LSP	12	6	18
29	Naogaon	Kusumba	Kusumba	NGO	9	9	18
30	Naogaon	Aihai	Mirzapur	NGO	11	7	18
31	Natore	Chaugarm	Choto/Boro Chougram	Control	18	0	18
32	Natore	Bipra Belgha	Harida khalosi	Control	11	7	18
33	Natore	Kafuria	Jalalabad	LSP	15	3	18
34	Natore	Nagar	Merigacha	NGO	16	2	18
35	Pabna	Mulgram	Artlongka Simagram	NGO	9	9	18
36	Pabna	Munotosh	Boylamari Tunipara	Control	13	5	18
37	Pabna	Danthia Bam	Kathalbaria	LSP	10	8	18

Serial	District	Union	Village	Treatment Status	Panel HHs	Non-Panel HHs	Total
38	Pabna	Mulgram	Khoto bari	LSP	12	6	18
39	Pabna	Majh Para	Majpara/Purbo Para	LSP	18	0	18
40	Pabna	Satbaria	Nakhothati	Control	9	9	18
41	Pabna	Sujanagar	Vobanipur	Control	14	4	18
42	Rajshahi	Talanda	Narayan pur	NGO	11	7	18
43	Rajshahi	Pakri	Pakri	NGO	10	8	18
44	Rajshahi	Chanduria	Ratoli	Control	13	5	18
45	Rajshahi	Haripur	Tangach	NGO	12	6	18
46	Rangpur	Chatra	Anontopur	Control	10	8	18
47	Rangpur	Kaunia Bala	Dhopadi	LSP	12	6	18
48	Rangpur	Pairaband	Joyrampur Anowar	Control	7	11	18
49	Rangpur	Sarai	Kachu	Control	11	7	18
50	Rangpur	Chandandpat	Shahabajpur	NGO	12	6	18
Total					586	317	903

Note: HH = household.

Appendix C: Aquaculture outcomes (area under cultivation, expenditure, productivity, and income)

Figure 26: Changes in average area under pond cultivation in control and treatment areas

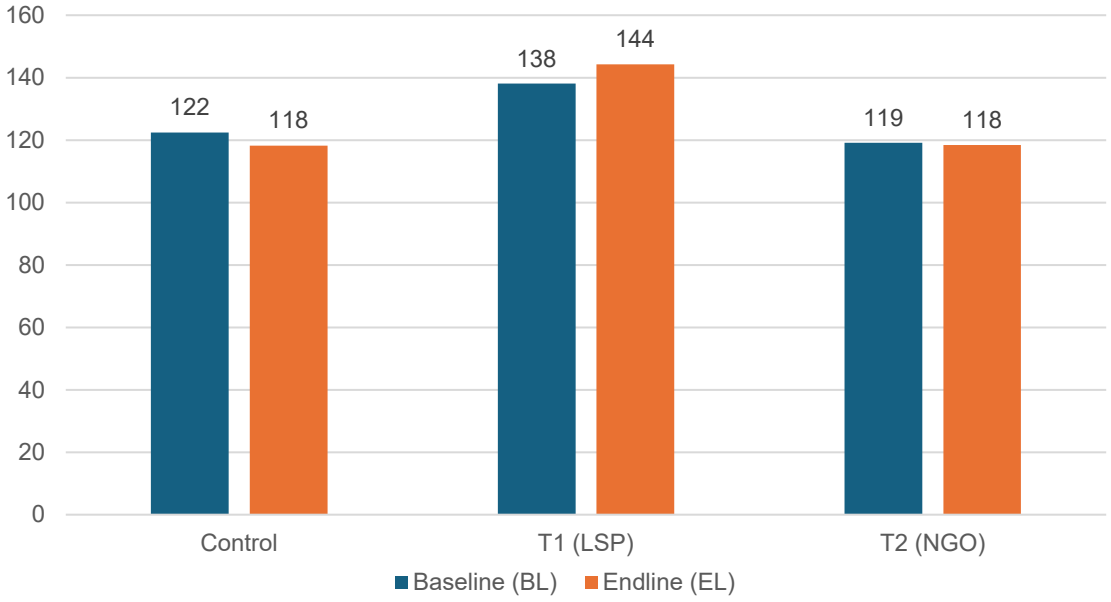
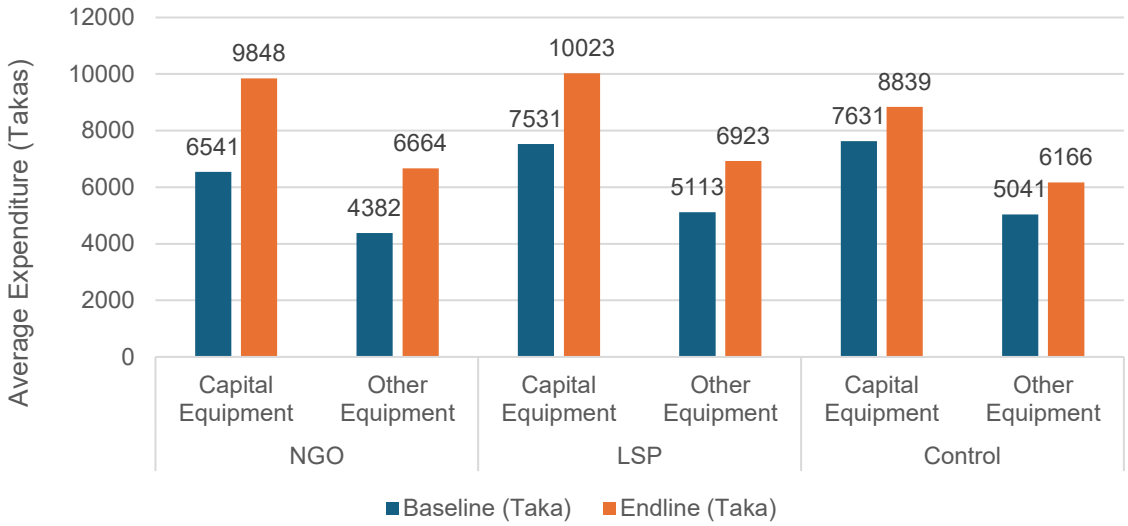


Figure 27: Changes in expenditure on capital and other aquaculture equipments in LSP, NGO, and control areas



Note: Capital equipment: shallow tube well, deep tube well, pump, boat, aerator, guard shade, dike fencing. Other equipment: Net for fishing, hapas, feeding trap, harvest trap, packing/storage material, bamboo and wooden material, electric and angling tools.

Table 22: Key aquaculture outcomes

	Baseline	Endline	Difference
Pond cultivation area	126.59	127.09	1.40
(hectares)	(200.76)	(227.14)	(1.99)
Productivity (kg/decimal)	12.16	16.56	4.51***
	(23.02)	(28.51)	(0.58)
Fish harvested (kg)	1,762.96	2,124.49	343.05***
	(5,723.64)	(5,851.81)	(98.43)
Fish sold (kg)	1,620.83	1,978.72	338.49***
	(5,661.15)	(5,910.88)	(99.69)
Fish consumed (kg)	89.95	171.81	81.79***
	(66.18)	(552.30)	(9.82)
Aqua income ('000' takas)	268.56	311.44	44.70***
	(987.18)	(1,043.89)	(16.51)
Household income ('000' takas)	624.95	664.21	41.07**
	(1,197.15)	(1,163.27)	(20.24)
Total exp: Aquaculture	139.09	174.92	35.09***
('000' takas)	(507.36)	(668.58)	(10.63)
Observations	3,716	3,654	

Note: This table reports average pond area under cultivation (hectares), productivity (kilograms/decimal), quantities of fish harvested, sold, and consumed (kilograms), area under pond cultivation (hectares), income from aquaculture, and household income measured in thousands of takas. Standard deviations in parentheses for first two columns. Standard errors clustered at union level in parentheses for the difference of means. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$

Appendix D: Nutrition survey sample size and results

In the nutrition survey, sample size calculations were conducted for the main outcome of dietary diversity, with a desired precision of 10 percent and an estimated prevalence of 50 percent, which was considered adequate. Based on this, it was estimated that 107–134 households per stratum would be sufficient (Table 24). The total sample size of 415 households was distributed between Rangpur and Rajshahi across 145 unions.

Households with young children were prioritized to assess the seasonality of infant and young child feeding practices and diets, with 41 percent of sampled households including a child aged two years or younger. Only women were surveyed, as baseline and endline data indicated similar consumption patterns between men and women in the same households.

Surveys were not conducted during Ramadan, which took place from March 10 to April 10, 2024. Data collection was carried out over five rounds from October 2023 to July 2024 (Table 25).

Table 23: Sample size calculation for nutrition survey

Estimated prevalence	Desired precision	ICC	Cluster size	Non-response rate	Sample size
50%	10%	0.06	5	10%	134
50%	10%	0.06	2	10%	114
50%	10%	0.06	1	10%	107

Table 24: Survey dates for nutrition

Survey round	Dates	Approximate season
1	19 Oct–10 Nov 2023	Late autumn
2	19 Dec 2023–4 Jan 2024	Winter
3	15 Feb 2024–2 March 2024	Spring
4	17 April–30 April 2024	Summer
5	26 June–8 July 2024	Monsoon

Note: Data for the sixth season of autumn were not collected (15 August–14 September) due to political unrest in the country at that time. Surveys were not conducted during Ramadan (10 March–10 April 2024).

Table 25: Calendar of aquaculture activities among farmers in Rangpur and Rajshahi, Bangladesh

Calendar months																								
Bangla	Falgun		Chaitra			Baisakh			Jaistho	Aasharh			Shraban		Bhadra		Aashin		Kartik		Agrahan		Poush		Magh			Falgun
Gregorian	March			April			May			June		July		Aug		Sept			Oct		Nov		Dec		Jan		Feb	
Seasons	Spring					Summer				Monsoon					Autumn				Late autumn				Winter					Spring
Festivals						Pohela Boishakh		Eid al-Fitr			Eid al-Adha							Durga Puja										
Rainfall	Drought					Moderate rainfall				Heavy rainfall					Sparse/occasional light rainfall - rare flooding													
Aquaculture activities																												
Rangpur (<2 ha land)	Pond preparation activities liking drying					Stocking ponds with fingerlings				Feeding, pond management, harvesting, restocking																		
Rangpur (≥2 ha land)	Pond preparation and fingerling stocking									Feeding and pond management, including harvesting													Restocking fish					
Rajshahi (<2 ha land)	Pond preparation activities liking drying					Stocking ponds with fingerlings				Feed and pond management							Harvesting				Restocking		Feed and pond management				Harvest

Note: Farmer focus groups were conducted on the basis of farmer division (Rangpur or Rajshahi) and arable land or ponds operated by the participating farmer (fewer than 2 hectares, or 2 hectares or more).

Table 26: Detailed food group intake among women as compared to control, adjusting for baseline values

	LSP		NGO	
	Beta coef.	**SE**	**Beta coef.**	**SE**
Starch	0.01	(0.01)	0.018**	(0.01)
Beans and peas	0.013	(0.03)	-0.003	(0.02)
Nuts and seeds	-0.006	(0.02)	-0.036**	(0.02)
Dairy products	0.015	(0.03)	0.058**	(0.03)
Organ meats	0.007	(0.01)	-0.008	(0.01)
Dried fish	-0.002	(0.01)	-0.005	(0.01)
Small fish	-0.014	(0.02)	-0.005	(0.01)
Large fish	0.049*	(0.03)	0.044	(0.03)
Flesh foods / small animal proteins	0.086***	(0.03)	0.02	(0.03)
Eggs	0.006	(0.03)	0.034	(0.03)
Dark, green leafy vegetables	0.050**	(0.02)	0.008	(0.02)
Vitamin A-rich fruits	0.023	(0.02)	0.028	(0.02)
Vitamin A-rich vegetables	0.015	(0.02)	0.007	(0.02)
Vitamin C-rich fruits	0.02	(0.03)	0.048*	(0.03)
Vitamin C-rich vegetables	-0.012	(0.02)	0.053***	(0.02)
Other vegetables	-0.047*	(0.03)	-0.032	(0.02)
Other fruits	0.015	(0.03)	0.008	(0.02)
Edible oil	-0.077***	(0.03)	-0.053*	(0.03)
Sugary foods	0.029	(0.02)	-0.011	(0.02)
Condiments	-0.002	(0.03)	-0.012	(0.02)
Tea / Coffee	0.029	(0.02)	0.024	(0.02)
Other drinks	0.021*	(0.01)	0.024***	(0.01)

Note: * p < 0.10, ** p < 0.05, *** p < 0.010

Table 27: Regression results for household fish consumption, reported by women, adjusted for baseline values

	Any fish consumed	**Any small fish consumed (%)**	**Any dried fish consumed (%)**	**Any large fish consumed (%)**	**Days any fish was consumed**	**Days small fish was consumed**	**Days dried fish was consumed**	**Days large fish was consumed**	**Any SIS consumed (%)**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
LSP	0.004	-0.048**	-0.008	-0.012	-0.253**	0.14	-0.118	-0.088	-0.018
	(0.01)	(0.02)	(0.02)	(0.01)	(0.1)	(0.1)	(0.1)	(0.08)	(0.02)
NGO	0.009	-0.025	-0.009	-0.002	-0.085	0.114	0.262	0.009	0.012
	(0.01)	(0.02)	(0.02)	(0.01)	(0.09)	(0.08)	(0.21)	(0.07)	(0.02)
Observations	3,439	3,435	3,435	3,435	3,319	1,120	239	3,115	3,439

Note: Standard errors clustered at union level in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.010

Table 28: Odds of consuming fish by season and treatment arm among women in Rajshahi and Rangpur, Bangladesh

	Any fish		Any small fish		Any dried fish		Any large fish		Any SIS	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**	**OR (95% CI)**	**p**
Late autumn	*ref*	-	*ref*	-	*ref*	-	ref	-	ref	-
Winter	1.00 (1,1)	-	0.88 (0.62,1.24)	0.45	3.13 (1.84,5.35)	<0.001	2.70 (1.08,6.77)	0.03	1.20 (0.88,1.65)	0.25
Spring	1.51 (0.24,9.64)	0.67	0.93 (0.63,1.38)	0.72	2.77 (1.81,4.26)	<0.001	2.02 (0.76,5.40)	0.16	0.65 (0.45,0.94)	0.02
Summer	6.43 (0.67,61.2)	0.11	0.41 (0.28,0.58)	<0.001	1.44 (0.84,2.47)	0.18	1.21 (0.53,2.74)	0.65	0.85 (0.63,1.15)	0.28
Monsoon	3.14 (0.43,22.7)	0.26	0.25 (0.18,0.36)	<0.001	0.69 (0.39,1.20)	0.19	0.68 (0.28,1.67)	0.40	0.67 (0.48,0.94)	0.02
Control	*ref*	-	*ref*	-	*ref*	-	*ref*	-	*ref*	-
LSP	8.35 (0.88,79.6)	0.07	1.04 (0.78,1.39)	0.77	1.15 (0.61,2.17)	0.66	1.79 (0.94,3.43)	0.08	0.89 (0.63,1.26)	0.51
NGO	1.93 (0.37,10.2)	0.44	1.17 (0.91,1.51)	0.23	1.76 (1.01,3.07)	0.05	1.76 (0.85,3.62)	0.13	1.13 (0.80,1.58)	0.48

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