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SOCIO-ECONOMIC AND CONSTRAINTS HINDERING AQUACULTURE PRODUCTION IN THE LIMPOPO PROVINCE, SOUTH AFRICA

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ABSTRACT

Limpopo Province, South Africa, holds significant potential for aquaculture development. However, the industry remains underdeveloped with low production rates due to various constraints. To foster growth in aquaculture, it is crucial to identify and address these constraints effectively through research, training initiatives, and policy interventions. This research employed semi-structured in-depth interviews and on-farm observations to gather primary data from 75 active farms across five districts of Limpopo Province. The data collected was analyzed using SAS software to identify key challenges and inform targeted interventions for enhancing aquaculture production in the region. The research identified ten major constraints affecting aquaculture production in Limpopo Province, South Africa. Some of the current major constraints identified for current research might be attributed to findings on socioeconomic characteristics and aquaculture production practice. These constraints varied in severity and were ranked as follows in terms of their impact on hindering aquaculture development: Cost of feed (70%), Access to finance (70%), Lack of equipment to measure water quality (70%), Access to market (68%), Limited training (66%), Poor infrastructure (64%), Predation (63%), Lack of information (60%), Lack of feed (57.54%), Lack of weighing scale (56.17%). These constraints were not uniform across districts highlighting the diverse challenges faced by aquaculture farmers in different areas of the province. Addressing these constraints is crucial for promoting sustainable growth and development of the aquaculture industry in Limpopo Province.

Keywords: Aquaculture, Constraints, Limpopo Province

INTRODUCTION

Aquaculture production in Africa has shown gradual growth, yet its global contribution remains below 3%, primarily led by Egypt as the largest producer (Adeleke *et al*., 2020; FAO, 2020). This low productivity is reflected in South Africa, where aquaculture contributes less than 1% to the continent's overall production (AgriSETA, 2019). Although aquaculture production in South Africa started in the 1980's (Hecht and Britz, 1990), South Africa ranked tenth among the top 10 aquaculture producing countries in Africa (Adeleke *et al*., 2020). Despite these rankings, reviews of South African freshwater aquaculture emphasize its substantial biophysical potential for increased production, especially in regions like Limpopo Province (Ngarava *et al*., 2023).

Limpopo Province, characterized by suitable agroecology and soil types, is poised for the development of earthen pond-based aquaculture. Recognizing this potential, Limpopo Department of Agriculture and Rural Development (LDARD) food security sub-branch supplied fish farmers with aqua-tanks, tilapia fingerlings and fish feed in 2004. This initiative included aquaculture programs aimed at addressing socio-economic challenges faced by disadvantaged groups. Subsequently, the

Water Research Commission (WRC) engaged with the province through the LDARD in participative workshops to formulate a strategic plan in 2010. As the first step of the key intervention by WRC, series of research projects to support aquaculture development was conducted in early 2000s (Rouhani and Britz, 2011; Rouhani and Britz, 2014). Concurrently, the revitalization of Turfloop hatchery was the focus of special attention to provide the fingerlings and technical training for both the extension officers and famers (Rouhani and Britz, 2011)

Subsequently, LDARD adopted a series of Community-Based Aquaculture (CBA) pilot projects in Limpopo Province by identifying aquaculture potential near irrigation schemes. Phetwane Irrigation Farmers' Cooperative was the first pilot project in 2011, then replicated at Herford Irrigation Farmers' Cooperative in 2016 and PRISCA Irrigation Farmers' Cooperative in 2018. The CBA was initiated and led by the Department of Forestry, Fisheries, and the Environment (DFFE, formerly DAFF), aimed to diversify aquatic food products (DAFF, 2012).

Despite these interventions and recommendations, by the successive government to improve aquaculture production, aquaculture in Limpopo Province remains underdeveloped compared to other South African provinces (DAFF, 2014). Challenges persist due to unrealistically short project timelines driven by donors, inadequate monitoring of fish farming performance and socioeconomic impacts, and insufficient coordination between development and research efforts. These factors contribute to the slow growth and hindered production of aquaculture in the province.

Additionally, inadequate production data and a lack of a centralized fish farm registry further impede the industry's growth and hinder the formulation of clear strategies. Thus, this survey was conducted to assess farmers' perceptions on aquaculture development, focusing on identifying major constraints, causes affecting development, and strategies to overcome these obstacles.

METHODOLOGY

The survey covered five districts of Limpopo Province: Vhembe, Sekhukhune, Waterberg, Capricorn, and Mopani. Farmers were selected using purposive sampling, comprising 75 functional farmers/projects, and were interviewed using a semi-structured questionnaire to gather comprehensive insights. This qualitative research approach aimed to obtain a deep understanding into the respondents' experiences, opinions, thoughts, and perspectives through in-depth questionnaire interviews and on-farm observations.

The questionnaire was developed based on key issues identified during preliminary interactions with farmers and was available in English, with interviews conducted in the interviewee's preferred language. Ethical procedures were followed, and confidentiality of information was assured to participants. Prior to administering the questionnaire, a pre-test was conducted at two fish farms in selected districts to ensure clarity and relevance.

During the interviews, farmers were briefed about the research objectives, and interviews were scheduled by appointment on their farms. This allowed for observations to support the validity of the research findings based on farmers' responses. Data obtained from the interviews were analyzed using the frequency procedure of Statistical Analysis Software (SAS) version 9.4. Descriptive statistics is presented in frequencies and percentages.

Challenges encountered during data collection.

- The lack of written records among respondents regarding their farming business and production figures led to unreliable data. This necessitated the reliance on observations and data provided by respondents based on their memory, which may not always be accurate or comprehensive.
- Many respondents had limited experience in fish farming, indicating

that the information provided was based on their relatively short period of involvement in the industry. This limited experience, coupled with various constraints encountered, may have influenced the accuracy and depth of the information provided during the interviews.

- All the respondents are the farm owner, therefore any information they give as regards constraints facing their farms tend to be reliable because they are the highest decision maker in their enterprise.

RESULTS AND DISCUSSION

Socioeconomic characteristics and aquaculture production practice

The socioeconomic characteristics and aquaculture production practices of respondent fish farmers are detailed in Table 1. The majority of respondents were male (72%) compared to female (28%); a trend consistent with findings from Ifejika *et al.* (2007) in Nigeria but differing from Gupta's (1990) observations in Bangladesh. Ifejika *et al*. (2007) attributed the low participation of women in aquaculture to religious practices, oppressive land tenure systems, and competing household responsibilities. Haimene (2018) noted that aquaculture is often viewed as labor-intensive, leading to its association as a male-dominated activity globally.

Table 1 further illustrates that the highest proportion of participants fell within the age range of 46-65 years (59%), followed by the elderly (16%) and youth (9%). This distribution indicates limited youth and elderly participation in aquaculture, which has implications for labour availability and future succession planning. The aging workforce may struggle to meet physical demands, particularly evident in tasks like pond digging, which require significant physical exertion that diminishes with age (Adelodun, 2015).

In terms of education, 52% of respondents had attained a senior secondary school education level, more than half (52%) received training and nearly half (48.57%) were members of cooperative societies. These findings suggest that adopting new aquaculture technologies within group settings should not pose any significant challenges. However, given their credential level (Table 1) majority of the participants lack business plan (86%) and project not registered (53.33%). Operating without above mentioned variants will channel farmers to make uninformed decision leading to most of the projects being abandoned due to failure reaching sustainable levels, hence most participants (42.67%) had 1 - 5 years of experience.

The question about the type of cultural practice, species cultured, source of fingerlings and source of water was a multiple tick question, and this explains why the sum of the percentage was higher than 100% (Table 1). Most participants practice (99%) mixed sex with mixed tilapia (97.33%) being the most widely farmed species (97.33%). Mixed sex tilapia culture practice is the major drawback due to its high level of unrestrained reproduction that may occur in a confined grow-out ponds before they reach a marketable size. Among the many strategies implemented to control undesirable tilapia reproduction is polyculture practice by stocking tilapia with predator fish species (Lazard and Oswald, 1995). However, majority of participants (81.32%) practice monoculture and only 20% practice polyculture by stocking both African catfish and mixed tilapia.

More than half (59.46%) of the farmers never restocked fingerlings due to lack of consistent and reliable source of fingerlings (Table 1). Fingerling production is an African problem where many governments have failed to invest in hatcheries that would otherwise address the shortages of quality fingerlings (Koge *et al.*, 2018). More than half (55.17%) of farmers sourced fingerlings from the wild or fingerlings reproduced (13.79%) from initial stock of mixed-sex tilapia culture production for subsequent production cycles. Sourcing fingerlings from the wild with unknown age and not guaranteed of continuous supply is normally limited because availability is

seasonal, hence, this will seriously limit the growth and development of fish farming in this province. Additionally, government hatchery is not conveniently located close to large or clustered fish farms and these findings suggests that at least each district requires its own state fish hatchery.

Most of the projects observed are not fully operational with some of the production system not in use or abandoned due to poorly constructed or located. Hence, majority of participants utilise one production system (43.24%) with low harvest output and mostly used for home consumption (63%) with little or no surplus for the market. Conversely, an average number of 3-4 ponds per fish farmer has been recommended by Igwe and Mgbaja (2014) and Amin (2015) because the high the number of ponds (given availability of other inputs), the scale of fish production will proportionally increase (Abbas, 2015).

Water quality and quantity is a predominant factor for success of aquaculture. Poor water quality due to poorly slope design of concrete dams for self-cleaning and earthen ponds designed without outlets pipes to easily drain deteriorated water was evident during our farm observation. Majority of participants (37.33%) source water from borehole and the least (4%) from the stream. In contrast, Abbas (2015) reported a significant portion of fish farmers (74%) sourcing their water from the stream as this had little or no cost implication attached to it

Table 1: Socioeconomic characteristics and aquaculture production practice in Limpopo Province

Categories	Variables	Percentage of farmers (%)
Gender	Male	72
	Female	28
Education	No school	1.33
	Primary	18.67
	Secondary	52
	Diploma	24
	Post graduate	4
Received Training	Yes	52
	No	48
Age	18 –35	9
	36 –45	16
	46 –65	59
	>65	16
Operational years	<1	9.33
	1-5	42.67
	6-10	18.67
	11-15	18.67
	16-20	6.67
	21-25	2.67
	>25	1.32
Production system	1	43.34
	2	22.97
	3	9.46
	4	6.67
	5	2.70
	6	5.41
	7	2.70

	9	2.70
	10	1.35
	11	1.35
	13	1.35
Home consumption	No	37.31
	Yes	62.69
*Culture Practice	Mixed sex	99.99
	Monoculture	81.32
	Aquaponics	2.66
	Polyculture	20
	Mono sex	1.33
	Integration	13.33
*Cultured Species		
	Mixed tilapia	97.33
	Catfish	20.00
	Carp	5.33
	Unknown	2.66
*Source of fingerlings		
	Reproduced	13.79
	Government supply	17.24
	Private supply	32.76
	Wild caught	55.17
Restocking		
	After harvesting	13.51
	Anytime	10.81
	Every six months	5.42
	Every year	9.46
	Every two years	1.35
	Never	59.46
*Source of water		
	Borehole	37.33
	River	26.66
	Municipality water	25.33
	Fountain	8
	Spring	4
Project registration	Government trucks	1.33
Business type	No	53.33
	Yes	46.67
	Closed corporation	14.29
	Cooperation	48.57
	NPO	2.86
Business plan	Pty Ltd	31.43
	Sole trade	2.86
	No	86
	Yes	14

***Some of percentages do not add to 100 due to multiple responses.**

Major constraints identified

Several constraints varied across district have been identified in the current research to be major contributors to the slow pace of fish farming in Limpopo Province. Key among these, the 10 major constraints identified and presented in Figure 1 were cost of feed, lack of equipment, limited training, predation, lack of feed, access to finance, access to market, poor infrastructure, lack of information, and lack of weighing scale. Some of the major constraints identified might be attributed to findings on socioeconomic characteristics and aquaculture production practice as presented in Table 1.

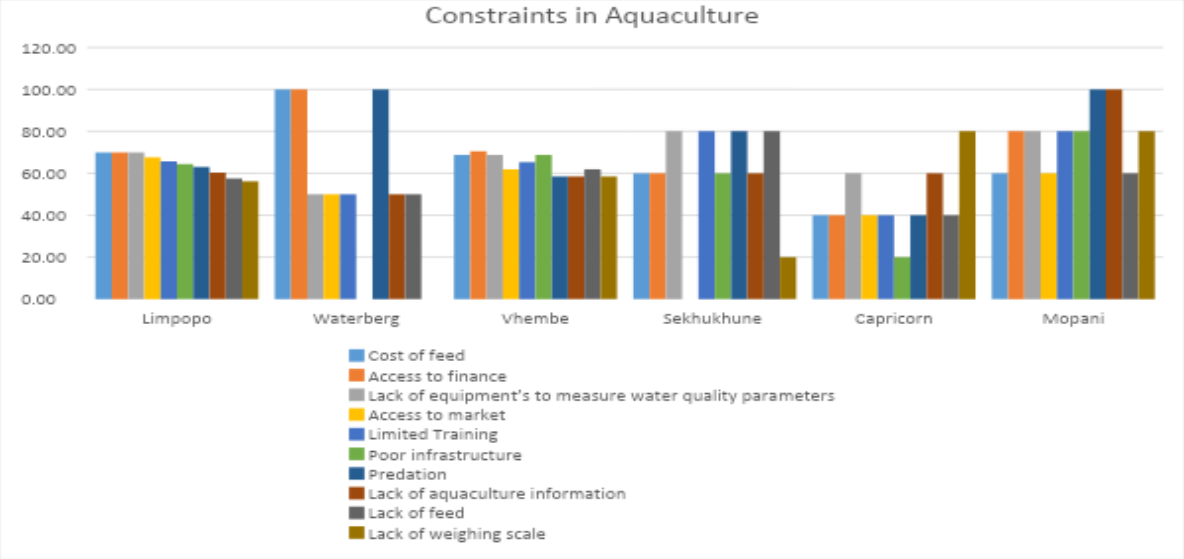


Figure 1: Major constraints hindering aquaculture production in Limpopo Province

Access to finance

Access to finance emerged as a predominant constraint among the respondents, with more than half indicating its significance, except for respondents in the Capricorn district (40%). This constraint is critical as it directly impacts the ability of farmers to maintain their fish farms by hindering their procurement of essential inputs such as fingerlings and fish feed. The absence of adequate financial resources makes aquaculture operations unsustainable in the long term.

Investors are also hesitant to support aquaculture projects due to high-interest rates imposed by banks and other credit institutions. Additionally, the lack of collateral among farmers, with a substantial percentage not registering their projects or having a business plan, further complicates access to finance. A well-developed business plan is crucial for considering aquaculture as an independent business entity with a long-term vision and growth strategy.

Furthermore, financial institutions are sceptical about investing in aquaculture due to the lack of concrete evidence showcasing the potential returns on investment. Most respondents operate on a small scale with limited production capacity, which reduces their attractiveness to financial institutions and discourages further investment. The relatively short duration of involvement in fish farming (1-5 years) among respondents indicates a trial-and-error phase, with a high risk of production cessation when problems arise.

The dominating age group of respondents (46-65 years) also contributes to potential exhaustion from physical challenges associated with fish farming activities, such as pond excavations, canal construction, and security provision. Experience is cited as a factor that reduces management risk and contributes to the success of aquaculture, as highlighted by previous studies (Krause, 1995; Ifejika *et al.*, 2007).

In summary, addressing the constraint of access to finance is essential for promoting sustainable

aquaculture development in the province. This includes improving financial literacy among farmers, encouraging the development of comprehensive business plans, and fostering partnerships with financial institutions to provide tailored financial support to aquaculture ventures.

Cost of feed and lack of feed

The expense of feed emerges as a significant limitation across the research area, particularly pronounced in the Waterberg district, followed by the Vhembe, Sekhukhune, and Mopani districts, with less prominence in the Capricorn district. Correspondingly, more than half of the respondents identified feed scarcity as a critical constraint, except for those in the Capricorn district, where it is deemed less pivotal.

The reduced emphasis on feed constraints in the Capricorn district can be attributed to its proximity to Polokwane town, ensuring more evenly distributed feed supplies compared to other districts. Conversely, other districts face challenges such as irregular or insufficient feed supplies due to further proximity to main supplies, resulting in elevated costs due to transportation from other towns.

The challenge of costly feeds impacting fish production aligns with findings from previous studies in central Uganda (Hyuha *et al.*, 2011; Kasozi *et al.*, 2014). High feed expenses and frequent unavailability can render fish farming unproductive, as resource-constrained farmers may suspend feeding their fish during periods of high feed prices, resuming only when costs become manageable, as observed by Ume *et al.* (2016).

To address these challenges, integrated Aquaculture Agriculture (IAA) is proposed, aiming to synergistically recycle nutrients to enhance the production of natural fish food. However, only a small percentage of respondents report practicing integration (Table 1), indicating that aquaculture is primarily perceived as a supplementary source of household protein and income rather than a fully integrated and sustainable farming practice.

Overall, mitigating the constraints associated with the cost and availability of feed is crucial for enhancing the productivity and sustainability of aquaculture ventures in the province. This may involve exploring alternative feed sources, promoting integrated farming practices, and addressing logistical challenges in feed distribution across different districts.

Access to market

Access to the market emerged as the fourth major constraint hindering the development of aquaculture across the research area, with the Waterberg district highlighting its significance. However, it was considered less important in other districts. The lack of market access was attributed to factors such as the absence of a business plan (86%) and the utilization of products primarily for home consumption (63%), resulting in a limited surplus for commercial purposes.

Mulokozi *et al.* (2020) noted that the high consumption of fish products indicates a significant contribution to food security among low-income households compared to high-income households. Farmers typically employ a mixed-sex population of tilapia species, leading to uncontrolled reproduction and a size disparity among harvested fish, thus affecting marketability. The excessive recruitment of fingerlings beyond the pond's carrying capacity leads to stunted growth of the original stock, hindering aquaculture production, especially in developing countries lacking efficient technologies like sex reversal (Haji and Workagegn, 2021).

Furthermore, the lack of a weighing scale, particularly significant in the Capricorn district, contributed to uncertainties regarding market size, timing, and demand for products. Heinemann (2002) highlighted similar issues faced by farmers in rural African areas due to low production levels. Daniel *et al.* (2015) recommended that farmers align their production with market demand and adopt cluster production and marketing approaches through cooperative societies to enhance bargaining power and benefit from economies of scale.

Addressing these challenges requires strategic planning, market-oriented production, and collaboration among farmers through cooperative societies to improve market access, optimize production efficiency, and ensure sustainable growth in the aquaculture sector.

Limited training

Limited training emerged as the fifth major constraint across the research area, with the Sekhukhune district leading in its significance (80%). Aquaculture is not a traditional agricultural activity in the province, highlighting the importance of prior hands-on training and knowledge in fish farming. Hara *et al.* (2017) stressed that most aquaculture farmers come into the aquaculture industry without any knowledge or skills, unless they have been previously employed in the industry.

The lack of experience can hinder farmers' ability to learn through practical experience or from neighbouring farmers. Many farmers are unaware that limited training is a key factor contributing to the slow pace of fish farming. Despite the low illiteracy rate among respondents (only 1.33% reported having no formal education, as shown in Table 1), there is still a gap in aquaculture knowledge and practice, thus training becomes more relevant.

Information plays a crucial role in assisting farmers in tasks, decision-making, and problem-solving. However, not all districts reported a lack of information as a significant constraint. Only Mopani district reported it as more important (100%), followed by the Capricorn district (60%). Limited information can lead to poor fish management, resulting in issues such as underfeeding or overfeeding, which can impact water quality. Unfortunately, more than half of the respondents ranked the lack of equipment to measure water quality as a predominant factor across all the districts.

During interviews, farmers mentioned that the only way to maintain effective water quality without proper equipment is by changing water frequently in their production systems. However, this option presents a challenge due to insufficient water supply in the province. Table 1 shows that respondents source water from various sources, including boreholes, rivers, municipality water, and others. This shortage of water supply poses a threat to ongoing projects, especially those relying on boreholes, which incur additional costs associated with pumping underground water.

Furthermore, poor infrastructure was reported by more than half of the respondents across the district, with the exception of Capricorn district (40%). In additional, farmers highlighted their initial challenges in building concrete dams and digging fish ponds without guidance from engineers. Hence, most of the projects are not fully operational due to earthen ponds and concrete dams observed to be poorly designed and leaking, only one or two production systems being utilised to practice aquaculture. In contrast, the Capricorn district benefited from well-designed aqua tanks provided by LDARD, showcasing the importance of infrastructure support in enhancing aquaculture practices.

Predation

Predation emerged as a significant constraint for aquaculture production, with all respondents in the Waterberg and Mopani districts (100%), followed by the Sekhukhuni district (80%), highlighting its impact on fish farming. Piscivorous bird species were identified as the primary predators, which could be attributed to the practice of aquaculture away from residential areas, surrounded by dense trees. This observation aligns with findings from Otieno (2019), indicating that birds become more abundant in areas with increased distance from dwellings and dense tree cover, providing resting spots between foraging episodes.

Moreover, since all respondents culture tilapia species, it was noted that piscivorous birds tend to prey on tilapia more frequently than catfish. This preference could be due to catfish's ability to defend themselves, as observed by Otieno *et al.* (2021). Otieno (2019) suggested using physical barriers such as wire netting to exclude birds can significantly reduce pond-fish predation. However, such measures come with initial installation costs and require regular

maintenance, posing a financial commitment to farmers.

Interestingly, Vhembe and Capricorn districts reported less significant predation issues. This could be attributed to their practice of backyard aquaculture, where birds may be more prone to human disturbance, thus reducing their impact on fish farms. Overall, addressing predation requires strategic measures such as physical barriers, however, farmers must consider the associated costs and maintenance requirements for long-term effectiveness.

CONCLUSION

Aquaculture practice in Limpopo Province is mostly homesteaded to encourage more woman to actively participate without being away from their homes for long period and neglect their household responsibilities. Looking at variables such as number of production system and operational years, thus further confirmed that the industry is at infancy stage characterised by low production and is seen by the farmers as a secondary source of household protein or income.

Aquaculture development within Limpopo Province exhibits notable disparities across its five districts, with the Vhembe district emerging as the primary locus of engagement among agricultural stakeholders. The district's advantageous soil composition, particularly conducive to pond construction, coupled with its housebound compatibility with subtropical and tropical crops, renders aquaculture integration more seamless compared to regions such as the Waterberg district. The latter, traditionally entrenched in cattle farming, faces logistical hurdles in amalgamating aquaculture with existing livestock activities.

The variability in aquaculture adoption across districts stems from distinct constraints prevalent in each locale. Notably, the Capricorn district experiences comparatively fewer constraints, likely attributable to the presence of proficient aquacultural extension officers and the robust technical support provided by the Aquaculture Research Units housed at the University of Limpopo and proximity to Polokwane town. This underscores the necessity for tailored interventions tailored to the specific needs of each district to effectively promote aquaculture development.

Foremost among the identified challenges is the pervasive lack of access to financial resources, posing a formidable barrier to aspiring aquaculture practitioners. Financial accessibility assumes paramount importance, as it enables farmers to procure essential resources and invest in aquaculture endeavours. Moreover, the provision of comprehensive aquaculture information emerges as imperative, facilitating informed decision-making among farmers regarding the costs and capital outlays associated with initiating and sustaining aquaculture enterprises. The paucity of such information exacerbates impediments to the sector's growth and development.

Given the prevalent literacy among the province's farming community, the dissemination of accessible and comprehensive information stands poised to empower stakeholders toward enhancing aquaculture development. Consequently, concerted efforts, including awareness campaigns, structured training initiatives, and research endeavours, orchestrated by the Limpopo Department of Agriculture and Rural Development (LDARD), are imperative in equipping farmers with the requisite knowledge and resources to surmount existing constraints.

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