Challenges and Opportunities for Small-Scale Aquaculture Development in Malawi

Maggie G. Munthali, Lemekezani Chilora, Zephania Nyirenda,
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ACRONYMS

ATI	Agricultural Transformation Initiative
BCR	Benefit-Cost Ratio
BSF	Black Soldier Fly
CDF	Community Development Fund
EPA	Extension Planning Area
EUS	Epizootic Ulcerative Syndrome
FAO	Food and Agriculture Organization
FINCA	Foundation for International Community Assistance
GDP	Gross Domestic Product
GM	Gross Margin
IRR	Internal Rate of Return
LUANAR	Lilongwe University of Agriculture and Natural Resources
MAS	MwAPATA Aquaculture Survey
MEDF	Malawi Enterprise Development Fund
MK	Malawi Kwacha
MM	Marketing Margin
NAC	National Aquaculture Centre
NGO	Non-governmental organization
NEEF	National Economic Empowerment Fund
MEDF	Malawi Enterprise Development Fund
MRFC	Malawi Rural Finance Company
MUSCCO	Malawi Union of Savings and Credit Cooperatives
PSLCE	Primary School Leaving Certificate of Education
ROI	Return on Investment
SACCO	Savings and Credit Cooperatives
SOP	Standard Operating Procedure

EXECUTIVE SUMMARY

Small-scale aquaculture in Malawi has the potential to contribute to economic growth and improve food and nutrition security. The current report presents key findings on the landscape of small-scale aquaculture in Malawi and the challenges faced by fish farmers. Specifically, the study (i) characterizes small-scale fish farmers and farms in Malawi, (ii) investigates the role of aquaculture in farmers' livelihoods, (iii) evaluates the profitability of fish farming, and (iv) identifies possible policy interventions to promote the growth of small-scale aquaculture.

A farm-level survey of 732 farms was conducted in June–July 2021 in 10 districts: Nkhatabay and Mzimba (Northern Region); Ntchisi, Nkhotakota, and Mchinji (Central Region); and Phalombe, Thyolo, Mulanje, Machinga, and Zomba (Southern Region). Detailed information was collected on the characteristics of the fish farms, inputs used, and fish production, consumption, and sales. Information was also captured on labor, credit, and perceptions of the importance of aquaculture in the lives of fish farmers. Both individually owned farms and communally owned farms were included in the sample.

Almost all small-scale fish farms in the surveyed districts produced fish in earthen ponds that drew on groundwater. On average, fish farms had 1.4 ponds and a total area of 400.9 m^2 (median = 208 m^2). About three-quarters (73.2%) of the farms practiced continuous production, in which farmers continuously produce fish without pond maintenance (cleaning/complete drainage). It was common for the fish farms to be integrated with crops (43.5%) or livestock (15.6%). While most farms owned relatively simple aquaculture assets, such as buckets, very few owned items such as oxygen meters or aeration devices, indicating a low level of technology uptake.

The most commonly stocked fish species were chilunguni (*Tilapia rendalli*), makumba (*Oreochromis shiranus*), and chambo (*Oreochromis karongae*), with an average stocking density of 3.6 fingerlings/m^2. Most fingerlings were of mixed sex, a practice associated with uncontrolled reproduction, fish overcrowding, and stunted fish growth. Almost all fish farms used homemade feed, while just 7.4% used any commercial feed. This lack of commercial inputs is understood to hinder the growth of small-scale aquaculture in Malawi. While it was common for fish farms to apply organic fertilizers (86.6%) and inorganic fertilizers (49.4%), just 19% applied lime and 25% utilized ashes to neutralize the water's acidity.

Harvesting was done in 96.5% of the fish ponds, as some farms did not harvest due to the Epizootic Ulcerative Syndrome (EUS) outbreak. Over the December 2019 to December 2020 reference period, the average fish harvest per farm was 184.5 kg. However, 75.9% of the farms harvested less than 100 kg of fish. Moreover, farms of greater than 1,000 m^2 (comprising just 7.8% of the farms) were responsible for 40.1% of the value of fish harvest. Among these non-industrial fish farms, it is clear that the relatively large and intensive farms play a significant role. On average, 60.1% of the value harvested on the fish farms was sold with almost no processing or value addition, primarily to community members purchasing the fish at pondside or to customers in rural markets.

An analysis of farm profits reveals that small-scale fish farming in Malawi was generally profitable, although the gross margins were usually rather small (mean = MK 116,258; median = MK 25,500). When this profit is scaled to the size of a "typical" pond (299.5 m^2), the average pond-level profit was MK 97,041. This is equal to MK 3.2 million per hectare or approximately USD 3,888 per hectare. The average gross margins and average measures of productivity varied across species, regions, farm sizes, farm types (individually owned versus communal), and production systems. In addition, the average gross margin for fingerling production was more than four times that of fish production.

Overall, this study demonstrates that small-scale fish farming has the potential to improve farmers' livelihoods and welfare through income and dietary diversification. On average, fish farming was estimated to contribute 21.0% towards the household income of the individually owned fish farms, and most respondents (59.4%) perceived fish farming to play an "extremely important" role in farmers' livelihoods.

Challenges of fish farming include a shortage of land for pond excavation; lack of fishing equipment; poor environmental conditions for fish production; lack of access to well-structured markets; theft and predators; fish diseases; lack of access to credit and low incomes; a high amount of labor required; lack of relevant extension services; lack of input markets; lack of access to quality feed; and poor quality of fingerlings. These challenges also point to important opportunities for the government and private sector to invest in aquaculture.

Based on the findings of this report, we offer the following recommendations to support and promote small-scale aquaculture in Malawi:

1. Improve the availability of and access to high-quality fish feed by manufacturing it within the country.
2. Promote best practices in fish farm management.
3. Train certified hatchery operators in order to reduce the use of recycled or low-quality fingerlings.
4. Develop protocols and standard operating procedures for fish feed production and hatchery operations/management.
5. Promote the integration of fish farming with crop or livestock production.
6. Improve small-scale fish farmers' access to credit.
7. Promote the active participation of youths and women in small-scale fish farming.
8. Invest in aquaculture extension services.
9. Strengthen the existing small-scale fish farmers' associations and organize other farmers into groups.
10. Develop guidelines for cage aquaculture.
11. Explore the use of lower-cost fishmeal alternatives, such as black soldier fly (BSF).
12. Promote tree planting, especially among fish farmers that cook their homemade fish feed.
13. Incentivize the private sector to venture into fish farming.

1. INTRODUCTION

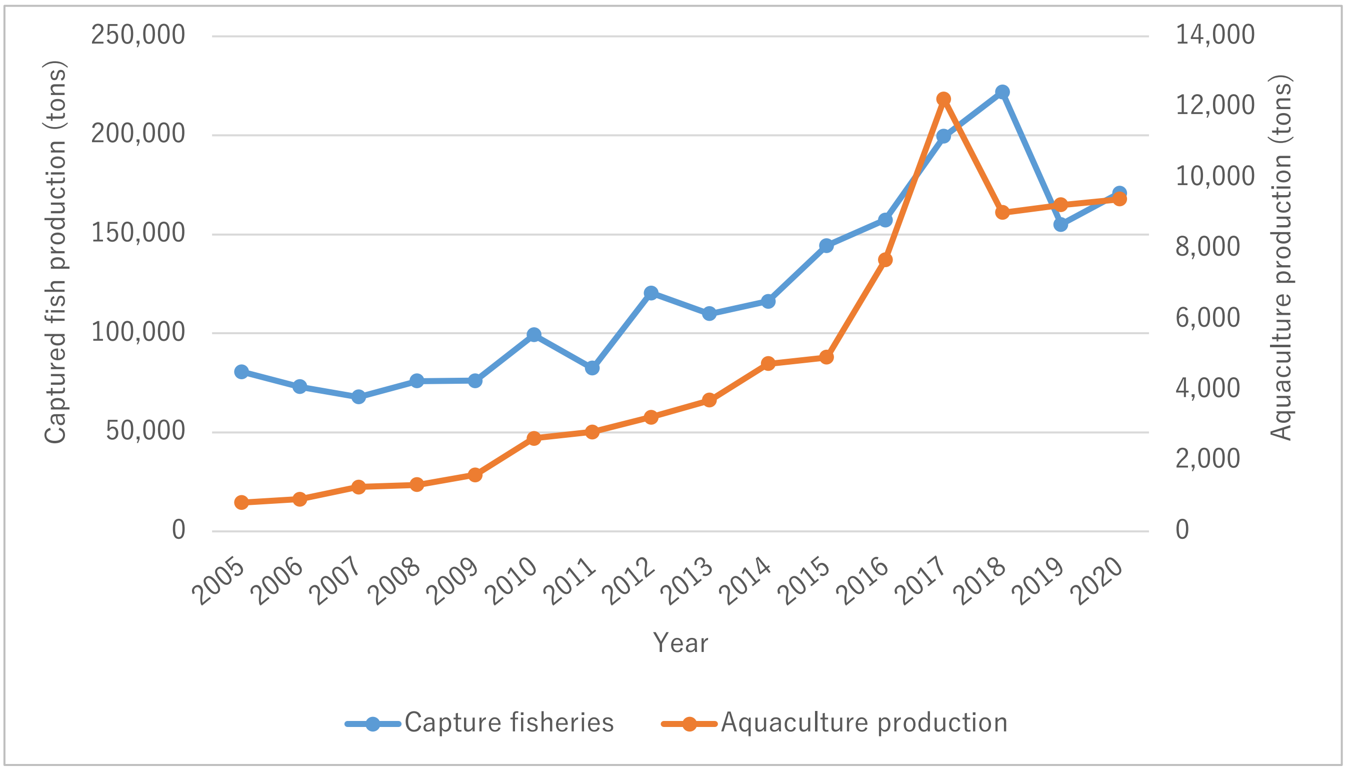
Fisheries (comprising capture fisheries and aquaculture) form a key component of rural livelihoods in Malawi, contributing 4% to the country's Gross Domestic Product (GDP) and playing an important role in food and nutrition security and foreign exchange earnings (Donda & Mafaniso, 2014; Government of Malawi, 2016). In Malawi, fish accounts for approximately 30% of total animal protein intake in the population (Russell et al., 2008), serving as a critical source of vitamins, minerals, micronutrients, and essential fatty acids (Chan et al., 2019). Moreover, local demand for fish is projected to grow as Malawi becomes increasingly urbanized and a greater share of the population enters the middle class (Russell et al., 2008; Tschirley et al., 2015; Chikowi et al., 2021).

Historically, the fish supply in Malawi has been largely dependent on capture fisheries and imports (Government of Malawi 2019; Munthali et al., 2021). However, wild fish stocks have been in steep decline due to overfishing, which is driven by population growth and a lack of alternative income-generating opportunities for the fishers (Allison & Mvula, 2002; Banda et al., 2005, 2016; Mulumpwa, 2016; Limuwa et al., 2018). Consequently, the per capita consumption of fish in Malawi declined from 13–14 kg/year in the 1970s to 4–7 kg/year as of 2005 (Russell et al., 2008).

Demand for fish in Malawi cannot be addressed through capture fisheries alone; aquaculture (fish farming) also has a role to play. Aquaculture has the potential to contribute to national economic development by serving as a secondary source of income for agricultural households, as well as contribute to food and nutrition security by increasing food production and making fish more readily available in remote communities (Jamu & Chimatiro, 2004). The promise of aquaculture has been recognized elsewhere in sub-Saharan Africa, where the average annual growth rate in farmed fish production was 21% between 2004 and 2014 (Belton et al., 2018). In addition, aquaculture is a more environmentally sound form of employment than other activities such as charcoal burning and brick-making that lead to forest degradation and deforestation. Researchers have also found that integrating aquaculture into existing agricultural systems can result in increased land productivity, higher farm incomes per hectare, and higher returns to family labor (Hishamunda & Ridler, 2006; Dey et al., 2008; Lehane, 2013).

Between 2005 and 2015, aquaculture contributed around 1–5% to the total fish production in Malawi, as shown in Figure 1. The aquaculture sector has experienced some increase in fish production, from 813 tons in 2005 to about 9,399 tons in 2020. While its growth has been limited in absolute terms, there is vast potential to further grow this sector, and it is estimated that 10–20% of Malawi's land area (1,165,000 ha) is suitable for aquaculture (Brooks, 1992). Malawi also has 35,000 ha of underutilized dambo land (wetlands) that can be used for aquaculture (Russell et al., 2008).

Figure 1. Fish production from 2005 to 2020



Source: Government of Malawi (2021) and Department of Fisheries database

However, key knowledge gaps exist regarding aquaculture in Malawi, including around the profitability of fish farming in this context, the role it plays in farming households, and whether and/or why some farmers abandon their aquaculture enterprises. Filling this knowledge gap will help policymakers determine whether to promote the adoption of aquaculture, how to guide fish farmers in maximizing their returns, and what support small-scale fish farmers need. If the challenges faced by small-scale fish farmers can be addressed, the aquaculture sector can better contribute to Malawi's national agenda (the

Malawi 2063) through wealth and employment creation and the provision of raw materials for the fish processing industry.

This study is aimed at examining the constraints and opportunities for increased production among small-scale fish farmers. Toward this end, the study addresses the following research questions:

1. What are the characteristics of fish farmers and farms in Malawi?
2. What is the role of aquaculture in the livelihoods of small-scale farmers?
3. Is small-scale aquaculture profitable to the fish farmers?
4. What are the challenges faced by small-scale fish farmers?
5. What policy recommendations can address these challenges?

This study is based on a survey of small-scale fish farmers in 10 districts spanning all three regions of the country. To our knowledge, this is the first small-scale aquaculture survey in Malawi to capture production across the entire country, rather than focus on one region or one study site. The sample size is relatively large, compared to other studies of aquaculture in sub-Saharan Africa. This study contributes to the growing body of literature on aquaculture in this region and provides a current view of the landscape of small-scale fish farms in Malawi, updating earlier work from 10–20 years ago (Chimatiro & Chirwa, 2007; Russell et al., 2008).

The remainder of the report is structured as follows. Chapter 2 introduces the data and details the empirical approach used to measure profitability. Chapter 3 presents the results. Chapter 4 draws on the findings to discuss opportunities in the small-scale aquaculture sector. Chapter 5 concludes with a summary of key findings and a set of recommendations to promote the growth of small-scale fish farming in Malawi.

2. DATA SOURCES AND METHODS

This study draws from primary data collected through the MwAPATA Aquaculture Survey (MAS 2021), a survey of small-scale fish farms in all three regions of Malawi.

2.1. Questionnaire

The questionnaire used in this survey captured information on the characteristics of the fish farms, the inputs used, fish production, consumption, sales, and income realized from fish farming between December 2019 and December 2020. Information was also captured on labor, credit, and perceptions of the importance of fish farming in the lives of fish farmers. In Malawi, some fish farms are owned and managed by individual households (what we refer to as “individually owned farms”), while others are communally owned and managed (what we refer to as “community farms”). For individually owned farms, information was captured on the farm-households, including demographics and wealth. For community farms, representatives of the farm were interviewed, and information was captured on the composition and management of the communal farm and the experiences of “typical” farm members.

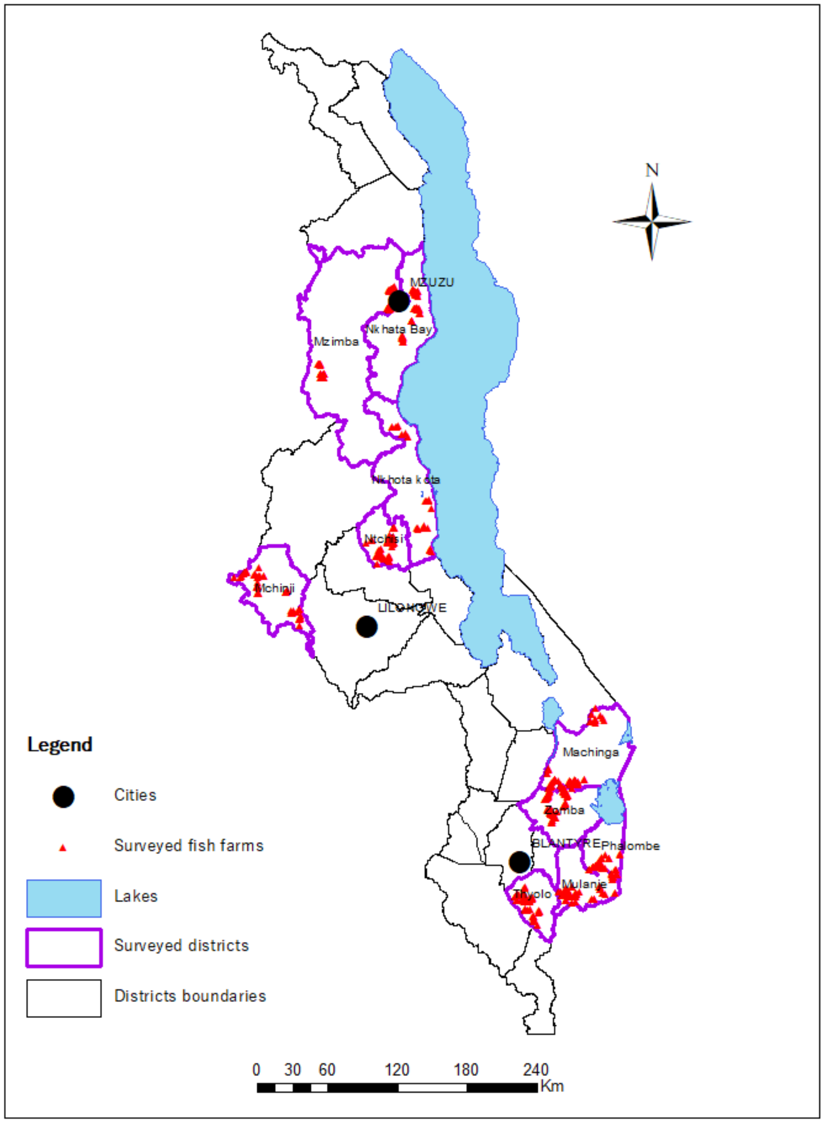
2.2. Study coverage and sampling design

A farm-level survey was conducted in 10 districts of Malawi (Figure 2). The survey targeted districts where fish farming is most common in each of Malawi’s three regions. Data shared by the Department of Fisheries in the Ministry of Forestry and Natural Resources shows that Malawi has approximately 9,000 small-scale fish farms and 15,465 individual fish farmers. These fish farms are either individually or communally owned and managed. The study targeted a sample of 900 fish farms, representing about 10 percent of the total population of fish farms.

A multistage sampling technique was employed to identify fish farms for inclusion in the sample. First, the districts in each region with the greatest number of fish farmers were identified with input from key informants (in this case, district fisheries officers), selecting five in the Southern Region, three in the Central Region, and two in the Northern Region. These are Nkhata Bay and Mzimba (Northern Region); Ntchisi, Nkhotakota, and Mchinji (Central Region); and Phalombe, Thyolo, Mulanje, Machinga, and Zomba (Southern Region).

Second, data on the fish farm population in all Extension Planning Areas (EPAs) in the 10 selected districts were gathered. This step was limited to the population of farms that were operational, excluding any farms that had ceased functioning or would not have harvested any fish during the study's reference period of December 2019 to December 2020. The EPAs were ranked based on the number of fish farms, and we selected the three EPAs with the highest number of fish farms in each district, subject to confirmation by district fisheries officers. Third, a list of all fish farms in each of the selected EPAs was created. This list included all types of fish farms (pond farms, dam farms, etc.). Then, 30 fish farms were drawn randomly from the list of fish farms. A census was conducted in EPAs with fewer than or equal to 30 fish farms.

Figure 2. Study districts and distribution of surveyed farms



Source: Authors

2.3. Data collection

The farm survey data collection took place between June and July 2021, with a questionnaire administered to fish farmers in the targeted districts. The questionnaire was first piloted in

Mitundu EPA, Lilongwe district, and later pretested in Mayani EPA, Dedza district. In total, 732 interviews were conducted, as shown in Table 1. Fewer than 30 fish farms were found in several of the selected EPAs (particularly in Nkhotakota and Ntchisi), which accounts for having fewer than 30 interviews conducted in the EPA and fewer than 90 interviews in the district. In some cases, fewer than 30 interviews were conducted when farmers in a given community were unavailable at the time of data collection due to a funeral or other extended community event.

Table 1. Interviews conducted

District	No. of interviews conducted	% of targeted interviews in the district
Thyolo	76	84.4
Mulanje	84	93.3
Phalombe	80	88.9
Zomba	86	95.6
Machinga	74	82.2
Mchinji	87	96.7
Ntchisi	60	66.7
Nkhotakota	29	32.2
Nkhatabay	82	91.1
Mzimba	74	82.2
Total	732	

Survey weights were applied in all analyses and were constructed as follows: farm weight = number of farms interviewed in the EPA / number of fish farms in the EPA. While the resulting statistics are not strictly representative of the total population of small-scale fish farms in the country, they can be considered representative of the hubs of small-scale fish farming in each region.

2.4. Measurement of farm profits

A key component of this analysis is an assessment of the economic viability of small-scale fish farming in Malawi. Toward this end, a profitability analysis was conducted. Some measures that are used to determine the profitability of an enterprise include the Marketing Margin (MM), Gross Margin (GM), Internal Rate of Return (IRR), Return on Investment (ROI), and Benefit-Cost Ratio (BCR or B/C) (Mhango, 2020). This study employs a Gross Margin Analysis (GMA) to determine the profitability of the aquaculture enterprise for small-scale fish farmers. GMA has been widely used by other researchers in similar settings (Hyuha et al., 2011; Akegbejo-Samsons & Adeoye, 2012; Issa et al., 2014; Namonje-Kapembwa & Samboko, 2020).

The variables used in this analysis include the value of production and variable costs such as costs of fingerlings, feed (commercial and homemade), fertilizer (organic and inorganic), lime, medication, energy (used for homemade feed preparation), and transport. Fixed costs are not accounted for in this analysis, though these seem to be marginal. The value of production is inclusive of all that is harvested, with a monetary value imputed for what is consumed or otherwise not sold.

The gross margin of a fish farm is calculated using the following formula:

$$GM = TR - TC \tag{1}$$

GM = Gross margin (profit)
TR = Total revenue
TC = Total cost of production

This calculation is used to determine whether each farm is profitable, what is the magnitude of the profit or loss, and what is the profit scaled to the size of a typical pond. The profitability of fish farming is then compared across categories, including different farm types (individually owned vs. communally owned), different systems of production (production cycles vs. continuous/recycled production), different regions of the country, different fish species, and different farm sizes.

3. STUDY FINDINGS

This chapter presents descriptive results from the survey data of small-scale fish farms in Malawi, drawing on both closed-ended and open-ended questions.

3.1. Characteristics of fish farming households and community farm leadership

Among the fish farms surveyed, there were 606 individually owned farms and 126 community farms. Individually owned farms accounted for 86.8% of the fish farms (with survey weights applied), whereas community farms accounted for 13.2%. The general characteristics of the individual fish farming households and community farms are summarized in Table 2 and Table 3. Overall, a majority of the individual fish-farming households were male-headed (85.5%), implying that fish farming in Malawi is male-dominated (Table 2). The mean age of the heads of fish farming households was 52.2 years. More than half (53.6%) of the surveyed household heads were more than 50 years old (51–89), 34.1% were within the age group of 36–50 years, and 12.3% were under 36 years of age.

Education is an important factor for any farmer, as farmers that are literate are more likely to implement and adopt new and modern (improved) aquaculture management practices, innovations, and technologies. In terms of education, most of the fish farming household heads (89.1%) were literate. Less than half (44.2%) had a Primary School Leaving Certificate of Education (PSLCE) or a higher-level certificate or degree.

The mean household size was 5.5 members. On average, households had 11.9 years of fish farming experience. About half (46.0%) of the households had more than 10 years of fish farming experience, while 19.0% had 6–10 years, and 35.0% had 5 years or less. A majority (71.0%) of the fish farming households were members of a fish farm organization. Among those that were members of an organization, 96.5%, 4.6%, and 4.5% were members of a fish farm club,[1] association,[2] and cooperative,[3] respectively.

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[1] A fish club is an organization that brings farmers together to manage a fish farm. This is a grassroots-level informal forum of farmers.

[2] An association acts as a focal point for the expression of farmers' needs and wishes. From our observation, fish farming associations are comprised of members from clubs, district fisheries offices, etc.

[3] A cooperative is a group of farmers that sell their product or buy inputs collectively, in large amounts that allow for better prices.

Table 2. Characteristics of fish farming households

Parameter	Unit	Mean value or percentage
Age of household head	Years	52.2
Male-headed household	%	85.5
Literacy of household head	%	89.1
Household size	Members	5.5
Fish farming experience	Years	11.9
Member of a fish farm organization	%	71.1
Observations		606

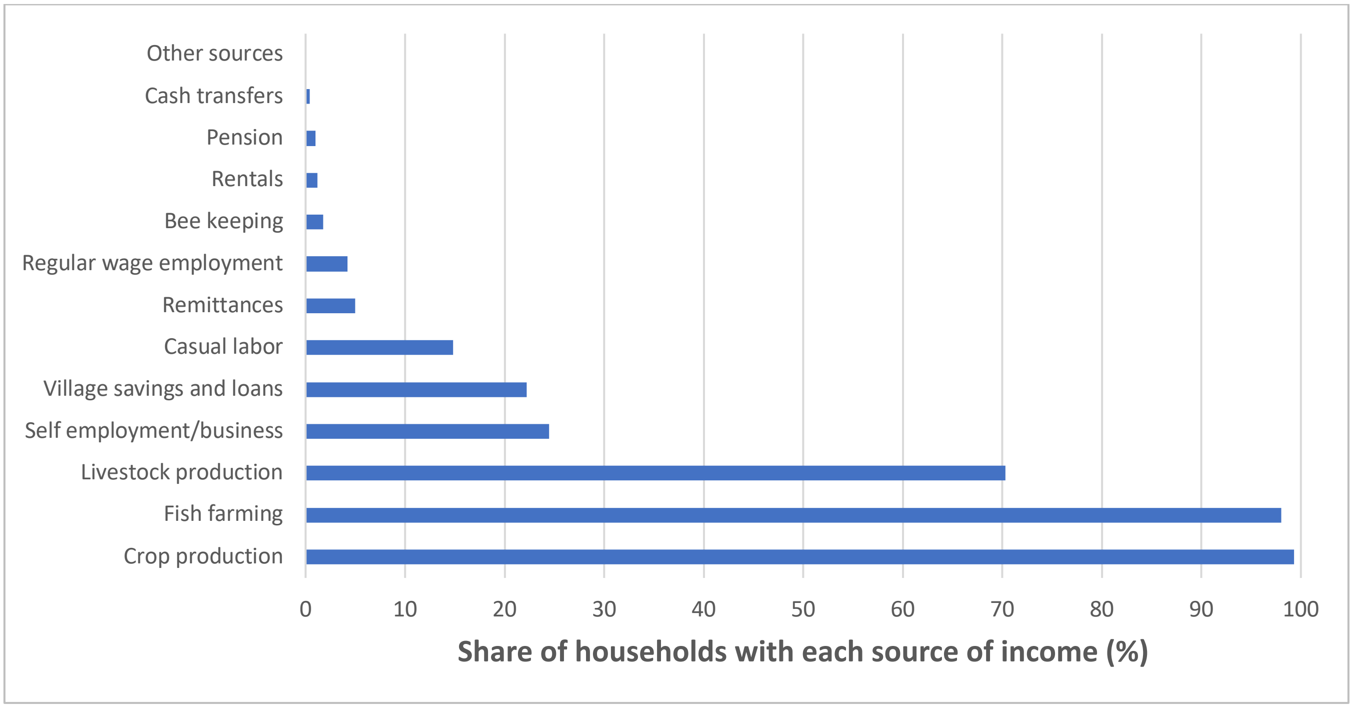
Source: MAS 2021

Although all fish farming households, by definition, were engaged in fish farming, most were also engaged in other pursuits. The rate of participation in different income sources (from both on-farm and off-farm activities) over the previous year is presented in Figure 3. Households generated their income from crop production (99.3%), fish farming (98.0%),[4] livestock keeping (70.3%), self-employment/small businesses (24.4%), and village savings and loans (22.2%).

As noted, some fish farms in Malawi are owned and managed in a communal manner. The community farms had an average membership size of 17.8 farmers (Table 3). The average shares of women and youths in the community farms were 61.3% and 31.2%, respectively. In total, a majority of the leadership positions in the surveyed districts were occupied by women (53.9%), with 46.1% of the positions occupied by men. The age of the community farm leaders ranged from 14 to 82 years with a mean age of 44.8 years. A large majority of the community farm leaders (90.4%) were literate. However, just 40.0% of the leaders had a Primary School Leaving Certificate of Education (PSLCE) or a higher-level certificate or degree.

[4] Some fish farms did not generate income from fish farming due to the EUS fish disease outbreak.

Figure 3. Fish farming households' income from various sources



Source: MAS 2021

Table 3. Characteristics of community farms

	Unit	Mean value or percentage
Community farms:		
Size of farm membership	Number	17.8
Average number of women in leadership positions	Number	3.3
Proportion of women in the community farm	%	61.3
Proportion of youths in the community farm	%	31.2
Observations		126
Community farm leaders:		
Proportion of women leaders	%	53.9
Age of leaders	Years	44.8
Literacy of leaders	%	90.4
Educational qualification of leaders	%	40.0
Observations		378

Source: MAS 2021

Note: Community farm leadership in this study refers to the chairperson, treasurer, and secretary.

3.2. Characteristics of fish farms

Fish farms in the surveyed districts were almost always in the form of ponds (94.5%), with the remaining 5.5% being in the form of dams. Most farms (99.5%) were constructed of mud (Figure 4; Plate 1). Note that earthen ponds are susceptible to floods and erosion if not properly constructed and are also vulnerable to natural predators. These challenges will be discussed in detail in Chapter 3. The most common water supply source for fish farms was groundwater (74.9%), followed by river water (24.2%).

On average, fish farms included 1.4 ponds,[5] with a range of 1 to 13. The average pond size was 299.5 m^2, though about half of the ponds (50.1%) had a size of ≤ 200 m^2. Pond depth is an important factor in fish production because it affects aeration, especially if aerators are being used. The ideal pond depth is 1.5 m (Boyd et al., 2020), and in Malawi,

[5] Because almost all farms were comprised of ponds, the term “ponds” is used throughout the remainder of this report to refer to both ponds and dams. All statistics are inclusive of both facilities.

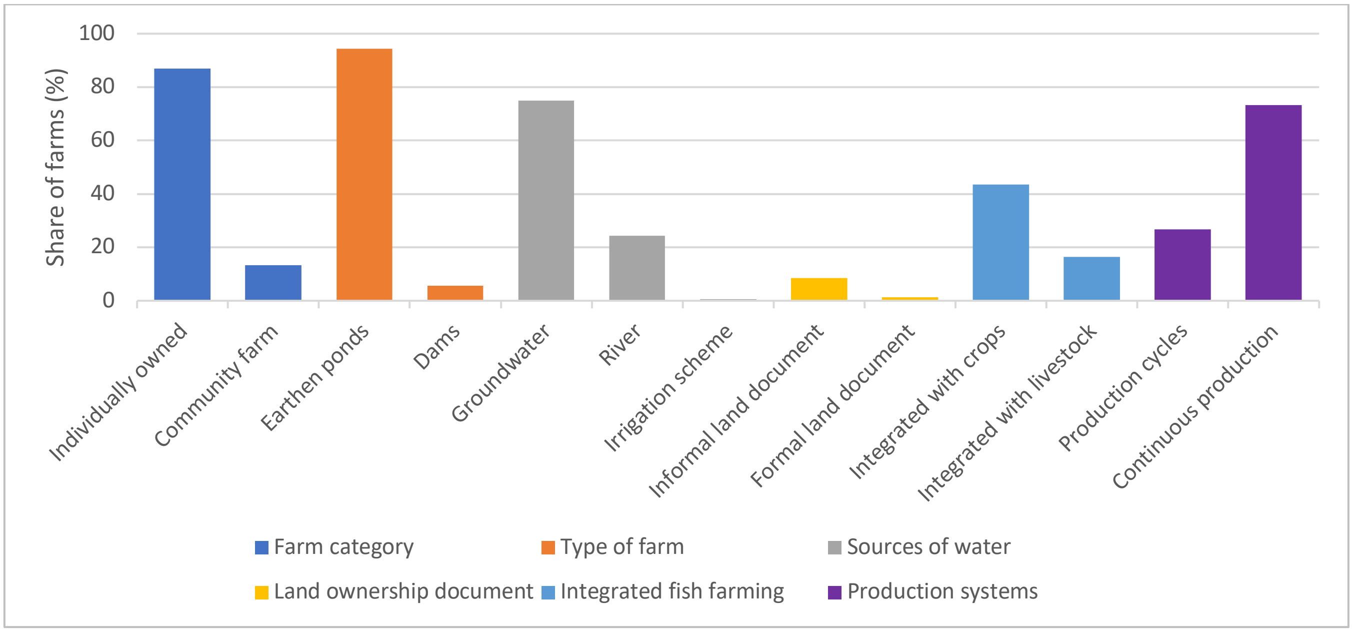
the average pond depth was 1.5 m. This implies that small-scale farmers have been following best practices with respect to pond depth.

The average fish farm had a total area of 400.9 m^2 (median = 208 m^2). About half of the farms (49.7%) were less than 200 m^2, 42.5% were between 200 and 1,000 m^2, and 7.8% were greater than 1,000 m^2. On average, community fish farms are much larger (646.5 m^2) than individually owned farms (363.5 m^2). As both community farms and individually owned farms had 1.4 ponds, on average, the size difference mostly reflects the larger pond sizes found on community farms. On average, fish farms tended to be larger in the Central Region (493.2 m^2) and the Northern Region (464.0 m^2) than in the Southern Region (356.7 m^2).

On average, the fish farms were established 11.3 years ago, with individually owned farms being in operation longer (11.8 years, on average) than community fish farms (8.0 years, on average). This suggests that some of these community farms were "young" and likely needed to build their managerial and technical skills. About one-third (34.8%) of all farms were established within the past 5 years, while 21.3% were established 6–10 years ago, and 43.9% were established more than 10 years ago. The farms spent an average of MK 212,902 to establish themselves. More than a quarter (28.8%) of the fish farms incurred no expenditures in establishment, as they used only family or community labor. Including those with zero costs, 80.6% of the farms used less than MK 100,000 (approximately USD 120) for establishment.

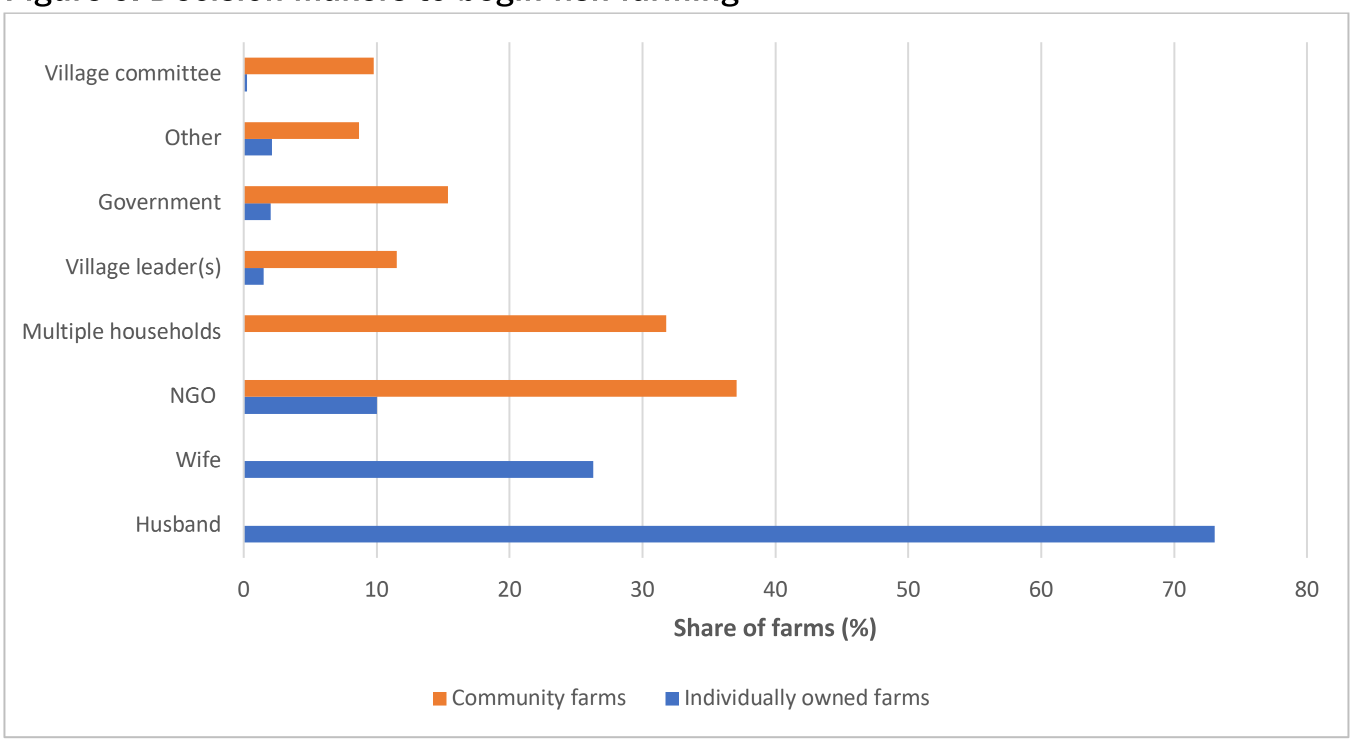
Most individually owned farms (85.5%) started fish farming on their own, rather than being established by an NGO or government. However, 37.1% of community farms were established by an NGO and 15.4% by government (Figure 5). This suggests that there is less of an independent drive to engage communally in fish farming, which may affect the sustainability of these farms once external support is withdrawn. The individually owned fish farms were influenced to begin raising fish through observations of other fish farmers (79.9%) and discussions with other fish farmers (27.6%) (Figure 6). Other sources of influence include NGOs, extension workers, government, and outreach programs, which account for 17.7%, 5.1%, 3.1%, and 1.8% of decision makers, respectively.

Figure 4. Characteristics of fish farms



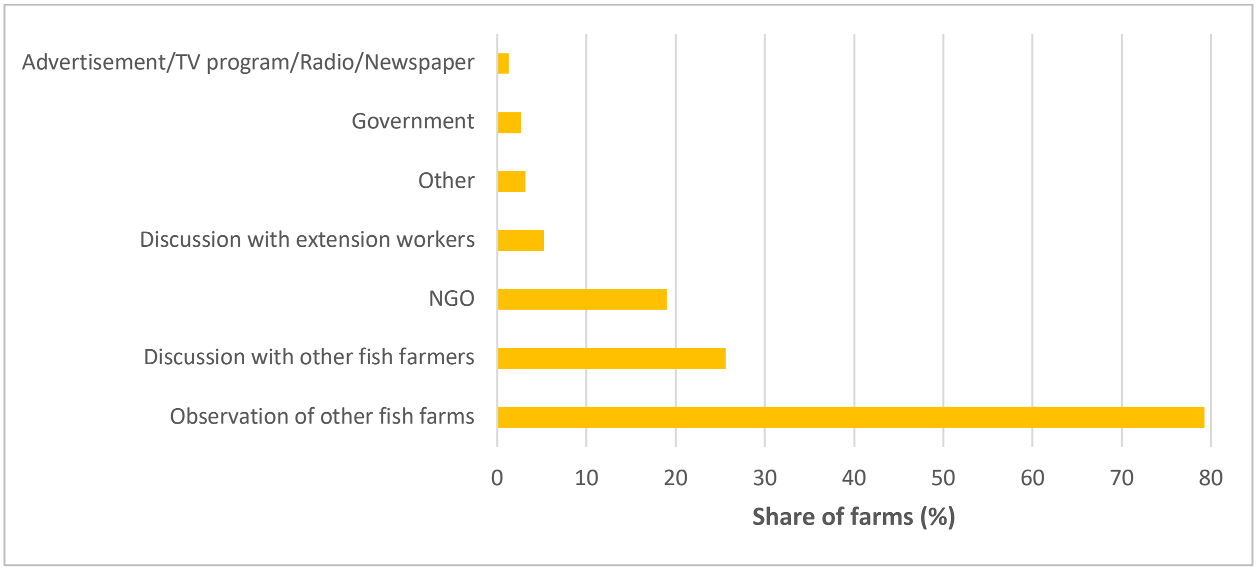
Source: MAS 2021

Figure 5. Decision makers to begin fish farming



Source: MAS 2021

Figure 6. Sources of influence to begin fish farming



Source: MAS 2021

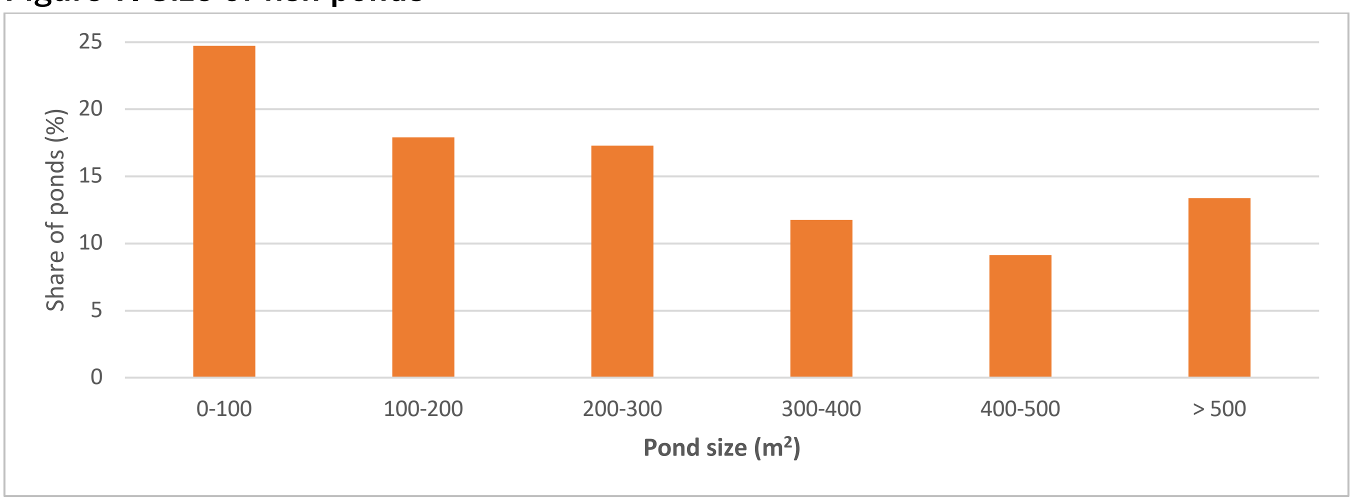
Plate 1. Example of an earthen pond

Source: Authors

The ponds of the fish farms surveyed were used primarily for fish production (95.9%), while 4.1% were used primarily for fingerling[6] production or hatchery operations. Fingerling production is done by hatchery operators who are trained by government and other stakeholders to supply quality seeds/fingerlings to farmers within their locality. In total, just 3.8% of farms had any ponds that were solely for fingerling production, and no farms focused exclusively on fingerling production. The distribution of pond sizes is shown in Figure 7.

About three-quarters (73.2%) of the fish farms practiced continuous production, in which farmers continuously produce fish (over more than six months) without pond maintenance (cleaning/complete drainage). A smaller proportion of fish farms (26.8%) produced fish in production cycles, whereby fish are reared within six months, followed by the time- and labor-intensive process of pond drainage. In this production system, farmers can produce twice a year if they have the necessary resources. However, during the 12-month reference period, a majority (84.2%) of the farms that adhered to production cycles produced fish in just one cycle. While larger farms were more likely than smaller farms to follow production cycles, a majority of even the largest farms practiced continuous cultivation. Specifically, the share of farms that followed production cycles was 23.8%, 26.4%. and 42.3% for farms of less than 200 m^2, 200–1,000 m^2, and greater than 1,000 m^2, respectively.

Figure 7. Size of fish ponds



Source: MAS 2021

[6] Fingerlings are the "seeds" of fish farming, such that a pond used for fingerling production is used specifically to produce young fish, often for sale to other fish farmers.

Integrated fish farming (IFF), also known as integrated agriculture aquaculture (IAA), is a system of diversified agricultural production that incorporates fish in order to maximize farm productivity and profits. IFF involves recycling farm wastes in one activity (such as manure from livestock keeping) as inputs in another (such as fish farming) to make efficient use of resources (Ayinla, 2004; EYO et al., 2010; Onada & Ogunola, 2016; Ajani et al., 2020). As shown in Figure 4 and Plate 2, it was common for pond farms in the surveyed districts of Malawi to be integrated with crop production (43.5%). Among these farms, the fish ponds were integrated with vegetables (88.9%), maize (16.1%), sugarcane (11.0%), banana (7.4%), and rice (3.4%). Some fish farms were also integrated with livestock (15.6%), and among these farms, the ponds were integrated with poultry (68.9%), goats (42.5%), and pigs (15.2%). Overall, it is much more common for individually owned farms to integrate their aquaculture facilities with crops (46.7% of individually owned farms, compared to 21.9% of community farms) and livestock (16.8% of individually owned farms, compared to 7.8% of community farms). To the extent that IFF is beneficial for farmers, communal aquaculture has less potential to tap into this option.

Plate 2. Fish farming integrated with crops and livestock

Fish integrated with rice

Fish integrated with goats

Source: Authors

Another important aspect of farming as a business is record keeping, which allows farmers to track information and make informed farm management decisions. Just 37.5% of the fish farms maintained any written records. Among these, farmers kept records regarding the usage of inputs (87.6%), purchase of inputs (82.9%), harvest (77.3%), income (69.4%), prices of fish sold (55.7%), family labor (39.1%), and hired labor (36.0%) (Table 4). It is much more common for written records to be maintained on community farms, at 73.9% versus 31.9% for individual farms, which likely reflects the complexity of managing communal farms. That most farms do not maintain records suggests that small-scale fish farming is regarded more as a livelihood than as a profit-maximizing business in Malawi. The implications of this finding will be discussed in Chapter 5.

As presented in Table 5, the source of funds to establish the farms was most commonly household savings (89.6% for individually owned farms or 43.9% for community farms). However, community farms were very often established with outside help, including as a government project (19.3%) or an NGO project (41.5%). This potentially poses a threat to the sustainability of these farms. From field observations, we noted that many fish farms were abandoned after NGO/government support was phased out.

None of the individually owned farms were established with credit from financial institutions. In addition, during the reference period, just 0.1% of farms took out loans or participated in credit programs, which together suggests that farmers have very limited access to credit. This will be discussed in more detail in section 3.7.

Table 4. Topics of record keeping by farms

	% of farms (among those that kept any records)
Use of inputs	87.6
Purchase of inputs	82.9
Harvesting	77.3
Income	69.4
Prices	55.7
Family labor	39.1
Hired labor	36.0

Source: MAS 2021

Table 5. Sources of funds for farm establishment

	Individually owned farms (%)	Community farms (%)
Household savings	89.6	--
NGO/project assistance	6.7	41.5
Other	6.3	7.6
Government project	0.7	19.3
Savings from multiple households	--	43.9
Community Development Fund (CDF)	0.3	6.7
Borrowed from family/friends	0.7	0.0
Credit from financial institutions	0.0	0.4

Source: MAS 2021

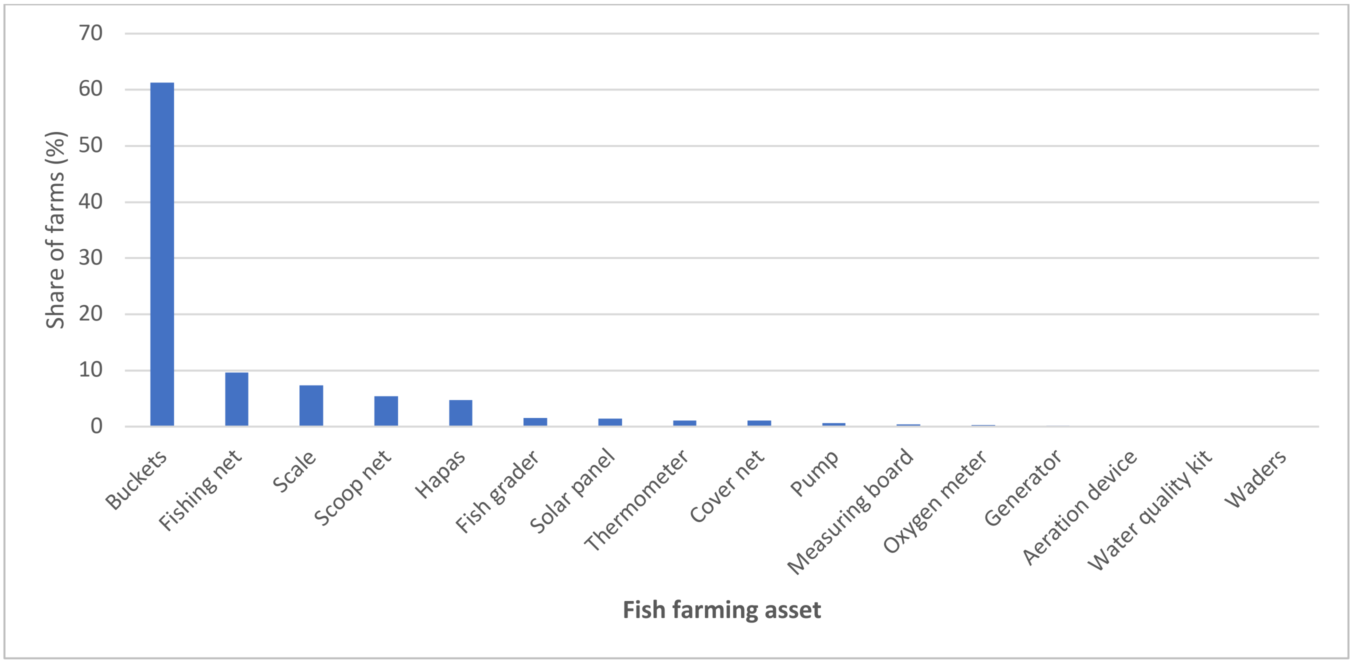
3.3. Farm assets

Farmers in the surveyed districts owned a variety of farm assets, as shown in Figure 8. A large majority of the farming households (99.5%) owned land. The size of land owned ranged from 0.00015 ha to 53.4 ha, with a mean landholding size of 1.9 ha and a median of 1.2 ha. Out of their total landholdings, fish farming households allocated an average of just 2.7% to fish farming.

With respect to the land on which the fish farms were situated, a majority (98.8%) of the land was under customary tenure and was most commonly acquired through inheritance (67.9%), followed by purchase (12.4%) and allocation by traditional leaders (10.7%), family (5.3%), non-family members (2.5%), and government (1.2%), as shown in Figure 9. This pattern varied across farms that were communally and individually owned, as it was far more common for community farmland to be allocated by local leaders (51.1%), government (4.7%), or other sources (6.6%).

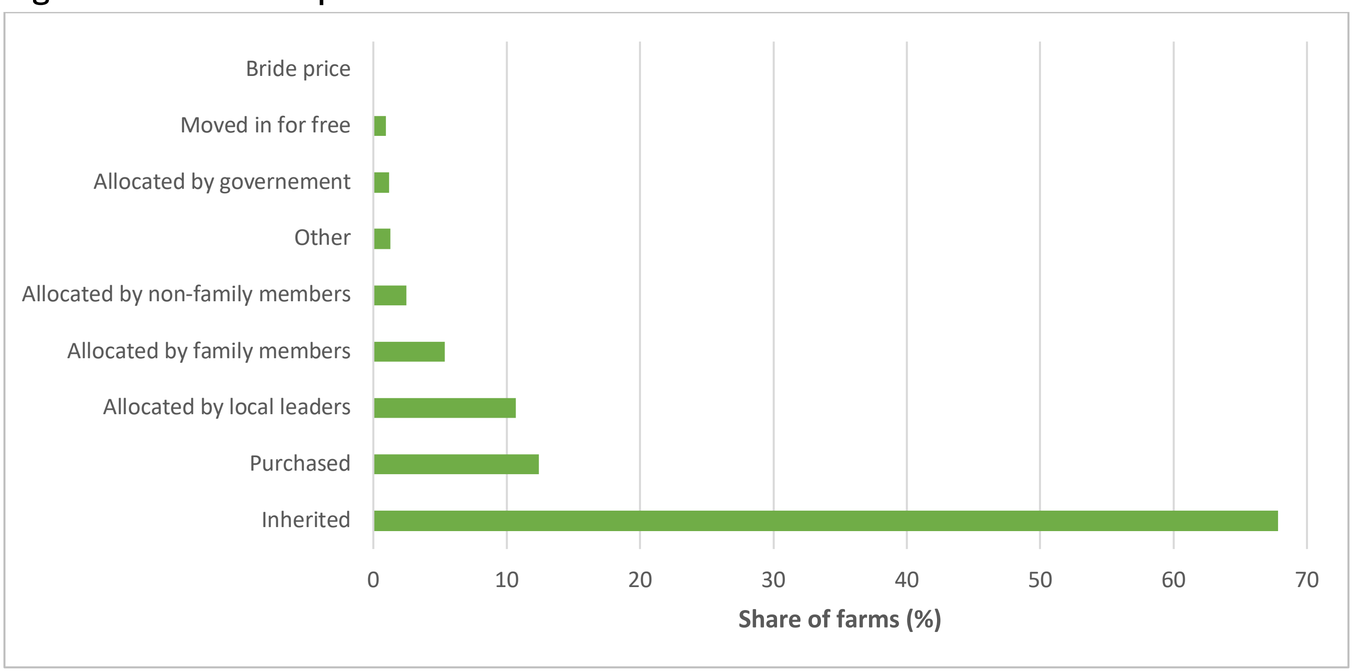
Farms also owned other farm assets such as buckets (61.4%), fishing nets (9.6%), scales (7.4%), scoop nets (5.4%), hapas (4.8%), fish graders (1.6%), solar panels (1.4%), thermometers (1.1%), cover nets (1.1%), and pumps (0.6%) (Figure 8). Very few or none of the farms owned a measuring board, oxygen meter, generator, aeration device, water quality kits, or waders. The lack of such equipment may affect fish farming operations, as explained in Table 6.

Figure 8. Assets owned by fish farms



Source: MAS 2021

Figure 9. Mode of acquisition of land for the fish farms



Source: MAS 2021

Table 6. Fish farm assets and their purpose in fish farming operations

Farm asset	Purpose	Implication if not owned
Fishing net	Catching and harvesting fish	o Affects harvesting operations o Risk of introduction of fish diseases such as EUS if farmers use nets borrowed from their fellow farmers
Thermometer	Measuring water temperature	o Affects fish survival, growth, activity/behavior, and reproduction in the pond o The dissolving of fertilizers and lime depends on the water temperature
Cover net	Protecting fish from predators	o Without a cover net, fish are easily attacked by animal predators
Oxygen meter	Measuring oxygen levels in the pond	o Affects the survival and growth of fish and other microorganisms and plants that support fish in the pond
Aeration device	Artificially supplying the appropriate oxygen levels to the fish ponds	o Affects the survival and growth of fish and other microorganisms and aquatic plants that support fish in the pond
Water quality kit	Measuring the water quality	o Affects the health and performance of fish and abundance of natural foods for fish such as planktons or other aquatic plants
Waders	Keeping the fish farmers dry, even if they get into the pond	o Affects the health of the fish farmers
Measuring board	Measuring the size of the fish	o Farmers may underestimate the value of the fish harvested, thereby affecting their revenues
Hapas	Rearing fingerlings	o Affects the survival of fingerlings

Source: Authors

3.4. Fish species produced and usage of inputs

The growth and productivity of farmed fish depend on optimally and correctly using farm inputs to realize maximum returns. A lack of access to fish farming inputs may impede small-scale fish farmers' ability to reach their maximum yield, which would contribute to the slow growth of aquaculture in Malawi. The main inputs in fish farming are fingerlings, feed, fertilizers, and hired labor (Ragasa et al., 2020).

3.4.1 Fish species

Table 7 shows that the most commonly stocked fish species in the surveyed districts were chilunguni (*Tilapia rendalli*), makumba (*Oreochromis shiranus*), and chambo (*Oreochromis karongae*). According to Russell et al. (2008), these species have slower growth rates and feed utilization than exotic species, which are not allowed to be cultivated in Malawi. It is more common for chambo to be produced on community farms (at 30.0%) than individually owned farms (at 17.1%). Few regional differences are observed with respect to species cultivated on small-scale fish farms.

Table 7. Fish species produced on small-scale fish farms

Fish species	% of farms	% of total value of production
Chilunguni (*Tilapia rendalli*)	53.3	45.6
Makumba (*Oreochromis shiranus*)	57.2	40.2
Chambo (*Oreochromis karongae*)	18.8	10.2
Mlamba (*Clarias gariepinus)*	1.8	3.6
Other	0.8	0.4

Source: MAS 2021

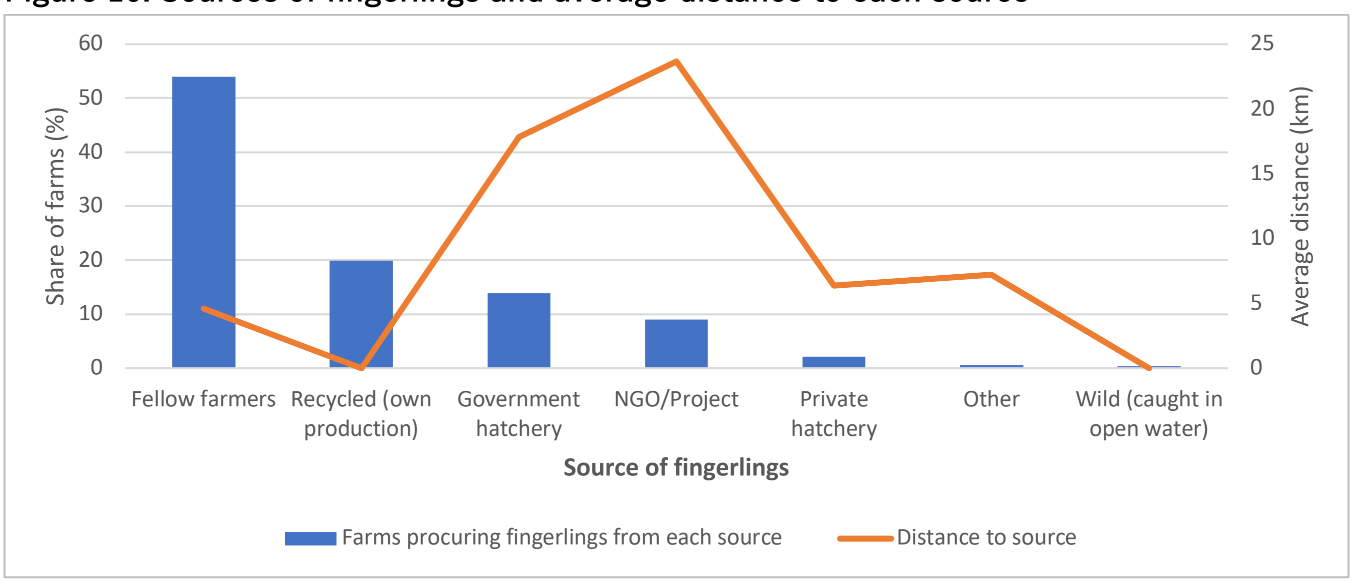
3.4.2 Fingerlings

The quality of fingerlings, which are used to stock fish ponds/dams, is a key determinant of a fish farm's productivity. Lack of access to quality fingerlings is one of the major constraints affecting fish farming in sub-Saharan Africa (Hishamunda & Manning, 2002). Fingerlings can either be mixed-sex or sex-reversed. The use of sex-reversed fingerlings is associated with faster growth, higher survival rates, and higher profits (Budd et al., 2015; Mbiru et al., 2015), while the use of mixed-sex fingerlings is associated with uncontrolled reproduction, fish overcrowding, and stunted fish growth (Celik et al., 2011; Omitoyin et al., 2013; Mbiru et al., 2015). In the surveyed districts in Malawi, a very large majority of ponds (99.8%) were stocked with mixed-sex fingerlings, while just 0.2% of ponds were stocked with sex-reversed fingerlings. This indicates that farmers in Malawi are not adhering to best practices in terms of using sex-reversed fingerlings.

Many farmers did not stock their ponds with new fingerlings each year/season. Among those that did, fingerlings were obtained from diverse sources, with 54.0% sourced from fellow farmers, 19.9% recycled, 13.9% received or procured from government, 9.0% received from NGOs/projects (majority from Deutsche Gesellschaft für Internationale Zusammenarbeit GIZ), and 2.2% sourced from private hatcheries (Figure 10). On average, farmers had to travel 9.0 km to source their fingerlings. However, the distance traveled tended to vary by the source of fingerlings. Specifically, farmers traveled an average distance of 6.4 km, 9.9 km, 18.8 km, and 31.1 km, to source fingerlings from fellow farmers, private hatcheries, government hatcheries, and NGOs, respectively. This indicates that other farmers are a more accessible source of fingerlings, which may have implications for strategies to improve farmers' access to quality fingerlings.

The number of fingerlings stocked ranged from 5 to 24,000 per pond, varying with the pond's size and primary use. The recommended stocking density is 3–8 fingerlings/m^2 (FAO, 2010; Pant, 2020). The surveyed farms had an average stocking density of 3.6 fingerlings/m^2. This implies that farmers in the surveyed district tend to follow the recommended stocking rate, though there may be room for higher density. Further research is needed to understand whether higher stocking densities would improve productivity on these farms or, as posited by Moyo and Rapatsa (2021), whether higher densities would lead to deteriorating water quality in low-technology earthen ponds.

Figure 10. Sources of fingerlings and average distance to each source



Source: MAS 2021

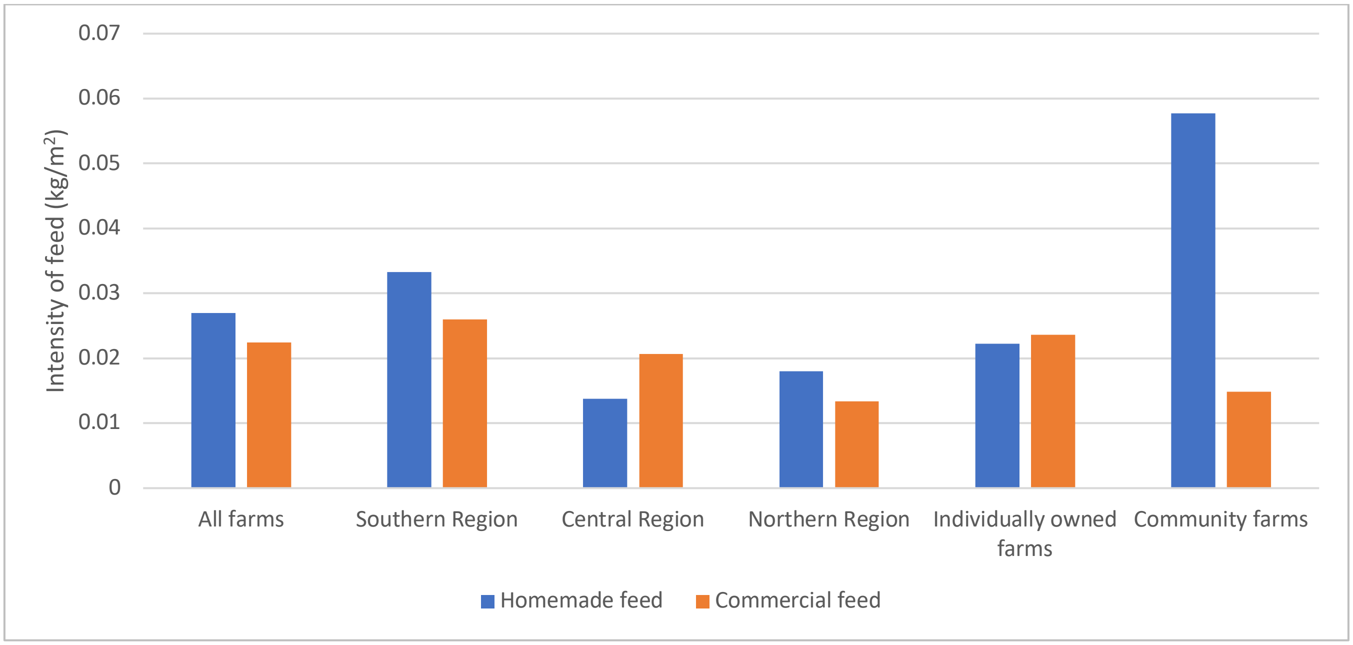
3.4.3 Fish feed

Feed is another major component of fish farming. The availability of quality feed and the amount applied by farmers are essential factors for optimal and vigorous fish growth and for the sustainable development of small-scale aquaculture (World Bank, 2007; Philemon & Rashid, 2019; Boyd et al., 2020). Feed can either be homemade (made from a mixture of maize, maize bran, soya bean, groundnuts, common beans, usipa (*Engraulicypris sardella*), kitchen waste, and/or vegetables) or commercial. Plate 3 shows an example of giving sinking feed to fish with homemade feed, feeding pots, and trays. Studies in Malawi and elsewhere have shown that home-formulated feed does not contain all the necessary nutrients for fish, leading to low productivity (El-Sayed, 2013; Pandey, 2013; Opiyo et al., 2018;). However, commercial feed used by fish farmers in Malawi is imported from Zambia, which raises the cost of commercial fish feed for Malawian farmers.

In the surveyed districts, 98.6% of fish farms used homemade feed, while just 7.4% used any commercial feed (also known as floating feed) (Figure 11; Plate 3). This lack of commercial inputs is understood to hinder the growth of small-scale aquaculture in Malawi (Genschick et al., 2017). A small share (13.2%) of the farms that did use commercial feed seemed to receive it for free from NGOs, projects, or government. Across all farms, an average of 0.02 kg/m^2 of both homemade and commercial feed was used by farms over the December 2019–December 2020 reference period (Figure 11). However, farms that used any commercial feed used an average of 0.3 kg/m^2, indicating more intensive use of inputs on a subset of farms. Community farms, being larger, tended to use more feed overall, and they also used homemade feed more intensively (at 0.06 kg/m^2, on average).

About 10% of the farms that used homemade feed reported that it was cooked. Among these farms, the feed was cooked using either collected or purchased firewood (93.7%) or charcoal (6.3%). This pattern is concerning because deforestation is one of the most pressing environmental challenges in Malawi. As will be discussed further in Chapter 5, fish farmers should be encouraged to plant trees or manage woodlots for the purpose of feed production.

Figure 11. Feed usage, by region and farm type



Source: MAS 2021

Plate 3. Homemade feed and feeding pots

Homemade feed

Feeding pots

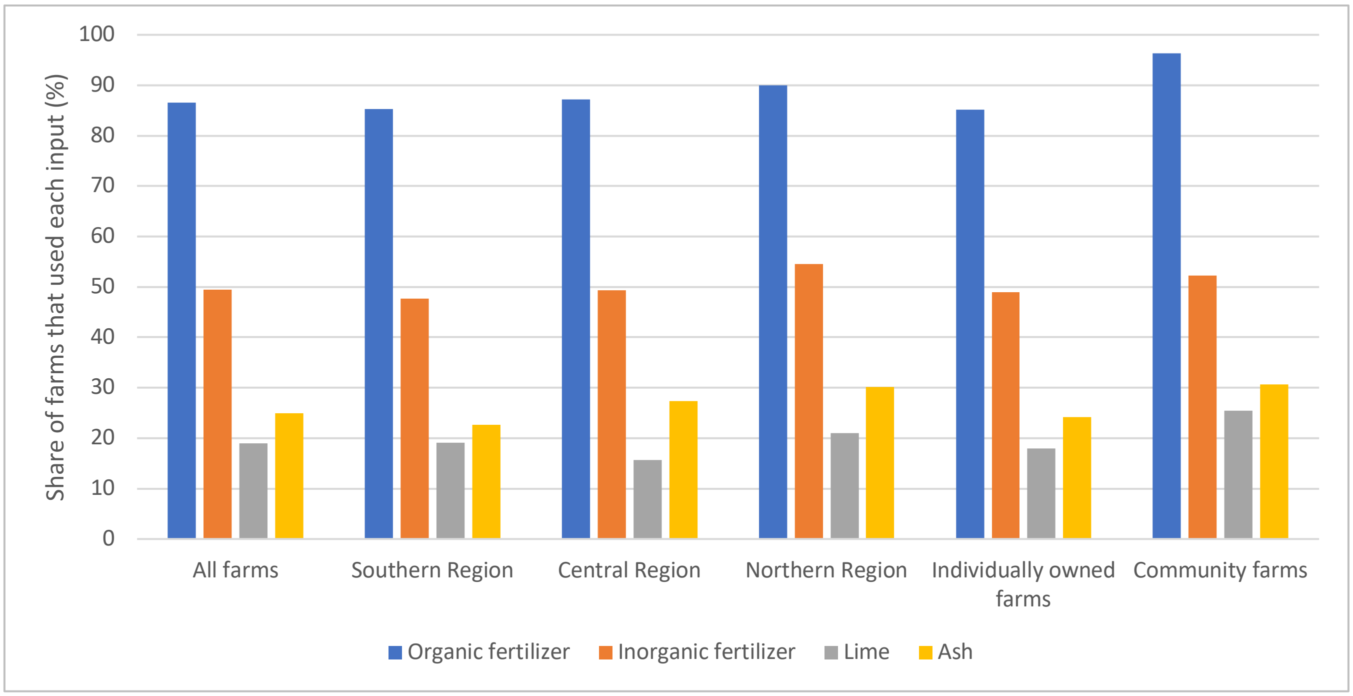
Source: Authors

3.4.4 Fertilizer, lime, and ash application

Farmers apply lime, ash, and fertilizers to their fish farms to neutralize the acidity of the water, enhance water quality by disinfecting the ponds, improve fertilization of fish, increase the growth of natural food (including plankton, worms, insects, snails, aquatic plants, and small fish), and prevent the farms from being invaded by invasive wild species (Ludoviko &

Kang'ombe, 2012; Boyd, 2017; Adhikary et al., 2018; Bouelet Ntsama et al., 2018). The usage rates of inputs such as lime, ash, and organic and inorganic fertilizers are shown in Figure 12. It was common for the surveyed fish farmers to apply organic fertilizers (86.6%) and inorganic fertilizers (49.4%). In addition, 19.0% of the fish farms applied lime, and 25.0% utilized ashes from kitchen fires as an alternative liming agent. On average, farmers applied 356.5 kg of organic fertilizer (median = 60 kg), 4.6 kg of inorganic fertilizer, 8.4 kg of lime, and 3.9 kg of ash perer year. There is some indication that farms in the Southern Region apply organic fertilizer more intensively (at 0.007 kg/m^2) than other regions.

Figure 12. Fertilizer, lime, and ash usage on fish farms



Source: MAS 2021

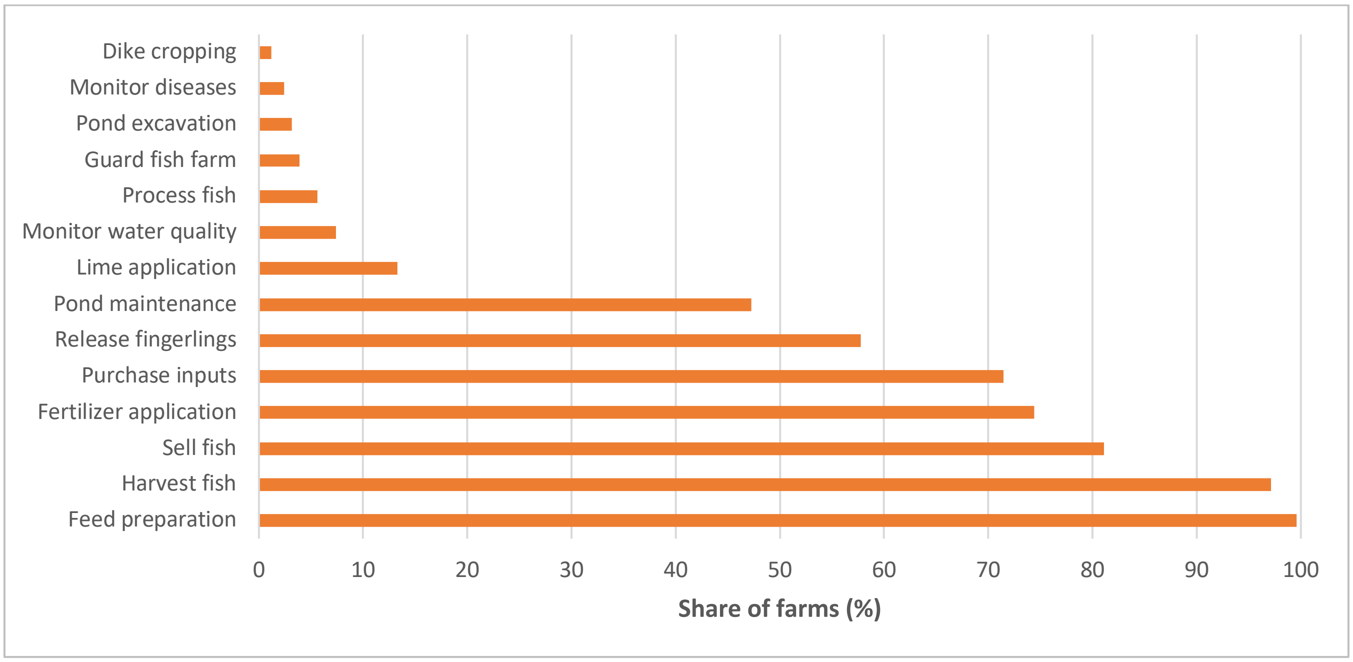
3.4.5 Veterinary drugs

Farmers were also asked about the administration of veterinary drugs, such as antibiotics, nutritional supplements, disinfectants, saline, ammonia removal, probiotics, and pesticides. Veterinary drugs not only treat fish disease and pests but are also used for pond preparation, management of water and soil quality, feed formulation, and manipulation of reproduction (Ali et al., 2014). However, the survey results show that such drugs were only administered on 0.3% of the fish farms. It is not clear whether fish farmers do not administer drugs due to lack of need, lack of access (i.e., high prices for veterinary drugs), or lack of knowledge regarding health management.

3.4.6 Labor

Fish farming entails a wide set of activities from excavating ponds to releasing fingerlings, applying feed and fertilizer, and harvesting and selling fish. As shown in Figure 13, some activities are practiced by almost all farms, while others (such as monitoring water quality or processing the fish) are practiced by just a small share of fish farms in Malawi.

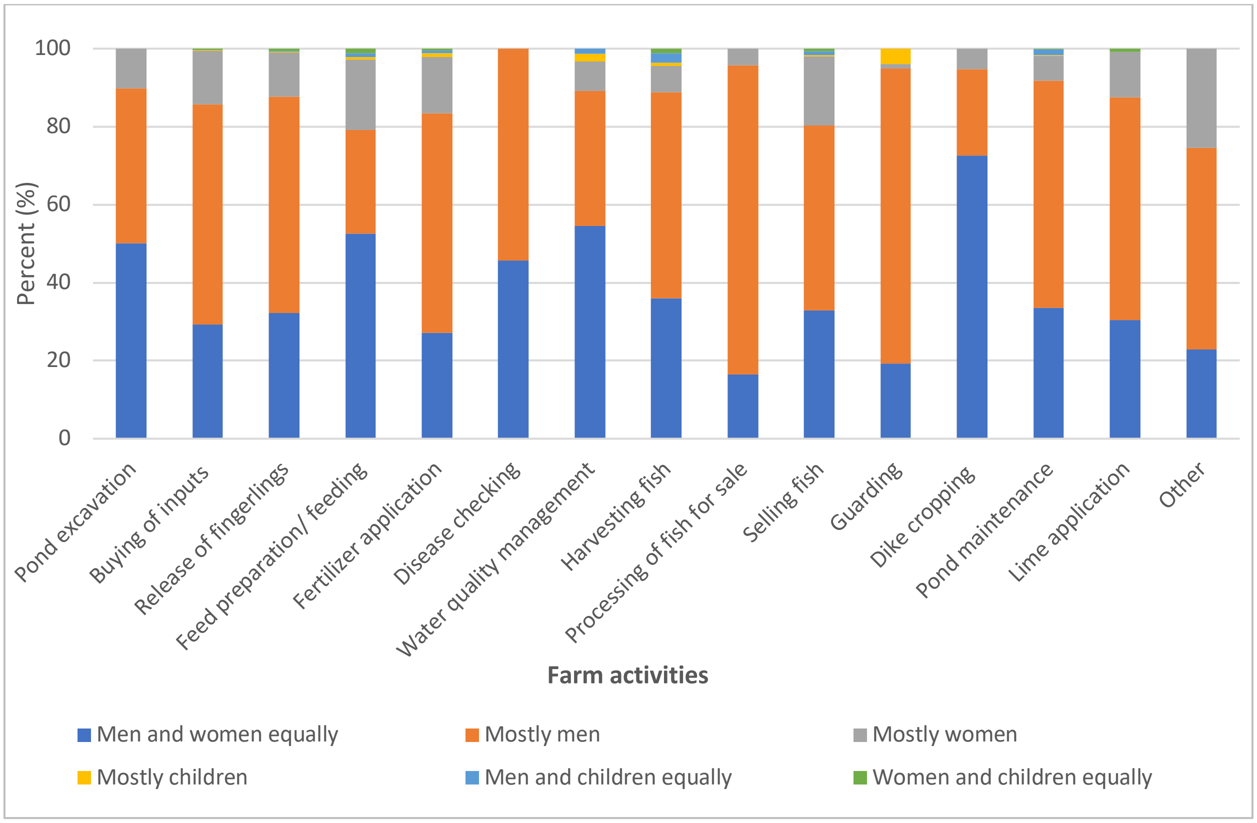
Figure 13. Activities undertaken by the farms



Source: MAS 2021

The survey results show that family is the main source of labor for most of the activities undertaken during fish production. For family labor, Figure 14 shows that most fish farming activities were done mostly by men, including pond excavation, the purchase of inputs, release of fingerlings, fertilizer application, processing of fish for sale, selling of fish, guarding of ponds, and pond maintenance. Activities such as feed preparation and feeding, water quality management, and dike cropping were done by both men and women. Labor was hired on 29.3% of the fish farms, and for almost all activities for which labor was hired, the work tended to be done by men. However, both men and women were hired for the release of fingerlings and for the processing of fish in preparation for sale (Figure 15).

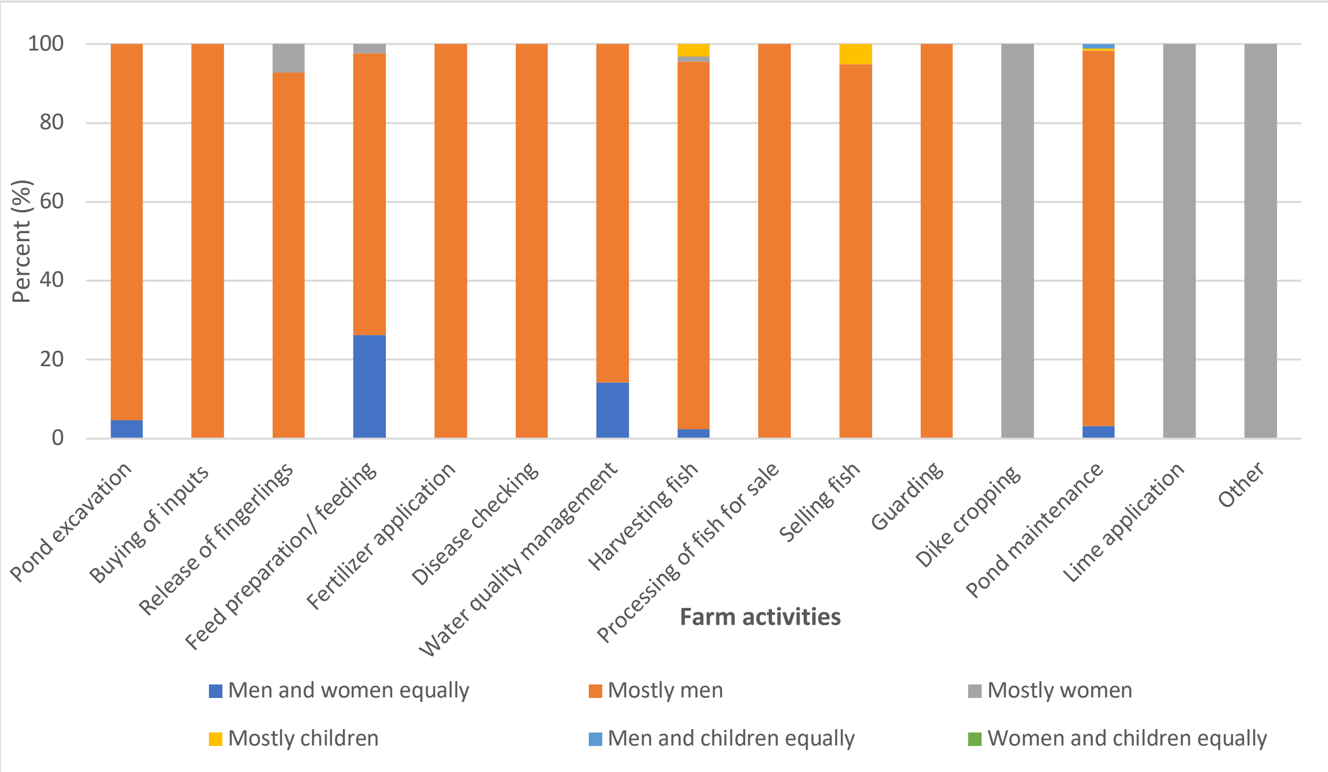
Figure 14. Division of labor for family labor



Source: MAS 2021

Note: These values refer to the percentage among farms that undertook each activity and used family labor.

Figure 15. Division of labor for hired labor



Source: MAS 2021

Note: These values refer to the percentage among farms that hired labor of each activity.

3.5. Fish production

Harvesting was done in 96.5% of the fish ponds on the farms surveyed. Despite having stocked their ponds with various fish species, some fish farmers did not harvest due to the Epizootic Ulcerative Syndrome (EUS) outbreak. This mostly occurred in the Mchinji district, where farmers were advised to drain their ponds and discard all their fish in an effort to contain the outbreak. EUS in Malawi was first reported in the Mchinji district around July 2020 and has since spread to other districts including Dowa, Kaungu, Ntchisi, Mzimba, Rumphi, Lilongwe, and Nkhotakota. If not controlled, the disease may affect those who depend on fish farming as a source of income and livelihood (Munthali, 2021).

The survey also gathered information on the harvesting method used. Farmers following production cycles (comprising 28.4% of the ponds) harvested their ponds completely at the end of each cycle. However, farmers practicing continuous production either selectively (41.8%) or partially (31.1%) harvested their ponds. In the selective harvesting system, farmers select fish to be harvested based on the desired size for sale, and harvesting is done more than once in the season. In the partial harvesting system, harvesting is also done more than once, but it is not based on the size of the fish.

Over the December 2019 to December 2020 reference period, the average fish harvest per farm was 184.5 kg. However, the median was just 37 kg, indicating an extremely skewed distribution of harvests. In fact, 75.9% of the farms harvested less than 100 kg of fish, while 8.6% of the farms harvested more than 500 kg (Table 8). Although about half of the farms were of less than 200 m^2, together these smaller farms produced 17.7% of the value of fish harvest. Farms of 200–1,000 m^2 produced 38.3% of the value of fish harvest, while farms of greater than 1,000 m^2 (comprising 7.8% of the farms) were responsible for 40.1% of the value of fish harvest. This is consistent with the observation of Belton et al. (2018) that a “missing middle” segment of non-industrial fish farms, relatively large and intensive, plays an increasingly large role in aquaculture in the Global South.

Community farms, which tended to be larger, saw a higher average harvest of 221.0 kg, relative to the average of 178.9 kg on individually owned farms (Table 9). Total harvests were much higher, on average, in the Southern Region and lower in the Northern Region. Specifically, farms in the Southern Region harvested an average of 232.6 kg, those in the Central Region harvested an average of 115.1 kg, and those in the Northern Region harvested an average of 93.0 kg. This is particularly noteworthy as farms tended to be smaller in the south (Section 3.2). While the average yield was 0.9 kg/m^2 across farms, there was strong variation across regions, with an average yield of 0.2 kg/m^2 in the Northern Region, 0.6 kg/m^2 in the Central Region, and 1.2 kg/m^2 in the Southern Region. The higher yields in the Southern Region could be at least partly attributed to the presence of the biggest aquaculture research center (the National Aquaculture Centre) based in the Zomba district. In addition, the Southern Region reported higher input usage than other regions, especially feed (Figure 11).

Across species, mlamba had the highest average fish harvest per farm (341.1 kg) (Table 10). This species also saw the highest average yield at 1.4 kg/m^2. Across systems of production, fish harvests and yields were considerably higher, on average, on farms that followed production cycles than farms that practiced continuous production (Table 11). It seems this is not only driven by farms that were able to complete two cycles in the year; the average harvests and yields for each of the production cycles were higher than those of farms with continuous (recycled) production over the whole year.

Table 8. Distribution of fish production quantities

Quantity harvested	% of farms
0 kg	2.1
1-100 kg	73.8
101-200 kg	9.4
201-300 kg	4.3
301-400 kg	2.1
401-500 kg	1.5
>500 kg	8.6

Source: MAS 2021

Table 9. Fish production quantity, yield, and value by farm type (mean values)

	Quantity per farm (kg)	Yield (kg/m²)	Value per farm (MK)	Value per square meter (MK/m²)
Individually owned farm	178.9	.8716	153,239	520.9
Community farm	221	.9035	106,224	292.0

Source: MAS 2021

Table 10. Fish production quantity, yield, and value by species (mean values)

Species	Quantity per farm (kg)	Yield (kg/m²)	Value per farm (MK)	Value per square meter (MK/m²)
Chilunguni	145.1	0.8	100,576.5	375.6
Makumba	147.2	0.6	97,675.9	408.0
Chambo	90.8	0.7	72,266.9	494.4
Mlamba	341.1	1.4	210,272.4	300.3

Source: MAS 2021

Table 11. Fish production quantity and yield by production system (mean values)

System	Quantity per farm (kg)	Yield (kg/m^2)	Value per farm (MK)	Value per square meter (MK/m^2)
Continuous production	154.6	0.8	90,879.4	468.3
Production cycles	266.9	1.1	301,674.1	552.7

Source: MAS 2021

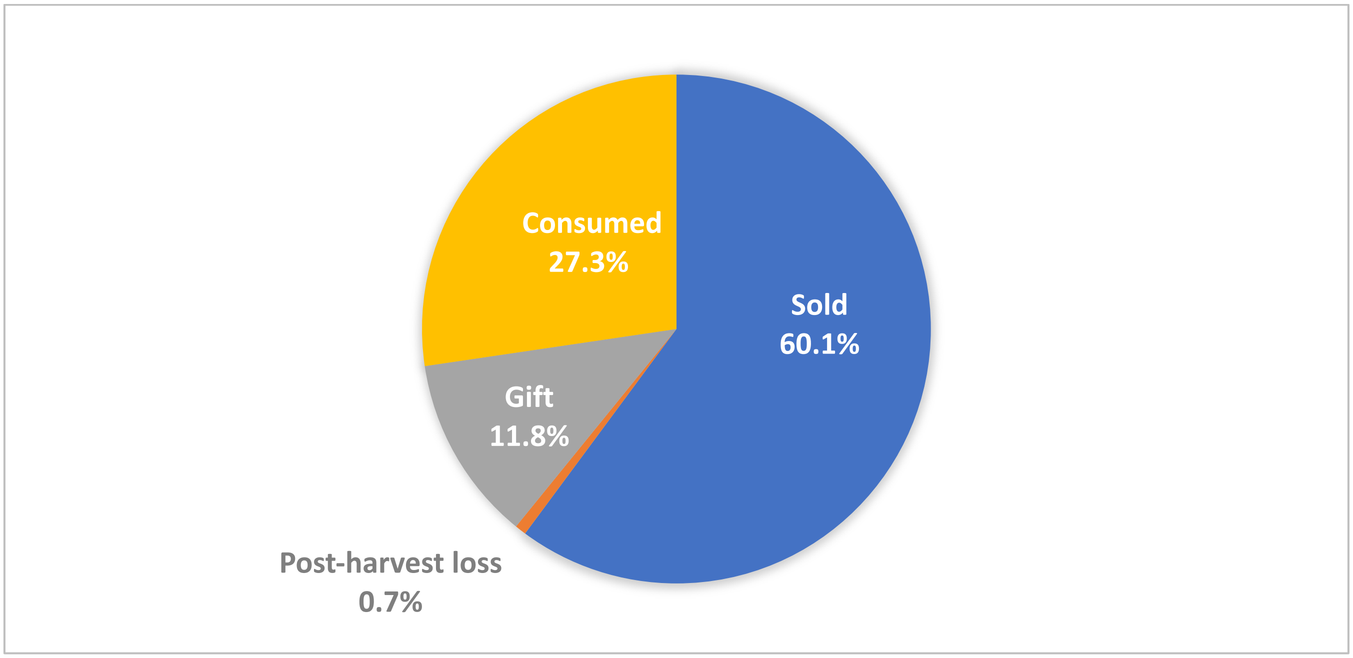
The harvested fish were either consumed by the households, sold, given away as gifts, or lost after harvesting. Regarding the latter, post-harvest losses can be costly to producers and can widen the gap between fish supply and demand (Maulu et al., 2020). About 1 in 10 (10.5%) of the farms experienced post-harvest losses. Among these, the most common reasons for post-harvest losses included poor-quality storage facilities (40.2%), lack of processing (23.5%), lack of storage facilities (22.1%), spoilage at the market (17.7%), and spoilage during transport to the market (8.8%). Post-harvest losses can also be attributed to pilferage by animals and lack of sanitation (Alam, 2015). As will be discussed further in section 3.6, to minimize post-harvest losses, farmers should be encouraged to adopt low-cost handling technologies and preservation methods such as smoking, sun-drying, and freezing.

3.6. Fish sales

It was very common for fish farms in the surveyed districts to produce for the market, with 82.6% of the farms (84.2% of those with a positive harvest) selling at least some of their production to the market. As shown in Figure 16, on average, 60.1% of the value harvested on the fish farms was sold. Farms of greater than 1,000 m^2 tended to be more commercialized, selling an average of 78.6% of the value of fish harvested. Farms in the Southern Region also tended to be more commercialized, selling an average of 66.2% of their production, compared to 55.2% in the Central Region and 45.5% in the Northern Region. This may partly be attributed to how transportation infrastructure is more developed in southern Malawi, with greater access to major urban areas such as Lilongwe, Blantyre, and Zomba.

Across the three main fish species, the average share of the value produced that was sold is roughly equal (55.8% to 62.3%). Almost all of the sellers sold their fish in the fresh form (99.7%), while other forms (sun-dried, smoked, and iced) accounted for just 0.3%. This indicates that there is a low level of value addition on the part of fish farmers to increase their profits. It follows that farmers can be encouraged to add value via smoking, frying, and para-boiling technologies to increase their revenue.

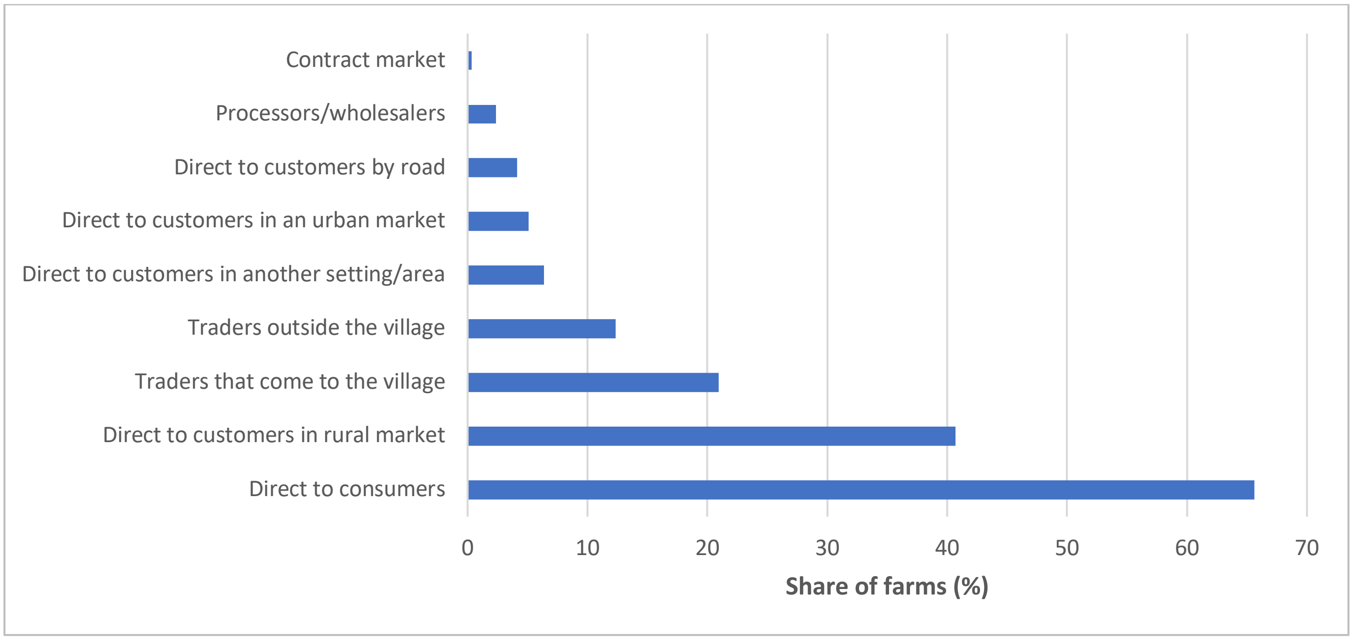
Figure 16. Proportion of value of fish sold, consumed, gifted, and lost (average across farms)



Source: MAS 2021

The fish were most often sold to customers at the farm-gate (65.6%) or in village or rural markets (40.7%), while it was less common to sell to traders that came to the village (20.9%), or to sell through other market channels (Figure 17). This suggests that the supply chain for fish raised by small-scale farmers tends to be short (limited in geographic extent and limited in the number of hands through which the product passes).

Figure 17. Marketing channels used in fish sales

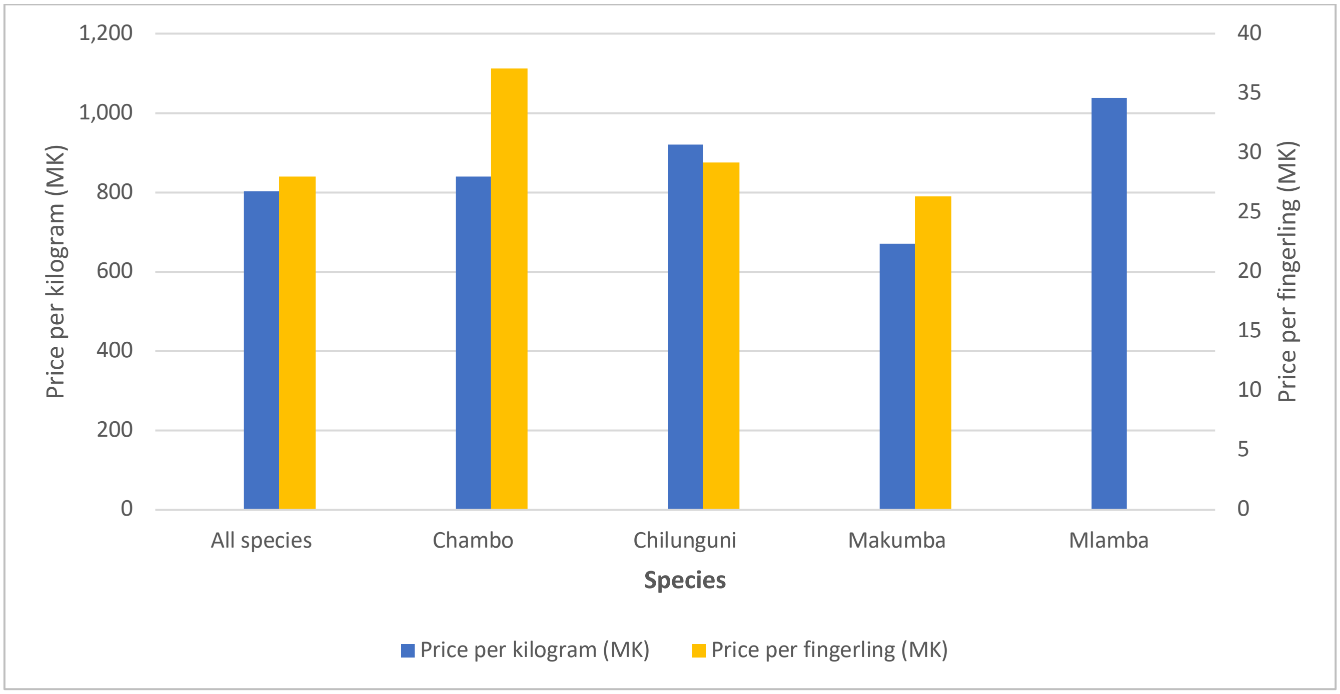


Source: MAS 2021

Across farms, the average price received for fish was MK 1,431/kg, while the average across kilograms sold was MK 803/kg. As illustrated in Figure 18, the prices received varied according to species. Mlamba received the highest average price (MK 1,038/kg), followed by chilunguni (MK 920/kg), chambo (MK 840/kg), and makumba (MK 670/kg). Fingerlings were also sold, and the average price received was MK 28. The median prices were similar across chambo, makumba, and chilunguni fingerlings. There were no mlamba fingerling producers in the districts surveyed.

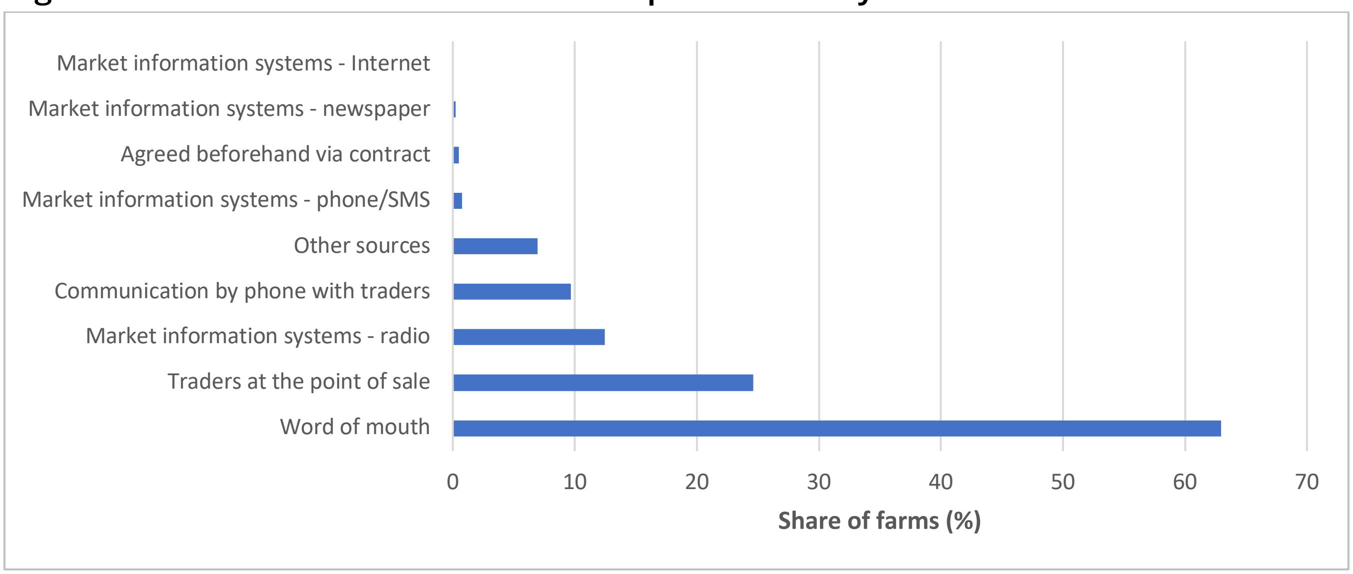
Most of the fish farms gathered information on prices and potential buyers via word-of-mouth (63.0%), while others gathered information via communication in person with traders at the point of sale (24.6%). Other sources of information on fish sales and buyers included radio and communication by traders via phone/SMS (Figure 19).

Figure 18. Prices received for fish and fingerlings



Source: MAS 2021

Figure 19. Sources of information on fish prices and buyers



Source: MAS 2021

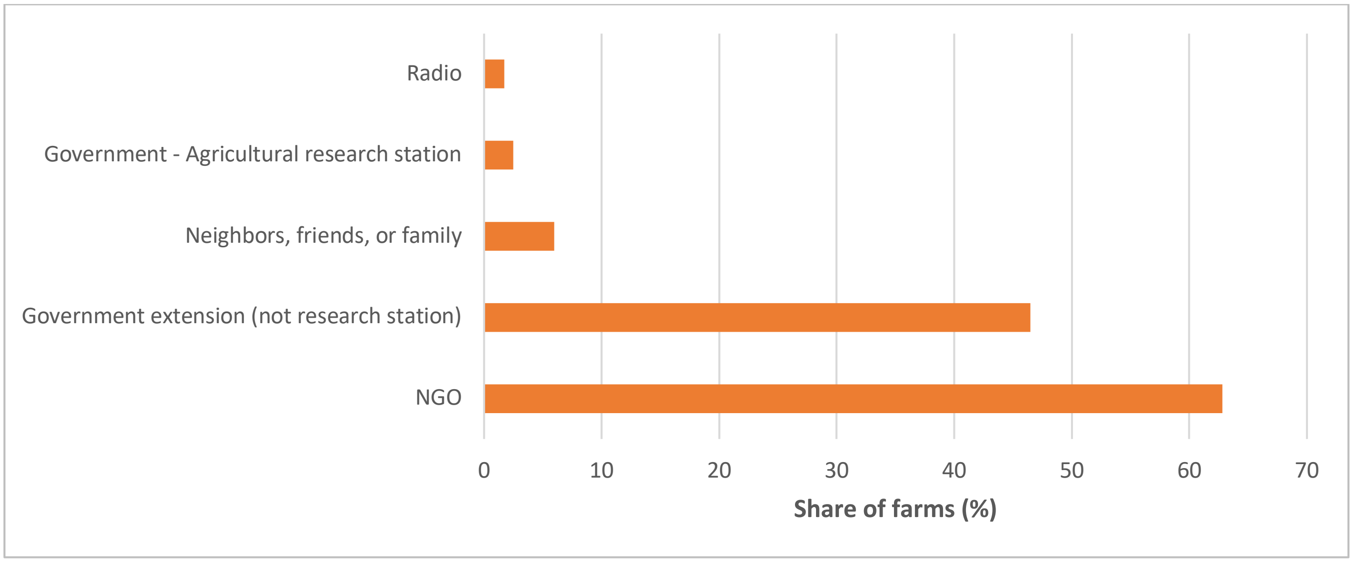
3.7. Access to extension services and credit

Extension services play a crucial role in expanding farmers' access to information and improving their skills, thereby increasing the likelihood of technology adoption and raising farm productivity (Richardson, 2006; Masangano & Mthinda, 2012; Danso-Abbeam et al., 2018). In Malawi, the National Extension Services Policy of 2000 acts as a guide for the implementation of extension services. The policy promotes a demand-driven, decentralized, and pluralistic agricultural extension services system, encouraging the involvement of multiple extension service providers (Chowa et al., 2013; Spencer et al., 2018). Various organizations offer agricultural services to farmers in Malawi, including government, NGOs, private firms, multilateral organizations, and farmer-based organizations (Masangano & Mthinda, 2012).

In the surveyed districts, 72.8% of the fish farms accessed extension services. Altogether, they received extension services through five platforms or organizations (Figure 20). Most of the farms (62.8%) received extension services from NGOs, followed by government (most commonly the Ministry of Agriculture), friends, neighbors and family members, and radio. No farms accessed extension services from commercial aquaculture companies (e.g., Maldeco, Chambo Fisheries, Rift Valley Fisheries), agricultural research stations/universities, input suppliers, fish traders, newspapers or other readings, phones/SMS, or the internet. Among those that accessed extension services, just 0.7% of the farms paid a fee, with amounts ranging from MK 2,000 to MK 5,000.

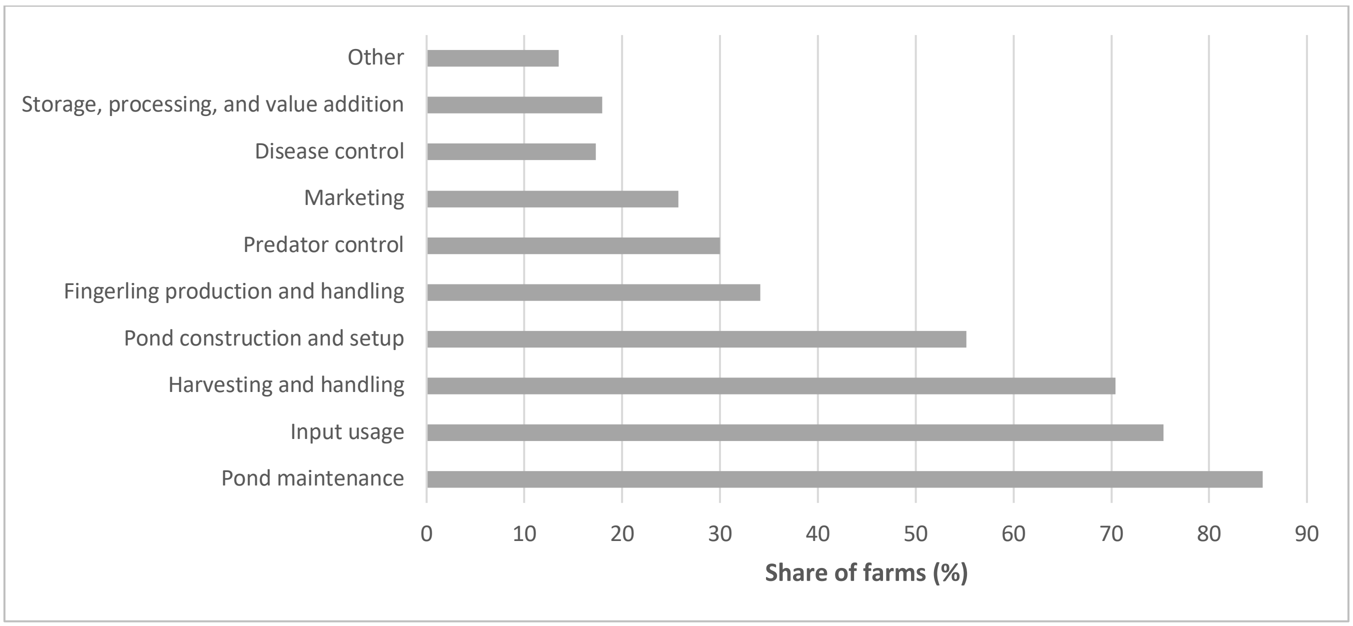
The surveyed fish farms accessed extension/training services on five major topics: pond maintenance (85.0%), input usage (71.0%), harvesting and handling (65.4%), pond construction and setup (52.4%), and fingerling production and hatchery management (32.7%) (Figure 21). Although most fish farmers accessed extension services, providing extension in Malawi is generally constrained by a shortage of agricultural extension staff, inadequate resources (e.g., finances), lack of a proper means of transport, and lack of incentives for extension workers (Masangano & Mthinda, 2012; Magomero & Park, 2014).

Figure 20. Sources of extension services



Source: MAS 2021

Figure 21. Topics of extension or training



Source: MAS 2021

Small-scale aquaculture enterprises in developing countries face high input costs, a scarcity of capital, and a lack of access to credit (Duflo, 2004; Jimi et al., 2019). Credit is an important tool for improving farm productivity, particularly because it facilitates the adoption of modern technologies and the expansion of farming operations (Diagne & Zeller, 2001; Henning et al., 2019; Jimi et al., 2019). Credit for farmers is provided by public banks; microfinance institutions; private sector savings and credit unions such as the Malawi Union of Savings and Credit Cooperatives (MUSCCO) and Savings and Credit Cooperatives (SACCOs), Foundation for International Community Assistance (FINCA) Malawi, and Malawi Rural Finance Company (MRFC); and government finance institutions such as the National Economic Empowerment Fund Limited (NEEF), previously known as the Malawi Enterprise Development Fund (MEDF) (Burritt, 2006).

Nevertheless, just 6.2% of the small-scale fish farms had access to credit (i.e., had taken out a loan in the past year). Among those that did receive a loan, 65.0% used the funds to purchase inputs or hired labor, 26.2% used the funds to conduct maintenance on their farms, and 9.2% used the funds to establish their fish farms (Table 12). Loans were accessed through village banks (58.6%), relatives/neighbors/friends (29.6%), and money lenders (6.7%).

As will be discussed in section 3.7, a lack of access to agricultural finance is a common challenge cited by fish farmers. Loans for agriculture in Malawi tend to be characterized by high repayment interest rates, which farmers cannot afford, and high collateral requirements, which farmers cannot meet (Burritt, 2006; Mkandawire & Duan, 2016; Chandio et al., 2017). Both microfinance institutions and banks estimate a high risk for loans provided to small-scale farmers and rural communities. This is because agricultural enterprises face irregular income and are highly susceptible to shocks such as extreme weather (e.g., drought), pests and diseases, and output price fluctuations—all of which are prevalent in the small-scale aquaculture sector.

Table 12. Sources of credit and reasons for obtaining credit

	% of farms
Source of credit	
Village bank	56.3
Relatives/neighbors/friends	30.0
Money lenders	6.1
NGO	2.0
Microfinance institution	1.9
MERDEF/MRFC/NEEF	1.6
Input supplier/agro-dealer	1.9
Commercial bank	0.0
SACCO	0.0
Output buyer/trader/processor	0.0
Reason for obtaining credit	
Purchase inputs or hired labor for fish production	65.0
Maintenance of the fish farm	26.2
Establish fish farm	9.2
Other	0.8

Source: MAS 2021

3.8. Role of aquaculture in livelihoods

Fish is a particularly inexpensive source of animal protein, and for this reason, aquaculture has the potential to reduce malnutrition in low-income countries (Finegold, 2009; Chikowi et al., 2021). In addition, small-scale aquaculture can serve as a form of self-employment, can improve household consumption and income (Belton & Thilsted, 2014; Bene et al., 2016; Hernandez et al., 2018; Ragasa et al., 2018; Steenbergen et al., 2019), and can enhance farm sustainability through integrated aquaculture (Kassam, 2003). Aquaculture can also improve the sustainability of capture fisheries by reducing pressure on wild fish populations.

Toward this end, fish farmers were asked about the contribution of aquaculture to their welfare (or, in the case of community farms, its contribution to the welfare of a "typical" member of the farm). A large majority (74.6%) of farm respondents perceived fish farming to be an activity that positively contributes to both income and consumption (Table 13). Around 24.4% of respondents reported that they only benefited in terms of consumption, while 0.9% reported that they only benefited in terms of income. A negligible share of farmers (0.1%) reported that they didn't benefit at all from fish farming.

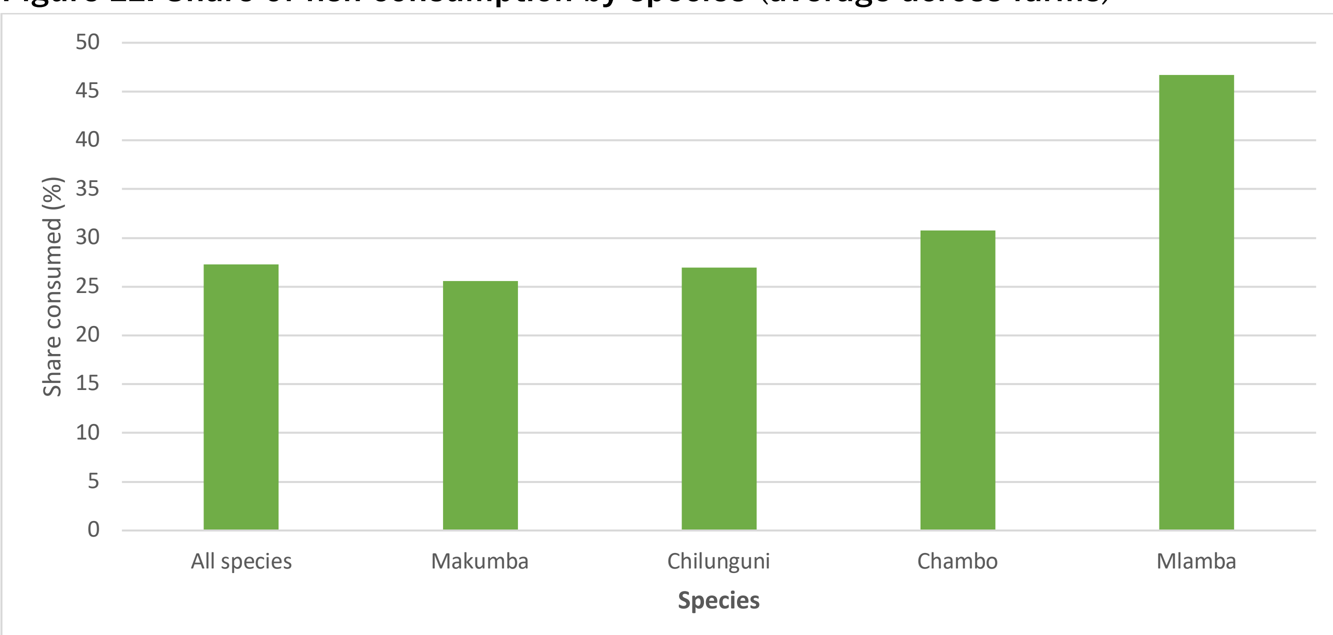
Table 13. Benefits of fish farming

	Consumption benefit		
Cash benefit	No (%)	Yes (%)	Total
No (%)	0.1	24.4	24.6
Yes (%)	0.9	74.6	75.4
Total	1.0	99.0	100.00

Source: MAS 2021

A majority (95.6%) of the fish farmers consumed fish from their own production and this constituted, on average, 27.3% of the harvest. The average share consumed was higher in the Northern Region (39.3%) than in the Central Region (23.1%) or Southern Region (22.1%). In total, 82.0% of the farmers reported having enough fish for home consumption. Across species, the average share consumed from the farms was 46.7% for mlamba, 30.7% for chambo, 26.9% for chilunguni, and 25.6% makumba.

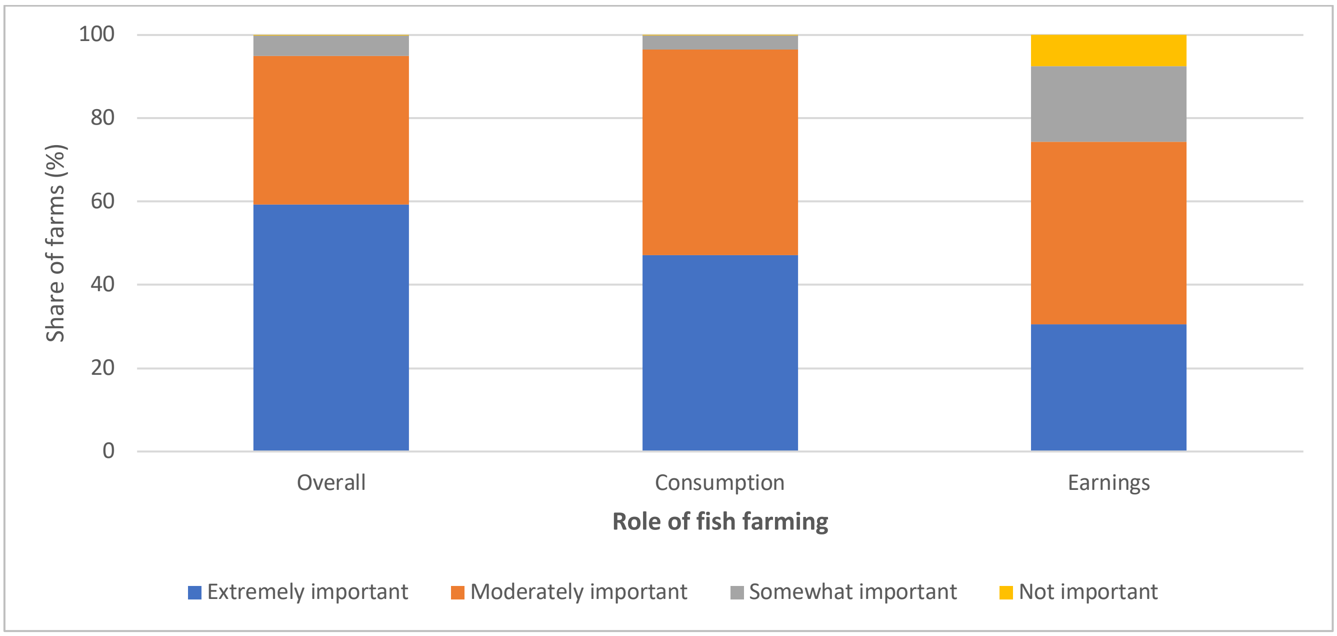
Figure 22. Share of fish consumption by species (average across farms)



Source: MAS 2021

When evaluating the role of fish farming in farmers' livelihoods, most respondents (59.4%) perceived fish farming to be "extremely important." Likewise, 47.1% perceived fish farming to be a significant contributor towards their household consumption, and 30.6% reported that they draw “most or all” of their cash earnings from the fish farm (Figure 23). The farms were a more significant source of consumption and cash earnings for fish farming households with their own farms than for farmers on community farms. Specifically, it was more likely for individually owned farms (48.5%) to report that fish farming was an extremely important contributor to their household consumption, as compared to the respondents for community farms (37.8%). It was also more common for individual farmers (31.4%) than for community farm members (25.0%) to realize “most or all” of their income from fish farming (Figure 25).

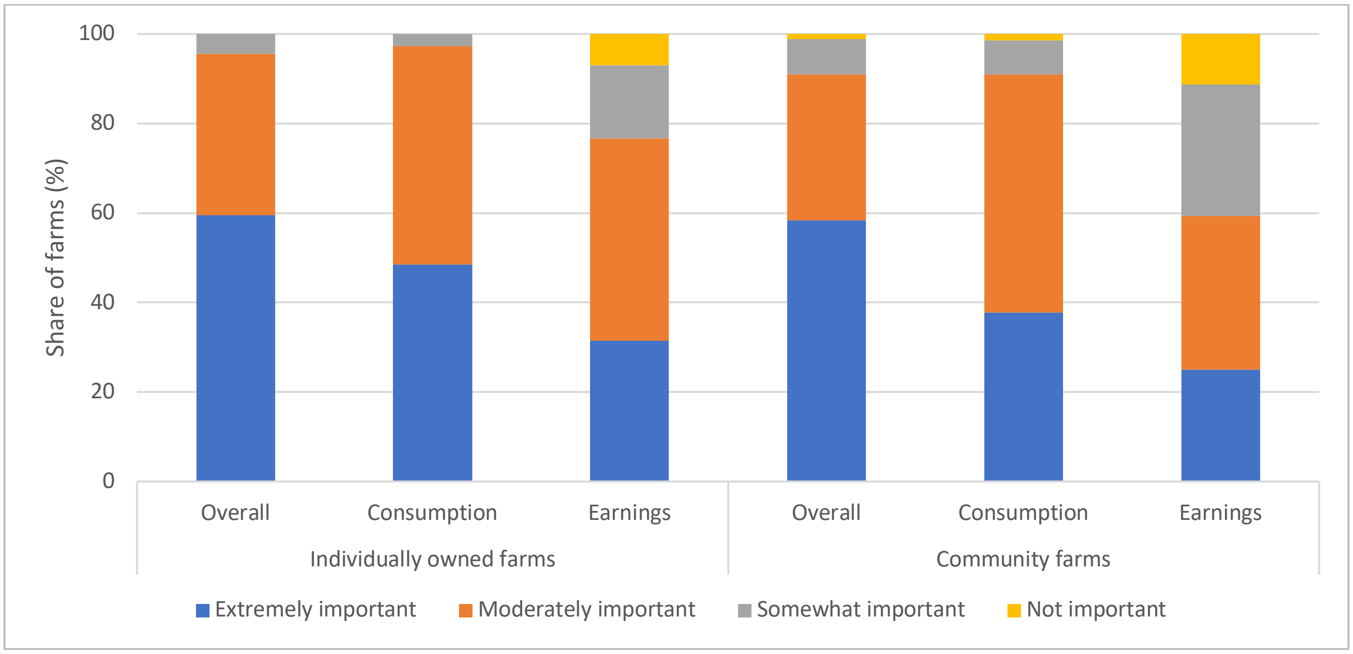
Figure 23. Farmers’ perceptions of the role of fish farming in livelihoods



Source: MAS 2021

Note: For cash earnings, a response that “most or all” earnings were derived from the fish farm is considered “extremely important”; “some” is considered “moderately important”; “a small amount” is considered “somewhat important,” and “none” is considered “not important.”

Figure 24. Farmers' perceptions of the role of fish farming in farmers' livelihoods, by farm type

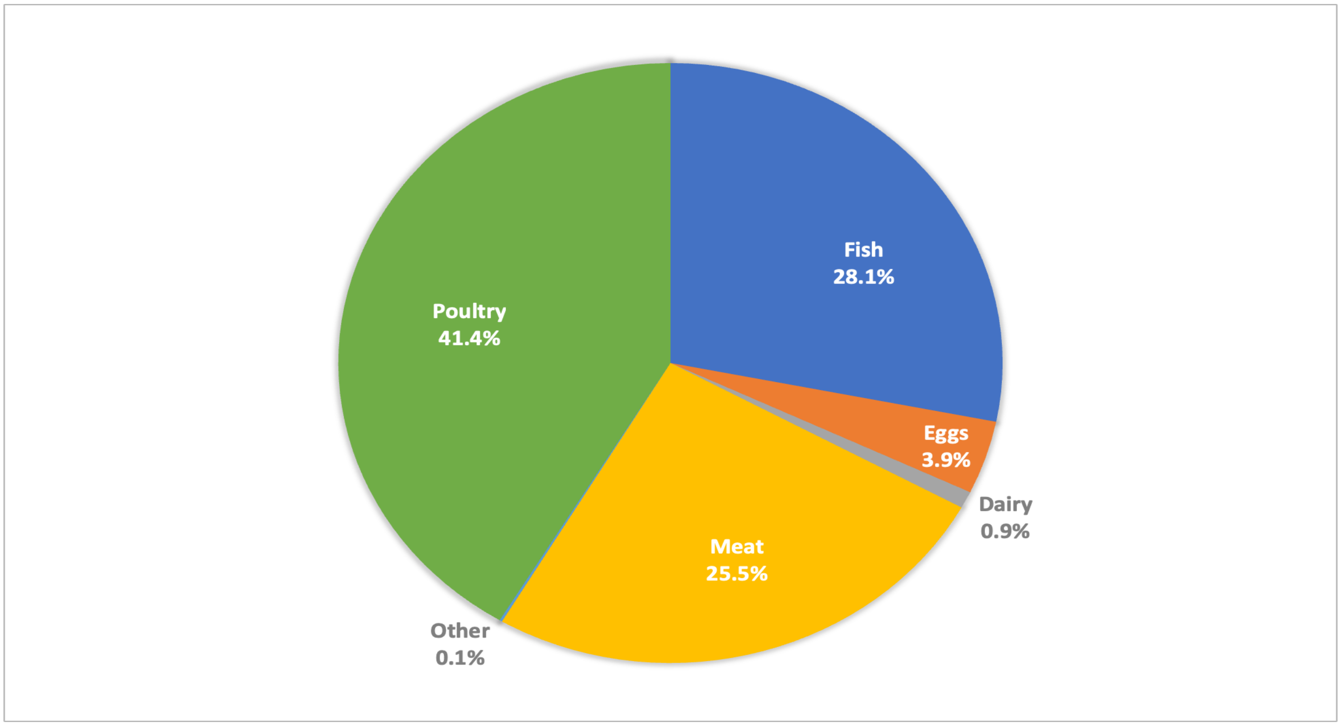


Source: MAS 2021

Farmers were more likely to view fish farming as extremely important in the Southern Region (61.0%) than in the Northern Region (59.0%) or the Central Region (53.5%). Similarly, farmers in the Southern Region reported that they derived most or all of their cash earnings from the farm (33.2%) more commonly than those in the Northern (26.7%) or Central (25.1%) Regions. At the same time, farmers in the Northern Region (56.2%) were more likely to regard fish farming as extremely important for consumption, compared to those in the Central (46.1%) and Southern (38.7%) Regions.

Nevertheless, it was clear that fish was not the most preferred source of animal protein among fish farmers (Figure 25). Rather, poultry (41.4%) was most preferred, followed by meat (25.5%) and fish (28.1%). Notably, even when fish was the preferred protein source, it was rarely preferred because it tastes better than other options. Instead, 52.3% of those who preferred fish cited its nutritional value as the main reason, followed by its relatively low price (27.8%). In contrast, the taste of poultry and meat were most commonly cited as the reasons for preferring those products.

Figure 25. Preferred sources of animal protein



Source: MAS 2021

Similarly, while fish farming was perceived to be an important contributor to household income, crop production tended to be a more significant income source. On average, fish farming was estimated to contribute 21.0% towards household income (with this analysis limited to individually owned farms for which detailed information was collected on individual household incomes). This value was higher in the Southern Region (24.9%) than in the Northern (16.0%) and Central (12.4%) Regions. Nevertheless, aquaculture clearly plays a significant role (if not the *most* significant role) in farmers' livelihoods. This likely explains why a large majority of all farmers plan to either expand their production (88.3%) or maintain production (7.4%) in the future.

3.9. Profitability of fish farming

The profitability of any agricultural enterprise determines the sustainability/continuity of the investment, the farmers' adoption of new technologies, and the ability of financial service providers to offer credit to farmers (Njuki et al., 2007; Patrick & Kagiri, 2016; Sserwambala, 2018; Lucas et al., 2019). The profit margin for small-scale aquaculture is usually small, though it can be improved by adopting good farm management practices (Hyuha et al., 2011; Sserwambala, 2018). Studies elsewhere have found that farming experience, pond size, access to credit and loans, cost of inputs (feed and fingerlings), sex of the farmer, and distance to fish markets have implications for the profitability of fish farming (Awoyemi & Ajiboye, 2011; Musaba & Namanwe, 2020; Namonje-Kapembwa & Samboko, 2020).

In this section, the gross margin (profit) of each farm is calculated as in equation (1), presented in Section 2.4. Harvested fish that were sold are valued at the price received. Fish that were consumed, gifted, or lost are valued at the median per-kilogram price observed for a given species for the smallest geographic unit for which at least 10 sales were observed in the data set. For the main analysis presented below, only pecuniary input costs are considered. Thus, expenditures on hired labor are included while the value of family labor is not. In addition, this simple one-year analysis only considers variable costs (including equipment purchases) incurred in the year. As discussed in Section 3.2, setup costs tend to be minimal among small-scale farmers.

Most of the fish farms (81.5%) realized positive profits, with a mean of MK 116,258 and a median of MK 25,500. Variation in the gross margin may be due to factors such as differences in fish species cultivated, stocking rates, types and rates of inputs used, production of fish or fingerlings, pond sizes/farm sizes, and various challenges faced by fish farmers (as described in Section 3.10). Notably, farms were less likely to be profitable in the Central Region (77.0%) than in the Southern (82.8%) or Northern (85.3%) Regions. The survey team observed that many farms in the Nkhotakota and Ntchisi districts (in the Central Region) had abandoned fish farming because their ponds had dried up.

The annual gross margins of fish farming are reported in Table 14. As noted, the average gross margin was positive, implying that small-scale fish farming is profitable in Malawi. When the average profit (MK 116,258) is scaled to the size of a “typical” pond (299.5 m^2), the average pond-level profit was MK 97,041. This is equal to MK 3.2 million per hectare or approximately USD 3,888 per hectare. A detailed analysis of production costs reveals that feed (both commercial and homemade) accounted for a large share of costs. Specifically, feed accounted for 54.9% of the cost of production (on average), while hired labor accounted for 12.0%, fingerlings accounted for 11.0%, fertilizers accounted for 7.2%, and other costs were more marginal. It follows that the cost of fish feed, fertilizers, fingerlings, and hired labor are important factors to consider when venturing into fish farming.

Recall that farmers devoted some ponds primarily to fingerling production (with some fish also produced) and others primarily to fish production (with some fingerlings also produced). When ponds devoted primarily to these two purposes are treated as two separate enterprises, the average gross margin for fingerling production was more than four times that of fish production. However, these two activities had roughly equal returns per typically sized pond.

Table 14. Gross margins and productivity of fish farming in Malawi (mean values, MK)

	All production		**Fish production**		**Fingerling production**	
	Mean	% of cost	Mean	% of cost	Mean	% of cost
Harvest value	147,026.96		139,769.75		206,269.12	
Fingerling revenue	18,744.25		6,029.47		339,163.62	
Total revenue	**165,444.03**		**145,799.22**		**545,432.73**	
Commercial feed	11,751.94	23.9	9,842.20	22.5	51,773.41	39.4
Homemade feed	15,223.54	31.0	14,905.74	34.0	9,850.18	7.5
Energy cost	186.39	0.4	187.04	0.4	0.00	0.0
Organic fertilizer	1,318.33	2.7	1,253.68	2.9	1,838.34	1.4
Inorganic fertilizer	2,210.74	4.5	1,955.90	4.5	6,968.45	5.3
Lime	1,419.21	2.9	1,196.96	2.7	6,030.21	4.6
Medication	0.00	0.0	0.00	0.0	0.00	0.0
Fingerlings	5,416.72	11.0	4,554.94	10.4	23,373.62	17.8
Hired labor	5,923.51	12.0	5,015.67	11.4	15,147.24	11.5
Other inputs	2,873.10	5.8	1,838.18	4.2	12,090.19	9.2
Transport	3,214.61	6.5	3,070.29	7.0	4,298.43	3.3
Total variable costs	**49,185.69**		**43,820.60**		**131,370.07**	
Gross margin	**116,258.34**		**101,978.62**		**414,062.66**	
Productivity (Gross margin per pond of size 299.5 m^2)	**97,041.30**		**99,177.25**		**92,780.25**	
Observations	732		728		24	

Source: MAS 2021

The same analysis for different farm categories is presented in Table 15 with detailed results also available in the Appendix. Individually owned farms had much higher average gross margin and profits per typically sized pond (MK 128,012 and MK 108,525) than community fish farms (MK 38,876 and MK 21,945). Note, however, that it is difficult to assign an accurate value to household labor, and household labor for fish farming does have an opportunity cost.

On average, farms that followed production cycles incurred much higher costs than those that practiced continuous production, but they also saw higher annual profits per typically sized pond (MK 101,980 with production cycles, compared to MK 95,274 with continuous production). With regard to farm size, it is not surprising that smaller farms tended to have much smaller gross margins. However, there is an inverse relationship between farm size and productivity (profits per typically sized pond). Specifically, average profits per pond are higher on farms of 0–200 m^2 (MK 126,057) than those of 200–1,000 m^2 (MK 63,238) or those larger than 1,000 m^2 (MK 96,165).

Farms in the Northern Region had higher average gross margins than those in the Central or Southern Regions. However, recall from Section 3.2 that farms in the Northern Region tended to be larger than elsewhere. As shown in Table 15, the profits per typically sized pond in the Southern Region are much higher (MK 112,956) than in the Central (MK 75,783) or Northern (MK 65,559) Regions. It is not surprising that farms in the Southern Region exhibited higher productivity than those found elsewhere. Among other reasons, water temperature tends to be higher in the south of the country (Russell et al., 2008). Further, farms in the Central Region were affected by the EUS outbreak, which contributed to the relatively low productivity in this region.

Figure 26 shows that the average gross margin at the farm level was highest in Zomba (MK 214,069) and Nkhatabay (MK 206,505) and lowest in Ntchisi (MK 36,065). At the same time, average productivity (profits per typically sized pond) was highest in Thyolo and Machinga. This analysis is also conducted at the species level (Table 15). As multiple species can share a pond, this species-level analysis divided the costs of pond-level inputs equally amongst the species. Productivity (gross margin per typically sized pond) was highest for chambo (MK 105,517), followed by chilunguni (MK 84,957).

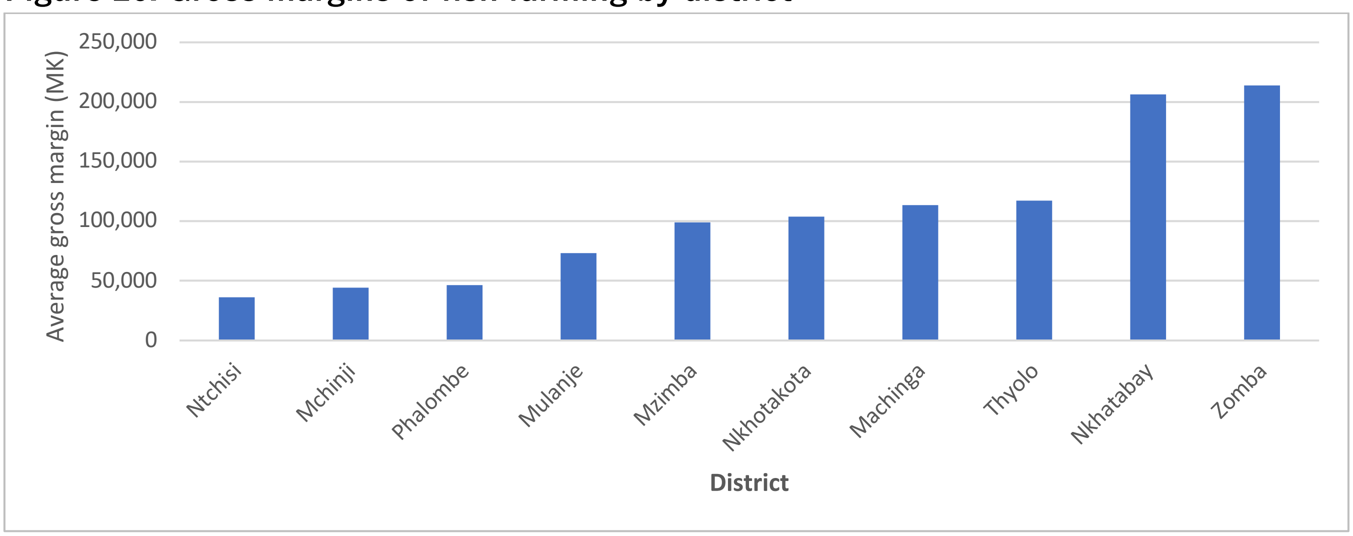
Table 15. Summary of gross margin for various categories (mean values)

Category	Gross margin (MK)	Productivity (Gross margin per pond of size 299.5 m^2)
By farm type		
Individually owned	128,012.17	108,525.44
Community farm	38,875.87	21,944.85

By production system		
Continuous production	62,765.09	101,980.12
Production cycles	262,508.92	95,274.39
By species		
Makumba	79,440.35	79,145.71
Chilunguni	106,113.02	84,957.03
Chambo	54,941.63	105,516.62
Mlamba	247,884.03	66,050.47
By region		
Southern Region	124,487.40	112,956.18
Central Region	47,502.11	75,783.35
Northern Region	142,082.74	65,559.47
By farm size		
0–200 m^2	34,516.18	126,056.91
200–1,000 m^2	91,770.95	63,238.07
>1,000 m^2	693,008.04	96,165.46

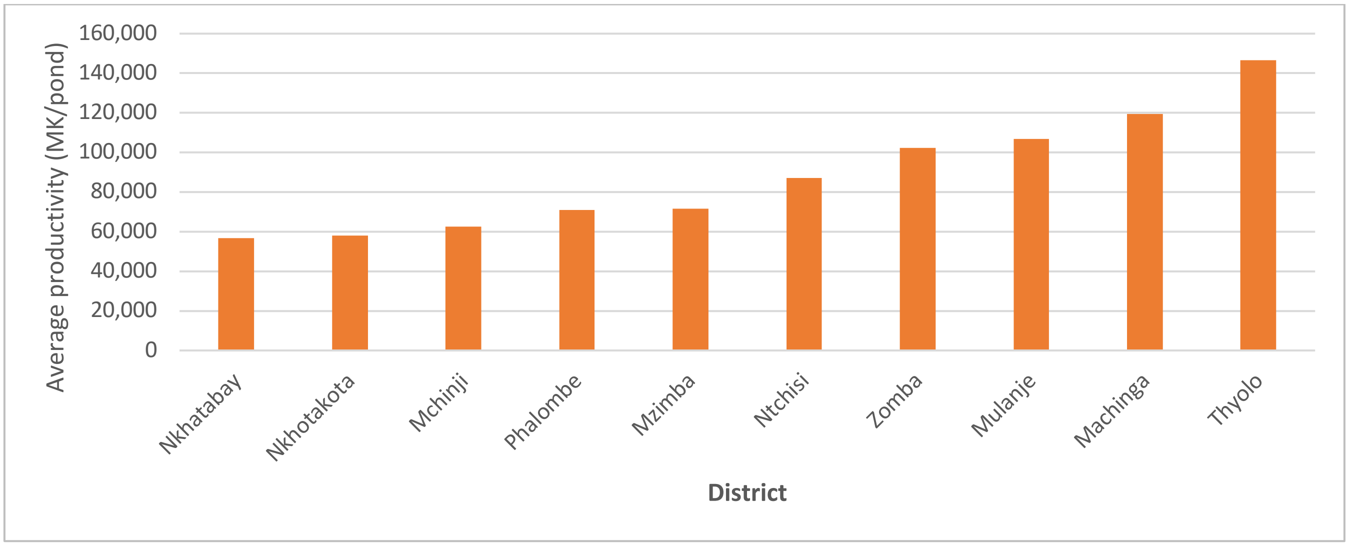
Source: MAS 2021

Figure 26. Gross margins of fish farming by district



Source: MAS 2021

Figure 27. Productivity of fish farming by district



Source: MAS 2021

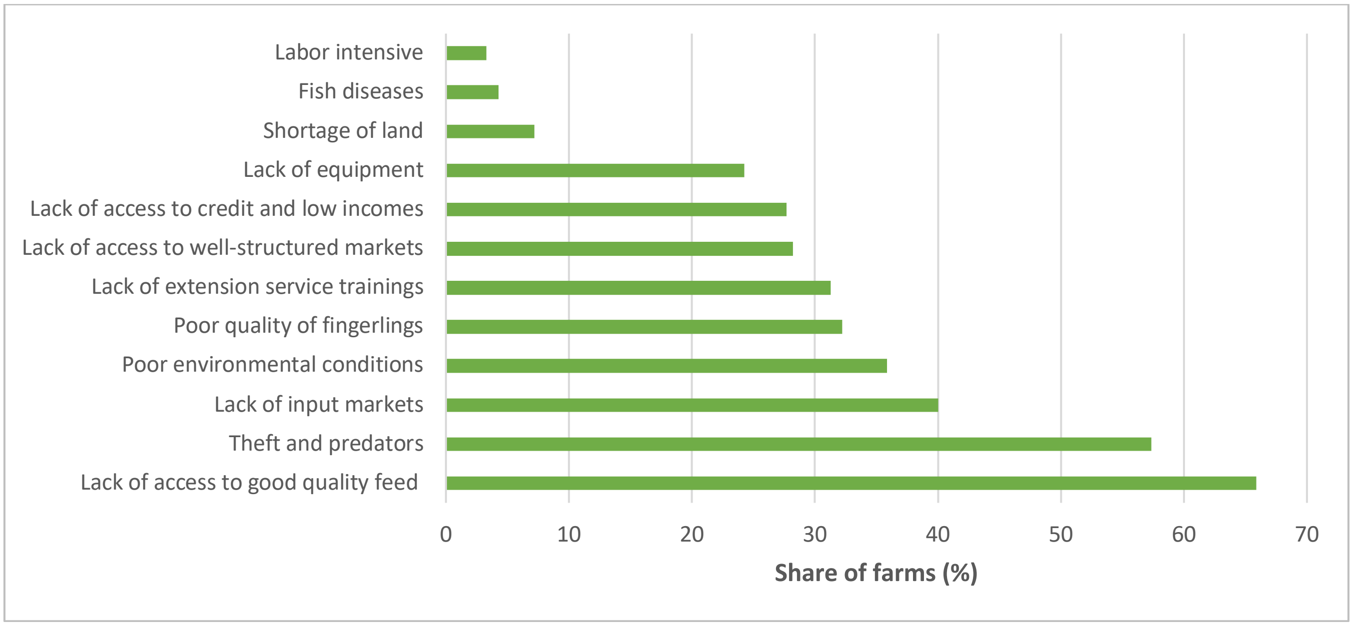
3.10. Challenges affecting small-scale fish farmers

Almost all respondents (99.5%) reported that they faced some challenges related to aquaculture. These challenges are discussed in turn, combining both a quantitative analysis of the survey responses and a qualitative analysis of several open-ended questions that were asked.

3.10.1 Challenges

As shown in Figure 28, fish farming challenges include a shortage of land for pond excavation; lack of fishing equipment; poor environmental conditions and climate change; lack of access to well-structured markets; theft and predators; fish diseases; lack of access to credit and low incomes; the high amount of labor required in fish farming; lack of relevant extension services; lack of input markets; lack of access to high-quality feed; and poor quality of fingerlings.

Figure 28. Challenges faced by small-scale fish farmers



Source: MAS 2021

Lack of access to high-quality feed

A lack of access to high-quality fish feed was the most commonly cited challenge that impeded fish production in the surveyed districts (Figure 28). About two-thirds (65.9%) of farmers reported that commercial fish feed is often unavailable in local markets and that it is expensive because it is imported from neighboring countries like Zambia. When they cannot access commercial fish feed, farmers instead use maize bran and plant-based feed. These kinds of feed retard fish growth since they have limited macro- and micronutrients needed for fish growth, and they are also characterized by a high crude fiber content which affects its digestibility (Kirimi et al., 2020; Munguti et al., 2021).

Theft and predators

More than half (57.4%) of the farmers reported that fish productivity was low because of theft and animal predators that prey upon the fish before harvest. Some of these predators include otters, swans, and monitor lizards. Theft of fish is more common among the fish farms that are relatively far from the farmers' homestead. On average, most farms were approximately 1 km from the farmers' homestead.

Lack of input markets

About 40.0% of farmers reported that they lacked markets in which to purchase aquaculture inputs. Such inputs include thermometers, oxygen meters, fishing nets, and others. Some farmers had been borrowing fishing nets from agriculture extension stations during harvesting. However, this practice is discouraged because fish diseases can be transmitted through shared nets.

Poor environmental conditions and climate change

Fish production requires adequate land and water for breeding. However, 35.9% of the surveyed farmers faced environmental stressors such as drought (which causes fish ponds to dry up) or flooding of dams. Flooding poses a problem particularly because the farmers lack equipment such as pipes to set up water outlets for drainage when dams are full.

Poor quality of fingerlings

The use of recycled fingerlings lengthens the production cycle, allowing fish to grow larger before they are harvested. However, most of the surveyed farmers used recycled fish for production due to a lack of markets in which they could purchase new hybrid fingerlings. Just under one-third (32.2%) of fish farmers reported that they lacked access to good-quality fingerlings, resulting in smaller fish.

Lack of relevant extension services

A lack of access to trainings and relevant extension services was yet another challenge farmers faced. Specifically, 31.3% of the surveyed farmers reported that the topics covered during extension trainings were not relevant for fish farming, with the available extension programs mostly focused on crop production. In addition, the fish farmers noted that extension agents do not make farm visits to provide guidance regarding fish production.

Lack of access to well-structured markets and market information

Information on markets, consumers, and fish prices was reported to be inaccessible to farmers. Moreover, 28.2% of the farmers reported that they lack markets for fish and that the prices offered are low. When fish is harvested, most farmers sell in their local markets or to their neighbors at a low price, because they lack access to well-structured markets where they could potentially reach urban consumers at a higher price. Furthermore, because of a lack of storage facilities, farmers must sell all the fish on the same day it is harvested to avoid spoilage.

Lack of credit and limited cash flow

Another challenge faced by farmers is a lack of credit and limited cash flow. Results show that 27.7% of farmers lack access to credit from commercial banks, microfinance institutions, or any government programs. They furthermore lack incomes to invest in fish farming, i.e., to pay for land, fish feed, fingerlings, hired labor, and equipment for fish production.

Lack of equipment for fish farming

Nearly one-quarter (24.3%) of farmers reported that equipment for fish farming is expensive and unaffordable. This is consistent with the findings on farm assets (see Section 3.3), as farmers reported that they did not own important pieces of farm equipment such as thermometers, oxygen meters, fishing nets, fish graders, or scoop nets.

Shortage of land

A shortage of land is yet another problem faced by fish farmers. Specifically, 7.2% of the farmers reported that the land they possess is not enough to expand fish production due to competition with crop production, and access to land is further limited by land disputes, especially for community farms.

Fish diseases

In addition to other challenges, fish diseases were reported to have a negative impact on fish farming. Specifically, 4.3% of farmers were affected by Epizootic Ulcerative Syndrome (EUS) fish disease. This was reported mostly in Mchinji district, where a EUS outbreak was first reported in 2019. Farmers were asked to discard all the fish on their farms and drain their ponds, which had severe negative consequences for their livelihoods. If not controlled, EUS has a high rate of fish mortality and profound effects on food security and the livelihoods of rural households that depend on fish farming (Munthali, 2021). In addition to the Mchinji district, the disease has affected farmers from Dowa, Kasungu, Lilongwe, and Nkhotakoka in the Central Region and Mzimba and Rumphi in the Northern Region.

Fish farming is labor-intensive

A shortage of labor was another challenge reported by 3.3% of the farmers. Although this was not experienced by most farmers, it was typically noted by farmers working on community farms where “free-riding” (or the shirking of one’s responsibilities to contribute labor to the shared farm) is a problem. Farmers also noted that their low incomes make it difficult to pay for seasonal laborers.

3.10.2 Solutions

Fish farmers in the surveyed districts were asked to suggest solutions to the challenges they face. Table 16 summarizes the proposed solutions that were suggested.

Table 16. Solutions to the challenges faced by small-scale fish farmers

Challenges faced	Proposed solutions
Lack of access to high-quality feed	o Farmers proposed having a local feed manufacturing plant in the country to lower the cost of feed and make it more readily available in local markets.
Lack of markets for inputs	o Make commercial feed available in local markets. o Form associations or cooperatives to purchase inputs in bulk. o District fisheries departments could produce fingerlings in their own hatcheries to ease farmers’ access to hybrid fingerlings. o A fish feed manufacturing plant could be established in each district of Malawi, making commercial feed accessible at a lower price. o Contract farming arrangements may address farmers’ needs for inputs.
Lack of trainings and extension services	o Make relevant extension services and trainings accessible and available for farmers.
Lack of access to loans	o Commercial banks and microfinance institutions should give fish farmers access to loans.

	o Government programs that offer loans in rural areas should reach out to farmers. o Agricultural diversification could help farmers earn a higher income, which would reduce the need for loans. o The government can subsidize the price of fish inputs, thereby reducing income-related stress.
Lack of access to well-structured markets and market information	o Fish farmers can form associations to supply fish in bulk and negotiate better prices.
Poor environmental conditions for fish farming	o Ponds should be constructed with concrete and should have water inlets and outlets and other draining systems to reduce flooding. o Government should assist farmers in accessing water pumps to pull water from lakes or rivers in areas that are near large water bodies.
Predators and theft	o Farmers should guard their ponds, scare away predators, construct fences around the ponds, and set up animal traps. o Farmers can apply manure to the water to increase the level of turbidity and thereby deter predators that rely on sight to prey on the fish.
Lack of fish farming equipment	o Improve farmers' access to credit.
Fish diseases	o The government should provide guidance to farmers on how to best manage fish diseases. o The government should intensify awareness campaigns regarding EUS disease.
Fish farming is labor-intensive	o Farmers can recruit seasonal laborers in times of high labor, although it is expensive.
Slow growth of fish	o Use commercial feed. o Use hybrid fish fingerlings and avoid the use of recycled fingerlings.

Source: MAS 2021 and authors

4. OPPORTUNITIES FOR SMALL-SCALE AQUACULTURE IN MALAWI

This study has highlighted a number of challenges faced by small-scale fish farmers in Malawi. However, alongside these challenges, there are also opportunities for the growth of aquaculture. The opportunities are discussed in detail below.

Feed production

The high cost of fish feed was the most cited challenge by both individual and community fish farmers. Farmers tend to use imported fish feed, most of which is sourced from Zambia. It is therefore not surprising that the cost of feed is high. Some farmers also use local resources to make fish feed, specifically maize bran from their maize milling activities. However, this is generally not adequate to sustain fish feeding throughout the production cycle. Clearly, there is a large opportunity to invest in domestic fish feed production, which would meet the local demand for commercial fish feed, bring down the price of feed, and create employment in feed processing. The Centre of Excellence for Aquaculture and Fisheries Science (Aquafish) in Malawi presumably has the capacity to train others in feed production. Black soldier fly (BSF) can also be considered as an alternative to fish feed, as studies have shown that BSF larvae can replace fishmeal (Diener et al., 2009; Kroeckel et al., 2012; Barragan-Fonseca et al., 2017; Belghit et al., 2019; Adeoye et al., 2020; Rawski et al., 2020; Sumbule et al., 2021; Tippayadara et al., 2021). Other options include the use of mopane worm meal and kikuyu grass, both of which are readily available in Southern Africa (Moyo & Rapatsa, 2021).

Food, skin, and hides from animal predators

The second most cited challenge faced by farmers was that of predators. Both monitor lizards and birds were listed as troublesome predators that poach fish from farmers' fish farms. In some parts of the world, monitor lizards are used for food, leather, and medicine. In terms of medicine, various products from monitor lizards can be used to treat or cure arthritis, blood clots, skin ailments, spider and snake bites, pains, burns, and rheumatism (Janakiraman & Reddy, 2012; Uyeda et al., 2014). The skins of monitor lizards are soft but strong enough to produce high-quality leather, which can be sold and serve as a source of income for households. We therefore suggest that trapping predators may, in itself, serve as an opportunity for fish farming households.

Formal fish markets

Fish farmers lamented the lack of reliable fish markets, especially in rural areas. The lack of reliable markets was compounded by the low fish prices that fish farmers received. In remote rural areas, farmers would make announcements on the day that they would harvest their fish, so community members could come to buy the fish. Where there is a good road network, we suggest that farmers coordinate their plans to harvest their fish at the same time and sell in more lucrative markets as a group. This creates incentives for farmers to organize themselves in marketing their produce. In addition, farmers who are located close to (or in) urban centers can strike contractual deals with food markets (including supermarkets and restaurants), where they can sell their fish at reasonable prices.

Provision of loans and credit

Fish farmers also noted a lack of credit to support their fish farming businesses. Nonetheless, we found that some communities had vibrant village savings and loans groups from which the farmers borrowed money to boost their businesses. The lack of credit in rural areas is therefore an opportunity to invest in village savings and loans groups that can potentially foster the growth of small-scale aquaculture in Malawi.

Fingerling production

This study revealed that most farmers used recycled fingerlings because new fingerlings were either unavailable or prohibitively expensive. Farmers who procured new fingerlings in each production cycle tended to either receive support by NGO projects or receive fingerlings from fellow farmers who were fingerling producers. Malawi does not currently have certified fingerling producers, because certification protocols have not yet been developed. Nevertheless, through NGO projects and government, some farmers can access quality fingerlings from the National Aquaculture Center in Domasi, the Centre of Excellence for Aquaculture and Fisheries Science (Aquafish) at LUANAR, and the Mzuzu government fish farm. In addition, as noted, some farmers do produce fingerlings and sell them to other farmers. The high percentage of farmers recycling fingerlings in our sample demonstrates a large opportunity for investing in fingerling production both at large-scale, commercial facilities and at the farmers' level.

Low fish farm start-up costs

This study has revealed that aquaculture involves relatively low setup costs. We conclude that farmers who are interested in fish farming can easily establish farms wherever water is available without large capital investments. This low barrier to entry presents an opportunity for agricultural diversification and the growth of small-scale aquaculture.

Fish farming to improve food security and import substitution

Fish tends to have the lowest retail price among the sources of animal protein for human consumption. Fish is also considered healthier than red meat (Belton et al., 2018). For these reasons, the demand for fish is increasing. In addition, Malawi is a net fish importer, which confirms that there is domestic demand for fish that is not yet satisfied by domestic production. This presents an opportunity for fish farmers to earn income by meeting this demand through local production (Chan et al., 2019). For this reason, aquaculture deserves special support to deal with the challenges highlighted in this study so that it can achieve its potential to improve the lives of Malawian fish farmers.

Cage farming

This study has clearly shown that most fish farmers in the surveyed districts practice pond-based fish farming. However, Malawi has great potential for cage farming in existing untapped water bodies such as lakes, large reservoirs (e.g., irrigation schemes and dams), and rivers. Cage farming has advantages over other fish farming technologies because it is a simple technology; has relatively low capital requirements (initial investments costs); has no requirement of land ownership; uses less labor; and is characterized by high fish survival and growth rates (Kwikiriza, 2018; Opiyo et al., 2018; Orina et al., 2018). Nevertheless, the rate of adoption for cage farming in Malawi is low due to a lack of information, limited access to extension services, and a lack of guidelines for cage farming (Mulumpwa, 2020). Cage farming can help Malawi to meet domestic demand for fish and reduce fish imports (Munthali et al., 2021). Furthermore, it was observed that some fish farmers had abandoned fish farming when their ponds dried up due to climate change. Fish farmers in these affected areas can venture into cage farming, as they would be culturing fish in waterbodies such as rivers and dams within their locality.

5. CONCLUSION

Capture fisheries in Malawi have been affected by overfishing due to the country's growing population and a lack of alternative income-generating options available to the fishers. As a result, capture fisheries alone cannot supply the increasing demand for fish in Malawi. Aquaculture (commonly known as fish farming) is a promising alternative with potential to transform the fisheries sector in Malawi, reduce pressure on wild fish populations, present new employment opportunities, and increase food and nutritional security.

The current study has sought to investigate the challenges that small-scale fish farmers face in Malawi and how they can be addressed. Specifically, it aimed to characterize small-scale fish farmers and farms in Malawi, investigate the role of aquaculture in the livelihoods of small-scale farmers, evaluate the profitability of fish farming, and identify opportunities for investment based on the performance and experiences of small-scale fish farms.

Understanding the constraints of fish farming in Malawi is crucial for designing effective strategies and policies for small-scale aquaculture growth. This study found that fish farming is either undertaken by individual fish farming households or by communities (i.e., collectively). Small-scale fish farming is dominated by men, as a majority of the individual fish-farming households were male-headed and much of the labor was completed by men.

Fish farmers are overwhelmingly engaged in low-technology earthen pond farming, drawing from groundwater. Usage of inputs, such as feed, fertilizers, veterinary drugs, and lime, is low, and farmers have limited access to aquaculture extension services or credit. Almost all the harvested fish were sold fresh, indicating short value chains (sold to buyers in the community at pondside). In addition, few farms seem to maintain written records of their farm operations or engage in any value addition. This suggests that small-scale fish farmers lack an entrepreneurial mindset and do not generally regard their farms as a business. This study has documented a very weak linkage between small-scale fish farmers and large-scale (commercial) aquaculture facilities, as few or no farmers received extension services or bought fingerlings from commercial farmers or companies.

Further results show that the total annual production of most fish farms is low. Although small-scale fish farming in Malawi is generally profitable, the gross margins are rather small and likely too low to attract many new entrants to fish farming. Nevertheless, fish farming is regarded as an important contributor to fish farmers' household consumption and incomes, and farmers often expressed an interest in expanding their farms. Together, these results suggest that fish farming has the potential to improve small-scale farmers' livelihoods and welfare through economic and dietary diversification and increased food and nutritional security. However, aquaculture productivity needs to be raised and aquaculture value chains need to be more inclusive.

From the farmers' perspective, several key challenges limit their fish farms' production potential. These include the limited availability and high cost of feed and other inputs, poor-quality fingerlings, predation, lack of access to extension services and credit, and lack of formal and well-structured markets for fish. Climate change is another challenge that is hindering the growth and development of small-scale fish farming, causing farmers in some districts to abandon their farms. The highlighted challenges also point to important opportunities for government and the private sector to invest in aquaculture. These opportunities arise in the areas of fingerling and feed production, the development of formal and well-structured markets, the provision of loans and credit, and the adoption of cage farming. It is prudent to conclude that the small-scale aquaculture sector in Malawi can be developed if key challenges are addressed and opportunities are seized.

Based on the findings from this report, several recommendations have been identified for sustainable small-scale aquaculture development in Malawi, as outlined below:

Improve availability and access to high-quality fish feed.

Small-scale farmers do not have access to high-quality and affordable commercial feed. As such, most farmers use homemade feed, which does not meet the dietary requirements for fish. The floating feed (commercial feed) that is available in Malawi is imported from Zambia and perceived as expensive. Moreover, it is not available in the markets where farmers buy their inputs. There is a need for Malawi to manufacture its own floating feed so that it will be affordable and widely accessible. The Centre of Excellence for Aquaculture and Fisheries Science (Aquafish) at LUANAR, the National Aquaculture Centre (NAC), and MALDECO Fisheries are some entities that can potentially manufacture floating feed if they are properly equipped and capacitated.

Promote best practices in fish farm management.

Small-scale fish farmers can improve their fish production and expand their profits by following the recommended fish farming practices. For instance, farmers ought to increase their input usage rates and practice a system of production cycles rather than continuous production. Farmers should also be encouraged to maintain records.

Train certified hatchery operators.

This study established that most fish farmers obtain their fingerlings from fellow farmers and, in many cases, use recycled (and therefore low-quality) fingerlings. As such, there is a need to train certified hatchery operators to supply high-quality fish seed within their localities.

Develop protocols and standard operating procedures for fish feed production and hatchery operations/management.

Malawi has guidelines for tilapia hatchery operators, which were developed in 2011, but it does not have protocols and standard operating procedures (SOPs) for certifying hatchery operations and fish feed producers. If SOPs are not developed, farmers will continue using recycled seed and/or access poor-quality fingerlings from uncertified hatchery operators.

Promote integrated fish farming.

Fish farmers should be encouraged to integrate their fish farms into the existing crop and livestock-based farming systems to diversify their economic base, enhance their fish (or crop or livestock) production, and improve the use-efficiency of inputs and other resources.

Improve small-scale fish farmers' access to credit.

Fish farmers need access to credit to make capital investments and boost their fish farming enterprises. Currently, farmers access loans from informal financial service providers such as village loan banks. There is a need to support these informal microfinance schemes to strengthen their investment capacity.

Promote the active participation of youths and women in small-scale fish farming.

There is a need for government to empower and engage women and youths in fish farming enterprises through targeted interventions and strategies. The high unemployment rate can be at least partially addressed if the youths are organized into fish farming clubs and provided with the necessary inputs and farm equipment, skills, and fish farming knowledge.

Invest in aquaculture extension services.

In most districts, the district fisheries offices are using agricultural extension workers and, in some cases, lead farmers to provide extension services to fish farmers. Most of these extension agents lack expertise or technical know-how of fish farming. There is therefore a need to train more fisheries and aquaculture extension agents.

Organize small-scale fish farmers into groups/organizations/cooperatives and strengthen existing small-scale farmers' associations.

There is a need to strengthen the fish farmers' associations to facilitate the provision of training and extension services, ease access to farm inputs and loans, and enable the marketing of fish. In particular, it will be easier to link farmers to formal and reliable markets if they are organized into cooperatives or associations.

Develop guidelines for cage aquaculture.

This study has shown that fish farmers are being negatively affected by climate change. To reduce these impacts, it is imperative to promote climate-smart aquaculture technologies such as cage farming. Presently, Malawi does not have any guidelines for cage farming, so it is necessary to first address this oversight.

Promote the use of insects as an alternative to fish feed.

The imported/commercial fish feed used by a handful of small-scale fish farmers in Malawi is expensive. As such, there is a need to promote alternative types of fish feed. One potential alternative is the use of insects such as black soldier fly (BSF). Before BSF is promoted for this purpose, there is a need to assess the economic viability of BSF production in Malawi.

Promote tree planting among small-scale fish farmers.

Fish farmers often use homemade fish feed, which usually needs to be cooked and therefore requires firewood. Programs can be introduced that encourage fish farmers to plant trees around their farms or establish woodlots to reduce pressure on existing forests that are already under threat. Trees planted around fish farms may even serve as a barrier to predators, which are another challenge affecting small-scale aquaculture production in Malawi.

Incentivize the private sector to venture into fish farming.

There is a need for effective strategies and mechanisms to attract the private sector (both domestic and international) to invest in aquaculture. Such strategies may include reducing or removing taxes on imported feed milling machinery and other imported aquaculture equipment.

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APPENDIX

Table A1. Gross margins and productivity of fish farming by farm type (mean values, MK)

	Individually owned farms		Community farms	
	Mean	% of cost	Mean	% of cost
Harvest value	153,238.76		106,223.96	
Fingerling revenue	21,437.69		1,052.03	
Total revenue	174,279.33		107,275.99	
Commercial feed	10,654.43	23.0	18,961.09	27.7
Homemade feed	13,802.80	29.8	24,555.88	35.9
Energy cost	164.99	0.4	326.93	0.5
Organic fertilizer	1,237.35	2.7	1,850.24	2.7
Inorganic fertilizer	2,288.20	4.9	1,701.93	2.5
Lime	1,471.60	3.2	1,075.07	1.6
Medication	0.00	0.0	0.00	0.0
Fingerlings	4,857.86	10.5	9,087.69	13.3
Hired labor	6,473.81	14.0	2,308.81	3.4
Other inputs	3,244.32	7.0	397.91	0.6
Transport	2,461.09	5.3	8,175.47	12.0
Total variable costs	46,267.16		68,400.12	
Gross margin	128,012.17		38,875.87	
Productivity (Gross margin per pond of size 299.5 m^2)	108,525.44		21,944.85	
Observations	606		126	

Source: MAS 2021

Table A2. Gross margins and productivity of fish farming by production system (mean values, MK)

	Production cycles		Continuous production	
	Mean	% of cost	Mean	% of cost
Harvest value	301,674.13		90,879.41	
Fingerling revenue	63,782.25		2,392.36	
Total revenue	362,763.06		93,271.77	
Commercial feed	27,934.91	27.9	5,876.41	19.3
Homemade feed	20,053.41	20.0	13,469.97	44.2
Energy cost	310.78	0.3	141.23	0.5
Organic fertilizer	2,495.09	2.5	891.08	2.9
Inorganic fertilizer	4,938.02	4.9	1,220.55	4.0
Lime	3,693.13	3.7	593.62	1.9
Medication	0.00	0.0	0.00	0.0
Fingerlings	18,630.29	18.6	619.29	2.0
Hired labor	10,607.41	10.6	4,222.93	13.8
Other inputs	7,725.29	7.7	1,006.06	3.3
Transport	4,973.06	5.0	2,571.43	8.4
Total variable costs	100,254.14		30,506.67	
Gross margin	262,508.92		62,765.09	
Productivity (Gross margin per pond of size 299.5 m^2)	101,980.12		95,274.39	
Observations	170		562	

Source: MAS 2021

Table A3. Gross margins and productivity of fish farming by farm size (mean values, MK)

	0–200 m^2		200–1,000 m^2		>1,000 m^2	
	Mean	% of cost	Mean	% of cost	Mean	% of cost
Harvest value	52,418.45		133,131.42		757,699.79	
Fingerling revenue	659.40		3,254.35		196,762.11	
Total revenue	53,077.85		136,385.77		954,461.89	
Commercial feed	805.70	4.3	8,253.39	18.5	94,312.26	36.1
Homemade feed	10,384.07	55.9	16,076.81	36.0	40,509.85	15.5
Energy cost	209.34	1.1	186.56	0.4	48.89	0.0
Organic fertilizer	578.66	3.1	1,213.20	2.7	6,582.03	2.5
Inorganic fertilizer	774.74	4.2	1,735.51	3.9	13,068.95	5.0
Lime	232.85	1.3	765.01	1.7	12,531.64	4.8
Medication	0.00	0.0	0.00	0.0	0.00	0.0
Fingerlings	1,631.37	8.8	6,623.85	14.8	22,984.41	8.8
Hired labor	2,239.72	12.1	6,030.33	13.5	28,771.92	11.0
Other inputs	493.71	2.7	1,407.71	3.2	23,781.99	9.1
Transport	1,270.68	6.8	2,426.25	5.4	19,005.71	7.3
Total variable costs	18,561.67		44,614.83		261,453.86	
Gross margin	34,516.18		91,770.95		693,008.04	
Productivity (Gross margin per pond of size 299.5 m^2)	126,056.91		63,238.07		96,165.46	
Observations	349		321		58	

Source: MAS 2021

Note: Farm area is missing for four observations.

Table A4. Gross margins and productivity of fish farming by region (mean values, MK)

	Southern Region		Central Region		Northern Region	
	Mean	% of cost	Mean	% of cost	Mean	% of cost
Harvest value	154,655.75		75,864.79		176,461.04	
Fingerling revenue	18,591.26		23,311.12		15,859.79	
Total revenue	172,705.61		99,175.91		192,320.84	
Commercial feed	9,597.83	19.9	20,455.39	39.6	11,763.48	23.4
Homemade feed	15,534.98	32.2	12,623.81	24.4	16,202.00	32.3
Energy cost	233.73	0.5	249.87	0.5	0.00	0.0
Organic fertilizer	1,435.46	3.0	1,230.94	2.4	1,035.76	2.1
Inorganic fertilizer	1,891.06	3.9	1,283.70	2.5	3,833.60	7.6
Lime	1,192.74	2.5	431.02	0.8	2,811.09	5.6
Medication	0.00	0.0	0.00	0.0	0.00	0.0
Fingerlings	6,976.09	14.5	3,596.59	7.0	2,134.64	4.2
Hired labor	5,324.19	11.0	3,713.49	7.2	9,310.91	18.5
Other inputs	3,864.16	8.0	1,193.37	2.3	1,254.31	2.5
Transport	2,701.72	5.6	7,040.91	13.6	1,940.48	3.9
Total variable costs	48,218.20		51,673.80		50,238.10	
Gross margin	124,487.40		47,502.11		142,082.74	
Productivity (Gross margin per pond of size 299.5 m^2)	112,956.18		75,783.35		65,559.47	
Observations	400		176		156	

Source: MAS 2021

Table A5. Gross margins and productivity of fish farming by species (mean values, MK)

	Chilunguni		Makumba		Chambo		Mlamba	
	Mean	% of cost	Mean	% of cost	Mean	% of cost	Mean	% of cost
Harvest value	126,006.32		103,621.22		79,881.13		298,763.56	
Fingerling revenue	12,722.77		13,792.86		21,061.39		0.00	
Total revenue	138,729.09		117,414.08		100,942.52		298,763.56	
Commercial feed	6,775.14	20.8	8,417.73	22.2	16,738.35	36.4	11,431.47	22.5
Homemade feed	11,683.87	35.8	11,836.90	31.2	9,918.50	21.6	20,912.86	41.1
Energy cost	90.98	0.3	216.46	0.6	77.24	0.2	0.00	0.0
Organic fertilizer	786.64	2.4	1,157.48	3.0	1,169.81	2.5	1,122.73	2.2
Inorganic fertilizer	1,577.27	4.8	1,521.50	4.0	2,252.82	4.9	4,565.86	9.0
Lime	1,284.93	3.9	937.36	2.5	524.28	1.1	5,721.38	11.2
Medication	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Fingerlings	3,882.94	11.9	4,800.88	12.6	3,233.49	7.0	0.00	0.0
Hired labor	4,536.33	13.9	4,255.58	11.2	3,346.42	7.3	5,469.23	10.7
Other inputs	464.83	1.4	2,655.39	7.0	2,784.94	6.1	30.88	0.1
Transport	1,533.12	4.7	2,174.44	5.7	5,955.04	12.9	1,625.14	3.2
Total variable costs	32,616.07		37,973.72		46,000.89		50,879.53	
Gross margin	106,113.02		79,440.35		54,941.63		247,884.03	
Productivity (Gross margin per pond of size 299.5 m^2)	79,145.71		84,957.03		105,516.62		66,050.47	
Observations	364		409		142		14	

Source: MAS 2021

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