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Profitability of catfish fingerlings production among small holder farmers in Delta North Agricultural Zone, Delta State

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Abstract
This study estimated smallholder farmers' profitability in catfish fingerlings production in Delta North Agricultural Zone, Delta State. The multi-stage sampling technique was employed to select 112 respondents, and data were collected using structured questionnaires and face-to-face interviews. Descriptive statistics, gross margin analysis, and multiple regression analysis were employed to analyse the data. The results showed that catfish fingerlings production was profitable with net income of ₦473,727.63 and Benefit-Cost Ratio (BCR) of 1.16, implying a return of ₦1.16 for every ₦1 invested. Stocking density (β = 0.431, p < 0.01), access to credit (β = 0.210, p < 0.01), and feed cost (β = -0.389, p < 0.01) were the important determinants of profitability with negative effect on profitability by feed cost. The major challenges observed were on high feed cost (mean = 4.32), credit restraint (mean = 4.15), and price risk (mean = 3.98). In order to address these, the farmers used some measures including formation of cooperative societies (Mean = 4.18) and water quality management (Mean = 4.05). The study determined that while catfish fingerlings production is economically sustainable, outpacing input costs, credit accessibility, and market stability challenges is essential to sustainability. The study suggested that policy actions must prioritize subsidizing the feed, ease of access to finances, and extension service enhancement to benefit smallholder farmers.

Keywords: Catfish Fingerlings, Profitability Production, Smallholder Farmers, Aquaculture, Revenue, Delta State

Introduction
Aquaculture is an essential sector within Nigeria's agriculture, playing a major role in food security, employment, and rural livelihood (Ahmadu et al., 2021). Among all the aquaculture enterprises, catfish rearing is the most significant due to its diversity, fast growth rate, and high market value (Oyita & Aberji, 2024). However, catfish fingerling production a core component in catfish production has been relatively less prioritized in spite of its inherent role in sustaining and enhancing the general productivity of the industry. Catfish fingerling production is the pillar of the catfish value chain, which provides juvenile fish to grow-out farmers on a sustainable basis (Nwigwe & Ndem, 2024). Given the increasing reliance on aquaculture to bridge the fish demand-supply gap, optimizing the profitability of catfish fingerlings production remains imperative (Umaru et al., 2021). Moreover, Olagunju et al. (2022) noted that aquaculture production in Nigeria has grown significantly over the past two decades, yet the industry continues to experience challenges that affect sustainability and profitability.

The relevance of catfish fingerlings production lies in its direct impact on the profitability and viability of the entire catfish farming sector. The quality of fingerlings sold determines the growth and survival rate of catfish, thereby impacting farm output and investment returns overall. Empirical studies have demonstrated that catfish aquaculture is a source of significant household income and rural economic growth. For instance, Oyita and Aberji (2024) reported that catfish production accounted for 42.2% of total annual household income in Ukwuani Local Government Area of Delta State, signifying its economic importance. However, small-scale catfish fingerlings producers face a series of constraints

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including high cost of production, inadequate access to quality broodstock, inadequate water quality control, and inadequate financial support (Ahmadu et al., 2021; Umaru et al., 2021).

Profitability analysis of aquaculture enterprises has been studied at large, with various studies confirming the economic profitability of catfish production. Ahmadu et al. (2021) conducted research on the profitability and efficacy of catfish fingerlings production in Edo State through budgetary and stochastic profit function estimates. Their study found fingerlings production to be highly profitable, with producers earning a mean revenue of ₦2,885,443.2 and net profit of ₦2,084,004.24 per production cycle. Similarly, Umaru et al. (2021) captured a gross margin of ₦652,700.00 per 1,000 catfish fingerlings grown to maturity in Enugu State, once more pointing to the economic feasibility of the business. However, the studies also highlighted relevant cost considerations such as feed, labor, and transport that affect profitability, with it being demonstrated that production efficiency is critical if profits are to be sustained in the industry.

Despite the established profitability in catfish production, small-scale fingerlings producers are confronted with myriad constraints that eat into their profitability and efficiency. One such challenge is the excessively high cost of inputs, particularly good quality feed and broodstock, which significantly erodes profit margins. Ahmadu et al. (2021) indicated that feeds alone accounted for 60-70% of the overall cost of production, thus cost control forming a critical element in profitability enhancement. Apart from that, limited access to credit facilities hinders smallholder farmers from investing in sophisticated hatchery technologies and expanding their businesses (Umaru et al., 2021). Moreover, inadequate technical know-how in hatchery management has been mentioned as a constraint that leads to low fingerling survival rates and subpar production outcomes (Olagunju et al., 2024). Besides, market and price volatilities are challenges considering that farmers struggle to sell their products at profitable prices (Oyita & Aberji, 2024).

There is a gap in the literature concerning the specific profitability trends of catfish fingerlings production among Delta North Agricultural Zone smallholder farmers. While a number of studies have analyzed the economic performance of catfish farming in different regions (Nwigwe & Ndem, 2024; Olagunju et al., 2022), there have been few empirical analyses of the profitability and issues of fingerlings production in this specific agricultural belt. Most of the available studies extrapolated findings over vast geographical regions or opted for grow-out production rather than the hatchery stage. Closing this gap is critical to the formulation of effective interventions aimed at improving the productivity and profitability of smallholder catfish fingerlings producers in the area.
Therefore, this study to assess the profitability of catfish fingerlings production among smallholder farmers in the Delta North Agricultural Zone of Delta State.

Objectives of the Study
Specifically, the study aims to:

i. determine the cost and revenue structure of catfish fingerlings production;
ii. analyse the profitability of catfish fingerlings farming using relevant economic indices;
iii. identify the key factors influencing the profitability of catfish fingerlings production;
iv. examine the constraints faced by smallholder catfish fingerlings producers in the study area; and
v. identify the strategies adopted to mitigate challenges faced by catfish fingerlings producers.

Research Methods

Study Area
Delta North Agricultural Zone, Delta State, Nigeria, is the study area in this work. The State lies within latitudes 5°00' and 6°30' N and longitudes 5°00' and 6°45' E and has a geographical area of about 18,050 square kilometres, with more than 60% being land. The state is bordered in the north by Edo State, in the east by Anambra and Rivers States, in the southeast by Bayelsa State on the Niger River, and in the

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south by the Bight of Benin, which forms about 160 kilometres of the state's coastline. The topography is low-lying with no prominent hills, having a wide coastal belt permeated with rivulets and streams, part of the Niger Delta. The climate is characterized by high rainfall, with a mean of 36.9 mm yearly rainfall, which gives rise to the ecological characteristics of the state as lowland rainforest, freshwater swamp, and mangrove swamp. The Delta North Agricultural Zone spans several Local Government Areas (LGAs), including Aniocha North, Aniocha South, Ika North East, Ika South, Ndokwa East, Ndokwa West, Oshimili North, and Oshimili South. The rich land and water resources of the zone provide a good ecosystem for aquaculture activities.

Population, Sampling Technique, and Sample Size

The targeted population of this study was smallholder catfish fingerlings producers in the Delta North Agricultural Zone. A multi-stage sampling procedure was employed in getting a representative sample. In the first stage, four Local Government Areas (LGAs) which include Ndokwa East, Oshimili South, Ika South, and Ndokwa West were purposely chosen from the eight LGAs of the Delta North Agricultural Zone because of the dominance of catfish fingerlings production. In the second stage, four communities were randomly chosen in each of the selected LGA, totalling sixteen communities. For the final stage, seven smallholder catfish fingerlings producers were chosen randomly from each of the selected communities to give a total sample size of 112 respondents.

Data Collection and Method of Data Analysis

Primary data were collected through structured questionnaires and personal interviews. Descriptive statistics summarised significant variables, and gross margin analysis ascertained profitability. Multiple regression analysis identified significant contributors to profitability.

Model Specification

Gross Margin Analysis

The gross margin (GM) is defined as:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

TR = total revenue from fingerlings production (₦)

TVC = total variable cost (₦)

Net Income is expressed as:

$$NI = TR - TC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

TC = total cost and

$$TC = TFC + TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

TFC = total Fixed Cost

Multiple Regression Model

To analyse the factors influencing profitability, the following multiple regression model is specified:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + e_i \ldots\ldots\ldots (4)$$

Where:

Y = Profitability (net income)

X_1 = Age: Measured in years.

X_2 = Education Level: Categorized based on the highest level of formal education attained.

X_3 = Farming Experience: Measured in years of involvement in catfish fingerlings production.

X_4 = Access to Credit: Binary variable indicating whether the farmer has access to credit facilities (1 = Yes, 0 = No).

X_5 = Extension Services: Binary variable indicating whether the farmer has access to extension services (1 = Yes, 0 = No).

X_6 = Stocking Density: Measured as the number of fingerlings stocked per square meter.

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X_7 = Feed Cost: Measured as the total cost of feed used during the production cycle.
X_8 = Labour Cost: Measured as the total expenditure on labour during the production cycle.
β_0 = Intercept
$\beta_1 - \beta_8$ = Coefficients of independent variables
e = Error term

Results and Discussions

Socioeconomic Characteristics of Respondents

The results in Table 1 reveal that catfish fingerling production in Delta North Agricultural Zone is strongly male-dominated (69.6%), which supports findings by Oyita and Aberji (2024) in Ukwuani LGA, Delta State, where 70.8% of the farmers were males. The mean age of the respondents (39.8 years) shows that the industry is dominated by individuals in their productive years, in affirmation of Olagunju et al. (2022), who reported that most of the catfish farmers in Nigeria were below 45 years of age. Most (60.7%) of the respondents were married, a demographic pattern also reported by Esiobu et al. (2022), who reported 78.88% of the catfish farmers in Imo State as married. The mode of educational level (secondary) implies a fairly high literacy level among the respondents, which is crucial for adopting improved aquaculture practice, according to Nwabueze and Ofuoku (2020). Average household size (5.6 persons) implies the potential availability of family labor for fish farming, which could reduce the labour cost. The 9.4 years average experience in farming suggests that farmers have gained exposure in the field, supporting the work of Ahmadu et al. (2021) who reported that experience is essential to profitability in fish farming. Financing continues to be a problem, with private savings (40.2%) being the leading source, supporting Onyekuru et al.'s (2019) finding that 80% of catfish farmers used personal savings. Although 58.9% of the respondents were members of cooperative societies, access to extension services was limited (42.0%), limiting knowledge transfer and technical support, as also documented by Enimu et al. (2024). The findings call for the need to enhance credit accessibility, extension services, and training programs to enhance profitability in the sector.

Table 1: Socioeconomic Characteristics of Respondents

Variable	Frequency	Percent	Mean/Mode
Gender			Mode = Male
Male	78	69.6	
Female	34	30.4	
Age (Years)			Mean = 39.8
Below 20	5	4.5	
20 – 29	18	16.1	
30 – 39	32	28.6	
40 – 49	27	24.1	
50 – 59	19	17.0	
60 and above	11	9.8	
Marital Status			Mode = Married
Single	28	25.0	
Married	68	60.7	
Divorced	9	8.0	
Widowed	7	6.3	
Educational Level			Mode = Secondary
No Formal Education	9	8.0	
Primary	24	21.4	
Secondary	52	46.4	
Tertiary	27	24.1	
Household Size (Persons)			Mean = 5.6
1 – 3	16	14.3	
4 – 6	55	49.1	

7 – 9	30	26.8	
10 and above	11	9.8	
Years of Experience (Years)			Mean = 9.4
Less than 5	12	10.7	
5 – 10	42	37.5	
11 – 15	28	25.0	
16 – 20	18	16.1	
Above 20	12	10.7	
Primary Source of Funding			Mode = Personal Savings
Personal Savings	45	40.2	
Loan	26	23.2	
Cooperative Society	18	16.1	
Government Grant	14	12.5	
Family and friends	9	8.0	
Membership in Cooperative Society			Mode = Yes
Yes	66	58.9	
No	46	41.1	
Access to Extension Services			Mode = No
Yes	47	42.0	
No	65	58.0	

Cost and Revenue of Catfish Fingerlings Production

Catfish fingerlings cost of production and profitability analysis in Delta North Agricultural Zone as shown in Table 2 revealed that 77.2% of the costs were made up of variable costs, while feed alone accounted for 43.2%. This is in accordance with Ahmadu et al.'s (2021) study, which similarly used the term feed as the most expensive factor of catfish production. Olagunju et al. (2022) further elaborated that costly feeds will largely affect profitability, especially in small-scale production. Labour expenses had 14.3% in the total cost. According to Esiobu et al. (2022), this could be due to the application of expert labour to gain maximum efficiency during fish production. Transportation costs and water management expenses were also important, having 6.1% and 4.0%, respectively, this could be as a result of the infrastructural and operational burden on small-scale fish producers, based on Umaru et al. (2021).

Profitability indicators demonstrated that catfish fingerlings production is a viable enterprise undertaking in the study area. The total income realized from selling 32,845 fingerlings at an average unit price of ₦105.75 was ₦3,473,358.75 with a gross margin of ₦1,157,368.83 and a net income of ₦473,727.63. This finding concurs with Nwigwe and Ndem (2024), which also indicated a positive net income for smallholder catfish farmers, which supports the viability of aquaculture business in Nigeria. The study by Oyita and Aberji (2024) further corroborated these findings, emphasizing that catfish production contributes significantly to household income and food security. Nevertheless, despite the perceived profitability, constraints such as high input costs and adverse credit access remain issues with fish farmers, as documented in research by Esiobu et al. (2022) and Ahmadu et al. (2021). Since BCR is above 1.0, the enterprise is viable from an economic point of view and brings about more revenue compared to cost. A BCR of 1.16 points towards a return of 16% on the investment once all the costs have been settled. Methods such as reducing feed costs, increasing stocking density, and adopting proper water management could similarly enhance profitability and drive the BCR to over 1.16.

Table 2: Cost and Return of Catfish Fingerlings Production

Item	Quantity	Unit Price (₦)	Amount (₦)	% of Total Cost
Fixed Costs				
Pond construction	1 unit	342,836.73	342,836.73	11.4

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Facility Rent	12 months	21,416.67	257,000.04	8.6
Maintenance		49,520.75	49,520.75	1.7
Equipment Depreciation		34,283.67	34,283.67	1.1
Total Fixed Costs			**683,641.19**	**22.8**
Variable Costs				
Brood stock Cost	7 brood stocks	20,625.30	144,377.10	4.8
Feed Cost	1,180.5 kg	1,098.75	1,297,074.38	43.2
Labour Cost	12 months	35,750.40	429,004.80	14.3
Water Management Cost	12 months	9,875.60	118,507.20	4.0
Medications & Treatments		49,330.25	49,330.25	1.6
Transportation Cost	12 months	15,150.75	181,809.00	6.1
Utilities (Electricity, etc.)	12 months	7,990.60	95,887.20	3.2
Total Variable Costs			**2,315,989.93**	**77.2**
Total Costs			**2,999,631.12**	**100.0**
Revenue				
Sales of Fingerlings	32,845 fingerlings	105.75	3,473,358.75	
Gross Margin			1,157,368.83	
Net Income			473,727.63	
Benefit Cost Ratio (BCR)			1.16	

Factors Influencing the Profitability of Catfish Fingerlings Production

Research data presented in Table 3 confirms multiple variables play a vital role in determining the profitability rates for catfish fingerling cultivation by small-scale farmers within Delta North Agricultural Zone. The results demonstrate that stocking density shows the strongest positive influence ($\beta = 0.431$, $p < 0.01$) on profitability because optimized stocking densities lead farmers to achieve better financial returns. Nwabueze and Ofuoku (2020) validated the pivotal role of stocking density as a profitability factor in aquaculture through their research. A positive effect emerged between farming experience on profitability ($\beta = 0.072$, $p < 0.01$), thus confirming previous research by Olagunju et al. (2022) which demonstrated that experienced farmers become more profitable. Results demonstrated that farmers with higher education levels ($\beta = 0.158$, $p < 0.01$) and better credit access ($\beta = 0.210$, $p < 0.01$) achieved higher profitability which supports findings presented by Esiobu et al. (2022) who revealed that well-informed farmers who obtain credit make sustainable success decisions. The findings indicate that extension services enhance profitability ($\beta = 0.118$, $p < 0.05$) in agreement with Ahmadu et al. (2021).

The analysis revealed that feed costs had a negative impact on profitability ($\beta = -0.389$, $p < 0.01$) corresponding to findings from Umaru et al. (2021) along with Oyita and Aberji (2024) that high feed costs act as a primary limitation in catfish farming. Profitability improvement can occur by implementing cost-effective feeding practices or by receiving government financial support. Results show that labor expenses ($\beta = -0.102$, $p = 0.183$) did not show significant influence on profitability in the study area. The model demonstrates an extensive relationship between independent variables and profitability through its R-squared value of 0.732. The F-statistic value (41.652) together with $p < 0.01$ demonstrates the statistical significance of the overall model. The Durbin-Watson test statistic value of 1.928 indicates no pertinent autocorrelation problems thus ensuring the accuracy of regression model results. The research findings validate previous empirical studies and demonstrate that effective resource allocation combined with financial accessibility and technical assistance results in optimal profitability for catfish fingerlings farming.

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Table 3: Factors Influencing the Profitability of Catfish Fingerlings Production

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Constant	3.215	0.874	3.678	0.000 ***
Age	0.024	0.012	1.980	0.051
Education Level	0.158	0.049	3.224	0.002 ***
Farming Experience	0.072	0.018	4.000	0.000 ***
Access to Credit	0.210	0.065	3.231	0.002 ***
Extension Services	0.118	0.052	2.269	0.025 **
Stocking Density	0.431	0.087	4.954	0.000 ***
Feed Cost	-0.389	0.102	-3.814	0.000 ***
Labour Cost	-0.102	0.076	-1.342	0.183
Model Summary				
R-Squared	0.732		F-Statistic	41.652
Adjusted R-Squared	0.714		Durbin-Watson	1.928

*** and ** are significant at 1% and 5% respectively

Constraints Faced by Smallholder Catfish Fingerlings Producers

Table 4 demonstrates the essential difficulties experienced by Delta North Agricultural Zone smallholder catfish fingerlings producers according to their evaluations. The cost of feed emerged as the foremost challenge according to respondents (Mean = 4.32) because it makes up between 60–70% of total production costs as described by Ahmadu et al. (2021). The study found that farmers faced hindrances because of restricted credit availability (Mean=4.15) in line with Esiobu et al. (2022) who revealed that 68.89% of Imo State catfish farmers could not obtain formal credit thus preventing them from growing their production scale. Market price instability (Mean = 3.98) emerged as a meaningful challenge due to market volatility and the seasonal fluctuations of demand. Olagunju et al. (2022) observed that unstable markets created difficulties for catfish farmers with a special impact on those operating on a small scale. Broodstock quality issues (Mean = 3.87) along with high levels of mortality (Mean = 3.45) made production challenges worse due to insufficient broodstock management which results in poor survival rates according to Olagunju et al. (2024).

The research found that farmers in the study area effectively handle water quality since poor water quality stood out as the only factor where respondents differed (Mean = 2.74). The research by Umaru et al. (2021) discovered poor water quality as a main challenge for catfish farming in Enugu State but this finding contrasts with the current study. The study revealed that disease outbreaks (Mean = 3.62) and high transportation costs (Mean = 3.89) were major hindrances due to their negative impacts on financial losses and rising operational costs. Research by Oyita and Aberji (2024) showed that catfish farm profitability experienced declines due to disease outbreaks alongside high logistics costs in Delta State.

Table 4: Constraints Faced by Smallholder Catfish Fingerlings Producers

Constraints	Mean	Standard Deviation	Remark
High Cost of Feed	4.32	0.754	Agree
Poor Quality Broodstock	3.87	0.812	Agree
High Mortality Rate	3.45	0.690	Agree
Limited Access to Credit	4.15	0.725	Agree
Unstable Market Price	3.98	0.841	Agree
Poor Water Quality	2.74	0.913	Disagree
Disease Outbreaks	3.62	0.768	Agree
High Cost of Transportation	3.89	0.801	Agree

Decision: mean <3.0 is Disagree, mean ≥3.0 is Agree

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Strategies Adopted to Mitigate Challenges Faced by Catfish Fingerlings Producers

Table 5 results indicate that Delta North Agricultural Zone smallholder catfish fingerlings producers used several strategies in overcoming challenges, and all the strategies had a mean score above 3.0, signifying agreement. Cooperative society membership (Mean = 4.18) was the most widely used strategy, confirming the hypothesis that farmers gain from improved access to inputs, resources, and finance in groups (Esiobu et al., 2022). Similarly, improving water quality management (Mean = 4.05) was also very highly ranked and agrees with a study by Ahmadu et al. (2021), who noted that fingerlings' survival is highly affected by water quality. This means farmers pay attention to water quality control measures such as filtration systems and proper waste disposal to improve production efficiency. Implementing modern hatchery technology (Mean = 3.89) was yet another shared strategy in practice, testifying to the role played by technological improvements towards enhancing productivity as noted by Olagunju et al. (2022). Producers who employ better breeding technology and computer-aided water management monitoring will tend to post higher survival and profit levels.

Besides, government support access (Mean = 3.72) and capacity building and training (Mean = 3.25) show the need for policy interventions and continuous knowledge acquisition. This is consistent with Enimu et al. (2024), who observed the need for extension services and technical training in improving farm efficiency. The application of substitute feeds (Mean = 3.45) also led the list, which suggests that farmers are looking for cheap feeding options due to rising feed prices, a constraint that was outlined by Oyita and Aberji (2024). These results suggest that diversified approaches to the surmounting of production constraint are necessary in the enhancement of the profitability of catfish fingerlings production among smallholders in Delta State, incorporating financial empowerment, knowledge acquisition, and technology uptake.

Table 5: Strategies Adopted to Mitigate Challenges Faced by Catfish Fingerlings Producers

Strategies	Mean	Standard Deviation	Remark
Joining Cooperative Societies	4.18	0.738	Agree
Seeking Government Support	3.72	0.895	Agree
Using Alternative Feeds	3.45	0.768	Agree
Improving Water Quality Management	4.05	0.692	Agree
Adopting Modern Hatchery Technologies	3.89	0.798	Agree
Engaging in Capacity Building and Training	3.25	0.915	Agree

Decision: mean <3.0 is Disagree, mean ≥3.0 is Agree

Conclusion and Recommendations

Production of catfish fingerlings by small-scale farmers in Delta North Agricultural Zone is a profitable venture with a positive net income and a BCR greater than one, which indicates economic feasibility. The viability of the project, however, depends on some of the factors of production like stocking rate, feed cost, and access to finance. Despite the profitability, there are some constraints that reduce optimal productivity such as high prices of feed, credit constraint, and unstable market conditions. Immediate interventions are needed to solve these problems for the capacity of smallholder farmers to increase production in a sustainable way and improve the level of income. Technical efficiency, improved finance mechanisms, and effective resource management are emphasized as key factors to further improve profitability. Resolving these issues will not only enhance farm revenues per farm but also contribute to the general development of Delta State and Nigeria's aquaculture sector as a whole. Based on the findings, the following were recommended:

i. The government should implement subsidies on broodstock and fish feed to lower production costs because feed alone accounts for over 40% of total costs.
ii. Low-interest credit facilities for smallholder fish farmers must be provided by financial institutions to allow them to expand their production.
iii. Farmers must be encouraged to take training in disease management, water quality, and optimal stocking density methods.

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iv. The government must establish regulated fish markets to protect farmers from price fluctuations and equitable prices.
v. Cooperatives must adopt joint marketing strategies where farmers bargain for better prices for their fingerlings.

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