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Productivity and profitability performance of small-scale tilapia aquaculture in Myanmar

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List of abbreviations

BC	benefit-cost
BCR	benefit-cost ratio
FCR	feed conversion ratio
GIFT	Genetically Improved Farmed Tilapia
SGR	specific growth rate

Executive summary

Among the world's major aquaculture-producing countries, Myanmar ranked ninth in fish consumption and 11th in seafood consumption, per capita in 2017 (FAO 2022). Fish is a critical source of animal protein and micronutrients in Myanmar, with an average annual per capita fish consumption estimated at 30 kg (WorldFish 2017). However, although the country's rapidly growing aquaculture sector is playing a vital role in increasing fish supply, it constitutes the smallest proportion of total fish production, so its share is still below that of captured fish (FAO 2022).

Still, aquaculture is growing in Myanmar. From 2010 to 2019, the sector experienced an average annual growth rate of 4.4% (FAO 2021). Looking at fish demand, if household income increases, fish consumption from aquaculture is projected to grow faster than other sources because of its higher income elasticity of demand (Aung et al. 2022). Aquaculture is regarded as an essential contributor to livelihood opportunities of households, especially in regards to increasing the income of small-scale farmers, providing food and nutrition security, increasing employment opportunities, and empowering women.

To promote the sustainable development of aquaculture in Myanmar, WorldFish and its partners implemented the Scaling Systems and Partnerships for Accelerated Adoption of Improved Tilapia Strains (SPAITS) project, funded by the German Federal Ministry for Economic Cooperation and Development and commissioned by the Deutsche Gesellschaft für Internationale Zusammenarbeit through the Fund International Agricultural Research. The goal was to increase the adoption of improved tilapia strains among poor fish producers and deliver improved productivity and profitability of small-scale aquaculture so that poor producers, particularly women, are able to exit poverty and natural resource systems are improved to sustain future fish production. The project's purpose is to design systems that accelerate the dissemination and adoption of improved tilapia strains and aquaculture management practices developed by WorldFish, based on relevant gender-sensitive and contextual knowledge, that will enable poor small-scale fish farmers to have access to, adopt and benefit from improved strains of tilapia.

SPAITS operates in three countries: Bangladesh, Malawi and Myanmar. In Myanmar, specifically, the project has three objectives:

1. Assess the performance of small-scale aquaculture, particularly of improved tilapia strains, within the country's real farming contexts to generate scientific evidence, technical guidelines and scientific publications.
2. Together with national partners, develop a strategy to build the country's capacity for developing and disseminating improved tilapia strains and good aquaculture practices.
3. Deploy capacity building interventions through training sessions, workshops and digital learning platforms to disseminate project findings to policymakers and aquaculture value chain stakeholders to accelerate the adoption of improved tilapia strains among small-scale fish farmers.

As an activity of the project, this study focuses on assessing the performance of small-scale tilapia aquaculture operated by aquaculture households in Myanmar. To this end, it attempts to address four key research questions:

1. What characterizes existing aquaculture production systems in Myanmar?
2. How do these systems perform in terms of productivity, profitability and benefit-cost (BC) at the farm level?
3. Which of these systems has the potential to contribute sustainably to household income in the country?
4. How do households in different aquaculture production systems view climate changes and adapt to climatic shocks that affect aquaculture farms?

The overall findings of the study are as follows:

- Among the surveyed households, 21% cultured an improved strain of tilapia seed known as Genetically Improved Farmed Tilapia (GIFT), 46% stocked non-GIFT and the remaining 33% stocked other fish species.
- As the average pond size among surveyed farmers was approximately 0.34 ha, their aquaculture production systems are considered small-scale facilities.
- The demographics of household heads are not significantly different among the three household groups.
- In terms of the proportion of households that adopted aquaculture practices (monoculture or polyculture) and GIFT, the aquaculture production systems of small-scale farmers in Myanmar are still technologically underdeveloped.
- Looking at the productivity of GIFT and non-GIFT at the pond level, the daily growth rate and survival rate of GIFT are both significantly higher than that of non-GIFT. For this reason, the average productivity per hectare of GIFT is significantly higher than non-GIFT, making aquaculture the main source of income rather than a subsistence source of consumption.
- In terms of BC analysis, GIFT farmers had a higher benefit-cost ratio (BCR) than non-GIFT farmers and those who farmed other species because of the higher productivity and low operation costs associated with culturing GIFT. Compared to GIFT in Bangladesh (Tran et al. 2021), the BCR in this study was relatively higher. However, it should be noted that geographic price differences led to GIFT being sold at significantly lower prices than non-GIFT.
- As almost half of the farmers are aware of climate changes, they adopted adaptation strategies to mitigate climatic shocks. The most common strategies are harvesting fish early, monitoring water quality and moving fish between sites.
- More than half of all farmers implemented improved pond management practices because this is one of the most important strategies to improve aquaculture production.
- The high demand for fish is an important motivation for small-scale farmers to engage in food certification schemes.
- Fish is the second-most important source of income among farmers, with GIFT farmers having the largest share of income from fish.
- Almost half of all households participate in farmer groups, with access to information on weather conditions highest among GIFT households.
- The risk preference of farmers is most likely risk-averse.
- Farmers allocate the largest share of the land that they own to crop production, followed by aquaculture.
- Knowledge and findings from this study improved the performance of aquaculture production systems in Myanmar. To further support the development of small-scale aquaculture in the country, it is important to emphasize appropriate investment and interventions, such as fish breeding and genetic improvement programs to provide good quality seed.

Introduction

As the largest country in Southeast Asia, Myanmar has abundant freshwater and marine water resources that cover 8.1 million ha of lakes, rivers and reservoirs (FAO 2019). The aquaculture and fishery sectors play a vital role in the country's economy, accounting for 2% of the gross domestic product and generating approximately 6% of total employment (World Bank 2019). In terms of its income elasticity, fish demand from all fishery sources has increased with income (Aung et al. 2022), so the country's fish production has grown to meet the demand both locally and internationally. Overall, domestic fish production increased approximately four-fold over 30 years, from 700,000 t in 1990 to 3 million metric tons in 2019 (FAO 2022). Fish also provides about half of all animal-sourced food for household consumption and is a critical source of nutrients in Myanmar (Belton et al. 2015). Overall, the sector plays an essential role in economic growth, job creation, and food and nutrition security in the country (Tezzo et al. 2018).

In Myanmar, aquaculture is comprised of the freshwater, brackish water and marine subsectors. Since 1990, the industry has experienced substantial growth in terms of total output, growing at 18.9% annually compared to only 3.4% for capture fisheries (FAO 2022). In 2019, aquaculture produced 1.14 million metric tons of fish, making up 38.2% of total production (FAO 2022). Compared to capture fishery groups, farmed fish consumption is the most income-responsive because of its higher elasticity of demand. This suggests that increasing the supply of fish from aquaculture could compensate somewhat for declining and stagnant capture fish production to meet the increase in demand from changes in income growth.

In addition to this, a substantial share of increasing demand is likely to come from poor and rural households because of their higher income elasticity of demand. Therefore, reducing the costs of aquaculture production with a corresponding decrease in market prices is a development strategy that would benefit poor and rural households. Likewise, investing in aquaculture to increase supply, which reduces the price of aquaculture fish and contributes to growth in total fish consumption, would be pro-poor in terms of growth (Aung et al. 2022).

As Myanmar's aquaculture sector is dominated by pond-based commercial farms, the size of aquaculture production in the country varies from small scale to large scale. Although several factors, such as restrictive land-use policies and poor infrastructure, have limited the expansion of small-scale aquaculture, profitability, employment opportunities and low entry costs have all resulted in high growth rates in the quantity and area of small-scale aquaculture (Belton et al. 2015). Compared to large-scale aquaculture producers, research shows that small-scale fish farmers generate a larger income spillover per acre of ponds (Filipski and Belton 2018). Furthermore, small-scale aquaculture mainly caters to the local market and contributes directly to local food security (LEI Wageningen UR 2012; World Bank 2019).

In Myanmar, small-scale farmers get higher yields from tilapia than does large-scale aquaculture (Belton et al. 2015). However, a lack of access to quality seed has restricted their development. To develop small-scale tilapia farming in Myanmar, WorldFish provided GIFT to small-scale farmers in a selected study area through various projects, such as MyCulture and INLAND MYSAP (WorldFish 2019 and 2021). To continue promoting the adoption of GIFT strains, it is essential to understand the overall impacts of GIFT.

In this study, we use a survey sample of small-scale aquaculture farmers in Myanmar to evaluate the performance of aquaculture and the overall socioeconomic effects of GIFT. This report highlights key findings from an aquaculture performance assessment, including input characteristics, productivity characteristics and a cost-benefit analysis at the pond level. It also summarizes many other socioeconomic indicators among households, such as food security, recognition of climate change among farmers, adaptation to climatic shocks, pond management strategies, awareness and participation in food certification schemes, access to information, risk preference, land allocation for activities, and share of income.

1. Methodology

In this study, we applied a primary data collection approach using a survey questionnaire to assess the aquaculture performance of GIFT and non-GIFT at the pond level. The survey instrument was adapted from the SPAITS baseline survey conducted in 2019 (Zeller et al. 2020), comprising the following modules: general household characteristics, details of aquaculture production, and other socioeconomic indicators.

In the general section, respondents were asked about the characteristics of each household member, such as age, gender and education level. In the following section, respondents were asked to provide details of their most recent fish farming cycle. This included information on their pond, fishstocking and harvest, quantity and source of inputs, labor composition, fish mortality rate and management practices. At the farmer and household level, other socioeconomic indicators were asked in the survey. These included recognition and adaptation among farmers to climatic shocks, household food security status, fish consumption, food safety and certification, access to information and credit, risk preference, and how households allocate land and income.

For the study, convenience and snowball sampling techniques were used to select the survey sample. We used preexisting farmer lists from completed and ongoing aquaculture projects implemented in Myanmar, such as SPAITS, MYCulture, Fish for Livelihoods, and MYSAP Inland, to select a total of 649 small-scale farmers from across the following regions: Ayeyarwady, Keng Tung, Mandalay, Sagaing and Shan State.

Based on the classification of previous projects at the time, 390 of the respondents were GIFT farmers and 259 were non-GIFT farmers. However, because of the unstable situation in Yinmarbin District and Eastern Shan State, 92 respondents from the existing farmer list were dropped. During the survey period, we added 58 new respondents from the Ayeyarwady region using a snowball sampling technique. This left us with a total of 615 farmers as our sample size, of which 576 consented to proceed with the interview. Of these 576 farmers, 83 are based in the Ayeyarwady region, 225 in Mandalay, 101 in Sagaing and the remaining 206 in Shan State.

Since the survey questionnaire was based on the most recent fish farming cycle, we reclassified the farmers from previous projects into three groups based on the types of fish stocked in their last completed fish farming cycle: GIFT, non-GIFT and other fish species. Therefore, the current study consists of 120 GIFT farmers, 265 non-GIFT farmers and 191 farmers of other fish species. Table 1 and Figure 1 provide the total number and percentage of farmers, separated into GIFT, non-GIFT and other fish species in different states and regions in Myanmar.

State/Region	GIFT	Non-GIFT	Other fish species
Ayeyarwady	29	10	44
Mandalay	19	51	125
Sagaing	70	1	21
Shan	2	203	1
Total	120	265	191

Table 1. Total number of farmers in the study.

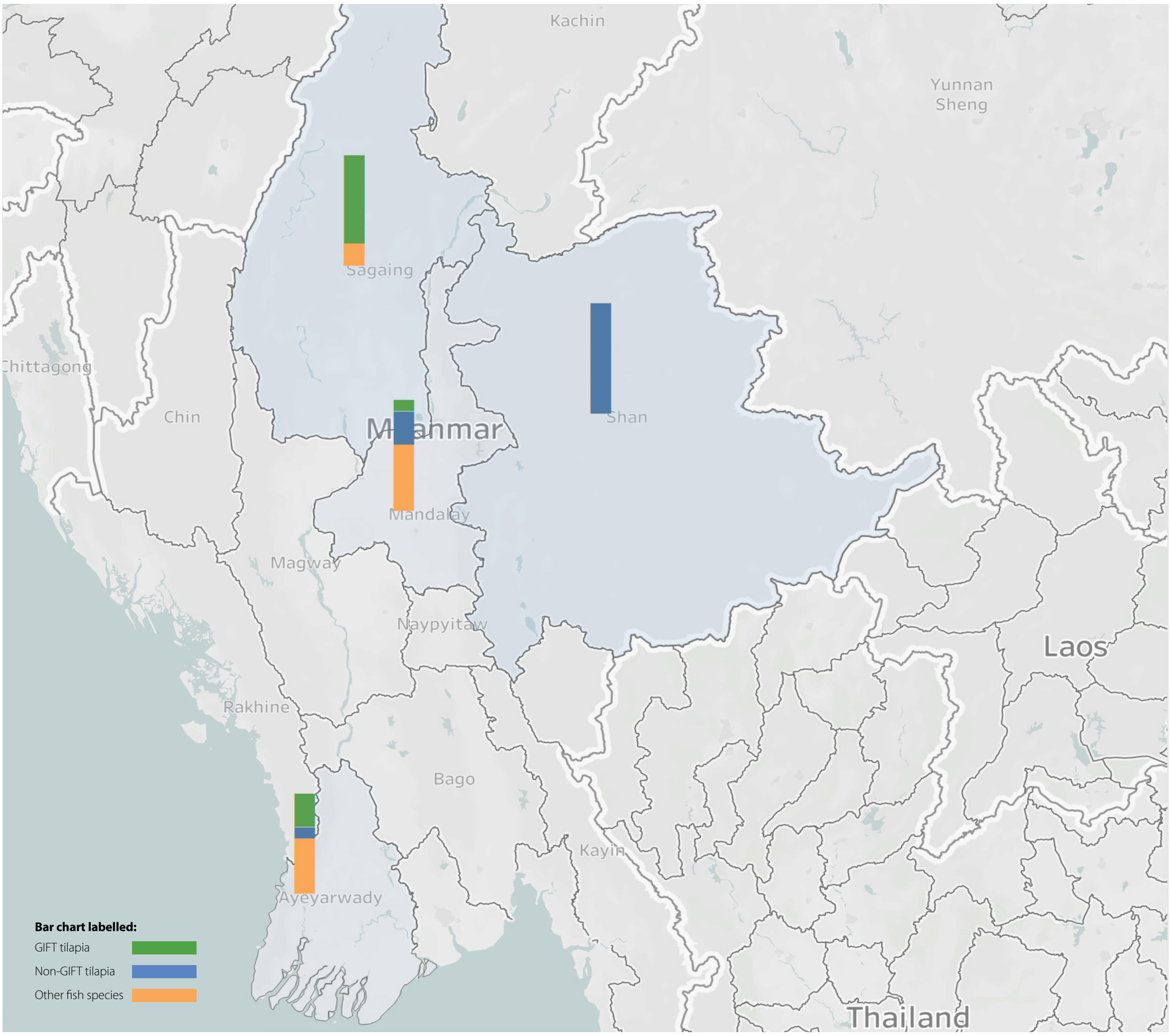

Figure 1. Share of farmers.

The survey was carried out over approximately 5 weeks, from March to early April 2022. Because of COVID-19 restrictions, the enumerators had to conduct the interviews by phone. To reduce the length of the interviews, we modified the survey that we adapted from the SPAITS baseline survey in 2019 into a shorter version by eliminating some of the sections. We also updated the questions to 2021, the latest year. After modifying the survey, team members from Myanmar reviewed and translated the questionnaire into Burmese before it was programmed into KoBoToolbox, a mobile data collection tool for primary survey data.

After pretesting the digital questionnaire, a 3-day virtual training workshop was scheduled on February 7–9, 2022. The main objectives of the workshop were to provide training to enumerators on how to use KoBoToolbox and to explain each question in detail in both the English and Burmese versions. Each session ended with an open discussion to allow enumerators to raise any concerns or issues and to provide suggestions on how to improve the questionnaire. Upon completing the training, the enumerators were given a week to perform pilot testing on the digital questionnaire in KoBoToolbox. Afterward, another discussion was scheduled to address any issues or concerns among the enumerators before beginning to collect the field data. During the survey period, the enumerators submitted the data they collected to the server on a daily basis, and a project member from WorldFish performed a data quality check on the datasets and emailed the enumerators about any issues.

2. Survey results

2.1. Descriptive statistics of surveyed households

Table 2 presents the descriptive statistics of surveyed households according to type of species grown in their latest fish farming cycle.

At the household level, 21% of surveyed households cultured GIFT, 46% stocked non-GIFT, particularly imported tilapia from Thailand and locally produced tilapia from the Department of Fisheries and private hatcheries, while the remaining 33% stocked other fish species.

Looking at socioeconomic characteristics, the average number of people in the surveyed households was 3.7, with non-GIFT households slightly larger at an average of 4. The average age of the household head was 50, with seventh grade being the level of highest education.

Regarding fish farming experience, the overall average was approximately 9 years. Most notably, non-GIFT farmers had the most experience, and they also owned the oldest ponds. In contrast, farmers who cultured other fish species had both the least amount of experience and the youngest fishponds.

Variables	Total (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Average number of household members	3.7	3.4	4.0	3.5
	(1.6)	(1.7)	(1.8)	(1.2)
Age of household head	49.9	49.5	51.6	47.7
	(12.0)	(8.5)	(13.2)	(11.8)
Highest education level of household head				
School education (0 to 11 = preschool to grade 11; 12=university student; 13=degree/diploma; 14=PhD/master)	7.3	7.8	6.6	7.6
	(2.9)	(2.8)	(2.9)	(3.0)
Vocational training (0=no; 1=yes)	0.0	0.0	0.0	0.1
	(0.2)	(0.0)	(0.2)	(0.3)
Monastic school (0=no; 1=yes)	0.3	0.1	0.5	0.1
	(0.5)	(0.3)	(0.5)	(0.3)
Fish farming experience (years)	9.3	8.0	13.1	5.0
	(10.4)	(5.4)	(13.7)	(3.4)
Average age of pond (years)	10.8	9.7	14.7	6.3
	(11.0)	(5.9)	(14.4)	(4.2)
Total size of pond owned (ha)	0.4	0.7	0.2	0.4
	(0.7)	(0.9)	(0.4)	(0.6)

Note: All statistics are reported in means with standard deviations in parentheses.

Table 2. Survey statistics.

2.2. Aquaculture pond details

Our survey datasets consist of 576 farmers operating 626 ponds. For their last completed fish farming cycle, 20% of the ponds stocked GIFT, 43% stocked non-GIFT and the remaining 37% cultured other fish species (Table 3).

At the pond level, significantly more GIFT ponds and other fishponds practiced monoculture. In contrast, more than two-thirds of farmers performed polyculture on non-GIFT ponds. Overall, the results show that almost two-thirds of all surveyed ponds performed monoculture in their last completed fish farming cycle, while the rest performed polyculture. Practicing polyculture with compatible fish species has been shown to increase productivity and technical efficiency because it allows advantageous interactions and coexistence between fish species cultured in the same pond, which encourages efficient use of inputs and reduces waste (Aung et al. 2021a).

Table 4 shows the pond details among GIFT, non-GIFT and other fish species at the pond level.

Pond type	Monoculture	Polyculture	Total
GIFT	112	14	126
Non-GIFT	84	185	269
Other fish species	206	25	231
Total	402	224	626

Table 3. Number of survey households that practiced monoculture or polyculture.

Variables	Total (N=626)	GIFT (N=126)	Non-GIFT (N=269)	Other species (N=231)
Average pond size (ha)	0.3	0.5	0.2	0.4
	(0.6)	(0.6)	(0.4)	(0.6)
Average walking distance to pond (minutes)	11.9	19.0	8.7	11.7
	(15.0)	(22.1)	(8.3)	(15.0)
Average pond depth (m)	4.6	5.6	3.9	4.8
	(3.9)	(8.4)	(1.0)	(0.7)
Number of days in the last fish farming cycle	328.3	322.9	366.6	286.6
	(166.5)	(185.5)	(197.6)	(87.7)

Note: All statistics are reported in means with standard deviations in parentheses.

Table 4. Pond types.

Generally, the average size of owned ponds was approximately 0.3 ha. As compared to non-GIFT ponds and other fishponds, our analysis shows that farmers with larger ponds cultured GIFT. The average size of GIFT ponds was slightly larger relative to other fishponds and more than double that of non-GIFT ponds.

Our survey analysis also reveals that larger ponds tend to be deeper. GIFT ponds were the deepest, followed by ponds with other fish, while non-GIFT ponds were the shallowest.

However, despite having both the largest and deepest ponds, on average, the walking distance to GIFT ponds was the farthest. In contrast, ponds in the other two groups were significantly closer, especially non-GIFT ponds, which were less than half the walking distance of GIFT ponds.

2.3. Aquaculture production characteristics

Table 5 contains statistics on average biological productivity, separated by the type of species grown. Between the GIFT and non-GIFT groups, there are some similarities as well as some notable differences. Regarding cycle length (time to harvest), on average GIFT was harvested sooner than non-GIFT. While shorter cycle lengths could have several exogenous reasons, such as high discount rates, the daily growth rate of GIFT is significantly higher than non-GIFT. This allows for an increased weight at harvest relative to non-GIFT, despite shorter average cycle lengths.

GIFT has a lower weight at stocking, but it is harvested at a heavier weight than non-GIFT, despite the short cycle lengths. This further indicates GIFT's increased specific growth rate (SGR) compared to that of non-GIFT. All variables regarding weight are statistically significant. For the feed conversion ratio (FCR), measured as the ratio between the total amount of feed used and the total amount of fish harvested, GIFT is lower than non-GIFT. This could indicate that GIFT is more efficient in turning feed into food, though this result is not statistically significant. Additionally, the survival rate of GIFT (91%) was substantially higher than non-GIFT (50%) in the study and statistically significant, indicating the resilience of the genetically improved species. Because of these factors, the average per hectare productivity of GIFT was significantly higher in our sample than non-GIFT.

Variable	GIFT (G)	non-GIFT (nG)	Difference (nG – G)
Cycle length (days)*	326.3	367.3	41
	(189.3)	(196.4)	
Stocking density (pieces/ha)	12,528.4	12,050.7	-478
	(18,067.8)	(6215.0)	
Stocking weight (g)**	3.8	9.6	6
	(4.2)	(18.8)	
Harvest weight (g)*	433.3	404.8	-29
	(133.3)	(142.7)	
Specific growth rate (SGR)**	1.85%	1.48%	-0.38
	(0.6)	(0.8)	
Feed conversion ratio (FCR)	2.60	3.34	0.74
	(3.96)	(6.09)	
Survival rate**	91%	50%	-41%
	(0.17)	(0.01)	
Productivity (kg/ha)**	4370.9	2386.2	-1,996
	(5376.8)	(2943.0)	

Note: All statistics are in means with standard deviation in parentheses.

** Statistical significance of two-sample t-test of GIFT and non-GIFT variables at 10%.*

*** Statistical significance of two-sample t-test of GIFT and non-GIFT variables at 1%.*

Table 5. Productivity characteristics of GIFT and non-GIFT aquaculture.

2.4. Input characteristics

To fully understand whether GIFT is more cost-effective, we provide an analysis of the inputs required for each species. Table 6 provides an initial analysis of the various inputs used for the two tilapia species, as well as for other species of farmed fish. In terms of stocking density, the production of GIFT and non-GIFT is not significantly different, with both species stocking about 12,000 fingerlings/ha on average. Compared to other fish species, the stocking density of tilapia species is significantly higher. A similar trend in stocking density was also observed in the study by Karim et al. (2019). However, in our sample, GIFT is more intensive in terms of feed and labor use but less intensive regarding fertilizer. On average, GIFT farmers used almost 2000 kg/ha more feed than their non-GIFT counterparts. Furthermore, almost half of GIFT farmers hired labor, compared to only 15% of non-GIFT farmers. However, GIFT farming requires approximately 1000 kg/ha of less fertilizer on average than traditional tilapia.

We do not have precise statistics on the average amount of water the farmers used per cycle, but we do know if they exchanged the water in their facilities as well as how many times they did so during their last cycle. These statistics are similar between GIFT and non-GIFT, though GIFT farmers exchanged their water five times more often. Given that GIFT ponds were generally larger and deeper in our sample, GIFT can be considered more water-intensive, though more research is needed to come to any definitive conclusions.

	GIFT	non-GIFT	Other species
Material inputs			
Stocking density (pieces/ha)	12,528.43	12,050.71	7183.43
	(148,263.10)	(57,657.87)	(16,533.33)
Seed price (USD/piece)	$0.034	$0.046	$0.046
	(0.012)	(0.022)	(0.035)
Feed use intensity (kg/ha)	7395.03	5633.61	9172.20
	(8588.20)	(7946.23)	(14,436.67)
Feed price (USD/kg)	$0.26	$0.35	$0.31
	(0.14)	(0.20)	(0.16)
Fertilizer use intensity (kg/ha)	1284.90	2247.89	2191.06
	(1868.84)	(3090.40)	(14,270.39)
Fertilizer price (USD/kg)	$0.098	$0.13	$0.1
	(0.213)	(0.19)	(0.213)
Water use			
Exchanged water	57%	48%	57%
Exchange rate:			
1–2 times per cycle	60%	75%	71%
3–5 times per cycle	22%	19%	23%
> 5 times per cycle	18%	3%	5%
Labor inputs			
% of households using hired labor	48%	15%	17%
# of days of hired labor	6.7	6.26	7.94
	(8.4)	(16.10)	(8.75)
Daily salary (USD)	3.16	2.58	3.39
	(1.17)	(1.13)	(2.68)

Note: All statistics are reported in means with standard deviations in parentheses.

Table 6. Statistics for inputs.

Figure 2 displays the source of fingerlings for the farmers in our sample. The top two sources, which provide the majority of GIFT and non-GIFT, are similar. However, most GIFT are sourced from private hatcheries, with non-governmental organizations (NGOs) being the second-largest supplier. For non-GIFT farmers, this is switched, with NGOs being the dominant supplier, followed by private hatcheries.

The percentage of farmers using different types of feed and fertilizer, separated by species grown, is shown in Figure 3. There are notable differences in the distribution of fertilizer use between GIFT and non-GIFT farmers. The majority of both subsamples use manure, but a significantly higher proportion of non-GIFT farmers use triammonium phosphate (TSP), urea and lime, while a high percentage of GIFT farmers use "other" types of feed. The increased use of TSP, urea and lime (all of which are more expensive than manure) among non-GIFT farmers is the reason they pay more for feed per hectare than GIFT farmers. It should be noted that almost half of all farmers used multiple types of feed during their last cycle.

The type of feed that GIFT and non-GIFT farmers use is more homogenous, with the exceptions of pellet feed and groundnut feed. Similar percentages of both samples use rice bran and other feed types, but the majority of GIFT farmers use pellet feed. Regarding groundnut cake, only 10% of GIFT farmers use it, and none among non-GIFT farmers. While differences in feed type could affect the productivity of various species, there are no significant differences within the same species in the harvested weight of fish that were fed different types of feed.

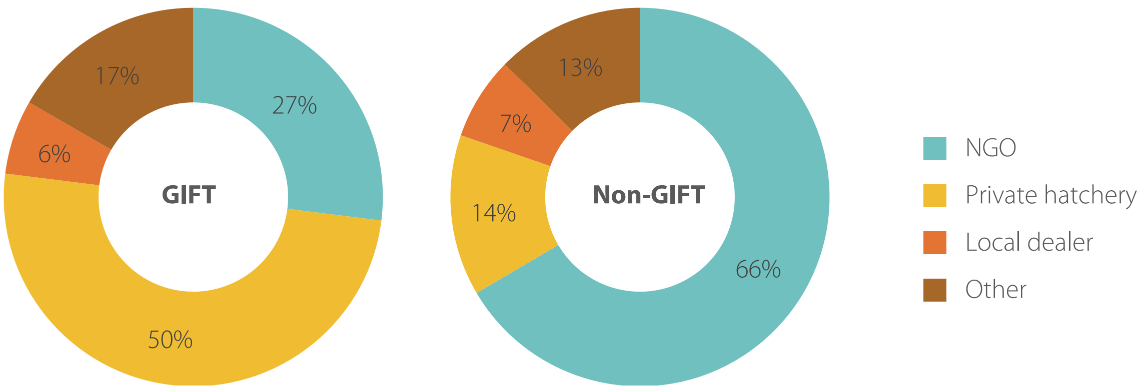

Figure 2. Sources of fingerlings.

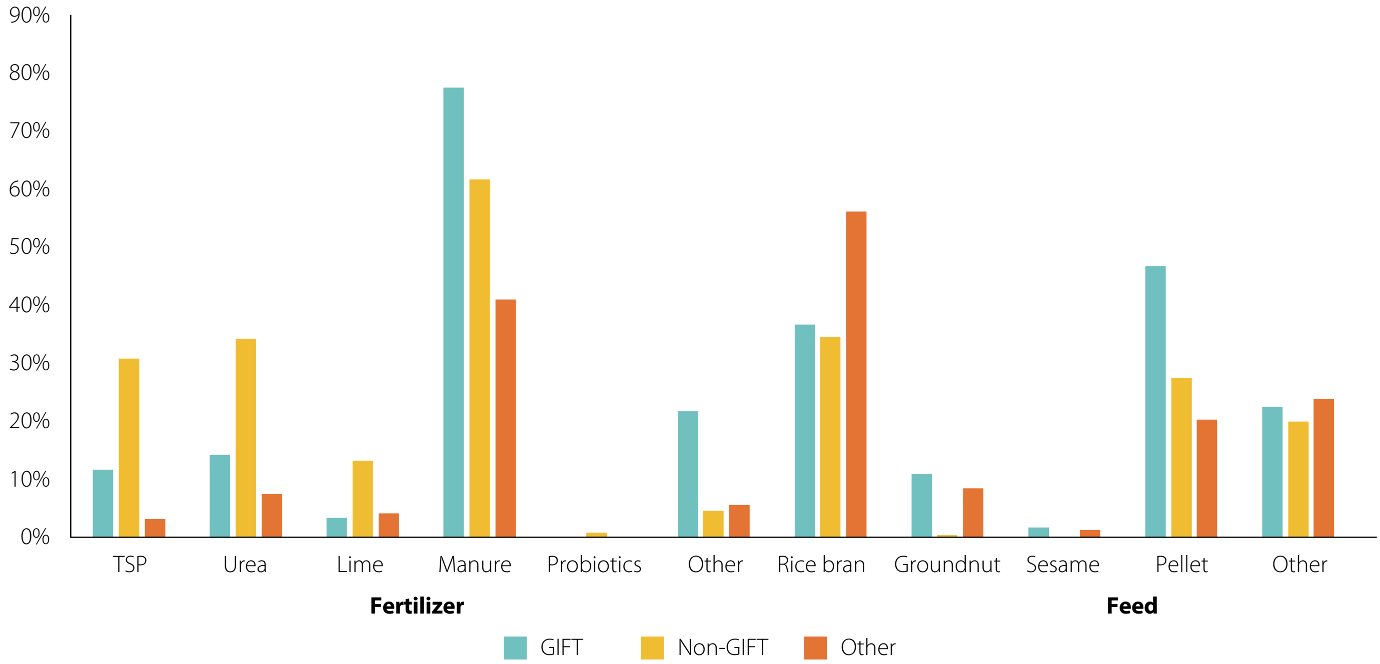

Figure 3. Distribution of fertilizer and seed types.

2.5. Profitability

Table 7 provides statistics on the profitability of GIFT, non-GIFT and other aquaculture species in Myanmar. All three are profitable, with BCRs ranging from 1.47 for traditional tilapia to 1.75 for GIFT. The findings of the study are similar to those of both Karim et al. (2019) and Aung et al. (2021b), meaning that every dollar invested in GIFT production yields a return of USD 1.75/ha, or a gross profit of USD 0.75/ha. Feed costs were the highest proportion of expenses for all farmers across the different subsamples, ranging from about 70% of total costs for both GIFT and non-GIFT farmers to 86% for farmers of other species. Labor costs contributed the least to total costs, with GIFT farmers having the highest percentage at 2%.

GIFT aquaculture has the highest BCR, mainly because of its increased productivity compared to traditional tilapia production, averaging almost double the amount per hectare. As discussed in section 1, GIFT has a significantly faster growth rate than traditional tilapia. However, on average, GIFT was also sold at about USD 0.50/kg less than traditional tilapia because of geographic market price differences in Myanmar. The price of tilapia sold in Shan State, where the majority of non-GIFT

Statistic	GIFT	non-GIFT	Other species
Production			
Price (USD/kg)	$0.935	$1.50	$1.21
	(0.214)	(0.45)	(0.73)
Productivity (kg/ha)	4370.90	2386.20	3328.50
	(5376.80)	(2943.00)	(5602.30)
Total revenue (USD/ha)	$4086.79	$3579.30	$4027.50
Variable costs			
Feed (USD/ha)	$1797.44	$1680.85	$2199.22
	(2482.47)	(2844.85)	(3691.35)
Seed (USD/ha)	$406.853	$577.258	$219.973
	(585.21)	(366.896)	(496.0081)
Fertilizer (USD/ha)	$91.12	$143.04	$85.26
	(287.29)	(366.95)	(424.45)
Labor (USD/ha)	$39.61	$28.602	$35.15
Total variable costs (USD/ha)*	$2335.023	$2429.75	$2539.60
Profit analysis			
Net profit (USD/ha)	$1751.76	$1834.28	$1487.9
BCR	1.75	1.47	1.58

Note: All statistics are in means with standard deviations in parentheses.
**Cost analysis does not take into account fixed costs or interest/depreciation.*

Table 7. BC analysis across the pond groups.

farmers and very few GIFT farmers in our sample are based (Figure 1), is significantly higher than in other regions. The average price of tilapia in Shan was USD 1.7/kg, while in all other regions the price was around USD 1/kg. Because of this price discrepancy, and there being 143 non-GIFT farmers in our sample based in Shan compared to only two GIFT farmers, the average price of GIFT in our sample was substantially less. Yet in regions where both types of tilapia were sold, the prices were similar, if not slightly higher for GIFT. It is likely that the BCR of GIFT is lower than the actual BCR because of this geographic price discrepancy.

Despite GIFT being substantially more feed-intensive in our sample, GIFT farmers spent less on feed per hectare than their non-GIFT counterparts. This implies that GIFT farmers generally use high amounts of inexpensive feed to offset the more feed-intensive nature of GIFT. As noted above, the differences between the FCR of both GIFT and non-GIFT are not statistically different, indicating that increased growth rates offset the more feed-intensive nature of GIFT. However, GIFT farmers spent more per hectare on both fertilizer and hired labor, despite using less fertilizer per hectare on average (Table 6).

2.6. Food security

In Myanmar, is a major source of animal protein and an essential supply of micronutrients that improves food security and provides good nutrition to households. Annual per capita fish consumption accounted for an average of 45.6 kg in 2018 (FAO 2022). To ensure sufficient availability and accessibility of fish among surveyed households, we analyzed fish consumption patterns of households during the previous 7 days of the survey period, as shown in Figure 4. From the results, almost half of the households consumed fish from their own production.

We asked the surveyed farmers about the quantity of fish they consumed during the previous 7 days of the survey period, as shown in Table 8. Overall, among the households, average per capita fish consumption was 0.9 kg and total fish consumption was 3.06 kg. From the results, GIFT and non-GIFT households consumed approximately 0.25 kg more fish than the households that stocked other fish species. In terms of total fish consumption, non-GIFT households consumed the most fish per household during the 7-day period.

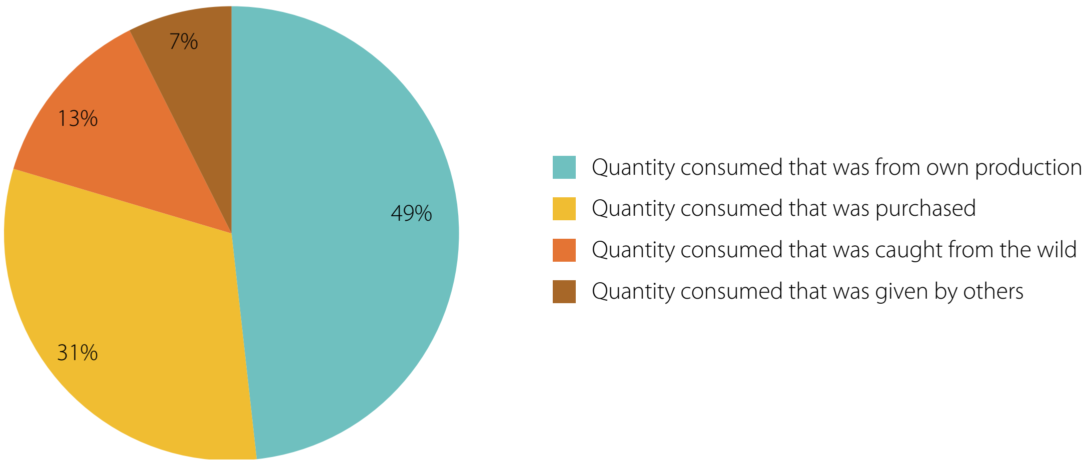

Figure 4. Source of fish consumption in the previous 7 days during the survey period.

Type of farmer	Per capita consumption (kg)	Total consumption per household (kg)
GIFT	0.98	3.36
Non-GIFT	0.99	3.50
Other fish species	0.73	2.36
Total	0.90	3.06

Table 8. Per capita and total fish consumption.

2.7. Recognition and adaptation to climatic shocks

As mentioned in Section I (methodology), our survey datasets consist of 576 households operating 626 ponds. The following analysis was calculated based on the household level. It includes recognition and adaptation among farmers regarding climatic shocks, pond management strategies, awareness and participation in food certification schemes, household access to information, risk preference, land allocation to different activities, and percentage of income sources. The households were split into three groups based on their stocked fish type: 21% mainly cultured GIFT, 47% mainly stocked non-GIFT and the rest primarily stocked other species.

Table 9 shows the ways in which households in each group view how climate changes and climate shocks affect their livelihoods and then how they adapt to cope. The significant climate changes in the study areas are erratic rain, flooding, delayed rainfall, and drought.

	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Recognition of climate change				
Yes	321(55.73)	95(79.17)	132(49.81)	94 (49.21)
Flooding	89 (27.23)	20(21.05)	21(15.91)	48(51.06)
Drought	46(14.33)	16(16.84)	16(12.12)	14(14.89)
Prolonged drought	49(15.26)	36(37.89)	6(4.55)	7(7.45)
Erratic rain	96(29.91)	25(26.32)	62(46.97)	9(9.57)
Early rainfall	9(2.80)	1(1.05)	3(2.27)	5(5.32)
Delayed rainfall	70(21.81)	36(37.89)	19(14.39)	15(15.96)
Effects of climatic shocks on fish farming in last completed cycle				
Yes	290(90.34)	86(90.53)	125(94.70)	79(84.04)
Increased disease incidences	13(4.48)	5(5.81)	1(0.80)	7(8.86)
Low productivity	150(51.72)	64(74.42)	35(28.00)	51(64.56)
Reduced water availability	183(63.10)	51(59.30)	108(86.40)	24(30.38)
Pond water is too hot	45(15.52)	33(38.37)	3(2.40)	9(11.39)
Adaptation strategies to cope with climatic shocks				
Yes	238(82.07)	80 (93.02)	97(77.60)	61(77.22)
Changed fish species	27(11.34)	13(16.25)	0(0.00)	14(22.95)
Monitored water quality	51(21.43)	7(8.75)	33(34.02)	11(18.03)
Harvested fish early	150(63.03)	56(70.00)	65(67.01)	29(47.54)
Exchanged water	26(10.92)	17(21.25)	4(4.12)	5(8.20)
Moved fish	50(21.01)	38(47.50)	6(6.19)	6(9.84)
Plans to protect their aquaculture activities against climatic shocks (N=576)				
Yes	217(37.67)	99(82.50)	58(21.89)	60(31.41)
Prepared or repaired pedal wheel	33(15.21)	18(18.18)	2(3.45)	13(21.67)
Reduced stocking density	38(17.51)	18(18.18)	8(13.79)	12(20.00)
Delayed stocking	23(10.60)	16(16.16)	3(5.17)	4(6.67)
Additional water storage	98(45.16)	57(57.58)	31(53.45)	10(16.67)

Note: The values in parentheses represent percentage.

Table 9. Recognition and adaptations to climatic shocks across the household groups.

Overall, results indicate that more than half of the surveyed households recognize climate changes. Looking at the specific household groups, more GIFT farmers recognize climate changes than the other two groups. Regarding specific climate changes, more than a third of GIFT households inferred prolonged drought and delayed rainfall, while about a fifth perceived flooding, drought and erratic rain. However, nearly half of the non-GIFT households gave other responses to climate conditions, particularly erratic rainfall. A slight majority among farmers of other fish species reported recognizing flooding.

Regarding the effects of climatic shocks, the vast majority of all farmers experienced such shocks on their fish farming in the previous cycle. The proportion of households affected in the GIFT and non-GIFT groups is higher than among those that farmed other species. Reduced water availability is the most significant climatic shock effect, accounting for nearly two-thirds of all households. Among GIFT farmers, the impacts of climate shocks on fish farming are attributed to (in order) low productivity, reduced water availability, hot pond water and an increase in disease incidences. Most households in the non-GIFT group reported having less water available. In comparison, the response of households in the other species group was low productivity and reduced water availability. The findings indicate that reduced water availability and low productivity are the major impacts of climate shocks on fish farming across the household groups. Tewabe (2015) mention that climate changes are likely to be lower water quality causing more disease and creating conflicts with other water users, both agricultural and industrial, resulting in reduced supplies of freshwater and productivity.

Among the climate shocks that affected households, most farmers adopted adaptation practices, such as changing fish species, monitoring water quality, harvesting fish early, exchanging water and moving fish between sites. Among the strategies, the main adaptation against climatic shocks was harvesting fish early. Accordingly, GIFT households appeared to have changed their management in response to climatic shocks, with more than two-thirds harvesting fish early and nearly half moving fish between sites. Monitoring water quality and harvesting fish early are the major adaptation strategies for non-GIFT households, while changing fish species and harvesting fish early are the most used practices for the other species group.

When we looked at plans to change aquaculture activities against climate change over the next 5 years, only 38% of households have plans in place to protect their aquaculture activities. Overall, the major change in future aquaculture activities is storing additional water because reduced water availability is one of the major climate effects on fish farming. This implies that maximum fish growth and production depends entirely on water for feeding, growth and the performance of other biological functions (Johnson 1995). Accordingly, more than half of both GIFT and non-GIFT households plan to store additional water, while less than a quarter of those that stocked other fish species plan to prepare or repair the pedal wheel in their aquaculture activities.

2.8. Pond management practices

The respondents were asked if they undertook any pond management practices in the previous 12 months. Overall, as shown in Table 10, three-quarters of all households performed various pond management practices. Most GIFT and non-GIFT farmers applied these practices. Regarding the respective pond management practices, most households applied every one of them, except for lining ponds to reduce salinity intrusion.

Adopting sustainable aquaculture technologies that include pond management practices increases the fish productivity, technical efficiency, income and food security of small-scale aquaculture households and can also help farmers reduce production losses from climatic shocks. This shows that it is imperative to increase the productivity, economic efficiency and sustainability of the country's small-scale aquaculture sector (Aung et al. 2021a and 2021b).

Looking across the households, we also found that more households in each group applied every practice, except for lining ponds to reduce salinity intrusion. Among the practices, stocking the proper size of fingerlings was highest in GIFT (99%) and other species farmers (92.31%), while improved fish feeding was prominent in households that stocked non-GIFT (92.31%).

	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Pond management practices				
Yes	432(75.00)	91(75.83)	224(84.83	117(61.26)
Pond upgrading	333(77.08)	72(79.12)	186(83.04	75(64.11)
Lining ponds to retain water better	308(71.30)	64(70.33)	166(74.11	78(66.67)
Lining ponds to reduce salinity intrusion	80(18.51)	37(40.66)	138(5.80)	30(25.64)
Increased height of bunds to protect ponds from floods	308(71.29)	69(75.82)	155(69.20	84(71.80)
Stress-tolerant strains of fish	246(56.95)	78(85.71)	91(40.63)	77(65.81)
Stocking the proper size of fingerlings	374(86.57)	90(98.90)	176(78.57)	108(92.31)
Improved fish feeding	388(89.81)	87(95.60)	209(93.03	92(78.63)
Improved pond water management	367(84.95)	89(97.80)	196(87.5)	82(70.09)
Improved fish disease and health management	322(74.74)	77(84.62)	164(73.21)	81(69.23)
Improved postharvest handling	363(84.03)	78(85.71)	202(90.18)	83(70.94)

Note: The values in parentheses represent percentage.

Table 10. Pond management practices.

Little and Bunting (2016) and Pucher et al. (2015) mention that an improved or modified pond water management system can improve the productivity of small-scale ponds by helping increase natural food resources, such as plankton, and decrease the turbidity of pond water and loss of nutrients caused by water being flushed out. Improved fish feeding is linked with the fact that access to high-quality and cost-effective feeds with improved feed management practices is a prerequisite to successful fish farming (Munguti et al. 2021). This implies that commercial feeds are the most effective, providing the nutrients that fish need and leaching fewer nutrients into the pond, minimizing the adverse environmental effects (Pucher et al. 2013).

2.9. Food safety and participation in certification schemes

We asked the sampled farmers about whether they applied fish quality/safety practices and their willingness to participate in certification. As shown in Table 11, the results reveal that nearly all of the households have implemented these practices, including using fewer chemicals, drying fish properly, selling fish immediately after harvest and testing fish for disease-causing organisms to ensure the production of quality or safety fish. Looking at the households groups, just about every GIFT household and those that farmed other species applied the practices. Our survey also shows that the most common practice among all farmers is to sell their fish right after harvest, though more non-GIFT farmers did so relative to the other two groups.

The surveyed farmers were also asked whether they had heard about the aquaculture and seafood safety certification schemes. Overall, less than half of all households knew about it, the fewest being non-GIFT farmers. Based on the responses of the households that are aware of the certification scheme, only just over a third of them had participated in it, with those in the GIFT group higher relative to the other two groups.

As for the benefits of participating in a certification scheme, higher demand and better quality fish are the most mentioned. Approximately two-thirds of the participated households in each group benefitted in these two ways. Compared to non-GIFT and farmers culturing other species, half of the participated GIFT farmers received higher prices for their good quality products.

2.10. Source of income

Table 12 displays the percentage of household income coming from different sources.

Crop production was the primary source for the sampled households, followed by fish production. In comparing the importance of the different sources of income, the trend was similar across the three household groups, with the largest share being crop income. When viewed as a whole, the information on income sources showed the potential for growth in aquaculture in the study area.

	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Practices of quality/safe fish production				
Yes	546(94.79)	119(99.17)	241(90.94)	186(97.38)
Reducing use of chemicals	74(13.55)	24(20.17)	22(9.13)	28(15.05)
Drying fish properly	63(11.54)	2(1.68)	56(23.24)	5(2.69)
Selling immediately after harvest	509(93.22)	104(87.39)	237(98.34)	168(90.32)
Testing for disease-causing organisms	55(10.07)	22(18.49)	12(4.98)	21(11.29)
Awareness about aquaculture and seafood safety certification				
Yes	261(45.31)	85(70.83)	61(23.02)	115(60.21)
Participating in an aquaculture/seafood certification scheme				
Yes	99(37.93)	51(60.00)	10(16.39)	38(33.04)
Benefits of participating in a certification scheme				
Better quality fish	41(41.41)	13(25.49)	8(80.00)	20(52.63)
High price	33(33.33)	26(50.98)	0(0.00)	7(18.42)
High demand	66(66.67)	35(68.63)	6(60.00)	25(65.79)
Fish can be stored longer	5 (5.05)	4(7.84)	0(0.00)	1(2.63)

Note: The values in parentheses represent percentage.

Table 11. Food safety and participation in certification schemes.

Income source (%)	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Fish production	15.90(12.95)	20.17(12.56)	12.67(11.30)	17.70(14.19)
Crop production	36.86(27.75)	30.10(28.60)	34.05(22.30)	45.00(31.96)
Livestock	6.70(9.58)	4.98(7.07)	7.90(10.48)	6.11(9.45)
Off-farm income (business)	9.41(13.09)	10.17(12.33)	8.14(13.65)	10.68(12.66)
Off-farm job (full-time)	5.08(9.73)	6.25(7.95)	4.52(11.10)	5.13(8.63)
Off-farm job (part-time)	7.39(12.82)	4.55(8.22)	11.05(15.80)	4.09(8.45)
Remittances	3.86 (10.61)	1.35(5.56)	6.5(13.48)	2.41(7.50)
Other sources	4.22(8.19)	4.70(7.75)	4.57(8.76)	3.43(7.61)

Note: The values in parentheses represent standard deviation.

Table 12. Percentage of income from different sources.

2.11. Access to information, participation in farmer groups, and risk preferences

As shown in Table 13, we also examined the characteristics that could help or hinder aquaculture activities among households, such as access to information, participation in fish farmer groups, and risk preference.

Of the sampled households, just over half participated in a fish farmers group, and over a third received information on weather conditions, which could influence household decisions on the timing of various fish farming activities. About half of all households participated in a fish farmer organization.

In terms of access to information, more GIFT households received weather information relative to the other two groups. Because the study areas experience climate shocks almost every year, access to information about weather and climate change is important for households to reduce the negative effects on their fish farming. Participation in a farmers organization plays a significant role in determining a farmer's decision to adopt aquaculture technologies that could increase the welfare outcomes of their household (Aung et al. 2021b). On a scale of 0 to 9, with 0 being fully avoiding risks and 9 being fully prepared to take risks when applying a new aquaculture technology, the average risk preference of the households was 2.90. This shows that the households generally avoid trying out new aquaculture technologies, especially households that farm other species.

2.12. Land allocation

Table 14 shows the total land that the surveyed farmers own and the amount they allocate to different activities, specifically aquaculture, crop production, livestock production, rented out, and leaving the land empty.

On average, households owned 5.34 acres of land and allocated the largest area to crop production, followed by aquaculture. The results show that the average land area owned by farmers who stocked other fish species was slightly larger relative to both GIFT and non-GIFT farmers. However, land for aquaculture was significantly higher among GIFT farmers than that of the other two household groups.

	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other (N=191)
Access to and participation in the past year				
Participated in a fish farmer group*	300(52.08)	59(49.17)	154(58.11)	87(45.55)
Received weather information*	225(39.06)	84(70.00)	71(26.79)	70(36.35)
Risk behavior (0 to 9; from risk averse to risk taking)				
Risk preference**	2.90	3.23(2.70	2.18(2.09)	3.68(2.35)

**The values in parentheses represent percentage.*
***The values in parentheses represent standard deviation.*

Table 13. Access to information, participation in a farmers group, and risk preferences.

	Total respondents (N=576)	GIFT (N=120)	Non-GIFT (N=265)	Other species (N=191)
Total land area	5.34(4.99)	6.25(6.16)	4.08(4.13)	6.49(4.89)
Aquaculture	0.95(1.65)	1.83(2.19)	0.56(1.09)	0.96(1.69)
Crop production	3.58(4.26)	3.79(5.40)	2.86(3.29)	4.45(4.49)
Livestock production	0.28(0.56)	0.31(0.65)	0.25(0.50)	0.32(0.59)
Rent it out	0.21(0.82)	0.11(0.49)	0.18(0.77)	0.32(1.02)
Leave the land empty	0.18(0.85)	0.10(0.58)	0.17(0.92)	0.27(0.87)

Note: The values in parentheses represent standard deviation.

Table 14. Land-use allocation to different activities.

3. Discussion

As Myanmar is one of the world's major aquaculture producing countries, understanding the performance of the sector's practices is crucial for sustainable fish production and attaining the Sustainable Development Goals. Given the limited capacity for growth in capture fisheries, aquaculture has the potential to fulfill increasing fish demand through public and private sector investment. Compared to capture fisheries, research shows that rising household incomes in Myanmar will create a substantial increase in demand for aquaculture fish, putting pressure on production to grow in the sector. If the fish supply from aquaculture does not keep pace with income increases, fish prices will rise, which will affect household food security to a greater extent (Aung et al. 2022).

As the respondents in the survey are all small-scale aquaculture farmers, averaging 0.34 ha ponds, the aquaculture characteristics analyzed in this study represent their production facilities. Toufique and Belton (2014) reported that development in the small-scale aquaculture sector has reduced poverty, decreased hunger and helped grow the national economy. According to Aung et al. (2022), however, Myanmar's aquaculture sector needs to be more competitive and inclusive of smallholders, with accompanying land-use regulatory reforms. Over the long run, this will increase fish consumption through sustainable increases in fish production from aquaculture in order to secure food and nutrition security in the country.

Our analysis of the biological performance of the two tilapia species largely confirms previous findings regarding GIFT, adding to the overall literature. In line with a study by Tran et al. (2021), we find the daily growth rate of GIFT to be significantly higher than non-GIFT, allowing for increased weight at harvest relative to non-GIFT, despite its lower stocking weight. In addition, because of the resilience of GIFT, its survival rate is significantly higher than non-GIFT. These two factors attributed to GIFT's increased productivity per hectare compared with non-GIFT. A previous study by Khaw et al. (2008) also supported the higher survival rate of GIFT. Tran et al. (2021) reported that the survival rate of GIFT was significantly lower than non-GIFT in polyculture ponds in Bangladesh, reflecting the smaller stocking size of GIFT. Although the FCR is lower for GIFT, the difference is not statistically significant. Other studies have found significant improvements in the FCRs of GIFT.

In terms of required inputs, GIFT is slightly more feed-intensive, though this is offset by higher yields. The stocking density of GIFT ponds in this study was approximately 1.2 fish/m^2, revealing a lower stocking density of GIFT ponds compared to a study in Bangladesh (4 fish/m^2) (Tran et al. 2021).

There are notable differences in the distribution of hired labor between GIFT and non-GIFT farmers. However, as less than half of the households hired labor for aquaculture activities, most surveyed farmers were able to manage the work themselves because their ponds are relatively small. Feed made up the highest share of total production costs for all species across the surveyed farmers. In terms of fingerling sources, private hatcheries are the major supplier for GIFT farmers, while the majority of non-GIFT farmers source them from NGOs.

In terms of profitability across the various subsamples, GIFT farmers had the highest BCR (1.75) because of their low operational costs and higher productivity. It should be noted, however, that GIFT was also sold at significantly lower prices because of geographic price differences. Although the average yield per hectare in Bangladesh was almost double compared to this study, the BCR was lower in Bangladesh (1.43) than in Myanmar (1.67) because of higher production costs (Tran et al. 2021). WorldFish (2016) highlighted that fast-growing fish reached harvestable size rapidly, allowing a farmer to start their new fish cycle sooner and making their farm more productive and cost-effective.

Looking at perceptions and adaptation strategies to climate shocks, the proportion of GIFT farmers who recognized climate changes was higher than the farmers in the other two groups. Among the climatic shocks, lower productivity and reduced water availability were the most cited across all three groups. As more tilapia farmers recognized climate changes, the number of households that adopted adaptation strategies was high in GIFT and non-GIFT relative to the other fish species group. Harvesting fish early and storing more water were the main strategies to protect aquaculture activities against climatic shocks in the future. This could explain the fact that recognizing climate change and adopting adaptation strategies can help farmers expand outcomes and reduce exposure to the risks posed by climate change.

In addition to this, more than half of all households applied improved pond management practices. This implies that adopting such practices is one of the most important strategies to improve the performance of aquaculture production and the welfare outcomes of small-scale fish farming households (Aung et al. 2021). To ensure safe, quality fish production, almost all surveyed households sold their product immediately after harvest.

Regarding the fish certification scheme, as less than half of the households are aware of it, only a third of them actually participated in it. High demand and good quality were the main motivations for farmers to participate in the scheme.

Looking at other socioeconomic indicators, the main source of income across all households was crop production, followed by aquaculture. This indicates that aquaculture is a source of income for small-scale households, rather than a subsistence food and nutrition source. Although the percentage of crop income for GIFT farmers is the lowest among the household groups, their share of fish income is the largest. This implies that faster-growing, hardier and more disease-resistant GIFT gives farmers a greater return on their investment (WorldFish 2016).

In terms of access to information, almost half of all households participated in fish farmer organizations, which would facilitate the flow of information about aquaculture practices. This finding highlights the importance of developing and forming groups or organizations for farmers to share information and knowledge, especially about the weather. Across the household groups, access to information on weather conditions is highest among GIFT farmers. Having such access could influence a household's decision and management related to aquaculture activities in response to climatic shocks, potentially resulting in reduced production losses from climatic shocks.

Regarding the scale of risk preference, non-GIFT farmers were more risk-averse. In terms of land allocation of the surveyed households, the largest amount was used for crop production, followed by aquaculture.

4. Conclusion

Using survey data, the findings of this study further endorse improving technologies and management practices in Myanmar to improve and increase aquaculture production. Since GIFT aquaculture shows profitable and sustainable evidence of improvements, developing and strengthening the GIFT program will benefit farmers, particularly in the small-scale aquaculture sector.

However, the number of farmers who access improved strains, especially GIFT, is still limited in Myanmar. In our study results, only about a fifth of the farmers adopted GIFT, while nearly half cultured non-GIFT species. This reveals a major constraint to GIFT adoption in Myanmar—the inadequate supply of GIFT fingerlings. In addition, the fact that GIFT is feed-intensive could be another challenge for small-scale farmers to adopt this technology because of high feed costs. Our study shows that more GIFT farmers use pellet feed compared to non-GIFT farmers. GIFT farmers also tend to use high amounts of inexpensive feed such as rice bran to offset the more feed-intensive nature of GIFT.

The following outlines three policy recommendations and appropriate interventions to promote the adoption of GIFT in Myanmar:

1. Strengthen the dissemination channel of GIFT fingerlings by developing a broad-based national network. Our study reveals that there are geographical differences in accessing GIFT fingerlings in the study areas. As such, it is important to make sure that farmers have wider access to GIFT fingerlings by being able to tap into well-established networks in different states and regions across the country.
2. Promote improved fish seed through adequate extension services to create links among GIFT farmers, and encourage good aquaculture practices in support of GIFT adoption. This includes establishing marketing networks, building innovative infrastructure and developing skills for proper farm management.
3. The government needs to support the collaboration of private-public partnerships to invest in aquaculture research, such as genetic improvement programs. These efforts would help boost technological progress and increase the supply of good quality GIFT fingerlings in Myanmar.

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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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