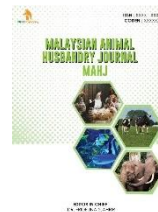




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RESEARCH ARTICLE

ASSESSMENT OF RISKS AND UNCERTAINTIES IN CATFISH FARMING IN NIGERIA

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ABSTRACT

The risks and uncertainties encountered by fish farmers play a big role in the productivity of a fish farming enterprise. The study sought to identify and determine the severity of risks and uncertainties faced by fish farmers in Nigeria. A multi-stage sampling technique was used to collect data from 120 respondents by administering a well-structured questionnaire which was analyzed using descriptive statistics and ordinal logistic regression. Results indicated that the primary risks faced by fish farmers include environmental factors such as wind and inadequate water supply, alongside market, financial, and personal risks. Further, factors influencing the severity of risk in fish farming included age, farm experience, credit access, household size, and water supply. The study concludes that while fish farming remains a viable livelihood option, addressing risks through improved farming practices, access to credit, and capacity-building programs is essential to ensure sustainability and productivity in the sector. The findings highlight the need for policymakers and stakeholders to develop effective risk mitigation strategies to enhance the resilience of fish farmers against both natural and human-induced risks.

KEYWORDS

Aquaculture, Catfish farming, Ordinal logistic regression, Risk management, Socioeconomic factors, Uncertainty.

1. INTRODUCTION

Fish represent one of the most diverse groups of aquatic animals, utilizing gills for respiration. With over 20,000 identified species, they surpass the diversity of all other vertebrates (Keddy, 2010). Additionally, fish and fisheries products dominate consumer markets in Africa, catering to a vast number of consumers (Ogunji and Wuertz, 2023). The development of aquaculture holds significant potential for addressing issues of undernutrition and poverty (Oyase et al., 2016). The fishery sub-sector offers employment opportunities across all age groups, serving as a sustainable alternative to depleted capture fisheries and a source of foreign exchange (N'Souvi et al., 2021). Aquaculture can be practiced at various scales, ranging from small-scale to intensive operations requiring medium to high investments. This enables fishermen and farmers to enhance their living standards through the income generated from fishery production (Kwatra et al., 2024). The fishery industry occupies a unique and significant role within the agricultural sector of the Nigerian economy (Hasan et al., 2020).

Aquaculture refers to the controlled cultivation of aquatic organisms in various enclosed water bodies, including dams, pens, ponds, cages, tanks, raceways, reservoirs, and rice fields (Verdegem et al., 2023). Specifically, fish farming, often known as aquaculture, is the controlled cultivation of fish in certain settings. In Nigeria, fish farming has emerged as a means to improve food production, employment, and diversification of livelihood (Subasinghe et al., 2021). This was necessary since the traditional method of fishing, known as artisanal fishery, was extensively exploited in the 1960s and 1970s, resulting in a significant decline in capture fisheries (Dienye, 2020). Fish plays a crucial role in supporting the survival and overall health of a substantial population in the country. It is widely recognized as a significant source of animal protein that is not subject to religious restrictions or cultural limitations, unlike pork and beef (Oladimeji et al., 2017). The primary goal of fish culture is to rear fish in

streams, pens, cages, and ponds, ensuring they grow to table size within a short period. In Nigeria, fish farming remains in its early stages, despite the extensive inland water resources estimated at 12.5 million hectares, encompassing rivers and streams. Additionally, natural lakes, reservoirs, and artificial ponds are underutilized, estimated at 11.5 million hectares (Adesoji et al., 2013). In most regions in Nigeria, private individuals predominantly practice fish cultivation at a subsistence level, with only a few engaging in commercial-level operations (Miller and Atanda, 2011). The decline in oceanic fish catches has hindered the ability of capture fisheries to effectively bridge the gap between fish demand and supply. Consequently, it is essential to replace capture fisheries with a more sustainable and modern approach, namely aquaculture (Achionye-Nzeh, 2021).

The African Catfish, scientifically known as *Clarias gariepinus*, is the primary fish species cultivated in Nigeria because of its excellent ability to adapt to the environment, rapid development rate, efficient feed conversion, resilient nature that enables easy retailing of live fish, and high market value (Kadurumba et al., 2021). Catfish production primarily occurs in concrete ponds, earthen ponds, tarpaulins, plastic containers, and collapsible ponds. It serves as a livelihood sustenance for farmers, possesses a notable capacity for preserving protein inside the body, contains minimal amounts of fat and cholesterol, and acts as a nutritious source of animal protein (Agyei, 2022). Catfish production not only provides a means of earning a living but also helps to decrease the unemployment rate in the economy and boost the Gross Domestic Product (GDP) (Folorunso et al., 2021). It is more economically advantageous than tilapia in some countries due to its ability to be sold while still alive and its higher demand, which can be two to three times greater than tilapia (Aminu et al., 2021).

There is a growing demand for fish in Nigeria due to its significant impact on personal and national well-being (Fakoya et al., 2021). Fish is a

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recommended source of animal protein for individuals aged 50 and over due to its high content of omega-III fatty acids, which have been shown to decrease the risk of cardiovascular illnesses, hypertension, and arteriosclerosis (Balogun et al., 2021). Omega III fatty acids have been found to promote optimal brain cell growth in growing fetuses, making them an essential component of the diet for pregnant women and contributing to higher intelligence quotient (IQ) in a child's development (Huffman et al., 2013). Aquaculture presents an effective solution for ensuring protein security, reducing hunger, and mitigating fluctuations in the availability of fish. To address the supply shortage and meet the growing demand, it is essential to increase fish farming production products (Dewali et al., 2023). This need arises from the decreasing resources of capture fisheries due to pollution, over-exploitation, and habitat degradation. However, fish production entails biological production processes that are vulnerable to various unpredictable natural factors, including pests and diseases, weather conditions, and infertility, which all contribute to yield fluctuations. The complex nature of weather and climate, combined with environmental and physical factors, makes managing fish farming operations challenging and risky (Oladimeji et al., 2017).

Risk refers to the likelihood of negative outcomes or anticipated losses resulting from the combination of natural or human-caused hazards and vulnerable circumstances. These risks can be foreseen and quantitatively assessed, making them insurable (Thomas, 2023). Uncertainty describes a situation where a course of action can lead to multiple outcomes, with the specific nature of each outcome being unknown (Cascaledi-Garcia et al., 2023). In practice, risk and uncertainty are often used interchangeably due to the inherent uncertainty associated with risk and the presence of risk in most uncertainties (Banjoko et al., 2015). The threat posed by risk and uncertainty is substantial, leading to significant financial losses, psychological distress, and even business collapse (Hamid and Chiman, 2010). Effective risk management in agriculture is crucial for several reasons, even though it does not necessarily enhance farmers' well-being. Poor risk management directly affects the stability of farmers' income, market conditions, and potential for food security (Claire, 2010). The risks associated with fish farming encompass not only technical and production aspects but also market, socioeconomic, financial, human-induced, and political factors (Oladimeji et al., 2017).

Although the catfish sector plays a crucial role in alleviating hunger, ensuring food and protein security, and improving the standard of living of farmers, it faces numerous risks that are largely outside the farmers' control. Risk in catfish production can arise from various factors, including breeding, production, marketing, personal, financial, and institutional aspects (Aminu et al., 2021). Production risk arises from various factors such as unfavorable weather, pests, diseases, technological issues, and other events that directly impact the quantity and quality of output (Ranjbar et al., 202). Marketing risk arises from a lack of confidence in the catfish market, which can be attributed to the unpredictable changes in both output and input prices (Omananyi, 2021). Financial risk is closely tied to the process of obtaining and funding capital, as well as the farmer's ability to generate sufficient returns to repay loans or credit (Pasch and Palm, 2021). Institutional risk stems from the uncertainties surrounding standards, and legal and government policies that impact the agricultural sector (Komarek et al., 2020). Personal risk can stem from various human factors, including illness, accidents, asset loss, income loss, labor shortage, unfortunate events like death or divorce, as well as incidents like fire outbreaks, burglaries, or theft (Dziwornu, 2019). These are inherent risks in catfish production that farmers must consistently address to mitigate their impact on their fishing business. When it comes to risk management, one must carefully consider different options to minimize the financial impact that may arise from uncertainties and potential risks (Aminu et al., 2021).

The fish industry has a significant impact on both the economy and nutrition of the nation. Nigeria possesses a wealth of inland water bodies that are utilized by small-scale fish farmers thereby making it important to harness these resources prudently and sustainably (Ibok et al., 2017). Given the impact of risks and uncertainties on farmers' productivity, profit, management, and investment decisions and the scarcity of studies focusing on risk and uncertainties in fish farming in literature, it becomes crucial to evaluate fish farming to gain a deeper understanding and explore avenues for enhancing the fish farming enterprise. This study therefore examined the risks and uncertainties that fish farmers in Kwara state, Nigeria face. The specific objectives were to analyze the risks and uncertainties faced by the fish farmers, assess the severity of these risks, and understand the factors that influence their severity.

2. METHODOLOGY

2.1 Study area

The study was carried out in Kwara State, Nigeria (Figure 1), which is located at approximately 8.9669°N latitude and 4.3874°E longitude. Covering an area of around 32,500 square kilometers, Kwara State encompasses a total land area of 3,682,500 hectares and has an estimated population of approximately 3.5 million people (NPC, 2022). The region experiences annual rainfall ranging from 800 mm to 1500 mm. The dominant fish species in the area include various types of catfish, such as *Clarias gariepinus*, the hybrid *Heterobranchus* (commonly known as hetero clarias), *Heterobranchus bidorsalis*, and *Chrysichthys nigrodigitatus*, among others.

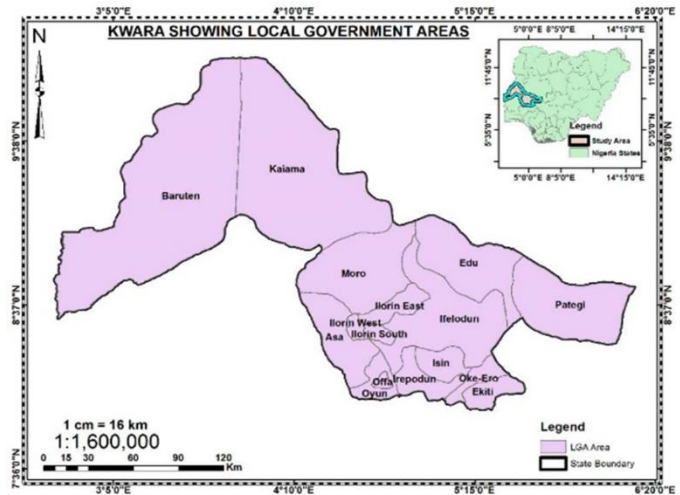


Figure 1: Map of Kwara State, Nigeria showing the local government areas (LGAs) (Omotosho et al., 2019)

2.2 Sampling procedure

A multi-stage random sampling technique was employed. The first stage involved the purposive selection of the three local government areas: Ilorin South, Ilorin West, and Asa (Fig 1). This was based on the density of fish farmers in the local government area and their proximity. The second stage involved the purposive selection of two fishing settlements in each of the three LGAs due to their higher volume of fishing activities. In the third stage, 120 fish farmers were randomly selected across the two fishing settlements to arrive at a representative sample for the survey.

2.3 Data collection

A structured questionnaire was employed to gather primary data on various socioeconomic factors, including education level, age, fishing experience, farm size, availability of credit facilities, and access to extension services. The questionnaire incorporated a five-point Likert scale to evaluate the risks and constraints encountered by fish farmers, with the following scale: 1 = not severe, 2 = less severe, 3 = severe, 4 = very severe, and 5 = extremely severe. A mean cut-off point was calculated and utilized to rank the identified risks and constraints accordingly

$$5+4+3+2+1=15/5=3.0$$

Items above the mean cut-off (3.0) were considered as risks/constraints faced by fish farmers in the study area while items below the mean cut-off (3.0) were not considered as risks/constraints faced by fish farmers in the study area.

2.4 Data analysis

2.4.1 Descriptive statistics

Frequency and percentage were used to describe the socioeconomic characteristics of the respondents and the risks/challenges faced by the respondents.

2.4.2 Ordinal Logistic Regression

This is used to model the relationship between an ordinal dependent variable and one or more independent variables. An ordinal dependent variable has ordered categories but the distances between the categories are not necessarily equal. The model can be represented as.

$$\text{Log}(P(Y \leq j)/P(Y > j)) = \alpha_j - \beta_1X_1 - \beta_2X_2 - \dots - \beta_kX_k \quad (1)$$

where:

$P(Y \leq j)$ is the probability that the dependent variable Y is less than or equal to category j .

α_j is a threshold parameter for category j .

$\beta_1, \beta_2, \dots, \beta_k$ are the coefficients for the independent variables X_1, X_2, \dots, X_k .

Specifically.

Y = Severity of risk (Ranges from seriously severe to not severe)

X_1 = Sex, X_2 = Age, X_3 = Education qualification, X_4 = Distance to fishing site, X_5 = income from fish farm, X_6 = income from other source, X_7 = Farm size and X_8 = Farming Experience

E = Error Term

3. RESULTS AND DISCUSSION

3.1 Socioeconomic characteristics of the respondents

Results revealed that most respondents were male, representing about 76% of the total sampled respondents implying that males are highly involved in fish farming (Table 1). This may be because fish farming requires energetic individuals in the fish production process. This result supports the findings of researchers in 2019 who observed that male catfish farmers have superior abilities in managing the risks and uncertainties inherent in catfish farming (Baruwa et al., 2019). A study reported that females are majorly involved in marketing and processing (Mmanda et al., 2020). Most of the farmers were between 31 – 40 years of age, which means they are still active and agile. Majority of the respondents, representing about 63% of the sampled fish farmers, were married. This is probably due to their necessity to cater to the families' needs. This agrees with the study in 2020 was reported that the majority of farmers are married (Chettri and Kundu, 2020). Most fish farmers were taught, with few having no formal education. This is reflected in the proportion (96%) of the sampled fish farmers having at least primary education as their highest level of education. Most of the respondents, representing about 70% of the fish farmers had household sizes below 5 people with the average household size of the respondents being 4 people. This contradicts the discovery of Olaoye et al., in 2013 who reported that the average household size of a fish farmer is 9. The mean farm size of the fish farmers was 5 hectares with the majority (62%) of the farmers having farms below the average farm size. The majority (52%) of the fish farmers had farm experience of less than 5 years with the average years of experience being 7 years. This aligns with the findings of a study in 2021 that indicated that catfish farmers with more years of experience have developed strong skills, improved strategies for their fish farming business, the ability to predict market conditions for increased sales, awareness of potential risks, and effective adaptive mechanisms (Aminu et al., 2021). Furthermore, most of the respondents, representing about 65% of fish farmers use the concrete type of pond for fish production and about 53% of the fish farmers owned their fish ponds. Also, about 51% of the respondents had no access to credit facilities and this can limit fish farming business expansion.

Table 1: Socioeconomic characteristics of the respondents (N = 120)			
Variables	Frequency	Percentage	Mean
Gender			
Female	29	24.17	
Male	91	75.83	
Age			
21-31	39	32.50	34
31-40	46	38.33	
41-50	21	17.50	
51-60	10	8.33	
61-70	4	3.33	
Marital Status			
Single	41	34.17	
Married	76	63.33	
Divorced	1	0.83	

Table 1 (Cont): Socioeconomic characteristics of the respondents (N = 120)			
Widowed	2	1.67	
Level of education			
No formal	4	3.33	
Primary	15	12.50	
Secondary	55	45.83	
Tertiary	45	37.50	
Islamic	1	0.83	
Household size			
<5	84	70.0	4
6-10	35	29.17	
>10	1	0.83	
Farm size (Hectares)			
<5	74	61.67	5
6-10	41	34.17	
>10	5	4.17	
Farm experience			
<5	61	52.50	7
6-15	50	41.67	
16-25	5	4.17	
26-35	2	1.67	
Land ownership			
Owned	67	55.83	
Rented	35	29.17	
Borrowed	18	15.00	
Access to credit			
No	61	50.83	
Yes	59	49.17	
Pond type			
Concrete	78	65.0	
Earthen	42	35.0	

Source: Field survey

3.2 Risk and uncertainty sources in fish farming

Results revealed that the sunny weather was highlighted by the respondents as the major risk from the weather conditions of the area (Table 2). Majority (60%) of the farmers indicated that the water supply was moderate during the fish farm period. Also, most of the respondents highlighted that they get veterinary services for their livestock from educated doctors, which reduces the risk of losing their fish to improper treatments. Furthermore, most of the respondents, representing about 68% of the fish farmers, feed their fish twice a day. Most (69%) of the sampled fish farmers raised the pure fish breed while a majority (47%) of the farmers stock their fish at the hatchling stage and raise them till they reach table size. This aligns with the findings of Biswas in 2019 who reported that most farmers stock hatchlings since they can resist some percentage of stress and diseases at this stage. The intricate characteristics of weather and climate, along with environmental and physical factors, pose challenges in the management of fish farming enterprises (Oladimeji et al., 2017). Risks associated with fish farming encompass not only technical and production aspects, but also price and market, socioeconomic, physical, human, political, and financial triggered risks (Le and Cheong, 2010).

Table 2: Risk and uncertainty encountered			
Risks	Categories	Frequency	Percentage
Weather	Rainy	42	35
	Cool	18	15
	Sunny	60	50

Table 2 (Cont): Risk and uncertainty encountered

Water supply	Excess	35	29.17
	Moderate	72	60.0
	Scarce	13	10.83
Veterinary	Local doctor	36	30
	Educated doctor	84	70
Feeding frequency	1 time	38	31.67
	2 times	81	67.50
	3 times	1	0.83
Fish breed	Pure breed	83	69.17
	Hybrid	37	30.83
Stock	Hatchling	56	46.67
	Fingerling	42	35.00
	Others	22	18.33

Source: Field survey

Table 3: Severity of risk and uncertainty encountered

Constraint	Not severe	Less severe	Severe	Very severe	Seriously severe	Mean score	Rank
Wind	35	27	34	15	9	3.47	1 st
Inadequate water supply	32	30	20	26	12	3.35	2 nd
Environment risks	36	26	35	16	11	3.35	2 nd
Marketing risk	29	23	43	15	10	3.33	3 rd
Erosion	28	29	30	18	15	3.32	4 th
Disease	30	26	28	24	12	3.28	5 th
Health risks	30	20	20	28	12	3.15	6 th
Chemical spillage incidence	25	28	19	20	28	3.04	7 th
Visitors	23	21	34	21	21	3.02	8 th
Poor access to farm credit	22	19	27	27	26	2.86	9 th
Theft	25	16	25	32	22	2.84	10 th
Neighbourhood	22	18	26	30	24	2.83	11 th
Water availability in the dry season	18	24	26	22	30	2.83	11 th
Price fluctuation in feed and fish	14	12	41	35	18	2.73	12 th
Inadequate fund	24	16	33	28	19	2.67	13 th
High cost of labor	18	13	34	26	29	2.67	14 th
Poor extension contact	17	8	24	40	31	2.43	15 th

Source: Field survey

3.4 Factors influencing the severity of risk and uncertainties encountered by fish farmers

Results regarding the factors influencing the severity of risk and uncertainties encountered by fish farmers are presented in Table 4. Regarding the “not severe” category, age, farm experience, credit access, and water supply were found to be significant factors influencing the severity of risk and uncertainties by fish farmers in the region. Younger fish farmers are less likely to experience severe risks and uncertainties. This could be attributed to their potentially higher adaptability and willingness to adopt new technologies and practices, which may mitigate risks. This conforms with the findings of Ahmad et al., in 2020 who reported that younger farmers are more averse to risk. Risk and uncertainties are likely not to be severe for those who have access to water supply. Access to a reliable water supply is crucial for fish farming. Adequate water supply reduces the severity of risks related to water scarcity, such as reduced fish growth and increased disease susceptibility. Further, access to credit increases the probability of non-severe risks among fish farmers. Credit can provide the financial resources to invest in risk mitigation strategies, such as improved infrastructure, better feed, and disease control measures. The probability of non-severity increased with increasing farm experience. Adequate farm experience enhances the

3.3 Severity of risk and uncertainty encountered by fish farmers

Results (Table 3) showed that farmers highlighted the incidence of wind as the major severe risk they encountered. This could cause turbidity in the fish ponds as a result of excessive mixing caused by heavy winds. Inadequate water supply and environmental risk were highlighted as the second major severity encountered by the fish farmers. Water is paramount in fish production and environmental factors are crucial to sustainable fish production. Marketing risk was highlighted as the third major severity faced by the fish farmers which could be as a result of lack of consumer demand for the fish product due to price. Erosion was also highlighted as the fourth major risk and uncertainty encountered by the farmers. Further, disease and health risks were highlighted as the fifth and sixth major risks and uncertainty encountered by the fish farmers. Chemical spillage incidence was highlighted as the seventh major risk and uncertainty encountered by fish farmers in the region. Visitors were regarded as the last major risk and uncertainty encountered by fish farmers in the region.

likelihood of managing risks effectively. Experienced farmers may possess better knowledge and skills, allowing them to anticipate and mitigate potential challenges. Also, it was reported years of farming experience as a significant factor influencing risk perception (Akhtar et al., 2018).

Age, marital status (Married), farming experience, and access to credit were significant factors at the “less severe” level of risk and uncertainties. Similar to the “not severe” category, younger farmers are more likely to encounter less severe risks. Their energy, innovative mindset, and flexibility might contribute to better risk management. Married farmers are likely to face less severe risks and uncertainties. This could be due to the support system provided by a family, which may offer additional labor and financial stability, contributing to better risk management. A study reported that married farmers are more likely to request loans from friends to mitigate risks associated with farming (Ellis, 2017). Also, farmers who have access to credit are more likely to encounter less severity of risk and uncertainties. Similar to the “not severe” category, access to credit helps farmers manage and mitigate risks, reducing their severity. Also, more experienced farmers face less severe risks, as their accumulated knowledge and skills help them navigate challenges more effectively.

Household size, access to credit, and water supply were significant factors

at the “severe” level of risk and uncertainties. Farmers with smaller household sizes are more likely to encounter severe risks in their fish farming enterprises. A larger household might provide additional labor and support, helping to manage farm operations more effectively and mitigate risks. This agrees with those of researchers who reported that risks are likely to be mitigated with increasing household size (Zeweld et al., 2019). Further, fish farmers are more likely to encounter severe risks and uncertainties with an increase in water supply on their farms. This counterintuitive finding might indicate that excessive water could lead to management challenges, such as higher maintenance costs or issues with water quality control. Interestingly, access to credit is associated with more severe risks. This might suggest that farmers with access to credit are more likely to take on riskier ventures or expand operations, which could lead to greater exposure to risks. This corroborates the findings of Aminu et al., who reported that farmers who had access to bank loans were more likely to encounter risks (Aminu et al., 2019).

Age, farm experience, access to credit, and water supply were the significant factors that influenced the “seriously severe” level of risk and uncertainties encountered by the fish farmers. Results implied that older farmers are more likely to encounter seriously severe risks and uncertainties in their fish farming enterprise. This may be due to lower adaptability to new technologies and practices, or physical limitations that impede effective risk management (Ahmad et al., 2020). Farmers with fewer years of farming experience are more likely to encounter seriously severe risks and uncertainties in their fish farming enterprise. This may be because they lack the necessary skills and knowledge to anticipate and mitigate challenges effectively. Furthermore, farmers who have no access to credit are more likely to encounter serious severity of risks and uncertainties. Lack of access to credit leads to more severe risks. Without financial resources, farmers may struggle to invest in essential risk mitigation measures, leaving them more vulnerable to severe uncertainties. Also, fish farmers are more likely to encounter serious severe risks and uncertainties with an increase in water supply on their farms similar to the severe category.

Table 4: Factors influencing the severity of risk and uncertainties

Variables	Not severe	Less severe	Severe	Seriously severe
	Coeff (S.D)	Coeff (S.D)	Coeff (S.D)	Coeff (S.D)
Gender	1.088 (0.809)	0.694 (0.826)	1.094 (0.966)	-0.233 (0.750)
Age	-1.238 (0.588) **	-2.072 (0.659) ***	-0.754 (0.648)	1.997 (0.613) ***
Marital status (Married)	1.205 (0.850)	2.742 (1.002) ***	1.070 (0.928)	0.961 (0.830)
Education	-0.308 (0.416)	-0.129 (0.448)	0.422 (0.476)	0.242 (0.439)
Household size	0.080 (0.157)	-0.259 (0.183)	-1.088 (0.527) **	-0.048 (0.158)
Farm experience	0.196 (0.117) *	0.283 (0.128) **	-0.049 (0.153)	-0.279 (0.120) **
Farm size	0.084 (0.122)	0.120 (0.124)	0.048 (0.127)	-0.017 (0.126)
Land own	-0.15 (0.422)	-0.578 (0.511)	-0.033 (0.465)	-0.133 (0.424)
Credit access	0.661 (0.320) **	1.313 (0.730) *	1.257 (0.732) *	-0.888 (0.510) *
Water supply	-1.729 (0.792) **	-0.824 (0.589)	0.061 (0.023) ***	0.687 (0.410) *
Veterinary	0.917 (0.708)	-0.512 (0.723)	0.754 (0.777)	0.827 (0.506)
_constant	1.279 (0.7445) *	0.690 (0.224) ***	0.503 (0.110) ***	0.151 (0.013) ***

4. CONCLUSION AND RECOMMENDATIONS

The conclusion drawn from this research is that the majority of the farmers are learned and the major risks they encounter are from their practices which arise from their feeding, drug administration, water replacement, veterinary services, and some others. Age, farm experience,

credit access, water supply, marital status (married), and household size were the significant factors influencing the level of severity of risk and uncertainty in fish farming. It can be concluded that there is no way a farmer can escape risks and uncertainties either from nature or by his practices, however, policymakers and stakeholders can develop more effective strategies to mitigate the risks and uncertainties faced by fish farmers, ultimately enhancing the sustainability and productivity of the sector.

Based on the study's findings, the following recommendations were proposed:

- Relevant agencies and research institutes like FAO should create awareness programs for fish farmers about the risks and uncertainties in fish farming.
- Improved farming practices should be encouraged among fish farmers such as the provision of drugs, regular veterinary attention, using improved feeds, and giving the fish the maximum nutrients needed for their specific stage.
- The government should develop accessible credit facilities with appropriate risk assessment and management advisory services to ensure that credit use does not inadvertently increase risk exposure.
- Relevant agencies should implement best practices in water resource management to optimize the benefits of increased water supply while mitigating associated risks.
- Training and capacity-building programs tailored to younger and less experienced farmers should be provided to enhance their risk management skills and adaptability.

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