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A Risk Management Framework for Catfish Farming in Ghana

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Abstract

Purpose: The growth of the catfish farming industry in Ghana has created opportunities for economic advancement and food security; however, significant risks threaten its sustainability. This study aims to propose a comprehensive risk management framework specifically tailored for catfish farming in Ghana, addressing production and financial risks.

Methodology: Data was collected from 120 respondents at Catfish Adwoa Atta Farms. The study analyzed production risks such as disease outbreaks and poor water quality, alongside financial risks including market fluctuations and limited access to credit.

Findings: The research revealed that production risks account for 40% of total yield losses, with disease-related mortality causing 25% of these losses. Financial risks were also prominent, with 21% of respondents reporting a profitability decline of over 20% due to limited access to financial support.

Unique contribution to theory, practice, and policy: The proposed framework integrates modern technologies such as IoT sensors for water quality monitoring, structured contract farming, and government-backed insurance schemes. Pilot testing in regions like the Volta and Ashanti regions is recommended to evaluate its effectiveness. Implementation of the framework could significantly enhance the resilience of catfish farms, reduce production losses, and improve profitability, positioning Ghana's aquaculture sector as a model for sustainable development.

Keywords: *Catfish Farming, Risk Management, Aquaculture, Financial Risk, Sustainability, Water Quality Management.*

Introduction

Aquaculture is essential to Ghana's agricultural sector, significantly contributing to national food security, employment, and economic growth. Among its subsectors, catfish farming has emerged as a critical component, growing at an annual rate of 14% between 2016 and 2020 and contributing 4.5% to Ghana's gross domestic product (Hasselberg et al., 2020). However, despite this growth, Ghana's fish production is unable to meet domestic demand, resulting in substantial fish imports to bridge the gap. Recognizing this challenge, the Ghanaian government introduced national initiatives such as the "Aquaculture for Food and Jobs" program, aimed at boosting domestic fish production, creating jobs, and enhancing food security (Zornu et al., 2023). Within this framework, catfish farming, especially involving species like Clarias gariepinus, is vital in tackling the nation's protein needs while reducing dependency on imports.

Catfish Adwoa Atta Farms, established in 2020, is a prime example of the sector's growth. It has expanded from rearing 100 fish at inception to managing over 5,000 catfish by 2023, contributing not only to food production but also to employment and economic diversification. However, like many farms in the sector, Catfish Adwoa Atta is exposed to various risks, including high mortality rates due to disease outbreaks, poor water quality, and price volatility in the market. The escalating cost of feed, making up over 70% of production expenses (Rurangwa et al., 2015), further aggravates these challenges. The absence of structured risk management frameworks leaves farms like Adwoa Atta vulnerable to financial instability, which could undermine their contribution to Ghana's food security and economic goals.

In comparison to sectors like finance or logistics, aquaculture in Ghana lacks comprehensive risk management systems (Onumah et al., 2018). Given the industry's complexity, encompassing environmental, operational, and market-related risks, there is an urgent need for tailored frameworks that can address the specific vulnerabilities of fish farms. This study proposes a risk management framework designed to mitigate key risks facing Ghanaian catfish farms. By integrating advanced technologies like IoT-based water quality monitoring, financial instruments such as insurance, and structured contract farming models, this framework seeks to enhance farm productivity, safeguard profitability, and align with national strategies to bolster domestic fish production and food security.

Background

Catfish farming is an essential pillar within Ghana's agricultural landscape, playing a critical role in food security, employment, and income generation. With the fisheries and aquaculture industry contributing about 4.5% to the country's gross domestic product (GDP), the aquaculture sector, particularly catfish farming, has grown at an impressive rate of 14% annually between 2016 and 2020 (Akuffo & Quagrainie, 2019). Despite this progress, Ghana's fish production continues to lag behind national demand, resulting in heavy reliance on fish imports. This imbalance presents

significant opportunities for local fish farming ventures, especially catfish farming, to not only meet domestic demand but also tap into export markets.

The rising demand for protein-rich food has catalyzed the expansion of Ghana's catfish industry. The African sharp-toothed catfish (*Clarias gariepinus*) is a dominant species in Ghana's aquaculture, favored for its adaptability and consumer appeal. Over 80% of aquaculture production in Ghana consists of catfish, reflecting its critical role in the country's food supply chain (FAO, 2019). The sector is largely driven by small-scale farms, which account for 60% of Ghana's total aquaculture output (Ragasa et al., 2022). In addition to direct employment, catfish farming contributes to the economy through its value chain, involving feed manufacturers, processors, marketers, and exporters.

However, the rapid growth of the catfish farming sector is accompanied by significant risks that threaten its long-term sustainability. Price fluctuations, disease outbreaks, and environmental degradation are common challenges that undermine farmers' revenue stability (Mbokane et al., 2022). Market oversupply, caused by uncoordinated production, frequently results in price crashes, further eroding profitability. High input costs, particularly for feed and energy, which account for over 70% of production expenses, exacerbate these challenges (Abokyi et al., 2022).

Despite these obstacles, the expansion of catfish farming holds considerable potential for Ghana's economic development, particularly as the government seeks to increase domestic fish production and reduce import dependence. Catfish Adwoa Atta Farms exemplifies the sector's rapid growth. Starting with only 100 fish in 2020, the farm has scaled up to 5,000 catfish by 2023, contributing significantly to domestic food supply and job creation. However, the farm's expansion has also brought heightened risks, such as increased mortality rates, rising operational costs, and market volatility. These challenges underscore the urgent need for structured risk management frameworks that can protect businesses from financial loss while ensuring long-term sustainability.

Without broad risk management strategies, farms like Catfish Adwoa Atta remain vulnerable to operational, market, and credit risks, which could lead to financial distress or bankruptcy. In contrast to sectors such as finance and logistics, where risk management systems are well-established, aquaculture in Ghana has yet to develop comparable safeguards (Essegbey & MacCarthy, 2020). The unique nature of aquaculture, involving environmental unpredictability and unstandardized production practices, necessitates the creation of tailored risk management strategies. Developing a risk management framework hence, would help farmers mitigate these risks, protect their investments, and contribute to the broader goal of national food security. Such a framework would encompass both internal farm processes and external market and environmental conditions, ensuring resilience for both small-scale and commercial farms across Ghana.

Literature Review

Aquaculture in Ghana

Aquaculture in Ghana has grown substantially since its introduction in the 1950s, primarily focusing on tilapia and catfish farming. Initially, aquaculture was promoted to enhance rural economies, provide jobs, and improve food security in the face of declining wild fish stocks and environmental challenges (Amenyogbe et al., 2018). The effort was spearheaded by the former Department of Fisheries in the northern region of Ghana, where the construction of fishponds began in 1953, marking the start of the commercial aquaculture industry (FAO, 2006).

Ghana's government recognized the potential of aquaculture and, after independence, integrated fish pond construction into national irrigation projects. The government planned to convert 5% of all irrigation schemes into fish farms to supplement the national fish supply and provide new income sources for local communities (MOFAD, 2015). Despite these early efforts, aquaculture production remains relatively low. As of 2016, Ghana produced around 3,257 tons of fish annually, with the majority of the sector comprising small-scale subsistence fish farmers (FAO, 2016). This underperformance can be attributed to several challenges, including low innovation, insufficient output intensification, and weak infrastructure.

Tilapia dominates Ghana's aquaculture, accounting for about 80% of total production, while catfish contributes about 20% (FAO, 2018). The popularity of tilapia and catfish as farmed species is linked to high public demand, ease of cultivation, and decades of research on their biology and culture techniques (Ragasa et al., 2018). However, the sector's overall performance has been limited by poor management practices, lack of adequate technological interventions, and insufficient government support.

To address the fish supply gap, the Ghanaian government launched the "Aquaculture for Food and Jobs" program in 2018, aiming to boost fish production, provide jobs, and enhance food security (MOFAD, 2018). Although the program has made some progress, structural challenges such as the lack of reliable fish feed, inadequate investment in infrastructure, and limited access to markets remain significant obstacles to sustainable growth.

Globally, aquaculture has been one of the fastest-growing food production sectors, accounting for more than half of the fish consumed worldwide (FAO, 2020). However, in Ghana, it has not fully realized its potential due to the absence of efficient marketing strategies, the slow uptake of modern farming practices, and financial constraints (Anane-Taabeah et al., 2012; Kassam, 2014). In particular, financial data related to the viability of aquaculture enterprises, especially catfish farming, are limited. Asmah (2008) and Machena & Moehl (2001) argue that the lack of robust economic data has deterred investment, making it difficult to assess the potential returns on aquaculture investments.

Aquaculture development in Ghana is concentrated around Lake Volta, with a small but growing number of farmers adopting cage culture systems. Most commercial farms operate in the

Asuogyaman District of the Eastern Region, although smaller-scale operations are also scattered across other regions such as Kpeve in the Volta Region and Akuse in the Lower Manya Krobo District (Kassam, 2014; MOFAD, 2019). In northern Ghana, fish farming is primarily practiced at irrigation sites and dams, where culture-based fisheries dominate (Rurangwa et al., 2015).

Catfish Production in Ghana

Catfish, particularly Clarias gariepinus and Heterobranchus longifilis, represent the second most significant species in Ghana's aquaculture industry after tilapia (Ragasa et al., 2018). Despite its importance, catfish production remains relatively small, accounting for only 10% of the country's total aquaculture output. In recent years, the annual production of catfish has ranged from 95 to 200 metric tons, well below the national target of 88,512 metric tons set for 2018 (FAO, 2018). The disparity between target and actual production is largely due to underreporting by small-scale farmers, poor record-keeping, and a shortage of trained extension officers to provide technical support in rural areas.

Catfish farming in Ghana is also challenged by the high cost of inputs, particularly fish feed. Feed costs account for 70–80% of the total production expenses on catfish farms (Farm Armelio, 2023). Imported commercial feeds like Aller Aqua have proven highly effective, with feed conversion ratios (FCR) as low as 1:1, meaning one kilogram of feed produces one kilogram of fish. However, these feeds are prohibitively expensive for many small-scale farmers, and the absence of affordable, high-quality local alternatives exacerbates the problem. Consequently, some farmers resort to lower-quality feeds such as rice bran and brewers' waste, which negatively impacts fish growth rates and overall farm profitability (Kassam, 2014; Cobbina, 2010).

Risk Management in Aquaculture

Risk management is essential for ensuring the sustainability of aquaculture enterprises, including catfish farming. Farmers face various risks, including disease outbreaks, fluctuating market prices, environmental hazards, and regulatory challenges (Beveridge et al., 2012). Disease outbreaks, in particular, pose a significant threat to catfish farming, with the potential to decimate entire stocks within a short period (Davis et al., 2020). Biosecurity measures such as water quality management, regular health checks, and the use of vaccines can mitigate the impact of disease. However, most small-scale farmers in Ghana lack the technical knowledge and resources to implement these practices effectively.

Market volatility is another major challenge. The price of catfish can fluctuate due to changes in demand, competition from other protein sources, and external factors such as economic downturns or changes in consumer preferences (FAO, 2020). Price fluctuations make it difficult for farmers to plan and budget, leading to financial instability. One strategy to manage this risk is price hedging, which allows farmers to lock in prices for their products in advance, thus protecting themselves against sudden market downturns (Hishamunda & Ridler, 2014).

Environmental risks, such as water scarcity and pollution, are also critical concerns in catfish farming. The use of water resources for fish farming can lead to competition with other agricultural and domestic uses, particularly in regions prone to drought (FAO, 2019). Pollution from fish farms, including waste and uneaten feed, can degrade water quality, impacting both farmed and wild fish populations. Sustainable farming practices, such as integrated multi-trophic aquaculture (IMTA), where different species are farmed together to recycle nutrients, have been proposed as a solution to reduce environmental impacts (Chopin, 2017).

Aquaculture Risk Management in other Jurisdictions

Several international models provide insights into risk management in aquaculture that could be adapted to Ghana's catfish farming industry. In Vietnam, for example, shrimp farmers have successfully implemented biosecurity protocols and disease monitoring systems to reduce losses from viral diseases (Phan et al., 2021). Similarly, Norway's salmon industry has pioneered the use of vaccines and genetic selection to improve fish health and reduce reliance on antibiotics (Gudding et al., 2020). These strategies highlight the importance of proactive disease management in reducing financial losses and enhancing farm profitability.

In India, the introduction of cooperatives has helped small-scale fish farmers pool resources and access better markets, reducing individual exposure to price fluctuations (Barman et al., 2020). Cooperative models could be beneficial in Ghana, where small-scale catfish farmers often lack access to formal markets and rely on middlemen who offer low prices.

Methodology

Research Design

The study adopted a quantitative research design to analyze the risks associated with catfish farming and develop a risk management framework. A structured questionnaire was employed to collect numerical data from catfish farmers, vendors, and stakeholders. The focus was on identifying key risk factors, their impact on profitability, and existing risk management practices. The quantitative data was analyzed using descriptive and inferential statistics to uncover trends and correlations between risks and profitability (Creswell & Creswell, 2017).

Population and Sampling

The target population included 145 participants, comprised of employees, vendors, and stakeholders of Catfish Adwoa Atta Farms. A stratified random sampling technique was employed to ensure each subgroup was adequately represented:

Farm employees (75): Responsible for farm operations.

Vendors (50): Suppliers of inputs and services.

Stakeholders (20): Government officials and aquaculture experts.

A total of 120 participants completed the survey. Stratified sampling ensured representativeness, while the final sample size was determined based on population size guidelines (Israel, 2021).

Data Collection

A structured questionnaire was used to gather data on demographic information, risk factors, profitability, and risk management practices. Questions included Likert scales for risk severity and profitability impacts. This approach ensured consistency and clarity in responses (Field, 2013).

Data Analysis

Descriptive statistics, including percentages, were used to summarize the data. Inferential statistics to draw out comparisons, were applied to explore impact of risks and profitability ensuring precision and reliability (Hair et al., 2010).

Validity and Reliability

To ensure validity, the questionnaire was pretested, and adjustments were made to enhance clarity. Cronbach's alpha was calculated to measure internal consistency, yielding a value of 0.78, indicating high reliability (Tavakol & Dennick, 2011). Stratified sampling further reinforced the validity of the results.

Ethical Considerations

Ethical approval was obtained, and informed consent was secured from all participants. Data anonymity and confidentiality were ensured throughout the study (Kumar, 2014).

Findings

Demographic Characteristics

The demographic analysis of respondents shows that the majority (63%) are between 31-50 years old, with 25% aged 23-30 and only 3% over 60, indicating a predominantly middle-aged workforce. Males dominate the sector, comprising 77% of respondents, while females account for only 23%. In terms of experience, 38% have been in the catfish farming business for 1-5 years, 25% have 11-15 years of experience, and 18% have 6-10 years, showing a mix of both new and seasoned participants. Regarding education, 38% of respondents have completed 1-5 years of schooling, reflecting a diverse educational background within the industry. These findings reveal the appeal of catfish farming across various age groups and education levels but also emphasize the male dominance, possibly influenced by sociocultural factors in agricultural participation. Table 1 show the demographic results as found by the study.

Table 1: Respondents' Demographic Characteristics

Variable	Categories	Frequency (N)	Percentage (%)
Age	23-30	30	25
	31-40	38	32
	41-50	37	31
	51-60	12	10
	61-67	3	3
Sex	Male	92	77
	Female	28	23
Years in Catfish Farming Business	1-5years	46	38
	6-10yeas	22	18
	11-15years	30	25
	16-20years	13	11
	21-25years	9	8
Education level	1-5 years	46	38
	6-10 years	34	28
	11-15 years	28	23
	16-20years	4	3
	21-25years	8	7
Total Area of Catfish Ponds	500-1,000m^2	64	53
	1,001-2,000m^2	38	32
	2,001-3,000m^2	18	15
TOTAL		**120**	**100**

Source: *Author's Construct*

Perspectives on Risk and Risk Management Techniques

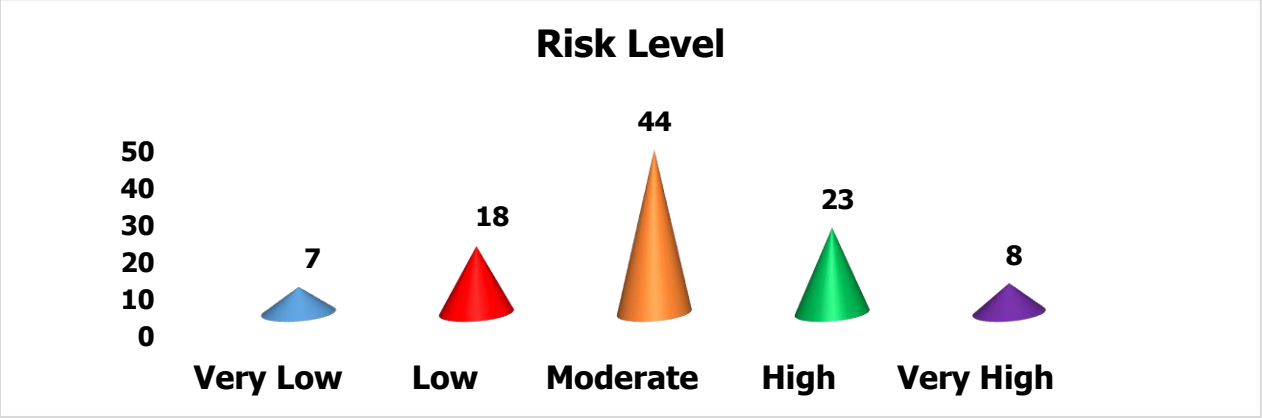

Figure 1: Percentage Distribution of Respondents' Risk Level

Respondents identified several risks in catfish farming, and their perceptions of these risks varied, as the study discovered that, majority of the respondents (44%) perceived a moderate risk level, with 23% considering it high. This suggests a general acknowledgment of risk but with varying concerns about severity as indicated in figure 1 above.

Risk Type

Production risk (37%) was deemed the most significant, followed by institutional risk (28%) and financial risk (21%). Pricing risk was viewed as the least critical at 14%. This prioritization signifies the vulnerability of catfish farming to factors such as yield and institutional policies. Table 2 reveals the risk type indicated by respondents.

Table 2: Risk Type (Multiple Responses, N = 120)

Risk Type	Frequency (N)	Percentage (%)
Production Risk	85	37
Pricing Risk	32	14
Institutional Risk	63	28
Financial Risk	48	21

Source: *Author's Construct*

Risk Management Techniques

According to table 3 below, the most commonly employed risk management technique was production contracts (48%), followed by insurance (32%). Less common methods included vertical integration (10%), diversification (6%), and hedging (4%).

Table 3: Risk Management Techniques (Multiple Responses, N = 120)

Risk Type	Frequency (N)	Percentage (%)
Diversification	12	37
Insurance	65	14
Production Contracts	98	
Hedging	8	28
Vertical Integration	21	21

Source: *Author's Construct*

Effectiveness of Catfish Industry

While risk management techniques are employed, their perceived effectiveness in figure 2 varied among respondents. The majority (46%) viewed them as moderately effective, while only 7% considered them extremely effective, highlighting room for improvement in risk mitigation strategies.

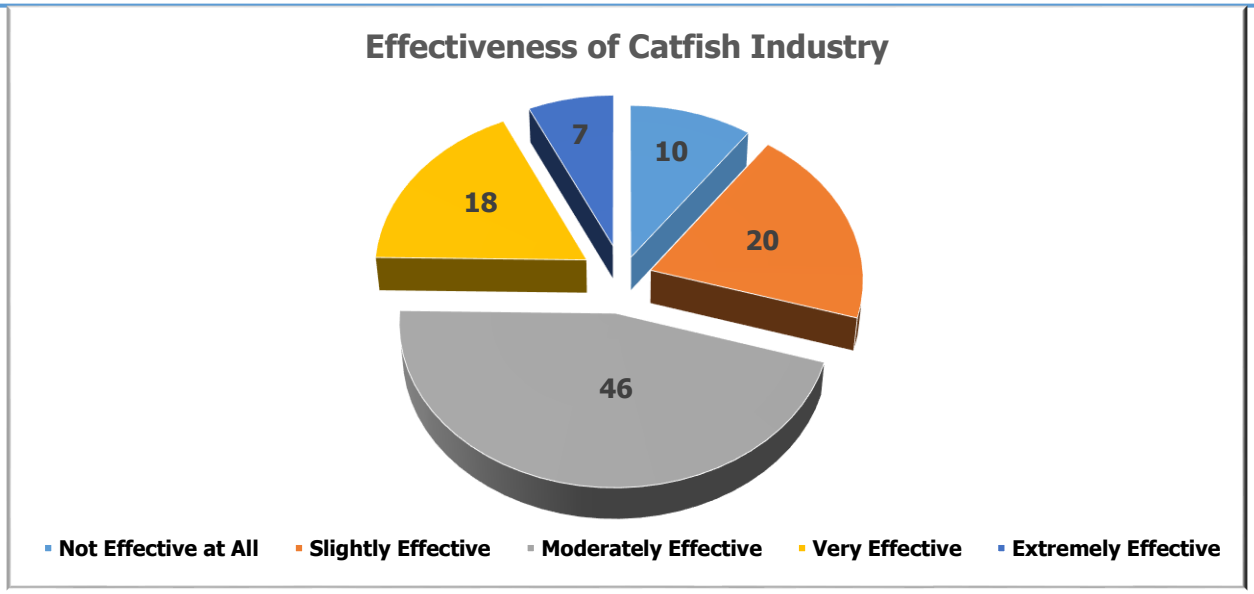

Figure 2: Percentage Distribution of Respondents' Perceived Effectiveness of Catfish Industry

Risk Impact

Causes of Production Losses in Catfish Farming

Disease-related mortality was responsible for 25% of production losses, while poor water quality contributed another 15%. Together, these two factors accounted for 40% of the total yield decline, stressing the critical need for improved biosecurity and water management practices as indicated in table 4 below.

Table 4: Causes of Production Losses in Catfish Farming

Causes of Production Loss	Frequency (N)	Percentage (%)
Disease-Related Mortality	30	25
Poor Water Quality	18	15
Other Causes	72	60
Total	**120**	**100%**

Source: *Author's Construct*

Financial Losses Due to Institutional and Financial Risks

Table 5 shows that, poor access to institutional support and financing led to a significant reduction in profitability, with 21% of respondents experiencing a 20% or more drop in profits. This underscores the impact of financial risks on farm performance and the necessity for better financial infrastructure and support mechanisms.

Table 5: Financial Losses Due to Institutional and Financial Risks

Financial Loss Impact	Frequency (N)	Percentage (%)
Drop in Profitability (>20%)	25	21
Stable or Increased Profitability	95	79
Total	**120**	**100**

Source: *Author's Construct*

Overall Risk Impact on Catfish Farming

The study from table 6 revealed that, the majority of risk impact comes from production-related factors (40%), followed by financial risks (21%), with other risks such as market fluctuations making up 39%. The analysis indicates a pressing need for risk management strategies in the areas of production and finance.

Table 6: Overall Risk Impact on Catfish Farming

Risk Type	Frequency (N)	Percentage (%)
Production Risks (Disease, Water)	48	40
Financial Risks	25	21
Other Risks	47	39
Total	**120**	**100**

Source: *Author's Construct*

Proposed Framework

Risk Management Framework for Catfish Farming in Ghana

The framework integrates technologies, best practices, and financial strategies tailored to the catfish farming industry in Ghana based on the findings.

Table 7: Technologies and Best Practices for Mitigating Production Risks

Risk Type	Mitigation Technique	Examples of Technologies or Best Practices
Disease Outbreaks	Biosecurity Measures	Regular water testing, use of UV filters, vaccination, and disease monitoring apps.
Poor Water Quality	Water Quality Management	Installation of aerators, water purification systems, and smart monitoring systems.
Yield Fluctuations	Precision Farming and Data Analytics	Use of IoT sensors to monitor water parameters and predict yield outcomes.
Nutrient Deficiency	Improved Feeding Systems	Adoption of automatic feeding systems and sustainable feed alternatives.

Source: *Author's Construct*

Technologies like UV filters for disease control, precision farming tools, and smart water monitoring systems play a significant role in reducing mortality rates and improving overall farm

yield. Biosecurity measures are dynamic to mitigating the 25% loss from disease outbreaks, while improved water quality management addresses the 15% losses caused by poor water conditions.

Table 8: Financial Risk Management Options for Catfish Farmers

Financial Risk Type	Mitigation Approach	Specific Options Available
Profitability Decline	Insurance Coverage	Ghana Agricultural Insurance Pool (GAIP), crop and livestock insurance.
Limited Access to Credit	Government-Supported Credit Programs	Agricultural Development Bank (ADB), Ghana Exim Bank financing.
Price Fluctuations	Structured Contract Farming	Contract agreements with local processing companies to secure fixed pricing.

Source: *Author's Construct*

To mitigate financial risks, farmers can explore insurance options provided by the GAIP to cover losses, including those from disease and environmental damage. Additionally, government-supported credit facilities from institutions like ADB offer loans with favorable terms, helping farmers overcome financial barriers and maintain operations even during challenging market conditions.

Table 9: Enhancing Environmental Sustainability

Sustainability Practice	Importance Level	Frequency (N)	Percentage (%)
Adopting Sustainable Farming	Extremely Important	26	21.7
Reducing Environmental Impact	Very Important	50	41.7
Alternative Feeds	Moderately Important	32	26.7
Not Important	Slightly Important	9	7.5
Total		**120**	**100**

Source: *Author's Construct*

The majority of respondents (41.7%) believe that adopting sustainable practices, such as using alternative feeds and reducing environmental impact, is essential for risk management. The use of eco-friendly practices like aquaponics and bio-based feed options ensures long-term sustainability in the catfish farming industry.

Table 10: Prioritized Risk Management Factors

Key Factors	Frequency	Percentage
Enhancing Farm Productivity	35	29
Ensuring Environmental Sustainability	28	23
Diversifying Income Sources	20	17
Strengthening Farmer Capacity	16	13
Promoting Collaboration	12	10
Building Resilience to Climate Change	5	4
Total	**120**	**100**

Source: *Author's Construct*

The survey reveals that enhancing farm productivity and efficiency (29%) is the highest priority for farmers, followed by ensuring environmental sustainability (23%). To improve risk management, diversification of income sources and stronger collaboration among stakeholders are key strategies that will help farmers become more resilient against market fluctuations and climate change.

Discussions

The demographic analysis revealed that the catfish farming industry is dominated by middle-aged males, with 63% of respondents aged 31-50 and 77% being male. This discovery aligns with a study conducted by Anaglo and Boateng, (2014), on gender and agriculture in sub-Saharan Africa, which note the male-dominated nature of many agricultural industries due to sociocultural constraints. However, the diverse range of participants, including those with varying years of experience, suggests that the industry is open to both new entrants and seasoned professionals. Targeted policies promoting inclusivity, particularly for women, could further improve participation in this growing sector.

Production risks were identified as the most significant, with 37% of respondents citing disease outbreaks and poor water quality as the primary concerns. This reflects global trends in aquaculture, where biological risks such as diseases are often the greatest threats to production (Ndashe et al., 2023). Current biosecurity measures, such as the use of UV filters and disease monitoring applications, can mitigate these risks, but their effectiveness depends on widespread adoption and proper implementation.

Financial risk was another major concern, with 21% of respondents reporting a decline in profitability due to poor access to institutional support and financing. This reflects findings by Ankrah et al., (2022), who stressed the importance of financial support structures, such as credit and insurance, in mitigating risks in aquaculture. The proposed inclusion of the Ghana Agricultural Insurance Pool (GAIP) and government-supported credit programs can help farmers manage these risks more effectively, providing them with a safety net against market fluctuations and production losses.

The study found that current risk management techniques, while present, are perceived as only moderately effective by most respondents (46%). This echoes the sentiments of studies in developing countries that emphasize the need for more robust, locally-tailored risk management frameworks (Renault et al., 2018). While insurance and production contracts are commonly used, the limited effectiveness of diversification and hedging strategies suggests that more advanced risk management tools are not widely utilized. Expanding access to these tools could improve resilience across the sector.

The proposed risk management framework integrates the use of modern technologies like IoT sensors for water quality monitoring and disease control, alongside financial solutions such as insurance and structured contract farming. These strategies are designed to address the specific challenges faced by Ghanaian catfish farmers and are consistent with broader trends in aquaculture risk management. National and regional policymakers should consider these findings when designing agricultural policies, especially those aimed at strengthening institutional support for farmers. The integration of environmental sustainability practices into the framework is also critical, as 41.7% of respondents identified sustainability as a priority.

This study builds upon existing aquaculture risk management models by emphasizing the role of local situation in the development of risk management frameworks. Previous models have largely focused on general approaches, but this research points the need for a framework that addresses the unique financial, institutional, and environmental risks in Ghanaian aquaculture. The findings support the argument made by Onumah et al., (2018) that location-specific strategies are more effective in managing risks in aquaculture, as opposed to a one-size-fits-all approach.

Recommendation

This study on a risk management framework for catfish farming in Ghana demonstrate the need for tailored, locally-relevant solutions that address these specific risks while promoting sustainability and productivity. By integrating modern technologies like IoT sensors for monitoring and precision farming, alongside financial tools such as insurance and structured contract farming. One key recommendation is to pilot the framework in regions with high concentrations of catfish farms, such as the Volta and Ashanti regions. These areas not only contribute significantly to Ghana's aquaculture production but also possess the necessary infrastructure to implement and evaluate the effectiveness of the proposed solutions. By starting in these regions, policymakers can assess the impact of the framework on farm productivity and sustainability, gathering valuable data for broader national implementation.

Conclusion

Over the long term, the adoption of this risk management framework has the potential to transform Ghana's aquaculture sector. By addressing the critical risks of disease, poor water quality, and financial instability, the framework can enhance the resilience of catfish farms, reduce losses, and improve profitability. Additionally, by promoting environmental sustainability and the use of

alternative feeds, the framework supports the country's broader goals of sustainable agriculture and resource conservation. As the framework is scaled up, it can also help to create more inclusive growth, encouraging greater participation from women and younger farmers, and fostering stronger collaboration among stakeholders. Ultimately, this framework can position Ghana's aquaculture sector as a model for sustainable and resilient farming across the region.

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