AQUACULTURE DEVELOPMENT IN SIERRA LEONE: A CASE STUDY OF BO DISTRICT

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ABSTRACT

Freshwater aquaculture in Sierra Leone began in 1977 with the introduction of tilapia and catfish production at the Makali and Bo fisheries outstations. Despite this long history, the sector's contribution to national food security and economic growth remains relatively low. This study aimed to collect comprehensive data on aquaculture operations in the Bo district, including seed and feed production, farm management practices, processing methods, and marketing strategies. A total of 24 fish farms were surveyed, and data from 21 were included in the final analysis. These comprised ten subsistence farms, six semi-commercial farms, and five commercial farms. Most respondents (52%) were between 51 and 60 years old, 86% were men, and 90% held a university degree or higher in various fields. Earthen ponds were the predominant production system (90%), and 38% of farmers sourced fingerlings from other fish farms. A majority (71%) relied on self-compounded feed for their production. Semi-commercial farmers reported an average annual production of 1,167 kg, while commercial farmers achieved a higher average of 2,480 kg. Commercial farms generated greater annual revenue (NLe252,000 or USD 11,195) than semi-commercial farms (NLe95,667 or USD 4,250). However, semi-commercial farmers sold fish at slightly lower prices per kilogram (NLe92 or USD 4.09) than commercial farmers (NLe96 or USD 4.26). Despite higher revenue, commercial farms reported lower profit margins (less than 25% or none) due to increased labour costs and dependence on commercial feeds, whereas semi-commercial farms achieved profit margins of 25–49%. The findings indicate that aquaculture in Sierra Leone remains in an early development phase, with significant potential for expansion. Realising this potential will require improving the profitability of commercial farms and providing targeted training to enhance farmer productivity and management skills. Support from government agencies, donor partners, FAO, NGOs, and private investors will be essential to advance sustainable aquaculture development in the country.

Key words: Aquaculture, Sierra Leone, fish farming, production systems, profitability.

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1. INTRODUCTION

1.1 Background

The Republic of Sierra Leone is located on the west coast of Africa, just north of the Equator. It borders the Republic of Guinea to the north and east, and Liberia to the south-east. The Atlantic Ocean lies to the south-west (Figure 1)Figure 1. The country covers a total area of 71,740 sq km (Dempsey, 2014) and experiences an average temperature of 30°C, with humidity ranging from 80 to 90%.

Figure 1. Map of West Africa showing Sierra Leone.

In Sierra Leone, there are two main seasons: the rainy season from June to September, and the dry season for the rest of the year. The estimated population of Sierra Leone is estimated to be 8.4 million (Statistics Sierra Leone, 2021). The southern and western parts of Sierra Leone have approximately 400 km of Atlantic coastline (FAO, 2005), which is believed to have rich fishing grounds for a wide variety of fish. These include high-value species, such as lobsters, shrimp, cuttlefish, bream, and snapper. Seafood comprises approximately 54.6% of the animal protein consumed by humans (FAO, 2023).

The fisheries sector comprises three subsectors: marine, inland fisheries, and aquaculture. Most fish come from marine fisheries, a small proportion from inland fisheries, and a very limited volume from aquaculture production. The fisheries sector is an important source of income, employment, and food and nutrition safety in Sierra Leone. The fishing industry contributes 10% of Sierra Leone's gross domestic product (GDP) (Neiland et al., 2016). In recent years, Sierra Leonean marine capture fisheries have been declining severely (Baio & Sei, 2017). This decline is attributed to overfishing by foreign industrial vessels, illegal practices, climate change, unreported and unregulated (IUU) fishing, the use of unsustainable fishing methods by artisanal fishers, and environmental degradation (Baio & Sei 2017; Belhabib et al., 2019; Ogbuafor & Gray, 2021; Ogbuafor et al., 2019). Considering these factors, aquaculture is seen as a vital alternative for development that can ease the pressure on marine capture fisheries and supply the growing need for fish. As such, it is unique as the main substitute for fish proteins.

Fishing and fish processing activities employ coastal communities. Approximately 100,000 individuals are directly involved in artisanal fishing, while approximately 300,000 people find employment in fishing companies (Samba, 2019). However, research has suggested that Sierra Leone’s capture fisheries are at risk of collapse (Thorpe et al., 2009). Over the past few years, international organisations have attempted to help Sierra Leone improve marine capture fisheries; however, they have been unsuccessful in resolving poverty and hunger in coastal areas (Finch, 2016; Ogbuafor et al., 2018).

Owing to the decline in marine capture fisheries, aquaculture has recently gained attention from the government, the Food and Agriculture Organization (FAO), non-governmental organisations (NGOs), research institutions, and other international agencies that are trying to help aquaculture development in the country. The focus is mainly on tilapia and catfish species. In previous years, aquaculture has been practiced in every part of the country as a backyard activity and is more concentrated in the southern provinces, mostly in Bo, and to a lesser extent, in Moyamba and Pujehun. Based on a district map of Sierra Leone (Figure 2), the majority of the population is in Tonkolili, with a lesser population in Bombali. Kailahun, Kenema, and Kono are the eastern regions where aquaculture operations take place. In these areas, households also commonly raise cattle and chickens as additional sources of protein.

Figure 2. Map of districts of Sierra Leone.

1.2 Rationale

The Ministry of Fisheries and Marine Resources (MFMR) is responsible for all fishing activities in Sierra Leone. The total number of commercial and subsistence fish farms is low in the MFMR, and the same can be said about production data, sources of fingerlings, marketing strategies, processing methods, and import or export activities. Owing to the decline in marine capture fisheries and limited data on all aquaculture activities, there is an urgent need to understand the status and development of aquaculture. Such information is crucial for policy and planning to stimulate production and productivity in the future. In addition, it is important to gather and analyse information that will be presented at various levels, including the Ministry of Fisheries and Marine Resources, other governmental bodies, non-governmental organisations (NGOs), and international organisations. The information collected will not only be valuable for the country but will also serve as a helpful tool for donor partners.

1.3 Study Objectives

The main objective of this study is to assess the aquaculture status of the Bo district. This district is characterised by the scale of operation, seed and feed production, overall fish farm management, processing techniques, and marketing.

By addressing potential challenges in the aquaculture sector, this study provides insights that can aid decision-making for short-term and long-term goals and policies for the country. The collected data will inform the government's decision-making process,
contribute to the development of a national strategy for growth in aquaculture. This strategy will be circulated to all stakeholders in the aquaculture sector, thereby promoting collaboration and contributing to poverty reduction across the country.

1.4 Main objectives

- To gather comprehensive data on different aspects of aquaculture activities in the Bo district, including seed and feed production, fish farm management, processing techniques, and marketing.
- To characterise the fish farms according to their respective operational scales.
- To evaluate the strengths, weaknesses opportunities, and threats (SWOT) in Sierra Leone aquaculture.
- To provide recommendations to overcome challenges in the production and profitability of aquaculture in the Bo district.

2. LITERATURE REVIEW

2.1 Aquaculture Development in Africa

In Africa, aquaculture utilises various natural resources, technologies, and production chain management techniques. Inland waterways account for approximately 82% of Africa's aquaculture production, according to the Food and Agriculture Organization (FAO, 2021). Production systems are often divided into three categories: extensive, semi-intensive, and intensive. Earthen ponds, cages, and basins are typical production techniques in sub-Saharan Africa (Satia, 2017). Large-scale aquaculture systems are common in North Africa, where nations like Algeria, Libya, Morocco, and Egypt are included. These systems are characterised by the restocking of juvenile fish in reservoirs (El-Sayed, 2017). Semi-intensive aquaculture is limited to earthen ponds and is characterised by elevated production levels attained by treating the water and adding feed.

Egypt's aquaculture industry has grown rapidly and is currently the largest in Africa and ranks sixth in the world in terms of output volume (El Sayed, 2017; Wally et al., 2022). In addition, Egypt is the world's third-largest producer of tilapia (Wally et al., 2022). Furthermore, Egypt has contributed significantly to food security and economic prosperity worldwide. The country produced an estimated 2.2 million metric tons of fish in total in 2021, of which 1.7 million metric tons were from aquaculture (Wally et al., 2022). Egypt aims to increase its fish production to 3 million metric tons by 2025. This successful development in Egypt should serve as an example for other countries in Africa.

Ponds for extensive and semi-intensive farming, grow-out cages, longlines for mussel and oyster farming, raceways for trout rearing, shallow flow-through systems in oyster culture, and recirculating aquaculture systems (RAS) are some of the production systems used in Southern Africa (Satia, 2017; Adeleke et al., 2020, FAO 2021). Dam ponds are widely used throughout West Africa. To generate an adequate amount of water, a valley is blocked to build these ponds. Furthermore, Nigeria and Benin have integrated agri-aquaculture systems (IAAS) for fish farming, which is a family farming system (Satia, 2017). For industrial privately-owned West African farms producing 1,000–10,000 metric tons or more per year, floating cage fish farming is the most common technique (Hinrichsen et al., 2022).

South Africa has adopted recirculating aquaculture systems (RAS) more broadly than other African countries (Adeleke et al., 2020). Advanced hatchery technology is used in land-based pumping systems for abalone farming, which uses either concrete or plastic tanks (Satia, 2017). Cage fish farms are also important in Southern African aquaculture production areas.

For intensive fish farming, certain companies and fish farmers in East Africa use cages, which help reduce the cost per fish produced (Satia, 2017). According to Musinguzi et al. (2019), Uganda has the highest number of cage farms among East African nations, followed by Kenya, Tanzania, Rwanda, Zimbabwe, Zambia, and Malawi. Seaweed is farmed using the 'tie-ti' technique in shallow lagoons in Tanzania, Mozambique, and Zanzibar (Satia, 2017). Malawi and Uganda have also implemented agri-aquaculture systems (Satia, 2017). The majority of caged aquaculture facilities are located in African countries with inland water bodies, including Lake Victoria (Musinguzi et al., 2019).

2.2 Aquaculture Development in Sierra Leone

Aquaculture in Sierra Leone has a history of poorly planned and unsuccessful enterprises, however it has great potential for development (WorldFish, 2016). According to FAO (2019), aquaculture production systems were initiated by the Sierra Leone Government in collaboration with IDRC (Canada) in 1974, focusing on the cultivation of the mangrove oyster (*Crassostrea tulipa*). During this time, a 10-year research program on oyster culture began in the Bonth district. Various culture methods, including rafts, trays, and sticks, were tested, with raft culture emerging as the most appropriate. Oysters demonstrated an impressive growth rate of 1 cm per month, leading to marketable oysters within a 7-month cycle.

The project successfully established the biological foundations for mangrove oyster production through raft culture. However, efforts to extend this technique to oyster farmers proved unsuccessful, primarily because of financial constraints and the high costs associated with essential inputs, such as 44-gallon oil drums for flotation and polyethylene strings for suspending oysters on rafts. These factors eventually led to the discontinuation of the project in 1981. Another oyster farming initiative was developed between 2014 and 2018 in the Bonthe district, a coastal town situated on Shebro Island (Murray et al., 2019). This also failed because of a lack of community interest and inadequate technical know-how. Sankoh et al., (2018) explained that fin fish, tilapia and catfish culture started in 1976 in the experimental fish farm at Makali and Bo. This was through a joint funding programmed with the Ministry of Fisheries, Catholic Relief Services, USAID, and the Peace Corps. During this time, farmers typically owned 1–4 fishponds, with surface areas ranging from 100 to 500 m^2 per pond. The yield from these ponds averaged 1.5–2.5 metric tons/ha/year, representing 50% of the maximum yield of tilapia and catfish achievable under these circumstances (FAO, 1992). This indicates that there is still significant potential for improvement in the sector.

The initial seeds for tilapia and catfish culture were obtained from Côte d'Ivoire by the Bo-Pujehun Gesellschaft für Technische Zusammenarbeit (GTZ) program in the 1980s, which promoted tilapia culture in ponds in the Southern Province. This initiative served as a method for spreading fish culture technology in the Southern Province, particularly in the Bo and Pujehun districts. The Bo-Pujehun project also included experimental tests of integrated fish and rice culture to demonstrate the technique for swamp rice farmers in the Bo district. Trials have also been conducted with other wild fish species, such as catfish (*Heterobranchus and Notopterus* spp.), and have shown success under experimental conditions; however, they have not been universally adopted by fish farmers (FAO, 2019). The primary constraint to their development is the challenge of breeding them in captivity, as fingerlings are caught in the wild.

During the 1990s and 2000s, several inland aquaculture initiatives were established in the Tonkolili and Bo districts. In the 1990s, there were 453 fishponds in the country, as stated in the Agricultural Sector Master Plan (Government of Sierra Leone, 1992). According to Ministry of Fisheries and Marine Resources (MFMR) officials in 2009 (Table 1), a total of 2,594 fishponds were recorded in Sierra Leone. Of these, 2,164 were in the Tonkolili district, followed by Bo.

Table 1 describes the total number of ponds in each district, as well as their sizes, and was conducted in all districts in Sierra Leone (Dabo et al., 2009). Sankoh et al. (2018) stated that subsistence inland aquaculture has been positive in Tonkolili in the northern part of Sierra Leone, where more than 1,500 active fishponds were growing Nile tilapia (Oreocromis niloticus), delivering an estimated 82 metric tons annually. The justification for their success is that the farmers in Tonkolil, who were trained by the Peace Corps on how to construct and manage fishponds, embraced the technology and have since continued to train other young Sierra Leoneans. However, in recent times, aquaculture has declined drastically, mainly because of financial constraints on fish feed procurement and fish seed costs, and lack of interest from the community. During the Peace Corps project, the farmers were supplied with fingerlings to stock their ponds. Additionally, they were provided with imported fish feed to support their aquaculture efforts. The present situation and trends in aquaculture indicate the problematic situation regarding seed and feed production in the area.

Table 1 Results from the 2009 aquaculture baseline study.

District	Number of ponds	Average size of pond	Percentage of active ponds	Number of fishponds in active production	Area of production (ha)	Production (t/year)
Bo	277	304	52	143	4.35	6.53
Bombalie	28	479	36	10	0.49	0.73
Bonthe	3	324	75	2	0.07	0.11
Kailahun	20	330	71	14	0.47	0.70
Kambia	12	195	0	0	0.00	0.00
Kenema	5	384	40	2	0.08	0.12
Koinadugu	7	763	100	7	0.53	0.80
Kono	25	347	8	2	0.07	0.11
Moyamba	4	233	0	0	0.00	0.00
Port Loko	12	560	57	7	0.38	0.58
Pujehun	11	196	88	10	0.19	0.28
Tonkolili	2,164	344	73	1,590	54.76	82.13
Western Area	25	295	53	13	0.39	0.58
Total	**2593**	**365.7 m^2**	**50.2%**	**1,800**	**61.78**	**92.67**

To help aquaculture become more successful in Sierra Leone, WorldFish led a project with the government of Sierra Leone. This project was different from their previous aid programs. This $3.5 million project was structured to pilot a business model aimed at enhancing fish production, consumption, and income among small-scale fish farmers (CGIAR, 2019). While this public-private partnership initiative seemed promising, Sankoh et al. (2018) emphasised the importance of incorporating local communities and needs into its design for long-term sustainability. The project emphasised that an inadequate understanding of local needs has led to the underperformance of commercial aquaculture in Sierra Leone. However, to date, all foreign experts have advised growing tilapia as the main culture species (Sankoh et al., 2009).

Bamba (2004) reported that aquaculture development in Sierra Leone needs refocusing and a new approach to make a meaningful contribution to poverty reduction and food security. Sankoh et al. (2018) highlighted a significant concern regarding the community, stating that the growth of inland aquaculture in Sierra Leone has largely been driven by foreign agencies in line with international donor programs, rather than local or grassroots efforts. Consequently, some projects have suffered from a lack of understanding of local conditions and contexts. Additionally, hindrances to the commercial development of aquaculture include inadequate site selection, the presence of natural predators and poachers, limited technical and biological

expertise, poor quality of feed and seed, insufficient labour inputs, fluctuating environmental conditions such as floods and droughts, and high costs of fishpond facilities.
In Sierra Leone, aquaculture is primarily used as a subsistence method, providing essential protein to many rural communities. The most common practices are fish rearing in concrete tanks and earthen ponds. However, international bodies, such as the European Union (EU), non-governmental organisations (NGOs), and the Food and Agriculture Organization (FAO), are actively advocating for the expansion of aquaculture in developing countries. Their objective is to foster economic opportunities and enhance nutrition (FAO, 2016; Kassam et al., 2017; Sankoh et al., 2018). Collaborative efforts involving entities such as the FAO, NGOs, and the government are aimed at constructing fishponds for local farmers. While some farmers independently manage their ponds, others receive support in construction and financing from these organisations. Nonetheless, establishing economically sustainable aquaculture ventures remains a formidable challenge. Three different fish farming techniques are generally used in Sierra Leone. Commercial fish farmers are those who raise fish exclusively as a business. To make a profit, they concentrate on increasing their sales and output. Semi-commercial fish farmers are producers who raise fish for both home and market use. They use part of the fish they harvest to meet their own family's needs and sell the remainder. Subsistence fish farmers produce fish for their own or domestic use and providing for their family's nutritional requirements takes precedence over making money from sales.

2.3 Fish Feed

An increasing supply of fish feed is seen in conjunction with the rise in aquaculture farming in Africa. According to Agboola et al. (2019), feed mills mainly manufactured feed for terrestrial animals before 2010 and only supplied fish feed in response to requests from farmers. This happened because feed producers found it difficult to invest in manufacturing fish feed production because of the lack of demand and a stable market (Hassan et al., 2007; Agboola et al., 2019). Fish farming has increased in Africa in part because farmers, particularly in Egypt, have switched from traditional cultural practices to more contemporary ones, such as semi-intensive or intensive farming (Waite et al., 2014). A large amount of fish feed is required for this type of production (El-Sayed et al., 2017). High-quality extruded feeds (90%) have replaced traditionally pelleted feeds (10%). According to Adeleke et al. (2020), Nigeria has the greatest number of feed mills in Sub-Saharan Africa, producing 60% of the fish feed used in the region. Typically, these mills can generate 0.5 to 3 metric tons of feed per hour. Large-scale aquaculture investors in nations such as Nigeria, Uganda, Kenya, and Zambia frequently rely heavily on imported fish ingredients and feeds. They favour them because local manufacturing is insufficient in quality, although they are more affordable. Additionally, ingredients are utilised in competing animal diets (Adedeji, 2011).

Regardless of the quantity of fish feed produced, farmers and the fish feed business are experiencing major price increases for fish feed ingredients and feed itself (Mustapha, 2020). The high cost of fish feed is often due to the high protein content requirement of fish feeds. As fish feed costs account for more than half of all production costs, it is a major economic problem that affects the viability and profitability of aquaculture operations (Hasimuna et al., 2019). Additionally, there are difficulties with the lack of supply of high-quality fish feed (Hasimuna et al., 2019), which could partly be attributed to the scarcity of trained employees in aquaculture nutrition-related fields, including formulation and processing (Udo & Dickson, 2017). Ensuring a sufficient feed supply is a concern for small-scale farmers who occasionally produce their own feed (Mustapha, 2020). However, this situation provides investors with the opportunity to produce high-quality, locally sourced feed at a lower cost, which will save farmers' expenses and promote economic production. The local demand for aquafeeds has not previously reached a level that demanded substantial attention and investment in the majority of Sub-Saharan African countries (except for Nigeria) (Hassan et al., 2007). This is beginning to change, though, as businesses, such as Aller Aqua, Novatek, and Skretting, build aquafeed mills throughout the continent to serve customers in the area. In Sierra Leone, the status of aquaculture is still at the developing stage, and commercial fish feed production is still in its infancy; therefore, most farmers rely on locally compounded feed. The use of commercial feeds is expected to increase as the intensification of farming increases.

2.4 Fish Seed

Aquaculture growth throughout Africa is sometimes hampered by the availability and quality of juvenile fish for stocking (Shaalan et al., 2018; Hasimuna et al., 2019). Juvenile fish are usually obtained from licenced hatcheries, production ponds, or from the wild (Brummett, 2007; Shaalan et al., 2018). However, due to concerns about sustainability, dependability, and biosecurity, the use of wild sources is highly discouraged (Bondad-Reantaso, 2007). The number of hatcheries on the continent has significantly increased in recent years, mostly due to the efforts of the private sector. Several hatchery systems are used, including concrete tanks, hapas (fixed net enclosures), indoor tanks, and small open ponds (Brummett, 2007). In certain situations, indoor recirculating raceways and flow-through tanks are also used. The demand for quality broodstock and, by extension, quality fingerlings, varies significantly throughout Africa (Adewumi, 2015). In Sierra Leone, owing to the gradual commercialisation of fish farming, the demand for quality fingerlings is also increasing, and there is a growing number of private hatcheries.

This need is a result of many problems, including declining genetic quality within parent fish populations and inadequate genetic management (Brummett, 2007). Furthermore, to guarantee the production of high-quality fish seed in Africa, there are insufficient quality control methods and a shortage of regulated hatchery operations. Additionally, many hatcheries lack or have insufficient biosecurity standards and policies intended to minimise the spread of infectious diseases (Brummett, 2007; Kajungiro et al., 2019). Researching modern breeding techniques is vital for the creation of new and improved fish seed strains and for establishing genetic breeding programs.

3. METHODOLOGY

3.1 Study area

This study focused on one district out of the 16 districts in the county, Bo district. Earthen ponds are believed to be the main cultural systems in this district because of their vast valley swamps and inland fisheries. Bo Town is the second largest city in Sierra Leone (after Freetown, the capital city) and the largest city in the Southern Province. The district has a total population of 756,975 (Bo population statistics, 2023).

3.2 Research design and sampling strategy

For this study, information was collected in two ways. First, detailed information was collected through relevant published and unpublished materials. Second, data were gathered directly from the study area through a questionnaire (APPEN). Four experienced staff members from the MFMR targeted all 17 chiefdoms in the Bo district to administer the questionnaires. The questionnaire was administered to obtain information from fish farmers about challenges, opportunities, weaknesses, and successful cases in operating their fish farms. Key topics, such as types of feeds, feed and seed prices, levels of performance, water quality management, types of ponds, and sources of raw materials, were questioned.

3.3 Data collection and analysis

Questionnaires were prepared using the Microsoft Word program and administered to different fish farms across the selected study area. As the locations of the fish farms were not known in the district, the enumerators visited villages to locate these fish farms and administer the questionnaires. The questionnaire responses were analysed using the Excel program, which was used to produce descriptive statistics in the form of tables and bar charts, providing a basis for the interpretation of the findings.

4. RESULTS AND DISCUSSION

4.1 Socioeconomic characteristics

Twenty-four fish farms were sampled in total. Two fish farms were found to be abandoned; one of which belonged to the government and was operated by MFMR staff, specifically designated as the Ministry's aquaculture outstation. Subsequently, twenty-one fish farmers were interviewed for the study. Among these were ten subsistence, six semi-commercial, and five commercial fish farms.

This observation indicates the dominance of subsistence fish farming over commercial and semi-commercial business enterprises in the Bo district. It also emphasises the need for increased training and support for fish farmers in the region to enhance their capacity and prepare them for commercial production. It implies that fish farmers become more knowledgeable, productive, and resilient in their operations by developing their capacities. It points to a move toward profitable and more sustainable farming methods, which might support national economic development.

Sierra Leone's provinces are subdivided into chiefdoms, which represent a traditional governance structure overseen by a paramount chief. This leader holds authority over a specific area and its residents. Each chiefdom typically consists of a collection of towns or villages, usually numbering between five and ten, with populations of differing sizes. Fish farms were sampled in four chiefdoms that are active in aquaculture production. Kakua reported the highest percentage at 43%, followed by Tikonko at 38%, with Bumpe and Wunde reporting 10% each.

This distribution indicates that fish farming is more dominant in the Kakua and Tikonko chiefdoms, as shown in Table *2*. The scarcity of ponds in certain chiefdoms can be attributed to several factors, including insufficient water availability, inadequate road infrastructure, and smaller population sizes in these regions. For instance, chiefdoms like Kakua and Tikonko, which are closer to urban centres and boast relatively better road access, tend to have more ponds compared to areas like Bumpe and Wunde. These latter chiefdoms are situated farther from urban centres, and their limited road networks contribute to fewer ponds within their territories. The fish farms in Selenga and Niawa Lenga chiefdoms were abandoned. Many other chiefdoms also had fish farms constructed by the FAO, NGOs, and the government; however, these are no longer in existence.

Table 2. Socioeconomic characteristics of fish farms in Bo district.

	Commercial	Semi-commercial	Subsistence	Total	Percentage
No. of sample	5	6	10	21	100%
Chiefdom					
Bumpe			2	2	10%
Kakua	3	3	3	9	43%
Tikonko	1	3	4	8	38%
Wunde	1		1	2	10%
Age Range					
<= 30	1			1	5%
31-40	1	1		2	10%
41-50	1		4	5	24%
51-60	2	4	5	11	52%
>60		1	1	2	10%
Gender					
Male	3	6	9	18	86%
Female	2		1	3	14%
Years of Experience					
Less than 1 year		3		3	14%
1 to 5	4		9	13	62%
10 and Above	1	3	1	5	24%
Educational level					
Degree and above	5	6	8	19	90%
Diploma			1	1	5%
Secondary			1	1	5%
Aquaculture training attended					
Yes	4	4	7	15	71%
No	1	2	3	6	29%
Other agricultural activities					
Yes	4	5	9	18	86%
No	1	1	1	3	14%
Labor engagement					
Yes	5	4		9	43%
No		2	10	12	57%
Nature of labor					
External labor (paid)	5	4		9	43%
Household labor (paid)		1		1	5%
Household labor (Unpaid)		1	10	11	52%

Additionally, out of the 21 remaining fish farms, three were less than a year old; therefore, these were not included in some of the results reported. Regarding the age distribution of respondents, the majority fell within the 51–60 age range, constituting 52% of the sample, followed by 24% at the age of 41–50. Meanwhile, those over 60 years comprised 10%, and those aged less than or equal to 30 years accounted for 5%. Fish farming is typically chosen by elderly men and women as a substitute source of income to sustain their families and guarantee that they have access to meals high in protein. As a result, they view fish farming as a way to support and provide for their families. In the Bo district, Sumanaa et al. (2023) also examined the ages of fish farmers. They disclosed that the majority of fish farmers in this region are over

46 years old, which corroborated with our findings that a higher proportion of older individuals engage in fish farming. However, 40-year-old farmers are energetic and have many positive effects on agricultural and animal output, according to Rahman (2008). Therefore, these farmers can pass on the knowledge they have gained to the younger generation. This indicates that in the future, aquaculture planning and interventions should prioritise the involvement of more youth and encourage fish farmers, processors, and other relevant stakeholders, such as the government and the FAO, to expand funding for higher productivity and production.

The majority (86%) of the farmers were men, while women constituted the remaining 14%. This population analysis breakdown suggests that within the Bo district, there is a significant difference, with greater male participation in fish farming than in females. In the Bo district, men are actively involved in the construction and management of fishponds, while women and children typically handle the daily maintenance and feeding of fish. The research revealed that years of experience in fish farming varied among respondents, with 1–5 years being the most common at 62%, followed by 10 years and above at 24%, and < 1 year at 14%. Educational attainment among respondents revealed that 90% held a degree or higher in any field, with 5% holding diplomas and another 5% having completed secondary school (high school). This indicates that more graduates are going into fish farming in recent times; however, some have limited knowledge in aquaculture. Additionally, 71% of respondents reported attending aquaculture training, while 29% never attended any training, indicating a growing interest in the field, particularly among subsistence fish farmers who comprised most training participants. This suggests a potential shift from subsistence to commercial fish farming as farmers gain expertise.

Many respondents acquired their training through seminars and workshops, with a minority obtaining training through social media or university studies. Furthermore, 86% of respondents reported engaging in other agricultural activities alongside fish farming, while 14% focused solely on fish farming or pursued other businesses to support their families. Notably, subsistence fish farmers were most likely to engage in multiple agricultural activities. Regarding employment practices, 57% of respondents stated that they did not employ any workers, while 43% reported employing workers, mainly on commercial and semi-commercial fish farms. The distribution of labour varied, with 52% of respondents relying solely on their labour, 43% employing paid labour, and 5% utilising household labour for which payment was made.

4.2 Operational Leverage

The results show that 71% of individual farmers operate their fish businesses independently, while 29% are collectively owned by groups (Table 3)Table 3. This highlights that most fish farmers choose to conduct their own businesses. In addition, 76% of fish farmers own the land themselves, followed by 14% who occupy family land and 10% who occupy community land. The study also explains the sources of startup support for fish businesses among farmers. A significant majority (86%) of respondents reported self-financing as their primary means of funding throughout their business projects. Alternatively, 10% received assistance from local organisations, while 5% benefited from support provided by non-governmental organisations (NGOs). In Sierra Leone, local organisations, often referred to as local councils, play a vital role in supporting ambitious fish farmers and encouraging the growth of their fish businesses. Furthermore, researchers investigated road access to fish farms. The findings revealed that 43% of the surveyed fish farms were accessible on foot, while 33% and 24% had access through motorbikes and cars, respectively. These insights emphasise the various transportation challenges faced by fish farmers, highlighting the need for improved infrastructure to facilitate easier access to their farms.

Table 3. Operational Leverage characteristics of fish farm in Bo districts.

	Commercial	Semi-commercial	Subsistence	Total	Percentage
Farm Ownership					
Group	2	1	3	6	29%
Individual	3	5	7	15	71%
Land Ownership					
Self	4	6	6	16	76%
Family			3	3	14%
Community	1		1	2	10%
Source of start-up support					
Self-help	4	6	8	18	86%
Local organization	1		1	2	10%
NGOs			1	1	5%
Access to farm					
Walk	1	4	4	9	43%
Motor bike	1	1	5	7	33%
Car	3	1	1	5	24%

4.3 Production Characteristics

In terms of the culture system, 90% of the surveyed fish farms used earthen ponds for fish culture, with the remaining 10% using concrete ponds. This information is detailed in Table 4.

The use of earthen ponds highlights a widespread practice within Sierra Leone's aquaculture sector. Therefore, there is a pressing need for increased awareness and training initiatives among fish farmers to encourage the adoption of more advanced fish farming methods. Moreover, the study revealed that the majority of farmers (52%) cultured both tilapia and catfish, with 33% culturing catfish alone and 14% culturing tilapia solely. These two species are the most commonly cultured in Sierra Leone. Regarding the sources of fingerlings, the majority (38%) purchased them from other fish farms, while 29%, 24%, and 10% obtained fingerlings from government farms, Njala University, and from wild-caught fish, respectively. Although most farmers in Sierra Leone lack access to fish hatcheries, most fish breeding in the country, particularly in subsistence fish farming, occurs naturally in ponds. Therefore, farmers typically keep their brood stock in ponds where they may breed naturally. By doing this, they only collect mature fish during the harvest season and refrain from purchasing fingerlings.

The high cost of purchasing fingerlings from a select few private fish farms prevents subsistence fish farmers from funding their farms. However, because of inbreeding and a lack of scientific breeding and broodfish selection, fish that spawn naturally in ponds produce low yields and poor-quality fingerlings, which is detrimental to the genetic quality of the next generation (WorldFish, 2017). Fingerling production centres are located in Makali and Bo, which supply fingerlings to fish farmers. To increase government input to these stations, fish farmers are required to pay fees in return for fingerlings from these stations. However, these fees are low; therefore, substitute farmers depend mostly on government farms for fingerlings.

Nonetheless, private fish farmers prefer to buy from other fish farmers because they believe other fish hatcheries offer high-quality fingerlings and a guaranteed supply. Our study revealed that the cost of purchasing a single fingerling from a private fish farm in the Bo district was NLe 10 ($0.44). However, government fish farms are free to use; only maintenance expenses are the sole cost.

Notably, domestic waste from kitchens serves as a primary source of feed for many fish farmers, such as rice bran, maize bran, and wheat bran, which are converted into pellets to feed their fish. The study found that 71% of farmers utilised domestic waste as feed, 19% utilised a combination of imported and domestic feed, and 10% depended solely on expensive imported feed. Furthermore, more than half of the respondents (52%) reported knowing the nutritional requirements of the fish they cultured, while 48% had no knowledge, indicating a degree of understanding among farmers regarding optimal feeding practices. The study also investigated the use of manure and fertilisers by fish farmers. The results showed that 71% of farmers acknowledged using manure or fertiliser in their ponds, while the remaining 29% did not utilise manure. This finding emphasises the various practices utilised by fish farmers to manage their aquaculture fish farms. However, pond productivity increases through the use of manure and fertiliser nitrogen, phosphorus, and potassium (NPK).

Table 4. Production Characteristics between fish farmers in Bo Districts.

	Commercial	**Semi-commercial**	**Subsistence**	**Total**	**Percentage**
Culture System					
Earthen Pond	5	4	10	19	90%
Concrete Pond		2		2	10%
Species Cultured					
Catfish	2	4	1	7	33%
Tilapia		1	2	3	14%
Tilapia and Catfish	3	1	7	11	52%
Fingerling source					
Government			6	6	29%
Njala University	2	3		5	24%
Other fish farms	3	3	2	8	38%
Wild			2	2	10%
Feed Type					
Domestic	2	3	10	15	71%
Imported		2		2	10%
Both	3	1		4	19%
Knowledge of nutritional requirements					
Yes	4	4	3	11	52%
No	1	2	7	10	48%
Manure and fertilizer use					
Yes	5	3	7	15	71%
No		3	3	6	29%

Aquaculture is considered one of the major food production sectors affected by climate change. From the study results, five farmers reported a limited water supply and pond drying, which can also be associated with the increasing temperature reported by three of the farmers. However, three farmers reported flooding incidences, which could also have led to the intrusion of the ponds by the alien species of catfish, as mentioned by four farmers. Another major environmental concern raised by five farmers was the prevalence of persistent weeds; only one farmer reported interference from animals such as birds and reptiles. The majority (n = 14) of the farmers utilised wastewater from pond pipes as manure to grow vegetables and plants. Only three farmers reported discharging waste into the environment, and the rest did not provide any responses. This calls for the implementation of a waste management plan for the aquaculture sector to expand and train farmers on environmentally safe practices and the utilisation of water and nutrients.

4.4 Profitability and capacity of the fish farms

The results revealed that commercial fish farmers had the highest average number of fingerlings stocked (average 21,800), followed by semi-commercial fish (7,633), while subsistence farms had the least number of fingerlings (Table 5). Table 5 shows that commercial fish farmers invest more in their businesses than semi-commercial and subsistence farmers. In terms of the average production cycle, it was discovered that most commercial and subsistence fish farmers grow their fish for seven months, while semi-commercial fish farmers have a period of six months, which means they harvest their fish twice a year. The results revealed that commercial fish farms had the highest average size of fishponds (255 m2), followed by subsistence farms with 167 m2, and semi-commercial farms with 118 m2 ponds.

Table 5. Profitability and capacity of the fish farm

	Commercial	**Semi-commercial**	**Subsistence**	**Grand Total**
Average number of fingerlings stocked	21,800	7,633	1,640	8,152
Average production cycle (months)	7	6	7	7
Average Size of pond (m2)	255	118	167	174
Total no. of ponds	48	30	41	119
No. of ponds in use	35	21	32	88
Pond utilization rate (%)	73%	70%	78%	74%
Average Annual Production in kg	2,480	1167	0	1988
Average Yearly Revenue (Nle)	252,000	95667	0	993,375
Average price per kg (Nle)	96	92	0	94
Average number of workers	8.2	2.8	0	5.27

The research showed that in Bo district, commercial fish farms had the highest number of fishponds (48), followed by subsistence (41), and semi-commercial (30). However, subsistence farmers had the highest utilisation rate (78%), while semi-commercial farmers had the lowest (70%). Overall, the pond utilisation rate of the farms was 74%, which indicates that there is potential for further growth. According to the FAO (2004) assessment, there were 541 active fishponds and 117 inactive ponds in the Tonkolili district (FAO, 2024). As stated by Dabo et al. (2009), there were 277 ponds in the Bo district, of which 143 were in active production. In the Tonkolili District alone, WorldFish identified 2,056 active fishponds out of 2,590 ponds across the country. However, according to the WorldFish Aquaculture Assessment Report (2016), only 13% of the ponds in the Tonkolili district are currently in use; the remaining ponds either produce irregularly or have been abandoned. Farmers have noted that this is mostly due to a lack of funding and maintenance. In terms of pond utilisation, commercial fish farms (73%)

and semi-commercial fish farms (70%) utilised more ponds than subsistence, which had the highest utilisation percentage (78%). Field experience indicated that most of the ponds constructed by the FAO, NGOs, some international organisations, and the government have been abandoned.

Commercial fish farmers reported the highest average annual production, which was 2,480 kg (2.48 metric tons), compared to that of semi-commercial fish farmers, which was 1,167 kg (1.167 metric tons). This simply shows that commercial fish farms produce more fish during the year than semi-commercial fish farms. In this case, subsistence fish farmers were asked about their annual production, but it was later discovered that they had no records of fish farming activities and that they only produced fish for their families. According to the Food and Agriculture Organization (FAO) 2001 annual statistics bulletin, the total production of Nile tilapia (*Oreochromis niloticus*) was estimated to be 30 metric tons (30, 000 kg) nationwide (FAO, 2024). This demonstrates that aquaculture has been growing gradually over the years but advancing at a relatively slow pace compared to world aquaculture production.

The revenue from the commercial fish farm was higher (NLe 252,000; $11,195) compared to semi-commercial, which is Nle95,667 ($4,250). This is because commercial fish farms employ more workers, use more feed, and use manure and general maintenance of the pond, and are more productive than semi-commercial farms.

Commercial fish farmers sell at higher prices per kg (NLe96; $4.26) than semi-commercial (NLe92) ($4.09). The research discovered that most commercial fish farmers sell their products frozen or fresh in hotels at generally higher prices. Nevertheless, they are still at a loss considering the expenses they incurred by employing more workers and spending too much on fish feed. Low production quantities of farmed fish were hardly available in the local market. According to WorldFish (2017), the cost of farmed tilapia in the Tonkolili area ranges from Le 10,000 ($0.44) to Le 7,000 ($0.31) per kg, depending on the size. When this study was conducted in 2017, the currency used in Sierra Leone was called Leones. However, three zeros were removed from the currency, and it is now known as New Leones (NLe). This indicates that the cost of farmed fish has increased in the present.

The average number of workers was higher in commercial (8.2) fish farms than in semi-commercial fish farms (2.8). This is simply because commercial fish farms employ more labour than semi-commercial fish farms, which engage both household unpaid labour and paid labour, while all workers on commercial farms are paid.

Figure 3 shows that semi-commercial farms make more profit (25%–49%) than commercial fish farms, with profits below 25%, and zero profit; only one commercial fish farm is reported to have made a profit of 25%–49%. This is probably because semi-commercial farms have longer years of experience in fish farming and employ fewer workers than commercial fish farmers. This indicates that in the fish farming business, the longer you stay in the business, the better the knowledge of management, which can eventually lead to profit. Semi-commercial farmers are all experienced, having 10 years of experience or more. Commercial farms mostly have less than five years of experience, and only one has 10 years of experience. Studies have established that the profitability of farms increases with their years of experience (Olagunju et. al, 2022, 2024). El-Sayed (2013) and Hassan & New (2013) found that to guarantee profitability, farmers must be able to get high-quality feed at reasonable costs and maximize feed by implementing suitable on-farm feed management practices. It was discovered that some fish farmers lack a basic understanding of the nutritional requirements of fish and are unaware of the quality of the feed they could produce. Cheng et al. (2010) added that in commercial aquaculture, the cost of fish feed can account for over 50% of overall production costs, with protein being the most expensive component. The best source of protein in Sierra Leone is fish meal, which is mostly made from the leftover parts of fish, such as the head and skin, which are crushed and combined with other ingredients to make fish feed. Although many varieties of fish are used, bonga (*Ethmalosa fimbriata*) and herring (*Sardinella spp*) fish are the most common. These fish are among the least expensive sources of protein for the underprivileged and have been used as food by humans. The need for bonga and herring as human sustenance has grown as a result of the nation's growing population. As a result, it is less accessible and economical as a source of animal feed. When these fish remnants were first discovered, local fish farmers in coastal marine communities sold them to aquaculture fish farmers because they understood the worth of it. Previously, people would discard these fish remains in the trash as waste. It is advised that fish farmers receive training so they may become knowledgeable about the composition of fish feed and the general nutritional needs of the fish they are targeting.

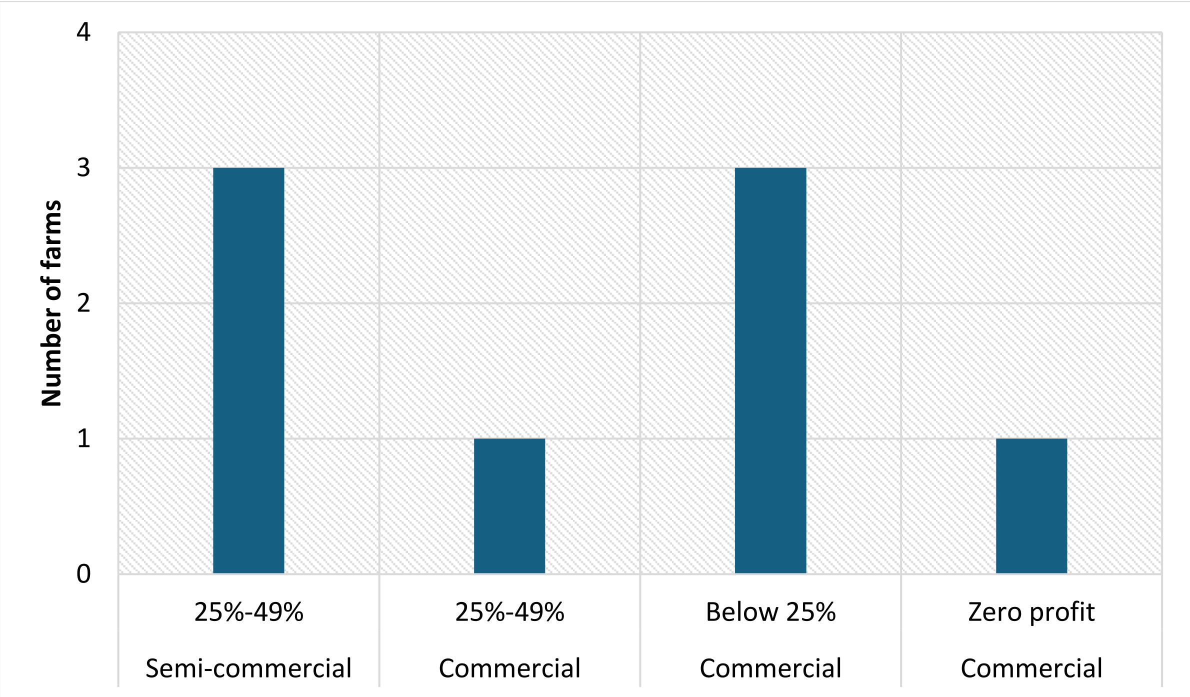

Figure 3. Profit ranges among commercial and semi-commercial fish farmers in Bo.

4.5 Strengths Weakness Opportunities and Threats (SWOT)

SWOT analysis is a method used to evaluate the opportunities, threats, weaknesses, and strengths of a project or development initiative. It comprises establishing the goal of the project and identifying the environmental factors, both internal and external, that could assist or prevent its achievement (Suh & Emtage, 2005). Local farmers provided information on all the strengths and weaknesses that they were facing in their farms at the time of the assessment, which enabled us to conduct a SWOT analysis. This was achieved by administering a questionnaire from farm to farm (
Table 6). The study identified the strengths of fish farmers and determined how these strengths can be increased to capitalise on opportunities or overcome their weaknesses. In addition, the study recommends strategies to further enhance and influence these strengths to gain a competitive advantage. Recognising areas of weakness or limitations among fish farmers, such as resource constraints, skills gaps, or technical know-how.

Table 6. SWOT analysis table for aquaculture development in Bo district.

Strengths	**Weaknesses**
➢ Sources of livelihood for many people substantially contribute to food security through high yields, sources of high-quality protein, and healthy diets. ➢ Fishponds serve as water storage for agriculture, aquaponics. ➢ Land availability.	➢ Limited feed production machinery and lack of quality feed /floating feed ➢ Lack of advanced tools and equipment ➢ Lack of quality fish breed ➢ Limited availability of hatcheries and limited quantity and quality seed production ➢ Poor road network, especially leading to fish farms and difficulties to reach the marketplaces. ➢ Poor infrastructure. ➢ Limited access to power (electricity) ➢ Lack of advanced technology to control disease outbreaks. ➢ Low-fish quality assurance and limited storage facilities ➢ Limited established market system ➢ Disturbing natural environment ➢ Local perception of fish farmers about the growth of fish due to marine capture fisheries ➢ More focus is on marine capture fisheries than farmed fish. ➢ Lack of incentives ➢ Lack of knowledge and awareness ➢ Availability and utilization of raw materials to produce fish feed. ➢ Inappropriate policies and lack of capital.
Opportunities	**Threats**
➢ Availability of water throughout the year in swamps, streams ➢ Raw material to produce fish feed. ➢ Excellent sites to construct a fish farm. ➢ Cheap employment/availability cheap labour ➢ Supply of fresh fish to the market. Market opportunities both local and for export. ➢ Good environmental conditions with no pollution from industries ➢ Improved organizational structure (central to local government). Responsive policy and environment for investors ➢ Open to new technology (opportunity for intensive systems) e.g., cages. Moving fingerling production towards closed and recirculating systems. ➢ Cooperative fingerling production from genetically selected broodfish. Breeding program (subsidized by government) ➢ Change of eating habits (preference for fish over red meat) ➢ Decline of fish production from the wild especially from marine capture fisheries	➢ Persistence of weeds, Sewage disposal and pollution. ➢ flooding /damages. ➢ Predators ➢ High temperature ➢ Environment constraints (climate change) e.g. droughts ➢ Market competition due to the high importation of fish ➢ Escaped fish can drive out wild populations.

5. RECOMMENDATIONS

- Employing more extension/field technicians: Increasing the number of extension and field technicians specialising in aquaculture will enhance support services and information dissemination, thereby promoting sustainable growth in the fish farming industry. These specialists will work directly with fish farmers on their farms, offering training on pond management, sustainable aquaculture techniques, fish health, feed management, and water quality control. They will help farmers achieve their goals and enhance their production systems by offering technical advice, on-site assistance, and training sessions. More extension/field technicians are needed to support the growing number of fish farmers as the aquaculture industry expands to fulfil the rising demand for seafood.
- Enhance the technical capabilities of technicians and fish farmers in the country: Supporting the technical knowledge of fish farmers and technicians in the nation is crucial for developing sustainable aquaculture methods and encouraging resilience and innovation in the sector.
- Introduction of intensive culture practices in tanks and cages and improvement of overall productivity: The implementation of intensive culture techniques in tanks and cages has the potential to significantly increase aquaculture production through optimisation of space usage, environment, feeding efficiency, and waste management measures.
- Establishing more aquaculture stations in all districts across the country: In terms of supporting rural lives, national food security, and economic development goals, adding additional aquaculture stations to every district in the country may promote the expansion and sustainability of the aquaculture business.
- Encouraging private sector involvement in aquaculture: This suggests that government policy, infrastructure development, aquaculture research, international market access, capacity building, risk management, and environmental sustainability may all be supported by the private sector. With the help of this private sector support network, aquaculture is expected to grow in Bo district.
- Organize fish farming groups and enhance support for them throughout the country: Governments, development agencies, and civil society organizations may empower subsistence fish farmers, enhance their standard of living, and assist the sustainable growth of the aquaculture industry in Bo district by forming fish farming groups and strengthening support for them.
- Establish quality fish feed mills for quality fish feed production: The establishment of high-quality fish feed factories is essential for the expansion and sustainability of the aquaculture sector. High-quality feed is important to optimise fish development, health, and overall production efficiency.
- Enhance collaboration with donor partners: Governments can address major issues, promote innovation, and accomplish sustainable development objectives in the aquaculture industry by collaborating more closely with donor partners. This allows governments to take advantage of international resources and knowledge. To fully reap the rewards of donor funding and promote constructive change in aquaculture, partnerships based on mutual respect, similar goals, and open communication are important.
- Monitoring, evaluation, and facilitating knowledge sharing and learning platforms to strengthen stakeholder coordination, collaboration, and understanding of aquaculture.

6. CONCLUSION

The aquaculture sector has grown slowly, even after it was established in the Bo district in 1977. Fish farming is practiced as a backyard or subsistence activity. The research revealed that the prospects for semi-commercial and commercial aquaculture remain slow. It is well known that aquaculture has the potential to provide underprivileged rural communities and future generations with much-needed jobs, food security, and family income. Against this backdrop, aquaculture has been prioritised in the country by the MFMA, FAO, NGOs, and other international organisations to increase its growth to international standards. Subsistence fish farmers interested in fish farming businesses lack the resources or know-how to engage in semi-commercial or commercial fishpond culture. Promoting private sector investment in the aquaculture production system at all levels should be the main goal. This strategy aims to provide young people involved in fish farming with firsthand experience of the profitability of the business.

It has been shown that there are potential and good environments for both local and foreign investors to develop aquaculture in the Bo district, such as abundant freshwater resources that are suitable for aquaculture practices. Additionally, there is great potential for establishing fish feed factories and a global market investment. The country can benefit more through aquaculture in terms of food security and the economy if more effort is put into it. It is necessary to address challenges such as poor production of high-quality fingerlings, poor fish feed quality, and a lack of expertise in farm management. It is important to educate aquaculture farmers nationwide about best practices in fish farming so that they can boost productivity and profitability while maintaining food security and supplying families with highly nutritious food. The study identified the strengths of fish farmers and determined how these strengths can be increased to capitalise on opportunities or overcome their weaknesses. In addition, the study recommends strategies to further enhance and influence these strengths to gain a competitive advantage. The study also recognises areas of weakness or limitations among fish farmers, such as resource constraints, skills gaps, or technical know-how.

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8. REFERENCES

Adedeji, O. B. (2011). Constraint to aquaculture development in Nigeria and way forward. *Journal of Applied Sciences Research*, 7(7), 1133–1140.

Adeleke, B., Robertson, A., & Moodley, G. (2020). Aquaculture in Africa: A Comparative Review of Egypt, Nigeria, and Uganda Vis-À-Vis South Africa. Reviews in Fisheries Science & Aquaculture, 1-31. *Fisheries and Aquaculture*, 1-3.

Adewumi, A. A. (2015). Aquaculture in Nigeria : Sustainability issues and challenges. *Direct Research Journal of Agriculture and Food Science*, 3(12), 223–231.

Agboola, O., Yossa, R., & Verreth, J. (2019). *Assessment of existing and potential feed resources for improving aquaculture production in selected Asian and African countries. Penang, Malaysia.* Malaysia.: Penang.

Baio, A., & Sei, S. (2017). *Management Plan for Small Pelagic, Shrimp and Demersal Fish Resources of Sierra Leone; Institute of Marine Biology and Oceanography.* Freetown, Sierra Leone: Institute of Marine Biology and Oceanography.

Bamba, V. (2004). *Report of the mission on sustainable aquaculture development in Sierra Leone. FAO Consultancy Report. .*

Belhabib, D., Sumaila, U., & Le Billon, P. (2019). The fisheries of Africa: exploitation, policy, and maritime security trends. *Marine Policy*, 101 80–92.

Bondad-Reantaso, M. (2007). *Assessment of freshwater fish seed resources for sustainable aquaculture.* Rome: FAO Fisheries Technical Paper. Food and Agriculture Organization of the United Nations.

Brummett, R. E. (2007). Freshwater fish seed resources and supply: Africa regional synthesis. In M.G. Bondad-Reantaso (ed.) Assessment of freshwater fish seed resources for sustainable aquaculture. *FAO Fisheries Technical Paper. Rome: Food and Food and Agriculture Organization of the United Nation*, 505.

CGIAR. (2019). *Sierra Leone Fisheries.* WorldFish.

Cheng Z., Qinghui A., Kangsen M., Wei X., Hongming. (2010). Effects of dietary canola meal on growth performance, digestion and metabolism of Japanese seabass, Lateolabrax japonicus. *Aquaculture*, 305(1–4): 102-108.

Dabo, K., Sei, S., Mamie, J., Kamara, S., Mansaray, M., Bundu, A., & Kamara, P. (2009). *Aquaculture baseline survey report. Ministry of Fisheries and Marine Resources. Sierra Leone: MFMR.* Sierra Leone Freetown: Ministry of Fisheries and Marine Resources.

Dempsey, C. (2014). *Sierra Leone Geography Geography, climate, and population of Sierra Leone.* Freetown: Food and Agricultural Organization.

El-Sayed, A. (2017). *Regional Review on status and trends in aquaculture development in the near east and North Africa , FAO Fisheries and Aquaculture Circular No. 1088. (Vol. 6).* Rome: Food and Agriculture Organization of the United Nations.

El-Sayed, A.-F. (2013). *On-farm feed management practices for Nile tilapia (Oreochromis niloticus).* Egypt Rome: Food and Agricultural Organization of the United Nations.

FAO. (1992). *Publications related to aquaculture for Sierra Leone ABCO. Agricultural Master Plan in Sierra Leone.* Rome: FAO.

FAO. (2005). *Geography, climate and population of Sierra Leone.* Rome: Food and Agricultural Organization.

FAO. (2008). Food and Agricultural Organization The Republic of Sierra Leone fishery country profile. Freetown.

FAO. (2016). *The State of the World Fisheries and Aquaculture.* Rome: Food and Agriculture Organization of the United Nations.

FAO. (2019). *Development Policies, nd. 〈http:// www.fao.org/3/v4762e06.htm〉. (Accessed 16 June 2019).* Rome: Food and Agriculture Organization.

FAO. (2021). *Fishery Statistical Collections, Food and Agriculture Organization.* Rome: Food and Agriculture Organization.

FAO. (2023). *Aquaculture growth potential in Sierra Leone. WAPI factsheet to facilitate evidence-based policymaking and sector management in aquaculture.* Rome: Food and Agricultural Organization of the United Nations.

FAO. (2024). *Sierra Leone. Text by Sheriff, M.F. in close collaboration with the Statistics Unit of the Ministry of Fisheries and Marine Resources.. In: Fisheries and Aquaculture.* Rome.: FAO https://www.fao.org/fishery/en/count.

Finch, R. (2016). *The Evil Empire- How the Common Fisheries Policy is Recolonising the Third World.*

Government of Sierra Leone. (1992). *Agricultural Sector Master Plan*. Sierra Leone: Author.

Hasimuna, O., Maulu, S., Monde, C., & Mweemba, M. (2019). Cage aquaculture production in Zambia: Assessment of opportunities and challenges on Lake Kariba, Siavonga district. *Egyptian Journal of Aquatic Research*, 45(3), 281–285.

Hassan, R., & New, B. (2013). *On-farm feeding and feed management in aquaculture. Fisheries and Aquaculture Technical Paper No. 583.* Rome: Food and Agricultural Organization of the United Nations.

Hassan, R., Hecht, T., De Silva, S., & Tacon. (2007). *Study and Analyses of Feed and Fertilizers for Sustainable Aquaculture Development.* Rome: Food and Agriculture Organization of the United Nations.

Hinrichsen, E., and Walakira, J. K., Langi, S., ibrahim, N. A., Tarus, V., Badmus, O., & Baumüller, H. (2022). *Prospects for aquaculture development in Africa: A review of past performance to assess future potential, ZEF Working Paper.* Bonn: University of Bonn, Center for Development Research.

Kajungiro, R., Mapenzi, L., Nyinondi, C., Haldén, A., Mmochi, A., Chacha, M., & Jan De Koning, D. (2019). The Need of a Structured Tilapia Breeding Program in Tanzania to Enhance Aquaculture Production: A Review. *Tanzania Journal of Science*, 45(3), 355–371.

Kassam, L., Lakoh, K., Longley, C., Phillips, M., & Siriwardena, S. (2017). *Sierra Leone Fish Value Chain Analysis with Special Emphasis on Tonkolili District, Program Report, WorldFish,.* Penang, Malaysia: World Fish.

Murray, F., Hoepfl, J., Sankoh, S., & Wadsworth, R. (2019). *Alternative Livelihood Opportunities for Marine Protected Areas Fisherwomen.*

Musinguzi, L., Lugya, Rwezawula, J., Rwezawula, P., & Kamya, A. (2019). Musinguzi, L., Lugya, J., Rwezawula, P., Kamya, A., Nuwahereza, C., Halafo, J., ... The extent of cage aquaculture, adherence to best practices and reflections for sustainable aquaculture on African inland waters. *Great Lakes Research*, 45(6) 1340-1347.

Mustapha, A. (2020). Improving the quality of aquafeed for an effective food security in small scale African aquaculture. . *World Journal of Advanced Research and Reviews,*, 7(3), 274–282.

Neiland, A., Cunningham, S., Arbuckle, M., Baio, A., Bostock, T., Coulibaly, D., Sei, S. (2016). Assessing the potential contribution of fisheries to economic development: The case of post-ebola Sierra Leone Natural Resources. *Research Gate*, 7:356–76.

Ogbuafor, N. O., Gray, T., & Stead, S. (2018). Consultancies in Sierra Leone's coastal fisheries: a critique,. *Marine Policy*.

Ogbuafor, N. O., Gray, T., & Stead, S. (2019). Is there a 'Wicked Problem' of small-scale coastal fisheries in Sierra Leone? *Marine Policy*, marpol.2019.02.043.

Ogbuafor, O., & Gray, T. (2021). Is Community-based Management of Small-scale Fisheries in Sierra Leone the Answer to their Problems. *World Development, Perspectives*, 21, 1–8.

Olagunju, O. F., Kristófersson, D., Tómasson, T., & Kristjánsson, T. (2022). Profitability assessment of catfish farming in the Federal Capital Territory of Nigeria. *Aquaculture*, 555, 738192.

Olagunju, O. F., Kristofersson, D., Tomasson, T., & Kristjánsson, T. (2024). Farm strategies and characteristics influencing profitability in Nigerian catfish aquaculture: Lessons on resilience during economic crisis and COVID-type shock. *World Aquaculture Society Wiley*, e13058.

Rahman, S. A. (2008). Women's involvement in agriculture in northern and southern Kaduna State, Nigeria. *Journal of Gender Studies*, 17(1), 17-26.

Samba, S. (2019). *Sierra Leone Produces 150 tons of fish. Glogal Times.*

Sankoh, S., Teoh, S., Phillips, M., & Siriwardena, S. (2018). *Sierra Leone Aquaculture Assessment with Special Reference to Tonkolili and Bombali.* Penang, Malaysia: World Fish.

Sankoh, S., Wadsworth,, R., & Rana, K. (2009). *Fish Market in Sierra Leone.* Freetown.

Satia, P. (2017). *Regional review on status and trends in aquaculture development in Sub-Saharan Africa - 2010. Rome: Food and Agriculture Organization of the United Nations. .*

Shaalan, M., El-Mahdy, M., Saleh, M., & El-Matbouli. (2018). Aquaculture in Egypt: insights on the current trends and future perspectives for sustainable development.. *Rev Fish Sci Aquacult*, 26(1):99– 110.

Statistics Sierra Leone. (2021). *Population and Housing census: Summary of Final results. Freetown.* Freetown: Statistics Sierra Leone.

Suh, J., & Emtage, N. (2005). Identification Of Strengths, Weaknesses, Opportunities And Threats Of The Community-Based Forest Management Program Annals of Tropical Research. *CABI Digital Library*, Vol. 27, No. 1, 55-66 ref. 15.

Sumanaa, S. L., Tarawallie, S., & Normanc, P. E. (2023). Challenges in Developing Aquaculture for Livelihood Enhancement in Bo City, Southern Sierra Leone. *International Journal of Fisheries and Aquaculture Research*, Vol.9, No.1, pp.1-13.

Thorpe, A., Whitmarsh, D., Ndomahina, E., & Baio, A. (2009). Fisheries and failing states: the case of Sierra Leone. *Marine Policy*, 513 33 393–400.

Udo, I. U., & Dickson, B. F. (2017). *The Nigerian aqua-feed industry: Potentials for commercial feed production*. Nigerian Journal of Fisheries and Aquaculture, 5(2), 86–95.

Waite, R., Beveridge, M., Castine, S., & Chaiyawan. (2014). *Improving Productivity and Environmental Performance of Aquaculture.* Washington D.C.: World Resources Institute.

Wally, A., Akingbe, O. O., & Kurt, S. (2022). *An Overview of the Aquaculture Industry in Egypt.* Egypt Cairo: Gain Global Agricultural Information Network.

WorldFish (2017). *Feed the Future Sierra Leone Scaling up Aquaculture Production (SAP).* Penang, Malaysia:: WorldFish. Factsheet:.

WorldFish (2016.). *Feed the Future Sierra Leone Scaling Up Aquaculture Project: Implementation Strategies and Management. Working Document. Penang, WorldFish.*

WorldFish Aquaculture Assessment Report. (2016). *Report of the aquaculture assessment studies for Tonkolili and Bombali district. WorldFish.* unpublished .

9. APPENDICES

Appendix 1

STRUCTURED QUESTIONNAIRE

Objective

This questionnaire is designed to gather information on the status of aquaculture development in Sierra Leone, with a specific focus on the activities undertaken by fish farmers in the Bo district.

SECTION 1. PRODUCTION RELATED QUESTIONS

Farm Information

1. What type of fish farming do you practice? a) subsistence (b) semi-commercial (c) commercial.
2. Are you registered with the Ministry of Fisheries and Marine Resources? a) Yes b) No
3. How long have you been practising fish farming? a) one month c) 6 months c) one year and above.
4. What type of cultural system do you practice? a) Earthen Pond b) Concrete Ponds c) Plastic Pond d) Aquaculture Recirculatory System (RAS).
5. What species of fish do you culture? ....
6. Number of ponds owed……………………………. …….Area(s) (m^2) ……………
7. No. of ponds in production……………. No. of ponds not in production…………….
8. Why is/ are the pond(s) not in use..
9. Do you have any knowledge of pond construction? a) yes, b) no
10. Do you have plans to continue fish farming? a) Yes b) No
11. What are your sources of fingerlings/broodstock? a) Njala University b) Makali out station c) Bo out station d) Wild e) Other fish farms …………………………. (please specify)
12. Do you practice fish farming alongside other agricultural activities? Yes….no…
13. Do you use manure or fertiliser in your fish farm? a) Yes b) no
14. If yes which type and cost…………………….
15. What is the average stocking density of fish on your farm?
16. Please give the average size of your fingerling stocked…………….
17. What type of feed do you feed the fish? A) Imported b) Domestic c) both
18. Where do you get the fish feed from? a) Self-made, b) bought, c) donation.

19. If self-made feed, where do you obtain the raw materials?
20. What is the current price of fish feed? Please provide both the unit cost of feed and the total yearly cost.
21. How many times a day do you feed the fish? A) once in the morning or evening b) two times c) three times d) four and above
22. What do you do with the fish? a) Home consumption c) sale c) both
23. How do you sell? a) By weight……… b) By pile……… c) Others (specify) d) by bucket please give answers in kg
24. Cost of fish sold?
25. Are you producing for yourself or producing for commercial use? a) yes b) no
26. Where do you sell your farmed fish? a) local market b) exports.
27. How accessible is the road from the farm to the market? a) walk b) cars c) motorbikes
28. What is your source/source of water a) stream b) borehole c) tap water
29. Is water available throughout the year? Yes/No……………………………………
30. How is the quality of water in your fishpond a) good b) average c) bad.
31. Have you tested the quality of water in your fishpond? a) yes b) no
32. If yes, how often do you check the water quality in your fishpond and by what means …………………………………………….
33. Who owns the land? a) the government, b) self, c) family, d) community, or e) others.
34. Do you have any other livelihood activities besides fish farming? a) Yes b) No
35. How many times do you harvest per year? a) once b) two c) three and above.
36. What is your average harvest? a) Buckets in kg b) c) others (specify)…………………………………
37. Select the main product form in which you sell your fish a) Live or fresh b) Frozen c) smoked d) Other product form

SECTION 2. SWOT RELATED QUESTIONS

38. What are the main challenges you face in managing your fish farm?
39. What do you see as the main strengths and opportunities in your fish farm?
40. Have you got any knowledge or training in Aquaculture Fisheries Management?
    a) Yes b) No

41. If yes, where? a) Seminar b) workshop c) school d) Social media e) other specifier……………………………………………….
42. How do you manage waste and ensure environmental sustainability in your fish farm?
43. How long do you grow the fish to marketable size?
44. What is your annual income?..
45. What are your annual costs?..
46. Do you make a profit?
47. How would you describe the profit margin?

    a) Zero profit b) 25% c) 50% d) 100%
48. Did you receive any assistance when starting your fish farm? a) Ministry of Fisheries and Marine Resources b) NGOs c) FAO d) local organisation e) other international organisations.

Climate and Environment

49. Which climate and environmental factors are affecting your pond
    a. Flooding
    b. Sewage and plastics
    c. Persistent weeds
    d. Alien species of catfish or any other fish (please indicate)
    e. High temperature
    f. Limited water supply and pond dry off.
    g. Others

SECTION 3. SOCIOECONOMIC AND OTHER INFORMATION

Basic information about farm owners and farm Managers

Date………..…

District……………………Chiefdom…………………Town/Village……………

GPS………………. Fish farm name……………………………………...

50 Name of fish Farm owner……………………………………………….

51 Name of farm manager?..

52 Who owns the farm? a) Individual b) Group

53 Sex a) male b) female c) others

54 What is the farm owner’s level of education?

a. None
b. Primary
c. Secondary
d. Diploma
e. Degree and above
f. Other, specify……………………………….

55 What is the farm manager's level of education? a. None, b. Primary, c. Secondary, d. Diploma, e. Degree and above, f. others specifier……………………
56 Did you employ workers at your farm? a) yes b) no
57 Total number of workers?
58 Do the workers have other responsibilities apart from the fish farm?
59 How can we best describe the nature of labor? a) Household/ family labor (unpaid) b) Household/family labor (paid) c) External individuals/ labor(paid) d) Combination of all.
60 Age range a) <= 30 b) 31-40 c) 41-50 d) 51-60 d)> 60

10. Appendix 2

Photos of the study site.

Abandoned fish farm.

Earthen Ponds

Using rice bran as fish feed

Poor road network leading to fish farms

Concrete ponds

Newly Constructed semi-commercial Earthen Pond

Earthen fishpond constructed by NGOs FAO that was abandoned

A fish feed company that was found in Bo District during research

Newly constructed hatchery

Newly harvested fish in a subsistence fish farm

 

Harvesting at a subsistence fish farm