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Front cover, page 12, Michael Akester/WorldFish.

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List of abbreviations

ATT	average treatment effect of treated
DID	difference-in-difference
FGD	focus group discussion
GIFT	Genetically Improved Farmed Tilapia
ITT	intention-to-treat
NN	nearest neighbor matching
ODK	Open Data Kit
PSM	propensity score matching
RCT	randomized controlled trial
SPAITS	Scaling Systems and Partnerships for Accelerating the Adoption of Improved Tilapia Strains by Small-Scale Fish Farmers

Introduction

Aquaculture contributes significantly to both income and nutrition of households as well as local and national economies (FAO 2020). In analyzing the past 20 years of aquaculture development, Naylor et al. (2021) found that inland aquaculture with freshwater fish is the sector with the largest contribution to total aquaculture volumes, rural livelihoods and food security. The growth of aquaculture also contributes to reducing income inequality (Irz et al. 2007; Rashid et al. 2019). At the household level, studies have shown the positive impact of aquaculture on household income in Bangladesh, Ethiopia, Ghana, Tanzania and the Philippines (Irz et al. 2007; Murshed-E-Jahan et al. 2010; Murshed-E-Jahan and Pemsl 2011; Pant et al. 2014; Kassam and Dorward 2017; Alemu and Azadi 2018; Mulokozi et al. 2020). Through analysis on changes in fish consumption in Bangladesh over 10 years, Toufique and Belton (2014) show that aquaculture growth has a pro-poor contribution, with an increase in consumption for extremely poor, moderately poor and rural consumers. In terms of the income elasticity of fish demand, a substantial share of increasing demand is likely to come from poor and rural households because of their higher income elasticity of demand (Aung et al. 2022). Increasing income through fish sales raises the purchasing power of households and enables them to access other types of nutrient-rich foods (Ahmed and Waibel 2019). Households can then diversify food consumption and improve their dietary intake with protein-rich and energy-dense foods, such as meat, eggs and legumes (Kawarazuka and Béné 2010; Murshed-E-Jahan and Pemsl 2011; Pant et al. 2014; Nguka et al. 2017; Ahmed and Waibel 2019).

In addition to income, research in this field also looks at the link between aquaculture and the environment (Burns et al. 2014; Naylor et al. 2021), employment opportunities (Irz et al. 2007; Kassam and Dorward 2017; Alemu and Azadi 2018), human and social capital (Murshed-E-Jahan and Pemsl 2011; Pant et al. 2014) and gender roles (Kawarazuka and Béné 2010; Murshed-E-Jahan et al. 2010; Ahmed and Waibel 2019; Aung et al. 2021). At individual level, based on a study of children between the ages of 6 and 59 months in Malawi, Aiga et al. (2009) concluded that fish farming households have a lower prevalence of malnutrition because of higher income and greater ability to purchase more diverse food. Nguka et al. (2017) found that lactating mothers from fish farming households in Kenya are more likely to have an optimal body mass index compared with those from non-fish farming households. An advantage of fish farming is the availability of fish for own consumption. According to Nguka et al. (2017), fish farming households experience severe food shortages less frequently. Easier access to fish also increases fish consumption and therefore contributes to intake of nutrients such as vitamin A, calcium, iron and zinc (Kawarazuka and Béné 2010; Pant et al. 2014; Ahmed and Waibel 2019).

Estimating the effect of an aquaculture technology and innovation, such as an improved fish strain and business model, based on data collected from observational studies is prone to confounding bias. The non-random assignment of the technology and innovation to different groups of farmers might be affected by systematic difference in pre-treatment characteristics among the farmers. Therefore, attributing the observed difference in outcome to the treatment alone is prone to bias, as we cannot rule out other alternative explanations for the observed outcome, including pre-treatment characteristics. For instance, in a study that investigates the impact of adopting an improved fish strain on household food security and dietary diversity, farmers who farm the new strain might differ in their characteristics from those who choose to farm the traditional strain. The adopters could be wealthier farmers with higher education who know the benefit of an improved fish variety and have the financial means to try farming a new strain. These kinds of farmers might also implement other productivity boosting measures, such as advisory services and improved feed, and could have better connections with markets than the non-adopters. Therefore, even if farming the new strain does not bring any benefits, the adopters of this technology are more likely to be food secure and have a diversified diet and better nutritional status because of other factors, such as wealth and education.

In this context, estimating the impact of an aquaculture technology and innovation might be biased unless we control for confounding bias. There are various methods to do so, which will be explained in more detail in this report. The aim of this guideline is to provide a methodological approach for an integrated aquaculture performance assessment. It was developed as a deliverable of the Scaling Systems and Partnerships for Accelerating the Adoption of Improved Tilapia Strains by Small-Scale Fish Farmers (SPAITS) project. One of the main outputs of the project is to conduct an integrated performance assessment of improved tilapia strains in participating small-scale fish farming households in Myanmar. The integrated assessment comprises three domains: economic, social and environmental. We use the experience from SPAITS for illustration.

The development of this technical guideline also draws on lessons from other projects. More specifically, the guideline focuses on assessing the performance of aquaculture technologies, such as improved fish strains, but it can also be used to assess innovations, such as business models. Section 2 of this report shows the steps to implement and operationalize the assessment together with tools and approaches for data collection. Section 3 illustrates the conceptual framework for a statistical performance assessment and non-statistical/qualitative assessment, focusing on gender scoping. The details of how to analyze the quantitative and qualitative data collected are explained in Section 4.

1. Performance assessment

A performance assessment is an important tool in influencing policy decisions, but holistic assessments of aquaculture systems are lacking (Rossignoli et al. 2021). On the one hand, monitoring is the continuous assessment of the implementation of a project or policy in relation to agreed upon schedules, and of the use of inputs, infrastructure and services by project beneficiaries. Monitoring provides policymakers, managers and other stakeholders with continuous feedback on implementation and identifies actual or potential successes and problems as early as possible to facilitate timely adjustments to project or policy implementation. In the following, the term "project" and the terms "policy" or "policy measure" are all used interchangeably. Evaluation, on the other hand, is the periodic assessment of a policy's relevance, performance, efficiency and impact (expected and unexpected) in relation to stated objectives.

As such, monitoring and evaluation record what has happened ex-post and seek to evaluate the past performance. However, there is also a strong demand from policymakers for ex-ante simulation of what are the expected effects on production, consumption and income, such as a scaled-up and widespread adoption of a new technology among smallholders over future years. Ex-ante simulation approaches hereby build on the existing theory of change of the project or policy. They also employ incoming monitoring data as well as results from evaluation studies, such as those on changes in fish yield due to a new technology. The purpose is to make projections of pathways of future implementation of policies or projects so as to simulate the interdependencies (through a sequence of causal links). Examples of the results include the number of households reached with new fish breeds to improve fish harvests and change in fish consumption and sales, and ultimately, to improve household food security.

1.1. Monitoring

A monitoring framework usually distinguishes between inputs, activities and outputs. Inputs refer to finances, and material and human resources used in the project. Activities are needed to transform inputs into outputs. Outputs refer to services and production generated directly by the project. Best practices in monitoring seek to record all input and output flows in a meticulous way and to obtain location- and gender-specific data. Data might be further disaggregated depending on the information requirements of policymakers and project managers. Much of the data needed for monitoring inputs, activities and outputs is generated by standard entrepreneurial information systems for accounting, liquidity management, warehousing, procurement, sales and delivery. However, a suitable monitoring framework needs to intertwine these partial information systems to allow for a seamless and continuous integration of data flows.

Whereas evaluations can be done on the basis of statistical samples, it is not common to do so for monitoring. Here, a monitoring system usually seeks to account—on a census basis—for all inputs used (e.g. money spent on training), all activities (e.g. number of women and men trained in producing fish feed from their own resources) and all outputs (e.g. number of farmers having adopted improved fish feed). This gets quite complex very quickly, and a suitable monitoring system needs to adopt a system that is manageable and reliable and can be funded and managed with existing financial resources. A monitoring system therefore needs to involve the major stakeholders of the project and also tries to obtain and record information at low cost, ideally at the source of where the information is generated in the system. For example, a project can work with several nongovernmental organizations (NGOs) for delivery of training services to fish farmers. Instead of doing ex-post surveys on the beneficiaries of these NGOs, a comprehensive monitoring system would contractually require all involved NGOs to record on a daily basis (as activities evolve) how many women and men were trained where and on what. Such data would, ideally, be uploaded to a central site automatically each day.

To enhance the cost-effectiveness of monitoring activities, the choice of indicators matters as well. Many monitoring systems suffer from indicators that are too complex. Instead of finding out how many households adopt a certain technology (which triggers the issue of what is meant by adoption and how one can measure it), it is, for example, simpler and more straightforward to monitor how many fish farmers use a certain technology, and at what scale, at a specific time.

A second principle is to build the monitoring system on a detailed theory of change based on how the project converts inputs into outputs and then eventually to outcomes and impact. The term "outcomes" refers here to outputs of the project that are not directly controllable by project managers. For example, an output of a project could be the number of farmers attending a training session on fish feed, whereas an outcome is the proportion of farmers producing the new fish feed after having attended a training session. This outcome cannot be directly controlled by the project but is heavily influenced by the participant, their socioeconomic environment and other factors that the project cannot control. Lastly, the term "impact" refers to the higher-level outcomes, usually linked to the strategic long-run objectives of the policy of a project, such as food security and income or welfare.

A third principle is to obtain not only facts and numbers but also insights on qualitative information, such as the confidence of farmers in using the new technology, satisfaction with the training element and so on. Here, monitoring can involve qualitative research methods to obtain such insights.

Overall, monitoring can provide valuable and timely information on lower-level hierarchy variables such as inputs, activities and outputs. However, monitoring has inherent weaknesses when it comes to attribution, so it is severely limited in measuring outcomes and impacts. Given these limitations of monitoring, coupled with its focus on looking back instead of ahead, the role of ex-ante simulation comes in as well.

1.2. Ex-ante simulation

These models simulate likely future pathways and/or strategies of project implementation and seek to estimate the effects on project outputs, outcomes and eventually impacts. The models are based on the assumptions of partial economic equilibrium—meaning, they simulate changes in an economy or society that affect partially selected markets but ignore economy-wide general-equilibrium effects triggered by projects.

Ex-ante simulation models have several information sources. First is the theory of change, which describes qualitatively the causal links between inputs, activities, outputs, outcomes and impacts. The ex-ante simulation model is in essence a simplified but quantitative version of the theory of change. The model is further disaggregated in terms of location, time and other variables of interest, such as gender, rural/urban or type of socioeconomic class within a society affected by the project.

The second information source is data about the past implementation of the project. This data is readily available from the monitoring system and may include information such as the number of households reached by the project directly or indirectly as producers or consumers. As such, the monitoring system provides the data for the initialization of base values in Year 0. The model may entail information on households, fish species adopted, type and scale of fishponds, pond management practices adopted, type of feed used and use of harvested fish. The model may also initialize the situation of conventional fish farmers in a society, specifically those not being reached by the project so far. For such initialization, socioeconomic data from various government institutions as well as official surveys and census data are all required.

The third information source is the results from statistical evaluation studies, often complemented by insights derived from qualitative research. Both sources of data provide information about the behavioral activities of the target group and related actors, including the percentage of fish farmers using improved home-produced fish feed in the third year after having received training, and so on. Thus, quantitative and qualitative evaluation research provides critical information on likely magnitudes of and ranges for conversion factors. These factors describe input-output ratios or behavioral processes, such as adoption, information diffusion, informal learning and disadoption.

The fourth information source of the ex-ante simulation model is the expected pathway of future subsequent inputs, activities and outputs of a project—in essence the planned future implementation of the project. Often, there is not only one but several strategies that need to be evaluated ex-ante. They differ depending on various scenarios for project budgets, or other factors and contingencies. As such, the agency implementing the project or policy needs here to at least specify its major planned inputs but ideally also to lay out the plans for different types of activities and desired outputs to be achieved. The simulation modeling team then integrates these inputs and activities into the model and evaluates independently the implied conversion factors from inputs and outputs. It further uses the model to simulate the likely effects on outcomes and impacts.

In practice, simulation models can be built simply using spreadsheet software such as Excel. Ex-ante simulation models are useful for answering forward-looking questions, such as the following:

1. If all project activities were stopped by end of year, how many producers and consumers would still be expected to benefit from the technological and institutional changes triggered by the project in 5 or 10 years? Are these effects growing over time even in the absence of future project activities? What are the effects on selected welfare variables?
2. If the budget for project activities can be doubled over the next 5 years, how many additional women and men would benefit from the project?

Thus, ex-ante simulation models can help gauge likely effects and estimate the size of the effects, given different scenarios and strategies for project implementation. They also allow the use of information from monitoring, management and statistical assessment.

1.3. Statistical assessment

Estimating the effect of a new technology in observational studies is prone to misleading results. The non-random assignment of a new technology (treatment) to farmers means that there could be a systematic difference in pre-treatment characteristics between the farmers who use the technology (treatment group) and those who do not (control group). Therefore, concluding that the adoption of the new technology causes any observed differences in outcome (e.g. harvest, income and food security) is prone to bias, because we cannot rule out other alternative explanations in observed outcome, such as the differences in pre-treatment characteristics between the farmers.

For instance, in a study that investigates the impact of farming improved tilapia on harvest, income and household food security, farmers who adopt the improved strain might differ in pre-treatment characteristics from farmers who choose not to adopt the new strain. Adopters might be well educated and wealthy farmers who know the benefit of an improved fish variety and also have better access to the new strain. These farmers might also implement other productivity boosting measures, such as improved pond management and consultation with extension services, and they might have a wider social network than the non-adopters. Therefore, even if the new strain does not differ in performance compared with the traditional strain, farmers who choose to adopt the improved strain will likely have a better harvest, higher income and greater food security. In this case, all the changes in outcome are caused by other factors, such as wealth and education, and not by the improved strain. Therefore, estimating the impact of adopting a new aquaculture technology and innovation might be misleading unless we control for confounding bias, which is explained in Section 4.

When conducting a statistical performance assessment, there are two main groups of data that should be collected. The first group is the outcome variables or the performance assessment indicators. The second group is the balance indicators, which include the characteristics of farmers, farms and households. These ensure that the treatment and control groups are balanced and that the farmers being compared have similar characteristics before the treatment or project intervention. This enables us to determine whether any changes in the performance indicators are a result of the project intervention and not some preexisting condition of different farmers. If a randomized controlled trial (RCT) is used in the performance assessment, one can assume that prior to the intervention the treatment and control groups are similar on average, but it is also good to show that they are indeed similar based on the survey data collected. Quite often, data on farmers before the introduction of a new technology is not available, so one has to rely on data collected after the farmers have adopted the technology to assess its performance. In this case, it is essential that the data on the farmers' characteristics is collected so that when we compare the performance of the adopters with that of the non-adopters, we are examining them with similar characteristics. The variables that are used to assess balance should be chosen carefully, and it has to be argued that they are not expected to change with the treatment, at least for the duration of the intervention.

Table 1 shows a list of indicators from the two main groups of data to be collected. Some could be both outcome indicators and balance indicators, depending on when the data is collected. For example, aquaculture income and pond size before the introduction of a new technology are balance indicators, as the farmers being compared should have a similar income and size of aquaculture operation before the adopters start using the new technology. On the other hand, aquaculture income and pond size after the introduction of a new technology can be used as outcome indicators to look at the effect of the new technology on income and the size of aquaculture operation. Basic fish production statistics to be collected include physical characteristics of the fish farm, aquaculture systems, costs and returns from aquaculture, and management practices (WorldFish 1998).

Appendix A and Appendix B show the basic aquaculture production and socioeconomic modules, respectively, of the questionnaire used in the SPAITS project. Basic household characteristics to be collected to ensure that a comparison can be made between similar households include household head and member characteristics, finances and information. This is the basic data needed to match the adopters with similar non-adopters and conduct a meaningful statistical performance assessment.

Categories	Indicators
Aquaculture production	Pond size; water depth; fish species; polyculture; integrated aquaculture-agriculture system; stocking density; weight and size of fingerlings at stocking; input level, costs and input use intensity (fingerlings, feed, fertilizer, chemicals, labor, other); culture duration; survival rate; total harvest; fish weight and size at harvest; yield; use of harvest (consumed/sold); gross return; net profit
Management practices	Pond upgrading; pond lining; bund building; improved fish feeding; pond water management; fish disease and health management; improved postharvest handling; climate adaptation strategies; quality/safe fish production practices
Household members	Age; gender; education; dependency ratio
Finances	Income; expenditures; land ownership; other assets; loans
Information	Participation in a farmers organization; information sources; access to extension services

Table 1. Basic indicators to achieve balance in comparison and to assess performance.

Based on the need of individual projects and the One CGIAR impact areas (WorldFish 2020), additional data could be collected to examine a more diverse set of outcome variables, such as sustainability, production issues and mitigation strategies, fish consumption and food security, gender dynamics and behavioral indicators (Table 2). All these indicators are just some examples of data to be collected. The final list will depend on the objective of individual projects.

Data can be collected using an online tool, such as Open Data Kit (ODK). ODK is a good alternative to the paper version of a questionnaire. It is free and can be loaded onto Android mobile devices. It saves time as it eliminates the need to transfer the data from a paper questionnaire to a digital format. In addition, rules can be added to the program to check for potential data entry errors while an enumerator is entering the data to allow the person to correct any potential mistakes on the spot. As the data can be uploaded immediately, or at the end of the day if the network in the field is not good, it is possible for researchers to monitor the data quality remotely. In cases of data errors or outliers, the information can be relayed to the field team in a relatively short period of time so that the enumerators can verify the information with the households or revisit them while the field team is still in the vicinity of the survey area. Some disadvantages of using this data collection method are that the setup costs are higher, as every enumerator will need to have an Android device. In addition, technical errors while in the field could cause delay in completing the surveys. However, as Android devices become more common and

Categories	**Indicators**
Economic sustainability*	Ratio between net income and initial investment; payback period; benefit-cost ratio; net present value; technical efficiency score; diversity of products and markets
Social sustainability*	Number of jobs generated; local consumption of output; labor pay per unit of output; labor pay equality; education of labor force; age inclusion; gender inclusion; racial inclusion; safety at workplace
Environmental sustainability*	Water use; water use efficiency; energy use; energy use efficiency; proportion of renewable energy; nitrogen use; nitrogen use efficiency; eutrophication; acidification; chemical and hormone pollution; risk of farmed species on biodiversity
Production issues and mitigation strategies	High fish mortality; fish diseases; seed quality; feed quality; slow growth; small size of fingerlings at stocking, lack of access to quality seed, small fish at harvest; overgrowth of weeds; technical assistance; flooding; water quality and pollution; drought; erratic rain; typhoons; sulfur upwelling; pond vandalism; poaching; increasing cost of inputs; high capital requirement; lack of credit; farm fragmentation; limited knowledge about aquaculture production activities; lack of awareness of climate change; low adoption rate of pond management and climate change adaptation practices; limited market access; low market price for fish
Fish consumption and food security	Household fish consumption (species, form, source, frequency, amount); total household food expenditures; household food consumption score; household food insecurity access scale; household dietary diversity score
Gender dynamics	Household labor in aquaculture (men/women); decision-maker in pond management; decision-maker in input use; decision-maker in harvest use; ownership of land and other assets; participation in a farmers organization (men/women); decision-maker in repaying the credit; decision-maker in land use; decision-maker in income use
Behavior	Risk preference; happiness; aspiration

** The sustainability indicators are taken from Valenti et al. (2018).*

Table 2. Other potential indicators for a performance assessment.

more people are familiar with them, the advantages outweigh the disadvantages over time. Maduka et al. (2017) conducted a study to compare ODK with a paper-based questionnaire and provide more information on the advantages and disadvantages of ODK and the conventional method of data collection. Details of the ODK program and how to use it can be found on the official ODK website (2019). The baseline and endline survey of the aforementioned SPAITS project was conducted using ODK. Appendix C shows a sample of coding from the basic socioeconomic modules of the questionnaire in an Excel file.

1.4. Qualitative assessment

A qualitative assessment needs to be conducted to understand the people engaged as part of projects or programs and how they influence and are influenced by them. Qualitative approaches are particularly suitable for investigating and exploring the context and cultural diversity (Rubin 2016). It also allows researchers to capture local voices through well-established research techniques, which is significant, especially for gender studies. The instruments in Table 3 can be used to conduct a qualitative gender assessment to understand gender relations within communities and how they relate to their participation in small-scale aquaculture.

1.4.1. Qualitative gender scoping tools and the roles of researchers

The tools used to collect data on gender as part of the project can be found in Appendix D. Tool 1 can be administered to community leaders or other key informants who are able to provide information on the community under study. This tool contains a set of questions for key informants. Its purpose is to enable researchers to understand the village or community and its occupants better, including their characteristics and the distribution of wealth groups. It can be used to select participants, specifically a range of people based on social and economic categories, for intervention and/or future studies.

Tools 2 through 5 can be administered to community members, specifically women and men fish farmers. In identifying gender roles and responsibilities (using Tool 2.1.1), the questions in the tool will enable an understanding of the roles and responsibilities of women and men fish farmers in a community. Using the information gathered from the roles matrix, researchers can conduct interviews and/or focus group discussions (FGDs) to (i) gather information on positive and negative outcomes for gendered engagement in aquaculture, (ii) identify non-typical roles in the community and (iii) get an overview of

Tool	Themes	Purpose
Tool 1	Demographic and wealth ranking	A set of questions for key informants that helps to understand the village and its occupants, including characteristics and the distribution of wealth groups, to enable participant selection for the intervention and/or future studies.
Tool 2	Gender roles and responsibilities	A roles matrix to understand the gender division of labor, identify positive and negative outcomes for gendered engagement in aquaculture, identify non-typical roles in the community, and to act as an overview of the benefits and costs of women's and men's engagement in aquaculture.
Tool 3	Enabling and constraining factors	A set of explorative questions to understand what is setting women and men back and what is enabling them to engage in the aquaculture intervention.
Tool 4	Access to and control over resources	A set of explorative questions on access to and control over resources.
Tool 5	Decision-making	A set of explorative questions on decision-making processes within households to identify what income is spent on, who spends it and how, as well as other relevant decisions.

Table 3. Summary of tools for qualitative scoping of gender in aquaculture.

the benefits and costs for women's and men's engagement in aquaculture. The rest of the questions in Tool 2 as well as questions in Tools 3 through 5 can be asked to women and men fish farmers using the information gathered from the roles matrix. However, it is important that the researchers have knowledge and experience in conducting qualitative research.

In using the tools, the researchers will assume the role of facilitators, as well as notetakers (in the case of FGDs). The facilitator directs the discussion, maintains the conversation's flow and makes a few notes to remember comments for future use. On the other hand, the notetaker makes detailed notes, operates the audio recorder, manages environmental conditions and logistics, responds to unanticipated disruptions and keeps track of the time.

As a facilitator, the researcher is primarily responsible for facilitating the FGD. Their role includes but is not limited to the following:

1. Introduce the instrument to the group.
2. Facilitate the FGDs.
3. Adjust the technique as necessary.
4. Act as a catalyst between the group's participants.
5. Find ways to integrate dominating and quiet individuals and ensure that all group members are able to voice their thoughts.
6. Make sure the group stays on the topic but is also able to change if important information needs to be added.
7. Clarify in one's own words what others have said to provide a thorough understanding of the conversation.
8. Be responsible for time management.
9. Assist the notetaker in collecting all pertinent information and filling out the documentation sheet when the group work has concluded.
10. Avoid the use of complex vocabulary and phrases.
11. Be able to speak the local language.
12. Listen attentively to everyone in the group and do not tell them what to say.
13. Understand the different socioeconomic categories of people in the group, and ensure that everyone, especially minorities and the marginalized, is able to speak.
14. Be accountable to the group leader.

Interviewers or FGD facilitators also need to probe to gather more information from informants or FGD participants. The following questions and statements can be used to probe the informants when using these tools:

1. Could you go into more detail?
2. Could you tell me what you mean by that?
3. Do you have more to say?
4. Tell us more.
5. Can you think of anything else?
6. Kindly explain what you mean.
7. I don't understand.
8. Does anyone have a different take on it?
9. Has anyone tried something different?

As a notetaker, the researcher must write down all the important information and relevant observations during the research. They must also note who is talking and who is not, observing whether there is equal participation from all the group members or if there are some key people within the group who are dominating the process. Notetakers also give signs to the facilitator if needed, such as through shoulder tapping.

It is important that a researcher with experience and knowledge of gender leads the administration of the tool. The tool can also be best used to complement other technical tools.

2. Conceptual frameworks

2.1. Statistical assessment

An observational study is empirical research that examines the effects of an intervention or policy where the researcher cannot randomly assign participants to the treatment. This assumes that the objective of a study is to assess the performance of a new aquaculture technology or innovation on household food security. In an experiment, the assignment of the new technology to farm households is random and controlled by the researchers. This ensures that the households who use the technology and the non-users are comparable. In an observational study, researchers cannot control which households receive the new technology. Therefore, they cannot ensure that the fish farmers who use the new technology are comparable with those who use the traditional technology. If these households do not have similar characteristics before the adoption of the new technology, the difference in household food security may just be a reflection of these initial differences (Rosenbaum 2002).

A directed acyclic graph is a tool that can help in conducting causal analysis (Williams et al. 2018). Figure 1 illustrates the flow and potential problems encountered when assessing the effect of a new aquaculture technology on household food security. In this example, the treatment examined in the study is a new aquaculture technology, and the outcome assessed is household food security. As can be seen from the graph, even though the main objective of the study concentrates on the two shaded boxes in the middle, they do not operate in a vacuum and are linked to other factors in the real world. Therefore, observational studies can lead to misleading results when other connected factors are not taken into consideration.

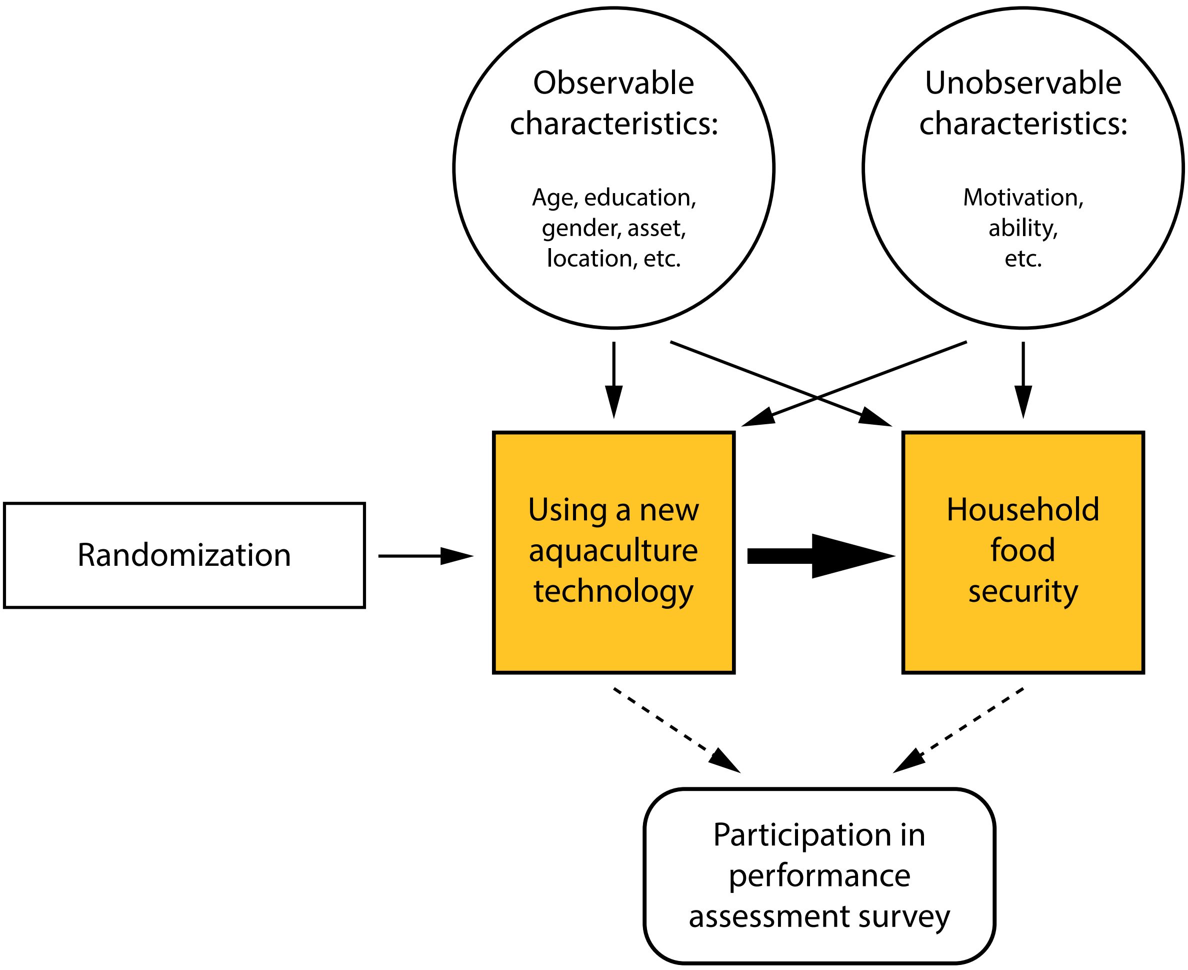

Figure 1. A directed acyclic graph for assessing the performance of an aquaculture technology.

A fish farmer may decide or be selected to adopt a new aquaculture technology based on various factors, such as household characteristics, household location or socioeconomic settings. Confounding arises when one or more of these factors that influence the adoption of the new aquaculture technology also influence household food security (Sterne et al. 2016; Gueyffier and Cucherat 2019), such as income, education, location and motivation.

In addition to confounding factors, selection bias can exist during the selection process for the treatment and control groups, especially when the selection process is not random (Rosenbaum 2002; Amankwah and Quagrainie 2019). For example, if it is not possible to conduct an experiment with random assignment of treatment, the assessment will have to be based solely on survey data collected. Depending on how the new technology is initially introduced in the study area, different types of selection bias can arise. If the technology is rolled out in a village by the local government, the target households may not be representative of households in the village. They could be selected for logistical reasons, such as proximity to the village center, or for technical reasons, such as ownership of ponds of certain size. They could also be selected because of their social status or network within the village. On the other hand, if the recipient of the new technology is not selected but the new technology is sold in the market and is available to everyone, the villagers will select themselves in this participation process. They might not be representative of the village households either, as the participation can be influenced by other factors, such as being part of a farmers group or having the financial means to purchase the new technology (Gertler et al. 2016).

Selection bias may also exist when selecting the households to participate in the performance assessment survey if they are not randomly selected. The surveyed households may be more accessible (e.g. located near a road or the village center) or might be more willing to participate in the survey because they have good experience with the new technology. In this case, even if there is no confounding factor between treatment and control groups, the results of the performance assessment will still be biased because the surveyed households are not representative of the study area.


Photo credit: Michael Akester/WorldFish

Grilled tilapia marketed in Myanmar.

There are various methods to control for these biases. The randomized assignment of treatment ensures that adoption status is not confounded with baseline characteristics of the households because each household has an equal chance of being selected for treatment (Schreinemachers et al. 2015; Gertler et al. 2016). In other words, randomization in assigning the new technology avoids the existence of a systematic difference in pre-treatment characteristics between the treatment and control groups. As a result, this allows attribution of the difference in the outcome between the two groups (e.g. harvest, income and food security) to adopting the new technology. However, randomly assigning the technology to farmers may not be feasible because of financial, technical, political or logistical considerations. For cases in which the new technology is not randomly assigned to farmers, it is necessary to address the bias before making any meaningful comparison and conclusion.

Confounding can be avoided if all these factors are identified and included in the analysis. For example, differences in household income between the farmers who use the new technology and those who use the traditional technology can be observed before the new one is adopted. These differences can be eliminated by comparing adopters and non-adopters with similar household income before the introduction of the new technology (Rosenbaum 2002). A method to achieve this is to match the farmers in the treatment and control groups based on pre-treatment characteristics, then compare the outcome between them. Matching the households in this way reduces the confounding problem by imitating some features of randomization (Austin 2011). It does not match every adopter with a control household that has the exact same values in confounding factors, as it is often not possible to find a control household that is exactly the same as the adopter. What the matching method does is estimate the likelihood of adopting the new technology based on some observable characteristics that are also the confounding factors in adoption. Households are then matched based on the likelihood estimated. Both the problems of confounding factors and selection bias are reduced by comparing the outcomes of adopters and non-adopters who are as similar as possible (Rosenbaum and Rubin 1983; Gertler et al. 2016; Kantavichai et al. 2019). Details of the methodology and how the analysis is conducted are elaborated in Section 4.

Matching the households based on pre-treatment characteristics is difficult to achieve for all confounding factors, as some characteristics may not be observable or measurable. For example, a farmer who likes to seek out new information is more likely to come across the information about the new technology and also information that improves household food security. A motivated farmer who spends more effort in running the aquaculture operation is more likely to have better food security and to try out the new technology. As these levels of preferences and motivation are neither observed nor measurable, the researchers cannot take into consideration these factors in the analysis. Due to this potential issue, it is good to conduct a sensitivity analysis to check whether the performance assessment results are robust. A sensitivity analysis provides an estimate on the likelihood that unobserved factors could alter the results of the study (Rosenbaum 2002; Islam et al. 2015).

2.2. Qualitative gender scoping

The conceptual framework that guided the gender scoping tool for this project was adopted from Danielsen and Newton's (2018) Gender Strategy for the African Chicken Genetic Gains program. The framework is based on a viewpoint that considers "gender as a social relation" rather than as categories independent of each other. The authors referred to the writings of Kabeer and Subrahmanian (1996), which were introduced to move the focus away from the latter viewpoint and onto the social ties that constituted them as unequal social categories (Danielsen and Newton 2018).

Often, projects or programs that aim to integrate gender focus on and stop at gender roles and gender gaps. These can lead to recommendations or solutions to provide training, assets or resources for women to reduce the gaps (Hillenbrand et al. 2014). However, these interventions, which fail to consider gendered relations and their dynamics, can lead the implementers to misjudge their impact on women and men (Hillenbrand et al. 2014).

The first dimension of the gender relations framework (Figure 2) is the gender division of labor. It relates to how work is divided between women and men within households and in fish farming activities. This dimension primarily requires analyzing the productive (i.e. income earning livelihood activities) and reproductive (i.e. caregiving roles and household chores) roles and responsibilities of women and men. To perform a gender analysis, project team members will need to break down the work that women and men perform. This will allow them to see if the division of labor is strictly adhered to, if the roles complement each other and if they overlap one another (i.e. if women and men are able to perform the roles normatively assigned to one gender in their community, especially when either one of them is not around). Therefore, questions were developed to unravel the different roles and responsibilities of women and men and whether (and under what circumstances) these are interchangeable.

The second dimension of gender relations is gender norms. These are the social rules and expectations that maintain a gender system (Cislaghi and Heise 2019). Gender norms reinforce commonly held gender stereotypes and idealized conceptions or ideas about women and men, and these often change (van Eerdewijk and Danielsen 2015). This dimension influences the other three (Figure 2).

The third dimension looks at access to and control over resources and benefits. The resources referred to here include land and ponds, inputs and equipment needed for fish farming and human resources/labor. It also includes social capital, which refers to other fish farmers as well as people from the government agencies and NGOs engaged or working on fish farming inventions and information. Women's and men's access to and control over these key resources determine their ability to engage in and benefit from fish farming activities.

The fourth and final dimension is decision-making. This is also related to women's and men's access to and control over resources. Still, it needs to be separated and viewed on its own to see how control over resources affects the way decisions are made between women and men (van Eerdewijk and Danielsen 2015).

This framework can be used in other sectors or farming systems, including small-scale agriculture. It can also be used beyond a single node within a value chain. In this project, the researchers used the tool to primarily explore the gender relations within the production (and market) node of the value chain.

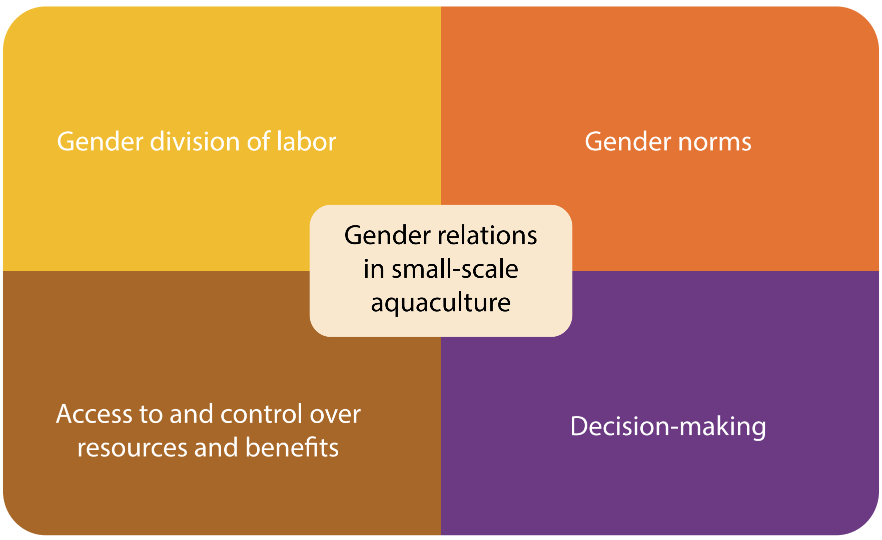

Figure 2. The four dimensions of gender relations in small-scale aquaculture in Myanmar.

3. Data analysis

3.1. Statistical analysis

Three of the most widely used approaches for statistical performance assessment are RCT, propensity score matching (PSM) and instrumental variable. It is difficult to obtain an appropriate instrumental variable from survey data. In addition, the method is easily misused (Cameron and Trivedi 2005). Therefore, this guideline focuses on the two approaches that are more practical for performance assessment studies: RCT and PSM.

An RCT is preferred for eliminating selection bias because of its randomization approach. As each unit in the study population has an equal chance of being selected for treatment, a properly conducted RCT produces an unbiased estimate of the average treatment effect. It provides evidence that the treatment causes the changes in the outcome (Schreinemachers et al. 2015; Gertler et al. 2016; Deaton and Cartwright 2018). However, because of the strict conditions of an RCT, it is difficult to reproduce these conditions in the real world. Even with a well-designed RCT, the Stable Unit Treatment Value Assumption may not be satisfied, as problems can arise when implementing the program resulting in attrition bias, substantial spillover and confounding factors (Blackmore et al. 2018; Kabeer 2019). In addition, it might not be politically feasible to assign the treatment only to certain households in the study area. It could also be logistically difficult to limit the treatment to only some households. When conducted properly, an RCT has high internal validity because of the randomization of the treatment. However, it has weak external validity because a new technology is rarely randomly assigned in the real world.

Another commonly used approach is PSM. This method has weaker internal validity when compared with an RCT because the propensity score is estimated based only on observed characteristics (e.g. education and assets) and not unobserved characteristics (e.g. preference and motivation). Therefore, only the observed characteristics are balanced between the treatment and control groups. In comparison, a properly conducted RCT can achieve balance in both observed and unobserved characteristics. Since it is not possible to include unobserved characteristics when estimating the propensity score, this can bias the results (Gertler et al. 2016). However, PSM has stronger external validity than an RCT because it is possible to conduct a performance assessment with PSM when the technology is not randomly assigned, which is more indicative of the real-world situation. It is also possible to use PSM when the data is not available before the introduction of the new technology and the assessment has to rely on only the data collected after the new technology has been adopted in the study area.

3.1.1. Randomized controlled trial (RCT)

A randomized controlled trial (RCT), also known as randomized assignment of treatment or randomized evaluation or experimental evaluation (among other terms), is widely considered the gold standard for causal inference (Gertler et al. 2016; Deaton and Cartwright 2018). In this method, once the target population and treatment program are identified, units within the study population are randomly assigned to the treatment group. This random assignment is considered fair and reliable because every unit has the same likelihood of being assigned for treatment. After the assignment, the treatment and control groups have statistically the same characteristics on average. The groups are balanced both in observed characteristics (e.g. education and income) and unobserved characteristics (e.g. ability and motivation). As both groups are similar before treatment, any difference in outcome after the introduction of the treatment program can be attributed to the treatment. In other words, the impact of the treatment is the difference between the mean outcome of the treatment group and the mean outcome of the control group (Gertler et al. 2016).

The first step in conducting an RCT is to identify the new technology and the outcome variable to be assessed and the target population in mind. Once these are identified, the next step is to calculate the sample size that needs to be included in the study. The sample size for each group (treatment or control) should be

(1) $N = 2 \times \left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2 \times \left(\frac{s}{\delta_0}\right)^2$

with ***s*** being the standard deviation of the outcome variable (e.g. income) in the baseline population and δ_0 being the acceptable treatment effect on the outcome variable. Conventional assumptions in the calculation are that the standard normal z-scores used are those for type-I error probability, α, of 0.05, and for statistical power, ***1-β***, of 0.8 (Zhong 2009). After the sample size is determined, the study population is randomly assigned to the treatment and control groups. In the SPAITS project, the randomization is at the household level. Depending on the research question, random assignment is also possible at the individual or village level. In a study by Tilley et al. (2021) to examine the effect of nearshore fish aggregating devices and behavioral change activities on household fish consumption in Timor-Leste, villages were randomly selected to receive one or both treatments or to participate in the control group. At times, it may not be possible to assign the new technology to only some households in the same village. Random assignment in a case like that would need to be carried out at the village level. In addition, some complications can occur during the implementation stage of the study, such as spillover or imperfect compliance (Gertler et al. 2016). If spillover is a concern, one can assign households by cluster, which means that all households in the cluster would be assigned to the same group, be it treatment or control. The issue of imperfect compliance happens when some households in the treatment group decide not to adopt the new aquaculture technology or when some households in the control group have access to the new technology from other means and decide to adopt it.

The performance of the new technology can be assessed by examining the difference in the average outcome between the treatment group and the control group. For example, in a study to assess the performance of a new fish strain, a round of surveys (baseline) is conducted before introducing the new strain into the community. After the new strain has been made available to the farmers and a farm cycle has been completed, another round of surveys (endline) is conducted. The average performance within the treatment group can be calculated by examining the difference between baseline and endline for any outcome indicators that are the focus of the study, such as income and food security. The same difference can be calculated for the control group using the same approach. The performance of the new technology can then be calculated by comparing the difference of the treatment group and the difference of the control group. The method used in this analysis is called the difference-in-difference estimation (Gertler et al. 2016). For example, in an RCT study that assesses the performance of an improved fish strain in terms of changes in aquaculture income, let ***A*** be the aquaculture income of households in the treatment group before the improved fish strain is introduced and ***B*** be the income of the same households after farming the improved fish strain for a cycle. Let ***C*** and ***D*** be the corresponding income of households in the control group during the same time period. The income ***C*** is before the introduction of the new fish strain while the income ***D*** is a cycle after the introduction. However, as the farmers in the control group do not have access to the improved fish strain, ***D*** is the income after farming other types of fish. They act as the control group to capture what the income of the treatment group would have been if the improved fish strain were not available during the same time period. To analyze the performance, the difference in income between baseline and endline for the treatment group is calculated (*B*–*A*). The difference in income for the control group during the same period is also calculated (*D*–*C*). The performance of the improved fish strain can then be calculated by taking the difference of the two previously calculated differences: (*B*–*A*)–(*D*–*C*). The technology is randomly assigned to the households and there is a balance in observed and unobserved characteristics between the treatment and control groups before introduction of the new technology. Therefore, the assumption here is that changes in income of the control group show what would have happened to the income of the treatment group if they did not adopt the new technology.

Noakes et al. (2012) use an RCT to assess the impact of increased intake of oily fish during pregnancy on neonatal immune responses. A total of 123 women in the UK were included in the study. The researchers randomly assigned 62 women to consume farmed salmon twice a week from the gestation period of 20 weeks until delivery and 61 women to continue their regular diet with a low amount of oily fish. The authors found that consumption of oily fish during pregnancy affects neonatal immune responses but not infant atopy.

Verbowski et al. (2018) evaluated the impact of homestead food production and small-scale aquaculture on the prevalence of inadequate nutrient intake among women and children in Cambodia. First, the researchers selected 90 villages from one of the poorest provinces in the country. They then used a cluster RCT to assign 10 randomly selected households from each village to the program, which included diversified home gardens and small fishponds. Data was collected 22 months after the start of the program. They found that participation in the program increased the intake of iron, vitamin A and riboflavin among the women. However, there was no significant difference in nutrient intake between the children in the treatment and control groups.

Within the scope of the same program but in a separate study, both Michaux et al. (2019) and Verbowski et al. (2018) assessed the impact of participation in the program on the anemia rate, micronutrient intake and anthropometry among women and children. The difference in this latter study is that there were two treatment groups and one control group, instead of the usual one treatment and one control. The first treatment group being examined included households with both homestead gardens and fishponds, while the second treatment group contained households with only homestead gardens. The authors found a significant impact on the concentration of retinol binding protein among women in the treatment group with both homestead gardens and fishponds.

Kvestad et al. (2021) examined the effect of increased maternal cod intake during pregnancy on the general and socioemotional development of infants in Norway. The researchers used an RCT by lottery to randomly assign 133 pregnant women to receive a cod fillet twice a week or continue their usual diet. They found a positive effect on maternal iodine status and socioemotional development of the infants.

Roos et al. (2021) studied the effects of farmed salmon consumption on nutrition status and health in the UK. Participants of the study were selected through a health questionnaire and a blood test before the start of the study. The farmed salmon used in the study differed by the types of fish feed given. The first group contained mainly fish oil and the second group mainly rapeseed oil. The researchers used parallel RCTs to randomly assign participants to consume fish oil salmon twice a week, rapeseed oil salmon twice a week or continue their usual fish consumption for 18 weeks. The authors found that consumption of rapeseed oil salmon instead of fish oil salmon increases the omega-3 index and the level of vitamin D.

As the use of an RCT involves strict conditions, researchers can encounter obstacles while implementing a study. In the SPAITS project, the initial plan was to perform the assessment using an RCT, and a round of baseline surveys had been conducted with the households being randomly assigned to either the treatment or control groups. However, because of the political situation in Myanmar and the COVID-19 pandemic, the project intervention and the endline survey had to be delayed and then altered. Without the random assignment of treatment, an RCT cannot be conducted and the analysis needs to be based on an alternative method, such as PSM.

In other cases, Kabeer (2019) compared the lessons learned from two RCT studies conducted in India and Pakistan. Both studies assessed the impact of programs providing training on raising livestock, fish farming and crop cultivation for women in extreme poverty. In India, the pilot program was conducted in rural areas of West Bengal. From the list of eligible households identified by an NGO through a baseline survey, 512 households were randomly chosen to receive the training while 466 were assigned to the control group. Out of the 512 households in the treatment group, 12.5% were later excluded for non-viability reasons and 35% declined to participate. At the end, only 266 households participated in the program. This household attrition caused the assessment to be an intention-to-treat (ITT) analysis. ITT is an impact assessment of households that are assigned to the program and not an impact assessment of households that actually participate in it. In addition, out of the 978 households included in the study, 166 were not available for the endline survey. As a result, only 83% of the original sample was considered for the impact assessment. Household attrition biased the randomization. By comparing the characteristics of households that did not take the endline survey with those that were part of the survey, it was found that households that dropped out at the endline survey were significantly poorer and had higher dependency ratios.

In Pakistan, five NGOs were selected to implement the pilot program in the least developed villages within their designated area in Sindh. From the eligible households identified within these selected villages, half were randomly chosen to receive the training with the other half assigned to the control group. The author found that in practice the randomization approach of an RCT was not followed. The reason is that while some NGOs assigned households through public lotteries, others chose the households for the training themselves with no mention as to whether the approach was random or non-random. It is also possible that there was a lack of balance between the treatment and control groups because the treatment households were not poor at all since only 10% of them were found to be below the poverty line.

In addition, Dhehibi et al. (2022) analyzed the impact of improved agricultural extension approaches on technology adoption in Tunisia. There were four treatment groups and one control group using the following criteria to identify the households: (i) ownership of 0.5 ha of land and (ii) ownership of 1–50 small ruminants. A total of 700 households who fulfilled both criteria were sampled in the study and divided into four treatment groups and one control group comprising 140 households each. Out of the 700 households involved in the baseline survey, the authors were able to revisit only 671 in the follow-up survey. Therefore, attrition in the study was about 4.14% on average, with some variation across control and treatment groups. The authors undertook a covariate balancing test using household baseline data in the balanced panel to assess the effectiveness of the randomization procedure (Dhehibi et al. 2018). The results from the balanced panel suggest that attrition did not introduce significant randomization bias (Ogutu et al. 2018). The authors found that technical training combined with economic and organizational training and female empowerment courses increase the technology adoption among households.

Nakano and Magezi (2020) used an RCT to examine the impact of microcredit on the adoption of technology and productivity in rice cultivation in Tanzania. In this study, out of 412 households interviewed in the baseline survey, 208 were randomly assigned to receive credit from the BRAC credit program while 204 were assigned to the control group. Although invitations to the program were randomly assigned in this study, borrowing or not was endogenously determined by the households. Therefore, the authors estimated an ITT effect to cope with the selection problem. Based on the findings, the study suggests that improving the credit program may not be enough to result in higher technology adoption and productivity of small-scale farmers.

3.1.2. Propensity score matching (PSM)

Because of the strict conditions of an RCT and its low external validity, PSM by Rosenbaum and Rubin (1983) is an alternative method that may be preferred. PSM assists researchers in drawing causal inferences in observational studies by reducing the selection bias. A common problem in analyzing the effect of technology adoption is self-selection bias, which occurs because the new technology is not randomly assigned to the fish farmers. Consequently, farmers who choose to adopt the new aquaculture technology or innovation could have different characteristics than those who choose not to adopt. The observed effect of adoption is represented by

$$(2) \quad E(y_{i1}|DI_i = 1) - E(y_{i0}|DI_i = 1) + E(y_{i0}|DI_i = 1) - E(y_{i0}|DI_i = 0)$$

with the first two terms being the true effect and the last two being the selection bias (Heckman et al. 1998). Applying this to the performance assessment of aquaculture technology is the yield or aquaculture income with the new technology, is the yield or aquaculture income without the technology, is the condition that the technology is adopted, and is the condition that the technology is not adopted. The bias arises because of the difference in the characteristics of the adopters and the non-adopters. PSM is a method that matches the technology adopters with the non-adopters. Through this matching, the aim is to identify treatment-control pairs with similar socioeconomic characteristics and with a similar propensity of being in the treatment group. In this case, the matched partners who are non-adopters will act as the control group to the adopters (Rosenbaum and Rubin 1985; Caliendo and Kopeinig 2008).

PSM helps examine whether a particular treatment is the cause of the observed effect (or outcome) in studies in which the researchers are unable to control who receive the treatment. The propensity score is defined as the conditional probability of assignment to treatment given a vector of factors that could affect the decision to adopt the technology. It is the likelihood of receiving the treatment given observed characteristics (Khan et al. 2012). When estimating the propensity score, variables that could influence the likelihood of a farmer being in a certain group are included (Caliendo and Kopeinig 2008). These include the characteristics of the household (e.g. visits by extension services, participation in a fish farming organization, and a loan request for the aquaculture operation), household head (e.g. age, education and gender) and pond (e.g. total size, depth and fragmentation).

After generating the propensity score, several methods can be used to match the farmers (Khan et al. 2012):

Nearest Neighbor (NN) matching – Each treated unit is matched with a unit from the control group with the closest propensity score. There are variations in this method, such as NN matching with replacement and NN matching without replacement. If a dataset has many treated units with high propensity scores but few control units with high propensity scores, matching with replacement can reduce bias and increase the quality of matching. In this case, it allows the same unit in the control group to be a neighbor of more than one unit in the treated group (Caliendo and Kopeinig 2008; Khan et al. 2012).

Kernel matching – Each treated unit is matched with the average of the control group. The average is weighted and based on the proximity of the propensity score between the treated unit and the control group. The further the treated unit is from the control unit, the lower the weight.

Caliper matching – This method is similar to NN matching but with a limit on caliper size. Each treated unit is matched with the nearest unit from the control group within the caliper size.

Radius matching – This method is similar to caliper matching. In the caliper method, the treated unit is compared with the nearest control unit within the caliper size. In the radius method, the treated unit is compared with all control units within the caliper size.

The first step to conducting an impact assessment using PSM is to have an evaluation question based on testable hypothesis. For example, what is the impact of a new aquaculture technology or innovation on the income of farm households? Or what is the impact of an improved fish strain on the food security of farm households? The treatment here is the adoption of a new aquaculture technology or an improved fish strain. The treatment group is the farm households who adopt the aquaculture technology and the control group is the farm households who do not. After having an evaluation question, the propensity score is estimated in a binary choice model, such as probit or logit, for each farmer based on a set of variables. The propensity score captures the likelihood of a farmer being in a certain group:

(3) $p(X) = \Pr[D = 1|X]$

where $p(X)$ is the propensity score and $\Pr[D{=}1|X]$ is the probability that an observation is in a certain group given a set of variables, X. Farmers in the group (e.g. adopters of the improved strain) are then matched with farmers outside of the group (e.g. non-adopters of the improved strain) based on their propensity scores. This helps ensure that a matching pair of households has similar characteristics so that they can be compared. Since the matching is done based on observed characteristics, these are the variables that will be included in the model. The selection of variables is based on economic theory and previous empirical studies on the adoption of a new aquaculture technology or an improved fish strain. The variables selected should be unaffected by adoption or participation, or the data should be collected before adoption of the aquaculture technology (Caliendo and Kopeinig 2008).

After running the binary choice regression, the propensity score is generated for each household from both groups. The score is the likelihood that each household in the sample adopts the new aquaculture technology or an improved fish strain based on the observed characteristics. It is a number between 0 and 1 that reflects the influence of all observed characteristics on the likelihood of adopting the new aquaculture technology. After the score is generated, households in the treatment group can be matched with households in the control group based on the proximity of their respective propensity scores. PSM is a quasi-experimental method because it tries to mimic random assignment to treatment and control groups by selecting control households that are similar to the treatment households for comparison. The observed characteristics should be well-balanced across treatment and control groups. This ensures that both household groups have on average the same characteristics in the absence of the program (Gertler et al. 2016).

There are balancing properties that must be satisfied for PSM to be valid. For example, two households with the same chance of adopting the new aquaculture technology must be placed in the treatment and control samples in equal proportions (Khan et al. 2012). This will determine whether the differences in characteristics between the treated and control households have been eliminated. If this is the case, the matched comparison group can be recognized as a reasonable counterfactual (Darmansyah et al. 2020). The balance or the quality of matching can be examined by checking the reduction in mean bias and the likelihood in predicting the selection into a certain group. After matching, there should be no significant difference in the variables used in predicting selection between the groups being compared. A further requirement for the propensity score is the common support or overlap condition. It implies that households with similar characteristics have a positive chance of being in the adopting or non-adopting group (Khan et al. 2012; Amankwah and Quagrainie 2019). This can be done by means of a graph that shows the overlapping areas of the two groups (Figure 3).

When the adopting and non-adopting households have similar characteristics, it will show large areas of common support. This shows the existence of common support or overlap between the propensity scores of the adopters and the non-adopters (Gertler et al. 2016). A sensitivity analysis can also be conducted as proposed by Rosenbaum (2002). It indicates how sensitive the

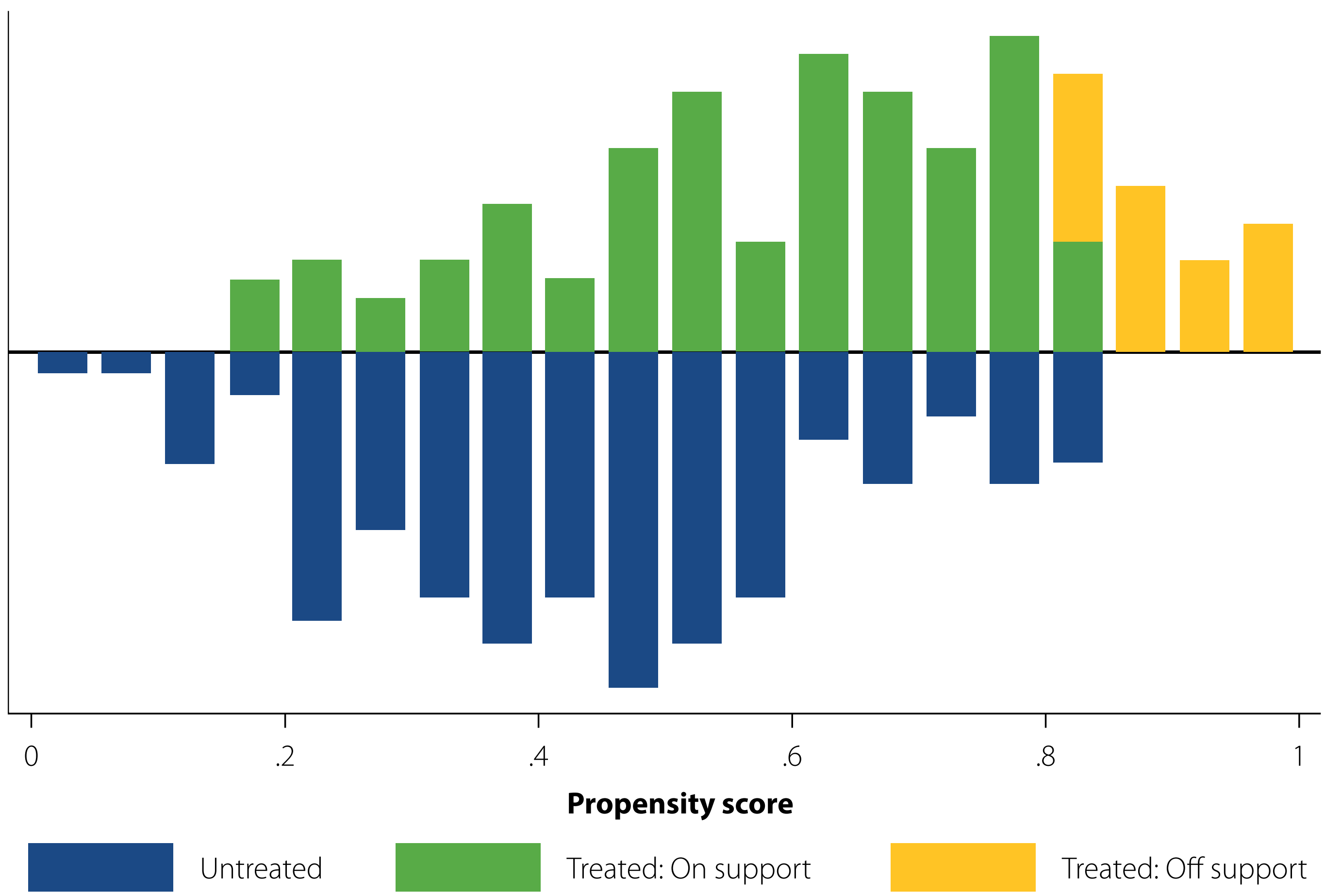

Figure 3. Graph showing the check of common support.

results are to unobserved variables. The matching models can identify a causal link between the treatment and the outcome variables, such as household income or food security, by simulating the random assignment of the treatment and control groups (Darmansyah et al. 2020). The average treatment effect on treated (ATT) groups can be computed based on the difference in mean outcome between the matched partners (Caliendo and Kopeinig 2008):

(4) $ATT = E(Y_1|p(X)) - E(Y_0|p(X))$

The ATT shows the average difference when comparing the mean outcome of the treated units and the mean outcome of these units had they not been treated. It is the impact of the treatment on the outcome (Rosenbaum and Rubin 1983; Islam et al. 2015; Kantavichai et al. 2019).

The PSM methodology has been widely used in the impact assessment literature to address the potential selection bias caused by the differences in characteristics between the farmers in a group, such as adopters of certain technology, and those outside of the group. In the SPAITS project, we compare the fish farming systems in Bangladesh, Egypt and Myanmar, focusing on how the performance of aquaculture differs based on the practice of polyculture systems (Khor et al. 2022). To account for the difference in the characteristics of fish farmers, which could also affect the outcome variables and lead to biased results, we use PSM to match the ponds in a group (e.g. polyculture) with those outside the group (e.g. monoculture) before conducting the comparison. In addition, we use Rosenbaum bounds to check for the sensitivity of results to unobserved variables. The analysis shows that polyculture ponds produce higher aquaculture revenue and profit. The farmers also keep more of their harvested fish for household consumption. The increase in revenue and profit is also observed when we focus on tilapia polyculture and rohu polyculture, which are the two most common systems in the study area. In addition, farmers of tilapia polyculture keep more of the harvest for their own consumption, while the difference in this aspect among rohu polyculture and other systems is not statistically significant. The results of the difference in profit also have high critical value of gamma in the Rosenbaum sensitivity analysis, indicating that the findings for this on-farm performance measure are robust.

In other studies, Kumar and Quisumbing (2011) evaluated the impact of early adoption of polyculture fish production in Bangladesh. A propensity score was estimated with a probit model that predicted the likelihood of each household becoming an early adopter of aquaculture technology given observed household and community characteristics. The authors verified the similarity of the means of the characteristics between early and late adopters to ensure that the two groups were balanced. They found positive and significant impact on household consumption expenditures and asset accumulation in individually operated fishponds.

Khan et al. (2012) studied the impact of community-based management on the income, expenditures and inequality of a fishing community in Bangladesh. The results suggest that there is a positive and significant impact on income and household expenditures for poor farmers who participate in community-based management.

A study by Islam et al. (2015) in the same country examined the determinants of adoption and impact of an integrated farming system of rice and fish among smallholders. The authors found a robust and significant impact of the integrated farming system on annual household income, farm income and the amount and frequency of household fish consumption.

Alawode and Oluwatayo (2019) analyzed the development outcomes of the Fadama III program among fish farmers in Nigeria. The program helped low-income fish farmers bridge the gap between the demand and supply of protein in the study area. The authors used PSM to select beneficiaries and non-beneficiaries who were as similar as possible in observable characteristics that could have influence participation in the program. Then, they estimated the ATT and found a positive impact of the program on production level.

Results from Amankwah and Quagrainie (2019) indicate that the adoption of improved fish feed technology in Ghana increases aquaculture income and reduces poverty. The authors used PSM to mimic a randomized dataset of adopters and non-adopters based on observable household characteristics that affect the adoption of the improved technology. In another study by the same authors, PSM was used to analyze whether engaging in fish farming increases a steady income flow and improves household access to fish for direct consumption in rural and urban areas of Ghana. The authors first estimated the decision to adopt fish farming based on household observable characteristics with a logit regression. Then, they examined the ATT to determine the impact of the adoption decision on household nutritional quality. After verifying the robustness of the results with a sensitivity analysis, the authors concluded that fish farming households have a higher nutritional quality and frequency of food consumption than non-fish farming households.

Other studies that have applied this methodology include an impact assessment of fish production in the Brazil on Human Development Index, where Flores and Pedroza Filho (2019) assessed the effect of tilapia production. A probit model was first used to estimate the likelihood of being a tilapia producing municipality based on observable characteristics. A propensity score that reflected the likelihood was then generated. The authors found that tilapia production does not have a statistically significant impact on per capita income but has a positive effect on health and education.

Kantavichai et al. (2019) evaluated the impact of artificial reefs on the income of smallholders in a fishing community in Thailand and found an increase in annual income from the fishery.

Darmansyah et al. (2020) used PSM to match adopters of shrimp-fish polyculture in Indonesia with similar farmers who are non-adopters. The authors found that adoption of this polyculture system significantly contributes to an increase in the income of farmers.

Tran et al. (2021) used PSM to analyze the current growth, yield and profitability of Genetically Improved Farmed Tilapia (GIFT) and non-GIFT strains in monoculture and polyculture systems in Bangladesh. The authors reported that GIFT has a faster growth rate and higher yield and so is more profitable and cost effective than non-GIFT in both monoculture and polyculture systems.

Aung et al. (2021) assessed the impact of sustainable aquaculture technologies on the welfare of small-scale aquaculture households in Myanmar. Results from the study indicate that adoption of sustainable aquaculture technologies in Myanmar increases the welfare of households.

3.2. Qualitative analysis

Qualitative data is non-numerical and unstructured. It is typically generated through interview transcripts, surveys with open-ended questions, audio and video recordings, observational notes, etc. Compared to quantitative data, which captures structured information, qualitative data is unstructured text-based data that has more subjective and in-depth information. Qualitative data analysis is a process of gathering, structuring and interpreting qualitative data to understand what it represents.

There are three major approaches to qualitative data analysis for the social sciences: (1) interpretative approaches, (2) social anthropological approaches and (3) collaborative social research approaches (Lune and Berg 2017). These differ based on the degree of involvement of inductive reasoning. In actual research, we do not just choose one approach to the exclusion of the others.

Given these diverse yet overlapping approaches, there are seven standard sequential steps of analytical activities: (1) gathering and collecting qualitative data, (2) turning collected data into text, (3) coding qualitative data, (4) transforming codes into categorical labels or themes, (5) sorting material by these categories and identifying similar phrases, patterns, relationships and commonalities or disparities, (6) establishing a small set of generalizations and (7) reporting on the insights derived from analysis (Lune and Berg 2017). Using software specifically designed for qualitative data management significantly reduces technical sophistication and eases the laboriousness of the task. QSR's NVivo is one of the qualitative data analysis software that can be used to mechanize this coding process in the qualitative data analysis process.

4. Conclusion

This report details the four common approaches used in a performance assessment: monitoring, ex-ante simulation, statistical analysis and qualitative assessment. All four approaches should be used as every method has its own advantages and disadvantages, and every approach complements the others. One should not spend the entire budget on only one approach. Monitoring is important, as donors want to know how many households are reached. Ex-ante simulation modeling is useful in estimating the outcome, and it is less time-consuming and less costly than surveys. Statistical performance assessment is more accurate and can explore the causality from inputs to outputs, though it is also more time-consuming and costly. Even though qualitative research tends to assess using words, images and descriptions, it can be far more concentrated, because it samples specific groups to gather meaningful data, adds context and explains something that numbers alone cannot reveal. Both qualitative and quantitative methods provide us with different, complementary pictures of the phenomena we observe.

Regarding statistical assessment, an RCT is the gold standard of a performance analysis, especially when one needs to establish causality from a new technology or innovation to specific outcomes. However, as can be seen from the report, the data requirement for an RCT is high, with at least two rounds of data collection needed: once before the introduction of the new technology and then the survey repeated after the farmers in the treatment group have used the new technology and harvested their fish. As the first round of surveys needs to be conducted before the study population has access to the new technology, advanced planning is essential. Quite often this is not possible in the real world because the technology could have been widely used in the community. Together with the consideration that an RCT has low external validity, another method of statistical performance analysis may be preferred, such as PSM. The choice depends on whether internal or external validity is more important for the analysis being conducted, and whether an approach is unsuitable because of financial, political or logistical considerations.

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Appendix A. Basic aquaculture production modules of the questionnaire

Aquaculture experience and facilities

D01. Which year did your household start fish farming for the first time?

D02. Has your household been involved in fish farming every year since?
1. Yes (skip to D04) 0. No

D03. How many years has your household NOT been involved in fish farming since then?

D04. Do you practice integrated agriculture/livestock aquaculture? [Enumerator: explain what integrated agriculture aquaculture is.]
1. Yes 0. No

Now, we would like to talk to you in detail about fish production activities for the last cycle that was stocked and completely harvested.

D05. How many ponds did your household stock and completely harvest in the last cycle?

	D06	**D07**	**D08**	**D09**	**D10**	**D11**	**D12**	**D13**	**D14**	
Facility number	Type of facility 1. Pond 2. Channel 3. Rice field 99. Other	Size [Enumerator: fingertip to elbow is equal to 1.5 feet.]	Unit 1. m^2 2. acres 3. hectares 4. ft^2	What year was the facility built?	Tenure 1. Owned 2. Rented 3. Borrowed 4. Right of use given by local authorities 5. Rented for sharecropping 99. Other (specify)	What is the walking distance in minutes from the homestead to the facility?	What is the average water depth in feet for the facility?	What is the source of pond water? 1. Surface (river, lake, creek, stream, etc.) 2. Groundwater (tube well, well, etc.) 3. Irrigation canal 4. Dam 99. Other (specify)	Which household member(s) made the decisions on the inputs used and general management of this facility? 1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)	
	code	amount	code	year	code	minutes	amount	code	code	ID/IDs

Aquaculture operation

Fish stocking, harvesting and use

Fish code for D18, D71, D81:

1. Tilapia (tilapia)	6. *Nga mote* (pacu)	11. Bighead carp	16. Stinging catfish
2. *Nga myitchin* (rohu)	7. *Shwe war nga gyinn* (common carp)	12. Mirror carp	17. Mola
3. *Nga gaung pwa* (catla)	8. *Nga kone ma gyi* (silver barb)	13. Climbing perch/anabas	18. Other carps
4. *Nga gyinn pyu* (mrigal)	9. *Nga ku* (walking catfish)	14. Grass carp	19. Other catfish
5. *Nga dan* (pangasius)	10. Silver carp	15. Snakehead	99. Other (specify)

	D16		**D17**		**D18**	**D19**	**D20**	
Facility number	What month and year did the cycle start?		What month and year did the cycle stop?		What species of fish did you stock in this facility for this cycle (select multiple)?	If tilapia, were the fingerlings monosex male? 1. Yes 2. No 99. Don't know	What was the source of the fingerlings? 1. Own farm (including wild fish let into the farm) 2. Male neighbor 3. Female neighbor 4. Relatives 5. Farmers group	6. NGO 7. Government 8. Private hatchery 9. Local dealer (commission agent) 99. Other (specify)
	month	year	month	year	fish code	code	code	

	D21	**D22**	**D22_1**	**D23**	**D24**	**D24_1**	**D25**	**D26**
Facility number	How many miles is it from the homestead to the source of the fingerlings? [Enumerator: Put '999' if they don't know.]	What mode of transportation did you use to source the fingerlings? 1. Headload 2. Bicycle 3. Motorcycle 4. Oxcart 5. Boat 6. Car/truck 7. Public transportation 8. Wheelbarrow 9. Rickshaw/three-wheeler (non-motorized) 10. Auto rickshaw/three-wheeler (motorized) 11. Flight 99. Other (specify)	When did you stock the fish?	How many fingerlings (pieces) were stocked?	What was the average weight of the fingerlings at stocking? [Enumerator: If the farmer does not know the weight per piece, you may ask them how many pieces of fingerlings made up one kyattha/g/viss and then calculate the weight per piece.]	What unit was used to measure the weight? 1. tika/kyattha 2. g 3. kg 4. viss 99. Other (specify)	How many inches was the average length per fingerling at stocking?	What was the price (MMK) of the fingerlings per piece?
	amount	code	date	amount	amount		amount	amount

	D27_1	D27_2	D27	D28	D29	D29_1	D30	D31	D32	D33	D34
Facility number	When did you completely harvest the fish?	How many times did you harvest?	What was the total quantity of fish harvested in this facility from this cycle?	Unit 1. viss 2. g 3. kg 4. single piece 5. kyattha	What was the average weight per piece of fish at harvest? [Enumerator: If the farmer does not know the weight per piece, you may ask how many pieces of fingerlings made up 1 kyattha/g/viss and then calculate the weight per piece.]	Unit 1. viss 2. g 3. kg 4. single piece 5. kyattha	How much was consumed by your household from your own production?	Unit 1. viss 2. g 3. kg 4. single piece 5. kyattha	How much was sold? [Enumerator: If none, put 0 and skip to D39.]	Unit 1. viss 2. g 3. kg 4. single piece 5. kyattha	What was the price (MMK) per [D33 unit] of fish sold from this pond and this cycle? (Enumerator: Average the price if multiple prices were given as answers.)
			amount	code	amount		amount	code	amount	code	amount

	D35	D36	D37	D38	D39		D40	D40_1
Facility number	In what form was the fish was sold? 1. Fresh 2. Dried fish 3. Processed 99. Other (specify)	To whom did you mainly sell to? 1. Traders 2. Rural consumers 3. Urban consumers 99. Other (specify)	How many miles was it to the point of sale?	What mode of transportation was used to the point of sale? 1. Headload 2. Bicycle 3. Motorcycle 4. Oxcart 5. Boat 6. Car/truck 7. Public transportation 8. Wheelbarrow 9. Rickshaw/three-wheeler (non-motorized) 10. Auto rickshaw/three-wheeler (motorized) 11. Flight 99. Other (specify)	Which household member(s) decided whether to consume or sell own production? 1. Choose from the household roster (multiple choice allowed) >> ID/IDs 99. Other (specify)		What percentage of the total fish produced was not sold or consumed because of post-harvest losses?	Unit 1. viss 2. g 3. kg 4. single piece 5. kyattha
	code	code	amount	code	code	ID/IDs	percentage	

Fish feed use

	D41	D42	D43	D44	D45	D46	D47	D48
Facility number	What type(s) of fish feed did you apply in this facility and for this cycle? 1. Maize 2. Wheat bran 3. Soybean oil cake 4. Rice bran 5. Cooked rice 6. Broken rice 7. Molasses 8. Maize flour 9. Fishmeal 10. Powder feed 11. Starter feed 12. Grow-out feed 13. Finisher feed 99. Other (specify) (Select multiple. If none, put 0 and skip to D49.)	What source of feed was used? 1. Own farm 2. Male neighbor 3. Female neighbor 4. Relatives 5. Farmers group 6. Research institution 7. NGO 8. Government hatchery 9. Private hatchery 10. Local dealer (commission agent) 99. Other (specify)	How many miles is it from the homestead to the source of the feed?	What mode of transportation was used to source the feed? 1. Headload 2. Bicycle 3. Motorcycle 4. Oxcart 5. Boat 6. Car/truck 7. Public transportation 8. Wheelbarrow 9. Rickshaw/three-wheeler (non-motorized) 10. Auto rickshaw/three-wheeler (motorized) 11. Flight 99. Other (specify)	How much feed did you use?	Unit 1. basket 2. kg	What was the price (MMK) per unit of feed? (If not bought, ask for an estimate of the cost.)	What was the percentage of protein in the feed? 99. Don't know
	code	code	amount	code	amount	code	amount	amount

Use of fertilizer and other chemicals

	D49	D50	D51	D52
Facility number	What type(s) of fertilizer or chemicals did you apply? (Select multiple chemical codes. If none, put 0 and skip to D53.)	How much fertilizer or chemicals did you use?	Unit 1. kg 2. L	What was the price (MMK) per unit of fertilizer or chemical?
	code	amount	code	amount

Chemical code for D49:

1. Diammonium phosphate (DAP)
2. Triammonium phosphate (TSP)
3. Calcium ammonium nitrate (CAN)
4. Lime
5. Muriate of potash
6. Manure
7. Oxygen tablets
8. Antibiotics
9. Herbicides
10. Pesticides
11. Growth hormones
12. Probiotics
13. Water treatment chemicals
14. Gypsum
15. Urea
99. Other (specify)

Water exchange and sediment disposal

	D53	D54	D55	D56	D57	D58	D59
Facility number	Did you exchange or add water in this facility? 1. Yes 0. No (skip to D57)	How often did you exchange or add water in the facility during a cycle? 1. 1–2 times 2. 3–5 times 3. More than 5 times 99. Other (specify)	What was your rate of water exchange/ addition in feet each time?	Where did you discharge the water? 1. River 2. Lake 3. Floodplain 4. Drainage 5. Irrigation canal 6. Crop field 7. Reused in pond 8. Evaporated (no discharge) 99. Other (specify)	Did you dispose of the sediment from this facility? 1. Yes 0. No (skip to next facility/cycle)	In general, after how many cycles did you remove the sediment?	Where did you dispose of the sediment? 1. River 2. Dike 3. Crop field 99. Other (specify)
	code	code	amount	code	code	amount	code

Labor use and costs

			D60	D61	D62	D63	D64	D65	D66	D67	D68
Facility number		Activities	Which household member worked in this [ACTIVITY] in 2018? 1. Choose from the household roster (multiple choices allowed)	How many days did the household member work on this [ACTIVITY] in 2018?	On average, how many hours per day did the household member work on this [ACTIVITY]?	On average, how many person-days were men hired to work on this [ACTIVITY] in 2018?	On average, how many hours per day of hired male labor worked in a day on this [ACTIVITY]?	What was the price (MMK) per person-day of hired male labor for working on this [ACTIVITY]?	How many person-days were women hired to work on this [ACTIVITY] in 2018?	On average, how many hours did hired female labor work per day on this [ACTIVITY]?	What was the price (MMK) per person-day of hired female labor for working on this [ACTIVITY]?
			ID/IDs	amount	amount	amount	amount	amount	amount	amount	amount
1	**a**	Pond preparation and repair									
	b	Grading and stocking fingerlings									
	c	Feeding									
	d	Fertilizer application									
	e	Weeding									
	f	Irrigation and drainage									
	g	Harvesting									
	h	Drying, salting, etc.									

Additional expenses in aquaculture production

Now, I will ask you about other expenses your household may have incurred in different fish production activities that you undertook in 2018 and for the fish facilities that were stocked and completely harvested.

D69	D70	D71	D72	D73	D74	D75
Expenses [expense code]	Was this [EXPENSE] incurred for a specific species? 1. Yes 0. No (skip to D72)	If yes, for what species was this [EXPENSE] incurred? [fish code]	Was this [EXPENSE] incurred for a specific facility? 1. Yes 0. No (skip to D75)	If yes, for what facility was this [EXPENSE] incurred?	For what cycle was this [EXPENSE] incurred?	What was the total cost (MMK) of this [EXPENSE]?
code	code	code	code	code	code	amount

Expense code for D69: 1. Grid electricity 2. Liquefied petroleum gas (LPG) 3. Fuel (diesel, petrol, etc.) 4. Wood/charcoal	5. Water supply and draining out 6. Transportation cost for feed 7. Transportation cost for fish 8. Harvesting cost (excluding labor)	9. Renting land 10. Equipment purchase 11. Maintenance of equipment 99. Other costs (e.g. ropes, tubes, batteries, torches, etc.)

Mortality rate and fish disease in aquaculture

[Enumerators: Please describe what abnormal mortality means. Abnormal mortality generally means a loss of fish that makes the farmer worried, such as a farmer losing 5% of his fish at once. But if the 5% is lost, say, over a span of 9 months, it should not be considered an abnormal mortality. Abnormal mortality can also mean a loss of fish that starts and increases in intensity, making the farmer worried about the situation.]

D76. During the past 5 years, did you experience any major (abnormal) mortality of fish?
1. Yes 0. No (skip to E01)

D77. In what year(s) did you experience it?
1. 2018 2. 2017 3. 2016 4. 2015 5. 2014

D78. What do you think was the cause?

1. Transportation stress 2. Handling stress 3. Grading stress 4. Treatment stress (chemicals, antibiotics, others) 5. Sudden heavy rainfall 6. Flooding 7. Change in salinity	8. Sudden temperature fluctuation 9. Long exposure to abnormal water temperature (too cold, too hot) 10. Water quality stress (due to exogenous pollution) 11. Water quality stress (due to high levels of ammonia, nitrite, low oxygen, pH or other factors) 12. Bacterial disease 13. Viral disease 14. Parasitic disease	15. Introduced new species 16. After introducing new stock 17. Affected by neighboring pond 18. No suspected causes 19. Other diseases 99. Other (specify)

D79. What action(s) did you undertake to respond to the major (abnormal) mortality of fish?

1. Harvest all the fish	5. Salt
2. Drain and dry the pond	6. No intervention (did nothing)
3. Apply chemicals, antibiotics, probiotics	99. Other (specify)
4. Use aquaproducts for water treatment	

D80. If the farmer mentions disease as a cause of the major fish loss, ask how he knows that it was a disease and not the result of another cause?

[Enumerators: Please show farmer the pictures of clinical signs.]

Disease code for D80:

1. Lethargy	6. Gasping for air at the surface	11. Skin discoloration	16. Gills rot
2. Loss of balance	7. Eye opacification	12. Open wounds	17. Gills paleness (anemia)
3. Loss of appetite	8. Eye exophthalmia/pop-eye	13. Abdominal distension/swelling	18. Other (specify)
4. Swimming at the surface	9. Eye endophthalmia/eye shrinkage	14. Scale protrusion/detachment	
5. Erratic swirling	10. Skin erosions	15. Fin rot	

D81	**D82**	**D83**
What species of fish was lost because of the abnormal mortality (select multiple)?	How much fish (viss) was lost because of the abnormal mortality?	What was the value (MMK) of the fish lost because of the abnormal mortality?
fish code	amount	amount

Appendix B. Basic socioeconomic modules of questionnaire

Household composition

	C01	C02	C03	C04	C05	C06	C07
Facility number	Name of household member.	What is the relationship to the household head? 1. Household head 2. Spouse 3. Son/daughter/in-law 4. Stepson/ stepdaughter 5. Grandchild 6. Father-in-law/ mother-in-law 7. Other relative 8. Live-in servant 9. Other non-relative	Age	Sex 1. Male 0. Female	Marital status 1. Single 2. Married 3. Co-habiting 4. Widow/widower 5. Divorced/separated 99. Other (specify)	Highest level of education completed 0. Pre-school/no formal education 1. Grade 1 2. Grade 2 3. Grade 3 4. Grade 4 5. Grade 5 6. Grade 6 7. Grade 7 8. Grade 8 9. Grade 9 10. Grade 10 11. Grade 11 12. University student 13. Degree/diploma 14. PhD/master's 15. Vocational training 99. Other (specify)	In 2018, was [NAME] disabled or chronically ill? 1. Yes 0. No
	name	code	year	code	code	code	code

F. Food consumption and other expenditures

F01. Which household member prepares the food that the household consumes?
1. Choose from the household roster (multiple choices allowed) >> ID/IDs
99. Other (specify)

Code	ID/IDs

F02. Which household member decides the type and quantity of food that the household consumes?
1. Choose from the household roster (multiple choices allowed) >> ID/IDs
99. Other (specify)

Code	ID/IDs

F03. Please describe a typical food year for your household. For each month, which was the main source of the food you consumed?
1. Own farm
2. Other source

	January	February	March	April	May	June	July	August	September	October	November	December
F04. What was your source of food? [code: food_source]												
F05. Have you ever been faced with a situation when you did not have enough food to feed the household?												

Now we have a few more questions regarding how often the household ate certain foods during the PAST 7 DAYS.
[Enumerator: Explain to the respondent that you want the number of DAYS, not the number of times.]

During the past 7 days, how many days did the household eat [name of the food]? Meaning, how many days, starting with the last day (specify the day), did the household eat [name of the food]. [Enumerator: Remember that if the household ate the food at lunch and at dinner on the same day, that just counts as one day.]

		F14
	How many days during the 7 days prior to this interview did members of your household eat the following food items, prepared and/or consumed at home?	Days consumed (Write 0 if not consumed in the past 7 days)
		days
a	Cereals and grains: rice, pasta, bread and/or donuts, sorghum, millet, maize, wheat, rice noodles, rice snacks	
b	Roots and tubers: potato, yam, cassava, sweet potato, and/or other tubers, radish, arrow root, pemyit, palm shoot, palawpenan, *No Ko*	
c	Legumes/nuts: beans, cowpeas, peanuts, lentils, nut, soy, pigeon pea and/or other nuts, *sadwape* (green peas), *gram* (chickpeas), green gram (*pedesane*), black gram (*matpe*), butter bean, groundnut, coconut	
d	Orange-colored vegetables (vegetables rich in Vitamin A): carrot, red pepper, pumpkin, orange sweet potato, squash	
e	Green leafy vegetables: spinach, broccoli, amaranth and/or other dark green leaves, cassava leaves, water leaf, horseradish leaf, radish leaf, pumpkin leaf, mustard leaf, kinmoon, subok gourd leaf	
f	Other vegetables: onion, tomato, cucumber, radish, green beans, peas, lettuce, fresh chili, *kha we*, critics, cat tongue	
g	Orange-colored fruits (fruits rich in Vitamin A): mango, papaya, apricot, peach	
h	Other fruits: banana, apple, lemon, tangerine, guava, watermelon, rambutan (*kyetmouk*), pineapple, durian, pear, pomelo, orange, grapefruit, Sunkist, jackfruit, plum, grapes	
i	Meat (meaning, meat in large quantities and not as a condiment): goat, beef, chicken, pork, dry meat, goose meat	
j	Organ meat: liver, kidney, heart, offal and/or other organ meats	
k	Eggs: chicken eggs, duck eggs, quail eggs	
l	Milk and other dairy products: fresh milk/sour, yogurt, cheese, other dairy products (excluding margarine, butter or small amounts of milk for tea or coffee)	
m	Oil, fat, butter: vegetable oil, palm oil, groundnut oil, sesame oil, shea butter, margarine, other fats or oils	
n	Sugar or sweets: sugar, honey, jam, cakes, candy, cookies, pastries, cakes and other sweets (sugary drinks)	
o	Condiments or spices: tea, coffee, cocoa, salt, garlic, spices, yeast/baking powder, sauce, meat or fish as a condiment, condiments including small amounts of milk in tea or coffee	

Fish consumption

		F15	F16	F17	F18	F19	F20	
	Fish type	What type(s) of fish was consumed? 1. Fresh 2. Fermented 3. Dried 99. Other (specify)	How many days during the past 7 days did members of your household eat [FISH TYPE] that was prepared at home? (If not consumed in the past 7 days, write 0 and skip to next [FISH TYPE])	How many ticals of [FISH TYPE] did the household consume in the past 7 days that were from your own production?	How many ticals of [FISH TYPE] did the household consume in the past 7 days that were purchased?	How many ticals of [FISH TYPE] did the household consume in the past 7 days that were given by others?	Which household members consumed [FISH TYPE] at home in the past 7 days? 1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)	
		code	days	amount	amount	amount	code	ID/IDs
a	Tilapia							
b	Rohu							
c	Pangasius							

Expenditures on consumption items in the PAST MONTH

	Expenditures on consumption items in the past month	**F21**. During the past month, did you purchase any [PRODUCT] or pay for any service? 1. Yes 2. No (skip to next item)	**F22**. Total value (MMK) of expenditures on [PRODUCT]?
a	Fish		
b	Food (including fish)		
c	Rent paid for housing		
d	Electricity and water		
e	Charcoal, kerosene, etc.		
f	Transportation (tickets, etc.)		
g	Mobile phone card, postage, phone service, etc.		
h	Cigarettes and tobacco		

Expenditures on consumption items in the PAST 12 MONTHS

	Expenditures on consumption items in the past 12 months	**F23.** During the past 12 months, did you purchase any [PRODUCT] or pay for any service? 1. Yes 2. No (skip to next item)	**F24**. Total value (MMK) of expenditures on [PRODUCT]?
i	Clothing and shoes		
j	Education (school fees, books, expenses, etc.)		
k	Medical		
l	Furniture, mattress, etc.		
m	House repairs and maintenance		
n	Funerals, weddings, religious expenses		
o	Contribution to community projects		
p	Land tax and other taxes		
q	Other large purchases (more than MMK 5000)		

H. Information and credit

H01. In the past 12 months, did you or any member of your household borrow money or ask for financial support?
1. Yes 0. No (skip to H05)

H02. If yes, which household member decided to borrow credit or ask for financial assistance?
1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)

Code	ID/IDs

H03. Was the credit or financial support received?
1. Yes 0. No (skip to H05)

H04. Which household member is responsible for repaying the credit?
1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)

Code	ID/IDs

H05. In the past 12 months, were you or any member of your household a member of a farmers organization or group that is involved in fish farming?
1. Yes 0. No (skip to H07)

H06. What service(s) has your household received from participating in the group?
1. Inputs 2. Financial 3. Fish seed (fingerlings) 4. Training 5. Building ponds 6. Land 7. None 99. Other (specify)

H07. In the past 12 months, did you ever receive information about expected weather conditions that was useful for managing your fish farming activities?
1. Yes 0. No

J. Housing characteristics, asset ownership, income

J01. What is the main material of the outer wall of your household's house?

1. Thatch/large leaves/palm/dhani 2. Bamboo 3. Earth/mud 4. Wood 5. Tile/brick/concrete 99. Other (specify)

J02. What is the main material of the floor of your household's house?

1. Bamboo 2. Earth/mud 3. Wood 4. Tile/brick/concrete 99. Other (specify)

J03. What is the main material of the roof of your household's house?

1. Thatch/large leaves/palm/dhani 2. Bamboo 3. Earth/mud 4. Wood 5. Corrugated sheet (plastic/metal) 6. Tile/brick/concrete 99. Other (specify)

J04. What is the household's main source of water for drinking?

1	Public tap	5	Unprotected well/unprotected spring	9	Purified bottled water
2	Piped water into the house or compound	6	Pool/pond/lake	10	Tanker/truck
3	Tube well	7	River/stream/canal	99	Other (specify)
4	Protected well/spring	8	Rainwater collection/tank		

J05. What type of toilet facility does the household use?

1	Flush, to piped sewer system	5	Pit latrine with cover	9	Hanging toilet
2	Flush, to septic tank	6	Pit latrine without cover (open pit)	10	No facilities or bush or field
3	Flush, to pit latrine	7	Composting toilet	99	Other (specify)
4	Flush, to elsewhere	8	Bucket		

J06. Is this toilet shared with other households?

1. Yes 0. No

J07. What is the main source of lighting for your household?

1. Electricity 2. Kerosene 3. Candle 4. Battery 5. Generator 6. Water mill 7. Solar system 99. Other (specify)

J08. What is the main fuel used by your household for cooking?

1. Electricity 2. Liquefied petroleum 3. Kerosene 4. Firewood 5. Charcoal 6. Briquette 7. Straw/grass/animal dung 99. Other (specify)

J09. Which household member(s) owns the house?

1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)

Code	ID/IDs

J10. Whose names are listed on the ownership document of the house?

1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)

Code	ID/IDs

J11. Who decides on how to use the land (for example, when deciding on the size of land allocated for crop production, aquaculture or other activities)?

1. Single household member >> ID1 (skip to J13)   2. Jointly >> Choose from the household roster (multiple choices allowed)   99. Other (specify) (skip to J13)

Code	ID1/List all the IDs chosen

J12. If the decision is made jointly in I03, how is the use of land decided if the decision-makers cannot agree?

1. One person makes the final decision >> ID1   2. Majority rules   3. Do not change anything and follow the decision from the previous season   99. Other (specify)

Code	ID1

J13. What was the total agricultural land area that your household owned at the beginning of this cropping season?

J14. Units?   1. m^2 2. acres   3. hectares

J15. Whose names are listed on the ownership document of the agricultural land?

1. Choose from the household roster (multiple choices allowed) >> ID/IDs   99. Other (specify)

Code	ID/IDs

J16. What was the total agricultural land area that your household rented in at the beginning of this cropping season?

J17. Units?   1. m^2 2. acres   3. hectares

J18. What was the total agricultural land area that your household rented out at the beginning of this cropping season?

J19. Units?   1. m^2 2. acres   3. hectares

J20. What was the total agricultural land area that your household cultivated at the beginning of this cropping season?

J21. Units?   1. m^2 2. acres   3. hectares

		J22	J23
		Does anyone in the household have [ASSET]? 1. Yes 0. No (skip to next asset)	How many [ASSET] do you have in the household?
		code	amount
a	Refrigerator		
b	Television		
c	Computer		
d	Car/pickup truck		
e	Motorcycle		
f	Tractor		
g	Boat		
h	Generator/battery		
	…		

		J24	J25		J26	
Activities		Approximately what percentage of total household net income came from [ACTIVITY] in 2018? (If none, put 0 and skip to the next activity)	Which household member(s) worked in the [ACTIVITY]? 1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)		Which household member(s) decided how the money from [ACTIVITY] is spent? 1. Choose from the household roster (multiple choices allowed) >> ID/IDs 99. Other (specify)	
		percentage	code	ID/IDs	code	ID/IDs
a	Fish production					
b	Crop production					
c	Livestock production					
d	Business					
e	Full-time employment					
f	Part-time employment					
g	Remittances					
	…					

Appendix C. Sample ODK coding from basic socioeconomic modules

type	name	label::Engli	hint::Englis	hint::Burme	appearance	constraint	relevance	calculation	choice_filte	repeat_cou	constraint n	constraint n	required	default
start	start	Automatic start time												
deviceid	id	ID of the device												
begin grou	**Section_F**	**FOOD CONSUMPTION AND OTHER EXPENDITURE**					**${B01} = 1**							
select_multip	F01	Which household member prepares the food that the household consumes?							name <= ${C00}				yes	
select_multip	F02	Which household members decide the type of food and the quantity of food that the househ							name <= ${C00}				yes	
note	note445_2	**I would now like to ask you to describe a typical food year for your household. For each month say whether the food you consume is mainly:**												
select_one fo	F03a	Source of food January											yes	
select_one fo	F03b	Source of food February											yes	
select_one fo	F03c	Source of food March											yes	
select_one fo	F03d	Source of food April											yes	
select_one fo	F03e	Source of food May											yes	
select_one fo	F03f	Source of food June											yes	
select_one fo	F03g	Source of food July											yes	
select_one fo	F03h	Source of food August											yes	
select_one fo	F03i	Source of food September											yes	
select_one fo	F03j	Source of food October											yes	
select_one fo	F03k	Source of food November											yes	
select_one fo	F03l	Source of food December											yes	
select_one y	F04a	Do you experience a shortage of food or difficulty to feed your household in January?											yes	
select_one y	F04b	Do you experience a shortage of food or difficulty to feed your household in February?											yes	
select_one y	F04c	Do you experience a shortage of food or difficulty to feed your household in March?											yes	
select_one y	F04d	Do you experience a shortage of food or difficulty to feed your household in April?											yes	
select_one y	F04e	Do you experience a shortage of food or difficulty to feed your household in May?											yes	
select_one y	F04f	Do you experience a shortage of food or difficulty to feed your household in June?											yes	
select_one y	F04g	Do you experience a shortage of food or difficulty to feed your household in July?											yes	
select_one y	F04h	Do you experience a shortage of food or difficulty to feed your household in August?											yes	
select_one y	F04i	Do you experience a shortage of food or difficulty to feed your household in September?											yes	
select_one y	F04j	Do you experience a shortage of food or difficulty to feed your household in October?											yes	
select_one y	F04k	Do you experience a shortage of food or difficulty to feed your household in November?											yes	
select_one y	F04l	Do you experience a shortage of food or difficulty to feed your household in December?											yes	
end group														
begin grou	**Section_F3**	**FISH CONSUMPTION**					**${B01} = 1**							
note	note449	**Now, I will ask you about consumption of fish by your household**												
select_multip	fishtypes	Fish types											yes	
text	otherfish1	Other type of fish					selected(${fishtypes},'99')						yes	
text	otherfish2	Other type of fish					selected(${fishtypes},'999')						yes	
text	otherfish3	Other type of fish					selected(${fishtypes},'9999')						yes	
text	otherfish4	Other type of fish					selected(${fishtypes},'99999')						yes	
text	otherfish5	Other type of fish					selected(${fishtypes},'999999')						yes	
begin repea	**R4**	**Fish consumed**								count-selected (${fishtypes})				
calculate	calc_fish							selected-at (${fishtypes}, (position(..)-1))						
calculate	calc_fishcons							(${calc_fish}=9						
select_multip	F15	In what form was the ${calc_fishcons} consumed?											yes	
text	F15oth	Please speci					selected(${F15},'99')						yes	
integer	F16	How many days during the past 7 days, did member				.<8							yes	
decimal	F17	Quantity of ${calc_fishcons} consumed by the household in that 7-day period that was from own production											yes	
select_one fi	F17a	Unit for quantity of ${calc_fishcons} consumed					${F17}>0						yes	
decimal	F17b	Quantity of ${calc_fishcons} consumed by the household in that 7-day period that was caught from the wild											yes	
select_one fi	F17c	Unit for quantity of ${calc_fishcons} consumed from the wild					${F17b}>0						yes	
decimal	F18	Quantity of ${calc_fishcons} consumed by the household in that 7-day period that was purchased											yes	
select_one fi	F18a	Unit for quantity of ${calc_fishcons} consumed from purchases					${F18}>0						yes	
decimal	F19	Quantity of ${calc_fishcons} consumed by the household in that 7-day period that was given by others											yes	
select_one fi	F19a	Unit for quantity of ${calc_fishcons} given by others					${F19}>0						yes	
select_multip	F20	Which household members consumed ${calc_fishcons} at home in that 7-day period?							name <= ${C00}				yes	
end repeat														
end group														
begin grou	**Section_F4**	**Expenditure on consumption items in the PAST 1 MON**					**${B01} = 1**							
select_multip	F21	During the past 1 month, did you or anyone in your household purchase any of the following items or paid for any of the following services?											yes	
begin repea	**R5**	**Consumption items (monthly)**								count-selected (${F21})				
calculate	check25							name(selected-						
decimal	F22	Total cost of expenditures on ${check25} (Kyat)?					not(selected(${F21},'88'))						yes	
end repeat														
end group														
begin grou	**Section_F5**	**Expenditure on consumption items in the PAST 12 MO**					**${B01} = 1**							
select_multip	F23	During the past 12 month, did you or anyone in your household purchase any of the following items or paid for any of the following services?											yes	
begin repea	**R6**	**Consumption items (annually)**								count-selected (${F23})				
calculate	check26							name(selected-						
decimal	F24	Total cost of expenditures on ${check26} (Kyat)?					not(selected(${F23},'88'))						yes	
end repeat														
end group														
begin grou	**Section_H**	**INFORMATION AND CREDIT**					**${B01} = 1**							
select_one y	H01	In the last 12 months, did you or any member of your household borrow money or ask for financial support?											yes	
select_multip	H02	Which household member decided to borrow credit or ask for fina					selected(${H01},'1')		name <= ${C00}				yes	
select_one y	H03	Was the credit or financial support received?					selected(${H01},'1')						yes	
select_multip	H04	Which household member is responsible for repaying the credit?					selected(${H03},'1')		name <= ${C00}				yes	
select_one y	H05	In the last 12 months did you or any member of your household participate in a farmers' organization or group that is involved with fish farming?											yes	
select_multip	H06	What service(s) has your household received from participating ir					selected(${H05},'1')						yes	
text	H06a	Other service received.					selected(${H06},'99')						yes	
select_one y	H07	In the last 12 months did you ever receive information about expected weather conditions that was useful for managing your fish farming activitie											yes	
end group														

begin grou	Section_J	**HOUSING CHARACTERISTICS, ASSETS OWNERSHIP, /**		**${B01} = 1**				
select_one v	J01	What is the main material of the outer wall of your household's house?						yes
text	J01a	Other type of wall material.		selected(${J01},'99')				yes
select_one fl	J02	What is the main material of the floor of your household's house?						yes
text	J02a	Other type of floor material.		selected(${J02},'99')				yes
select_one r	J03	What is the main material of the roof of your household's house?						yes
text	J03a	Other type of roof material.		selected(${J03},'99')				yes
select_one v	J04	What is the main source of water used by the household for drinking?						yes
text	J04a	Other source of water for drinking.		selected(${J04},'99')				yes
select_one t	J05	What type of toilet facility is used by the household?						yes
text	J05a	Other type of toilet facility.		selected(${J05},'99')				yes
select_one y	J06	Is this toilet shared with other households?						yes
select_one li	J07	What is the main source of lighting for your household?						yes
text	J07a	Other source of lighting for the household.		selected(${J07},'99')				yes
select_one fi	J08	What is the main fuel used by your household for cooking?						yes
text	J08a	Other type of fuel used by household.		selected(${J08},'99')				yes
select_multip	J09	Which household member(s) own the house?				name <= ${C00} or name = 99		yes
select_one y	J09a	Is there an ownership document for the house owned?						
select_multip	J10	Whose names are listed on the ownership document of the house		selected(${J09a},'1')		name <= ${C00} or name = 99		yes
select_multip	J11	Who decides on how to use the land (for example, deciding on the size of land allocated for				name <= ${C00} or name = 99		yes
select_one d	J12	How is the use of land decided if the decision makers cannot agr		count-selected (${J11})>1				yes
select_one h	J12a	Who makes final decision?		selected(${J12},'1')				yes
text	J12b	Specify other ways land use decision is decided		selected(${J12},'99')				yes
decimal	J13	What was the total agricultural land area that your household owned at the beginning of this cropping season?						yes
select_one la	J14	Unit of land						yes
select_one y	J14a	Is there an ownership document for the agricultural land owned?						
select_multip	J15	Whose names are listed on the ownership document of the agricu		selected(${J14a},'1')		name <= ${C00} or name = 99		yes
decimal	J16	What was the total agricultural land area that your household rented in at the beginning of this cropping season?						yes
select_one la	J17	Unit of land		${J16}>0				yes
decimal	J18	What was the total agricultural land area that your household rented out at the beginning of this cropping season?						yes
select_one la	J19	Unit of land		${J18}>0				yes
decimal	J20	What was the total agricultural land area that your household cultivated at the beginning of this cropping season?						yes
select_one la	J21	Unit of land		${J20}>0				yes
note	note453	**Now I would like to ask you some questions about the different assets that your household may be having**						
select_multiple a	J22	Which of the following assets are currently owned by you or any other member of the household?						yes
begin repeat	R7	**Assets currently owned**					**count-selected (${J22})**	
calculate	check27				name(selected-			
integer	J23	How many of ${check27} do you have in the household?						yes
end repeat								
decimal	J24a	What is approximately the percentage of total house	.<101					yes
select_multip	J25a	Which household member(s) worked in fish production?		${J24a}>0		name <= ${C00}		yes
select_multip	J26a	Which household member(s) decided how the money from fish pr		${J24a}>0		name <= ${C00}		yes
decimal	J24b	What is approximately the percentage of total house	.<101					yes
select_multip	J25b	Which household member(s) worked in crop production?		${J24b}>0		name <= ${C00}		yes
select_multip	J26b	Which household member(s) decided how the money from crop p		${J24b}>0		name <= ${C00}		yes
decimal	J24c	What is approximately the percentage of total house	.<101					yes
select_multip	J25c	Which household member(s) worked in livestock production?		${J24c}>0		name <= ${C00}		yes
select_multip	J26c	Which household member(s) decided how the money from livestc		${J24c}>0		name <= ${C00}		yes
decimal	J24d	What is approximately the percentage of total house	.<101					yes
select_multip	J25d	Which household member(s) worked in business?		${J24d}>0		name <= ${C00}		yes
select_multip	J26d	Which household member(s) decided how the money from busine		${J24d}>0		name <= ${C00}		yes
decimal	J24e	What is approximately the percentage of total house	.<101					yes
select_multip	J25e	Which household member(s) worked in full-time employment?		${J24e}>0		name <= ${C00}		yes
select_multip	J26e	Which household member(s) decided how the money from full-tim		${J24e}>0		name <= ${C00}		yes
decimal	J24f	What is approximately the percentage of total house	.<101					yes
select_multip	J25f	Which household member(s) worked in part-time employment?		${J24f}>0		name <= ${C00}		yes
select_multip	J26f	Which household member(s) decided how the money from part-ti		${J24f}>0		name <= ${C00}		yes
decimal	j24g	What is approximately the percentage of total house	.<101					yes
decimal	J24h	What is approximately the percentage of total house	.<101					yes
calculate	calc_income	Total percentage of income allocation			${J24a} + ${J24b} + ${J24c} + ${J24d} + ${J24e} + ${J24f}+${j24			yes
note	inc_allocatio	**Total allocation of income: ${calc_income}. Please confirm**		${calc_income}>100				yes
select_multip	J25h	Which household member(s) worked in other sources?		${J24h}>0		name <= ${C00}		yes
select_multip	J26h	Which household member(s) decided how the money from other s		${J24h}>0		name <= ${C00}		yes
end group								
end	end							

Appendix D. Qualitative scoping tool: Gender in aquaculture

Tool 1: Demographic and wealth ranking

Focus
Understanding the actors and the case (intervention) and identifying potential households for involvement in other tools.

Respondents
Community leaders or other key informants.

Key points

PART 1.1: Adapted wealth ranking/household economy tool

Purpose
1. To understand the socioeconomic composition of the community, particularly wealth groups, other key social or livelihood categories, and relations between groups.
2. To identify households from each wealth category for involvement in interviews.

How
1. Ask key informant to describe characteristics of households in "poor" and also (versus) "medium" or "high" wealth groups (e.g. income, size of landholding/ponds, enough food for X amount of time, other).
2. Ask them to indicate the names of at least 12 or so households in the poor wealth group and 12 or so in the medium and high wealth groups. These people must be involved in the type of aquaculture relevant to the specific case study and would be willing to be involved in the interviews.
3. Ask for more background on how wealth groups relate to different livelihoods in the community, and other key context-relevant social categories (e.g. migrant or none-migrant, religion, ethnicity or other).
4. If possible (not sensitive), ask for more information on the relationships between different groups.

PART 1.2: Discussion of case and context

Purpose
To familiarize with the case (e.g. intervention) and context.

How
Key informant interview, discussion points:
1. Regarding the role of aquaculture in the community and in relation to the different wealth and other groups, how significant is it for subs and for income (and for other) who is involved in aquaculture and who is not? (types of households * wealth groups)
2. Outline the history of aquaculture in the community? Specifically, what, why, who, how (types/practices), services, inputs, markets, etc.
3. What are the key innovations (technologies, practices, etc.)?
4. What are the issues, challenges and successes?
5. What are the roles for women and men? If known, how many women and men are in these roles? Why these roles? Are there any outliers? Specifically, are there any women who engage in non-traditional ways? Have there been any changes in these roles? Why have they changed?
6. Walk around, make introductions and field observations.

Tool 2: Gender roles and responsibilities

Method of data collection: Interviews

Demographic details

1. District
2. Village/community
3. Type of beneficiaries
4. Gender
5. Name of respondents
6. Age of respondents

2.1. Gender roles and responsibilities

The proposed interviews will identify the gender division of labor within aquaculture-related activities and the household. It will also probe gender norms that inform expectations about appropriate practices for women and men within the study community with regards to their engagement in aquaculture. It will investigate whether women and men are able to participate in the intervention given the social challenges and opportunities that exist. It will also identify the positive implications (i.e. income, social status, better relationships, etc.) as well as risks and negative implications (i.e. time burden, unappealing roles, social stigmas) that could result from implementing the intervention.

2.1.1. Roles matrix for the gender division of labor.

Tasks [Enumerator: ask the group to give… (from within the household to end of the value chain/ selling)	How long (days/ season or hours/day) does it take to complete this role?	Who performs this role?				Why?	What kinds of abilities/ skills are required to perform this role?
		Female		Male			
		Household member	Hired labor	Household member	Hired labor		
Fish farming							
Pond preparation							
Digging the pond							
Clearing the pond of weeds							
Removing mud and repairing dikes							
Liming							
Using manure							
Filling with water							

Tasks [Enumerator: ask the group to give… (from within the household to end of the value chain/ selling)	How long (days/ season or hours/day) does it take to complete this role?	Who performs this role?				Why?	What kinds of abilities/ skills are required to perform this role?
Removing predatory fish							
Buying and stocking mola and carp seed							
Buying fish feed							
Making fish feed							
Feeding fish							
Buying fertilizer, lime							
Harvesting fish from the pond							
Harvesting for household consumption							
Harvesting for sale							
Dike cropping for cultivating vegetables							
Pond monitoring and security							
Selling fish at the market							
Attending training on aquaculture							
Other							

2.1.2. Positive and negative outcomes

Looking at the distribution of these roles for [gender of informant]:

1. Which roles generate the most benefits? Why?
2. Which roles generate the most costs? Why?
3. Which roles generate the most risks? Why?

Looking at the distribution of these roles for [opposite gender of informant]:

1. Which roles generate the most benefits? Why?
2. Which roles generate the most costs? Why?
3. Which roles generate the most risks? Why?

2.1.3. Non-typical roles

Deviators (non-typical roles)

Looking at the distribution of roles, are there any examples of women doing non-typical roles?

Please describe the type of role and the type of women doing this? [Interviewer: Probe for age, marital status, religion, caste, wealth, etc.]

- How does it affect the household's well-being? What is the opinion of other household members or community members?

Looking at the distribution of roles, are there any examples of men doing non-typical roles? Please describe the type of role and type of men doing this. [Interviewer: Probe for age, marital status, religion, caste, wealth, etc.]

- How does it affect the household's well-being? What is the opinion of other household members or community members?

2.1.4. Wrap-up: Overview of the benefits and costs

1. Benefits
    a. Overall, what are the most important benefits/positive outcomes (e.g. income, food for family, other) for women from being involved in aquaculture, including its individual production activities? Why are these important?
    b. Are they the same for different women (poorer/wealthier; other)?
    c. Are they the same for different men? (poorer/wealthier; other)?

2. Costs
    a. Overall, what are the most serious costs, such as financial, time or opportunity costs (things given up, such as time to prepare healthy food) for women from being involved in GIFT aquaculture, including its individual production activities? Why are these costs significant?
    b. Overall, what are the most serious risks (e.g. getting into the water or harassment going to market) for women? Why are these risks significant?
    c. Are they the same for different types of women (poorer/wealthier; other)?
    d. Are they the same for men? Are there any differences across different types of men (poorer/wealthier; other)?

Tool 3: Enabling and constraining factors

Purpose
To identify enabling and constraining factors for women to participate in and benefit from the intervention and how this differs for different types of women. To understand how this might differ for men.

3.2.1. Factors regarding participation in aquaculture as a livelihood strategy (participation generally)

1. Why do [gender of informant] choose to engage in this type of fish farming (i.e. this case) for their livelihoods?
2. How is this different for the [opposite gender of informant]?
3. How is it different for [different types of gender of informant]? [Interviewer: Probe for differences for different types of women/different types of men.]

4. How does undertaking this type of fish farming compare with other livelihood strategies for women and men? [Interviewer: Probe for why fish farming is preferred more or preferred less for [gender of informant] compared to other livelihoods.]
5. How easy or difficult is it for women to engage in this type of fish farming?
   a. What factors make it easy?
   b. What factors make it difficult?
   c. Are these factors different for men? If so, how and why?
   d. Are there any differences depending on the type of woman you are? [Interviewer: Probe for age, marital status, religion, caste, etc.]
6. Would [gender of informant] want to do more or participate more in or with this type of fish farming? If no, why? If yes, in what way and why?
   a. What is stopping them?
   b. What would it take to enable them?

3.2.2. Factors enabling and constraining "success" for women with pond polyculture (outcome of participation)

1. What is their vision of success regarding the intervention? For example: Is it just food for the family in X times, X amount of income? Is it to become a business owner? Is it to gain the respect of the community? Other?
2. What factors (meeting their income goals, becoming a business owner, other) enable women to be "successful" regarding the intervention?
   a. What helps them? Having a supportive spouse? Access to credit? Education?
   b. Is this the same or different for all women? Why? How?
3. What limits, hinders or stops women from being successful at fish farming?
   a. Are these supporting and limiting factors the same or different for different types of women? Why? How?
   b. Is this the same or different for men? Why? How?
   c. Are there any examples of women who have overcome these challenges or limiting factors? Which women? Describe them. Why and how?
   d. If there are some women who have not been able to overcome them, what would need to happen for them to be able to do so? For example: policy change, change in norms or relations, access to land, other.

Tool 4: Access to and control over resources

Purpose
To identify which resources are most important for engagement in fish farming and how these are gendered. To identify gender differences in access to, ownership of and control over resources, including money and resources that are required for fish production.

Process
1. **LIST**: What are the most important resources or services for the fish farming being successful or beneficial? [Enumerator to list down using the guidance of matrix]
2. **RANK** the top three most important resources or services and discuss why.

3. **PROBE**: Who has access? Why? What are the implications in terms of who benefits and who does not? [Interviewer: Probe how it is specific for women, different from men and intersectionality.]

   For each gain listed, discuss and write down:

   - Who controls it? Meaning, who decides what to do with it?
   - Who benefits from it? How?
   - What factors influence whether or not a woman can control and benefit from the gain?

Tool 5: Decision-making

Purpose

To explore decision-making processes within the household to identify who decides how and on what [additional] income is spent, as well as food and other relevant decisions.

No.	Decision areas
1	Investing for aquaculture inputs (fish seed, feed, fertilizer, nets, other)
2	Buying or leasing a pond
3	Which varieties of fish to stock
4	How to deal with an aquaculture production problem
5	When to harvest fish
6	How much of the produce to sell and how much to keep for consumption
7	Which market and who to sell the fish to
8	What price to sell the fish for
9	Income from selling the fish (fresh)
10	Women getting involved in fish farming outside the homestead
11	Women getting involved in fish farming inside the homestead

For each decision-making area in the matrix above, ask the following questions:

a. How does your family typically make decisions about this issue?
   - Who is involved in the decision-making process?
   - How are they involved? Are they informed, consulted? Do they have a final say?
   - [Interviewer: Probe about who has a say, whether children, other relatives such as uncles, aunts and parents-in-law, religious or community leaders, etc.]

b. If there is disagreement, whose opinion usually prevails?

c. What types of issues usually influence the decision? Specifically, what issues matter around making the decision?

WorldFish CGIAR

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

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