Indian Fisheries Association

Journal of Indian Fisheries Association

An Economic Analysis of Rainbow Trout (Oncorhynchus mykiss) Farming in Sikkim, India

Abhilash Thapa[1], Rama Sharma[1]*, Stanzin Gawa[2] and Naila Majid Bhat[1]

[1]*Fisheries Economics, Extension & Statistics Division ICAR-Central Institute of Fisheries Education, Mumbai - 400 061, India*
[2] *Extension, Economics & Statistics Department, College of Fisheries Science, Gumla – 835207*

Abstract

Rainbow trout farming holds a long-standing tradition as one of the earliest forms of commercial fish production, primarily concentrated in the upper Himalayan region and the Western Ghats of India. It remains a crucial component of cold-water fisheries and has substantial untapped potential to serve as a means of livelihood in the resource-scarce Indian Himalayan region, thereby contributing to food security. While states like Jammu & Kashmir and Himachal Pradesh are leading the way in trout production, the northeastern state of Sikkim still offers opportunities for increasing its output. A comprehensive study was undertaken to assess the socioeconomic aspects, factors influencing production, and challenges faced by trout farmers in Sikkim. The study gathered primary data from 30 trout farmers in Sikkim through structured interviews. Statistical tools involved Benefit-Cost (B-C) ratio, multiple linear regression, and rank-based quotient. The findings unveiled a demographic profile where the majority of respondents were Hindu, married males, educated up to the primary level, and residing in joint families with monthly incomes ranging from ₹ 12,000 to ₹36,000. Two economic scenarios were considered: one with financial assistance in the form of subsidies and one without such financial support. Without subsidy, the total cost of trout farming amounted to ₹2.46 lakh per farm and ₹1.14 lakh per raceway. Variable costs comprised 67.67 % of the total, with feed costs representing the largest component at 40.35%, followed by seed costs at 23.16%. In contrast, with subsidies, the total cost dropped to ₹1.59 lakh per farm and ₹ 0.73 lakh per raceway, with variable costs accounting for 72.57%. Seed costs remained the major expense at 35.90%, followed by feed costs at 31.58%. The economic viability of trout farming in Sikkim was substantiated by B:C ratios of 1.87 and 1.21 with and without subsidies, respectively, highlighting its profitability even without financial aid. However, the study also identified a major constraint: the unavailability of quality feed. This issue highlights the attention of policymakers, who should consider solutions to improve feed quality and reduce its cost, possibly through the establishment of feed mills along the lines of those in the Kashmir valley. In conclusion, the study emphasizes the untapped potential of trout farming for income generation in Sikkim, underscoring the need for well-crafted policies and initiatives to harness this opportunity fully.

Keywords:
Trout, Socio-economics, Cost and Returns, MLR, Constraints, Sikkim

***Corresponding author:**
ramasharma61@gmail.com

Received : 01 January 2023
Accepted : 23 September 2023

Introduction

India is endowed with significant aquatic resources in terms of upland rivers, streams, springs, high and low altitude natural lakes in addition to man-made reservoirs existing both in Himalayan regions and Western Ghats. Cold water Fisheries occupy an important place amongst the freshwater fishes of India. Cold water fisheries deal with fisheries activity in water where temperature of water ranges from 5 to 25 degrees centigrade. Such conditions in India occur in Himalayan and peninsular regions. In India, trout farming is restricted to the upper Himalayan region and Western Ghats and is one of the oldest forms of commercial fish production. Trout introduction in India dates back to

late 19th and early 20th century under colonial rule by the British, who made independent efforts in north-western and peninsular region of the country where suitable cold water for trout is available (Vass *et al.,* 2010). Later in 1918, steelhead strain of rainbow trout was introduced from England, and it was then propagated to different regions of India, namely Nilgiri Hill region of Ooty in Tamil Nadu, Arunachal Pradesh, Sikkim, Himachal Pradesh and Jammu and Kashmir, etc. Among cultivable fishes, rainbow trout, *Oncorhynchus mykiss* contributes substantially to upland aquaculture production in the country. Superior growth in lower water thermal regime, hardy nature, simple breeding protocol, optimum artificial feed uptake, wide temperature tolerance and high market price are some of the useful attributes owing to which rainbow trout is widely preferred in upland aquaculture systems (Vass, 2002).

Trout farming has progressed steadily during last decade in India and its total production elevated almost five-fold from 147 tonnes during 2004-05 to 842 tonnes during 2015-2016 in the country. The trout production of one of the leading states, Jammu & Kashmir was 598 tonnes; Himachal 457 tonnes; Sikkim 120 tonnes while other states including Uttarakhand and Arunachal Pradesh was 40 tonnes during the year 2015-16. (Singh *et al*., 2017).

Trout farming is becoming popular in Sikkim with ample water bodies suitable for farming exotic carp species in the lower belt and rainbow trout in higher. Before 2008-2009, the development program for fisheries was confined to conservation of riverine fisheries, production and stocking of brown trout seed in cold water streams and lakes for promoting angling. However, after 2008-2009, Department of Fisheries (DoF), Sikkim has been continuously promoting fish farming to provide additional livelihood options for farmers, along with technical and research support from the Directorate of Coldwater Fisheries Research (Sharma *et al.,* 2017).

The promotion of trout farming by beneficiaries became effective from 2009 onwards (Pandey *et al.,* 2015) DOF started availing funds for rainbow trout raceways through various schemes, viz; National Fisheries Development Board (NFDB), Rashtriya Krishi Vikas Yojana (RKVY), National Mission for Protein Supplement (NMPS), Blue Revolution Mission and Fisheries Developmental Plan from state government (FDP). The government is providing financial as well as technical assistance for trout farming under the scheme named "Trout culture in raceways" (Chettri 2018). To date, state of Sikkim has 430 units of trout raceways and many new units are still under construction (DOF, Sikkim). DOF has provided an attractive Minimum Selling Price (MSP) of Rs. 900 per kg and supplies pelleted trout feed every year to the farmers. As a result, more farmers have opted for trout farming as their source of income in the state. The production of rainbow trout showed a record increase of 120 mt in the year 2015-16 from the year 2010-11, when it was around 53.4 mt (Pandey *et al.,* 2015; Singh *et al.,* 2017).

Trout culture in Sikkim has been practiced for almost a decade. Studies on economics of Trout culture in Jammu & Kashmir and Himachal Pradesh had already been performed in the past by Gawa *et al*., 2017 and Singh *et al.,* 2008. However, economics of trout culture in Sikkim has not yet been conducted till date; therefore the present study has been carried out to assess the actual cost-benefit and factors affecting trout culture in Sikkim to fill this research gap. Being one of the progressing states in terms of trout farming, Sikkim still has scope for increasing trout production (Sharma *et al*., 2018), thereby increasing livelihood options for the state farmers.

Methodology

The primary data was collected from 30 trout farmers from all four district of Sikkim by personal interview method following simple random sampling technique using pre-tested questionnaire designed for the study. The secondary data was collected from published literature and reports of Department of Fisheries, Government of Sikkim and other agencies related to trout farming. Both inputs purchased and homegrown inputs were priced on the prevailing market price. Trout harvested were evaluated at prevailing market price at the time of harvest. Simple statistical tools such as average, percentage, and farm business analysis were used to meet the objectives of the study. The data obtained by the survey was analyzed (descriptive statistics and Rank Based Quotient (RBQ) using MS Excel, and MLR) statistical software SPSS, version 22.0.

The Cost and Returns of the sample Trout farms was calculated under two scenarios i.e., Without subsidy and With subsidy. Here, without subsidy refers to inclusion of all cost of trout production, both fixed and variable at the prevailing market price. With subsidy refers to the reduced cost in trout production due to the financial assistance given by the Department of Fisheries, Government of Sikkim for construction of trout raceways and the yearly free supply of feed given to the trout farmers. To determine the cost and return in trout feed production following variable and tools has been followed.

Fixed cost includes the following items:

Depreciation on fixed assets: calculated @10 % using straight-line method.

Interest on fixed capital: It was calculated @ 12% per annum on fixed capital.

Expenses on repair and maintenance of fixed assets: estimated based on the information collected from each respondent separately.

Variable cost includes the following items i.e., seed, feed, hired labour, transportation, and miscellaneous.

Interest on working capital (It has been calculated at 8.75% interest rate for a period of 6 months)

Gross income: It was obtained by multiplying the quantity of produce with respective prices.

$$Gross\ income = Q \times P$$

Where, Q= quantity of trout produced (kg) and P = Selling price of trout (₹ /kg)

Net income: The return left after deducting all the expenditures such as fixed cost and variable cost from gross income.

$$Net\ income = GI - TC$$

Where, GI = Gross income, TC = Total cost and

$$TC = TFC + TVC.$$

Where, TFC = Total fixed cost and TVC = Total variable cost

Benefit cost ratio (B:C Ratio): B:C ratio was used to check the viability of the business. It estimates the ratio of benefit and cost incurred in the business. Mathematically, it can be expressed as:

$$BC\ Ratio = \frac{Gross\ income}{Total\ cost}: \quad (1)$$

Where, the dependent variable, Y = total trout production in kg, α= intercept, βi= coefficient & ε =Error term. The independent variables are $X1$= labour in hours, $X2$= feed in kg, $X3$=seed in numbers, $X4$=no. of raceways, $X5$= Gender (A dummy variable. It takes value of 1 if male, 0 otherwise) $X6$=Experience in years, $X7$=Education in years, $X8$=Age in years, βi= coefficient & ε =Error term.

Multiple linear regression

To determine the factors affecting trout culture multiple linear regression was used as given below:

$$Y = \alpha + \beta 1X1 + \cdots + \beta nXn + \varepsilon \quad (2)$$

Constraints Analysis

Constraints faced by trout farmers were identified from those farmers who were practicing the same and confirmed by the government officials of Department of Fisheries, Sikkim. Information regarding technical, environmental, infrastructural and economic constraints were gathered. The result shows four different constraint categories with 20 sub-heads. These constraints were analyzed using Rank-Based Quotient (RBQ) given by Sabarathnam (1988).

$$R.B.Q = \frac{\sum f_i(n+1-i)}{(N \times n)} \times 100$$

Where, f_i = Number of trout farmers reporting a particular problem under ith rank. N = number of trout farmers. n = number of problems identified.

Table 1. Socioeconomic profile of respondent trout farmers (N=30)

Variable	Description	Percentage	Variable	Description	Percentage
Gender	Male	86.67	Primary occupation	Farming	60
	Female	13.33		Horticulture	16.67
Age	Young (<40)	20		Retired	6.67
	Middle (40-60)	70		Business	6.67
	0ld (>60)	10		Fisheries	3.33
Religion	Hindu	60		Service	3.33
	Christian	10		Carpenter	3.33
	Buddhist	30	Secondary occupation	Farming	3.33
Caste	OBC	46.67		Fisheries	96.67
	BL	26.67	Family type	Nuclear	20
	ST	13.33		Joint	80
	General	13.33	Land holding	Marginal (<1ha)	76.67
Education	No formal education	6.67		Small (1-2 ha)	20
	Primary	36.67	Social participation	No participation	73.33
	Secondary	26.67		Cooperative society	20
	Higher secondary	20		SHG	6.67
	Graduation	10	Monthly income	Low income (<₹12000)	6.67
Experience	< 5 years	16.67		Middle income (₹12000-36000)	80
	≥ 5 years	83.33		High income (>₹36000)	13.33

Note: OBC: Other Backward Class; ST: Scheduled Tribe; BL: Bhutia Lepcha; SHG: Self Help Group

Results and discussion

Socio-economic profile

Analysis of socio-economic profile of selected trout farmers in Sikkim revealed that 86.67% of the respondent trout farmers were male, 70% belonged to middle age category (40-60 years) with an average age of 50.47 years. More than half (60%) followed Hindu religion, 46.67% were other backward class (OBC), 93.33% were literate with nearly 36.67 % educated upto primary level. Majority of them (96.67%) had taken up trout farming as the secondary occupation in addition to the primary occupation, agriculture (60%). The farmer's experience in trout farming was mostly in the range of 1 to 9 years, with majority (83.33%) being involved for more than five years. Nearly 80% lived with a joint family and 76.67% of them were marginal landholders. Among all, only 26.6 % were found to be members of SHGs and Cooperatives and 80 % belonged to middle income category (₹12000-36000 per month).

Factors affecting trout farming

According to the results of the regression analysis for estimating the factors affecting trout production, VIF values are smaller than 10, indicating that the independent variables are free from problem of multicollinearity (Gujarati, 2022). The multiple linear regression (MLR) model was statistically significant, $F(8, 21) = 213.979$, $p < .001$ and R^2 in this study show that total trout production in kg, the dependent variable in the model, is explained by 98% of the independent variables (R^2=.988 and Adjusted R^2=.983). Accordingly, the Multiple Linear Regression for trout production in Sikkim is as follows:

$$Y = 13.324 + 0.508X_1 + 0.387X_2 + 0.002X_3 + 23.431X_4 + 18.195X_5 - 7.317X_6 - 10.228X_7 - 0.933X_8 + \varepsilon$$

MLR from table 2. reveals that labour in hours (p=.080) and feed in kilogram (p=.000) are the significant variables that influence the trout production. Their coefficients indicate that an increase in one labour hour will lead to an increase in trout production by 0.505 kg, *ceteris paribus*. Previous studies by Sundari *et al.* (2017), Gawa and Kumar (2017) and Majid *et al.* (2021) have also found evidence that labor contributed to increasing fish production. Also, an increase in one kilogram of feed will lead to an increase in trout production by 0.387 kg, *ceteris paribus*. Similar findings were reported by Bozoglu *et al.* (2007) in Turkey, that with an increase in feed used by 1 kg, trout production should increase by 0.88 kg.

Table 2. Multiple linear regression model of trout production on related variables in Sikkim

Sl. No.	Independent variables	Coefficients	Standard Error	t value	P>|t|	VIF
1	Constant (α)	13.324	56.308	0.24	0.815	
2	Labour in hours ($_1$)	.508	.276	1.84	0.080*	4.667
3	Feed in kg ($_2$)	.387	.029	12.91	0.000***	7.266
4	Seed in numbers ($_3$)	.002	.006	0.35	0.728	6.799
5	No. of Raceways ($_4$)	23.431	13.829	1.69	0.105	5.443
6	Gender dummy ($_5$)	18.195	17.332	1.05	0.306	1.337
7	Experience in years ($_6$)	-7.317	2.621	-0.28	0.783	1.322
8	Education in years ($_7$)	-10.228	7.781	-1.31	0.203	2.854
9	Age in years ($_8$)	-.933	.930	-1.00	0.306	2.333

Model: R^2= 0.988, Adjusted R^2= 0.983, F= 213.979, p=0.000, N: 30

*Where, *** p<0.01, ** p<0.05, * p<0.1, Dependent Variable: Trout production (Kg)*

Fixed capital investment pattern

The fixed capital investment pattern was estimated per trout farm and per raceways of 40 m^3 each presented in Table 3. The table shows that total fixed capital investment per farm was ₹4.15 lakh and Rs. 1.9 lakh per raceway. The major investment was for raceway construction, which accounts for 95.85 % of the total investment. Investment in dirt settling tanks and pipelines were 1.78 % and 1.39 %, respectively. Other investments on the farm were fencing, weighing balance, nets, tubs and buckets with shares of 0.41 %, 0.25 %, 0.20 % and 0.11 %, respectively.

Table 3. Fixed capital investment pattern of trout farms

Particulars	₹/ Farm	₹/ Raceway (40 M3)	Percentage
Raceways	398433.3	183892.3	95.85
Dirt Settling Tank	7410	3420	1.78
Pipeline	5796.67	2675.39	1.39
Fencing	1723.33	795.38	0.41
Weighing Balance	1046	482.8	0.25
Nets	812.33	374.92	0.20
Tubs and Buckets	441	203.54	0.11
TOTAL	415662.6	191844.3	100.00

Table 4. Cost and returns without subsidy in sample trout farms

Particulars	Cost(₹/Farm)	Cost(₹/Raceway) (40 M3)	Percentage
Seed	57066.67	26338.46	23.16
Feed	99404.00	45878.77	40.35
Hired labour	423.33	195.38	0.17
Transportation	956.67	441.54	0.39
Miscellaneous	1870.00	863.08	0.76
Total working capital	159720.67	73717.23	64.83
Interest on total working capital	6987.78	3225.13	2.84
Total variable cost	166708.45	76942.36	67.67
Depreciation	24939.76	11510.66	10.12
Interest on fixed capital	49879.52	23021.32	20.25
Annual repair & maintenance	4833.33	2230.77	1.96
Total fixed asset	79652.61	36762.74	32.33
Total cost	246361.06	113705.10	100.00
Total production(kg)	373.00	172.15	
Cost of production (Rs./kg)	660.49	660.49	
Selling price (Rs./kg)	798.33	798.33	
Farmers margin (Rs./kg)	137.85	137.85	
Gross revenue	297778.33	137436.15	
Net revenue	51417.27	23731.05	
B:C ratio	1.21	1.21	

Cost and Returns without Subsidy in Trout Farming

The cost and returns without subsidy of trout farming in Sikkim per farm and per raceways was estimated for the sample trout farms as shown in Table 4.

As can be seen from Table 4. the total cost incurred in trout farming without subsidy was ₹2.46 lakh per farm and ₹1.14 lakh per raceway. The total variable cost worked out to 67.67%, whereas total fixed cost was 32.33 % of the total cost. The findings of this study were on par with Gawa *et al.* (2017), who estimated the cost and returns of trout farming in Kashmir, with total variable cost as 75.32 % and total fixed cost as 24.68 % of the total cost.

Among the total variable cost, feed holds the highest share to the total cost with 40.35%. Similar findings by Klontz`s (1991), Singh *et al.* (2008), Bozoglu *et al.* (2009), Gawa *et al.* (2017) and Aydın *et al.* (2018) reported that the biggest share of total cost was constituted by the feed price i.e., 57.05%, 64.33%, 43.45%, 45.35% and 45.53% respectively. So feed is an important factor in deciding profitability of Trout

farming. Under the fixed cost, interest on fixed capital accounted for the highest share of 20.25 % of the total cost followed by depreciation which accounted for 10.12 % of the total cost. Similar to the findings of Gawa *et al*. (2017) which reported that interest on fixed capital (14.85%), followed by depreciation (6.25%) of the total cost.

The average cost of producing 1 kg of trout without any subsidy was ₹ 660.49 while average selling price was ₹ 798.33 /kg. Farmers achieved a margin of ₹ 137.85. The finding is supported by a similar study by Gawa *et al.,* (2017) in Kashmir, India where the average cost of producing 1 kg of trout was ₹215.77 while average selling price was Rs.389.17/kg and the farmers achieved a margin of ₹173.40/kg. The benefit-cost ratio of the present study was estimated to be 1.21, which indicates the economic viability of trout farming in Sikkim even without any financial assistance from the Department of Fisheries, Government of Sikkim. However, it was comparatively less than other studies reported by Joshi (2014) in Nepal (2.18), Gawa and Kumar (2017) in Kashmir (1.80) and Barbosa *et al*. (2020) in Brazil (1.54).

Cost and Returns with Subsidy in Trout Farming

The cost and returns with subsidy of trout farming in Sikkim per farm and per raceways was estimated for the sample trout farms as shown in Table 5.

As shown in Table 5. the total cost incurred in trout farming with subsidy from the Department of Fisheries, was ₹ 1.59 lakh per farm and ₹ 0.73 lakh per raceway. The total variable cost worked out to 72.57 %, whereas total fixed cost was 27.43 % of the total cost. Among the total variable cost, seed and feed holds the highest share to the total cost with 35.9 % for feed and 31.58 % for seed. Here seed gets the highest share as the price was ₹ 20 per seed. Under the fixed cost, interest on fixed capital accounted for the highest share of 16.38 % in the total cost followed by depreciation which accounted 8.01 % of the total cost. Deduction in both cases was the result of financial assistance provided by the Department of Fisheries, Sikkim for the construction of trout raceways.

In subsidised trout farming, the average cost of producing 1 kg of trout was lower i.e., ₹ 426.16 while average selling price remained the same i.e., ₹ 798.33

Table 5. Cost and returns with subsidy in sample trout farms

Particulars	Cost(₹/Farm)	Cost(₹/Raceway) (40 M3)	Percentage
Seed	57066.67	26338.46	35.90
Feed	50204.00	23171.08	31.58
Hired labour	423.33	195.38	0.27
Transportation	956.67	441.54	0.60
Miscellaneous	1870.00	863.08	1.18
Total working capital	110520.67	51009.54	69.53
Interest on total working capital	4835.28	2231.67	1.18
Total variable cost	115355.95	53241.21	72.57
Depreciation	12730.43	5875.58	8.01
Interest on fixed capital	26039.52	12018.24	16.38
Annual repair & maintenance	4833.33	2230.77	3.04
Total fixed asset	43603.29	20124.59	27.43
Total cost	158959.23	73365.80	100.00
Total production(kg)	373.00	172.15	
Cost of production (₹/kg)	426.16	426.16	
Selling price (₹/kg)	798.33	798.33	
Farmers margin (₹/kg)	372.17	372.17	
Gross revenue	297778.33	137436.15	
Net revenue	138819.10	64070.35	

/kg. The farmers achieved a higher margin of ₹ 372.17 and Benefit-Cost ratio was estimated to be 1.87 (as compared to 1.21 without subsidy) which indicates better economic viability of trout farming in Sikkim because of subsidy.

Constraints faced by the trout farmers

Information regarding technical, environmental, infrastructural and economic constraints were gathered and the trout farmers were asked to rank them according to their preferences. The result shows four different constraints category with 20 sub-heads. These constraints were analysed using Rank Based Quotient given by Sabarathnam (1988) and the results obtained are shown in Table 6.

Technical Constraints: All the farmers ranked unavailability of quality feed as rank one with a RBQ score of 100. Similarly, Singh *et al*. (2008), Bista *et al.* (2008) and Thapa *et al.* (2023) reported quality feed as one of the major constraints of trout/fish farming in Himachal Pradesh, Nepal and Darjeeling Himalayas respectively. Since trout feed was little available in the local market, only members of cooperative society would import feed from Hyderabad. Second important technical constraint was high mortality, with RBQ score of 73.33, as some of the fingerlings died during stocking, followed by lack of knowledge on modern and scientific trout farming with RBQ score of 61.67. The farmers believed that they have many more things to learn regarding trout culture. Due to the presence of many state, cooperative and individual trout hatcheries, unavailability of quality seed was not a major constraint. Contrary to the findings of Thakur *et al*., (2008) in Nepal where the most significant constraint was inadequate fingerlings supply.

Environmental Constraints: Under environmental constraints, disease outbreak was ranked one with RBQ score of 97.50, as farmers have encountered fungal and whirling syndrome. Predation was ranked second with RBQ score of 57.50, since birds eat the fish

Table 6. Constraints Faced by the Trout Farmers in Sikkim (N=30)

Sr. No.	Constraints	RBQ Score	Rank
Technical Constraints			
1	Unavailability of Quality Feed	100	I
2	High Mortality	73.33	II
3	Lack of knowledge of Modern & Scientific Trout Farming	61.67	III
4	Lack of Clear and Continuous Availability of Water	42.78	IV
5	Unavailability of Quality Seed	40.56	V
6	Lack of Technical Guidance	31.67	VI
Environmental Constraints			
1	Disease Outbreak	97.50	I
2	Predation	57.50	II
3	Contamination of Water during Rainy Season	55.83	III
4	Freezing of Water	39.17	IV
Infrastructural Constraints			
1	Unavailability of Feed Mills	97.33	I
2	Lack of Marketing Infrastructure	71.33	II
3	Less Development of Roads & Transport Facility	62.00	III
4	Lack of Power Supply	48.00	IV
5	Lack of Drinking Water & Daily Needs	21.33	V
Economic Constraints			
1	High Price of Feed	96.00	I
2	High Price of seed	76.67	II
3	Lack of Initial Investment	58.67	III
4	Unavailability of Credit	44.67	IV
5	Problem of Theft	24.00	V

when the size is small, to overcome this problem proper fencing and bird scare can be used. Contamination of water during rainy season was not an important constraint with RBQ score of 55.83, which was pointed out by Gurung *et al*. (2003) to be a probable reason for failure of trout culture.

Infrastructural constraints: The most important infrastructural constraint was unavailability feed mills with RBQ score of 97.33. As the government feed mill was not functioning at the time of survey due to a shortage of staff. Second on the list was lack of marketing infrastructure with RBQ score of 71.33, since there was no established market in most of the area and maximum produce was being directly sold to hotels. Singh *et al*. (2008) also reported that a similar problem was faced by 90% of trout farmers in Himachal Pradesh.

Economic Constraints: The majority of farmers ranked the high price of feed as the first and the high price of seed as the second economic constraint, with an RBQ scores of 96 and 76.67, respectively. Nepal *et al*. 2002 and Gawa and Kumar (2017), also reported feed and seed costs as one of the major constraints to trout farming in Nepal and Kashmir. Since trout farming is intensive and depends purely on artificial feeding, the feed price directly impacts profitability. Average price of feed was ₹ 120/kg, which trout farmers believed to be quite high. The existing trout seed price ₹ 20/piece was very high compared to carp seed. This price was the same for both government and cooperative-run hatcheries. Trout farmers ranked high initial investment as third economic constraint with RBQ score of 58.67, as average fixed investment per raceway was ₹1.9 lakh and the operating cost was also high i.e. 67.67 without subsidy and 72.57 with subsidy, of the total cost.

Conclusion

The study revealed that labour in hours and feed in kilograms were the most significant factors that positively influence trout production. The major investment was incurred for constructing raceways, and cost of feed and seed was the major contributor to operating cost and jointly accounted for more than 60 % of the total cost. When subsidy was removed feed cost was the highest component of total cost, whereas with subsidy it was seed cost. Trout farming in Sikkim was found to be profitable even in the absence of any financial aid, with the B:C ratio of 1.21 and 1.87 for trout farming without subsidy and with subsidy, respectively. Unavailability of quality feed was the major constraint faced by the trout farmers of Sikkim. Hence, feed is an important factor in deciding profitability of Trout farming. Even though the problem of feed exists, trout farming can be further enhanced in this hilly state by locally manufacturing quality feed at an affordable price, which will lead to a reduction in the total cost and encourage the farmers to use more feed. Thus, increasing production and profit simultaneously. The present study concludes that trout farming in Sikkim is economically feasible and there exists potential for growth of trout farming in Sikkim, which in turn will ensure new and better means of livelihood opportunities for local communities.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aydin, A., Bashimov, G. and YAYKAŞLI, M., 2018. The structural and economic analysis of the rainbow trout farming: Case of Erzurum province. *Marine Science and Technology Bulletin*, *7*(1), pp.4-11.

Barbosa, A.S., Pereira, R.G., Rodrigues, L.A., de Matos Casaca, J., Valenti, W.C. and Fabregat, T.E.H.P., 2020. Economic analysis of family trout farming in Southern Brazil. *Aquaculture International*, *28*(5), pp.2111-2120.

Bista, J.D., Wagle, S.K., Pradhan, N. and Roy, N.K., 2008. Nutrition and pellet feed formulation for rainbow trout (Oncorhynchus mykiss) in Nepal. *Rainbow trout (Oncorhynchus mykiss)*, p.43.

Bozoglu, M. and Ceyhan, V., 2009. Cost and profitability analysis for trout and sea bass production in the Black Sea, Turkey. *Journal of Animal and Veterinary Advances*, *8*(2), pp.217-222.

Bozoglu, M., Ceyhan, V., Cinemre, H.A., Demiryürek, K. and Kiliç, O., 2007. Important factors affecting trout production in the Black Sea Region, Turkey. *Czech Journal of Animal Science*, *52*(9), pp.308-313.

Chettri, K.B., 2018. Present scenario of fisheries in the hills of Sikkim. *International Journal of Creative Research Thoughts,* 6(2), pp. 1784-1791.

Gawa, S. and Kumar, N.R., 2017. Economics and Factors Affecting Rainbow Trout (Oncorhyncgusmykiss) Production in Kashmir. Indian Journal of Agricultural Economics, 72(2), pp.166-176.

Gawa, S., Kumar, N.R., Tiwari, V.K., Prakash, S., Yadav, V.K. and Wani, G.B., 2017. Trout culture in Kashmir-An opportunity for profitable enterprise. Social entrepreneurship in Aquaculture.(Ed. Sinha, VRP, Krishna, G., Keshavanth, P and Kumar, NR). Narendra Publishing House, Delhi, India.

Gujarathi, D.M., 2022. *Gujarati: Basic Econometrics*. McGraw-hill.

Gurung, T.B. and Basnet, S.R., 2003. Introduction of rainbow trout Onchorynchusmykiss in Nepal: constraints and prospects. Aquaculture Asia, 8(4), pp.16-18.

Hassan, A., Ishaq, M., Farooq, A. and Sadozai, S.H., 2007. Economics of trout fish farming in the northern areas of Pakistan. Sarhad journal of Agriculture, 23(2), p.407.

Hinshaw, J.M., 1990. Trout Production Handling Eggs and Fry. Leaflet/Texas Agricultural Extension Service; no. 2407.

Jhingran V.G. and Sehgal K.L., 1978, Coldwater fisheries of India, Inland Fisheries Society of India, Barrackpore, 238p

Joshi, K.R., 2014. Trout farming enterprise and marketing potential in Nepal. *Nepalese Journal of Agricultural Sciences*, *12*(2), pp.142-147.

Klontz, G.W., 1991. A manual for rainbow trout production on the family-owned farm. Thomas Nelson & Sons.

Majid, M.S.A. and Seftarita, C., 2021, February. What determines aquaculture fish production? empirical evidence from South Aceh Regency, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 674, No. 1, p. 012040). IOP Publishing.

Nepal, A.P., Basnyat, S.R., Lamsal, G.P., Joshi, P.L. and Mulmi, R.M., 2002. Economics of rainbow trout farming system in Nepal. *Cold Water Fisheries in the Trans-Himalayan Countries. FAO Fisheries Technical Paper*, (431), p.376.

Nepal, A.P., Basnyat, S.R., Lamsal, G.P., Joshi, P.L. and Mulmi, R.M., 2002. Economics of rainbow trout farming system in Nepal. Cold water fisheries in the trans-Himalayan countries, 431, pp.179-192.

Pandey, N.N. and Ali, S., 2015. Rainbow Trout Farming in India: R&D Perspectives. Bulletin, (23), pp.65-74.

Sabarathnam, V.E. and Vennila, S., 1996. Estimation of technological needs and identification of problems of farmers for formulation of research and extension programmes in agricultural entomology. Experimental Agriculture, 32(1), pp.87-90.

Sabarathnam, V.E., 1988. Manuals of field experience training for ARS Scientists. NAARM, Hyderabad, 21.

Sharma, P., and Ritesh S.T., 2017 "Inspiring story of aquaculture in Sikkim: A journey from conservation to farming." Aquaculture.

Sharma, P., Pandey, N.N., Haldar, R.S. and Sarma, D., 2018. Trout farming in Sikkim: a glimpse at present status and way forward. *Bulletin*, (31), pp.1-79.

Singh, A.K. and Lakra, W.S., 2011. Risk and benefit assessment of alien fish species of the aquaculture and aquarium trade into India. Reviews in Aquaculture, 3(1), pp.3-18.

Singh, A.K., Pandey, N.N., and Ali, S., 2017. Current status and strategies of rainbow trout Oncorhynchus mykiss farming in India. International Journal of Aquaculture, 7(4), pp 22-30 http://dx.doi.org/10.5376/ija.2017.07.0004

Singh, R., 2008. Fish Production in Himachal Pradesh:(economic Analysis of Fish Ponds). Agro-Economic Research Centre, Himachal Pradesh University.

Sundari, R.S. and Priyanto, Y.A., 2016. Efisiensi Penggunaan Faktor-Faktor Produksi Pada Teknologi PendederanIkan Lele (Clariassp) Sangkuriang. *JurnalTeknologi PerikanandanKelautan*, *7*(2), pp.199-206.

Thakur, N.S., Gauchan, D., Rayamajhi, A. and Lamsal, G.P., 2008. Socio-economic study of rainbow trout farming in Nepal: A case study of Kathmandu-Trishuli-Rasuwa road corridor. *Rainbow trout (Oncorhynchus mykiss)*, p.83.

Thapa, A., Sharma, R., Sharma, A. and Lepcha, R.L., 2023. Constraints faced by Jhora fish farmers in the Darjeeling Himalayas. *Journal of Indian Fisheries Association*, 50(1).pp.46-51. Available at: https://epubs.icar.org.in/index.php/JIFA/article/view/142400

Vass, K.K., 2002. Practical concepts of trout farming–its status and potential in India. Highland Fisheries and Aquatic Resources Management.

Vass, K.K., Raina, H.S. and Haldar, R.S., 2010. Prospects of rainbow trout-Oncorhynchusmykiss, Walbaum culture in mid altitudes of Central Himaslayas, India. Journal of the Inland Fisheries Society of India, 42(1), pp.1-7.