International Journal of Sciences and Innovation Engineering

(Peer-Reviewed, Open Access, Fully Refereed International Journal)

website: www.ijsci.com
Vol.03 No.01

E-ISSN : 3049-0251
DOI: https://doi.org/10.70849/ijsci0301260491993

Economic Viability of Freshwater Trout Farming: A Profitability and Sensitivity Analysis

Shazia Yousuf[1], Imtiyaz-Ul-Haq[2]

[1] *Doctoral Candidate, University of Kashmir, Budgam*

[2] *Professor, University of Kashmir, Budgam.*

Article Info

Article History:

Published:20 Jan 2026

Publication Issue:
Volume 3, Issue 01
January-2026

Page Number:
409-426

Corresponding Author:
Shazia Yousuf

Abstract:

This study evaluates the economic viability of freshwater trout farming using primary data collected from operational farms. Profitability assessment tools such as benefit–cost ratio, break-even analysis, and sensitivity analysis were applied to understand costs, returns, and financial risks. The findings indicate that trout farming generates only modest profits and is highly sensitive to changes in key inputs, especially feed prices. Even small cost increases can reduce profitability, revealing limited financial resilience among farmers. The study offers practical insights into the economic realities of cold-water aquaculture in Kashmir and contributes new field-based evidence to support policy and investment planning.

Keywords: Trout Farming, Economic Viability, Sensitivity Analysis, Profitability Analysis.

1. Introduction

Aquaculture has become one of the fastest-growing sectors within the global food production system, significantly contributing to food security, employment, and income generation across both developed and developing countries. Among its various sub-sectors, inland freshwater aquaculture has demonstrated remarkable potential due to lower capital intensity, faster adaptability, and sustainable harvesting cycles. Fish, being a rich source of protein and micronutrients, has gained increasing importance in dietary systems worldwide. In this context, trout culture, particularly of cold-water species like rainbow trout (*Oncorhynchus mykiss*), offers high economic returns and growing market demand, especially in temperate regions. In recent decades, aquaculture has gradually shifted from traditional, small-scale subsistence models to more commercially oriented ventures. This transformation necessitates a deeper understanding of the economic dynamics, including cost structures, profitability patterns, and associated risks. While much research in aquaculture has been devoted to biological efficiency, breeding practices, and feed optimization, economic dimensions such as profitability analysis and sensitivity to key input-output variables have not received proportionate attention—especially in the Indian context.

Although there has been a considerable increase in academic interest surrounding aquaculture in South Asia, particularly carp and shrimp farming, trout culture remains under-researched, especially in terms of economic analysis. The existing literature is predominantly experimental in nature, relying on controlled or pilot studies that do not reflect real-world economic conditions faced by fish farmers operating in commercial environment. This gap is further reflected in studies by **Mohsin (2012), Shawon (2018), and Munthali (2024)** which emphasized the importance of **economic evaluation and risk sensitivity** in aquaculture systems. However, these investigations have primarily focused on species such as **carp, shrimp, and tilapia,** and are largely contextualized within **specific geographies** like **Bangladesh, Malawi, and Southeast Asia**. As a result, there remains a pressing need for **context-specific economic assessments** of trout farming—particularly in **understudied regions such as the Himalayan belt—**to inform policy, investment, and sustainable aquaculture development.

Furthermore, studies focusing on profitability often overlook the role of sensitivity analysis, which assesses the extent to which variables like feed cost, stocking density, seed quality, and market prices impact overall financial outcomes. There is, therefore, a clear gap in the literature when it comes to the economic assessment of freshwater trout farming in India. This study is designed to address this gap by analyzing profitability and conducting a detailed sensitivity analysis using real-time, primary data collected from operating trout farms in Kahmir.

Background

India has emerged as the third-largest fish-producing country in the world and the second-largest in aquaculture production. The sector plays a vital role in the national economy, contributing about 1.1% to the total GDP and 6.72% to the agricultural GDP. In the year 2021–22 alone, India produced 16.248 million tonnes of fish, a significant increase from 5.656 million tonnes in 2000–01. Additionally, India exported 1.36 million metric tonnes of fish worth USD 7.76 billion, underlining the commercial importance of this sector. The Indian aquaculture industry provides direct and indirect employment to over 28 million people. Despite these achievements, aquaculture in India is still largely dominated by carp farming in states like Andhra Pradesh, West Bengal, and Odisha. High-value species such as trout have not received comparable attention in policy frameworks, capacity-building programs, or academic research. In recent years, the Department of Fisheries in Jammu and Kashmir has made significant strides in promoting trout culture by providing subsidies, technical training, and support infrastructure. These efforts have led to increased trout production and a growing number of small- and medium-scale trout farms. However, the pace of growth in the trout sector has been hampered by several challenges—high input costs, inadequate access to quality seed and feed, marketing inefficiencies, and lack of financial risk mitigation mechanisms. Moreover, no comprehensive study has yet assessed the economic feasibility of trout farming under actual field conditions in Kashmir. Most available assessments remain anecdotal or administrative, lacking the analytical depth needed to understand cost structures, profit margins, and risk exposures.

This study attempts to fill this critical void by evaluating the profitability of trout farming in Kashmir and conducting a sensitivity analysis to assess how variations in key economic parameters influence net returns. The findings aim to inform not only fish farmers and entrepreneurs but also development agencies, financial institutions, and policymakers working to strengthen aquaculture in the region.

2. Review of Literature

Aquaculture has emerged globally as a sustainable response to declining capture fisheries, ensuring food security, livelihood generation, and economic development. Numerous international studies have evaluated the profitability and sustainability of aquaculture systems using various economic tools. For example, Mohsin (2012) conducted an economic analysis of carp polyculture in northern Bangladesh, where production costs ranged significantly depending on farm scale, and the average benefit-cost ratio hovered around 1.05, indicating marginal profitability. Similarly, Sarker (2016) assessed technical efficiency and risk factors in Thai koi farming and emphasized the critical influence of feed, zeolite, and pesticides on economic output. The significance of feed as a cost driver was also highlighted by Shawon (2018) in his assessment of shrimp farming and by Mukta (2019) in tilapia production, where feed accounted for nearly 70% of total production cost. Hossain (2022) reported similar findings in the context of carp polyculture, demonstrating how feed costs (57.3% of total inputs) significantly affect profitability. Further, Peng (2024) analyzed income structures across aquaculture systems in China and advocated reforms such as fishery insurance and input subsidies due to high farming risks and volatile market conditions. In the African context, Munthali (2024) used large-scale data from Malawi to explore profitability across various production systems. Results indicated that individually owned farms that engaged in both fingerling and grow-out production recorded higher economic returns, especially when using high-quality commercial inputs.

In Indian, aquaculture contributes substantially to the agricultural GDP, with inland aquaculture dominating fish production. However, the literature predominantly focuses on warm-water species such as carps and shrimp, leaving cold-water species like trout relatively under-researched. Katiha et al. (2005), in a nationwide study under the ICAR–WorldFish project, examined various inland aquaculture systems and found semi-intensive farming the most profitable. The analysis revealed that inland aquaculture in India holds considerable economic potential, with benefit–cost ratios for different systems ranging from 1.22 to 1.86. Semi-intensive aquaculture systems exhibited the highest profitability, providing greater returns compared to extensive and intensive systems. Returns to capital were significantly higher than returns to labour, largely due to low labour input requirements. The study further suggests that targeted investments in semi-intensive systems would maximize economic returns. However, achieving higher profitability would depend on addressing key constraints, particularly the availability of quality fish seed and feed. Yet, the study noted key constraints like seed quality, feed availability, and training. Devi (2014) observed that both small and large fish farms in Manipur showed positive cost-benefit ratios (1.17 and 1.40 respectively), though challenges such as poor seed access and volatile market prices affected overall economic stability. In (2025), Singh conducted a stochastic frontier analysis in Punjab to assess technical efficiency in fish farming and identified feed costs and inadequate infrastructure as significant inefficiencies. Similarly, Dhande (2023) examined Pangasius-based polyculture systems and found that feed accounted for more than half of total production costs across farm sizes. He recommended diversification and stable input pricing to enhance economic viability. De et al. (2024), though focusing on decentralized water treatment systems, highlighted how larger, integrated systems offered better financial feasibility—an insight applicable to fish farming clusters as well.

Despite this growing body of literature, most studies generalize aquaculture economics without distinguishing between capture and culture fisheries, especially in ecologically distinct regions. Capture fisheries, which involve harvesting fish from natural water bodies, are declining due to overfishing and environmental pressures. In contrast, culture fisheries—or aquaculture—entail controlled breeding and rearing of fish in ponds or raceways, offering higher yield potential and resource efficiency. However, the economics of such culture systems, particularly for high-value species like rainbow trout in Kashmir, remain poorly documented. This gap in literature underscores the need for a focused study that not only assesses the profitability of freshwater trout farming in Kashmir but also evaluates its economic sensitivity. Such research will inform investment decisions, guide policymakers, and support farmers in improving operational efficiency and financial sustainability.

3. Methodology

Materials and Methods

This study is based on cross-sectional primary data collected through a structured questionnaire administered during a field survey conducted through personal visits between 2023-2024. The survey was carried out in three key trout-producing districts of Kashmir—Srinagar, Baramulla, and Anantnag. These districts were selected due to their high concentration of active trout farms and significant production volumes, collectively amounting to 6,479 quintals (Directorate of Fisheries, J&K, 2023-24). A three-stage sampling procedure was employed to determine the sample size for this study. In the first stage, the three districts were purposively selected due to their prominence in trout farming. In the second stage, seven sub-districts within these districts were identified based on the presence of trout fish farms, with guidance from District Fisheries Officers. In the final stage, a complete enumeration method was employed to select a total of 91 trout farms from these sub-districts. Prior to the main survey, the questionnaire was pretested through a pilot survey to ensure its validity and reliability in capturing relevant data. This systematic approach to data collection ensured the robustness and representativeness of the study findings, providing a comprehensive understanding of the economic dynamics of trout farming in the region.

Data Analysis

Profitability Analysis

The total cost of trout fish farming was classified into variable costs and fixed costs. Variable costs included expenditures on essential inputs such as fingerlings, feed, labor, and medicines. Fixed costs comprised land use costs, depreciation, and interest payments on capital.

Land Use Cost

Since all farms operate on owned land, the imputed rental value was assessed for one year using the yield-based valuation (YBV) method. The YBV was determined using the following formula:

$$YBV = \text{Revenue-operating expenses}$$

The imputed rental value was derived as half of the yield-based valuation, representing the opportunity cost of land use in trout farming.

Depreciation Calculation

Depreciation was computed using the straight-line method to estimate the annual reduction in asset value over its useful life. The formula used for calculating annual depreciation was:

$$\text{Depreciation (per annum)} = \frac{\text{Original cost of assest} - \text{scrap vlaue}}{\text{Expected life of asset (in years)}}$$

Labor Cost Estimation

Labor costs were measured in monetary terms based on hourly wage rates. The valuation of labor was crucial in determining the operational expenses associated with trout farming.

Interest on Capital

The cost of capital was assessed through interest calculations on both working capital and fixed capital investments. The interest rate on working capital was determined based on the prevailing Kisan Credit Loan rate, while the interest on capital invested was calculated using the prevailing savings bank interest rate. This approach ensured a realistic assessment of financing costs incurred in trout fish farming.

By integrating these cost components, a comprehensive analysis of the economic feasibility and profitability of trout farming was conducted, facilitating informed decision-making for stakeholders in the aquaculture sector.

Farmer's financial profitability was assessed using key financial indicators, including gross profit, net return, benefit-cost ratio (BCR), gross profit margin (GPM), and break-even analysis. Feed use efficiency was estimated using the feed conversion ratio (FCR). The methodologies for calculating gross profit, net return, and BCR were adopted from (Mukta, 2019; Hossain, 2022), while the estimation methods for GPM, net profit margin (NPM), and FCR were based on the works of (Karim, 2014; Shawon, 2018) .Break-even analysis is a fundamental yet effective tool for evaluating financial profitability. The break-even point represents the threshold at which total revenue equals total costs, signifying a state of no profit and no loss. Beyond this point, a portion of each additional unit of revenue contributes to profit. This analysis is crucial for understanding the interrelationship among production volume, fixed costs, sales price per unit, and variable costs per unit.

In this study, the sales price per unit was determined as the average price per kilogram, while variable costs per kilogram were calculated by dividing the total variable costs by the total production. Following (Shawon, 2018), three types of break-even points were estimated:

- **Break-even Production:** The minimum production required to cover fixed and variable costs, calculated as:

$$\text{Breakeven production} = \frac{\text{fixed cost}}{\text{sales price per kg} - \text{variable cost per kg}}$$

- **Break-even Sale Value:** The revenue required to achieve the break-even point, calculated as:

$$\text{Breakeven sale value} = \text{Breakeven production} \times \text{Average price of output}$$

- **Break-even Price:** The minimum selling price per kilogram needed to cover all costs, calculated as:

$$\text{Breakeven price} = \frac{\text{Fixed costs}}{\text{Volume of Production}} + \text{variable costs per kg}$$

These break-even estimates provide valuable insights into the financial sustainability and risk management strategies for trout farmers, aiding in informed decision-making and profitability assessment.

Sensitivity Analysis

Sensitivity analysis is employed to assess the degree of influence and responsiveness of uncertain factors, such as sales price and feed price, on net income. This influence is quantified using a sensitivity coefficient (SC), which is computed as follows:

$$SC = \frac{\Delta NP / NP}{\Delta X / X}$$

where SC represents the sensitivity coefficient, $\Delta X / X$ denotes the proportional change in an uncertain factor, and $\Delta NP / NP$ represents the corresponding proportional change in net income while holding other conditions constant (Peng, 2024).

In this study, sensitivity analysis was conducted to evaluate the impact of variations in feed and fish prices on net returns, gross profit margin (GPM), net profit margin (NPM), and the benefit-cost ratio (BCR). The analysis was performed using the following systematic steps:

Establishing the Base Case: The baseline values for net return, GPM, NPM, and BCR were determined. The feed price at a particular reference level was considered as the input variable for which sensitivity was to be analyzed, while all other model inputs were maintained constant.

Computing Output Changes: The impact of changes in feed price on net return was evaluated by recalculating the net return, GPM, NPM, and BCR at a new feed price while keeping other inputs constant. Specifically, the analysis considered a 10% increase and decrease in feed price to determine the resultant changes in profitability metrics.

Thus, five distinct scenarios were examined to comprehensively assess sensitivity:

- *Decrease in feed price.*
- *Increase in feed price.*
- *Decrease in fish price.*
- *Increase in fish price.*
- *Simultaneous increase in both fish and feed prices.*

This approach enables a robust understanding of how variations in key input prices affect the overall economic performance of the system, thereby providing valuable insights for decision-making and risk assessment in the studied domain.

In the data analysis phase, the responses obtained from the interview schedule were systematically coded and entered Microsoft Excel to facilitate further examination. Descriptive statistical methods were employed to effectively summarize the findings related to profitability and sensitivity analysis. The results were presented as means and percentages for each cost item, providing a clear and comprehensive overview of the data collected.

4. Results and Discussion

Cost Analysis of Trout Production

The primary cost components of trout production included human labor, fingerlings, feed, medicine, imputed land lease value, and depreciation of equipment. All input costs were assessed for a single production cycle to calculate the per-kilogram cost of trout production.

Human labor was employed for essential farming activities such as feeding, stocking, raceway cleaning, and harvesting. The labor cost per kilogram of trout production was estimated at Rs 95.76, accounting for 19.93% of the total cost. Family labor contributed 17.21% of the total labor cost, while hired labor constituted 7.97%. Fingerlings were typically procured from hatcheries, and the average stocking density cost per kilogram was Rs 22.59, representing 4.70% of the total cost (Table 1). Feed constituted the most significant cost component in trout farming, with most farmers relying on commercial pellet feed. Across all locations, the average feed cost was estimated at Rs 184.79 per kilogram, contributing 38.44% to the total cost (Table 1). This finding aligns with previous studies (Prodhan, 2018; Khan, 2012; Mukta, 2019), which observed that feed is the major operational expense in fish farming, often constituting 60-75% of variable costs depending on production intensity. The substantial cost of feed can be attributed to the rising prices of commercial fish feed in the market. Additional expenditures were incurred on medicines and miscellaneous items. The average cost of medicines was estimated at Rs 0.86 per kilogram, contributing 0.18% to the total cost, while miscellaneous costs were Rs 0.32 per kilogram, accounting for 0.06%. These cost estimations provide a detailed insight into the economic structure of trout farming, highlighting the significance of feed costs and labor expenses in the overall production process.

In assessing the economics of trout farming, fixed costs are crucial in determining overall production expenses. Among these costs, land use represents the largest component, accounting for 17.57% of the total cost, with an estimated value of Rs 84.42 per kilogram of trout produced. Although trout farmers primarily use their own land for farming, an opportunity cost is assigned to land use, reflecting the potential income they could have earned by leasing it out instead. This approach allows for a more comprehensive estimation of economic efficiency by including implicit costs. In addition to the cost of land use, farms require durable assets for operations, which depreciate over time. The annual depreciation cost represents 5.83% of the total expenses, capturing the gradual reduction in the value of these assets used in trout farming. Additionally, the interest paid on capital investment, regardless of production levels, constitutes 10.75% of the total cost. This highlights the financial burden associated with capital investment in trout farming and emphasizes the importance of efficient capital utilization. Overall, the total cost of trout production is estimated at Rs 480.65 per kilogram, with variable costs making up the majority of total expenditures. These findings underscore the significance of variable costs in trout farming while also highlighting the need to consider fixed cost components, such as land use, depreciation, and interest on capital, in economic efficiency assessments.

Table 1: Cost and Input Structure (Rupees per Kg)

Cost items	**Total cost (Rs/kg)**	**Contribution to total cost (%)**
Fingerlings	22.583	4.698
Feed	184.789	38.44
Labor	95.764	19.924

Hired Labor	13.067	7.961
Family Labor	82.696	17.205
Medicines	0.863	0.179
Miscellaneous cost	0.32	0.066
Total working capital	304.32	63.315
Interest on Working Capital@4%	12.172	2.532
A) Total Variable Costs	**316.494**	**65.848**
Land use value	84.422	17.564
Depreciation	28.034	5.832
Interest on Capital Invested	51.692	10.754
B) Total Fixed Cost	**164.149**	**34.15**
Total Cost (A+B)	480.643	100

Source: ***Analysis of Survey Data***

Output: ***Stata 18.0***

Profitability of trout farming

The success of any enterprise depends on its ability to generate profit while maintaining sustainability. Table 2 presents key profitability and productivity indicators of trout farming. The estimated total annual yield was 238,400 kg, generating a total revenue of Rs. 115,705,000. The gross profit was Rs. 40,252,700.79, whereas the net return was Rs. 1,119,495.65**.** The Benefit-Cost Ratio (BCR**)** of 1.01 indicates marginal profitability, where revenues barely exceed costs. This razor-thin margin suggests that trout farms are highly vulnerable to external shocks, such as price volatility, disease outbreaks, or rising input costs. The findings (BCR) of this study are lower than those reported by (Sethi, 2024; Dhande, 2023; Devi, 2014; Hossain, 2022), which could be attributed to differences in **cost accounting methodologies**. Many of these studies **exclude implicit costs** (e.g., land use, family labor, capital interest) or benefit from **subsidized financing**, resulting in higher reported profitability. Despite a Gross Profit Margin (GPM) of 34.79%, indicating that 35% of revenue remains after covering total costs, the Net Profit Margin (NPM) is only 0.97%. This low NPM reflects the inclusion of both explicit and implicit costs, which artificially depress profitability metrics. From a cash-flow perspective, trout farms may appear more viable, as imputed costs (e.g., family labor, land opportunity cost) do not require direct monetary outlays. However, when considering total economic costs, the net return is significantly constrained.

The break-even yield, a critical metric for farm sustainability, was estimated at 231,770 kg, representing 97% of actual productivity. This implies a minimal buffer against risk, where even a slight decline in production could push farms into economic losses. Similarly, the break-even price was Rs. 480.64/kg, closely matching market rates. This suggests that any increase in costs (e.g., feed price inflation) or a slight dip in market price could erode economic profits, questioning the long-term sustainability of trout farming. The findings of this study contrast with those of (Ali, 2016; Mukta, 2019; Hossain, 2022), which reported significantly higher profitability in aquaculture. This discrepancy can be attributed to several factors:

- Exclusion of Implicit Costs: Many studies do not account for land use costs**,** opportunity costs of capital, or unpaid family labor, thereby overstating profitability.
- Access to Subsidized Financing: Government subsidies or low-interest loans in other studies may have lowered capital costs, improving reported financial metrics.
- Differences in Cultured Species: Studies on tilapia, carp, or shrimp farming often report higher BCR values due to:
    - Lower input costs (cheaper feed, less infrastructure-intensive systems).
    - Higher market demand, ensuring stable pricing.
    - Greater feed efficiency, reducing production costs.

The Feed Conversion Ratio (FCR) of 1.79 suggests that 1.79 kg of feed is required to produce 1 kg of trout. This is relatively high compared to tilapia or catfish. Since feed is the most significant operational cost, higher FCR values lead to lower profitability. Factors influencing feed efficiency include:

- Feed Quality and Composition: Trout require high-protein diets, increasing costs compared to omnivorous species.
- Culture System: Intensive production systems may improve FCR but also raise operational risks.
- Species-Specific Growth Rates: Trout have a slower growth rate compared to tilapia, extending the production cycle, and increasing costs.

Table 2: Profitability of Trout Fish Farming		
Indicators	**Units**	**Value**
Productivity	Kg	238400.00
Total return	Rs.	115705000.00
Gross profit	Rs.	40252700.79
Net return	Rs.	1119495.65
BCR	Ratio	1.01
GPM	%	34.79
NPM	%	0.97
Break-even yield	Kg	231770.00
Break-even yield in monetary value	Rs.	112487018.58
Break-even price	Rs./kg	480.64
FCR	Ratio	1.79

Source: ***Analysis of Survey Data***

Output: ***Stata 18.0***

Sensitivity Analysis

Farming operations inherently face uncertainties that can significantly impact profitability. To address this, a profit sensitivity analysis was conducted to evaluate the relationship between uncertain model parameters and expected financial outcomes (Saltelli, 2008) This analysis serves as a critical framework for assessing the financial viability of trout farming under changing economic conditions and offers valuable insights for developing sustainable farming policies. In this study, five distinct scenarios were analyzed against a business-as-usual baseline to quantify variations in key financial metrics, including the benefit-cost ratio (BCR), gross profit margin (GPM), net profit margin (NPM), break-even price (BEP), variable cost per kilogram (VCK), and benefits per kilogram of fish (BKF). The results highlight the significant sensitivity of trout farming profitability to fluctuations in feed costs and fish prices, emphasizing the importance of strategic policy interventions (see Table 3).

A 10% reduction in feed costs led to a substantial improvement in profitability. Under this scenario, the BCR increased from 1.01 to 1.05, the BKF rose from Rs. 4.69/kg to Rs. 23.17/kg, and the VCK decreased by 10%, going from Rs. 316.49/kg to Rs. 284.84/kg. These results indicate that feed cost is a critical determinant of profitability. Conversely, a 10% increase in feed costs rendered operations financially unviable, with the BCR dropping below the profitability threshold to 0.97, the NPM turning negative at -2.84%, and the BKF declining to Rs. -13.78/kg. These findings demonstrate the vulnerability of trout farming margins to rising input costs. Similarly, a 10% increase in the output price, while holding other factors constant, resulted in an increased BCR of 1.11 and a nearly 10% rise in NPM from the business-as-usual scenario, reaching 9.97%. The BKF also increased to Rs. 53.22/kg, exceeding the financial benefits obtained from a 10% reduction in feed costs. This suggests that an increase in fish prices has a more pronounced positive effect on profitability than a decrease in feed costs. On the other hand, a 10% reduction in fish prices led to a sharp decline in the BCR to 0.91, with the NPM turning negative. Overall, the study found that trout farming was marginally profitable, with profitability significantly influenced by changes in fish prices and feed costs. However, the most favorable financial outcomes were observed when both a 10% reduction in feed costs and a 10% increase in fish prices were implemented simultaneously. Under this combined scenario, the highest BCR of 1.16, BKF of Rs. 72/kg, and NPM of 13.43% were recorded, making it the most viable strategy for enhancing profitability.

Based on these findings, a policy framework that includes a combination of strategies—specifically, maintaining feed quality while reducing feed costs and implementing measures to increase fish prices—could improve the sustainability of trout farming in Kashmir. This study recommends establishing a dedicated nutritional feed research institute to lower feed costs while ensuring high-quality standards. Additionally, efforts should be made to facilitate the availability of locally produced nutritious feeds and feed ingredients in the market. These measures would help reduce reliance on commercial feeds over time, thus stabilizing feed costs while maintaining profitability. Furthermore, ensuring a price premium for trout, considering consumer demand and purchasing power, could further enhance the financial viability of the sector. Finally, the findings of this study align with previous research, which has similarly demonstrated that fish farming profitability is highly sensitive to fluctuations in feed and fish prices (Kumar G. E., 2016; Kumar G. &., 2017; Mukta, 2019; Hossain, 2022). These insights provide a foundation for policymakers and stakeholders to implement strategies aimed at ensuring the long-term sustainability and profitability of trout farming in the region.

Table 3: Sensitivity Analysis						
Scenario	**GPM (%)**	**NPM (%)**	**BCR**	**BEP**	**VCK**	**BKF**
Business as usual	34.79	0.97	1.01	480.64	316.49	4.69
Feed cost reduced by 10%	38.60	4.77	1.05	448.99	284.84	23.17
Feed cost increased by 10%	30.98	-2.84	0.97	512.29	348.14	-13.78
Fish price increased by 10%	40.72	9.97	1.11	480.64	316.49	53.22
Fish price decreased by 10%	27.54	-10.04	0.91	480.64	316.49	-43.83
Feed price decreased by 10% & Fish price increased by 10%	44.18	13.43	1.16	448.99	284.84	71.70

Source: ***Analysis of Survey Data***

Output: ***Stata 18.0***

BCR: Benefit-cost ratio.

GPM: Gross profit margin.

NPM: Net profit margin.

BEP: Break-even price.

VCK: Variable cost per kg fish.

BKF: Benefits from per kg fish.

5. Conclusions and Policy Recommendation

This study presents a thorough analysis of the economic viability and profitability of trout farming in three prominent trout-producing districts of Kashmir—Srinagar, Baramulla, and Anantnag. Utilizing primary cross-sectional data gathered through structured questionnaires, the research examines the cost structure, profitability, and significant economic challenges faced by trout farmers. The findings indicate that although trout farming in the region is marginally profitable, evidenced by a Benefit-Cost Ratio (BCR) of 1.01, its financial sustainability is highly sensitive to variations in feed costs and fish prices. Feed constitutes the most considerable operational expense, representing 38.44% of the total production costs. The study also underscores the influence of implicit costs, such as land use and family labor, which, when taken into account, significantly impact profitability estimates.

Break-even analysis reveals that trout farmers operate with minimal financial buffers, as the break-even yield of 231,770 kg is closely aligned with their actual production level of 238,400 kg. This close proximity indicates that even minor disruptions, such as increases in input costs or decreases in market prices, could lead farms into economic losses. Sensitivity analysis further emphasizes the sector's vulnerability, showing that a 10% rise in feed costs results in a negative net profit margin of -2.84%. Conversely, a 10% increase in fish prices significantly improves the benefit-cost ratio (BCR) to 1.11. These findings highlight the urgent need for strategic interventions aimed at enhancing economic resilience and ensuring long-term sustainability.

Feed Cost Reduction Strategies: The expense associated with feed constitutes the most significant operational cost in trout production systems. As such, it is imperative to implement policies aimed at reducing feed costs while ensuring the maintenance of nutritional quality. One potential strategy involves the establishment of local feed production units, which can contribute to the decentralization of feed supply chains. Additionally, incentivizing domestic feed manufacturing can mitigate reliance on costly commercial feed sources. These approaches not only provide opportunities for cost savings but also promote sustainability within the agricultural sector by fostering local economies and reducing transportation-related emissions. Such measures are critical for enhancing the overall efficiency and profitability of trout farming operations.

Enhancing Market Linkages and Price Stability: The volatility in fish prices significantly affects profitability in the industry. It is essential for both government and private stakeholders to collaborate on developing structured fish marketing channels. These channels should include contract farming agreements, cooperative marketing initiatives, and price stabilization mechanisms to ensure fair market rates for farmers. Such efforts will help promote economic stability and sustainability within the fish farming sector.

***Financial Support and Credit Accessibility*:** The considerable capital investment associated with trout farming highlights the importance of financial support, such as low-interest loans or subsidies. Increasing access to institutional credit tailored specifically for aquaculture operations could significantly assist farmers in effectively managing their capital costs.

***Technology Adoption and Farm Efficiency*:** The promotion of contemporary aquaculture methods, such as the implementation of automated feeding systems that optimize feed delivery and minimize waste, alongside advanced water management practices that ensure efficient utilization of water resources, can significantly enhance feed efficiency and lead to substantial cost reductions. To maximize these benefits, it is crucial for extension services to offer in-depth training programs for farmers. These programs should cover a range of best practices, including the use of precision aquaculture technologies, regenerative farming techniques, and strategies for sustainable resource management. By equipping farmers with this knowledge, we can foster a more resilient and economically viable fisheries sector.

Government Policy Support: Policies aimed at reducing input costs, promoting infrastructure development, and providing financial incentives for new entrants in the trout farming industry could enhance the sector's sustainability. Furthermore, it is essential to prioritize subsidies for high-quality fish feed and to invest in research that develops alternative, cost-effective feed options.

Risk Mitigation and Insurance Schemes: Considering the vulnerability of trout farming to external shocks, implementing an insurance program tailored specifically for aquaculture could offer essential financial protection to farmers against fluctuations in input costs, disease outbreaks, and market price volatility, thereby contributing to the overall resilience and sustainability of the aquaculture sector.

Value Addition and Diversification: Encouraging farmers to consider the development of value-added products, such as smoked or processed trout, alongside the diversification of income sources through integrated aquaculture-agriculture models, has the potential to enhance profitability and bolster economic resilience.

By implementing the outlined recommendations, policymakers and stakeholders can enhance the economic sustainability of trout farming in Kashmir. Strengthening this sector through cost-effective strategies, improved market access, and targeted financial support will not only increase profitability for farmers but also contribute to the overall growth of the regional aquaculture industry.

References

1. Ali, M. M., Asif, A. A., Shabuj, M. A. I., Vaumik, S., Zafar, M. A., & Sharif, B. M. N. 2016. "Status of polyculture Pangasius hypophthalmus with carps in Jhikargacha Upazila of Jessore District, Bangladesh." *International Journal of Fisheries and Aquatic Studies, 4(1).* 423-430.
2. De, I., & Tandel, V. 2024. "Social cost–benefit analysis of natural treatment systems in India: implications for benefits model and governance." *Water International, 49(8).* 991–1011. doi:https://doi.org/10.1080/02508060.2024.2431795.
3. Devi, S. Z., Singh, N. R., Singh, N. A., & Laxmi, T. H. 2014. " Fish production in Manipur-an economic analysis. ." *Journal of crop and weed, 10(2).* 19-23.
4. Dhande, K. K., Sharma, R., & PS, A. 2023. "Profitability and resource use efficiency of polyculture system in Andhra Pradesh. ." *Aquaculture International, 31(5).* 2905-2918.
5. Hossain, M. E., Khan, M. A., Saha, S. M., & Dey, M. M. 2022. "Economic assessment of freshwater carp polyculture in Bangladesh: Profit sensitivity, economies of scale and liquidity. ." *Aquaculture* 548, 737552.
6. Karim, M., Sarwer, R. H., Phillips, M., & Belton, B. 2014. "Profitability and adoption of improved shrimp farming technologies in the aquatic agricultural systems of southwestern Bangladesh. ." *Aquaculture* 61-70.
7. Katiha, P. K., Jena, J. K., Pillai, N. G. K., Chakraborty, C., & Dey, M. M. 2005. "INLAND AQUACULTURE IN INDIA: PAST TREND, PRESENT STATUS AND FUTURE PROSPECTS." *Aquaculture Economics & Management, 9(1–2).* 237–264. doi:https://doi.org/10.1080/13657300590961573.
8. Khan, M.A. 2012. " Efficiency, Risk and Management of Fisheries ." *Doctoral Thesis, UMB School of Economics and Business, Norwegian University of Life Sciences, Norway.*
9. Kumar, G., & Engle, C. 2017. " Economics of intensively aerated catfish ponds." *Journal of the World Aquaculture Society, 48(2).* 320-332.
10. Kumar, G., Engle, C., & Tucker, C. 2016. " Costs and risk of catfish split-pond systems. ." *Journal of the World Aquaculture Society, 47(3).* 327-340.
11. Mohsin, A. B. M., Islam, M. N., Hossain, M. A., & Galib, S. M. 2012. "Cost-benefit analyses of carp polyculture in ponds: a survey study in Rajshahi and Natore districts of Bangladesh." *Bangladesh Journal of Environmental Science, 23.* 103-107.
12. Mukta, M. A., Khan, M. A., Mian, M. R. U., & Juice, R. A. 2019. "Is tilapia farming financially profitable and efficient? Policy options for sustainable farming: Policy options for sustainable tilapia farming. ." *Journal of the Bangladesh Agricultural University, 17(1).* 92-98.
13. Munthali, M. G., Chilora, L., Wineman, A., Nankwenya, B., Chiwaula, L., & Muyanga, M. 2024. "Productivity and profitability of small-scale aquaculture in Malawi." *Agrekon, 63(1–2)* 30–50. doi:https://doi.org/10.1080/03031853.2024.2345396.
14. Peng, B., Shen, X., & Jiang, Q. 2024. "Profit or Loss? Delving into the cost-benefit dynamics of characteristic freshwater fish aquaculture in China. ." *Aquaculture and Fisheries.*
15. Prodhan, M.M.H. and Khan, M.A. 2018. "Management practice adoption and productivity of commercial aquaculture farms adoption and productivity of commercial aquaculture farms ." *Journal of the Bangladesh Agricultural University.* 111–116.
16. Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D., ... & Tarantola, S. 2008. *Global sensitivity analysis: the primer.* John Wiley & Sons.

17. Sarker, M. A. A., Arshad, F. M., Alam, M. F., Mohamed, Z. A., & Khan, M. A. 2016. "Stochastic modeling of production risk and technical efficiency of Thai koi (Anabas testudineus) farming in Northern Bangladesh." *Aquaculture Economics & Management.* 165-184.
18. Sethi, S., Kund, G. C., Swain, A. K., Patra, S. K., & Sial, N. K. 2024. "Benefit-cost ratio analysis of composite fish culture ponds in selected district of Odisha." *The Pharma Innovation Journal* 178-181.
19. Shawon, N. A. A., Prodhan, M. M. H., Khan, M. A., & Mitra, S. 2018. "Financial profitability of small scale shrimp farming in a coastal area of Bangladesh. 16(1) ." *Journal of the Bangladesh Agricultural University.* 104-110.
20. Singh, D. R., Vasisht, A. K., & Kumar, S. 2015. "Profitability and technical efficiency of aquaculture in Punjab, India." *Indian Journal of Fisheries, 62(2),* 49-55.