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Impact of the coronavirus pandemic on the aquaculture industry in Sunyani Municipality, Ghana

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Abstract

The coronavirus pandemic has substantially influenced the aquaculture industry in Ghana, particularly the socioeconomic situation of fish producers. The primary goal of this study was to assess the influence of COVID-19 on pond aquaculture in the Sunyani municipality, Ghana. To address this, the study used purposive and random sampling techniques to administer a semi-structured questionnaire to fifty (50) fish farmers. According to the survey, most respondents reported that the COVID-19 pandemic impacted pond aquaculture productivity, products, and farm operations. According to the respondents, the impact on pond aquaculture production was caused by the high cost of fingerlings, fish feed, and table-sized farmed fishes, as well as a scarcity of fingerlings, fish feed, and pharmaceutical supplies like lime. To avoid the pandemic's long-term damage, it is recommended that fish farmers should purchase pond aquaculture materials in bulk, including feed and pharmaceuticals.

1. Introduction

Aquaculture is a rapidly growing food sector that plays a significant role in meeting global food demand and enhancing food security. It is predicted to expand even more in the coming years (Ahmed, 2022; Fiorella et al., 2021). Aquaculture is crucial in providing sustained aquatic food production to inland communities in Sub-Saharan Africa, including Ghana. Aquaculture production in Ghana has increased dramatically, from 52,120 metric tonnes in 2019 to 162,000 in 2023 (MOFAD, 2024). Ghana is the second-largest farmed fish producer in Sub-Saharan Africa (SSA), after Egypt, with an annual growth rate of 28% between 2006 and 2019. Large-scale cage farming accounts for a significant share of Ghana's aquaculture growth, while pond aquaculture receives less attention in terms of research and logistics (Ragasa et al., 2021).

In Ghana, pond aquaculture has traditionally been vast and uses few external inputs. Despite its limitations, pond aquaculture has stronger backward and forward linkages and a more significant multiplier effect on local economic growth and poverty alleviation (Kassam & Dorward, 2017). Pond aquaculture activities are highly vulnerable to COVID-19 services, including reduced farmed fish consumption rates, productivity levels, and farm operations (Giannakis et al., 2020). Disruptions in feed access are substantially damaging to fish farming, resulting in high fish mortality and low production due to insufficient feed availability and timing (Ragasa et al., 2022). Furthermore, distractions in transportation services and the cold chain of highly perishable inputs like fingerlings reduce pond farming production (Loison et al., 2021).

Several studies have been undertaken on the influence of COVID-19 on coastal fisheries (e.g., Owusu et al., 2022; Rouille, 2022), large-scale aquaculture (e.g., Ragasa et al., 2022; Ragasa et al., 2021), and inland fisheries

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(e.g., Setufe et al., 2022; Ukasha et al., 2022; Alhassan et al., 2020). Nonetheless, there are few studies on the impact of COVID-19 on pond aquaculture in Ghana. The lack of such critical resources hinders aquaculture farm production in Ghana, particularly in the face of unforeseen challenges. Furthermore, diminished aquaculture productivity impacts food security in dependent populations and may lead to the collapse of aquaculture-related livelihoods. The study aimed to investigate the effects of COVID-19 on pond aquaculture production, products, and farm operations. The findings from the study will give valuable information for developing adaptable and resilient strategies. These measures will protect small-scale fish farmers in Ghana against economic shocks caused by unanticipated uncertainty in the future.

2. Literature review

2.1. Aquaculture in Ghana

Aquaculture can also be defined as the breeding, growing, and harvesting of fish and other aquatic plants, also known as farming in water. Diverse aquaculture practices result from human-environment interactions, as people have created aquaculture by controlling freshwater, brackish water, and marine environments. Aquatic environments serve as a valuable source of sustenance and commercial goods that enhance healthier ecological habitats. Furthermore, such resources are often utilized to restore populations belonging to endangered aquatic species. Ghana's landscape is full of a myriad of water bodies, including rivers, seas, dams, and dugouts, which collectively facilitate the practice of aquaculture throughout the country.

Furthermore, the nation benefits from favorable ecological and institutional conditions characterized by well-suited topography, climate, and robust governmental support. The abundant and resourceful human capital, the vast availability of natural aquatic resources, and the strong consumer demand for fish further enhance Ghana's prospects for successful aquaculture (Amenyogbe et al., 2018). Notably, the global aquaculture industry has seen remarkable advancements in increased fish production, driven by a surge in fish and fish product demand. Similarly, the aquaculture sector in Ghana has experienced significant progress in recent times, owing to the generous support provided by the government and the World Bank-funded fisheries program through the Ministry of Fisheries and Aquaculture Development (MOFAD). Ghana's venture into aquaculture began with establishing a colonial administration under British leadership in 1953.

The initial ponds constructed served as hatcheries aimed at promoting the development of culture-based fisheries, cultivating the national appetite for fish, and improving livelihood opportunities. After gaining independence in 1957, the government adopted a policy to establish fishponds in all irrigation systems throughout the country, particularly emphasizing the northern region (Amenyogbe et al., 2018). 5% of the state-owned irrigated schemes in the country have been designated for development into fish farms, and this policy remains in effect. Since 1970, the aquaculture sector has witnessed substantial growth, with an average annual rate of around 9%. This impressive progress has encouraged policy planners across various governments in the nation to prioritize aquaculture development.

At present, it is worth noting that the Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*), and African arowana (*Heterotis niloticus*) are the most prevalent cultured fish species in Ghana. It is important to note that Ghana has no primary marine culture due to a lack of technology, expertise, and cultural issues, such as misunderstandings over land ownership and the absence of proper policies, among other factors. The Government has recognized the considerable potential of the aquaculture industry in improving the economy, especially in light of the continued decrease in marine and inland fisheries production. This sub-sector is predominantly characterized by non-commercial systems, namely extensive, small-scale, and subsistence practices, frequently utilizing earthen ponds. Tilapia species account for 80% of yields, whereas catfish represent the remaining proportion.

Notably, in recent times, commercial initiatives in cage production have surfaced, which have positively impacted production and employment opportunities for the aquaculture sector. Despite facing several management and production problems challenges, the aquaculture sector has experienced significant growth. However, it is imperative to address the limited knowledge of modern aquaculture techniques, inadequate supplies of improved seed, lack of continuing aquaculture policy direction, and insufficient funding for research. Despite these challenges, the aquaculture industry in Ghana still holds tremendous potential. There are fantastic opportunities for producing live fish food, marine fish and shellfish culture, integrated fish farming, the culture of indigenous fish species, and investment in the fish feed industry. It is crucial to tap into these opportunities and overcome the challenges to ensure the continued growth and success of the aquaculture sector (Amenyogbe et al., 2018).

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2.2. Importance of Ghana's aquaculture sector

Fish is vital in Ghanaians' diets as it supplies protein and micronutrients. Ghanaians have developed taste preferences for consuming aquatic products such as *Oreochromis niloticus* (Nile tilapia), thereby booming the tilapia aquaculture industry (Asiedu et al., 2015). Small-scale fisheries and aquaculture play a crucial role in developing various sectors, including employment, food security and nutrition, and trade. Many people worldwide, primarily residing in developing countries, are engaged in fish production, making it a vital source of livelihood. Fish, an essential source of nutrients, particularly for the less fortunate, is a cost-effective animal protein. Additionally, approximately one-third of fishery commodity production in developing nations is exported, significantly contributing to global trade. Given the current state of most capture fisheries, which are either fully exploited or overexploited, aquaculture will be the key to meeting the growing demand for fish, which is expected to increase due to population growth, rising incomes, and urbanization.

One of the significant global methods of augmenting insufficient wild fish catches is aquaculture. Although Ghana possesses considerable potential for advancing aquaculture, it remains in its developmental stages. Typically, individuals who enter into aquaculture do so as a part-time endeavor. Ghana's demand for fish and seafood is projected to keep rising, driven by population growth, increasing urbanization (often associated with increased consumption of animal protein), and rising incomes. Aquaculture is perceived to have the most significant potential to meet this growing demand (FAO, 2017). Aquaculture's capacity to impact poverty is contingent upon the nature of the aquaculture systems that emerge within respective contexts. Flourishing aquaculture development among small-scale artisanal producers can augment revenues, bolster household food security, and mitigate risk while enhancing resilience. On the other hand, large-scale aquaculture farms hold the potential to yield food, employment, and income streams in both local and export markets.

2.3. Challenges of Ghana's aquaculture sector

One of the significant challenges in Ghana's aquaculture is the lack of efficient and inexpensive farm-made feeds for all stages of fish growth. Due to the surge in the requirement for fish feed, most vendors sell sub-standard feeds (Amenyogbe et al., 2018). The insufficiency of fingerlings, combined with their poor quality, the inadequacy of technical expertise, and the scarcity of extension services and training have been identified as the primary obstacles that have impeded the growth of aquaculture production within Ghana. The impediments to the development of the aquaculture industry have been identified as the exorbitant cost of commercially available diets, limited access to funds, deficient market of farmed fish products, and inadequate management of farms. In conjunction with unfavorable weather conditions and insufficient infrastructure, these challenges contribute to the escalating incidence of farm abandonment and hinder the overall growth of the aquaculture sector (Buchanan, 2016).

The study also revealed that a majority of fish farms in Ghana are inadequately managed. This can be attributed to the lack of technical expertise and unskilled labor across all production levels. Consequently, this has resulted in significant underdevelopment and negligible contributions from the sector toward the country's overall fish production and economic growth. Inadequate management can have detrimental economic and environmental impacts on aquaculture sustainability and development. Therefore, fish farmers must prioritize balancing social and environmental needs. Aquaculture extension services are provided free of charge in Ghana by the Ministry of Food and Agriculture through the Fisheries Commission. While fisheries extension officers typically receive general agricultural training, many lack specialized training in aquaculture, which poses a significant challenge to the quality of their technical support (Buchanan, 2016).

There is a lack of logistical support, such as vehicles, which makes the movement of extension field workers very difficult; thus, the extension services are ineffective in providing services to farmers in remote parts of the country. Key obstacles inhibiting the sector's performance relate to unsuitable fishing equipment, overfishing, difficulty accessing aquaculture inputs, and harmful effects of climate change on aquatic resources (N'Souvi et al., 2021). With the explosive interest in fish farming stimulated by the Ministry of Fisheries and Aquaculture Development, new challenges from environmental pollution, biosecurity, and the spread of diseases have also emerged and must be addressed. Maintenance of water quality is one major challenge faced by fish farmers. Very often, dissolved oxygen can quickly be altered by the decomposition of fecal waste, which harms their delicate gills and leads to other problems. Sadly, many farmers lack the skills to handle such issues.

2.4. The outbreak of COVID-19 pandemic in Ghana

The outbreak of COVID-19 in Ghana was a crucial part of the global pandemic of coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). On March 12, 2020,

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the first two cases were confirmed in Ghana after two infected individuals arrived from Norway and Turkey (Dalgıç et al., 2021; Demir et al., 2021). On January 12, 2020, the World Health Organization (WHO) officially confirmed that a respiratory illness affecting a group of people in Wuhan City, located in Hubei Province, China, was caused by the novel coronavirus. This information was reported to the WHO on December 31, 2019. On March 11, 2020, the WHO declared the novel COVID-19 a pandemic. During this month, the Ghanaian government responded to the first confirmed cases of COVID-19. Major stakeholders held joint meetings, and professionals such as teachers received training on handling suspected cases. To contain the spread of the virus, the President of Ghana implemented several measures on March 15, 2020. These measures included bans on school activities and social gatherings, a temporary lockdown, and restrictions on the movement of people in the Greater Accra and Ashanti Regions of Ghana.

2.5. Impact of COVID-19 pandemic on aquaculture

The earnings of many individuals involved in aquaculture primarily come from various fish-related activities. Additionally, the onset of COVID-19 has negatively impacted their income from alternative sources, worsening the vulnerability of household food security (Yaşar et al., 2023). The pandemic's effects on income and job opportunities, along with disruptions in the food supply chain and rising costs of inputs and other necessities, have increased household food security vulnerability (Alam et al., 2023). This situation has resulted in a rise in poverty cases and a looming food crisis. Fish farmers and their communities account for 10% of the global population (Fiorella et al., 2021). Beyond being a crucial source of livelihood for many, including vulnerable groups, the small-scale fisheries sector is a vital component of global food security. It often plays a significant role in household food security strategies. While COVID-19 does not directly affect aquatic organisms, specific policy measures implemented to curb the virus's spread may impose economic hardships on those involved, such as market disruption-related financial consequences.

The pandemic hindered farmers' movements, disrupted the transportation of inputs and products, and decreased consumer demand. Reports from various global regions indicate that the COVID-19 pandemic has significantly affected fish farmers, especially regarding marketing and processing. These challenges have led to the complete shutdown of operations at some fish farms or aquaculture centers (Dorji et al., 2023; Mangano et al., 2022). According to Bennett et al. (2020), 54% of fish growers faced difficulties accessing inputs—mainly fish feed. Among those harvesting during the crisis, many struggled to sell their fish due to low buyer demand, dropping tilapia prices, and increased transportation costs compared to pre-COVID-19 levels (Ragasa et al., 2021). Fish farmers are showing a decreased interest in fish farming and related aquaculture activities, resulting from the cumulative consequences of the pandemic (Gatto et al., 2022).

Aquaculture practitioners have also expressed challenges with labor, mainly due to the temporary unavailability of workers from stay-at-home orders, illness, layoffs, and permanent job losses caused by income disruptions from marketing channel issues. In India, it is noteworthy that the fisheries sector was suspended, unlike agriculture. However, after considerable pressure from civil society emphasizing the fisheries' critical role in food provision, fishing could resume under certain conditions (Bennett et al., 2020). In areas where fishing is deemed essential, many fish farmers have been prevented from participating in aquaculture activities due to social distancing measures (Bennett et al., 2020). Moreover, fish marketing and trade restrictions have impeded value addition for aquaculture products (Ahmed & Azra, 2022). The pandemic also significantly affected fish and feed prices. One issue faced by fish farmers and traders was disruption in the supply or purchase of fish, fingerlings, feed, and other inputs (Alam et al., 2023).

Despite the acknowledged importance of aquaculture to the Ghanaian economy, they are currently facing many obstacles that are stifling their growth potential, particularly in light of the COVID-19 pandemic. These innumerable challenges include but are not limited to, the effects of the lockdown, which have forced people to remain at home and prevented them from buying or selling goods, insufficient financing, inadequate marketing expertise, and harsh governmental regulations (Ragasa et al., 2021). Additionally, small-scale aquaculture firms face competition from foreign firms, a lack of innovation, and numerous other challenges (Amenyogbe et al., 2018). Therefore, it is unsurprising that Ghanaian small-scale aquaculture's growth has steadily declined. However, Ghana is positioned within the African region among the best twenty nations affected by COVID-19 widespread. Both developed and developing economies are affected by unemployment and other socioeconomic changes. However, some industries and groups are highly vulnerable to the socioeconomic impact of the COVID-19 crisis (Dorji et al., 2023). Thus, it is evident that outcomes differ among demographic configurations and geographic circumstances, as stated by Kassegn and Endris (2021).

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Moreover, contemporary data reveals that the pandemic has impacted consumption, food security, and farming-related livelihoods in various nations, including but not limited to India, Nigeria, the Caribbean, Bangladesh, and China, as reported by Mandal et al. (2021), and Alvi et al., (2021). Countries worldwide have implemented social distancing protocols in conjunction with vaccination to decelerate the transmission of the virus. Previous research (Kimani-Murage et al., 2022; Rahman et al., 2021) has illustrated that these measures and limitations aimed at curbing the pandemic can exacerbate susceptibilities such as anxiety, loss of income, uncertainty, and infringement of human rights.

2.5.1. Impact of COVID-19 on aquaculture input supplies

The impact of COVID-19 on the fisheries and aquaculture sector in developing countries has been significant, with challenges faced by fish supply chain actors including a shortage of inputs, a lack of technical assistance, and a decrease in demand for fish products (Alam et al., 2022). The COVID-19 pandemic has harmed the aquaculture input supply of fish stocking and feeding, affecting aquaculture production and value chains (Ahmed & Azra, 2022). The fisheries and aquaculture sector has encountered numerous challenges, encompassing constraints regarding the availability of input supplies such as chemicals and pharmaceuticals, brood stocks, bait and feeds as a result of suppliers' closure or their inability to furnish inputs on a credit-based system (Khan et al., 2023). Research has demonstrated that the global health crisis has had detrimental consequences on the economic resources possessed by individuals engaged in fish farming and fishing activities, resulting in a scarcity of input supplies and a lack of technical assistance (Alam et al., 2022).

Moreover, problems such as diminished earnings, scarcity or shortage of input supplies, scarcity of labor, and diminished consumer demand were recognized as the main drivers impacting the aquaculture industry (Hoque et al., 2021). Unlike anthropogenic stressors such as overfishing and the localized occurrence of disasters, the unprecedented and extensive reach of the COVID-19 pandemic has taken the aquaculture industry and society by surprise. Its swift onset and global scale have resulted in unforeseen disruptions to production and input supply, which were not anticipated or foreseen. A recent report by FAO 2022 showed that COVID-19 affects the aquaculture input supply by limiting, for instance, the ability to supply feed to fish farmers due to closed markets and feed-producing facilities and brood stock supplies, disrupting the logistics associated with transportation (both raw materials and final products) and increasing border restrictions. The COVID-19 pandemic undoubtedly exacerbated the vulnerability of socioecological systems that were already under immense stress (Bennett et al., 2020; FAO, 2020). This was achieved by exerting its impact on various input supplies like feeds.

2.5.2. Impact of COVID-19 on fish farm operations

Due to the challenges posed by the pandemic, many fishing and fish farming activities have been curtailed, leading to a decrease in the income of fish farmers (FAO, 2019). With low market prices, farmers opted to retain fish in their ponds, which escalated expenses for feed, labor, medicine, and water quality management. In certain areas, it became evident that having stocked fish in ponds imposed a regular financial strain on farmers, as they had to purchase more expensive feed to keep the fish alive (Mitra et al., 2022). Many hatcheries have been forced to halt their operations because of a shortage of broodstock and necessary pharmaceuticals and chemicals, including pituitary hormones essential for spawning and fry production.

The lockdown led to the closure of numerous small feed mills, most of which have remained inactive due to a lack of resources, limited technical expertise, and insufficient labor. As a result, the efficiency of fish production has been seriously hindered (Mitra et al., 2022). The pandemic has disrupted water quality monitoring activities, potentially undermining water quality management. However, because of reduced human activities during the pandemic, improvements in water quality were reported in some areas (Yusoff et al., 2021). A study in India indicated that the lockdown positively affected pond water quality. Ahmed et al. (2022) found that the COVID-19 pandemic has caused shortages in pharmaceutical supplies, complicating the culture of fingerlings in fish hatcheries. Despite the economy being impacted by the COVID-19 pandemic, research on its effects on aquaculture remains limited.

3. Methodology

The Ethics Committee Approval was obtained from The Unisa Research Ethics Review Committee (URERC), Pretoria, South Africa, with the decision numbered 117-2 and dated 18.06.2024.

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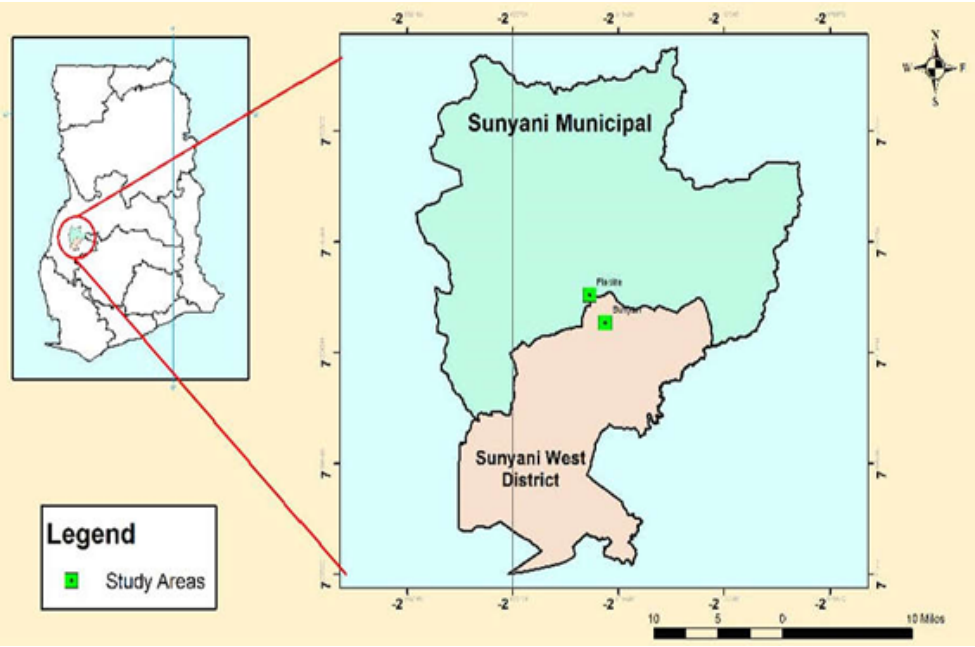
3.1. Study area

The study was conducted in Sunyani, one of the twelve districts of Ghana's Bono Region (Figure 1). Sunyani was chosen as the study site because it produces fish for the general market through fish farming. Sunyani has a population of 74,240 (GSS 2020). Sunyani Municipality is an administrative district in Ghana's Bono Region, with a population of 74,240 (GSS, 2020). It is located between Latitudes 70 20'N and 70 05'N and Longitudes 20 30'W and 2010'W and borders Sunyani West District to the north, Dormaa East District to the west, Asutifi District to the south, and Tano North District to the east (GSS, 2013).

Figure 1. Map of the study area



Source: Foli et al. (2020).

3.2. Data collection method

Semi-structured questionnaires were used to collect respondents' data between May and June 2023. A questionnaire is the most common method of collecting primary and quantitative data since it is faster and more accurate and makes data processing easier (Sivathanu & Radhika, 2023; Krosnick, 2018; Malhotra, 2006). According to Taherdoost (2022), semi-structured questionnaires follow a specified and clear pattern based on a sequence question, are pre-coded, are simple to conduct, and have fewer discrepancies. The questionnaire utilized in the study was validated using the content, face, and construction validation processes. The questionnaires were purposively and randomly administered to fifty (50) respondents using Cochran (1969):

$$n = \frac{Z^2 * P * (1-P)}{d^2}$$

where P is the proportion of fish farmers, Z = 1.96, and d = 0.05.

Respondents were chosen based on two criteria: i) they own a fish farm; ii) they work on fish farms for more than one (1) year; and iii) they are over the age of 18. According to Omona (2013), random purposeful sampling increases the credibility of a sample when the potential purposeful sample is too large. The questionnaire utilized in the study was divided into four categories: a) respondent demographics, b) aquaculture production, c) aquaculture goods, and d) aquaculture farm operations.

3.2. Data analysis

The data collected from the study was first coded and cleaned before being entered into the Statistical Package for Social Sciences (SPSS version 26.0). Descriptive statistics such as frequencies and percentages were used to describe variables such as demographic characteristics and attitudes towards aquaculture production, products, and

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farm operations. Inferential statistics, precisely the Chi-square goodness of fit test, were used to identify any significant differences with a p-value of 0.05 at a 95% confidence interval. The statistical application Minitab version 19 was used to generate charts and tables for the study.

4. Results

4.1. Socioeconomic characteristics of fish farmers

This study shows that 88% of respondents employed during its course were males, while 12% were females (Table 1). The study revealed that 54% of the respondents were between the ages of 21 and 40, followed by 44% of the respondents between the ages of 41 and 60 (Table 1). However, a minority (2%) of the respondents were between 61 and 80 (Table 1). The study revealed that 62% of the respondents employed for the study had attained tertiary education, while 20% had attained Junior High School education. Additionally, 18% of the respondents held a Senior High School Certificate (Table 1). The study reported that 22% of the respondents had a monthly income between GH₵3001 and 4000, while 36% had a monthly income between GH₵20001 and 3000 (Table 1).

Table 1. Socioeconomic characteristics of respondents

	Variables	Frequency	Percentage	Chi-square	Df	p-value
Gender	Male	44	88	0.43	1	0.510
	Female	6	12			
Age	21-40	27	54	2.64	2	0.268
	41-60	22	44			
	61-80	1	2			
Educational status	JHS	10	20	4.15	2	0.001
	SHS	9	18			
	Tertiary	31	62			
Monthly income	200-1000	7	14	10.10	4	0.018
	1001-2000	10	20			
	2001-3000	18	36			
	3001-4000	11	22			
	4001-5000	4	8			

4.2. Perception of the impact of COVID-19 on aquaculture production cost, products, and farm operations

Figure 2 shows that 64% of respondents confirmed that COVID-19 affected aquaculture production costs, while 36% disagreed. The study revealed that more than half of the respondents (66%) highlighted that COVID-19 affected the prices of aquaculture products, whereas 34% indicated that it did not (Figure 2). Regarding farm operations, 76% of respondents affirmed the impact of COVID-19, while 24% reported no effect (Figure 2).

Figure 2. Perception of respondents on COVID-19's impact on aquaculture activities

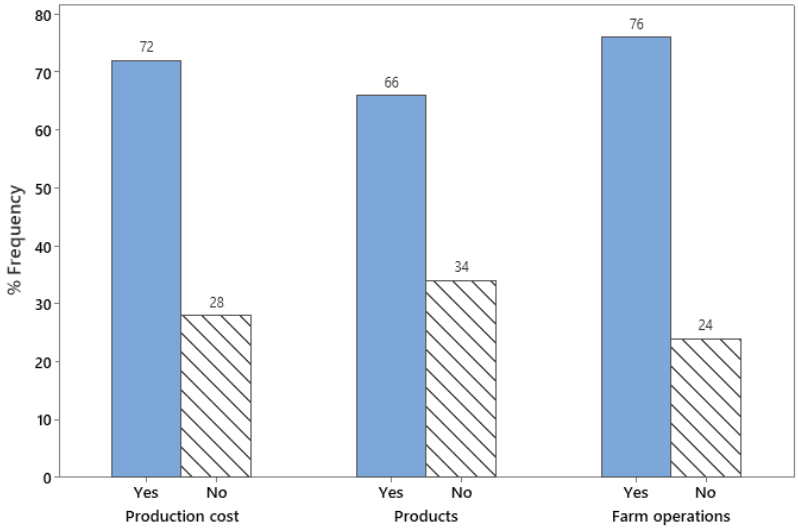

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Figure 3. Reasons for the impact of COVID-19 on aquaculture production cost

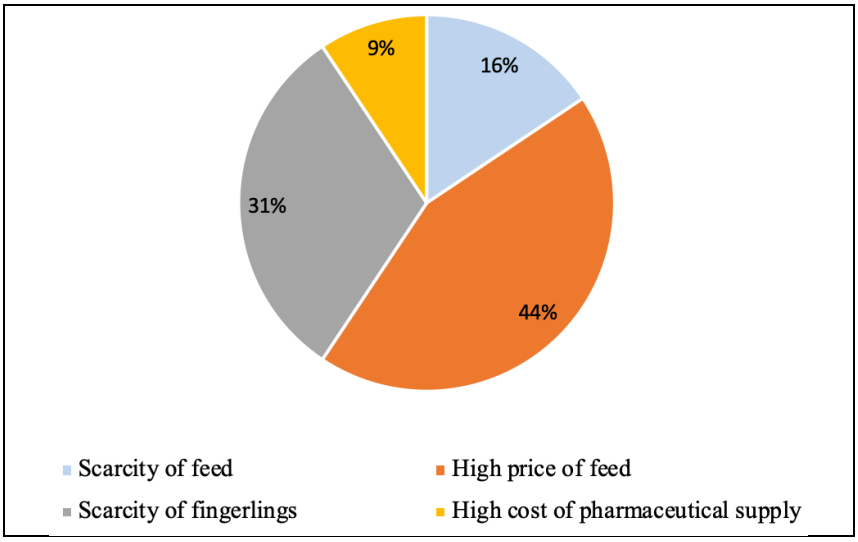


Figure 4. Reasons for the impact of COVID-19 on aquaculture products

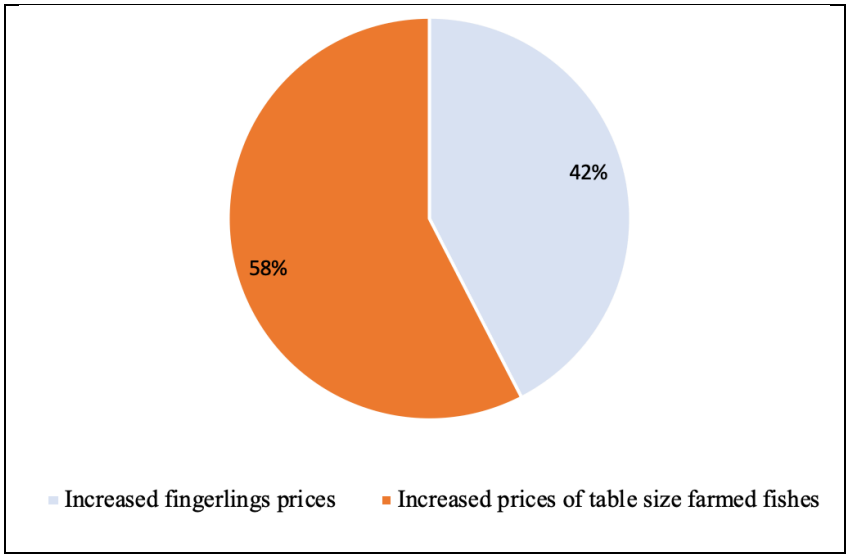
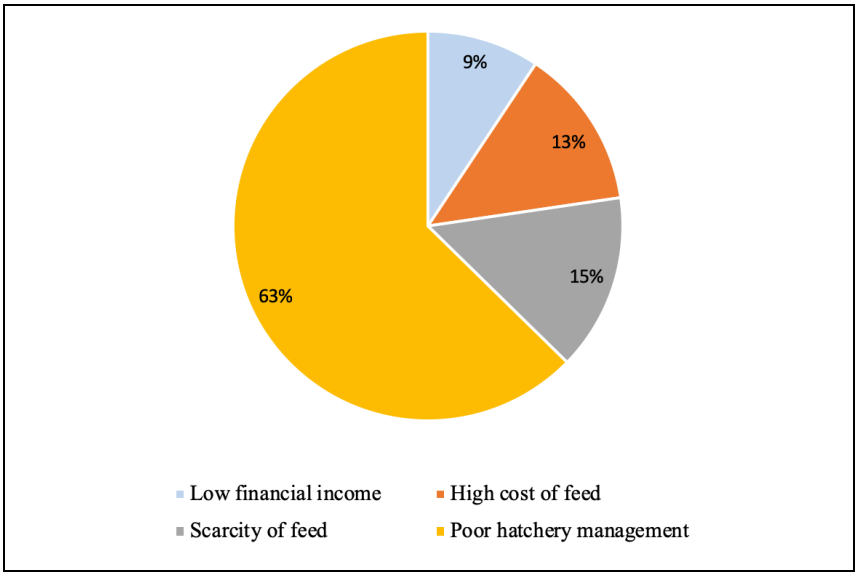


Figure 5. Reasons for the impact of COVID-19 on aquaculture farm operations



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4.3. Factors influencing impacts of COVID-19 on aquaculture activities

From Figure 3, four main reasons were identified for the impact of COVID-19 on aquaculture production costs. These included high feed prices, feed scarcity, a shortage of fingerlings, and the increased cost of pharmaceuticals. According to Figure 3, high feed prices (44%) and the scarcity of fingerlings (31%) were the primary factors affecting aquaculture costs due to COVID-19. The impact of COVID-19 on aquaculture products resulted from two main reasons: rising prices of fingerlings and table-sized farmed fish (Figure 4), with the increase in prices of table-sized farmed fish being the main contributing factor (58% of respondents). Figure 5 identifies four main reasons for the impact of COVID-19 on farm operations: poor hatchery management, feed scarcity, low financial income, and high feed costs. The most significant reason identified by respondents was poor hatchery management (63%), followed by feed scarcity (15%), as shown in Figure 5.

5. Discussion

According to Alhassan et al. (2020), low aquaculture production is primarily due to the lack of readily available feed and feed ingredients. Reductions in feed and its ingredients can hinder the growth rate of farmed fish (Islam et al., 2021). A study by Manlosa et al. (2021) indicated that mobility restrictions prevent fish farmers from acquiring fingerlings. Many fish farmers are increasingly using pharmaceutical chemicals such as growth hormones and probiotics to boost fish productivity (Wang et al., 2019). However, transport restrictions and lockdowns have decreased the availability of these essential pharmaceutical materials for most fish farmers (Lambert et al., 2020). Most respondents confirmed the increased prices of farmed fish products during the COVID-19 pandemic. The rise in prices of table-sized farmed fish during this period can be attributed to various factors, including geographic location and demand during the pandemic. Additionally, the high cost of scarce feed ingredients and pharmaceutical materials during the pandemic, which impacted production, may have contributed to the increased prices of aquaculture products. In light of the mobility restrictions during the pandemic, the demand for aquaculture products exceeded supply, resulting in rising prices for these farmed goods (Love et al., 2023).

The study revealed a negative impact on the feeding regimes of aquaculture farms in the Sunyani Municipality. This finding aligns with the studies by Sutcliffe et al. (2023) and Shamsuddin et al. (2023), which reported that low farmer incomes, a shortage of raw materials for fish feed production, and limited availability of fish feed affected feeding regimes in fish farms during the pandemic. However, to address the feed scarcity, many fish farmers resorted to bulk feed purchases to ensure a steady supply, allowing them to maintain their fish production and avoid losses from feed shortages (Alam et al., 2023). According to FAO (2021), bulk purchasing enables fish farmers to reduce feed costs while achieving substantial profit margins.

Fortunately, many respondents indicated that the water quality of numerous fish farms was not negatively affected during the pandemic. This observation aligns well with the study by Yusoff et al. (2021), which stated that the water quality index in various aquaculture farms improved during the pandemic. This improvement could be attributed to the reduced anthropogenic activities caused by movement restrictions during the lockdown period (Praavena et al., 2021). However, Araujo et al. (2022) documented that the pandemic negatively impacted input supply for water quality management due to domestic and international disruptions. Most respondents in the study indicated that COVID-19 significantly impacted their hatchery operations. This finding aligns with the research by Ahmed et al. (2022), which reported that inadequate feed during the lockdown period compromised hatchery management operations, leading to a decrease in aquaculture output. Additionally, the shortage of antibiotics and lime in aquaculture production was a common issue, resulting in poor hatchery management (Shamsuddin et al., 2023).

6. Conclusion

The study aimed to assess the impact of the COVID-19 pandemic on aquaculture activities in Sunyani, Ghana. According to the survey, the COVID-19 pandemic significantly affected aquaculture production, products, and farm operations. The main factors contributing to these impacts during the pandemic included feed scarcity, poor hatchery management, and the high prices of table-sized farmed fish. To mitigate any future effects of the pandemic, it is recommended that farmers engage in bulk purchasing of aquaculture materials, including feed and pharmaceutical inputs such as lime. This approach will ensure smooth farm operations and improved profit margins during periods of uncertainty.

6.1. Theoretical implications

The findings are specific to Sunyani and may not apply to other regions with different socio-economic and environmental conditions. Establishing a direct causal relationship between the pandemic and the observed impacts is

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challenging due to the presence of various confounding factors. The study may have concentrated on specific aspects of aquaculture, such as feed scarcity and hatchery management, potentially overlooking other impacts like shifts in market demand or labor availability. The study captures a short-term impact during the pandemic, and the long-term effects on aquaculture activities might vary as the situation evolves.

6.2. Practical implications

Due to financial and storage constraints, bulk purchasing may not be viable for small-scale farmers. Even with bulk purchasing, supply chain issues during a pandemic can affect essential inputs' availability and timely delivery. High farmed fish prices and other inputs during a pandemic can strain farmers' financial capacity, impacting operations and profitability. Poor infrastructure and logistical challenges in rural areas can hinder the effective implementation of bulk purchasing and storage practices. Farmers may lack the necessary information and training to manage hatcheries and implement recommended practices during a pandemic.

6.3. Limitations of study and future directions

The study did not address responses from large-scale aquaculture firms. In addition, geographical limitations may have affected the information as the survey did not cover a broader scope. Therefore, information from the study for academic purposes should be cautiously given. Future directions emanating from the study include:

- Enhance the capacity of relevant stakeholders in the aquaculture sector to integrate gender mainstreaming and acknowledge the significance of gender equity within the industry.
- The government needs to support the development of aquaculture research and infrastructure and subsidize feed and other input supplies.
- Government-supported research should be conducted to make catfish farming a more productive venture for fish farmers.
- Farmers should supplement commercial feeds with their feeds using less expensive and locally available inputs.

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Author contribution statements

Berchie Asiedu - reviewing,
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Samuel Kweku Konney Amponsah – data analysis, writing and data curation.

Disclosure statement

The author reported no potential competing interest.

Ethical committee approval

The Ethics Committee Approval was obtained from The Unisa Research Ethics Review Committee (URERC), Pretoria, South Africa, with the decision numbered 117-2 and dated 18.06.2024. All responsibility belongs to the researchers.

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