Aquaculture knowledge needs and accessibility among cage fish farmers in Mwanza, Tanzania

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ABSTRACT

Aquaculture becomes increasingly important in increasing fish production, food security, and employment opportunities, a limited understanding of aquaculture knowledge needs and accessibility among cage fish farmers hinders the productivity and sustainability of cage fish farming in Mwanza, Tanzania. This study assessed aquaculture knowledge needs and accessibility among cage fish farmers in Mwanza, Tanzania. This study was conducted in three districts: Nyamagana, Ilemela, and Magu. This research was guided by Mtega's Information Need, Access, and Use model. A cross-sectional research design was conducted involving 130 cage fish farmers and six key informants. Qualitative data were collected by using semi-structured interviews, and quantitative data were collected by using a structured questionnaire, respectively. Quantitative data were analyzed by using the Statistical Package for Social Sciences (SPSS), while qualitative data underwent thematic analysis.The results reveal that cage fish farmers need aquaculture knowledge in fish feed and feeding, fish breeding, disease prevention and treatment, weather conditions, and market situations. However, accessibility to this category of aquaculture knowledge is limited. Moreover, findings indicate that demographic factors such as education level, farming experience, cage size, and family income significantly influence both aquaculture knowledge needs and accessibility at $P < 0.05$. These results underscore the need to improve aquaculture knowledge needs assessment and improve its accessibility to improve the productivity of cage fish farming. The study recommends that governments and development partners, in collaboration with fishery extension officers, create schemes that link aquaculture knowledge needs and their accessibility to cage fish farmers to improve productivity and sustainability of cage fish farming.

Keywords: Aquaculture Knowledge, Cage Fish Farming, Knowledge Accessibility, Mwanza Region

I. INTRODUCTION

Aquaculture is the farming of aquatic organisms such as fish, Mollusks, crustaceans, and other aquatic organisms (Verdegem et al., 2023). The aquaculture sector makes a significant contribution to the economic development worldwide (Mulokozi et al., 2020). It also enhances global food security, livelihood support, and employment opportunities (Atukunda et al., 2022; Mmanda et al., 2020; Yang et al., 2021). In Sub-Saharan Africa, aquaculture is increasingly recognized as a vital sector in meeting regional growing demand for fish protein (Krause et al., 2022). Aquaculture production in Tanzania is mainly practiced on a small scale, particularly by rural communities living near water bodies such as lakes and rivers (Humphries et al., 2023). In Tanzania, aquaculture is practiced in various methods such as raceways, ponds, and Tanks (Benard et al., 2020). Apart from the different methods above aimed to address the decline of wild fish and increase fish protein in the region till it does not meets the expected outcomes(Food and Agriculture Organization [FAO], 2022). As the population increases, the demand for fish protein increases. In response, cage fish farming has become a priority to increase tilapia-based aquaculture globally (Obiero et al., 2022; Sangirova et al., 2020).

Unlike traditional pond-based aquaculture, cage fish farming involves holding fish in enclosed vessels with netting material placed in water bodies or rivers. These cages protect fish and allow water flow for oxygen supply to the fish while keeping them confined for easy management (Ng'wigulu, 2021). These farming practices are advantageous due to high stocking density, low land requirements, utilization of natural resources like water bodies, and easy management (Obiero et al., 2022). In Tanzania, cage fish farming has gained more attention due to its scalability,

presence of natural resources like Lake Victoria, and controlled approach type of aquaculture(Sangirova et al., 2020). It is significantly recognized as a viable strategy to supplement catch, income generation, and improve productivity levels for local communities, especially living near Lake Victoria (Ng'wigulu, 2021).

The successful adoption and sustainability of cage fish farming depend largely on farmers' ability to access and apply aquaculture knowledge (Mutyaba et al., 2024). Studies conducted by Bernard et al. (2018), Yang et al. (2021) confirm that fish farmers need knowledge regarding fish feeding, water quality management, fish breeding, and innovative technology suitable for their farming activities to increase productivity. Additionally, enhancing fish farming productivity depends on the accessibility of knowledge, as it enables the implementation of best practices in fish farming (Rukanda, 2018). Aquaculture knowledge needs and accessibility allow cage fish farmers to be informed about advancement of technology in fish farming sector such as automated feeding systems, water quality monitoring tools and others which will reduce tasks and increase the sustainability of fish farming. Furthermore, Mzula et al. (2021) revealed that access to aquaculture knowledge equips farmers to maintain healthy stocks and achieve higher productivity, minimizing environmental impact and ensuring the long-term viability of fish farming.

Aquaculture knowledge helps fish farmers to equip with the skills to manage farming activities and optimize other operations (Mramba & Kahindi, 2022; Mustafa et al., 2015; Rukanda, 2018). Despite its potential, cage fish farming faces notable challenges, including a lack of adequate knowledge among farmers, limited technical know-how, and of skills among educators in farming practices (Mosha & Daudi, 2020; Yang et al., 2021). Limited understanding of knowledge needs and its accessibility has been a major cause of low fish productivity, unhealthy stock, and unsustainability of cage fish farming (Mzula et al., 2021; Parmar et al., 2019). Previous studies conducted so far in Tanzania have focused broadly on aquaculture, environmental impacts, and other agricultural issues (Aura et al., 2021; Benard et al., 2020; Mboya et al., 2023; Rukanda, 2018). However, aquaculture knowledge needs and access specifically to cage fish farmers in Tanzania is not known. Therefore, this study aimed to assess the Aquaculture knowledge needs and accessibility among cage fish farmers in Mwanza, Tanzania.

1.1 Statement of the Problem

Aquaculture knowledge is important for empowering cage fish farmers with the skills to enhance the productivity and sustainability of cage fish farming (Mramba & Kahindi, 2022; Mustafa et al., 2015; Rukanda, 2018). It covers critical aspects of aquaculture knowledge in species selection, feeding and nutrition, site selection, cage design and construction, disease management, harvesting, marketing situation, and others (Mutyaba et al., 2024; Orinda et al., 2021). Access to aquaculture knowledge will improve fish farming production since farmers get insight, understanding, and experience, thereby improving fish farming production (Caffaro et al., 2020).

Despite its importance, cage fish farmers experience inadequate knowledge in managing and operating their daily farming practices (Mantey et al., 2020; Orinda et al., 2021). This gap is usually reflected in poor feeding practices, weak marketing strategy, poor disease treatment and control, poor fish processing and preservation, and others; all these turn to reduce productivity and profitability of cage fish farming(Ng'wigulu, 2021; Njiru et al., 2019; Sangirova et al., 2020). Previous studies conducted in the country have focused on knowledge sharing behaviour among fish farmers, the roles of ICTs among fish farmers, knowledge needs and accessibility in other sectors, like as pond fish farming and crop production (Benard et al., 2020; Mboya et al., 2023; Mosha & Daudi, 2020; Zain et al., 2022). However, aquaculture knowledge needs and access among cage fish farmers, particularly in Mwanza, where the practice is rapidly growing, is not known. Understanding aquaculture knowledge needs and their accessibility challenges among cage fish farmers provides the base for designing effective interventions to improve cage fish farming productivity. Therefore, this study was to assess aquaculture knowledge needs and access among cage fish farmers, specifically in the Mwanza region.

1.2 Research Objectives

i. To establish aquaculture knowledge needs among cage fish farmers,
ii. To determine the aquaculture knowledge accessibility among cage fish farmers,
iii. To examine the influence of social-demographic characteristics on cage fish farmer aquaculture knowledge needs and accessibility.

II. LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Information Need, Access, and Use Model

The study adopted the Information Need, Access, and Use model by Mtega (2012), which explains that every person has specific information needs that help them make informed decisions or answer particular questions in life and achieve specific developmental activities. Cage Fish farmers, like any other group, have various knowledge needs,

including knowledge of the market, fish harvest, fish breeding, and others (Obiero et al., 2022). In addition, once the knowledge need is identified, accessing the required information is the next step; however, access to the necessary knowledge is influenced by the available resources. As Mtega (2012) explains, the presence of disparities in information accessibility between rural and urban areas emphasizes the need to assess knowledge needs and accessibility among cage fish farmers in the Mwanza region. The model explains that knowledge needs and accessibility are influenced by various sociodemographic factors. In the context of this study, it describes how the cage fish farmers identify their knowledge needs and the accessibility of aquaculture knowledge. Additionally, it highlights those sociodemographic factors such as age, sex, education level, experience, farmer group membership, and income that influence knowledge need and access among cage fish farmers. Moreover, independent factors like fish farming technology, group membership, and the type of fish cultivated also affect knowledge needs and access.

2.2 Empirical Review

2.2.1 Aquaculture Knowledge Needs among Cage Fish Farmers

Cage fish farmers need diverse types of knowledge to operate effectively and efficiently. Ng'wigulu (2021) revealed that successful cage fish farming requires consideration of elements such as farmers' skills in feeding, financial management, and marketing. Also, skilled experts, research, and training are essential for improving cage fish farming productivity. Mutyaba et al. (2024) in Uganda identify key knowledge, including species selection, feeding and nutrition, site selection, cage design and construction, and disease management. Again, a study conducted by Lebel et al. (2015) in Thailand reported that cage fish farmers need aquaculture knowledge on risk management under climate change. In the Tanzanian context, Orinda et al. (2021) reports that many farmers lack access to field extension officers and formal training; they rely on peer-to-peer learning, which may limit the accuracy and relevance of the knowledge received. These findings emphasize the importance of ensuring that cage fish farmers are equipped with a relevant and comprehensive set of aquaculture knowledge to operate effectively and sustainably.

2.2.2 Aquaculture Knowledge Accessibility among Cage Fish Farmers

Knowledge accessibility among fish farmers is often hindered by inadequate extension services, lack of technological resources, and limited training programs (Haese et al., 2024). The finding indicates that farmers with better extension services and training programs will be in a good position to improve productivity in their farming practices. Moreover, a study conducted by Parmar et al.(2019) in India highlights that knowledge accessibility helps fish farmers to address various problems and uncertainties in their farming practices. Furthermore, Yule (2019), in Namibia, indicates that aquaculture knowledge accessibility boosts fish farming productivity by facilitating decision-making, connecting fish farmers across different platforms, and increasing the sustainability of fish farming. In Tanzania, the lack of formal training programs limits aquaculture knowledge accessibility among cage fish farmers. Cage fish farmers struggle with a limited understanding quality of feeds and seeds, disease prevention and treatments, which are core components for successful fish farming practices. Additionally, Mzula et al. (2021) in Tanzania report that limited technical know-how regarding fish health management further worsened the situation, leading to sub-optimal productivity levels. Ultimately, enhancing aquaculture knowledge accessibility is significant for boosting fish farming practices and ensuring the sustainability of Tanzania's cage fish farming sector. Limited assessment of aquaculture knowledge accessibility among cage fish farmers will hinder productivity levels.

2.2.3 Influence of Demographic factors on Aquaculture Knowledge needs and Accessibility

Aquaculture knowledge needs and accessibility among fish farmers are often shaped by socio-demographic characteristics. Factors such as age, sex, education level, farming experience, family income, and others significantly influence farmers' knowledge needs and their accessibility. A study conducted by Joshi et al. (2019) in America reports that age is a major contributing factor for farmers to access agricultural knowledge. Young farmers are more comfortable in using digital platforms to access agricultural knowledge compared to other groups. Moreover, a study conducted by Benard et al. (2018) in Tanzania highlights that, educated fish farmers are more likely to adopt new knowledge, synthesize knowledge, and read technical manuals compared to those with a lower level of education. Again, Orinda et al. (2021) in Tanzania report that gender dynamics play significant roles in fish farmers' participation in training programs, whereby males have more opportunities than females. Furthermore, Mtega et al. (2016) in Tanzania report that the level of knowledge accessibility among farmers increases with an increase in age. Understanding these variances is significant for designing inclusive and effective knowledge needs assessments and knowledge dissemination strategies among cage fish farmers.

2.3 Conceptual Framework

Figure 1 conceptual framework, shows the relationship between independent variables such as Age, Education level, Working Experience, Gender, Marital status, and Family income, and the dependent variable, which is

Aquaculture knowledge needs and aquaculture knowledge accessibility. Demographic factors influence both aquaculture knowledge needs and aquaculture knowledge accessibility of cage fish farmers. The assumption is that farmers' background and socio-economics shape the type of aquaculture knowledge they need and determine how easily they can access such aquaculture knowledge.

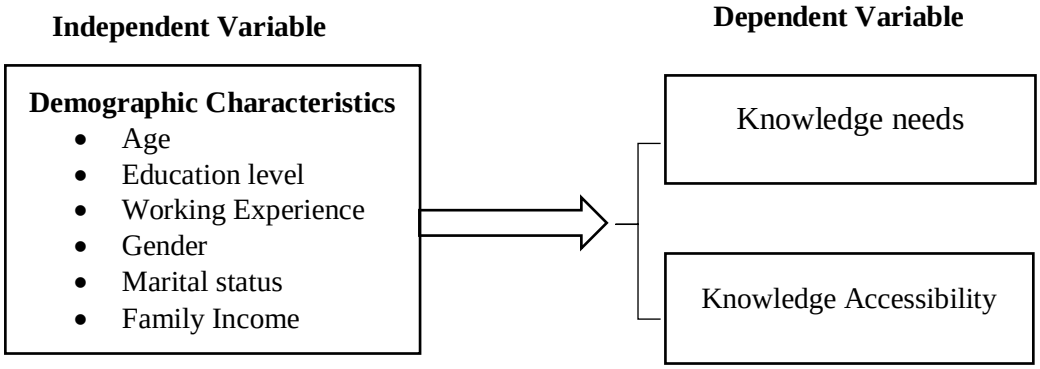

Figure 1
Conceptual Framework

III. METHODOLOGY

3.1 Description of the Study Area

The study was conducted across three districts: Ilemela, Nyamagana, and Magu in Mwanza, Tanzania. The districts were chosen due to the presence of cage fish farming activities, as they host the majority of cage aquaculture operations in the region (Mkuna & Baiyegunhi, 2021). Ilemela and Nyamagana are close to Mwanza city, providing good infrastructure services to reach markets and extension services, whereas Magu district is situated further from the urban center. All mentioned districts have demonstrated important engagement in cage fish farming, including multiple harvest cycles.

3.2 Research Design and Sampling Techniques

A cross-sectional research design was adopted for this study; data were collected at a single point in time. Both qualitative and quantitative methods were used to obtain a comprehensive insight. Quantitative data were collected by using a questionnaire survey that was administered to cage fish farmers, whereby Key informant interviews were used to collect Qualitative data among fishery extension officers and farm group leaders across three districts. Sampling techniques were undertaken in two stages. First, purposive sampling method was used to select districts in the study area based on their high concentration of cage fish farming activities and multiple harvest records (Mkuna & Baiyegunhi, 2021). Second, convenience sampling was used to obtain the number of respondents in the study for each district. This method was appropriate due to daily rotating and working schedules among cage fish farmers. Golzar and Noor (2022), report that convenience sampling can reduce bias and produce reliable data for quantitative research.

3.3 Sample Size

A total of 130 respondents were surveyed, with the following numbers: Nyamagana (n = 58), Ilemela (n = 52), and Magu (n = 20). Additionally, a total of six key informants were purposively selected to supplement quantitative data. These include one fisheries extension officer and one cage fish farm group leader from each of the three districts. These individuals were purposively selected because of their roles and in-depth knowledge of the aquaculture sector and direct involvement in cage fish farming in selected districts.

3.4 Data Analysis

This study was analyzed using a statistical package for social sciences (IBM SPSS), version 26. ANOVA was used to evaluate significant differences in the degree of aquaculture knowledge needed and accessibility among different categories of knowledge. Duncan's multiple range test was used to detect significant differences between means. Again, thematic analysis was used to determine the common themes and patterns regarding knowledge needs and accessibility.

3.4.1 To Establish Aquaculture Knowledge needs and Accessibility among Cage Fish Farmers in the Mwanza region

To determine respondents' aquaculture knowledge needs, they were given a list of possible aquaculture knowledge areas. They were then asked to rate their level of need for each item with options: "High," "Moderate,"

"Low," and "Not at all, " which were later scored as 4, 3, 2, and 1, respectively. Each respondent's knowledge need score was calculated by summing these individual scores.

Similarly, to assess respondents' aquaculture knowledge accessibility, they were provided a list of available knowledge sources and asked to rate their level of access with options: "Highly accessible," "Accessible," "Moderate," and "Not accessible," which were scored as 4, 3, 2, and 1, respectively. Each respondent's aquaculture knowledge accessibility score was obtained by summing all the access scores. Duncan's Multiple Range Tests were used to identify significant differences between group means, with a significance level of $P< 0.05$.

Multiple linear regression was used to analyze the demographic factors influencing respondents' aquaculture knowledge needs and accessibility.

$$Y = \beta_0+\beta_1X_1+ \beta_2X_2+\ldots+\beta_8X_8$$

Where;

Y= aquaculture knowledge needs score and aquaculture knowledge access scores

β= Régression Coefficients.

β0= Intercept.

$X_1 \ldots X_8$ are independents

The independent variables were measured as follows:Age of the farmer was measured as respondent's age (coded as 1=18–24, 2=25–34, 3=35–44, 4=45–54). 5 (more than 54), Sex was measured as being male or female (coded as 1= male, 0= female). Education level was measured in terms of level of literacy (coded as 1= primary education, 2= secondary 3=Diploma, 4=Vocational, 5=Undergraduate, 6=Postgraduate), Marital status was measured as to whether the respondent was single or married (coded as 1 = single, 0 = married). The size of the cage owned was measured in m² (coded as 1=less than 50, 2=51–100, 3=more than 100). Income was measured in Tanzanian currency (Tsh) (coded as 1=up to 500,000, 2=500,001-1,000,000, 3=1,000,001-1,500,000, 4=more than 1,500,000). Farming experience was measured as the number of years the person had been engaged in cage fish farming activities. Membership in farmers groups was measured by whether the respondent is a member or non-member in different farmers groups (coded as 1 = member, 0 = not a member). Prior to running the multiple linear regression model, the multicollinearity and autocorrelation assumptions using variance inflation factor (VIF) and Durbin-Watson, respectively, were performed.

IV. FINDING & DISCUSSION

4.1 Demographic Characteristics

Table 1 presents demographic characteristics of the respondents. The larger proportion of respondents were male, 79.2%; this may suggest that males are predominantly engaged in cage fish farming compared to females. This was due to a tedious type of farming activity. Most respondents (34.6%) were aged between 35 and 44 years old, which indicates that cage fish farming is attracting individuals in the mid-life stage. Regarding marital status, the majority are married, 45.4%. This suggests that aquaculture may be seen as a family-oriented activity in the region, where individuals prefer stability before venturing into farming. The education level varied, with the majority holding a diploma (33.1%), followed by secondary education. Furthermore, most of the cage fish farmers had 4 to 6 years of farming experience. This indicates that farming experience is a significant factor in cage fish farming. Moreover, regarding family income, 60% of cage fish farmers earn less than 500000. This suggests that a lack of credit access among them limits the highest investment in cage fish farming.

Table 1

Demographic Characteristics

Demographic	Response	Frequency	Percentage %
Gender	Male	103	79.2
	Female	27	20.8
Age	18-24	28	21.5
	25-34	29	22.3
	35-44	45	34.6
	45-54	23	17.7
	55+	3	3.9
Marital status	Single	53	40.8
	Married	59	45.4
	Separated	7	5.4
	Divorced	9	6.9
	Widow	2	1.5

Education level	Primary education	24	18.5
	Secondary education	35	26.9
	Diploma	43	33.1
	Undergraduate degree	13	10.0
	Post diploma	2	1.5
	Postgraduate degree	5	3.8
	Vocational/Technical training	8	6.2
Income	Less than 500,0000	78	60.0
	500,001-1000,000	31	23.8
	1000 001-1500,000	19	14.6
	More than 1500,000	2	1.5
Working experience	below 1	34	26.2
	1-3	34	26.2
	4-6	32	24.6
	7-9	18	13.8
	9+	12	9.2

Source: Field survey, 2025

4.2 Aquaculture Knowledge Needs among Cage Fish Farmers

Table 2 shows the results of aquaculture knowledge needs among cage fish farmers. The results indicate that there was a significant variation in the extent of aquaculture knowledge needs among cage fish farmers ($P<0.05$). The results indicate that the highly needed aquaculture knowledge was Fish feed and feeding, Fish breeding and Fish diseases. This suggests a strong demand for technical knowledge crucial to maintaining fish health and improving productivity.

These finding was echoed with qualitative data. One key informant resonated with similar concerns:

> "*Most of the farmers we work with frequently ask for more training on fish disease and treatment, especially on how to identify symptoms early and apply the right treatment''* KKI03 Another noted, ''*Feeding practices remain a common concern, with farmers frequently seeking guidance on appropriate feed types and quality.* KII05

Other priority aquaculture knowledge areas included understanding market dynamics, types and sources of feed, and weather conditions. These factors are important for informed production planning and risk mitigation. On the other hand, aquaculture knowledge, such as cage constructions, credit/loans, and fish preservation and processing, was reported as less needed. As one key informant stated

> ''*Cage construction is the part of daily practice, so many cage fish farmers have already mastered it''* (KII04)

The relatively lower demand for aquaculture knowledge on credit /loan access, Cage construction, and post-harvesting handling may indicate that either cage fish farmers already possess adequate knowledge in these areas or may not fully recognize their significance to overall productivity and profitability.

> ''*Frequently, cage fish farmers obtain training on credit /loans services so as they can help them to request funds, manage daily input and output also measure profitability, again this training influence a lot of people to engage in cage fish farming activities''*(KII 05)

Table 2

Aquaculture knowledge Needs and Accessibility of Cage Fish Farmers

Aquaculture Knowledge	**Needs**	**Accessibility**
Market situation	3.05^{ab}	2.05^{bc}
Weather conditions	3.15^{ab}	2.26^{b}
Credit/ loans	3.01^{bc}	3.13^{ab}
Cage construction	2.95^{c}	3.6^{a}
Fish Fingerling types/ sources	3.10^{bc}	2.11^{b}
Feed types and sources	3.18^{ab}	2.43^{b}
Fish disease prevention and treatment	3.26^{a}	2.01^{C}
Fish breeding	3.22^{a}	$2.4b^{c}$
Fish harvesting	3.01^{bc}	3.12^{ab}
Fish preservation and processing	2.87^{c}	3.54^{a}
Fish feeds and feeding	3.25^{a}	2.13bc

4.3 Accessibility of Aquaculture Knowledge among Cage Fish Farmers

The results in Table 2 showed a significant variation in the aquaculture knowledge accessibility among cage fish farmers (P<0.05). This means that cage fish farmers do not have uniform access to aquaculture knowledge. Findings highlight that most of the respondents have limited access to aquaculture knowledge in almost every category of cage fish farming. Aquaculture knowledge areas with the lowest accessibility scores included fish disease prevention and treatment, knowledge of the market situation, and feeding practices. These areas are foundational to the sustainability of aquaculture operations, and limited access represents a critical gap.

In contrast, aquaculture knowledge related to cage construction and fish preservation, and processing had the highest accessibility score. This can be attributed to the routine and practical nature of farming activities, which enable experimental learning and peer-to-peer knowledge sharing. As one key informant explained

> "*On-the-job practice and peer learning constitute effective and logical approaches for skill development in cage construction. This communal and experiential process ensures that all farmers, including newcomers, are well-equipped to construct and maintain cages efficiently, thereby supporting sustainable and productive aquaculture operations''* (KII 06)

4.4 The Influence of Social Demographic Factors on the Cage Fish Farmers' Aquaculture Knowledge Needs

The results in Table 3 showed the selected socio-demographic factors that influence aquaculture knowledge needs among cage fish farmers. The model included the following variables: sex, age, marital status, education level, farming experience, size of cage owned, and membership in farmers' groups. The results show that the multiple correlations of 0.60 imply that there is a positive and moderate relationship between the socio-economic characteristics and the knowledge needs. The coefficient of determination was 0.35, which means that the independent variables included in the model explained 35.40% of the respondents' knowledge needs.

Furthermore, the variance inflation factors of the independent variables ranged from 1.05 to 1.89, which is less than 10, implying that the independent variables do not have the problem of multicollinearity. Key note: Multiple R=.595, R Square=.354, Std. Error of the Estimate=5.81128, Durbin-Watson=1.588 sum square (Regression =2238.823, Residue=4086.285), Mean square (Regression =279.853, Residue=33.771), F 8, 121 =8.287, p=0.00

Table 3

Socio-Demographic Characteristics Influencing Aquaculture Knowledge Needs

Factor	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	53.374	3.014		17.707	.000		
Sex	-.584	1.285	-.034	-.455	.650	.957	1.045
Age	-.416	.464	-.075	-.898	.371	.770	1.298
Marital status	1.495	1.155	.107	1.294	.198	.786	1.272
Education level	-1.273	.352	-.287	-3.620	.000	.848	1.179
Farming experience	-1.110	.554	-.201	-2.005	.047	.529	1.891
Size of cage owned	-1.766	.893	-.195	-1.978	.050	.552	1.813
Annual income	-2.452	.679	-.279	-3.613	.000	.897	1.114
Member of farmer's group	-.849	1.481	-.044	-.573	.568	.910	1.099

The regression analysis revealed that education level, farming experience, and annual income all had negative and statistically significant beta coefficients, indicating an inverse relationship with aquaculture knowledge needs (P < 0.05). This suggests that farmers with higher education are better equipped to seek, interpret, and apply aquaculture knowledge independently. Moreover, farmers with more experience and higher income are more capable of independently accessing or already processing aquaculture knowledge, thus reporting fewer needs. Other factors, such as Sex, age, and group membership, did not have statistically significant effects, indicating these characteristics may have less influence on the perceived need for aquaculture knowledge.

4.5 The Influence of Socio-Demographic Factors on the Cage Fish Farmers' Aquaculture Knowledge Accessibility

The results in Table 4 reveal that socio-economic factors influence knowledge accessibility. The model includes the following variables: sex, age, marital status, education level, farming experience, size of cage owned, income, and membership in farmers' groups. The results show that the multiple correlation coefficient is 0. 594, indicating a positive and moderate relationship between socio- economic characteristics and knowledge accessibility. The coefficient of determination is 0. 353, meaning that the independent variables in the model explain 35. 30% of the respondents'

knowledge of accessibility. The findings are similar to those of Matelong (2019), who found that the independent variable contributes to a 34. 3% change in the dependent variable. The regression analysis showed that annual income, education level, and farming experience had a statistically significant positive effect on access to aquaculture knowledge among cage fish farmers ($P < 0.05$). These factors improve the ability of cage fish farmers to seek out and make use of aquaculture knowledge. Experienced farmers may have better access to networks, digital tools, and other extension services. Though factors like age, sex, and group membership were not statistically significant, they exhibited a positive trend in influencing aquaculture knowledge accessibility. This variable may still contribute indirectly through mechanisms such as social capital or digital familiarity.

Table 4

Socio-Demographic Characteristics Influencing Aquaculture Knowledge Accessibility

Factor	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	13.729	3.028		4.534	.000		
Sex	.846	1.291	.049	.655	.513	.957	1.045
Age	.335	.466	.060	.718	.474	.770	1.298
Marital status	-1.525	1.160	-.108	-1.315	.191	.786	1.272
Education level	1.062	.353	.239	3.006	.003	.848	1.179
Farming experience	1.295	.556	.234	2.328	.022	.529	1.891
Size of cage owned	1.609	.897	.177	1.794	.075	.552	1.813
Annual income	3.014	.682	.341	4.422	.000	.897	1.114
Member of farmer's group	1.311	1.487	.068	.881	.380	.910	1.099

4.6 Discussion

4.6.1 Aquaculture Knowledge needs of Cage Fish Farmers in the Study Area

Table 2 highlights that cage fish farmers are highly in need of aquaculture knowledge on Fish disease prevention and treatment, fish feeds and feeding, and fish breeding. This suggests that cage fish farmers need aquaculture knowledge on fish disease and treatments primarily to avoid the risks of losses and frequent treatments, because high stock densities in cages increase the risks of fish disease transmission, which can lead to significant economic losses if not well managed. Equipping farmers with this knowledge will enhance the productivity and long-term sustainability of cage fish farming operations. This was supported by the study conducted by Atukunda et al. (2022) in Uganda, which revealed that knowledge on fish feeding and disease control plays a significant role in enhancing the sustainability of cage fish farming. Understanding optimal breeding techniques and appropriate feed types helps to increase growth and reduce feed costs. This is a line with the study conducted by Magesi (2024) in Kenya, which reports that disease prevention knowledge is significant to minimizing fish mortality, which can have severe impacts on yields and income.

Moreover, the results highlight that aquaculture knowledge on market situations, credit loans/sources, fish harvesting, and fish fingerlings types was moderately needed. This implies that while cage fish farmers value these categories of aquaculture knowledge, they do not perceive them as more important compared to knowledge in fish feeding, fish disease control, and fish breeding. This is crucial because access to reliable knowledge on the market situation enables cage fish farmers to make informed decisions about where and when they can sell their fish for better profit and ensure that they are equipped with the risks of market fluctuations. Again, understanding credit/loans can help farmers to equip themselves with loans that are affordable to them and ensure profitability on their investments. This aligns with the study conducted by Mchombu (2024), who reports that fish farmers rarely need knowledge on credit or loans. Also, aquaculture knowledge on the Fish fingerlings type is significant for ensuring proper fish growth, minimizing feed wastage, and reducing cost. This was similar to the study conducted by Mantey et al. (2020), which showed that knowledge of fingerling is essential for cage fish farming by considering the size of fish and feeding times per day, and general management.

Surprisingly, the relatively lower aquaculture knowledge need was observed in the area of cage constructions, fish preservation, and processing. This implies that cage fish farmers already possess areas, whether through extension services, peer learning, or daily practical practice in maintaining and constructing cages. This was proven by one of the group leaders in Nyamagana district, who said Cage construction is their daily activities.

4.6.2 Aquaculture Knowledge Accessibility among Cage Fish Farmers in the Study Area

Table 2 reveals the aquaculture knowledge accessibility among cage fish farmers. The findings reveal that Cage fish farmers had limited aquaculture knowledge accessibility. This is due to inadequate extension services, illiteracy

rate, low level of education, and others. Similar results were conducted by Orinda et al. (2021) and Mutyaba et al. (2024), who reported that fish farmers rely on informal and unreliable aquaculture knowledge sources. Furthermore, the research conducted by Thomas et al. (2020) highlights that limited knowledge flows increase risks of poor farming practices and increase natural disasters among fish farmers. Furthermore, Mutyaba et al. (2024) showed that aquaculture knowledge accessibility is significantly associated with farming experience and level of education among fish farmers, as education increases the level of navigation in digital platforms to search for knowledge. Additionally, Benard et al. (2018) revealed that socioeconomic characteristics can influence farmers' access to knowledge positively or negatively. Moreover, Thomas et al. (2020) reveal that limited knowledge accessibility among farmers increases the risks of poor farming practices.

4.6.3 Influence of Demographic Factors on Aquaculture Knowledge Needs among Respondents.

The findings in Table 3 highlights the demographic characteristics that influence Aquaculture knowledge Needs among respondents. Education level showed a significant negative effect on aquaculture knowledge needs among cage fish farmers ($p < 0.05$). This indicates that a one-unit increase in education lowered aquaculture knowledge needs by 1.2 points. This may be due to cage fish farmers with a higher level of education are well equipped with the skills necessary to find, access, and utilize aquaculture knowledge compared to those with a lower level of education. This aligns with the research conducted by Chia et al. (2020), who report that access to education provides a foundation for learning resources.

Furthermore, farming experience was a negative but statistically significant influence on aquaculture knowledge needs among cage fish farmers. This indicates that experienced cage fish farmers have lower knowledge needs compared to cage fish farmers with no experience. This implies that experienced cage fish farmers have shaped their practical understanding of farming practices; they tend to acquire hands-on skills that influence them to infrequently require aquaculture knowledge. This was proven with the study conducted by Shemshack & Spector (2020), who report that farming experience enables farmers to expand their understanding, perspectives, and knowledge on a particular farming activity.

Additionally, family income has a negative beta coefficient and statistically significant influence on aquaculture knowledge needs among cage fish farmers. This highlights those farmers with higher incomes have lower aquaculture knowledge needs compared to those with lower incomes. This may be due to farmers with higher family income being in a better position to attend training opportunities and having access to knowledge resources, reducing the frequent need for additional knowledge. This aligns with the study conducted by Holeh et al. (2020) in Kenya reports that farmers with lower incomes tend to have higher knowledge needs, as they may lack access to training and resources like smartphones.

Moreover, regression analysis highlighted those demographic factors such as group membership, age, sex, and marital status did not have a statistically significant influence on aquaculture knowledge needs among cage fish farmers. These findings align with different studies conducted in aquaculture that report that demographic factors alone did not strongly determine the Knowledge needs among fish farmers, it supported by other factors such as easy accessibility and cost (Benard et al., 2018; Mboya et al., 2023; Ullah et al., 2020). This indicates that being single or married, young or old, and male or female does not shape cage fish farmers' aquaculture knowledge needs.

4.6.5 Influence of Demographic Factors in Aquaculture Knowledge Accessibility among Respondents.

The result in Table 4 indicates that family experience, level of education, and family income had positive and statistically significant influences on aquaculture knowledge accessibility among cage fish farmers in the Mwanza region ($p < 0.05$). This implies that cage fish farmers with higher income have greater access to aquaculture knowledge compared to those with lower income. This can be due to cage fish farmers with higher family income usually able to invest in aquaculture knowledge resources, such as ICTs, that facilitate aquaculture knowledge accessibility. This aligns with the study conducted by Ullah et al. (2020), who found that farmers with greater income in agriculture are more likely to access agricultural knowledge for better productivity. Furthermore, farmers with higher incomes are in a better position to engage in knowledge-sharing platforms and attend workshops, thereby enhancing their access to aquaculture knowledge. Moreover, education level has a positive beta coefficient and statistically significant influence on Aquaculture knowledge accessibility among cage fish farmers ($P < 0.05$). This is supported by the study conducted by Orinda et al. (2021), which revealed that education is a key aspect for successful cage fish farming, signaling that more educated fish farmers are more likely to succeed in this field.

Furthermore, farming experience has a positive beta coefficient, indicating that experienced cage fish farmers have higher aquaculture knowledge access; this variable was statistically significant ($P < 0.05$). This is due to experienced farmers being more familiar with different sources of aquaculture knowledge, which will simplify their access to knowledge, whereas those with less experience need to first need to build connections and become familiar with the activities. This was similar to the study conducted by Holeh et al. (2020), which indicated that fishing

experience is crucial for engaging in cage fish farming, as respondents noted they acquired knowledge from fellow fish farmers and parental sources. Additionally, cage size has a positive beta coefficient but is not statistically significant. The positive trends suggest that cage fish farmers with large cage sizes may also be more engaged in aquaculture knowledge accessibility.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The study highlights the significance of aquaculture knowledge needs and accessibility for improving cage fish farming productivity in Mwanza, Tanzania. Despite cage fish farming's potential for contributing in food security, employment and livelihood opportunities, cage fish farmers are required to understand their particular field effectively to avoid unnecessary risks. Fishery extension agents, stakeholders, and government institutions should collaborate with fishery extension officers and cage fish farmers to improve aquaculture knowledge needs assessments and increase access to aquaculture knowledge resources for authorizing farmers to adopt best farming practices and ensure sustainability and productivity of cage fish farming. With increasing technology in aquaculture worldwide, being knowledgeable about innovative solutions will enable cage fish farmers to address different challenges encountered during farming activities effectively. Additionally, socio-demographic factors such as education, farming experience, age, group, and membership should be considered in knowledge needs assessments and their accessibility levels among cage fish farmers, suggesting that aquaculture knowledge is not uniformly distributed across the farming population. A major contributor to this gap is the inadequate provision of extension services and the limited formal structures for disseminating aquaculture knowledge. Addressing this gap is crucial for enhancing productivity, mitigating risks, and ensuring the sustainability of cage fish farming in Mwanza, Tanzania.

5.2 Recommendations

The study recommends that fishery extension agents, government institutions, and other stakeholders should strengthen fishery extension services among cage fish farmers, particularly through distributing more extension officers who are specifically trained in cage fish farming. Moreover, the fishery extension commission should focus on the knowledge needs assessment before disseminating aquaculture knowledge to cage fish farmers, as this will increase the accuracy and relevance to the targeted audience. Furthermore, Future research should focus on assessing sources of aquaculture knowledge that are user-friendly to cage fish farmers and different training models and digital learning platforms that will suit cage fish farmers in accessing aquaculture knowledge. Understanding mechanisms to satisfy their needs will provide farmers with an understanding and help them make informed decisions.

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