Aquaculture Studies, 24(3), AQUAST1655
http://doi.org/10.4194/AQUAST1655

RESEARCH PAPER

Trout Production in District Ganderbal – An Analysis of Economic Challenges

Shyambir Singh[1,*], Salman Rauoof Chalkoo[2]

[1]District Development Commissioner, Ganderbal, Ganderbal J&K, India.
[2]Assistant Director Fisheries, Ganderbal, J&K, India

How to Cite

Singh, S., Chalkoo, S.R. (2024). Trout Production in District Ganderbal – An Analysis of Economic Challenges. *Aquaculture Studies*, *24(3), AQUAST1655*. http://doi.org/10.4194/AQUAST1655

Article History
Received 19 August 2023
Accepted 02 October 2023
First Online 21 November 2023

Corresponding Author
Tel.: +09469999980
E-mail: shyambir0902@gmail.com

Keywords
Rainbow trout
Cost and return
B-C ratio
Resource use efficiency
Returns to scale and J&K

Abstract

The present study carried during the year 2022-23, worked on the impact of the introduction of genetically improved strains of rainbow trout on the economy of the fish farmers, in comparison to the normal strains. The economy of 40 farmers in groups of 20 Normal stock (NS) and Genetically Improved Stock (GIS) each was conducted and interviewed using a pre-tested questionnaire. The investigation showed that fixed capital investment on sample farm was Rs.1.25 lakh per raceway in both the set ups. The major share of investment was for the construction of raceway, which accounted for 68.53% of total investment on sample farms. The share of total variable cost was 58.37% in NS and 48.50 in GIS per cent and fixed cost was 41.62 in NS and 51.49 in GIS group. Feed was the major cost component accounting for about 46.43 per cent of the total cost in NS, while as it was reduced to 37.15% in GIS, thereby encouraging as a key factor in deciding profitability of trout farming. Resource use efficiency showed that feed was overutilized while labor was under-utilized in NS, while as it was optimally utilized in GIS group. The returns to scale in trout production of 1.25 indicates increasing returns to scale in trout production. High price of feed and seed are found to be the major constraints in trout culture. The B-C ratio worked out to be 1.37 in NS group and 1.87 in GIS group, indicating the economic feasibility of trout farming in the Kashmir valley, and better economic profile of farmers farming GIS strain.

Introduction

Europe and United States of America are well established in commercial rainbow (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) fish farming, which is a 400-year-old trade in Europe and about 150 years in USA (Hinshaw, 1990; David *et al*., 2015). Worlds's largest producer of rainbow trout is Chile, followed by Norway, Iran, Italy and France (FAO, 2013; Ragnar *et al*., 2019). The first effort to introduce trout in India was made by Sir Frances Day in 1863, where he introduced eyed eggs and fry of brown trout in the Nilgiri hills, but was unproductive. Later Mr. F.J. Mitchell prospered in the introduction of eyed eggs of brown trout in Harwan hatchery, Jammu and Kashmir in 1990. With the assistance of European Economic Community (EEC), Rainbow trout (*Onchorinchus mykiss*) culture was successful in the state of Jammu and Kashmir and Himachal Pradesh (Ayyappan *et al*., 2006; Shahnawaz *et al*., 2023).

Currently, trout fish farming in India is limited to the upper Himalayan region and Western Ghats owing to the favorable climatic conditions. The Union territory of Jammu and Kashmir, especially Kashmir province is the major supplier in trout production, with 447 km of streams, 486 km of rivers and about 157 sq. km of lakes (Bhat and Pandit, 2009, 2018; Sodhi *et al.,* 2013; ACWADAM, 2019; Samiullah *et al*., 2020). Trout culture is an ideal choice for maintainable use of water resources in mountainous regions of Kashmir because both surface and underground water of the region are appropriate for the fish culture, particularly the trout. In the geographical regions, where employment opportunities are infrequent, trout fish farming is a promising culture to safeguard employment and stable incomes (Woynarovich *et al*., 2011; Sneha Mahale, 2021; D'Agaro *et al*., 2022). Comprehending the potential of trout fish farming in the Union Territory, Government of Jammu and Kashmir and Government of India have started a various centrally sponsored schemes to encourage trout farming in the state. Presently, the state of Jammu and Kashmir has 51 trout hatcheries and trout rearing Centres in public sector and 1144 rearing units in private sector. The total trout production in the state during the year 2019-20 was 21.35 tonnes worth Rs.749.47 lakh (Government of Jammu and Kashmir, 2023), which has escalated to 26.90 tonnes during 2022-23, equivalent to 1073.58 Lacs. Despite of huge market demand, vast natural and human resources, trout culture in Kashmir is far away from realizing its potential. The Department of Fisheries in 2018-19, imported all female stock of genetically improved eyed ova of rainbow trout fish for raising as pure-line brooders for cross breeding with the existing stock to increase heterozygosity among the livestock. With an attempt to investigate the impact of cross breeding the normal and genetically improved stock, the current research was carried out to assess the economic improvement of fish farmers in District Ganderbal and respective challenges.

Materials and Methods

During present research work, Mammar hatchery in District Ganderbal was selected as a sole source of rainbow trout fingerlings to the fish farmers of the District. Mammar hatchery has a spring source and 1.5-2.0 lacs fingerlings of rainbow trout are produced every year and supplied to various private as well as government run units. The all-female stock of genetically improved stock was raised in trout hatchery mammar to keep record of the growth performance and mortality and a pure-line was maintained for two years. The genetically modified brooders (all female) were cross bred with the existing male stock and the progeny was reared in separate raceways. The fingerlings (Average Weight=5 g) from NS and GIS were transported with full quarantine to the selected raceways and stocked with full care, after proper acclimatization. The water quality parameters were almost the same at all the farm sites, the water source being the spring source, with good gradient, the oxygen concentration fluctuated between 8-9 ppm. All the raceways (50 m^3) had more or less the same flow rate. The sampling for enumeration of growth parameters was done on weekly basis and the ration was decided on 2% basis of the total biomass.

The existing normal stock was bred as usual in the month of November 2021, along with the genetically improved stock, which matures prior to the normal stock. The F1 generation of the genetically improved stock was raised in separate raceways and monitored regularly on all the biological aspects. Forty farmers were selected and the water was analyzed for physio-chemical characteristics. Twenty farmers were stocked with 2000 fingerlings each of normal strain and twenty farmers were stocked with genetically improved strains. The stocking was done in the month of April 2022. Regular monitoring for disease occurrence, co-morbidities, physico-chemical water parameters were evaluated regularly.

Data

Primary and secondary data was used during the present study. The secondary data for the study was collected from the Department of Fisheries, Government of Jammu and Kashmir website (http://www.jkfisheries.in). The primary data was collected from the farm households by personal interview with the help of a pre-composed questionnaire specially designed for the current study from May 2022 to June 2023. Using simple random sampling a total of 40 trout farmers, 20 each from the two subsets rearing normal stock (NS) and Genetically Improved Stock (GIS), were selected for the study. Prices of inputs purchased from markets were considered as current market price and home-grown inputs were priced on the prevailing market price. Trout harvested were assessed 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. Interest on fixed capital was calculated at 12% and 8.75% for working capital for a period of 6 months. B:C ratio was used to ascertain the economic viability of trout culture.

Production Function

Production function analysis was used as a quantitative tool to govern the factors affecting trout production. Trout production was used as the dependent variable and five inputs, i.e., feed, seed, human labour, medicine and chemicals used in trout production, were used as independent variables in estimating the production function.

$$TP = f\,(F, S, M, L, Ui)$$

where:
TP = Trout production (kg/raceway)
F = Feed use (kg/raceway)
S = Seed use (no. /raceway)
M = Medicine and chemical (kg/raceway)
L = Labour hours (total hour/raceway)
Ui = Stochastic error term.

The Cobb-Douglas production function (Cobb-Douglas, 1928) was found best fit on the basis of a priori and statistical criteria to explain the production of trout. The Cobb-Douglas production function for trout was used as follows:

$$LnTP = ln\beta 1 + \beta 2lnF + \beta 3lnS + \beta 4lnM + \beta 5lnL + ui$$

where, all notations are same as used before except β's which are unknown parameters to be estimated.

Marginal Value Product (MVP)

The MVP was estimated as

$$MVP_{Xi} = B_i \frac{\bar{y}}{\bar{X_\iota}} P_y$$

Where
βi = regression coefficient of i-th input (I = 1, 2, 3)
$\bar{Y}$ = geometric mean of output
$\overline{X\iota}$ = geometric mean of i-th input (I = 1, 2, 3)
P_Y = price of output Y per kg

Resource Use Efficiency

The resource use efficiency was estimated based on Ugwumba (2010) by calculating the efficiency ratio of MVP/MFC that indicate resource use efficiency.

For the purpose, MVP was estimated at their respective geometric mean level and MFC was taken as unit price of the factor. The MVP-FC ratio of different inputs were estimated as

$$MVP_{Xi} = ß_i \frac{\bar{y}(P_y)}{\overline{X_\iota(P_{x\iota})}}$$

where,
P_{Xi} = market price of i-th input
Py= market price of output
Decisions:
IF MVP/MFC = 1, then resource is optimally used.
IF MVP/MFC = <1, then resource is over-utilized.
IF MVP/MFC = >1, then resource is under-utilized.

Constraints Analysis

Rank Based Quotient (RBQ) was estimated to quantify the severity of the constraints in trout production and marketing as given by Sabarathnam and Vennilla (1996).

$$RBQ = \frac{\Sigma fi(n+1-i)}{N\ x\ n}\ x\ 100$$

where,
f_i = Number of respondents reporting a particular problem under i-th rank
N = Sample size
n = Number of rank or number of problems identified.

Results and Discussion

Since the genetically improved stocks were imported from Denmark to Himachal Pradesh and Jammu and Kashmir. The work on the economic analysis was carried out for the first time in District Ganderbal and no references in support of this particular scientific experiment are available.

Fixed Capital Investment Pattern on Sample Trout Farm

The fixed capital investment pattern was estimated per hectare and per raceway since raceway dimension was same at all the sample trout farms, i.e., 500 m^3 and presented in Table 1, and was almost same in both the tested groups. Perusal of the Table 1 and Fig 1. revealed that total investment made on the sample farm was Rs.6.25 crore per hectare and Rs.1.25 lakh per raceway. It was also found that major investment was for the construction of raceway which accounted for about 68.53% of the total investment on sample farms. The share of cost incurred on construction of inlet-outlet was 8.98% and about 10.72% of the investment was for construction of fencing on the farm. The other investments on the farms were farm shed, handle net, lighting and cabling, balance, covering net and tubs and bucket with share of 7.45, 1.26, 0.97, 0.71, 0.29, and

Table 1. Fixed capital investment pattern on sample trout farm

Particulars	Rs./ha	Rs./raceway (50m^3)	Share (per cent)
(1)	(2)	(3)	(4)
Raceway construction	4,28,33,500	85,667.00	68.53
Inlets-outlet	56,17,500	11,235.00	8.98
Farm shed	46,60,000	9,320.00	7.45
Fencing	67,00,000	13,400.00	10.72
Lighting and cabling	6,10,000	1220.00	0.97
Weighing balance	4,44,000	888.00	0.71
Handle net	7,90,000	1,580.00	1.26
Covering net	4,45,000	890.00	0.71
Tub and buckets	4,00,000	800.00	0.64
Total	6,25,00,000	1,25,000.00	100

0.64 per cent, respectively in the total fixed investment. It was also found that construction of raceway involved the maximum investment which is due to high cost of construction material, topography of the site and high labour cost in the valley.

Input Use Pattern on Sample Trout Farms

The input use pattern was estimated for the sample trout farms and presented in Table 2. Since the trout culture is practiced in raceways with average area of 50 m^3 each, the inputs were projected per raceway. The key input in trout farming is the seed (fingerlings), which was being used at the rate of 4000 seed per raceway of average weight 5g of both NS and GIS varieties. Feed was being used at the rate of 2% of the body weight over the cycle, which amounted to 1379.00 kgs in NS group and 892 kgs in GIS group. Other inputs used were medicine and chemicals, labour and electricity since these inputs could not be measured in quantity and has been calculated at the end of the production cycle. Since the disease occurrence was less in GIS group, so the use of antibiotics was completely avoided.

Costs and Return in Trout Farming on Sample Farms

The costs and return in trout farming in terms of per raceway and per hectare was estimated for the sample trout farms and presented in Table 3.

It is evident from table 3, that total cost incurred in trout farming was Rs. 1.25 lacs per raceway, which was not variable because of the same components in the construction. The total variable cost worked out to 58.37% in case of NS group and comparatively less 48.50% in GIS group, which justifies the better conversion of food by the genetically improved stock. The total fixed cost was 41.62% in Ns group and 51.49% in GIS group, which is in line with the findings of Bonzoglu *et al.*, 2009; d'Orbcastel *et al.*, 2009 and Andressa *et al.*, 2020. Among the total variable cost, feed and seed holds the highest share to the total cost with 46.43% for feed in NS group and 37.14% in GIS group, and 6.12% for seed in NS group and 7.5% in GIS group. Bonzoglu *et al.*, 2009 and Engle, 2010 also found that feed cost accounted for about 45.53 and 47.73 per cent in total cost of trout and sea bass, respectively. From the above finding it is clear that feed and seed were the key factors in deciding the profitability.

Since the trout farms in District Ganderbal are scattered along the length and breadth of the district, the farmers feel it very inconvenient to collect feed individually from the feed mill Manasbal. The Department of Fisheries has been very active in helping the fisherman to get the feed to the district in a pooled manner. The cost of transport has been drastically reduced to 1.53% in case of normal stock and 1.89% in case of GIS stock in the district. Under the fixed cost, interest on fixed capital was 0 because most of the farmers are in possession of proprietary land, and the

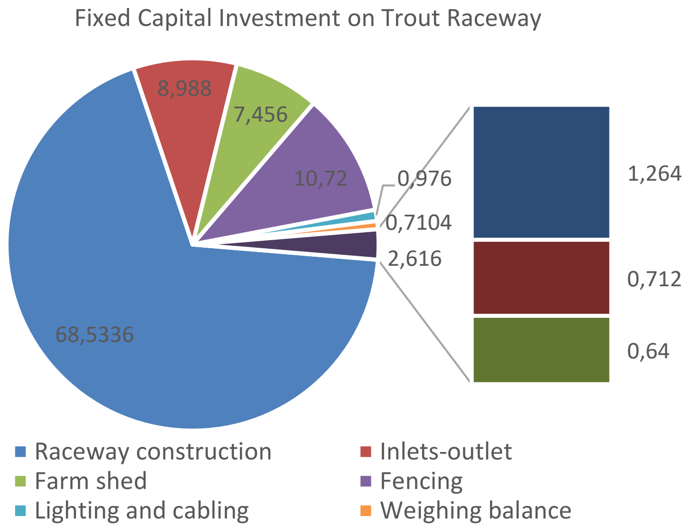

Figure 1. Fixed capital investment pattern on sample trout farm

Table 2. Input use pattern on sample trout farms

Particulars	NS			GIS		
(1)	Units	Amount	%age	Units	Amount	%age
Seed (No.)	4000	20000	10.48	4000	20000	15.610
Feed (kg)	1379	151690	79.54	892	98120	76.58
Medicine and chemicals (Rs.)	6500	6500	3.40	500	500	0.39
Labours (Rs.)	8000	8000	4.19	5000	5000	3.90
Electricity (Rs.)	4500	4500	2.35	4500	4500	3.51
Total		190690			128120	

farmers who don't have proprietary land, get the land on lease from their nearest relatives. So, the interest on the working capital and fixed capital was observed to be zero. During the study the prevailing price of feed was Rs.110/kg and seed price ranged from Rs.5 to Rs.10 per fingerling based on the sizes. Since both these vital inputs were produced by departments of fisheries price ceiling has been maintained to make them available to the trout farmers at reasonable price.

The average cost of producing 1 kg of trout was found out to be Rs.362.98 in case of NS and 266.78 in case of GIS, while average selling price was Rs. 500/kg. Since farmers sold trout directly from farm at farm gate price, they were able to achieve a margin Rs.137.02/kg in case of NS group and 233.22/kg in case of GIS group, marking a margin of 53.2%, as compared to 27.40% in case of NS group. The cost of production of trout has been convincingly consented by Valenti and Valenti (2010); Stanzin Gawa *et al*. (2017) and FAO (2020). The gross revenue was estimated to be Rs. 4.5 lakh per raceway in case of NS and 4.95 lakh per raceway in case of GIS, in contrary to the total cost of Rs. 3.26 and 2.64 Lakh per raceway respectively. Benefit-cost ratio was estimated to be 1.37 in case of NS and 1.87 in case of GIS group that indicates economic viability of the business which is in line with the findings of Olaoye (2013) who estimated that BC ratio of 1.69 indicating economic viability of trout farming in Nigeria. They found substantial difference between fixed cost in earthen and concrete pond which was lower for earthen pond. Antti Kause *et al*. (2022) worked on feed efficiency and reduction in nutrient loading from rainbow trout farms which lends complete support to our findings.

Estimated Trout Production Function

Three methods of production function, namely, Linear, Cobb-Douglas and Semi-log linear were tested to

Table 3. Costs and return in trout culture on sample farms

Particulars	Cost (Rs./Raceway) NS	%age share	Cost (Rs./raceway) GIS	%age share
Seed (Rs)	20000	6.12	20000	7.57
Feed (Rs)	151690	46.43	98120	37.14
Medicine and chemicals (Rs)	6500	1.98	500	0.18
Transportation (Rs)	5000	1.53	5000	1.89
Hired human labour (Rs)	8000	2.44	5000	1.89
Miscellaneous (Rs)	2000	0.61	2000	0.75
Total working capital (Rs)	125000	38.26	125000	47.32
Interest on working capital (Rs)	0	0	0	0
Total variable cost (Rs)	190690	58.37	128120	48.50
Depreciation (Rs)	6500	1.98	6500	2.46
Interest on fixed capital (Rs)	0	0	0	0
Annual repair and maintenance (Rs)	3500	1.07	3500	1.32
Land rent (Rs)	1000	0.30	1000	0.37
Total fixed cost (Rs)	136000	41.62	136000	51.49
Total cost A+B (Rs)	326690		264120	
Total production (kg)	900		990	
Cost of production (Rs./kg)	362.98		266.78	
Selling price (Rs.)	500		500	
Farmer's margin (Rs./kg)	137.02		233.22	
Gross revenue	450000		495000	
Net revenue	123010		230880	
B:C Ratio	1.37		1.87	

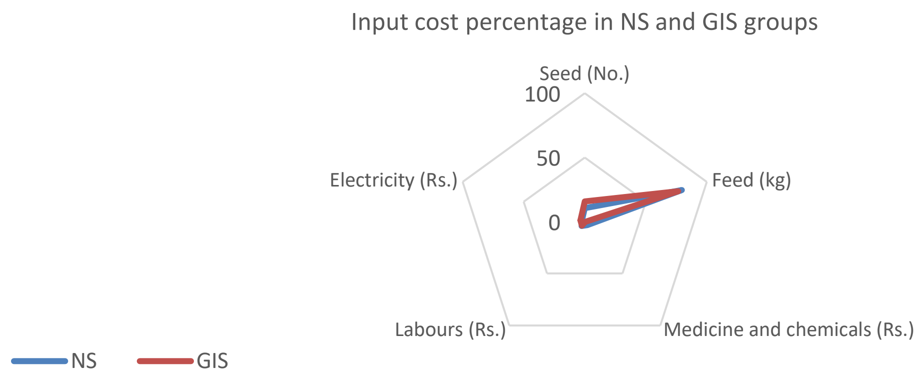

Figure 2. Input cost percentage in NS and GIS groups

look into the descriptive behavior of various inputs that go into the production of trout. The magnitude of the correlation coefficients indicated that multi-collinearity was not a serious problem in approximating the parameter of trout production function. The Cobb-Douglas form of the production function was found to be the best fit on the basis of both economic and statistical criteria. The basic Cobb - Douglas model was linearized by transforming into log linear form as used by Bozoglu *et al.* (2009). The parameters of the production function were assessed by stepwise method using SPSS 22.0 and results obtained in last run are presented below in the production function form along with the value of F, R^2 and summation of coefficients (β).

$$TP= 0.194*F^{-0.223**}L^{1.473*}$$

$$(-0.155) \qquad (0.921)$$

N=60 $R^2 = 0.772*$ F=89.62 Σbi = 1.250

Note: Figures in the parentheses represent standard error.

* and ** Significant at 5 and 1 per cent level of significance.

The projected production function designates that labor hour and trout feed used were the two factors mostly affecting the trout production. These factors are jointly responsible for 77.2 per cent variation in trout production as indicated by the estimated $R^2 = 0.772$. Co-efficient of feed used (-0.223) indicates that with increase in feed use by 1 per cent, trout production will decline by 0.22 per cent. Similarly coefficient of labor hours (1.473) indicates that one per cent increase in labor hour will increase trout production by 1.47 per cent. Thus, trout production can be increased by reduction in feed use and increase in labor hour to optimum level.

Return to Scale

The return to scale in trout production was estimated to be 1.25 which indicates existence of increasing return to scale in trout production. Thus there is scope to increase size of trout farms by adding more raceways to existing one. Ugwanba (2010) also found increasing return to scale for cat fish production in Nigeria. Stanzin *et al*., 2017 reported the return to sale in rainbow trout as 1.25, which justifies and supports our findings.

Resource Use Efficiency

Resource use efficiency was examined for those variables which had significant effect on trout production. The efficiency ratio (r) of marginal value of product (MVP) and marginal factor cost (MFC) determine the efficiency of the employed resources. If r=1, it indicates that particular resource is efficiently allocated or optimally utilized. The marginal value products of feed and labor hours were worked out at their respective geometric mean level. The acquisition costs of both the inputs were taken as MFC for the estimation of efficiency ratio. The results obtained are presented in Table 4.

Table 4. Estimated resource use efficiency in trout farming

Strain	Particulars	Geometric mean	Co-efficient	MVP	MFC	MVP/MFC	Decision
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NS	Feed (F)	22.75	- 0.233	- 59.48	73	- 0.8148	Over-utilised
	Labour (L)	43.22	1.473	301.7	43.75	6.896	Under-utilised
GIS	Feed (F)	24.33	- 0.157	- 69.1	68	1.01	Properly-utilised
	Labour (L)	43.22	1.473	301.7	43.75	6.896	Under-utilised

Table 5. RBQ ranking of constraints faced by sample trout farmers

Sl. No.	Constraints	NS		GIS	
		RBQ score	Rank	RBQ score	Rank
(1)	(2)	(3)	(4)	(5)	(6)
1.	High price of inputs (seed and feed)	97.47	I	81.36	II
2.	Transportation	88.87	II	78.33	V
3.	Lack of marketing facility	85.05	III	81.76	I
4.	Non availability of clear and continuous water	84.02	IV	81.36	II
5.	Lack of insurance on crop	79.43	V	80.17	IV
6.	Lack of knowledge of modern and scientific trout farming	79.25	VI	81.32	III
7.	Predation	77.95	VII	76.5	VI
8.	Difficulty in obtaining credit	76.21	VIII	65.29	VII
9.	Scarcity of skilled labour	76.04	IX	45.25	VIII
10.	Disease occurrence	65.66	X	5.01	X
11.	Non-availability of quality seed	37.72	XI	10.22	IX

Perusal of the table revealed that feed and labor hours were used at inefficient level since resource allocative efficiency for trout production (r) is not equal to 1 in case of NS strain and the feed and labour were rather efficiently utilized in GIS strain (r=1.01). The estimate of ‘r’ for feed in trout production is -0.8148 which is less than one and indicate the over-utilization of feed in trout farming in NS strain farming. Similarly more than 1 estimates of ‘r’ for labor hours (6.896) indicate the underutilization of labor in trout production, which is true for both the strains. Thus there is need to optimize the use of both the feed and labor resources for increasing the profitability in trout farming, as supported by Stanzin *et al*. (2017) and Ganesh *et al*. (2023).

Constraints Faced by Sample Trout Farmers

The constraints faced by farmers were identified and asked to rank them according to their preferences. Based on the responses of the farmers the RBQ score were estimated to know the harshness of the restraints and rank was accorded based on RBQ score and the results so obtained are presented in Table 5.

A total of 11 constraints were identified and ranked with the help of RBQ score to enumerate the severity of the constraints. The results revealed that majority of the farmers ranked high price of inputs mainly feed and seed as rank one with 97.47 per cent RBQ score in case of NS and 81.36 in case of GIS. Since trout culture is an intensive culture system purely dependent on artificial feeding, high price of feed has great impact on its profitability. The cost of feed during study period was 110 Rs/kg which trout farmers considered as quite high. Due to low demand for feed at present which constraint the feed mills to operate to its full capacity which resulted its high price. The existing trout seed price of 5-10 Rs./piece was very high in comparison to carp seed. The high price may be due to the reason that all the hatcheries were run by the government and under-utilized which leads to high cost of production. Privatization of seed and feed production may improve the seed and feed availability that will result in reduction in seed and feed price. The extra production can be sold to states like Himachal Pradesh, Sikkim and Arunachal Pradesh where trout culture is already practiced; this will help to earn some extra revenue. This will not only increase profitability of trout farming but also attract rural youth for trout culture which ultimately generate employment in the valley. The second most important constraint faced by the trout farmer was transportation of the inputs with 91.87 per cent RBQ score (NS).

The transportation of seed requires some technical knowledge as fingerling require high oxygen during transportation. Sometimes it becomes difficult for the farmers to transport the seed from hatcheries to the farm. The farmers in District Ganderbal get the seed from the Mammar hatchery, which is within the close proximity of the farmers, but the oxygen cost for the transportation is a constant and it is always a constant. The third most important constraints faced by the farmers was the lack of marketing facility in the valley and presently trout was sold on the farm gate price. Consumers prefer fresh over imported fish from other states and there is great demand for trout in city like Srinagar but due to lack of marketing facility they are unable to. The marketing wing of the Department of Fisheries provides the marketing vehicle to the farmers at nominal prices, which eventually reduces the production cost.

Other important constraints faced by the farmers which also seems to be severe as reflected from the RBQ score were lack of continuous availability of clean and clear water, lack of crop insurance, lack of knowledge of modern and scientific trout farming, predation, difficulty in obtaining credit, scarcity of skilled labour, disease occurrence and poor quality of seed. All these constraints are seems to be sever except the quality of seed which was reported by very few farmers in case of the GIS farming system. The seed produced in the hatcheries were of best qualities which were also exported not only to other state but neighboring countries like Nepal and Bhutan in the past as reported by the Department of Fisheries. The feed and seed are found to be the two most important factor in trout production and it adsorbs almost 70 per cent of cost of production as pointed out by Bombeo-Tuburan *et al*., (2001), Oluwemimo and Damilola (2013) and Ele *et al*., (2013). Lazard (2010) also highlights the fact that trout faced a number of constraints like environment, social, and economics.

Conclusion

Kashmir is prosperous with all the water resources adequate for the rainbow trout fish farming. The present study revealed that the rainbow trout farming is a profitable venture, with certain limitations. The seed and the feed cost are the main constraints for the economic upgradation of the fish farmers. The introduction of genetically improved strains in farming systems has led to the better conversion of the feed, leading to the less consumption as compared to the normal strains, thereby improving the economy of the fishermen. From the above findings, its clear that the traditional aquaculture, using flow through systems is manageable to be economically promising by adopting the culture of genetically improved strains if rainbow trout, the plenty of which is available in the hatcheries of the Department of Fisheries. An additional 27% profit is liable to be generated by the farmers by adoption of the genetically improved trout culture.

Ethical Statement

Ethical approval for this study/case/case series was obtained from District Development Commissioner of the District. The approval was sought from the farmers as well, who shared their data.

Funding Information

This research didn't receive any grant for the collection of data, as the authors are posted in the same district where the work was executed. The data is a primary data, which was collected from the farmers on regular basis.

Author Contribution

Shyambir (IAS) – Author, Dr. Salman Rauoof Chalkoo - Author, Data analysis and interpretation.

Conflict of Interest

The Author(s) declare(s) that there is no conflict of interest.

Acknowledgements

The authors want to extend gratitude to the fish farmers, who shared their concerns and the necessary data required to formulate this research paper. Thanks are due to District Administration, who supported to make this data analysis really happen.

References

Advanced Centre for Water Resources Development and Management (ACWADAM) (2019): Comprehensive report on springs in the Indian Himalayan Region-Status of springs, emerging issues and responses.

Andressa Steffen Barbosa, Raquel Grande Pereira, Laurindo André Rodrigues, Jorge de Matos Casaca, Wagner Cotroni Valenti & Thiago El Hadi Perez Fabregat (2020): Economic analysis of family trout farming in Southern Brazil. *Aquaculture International*. 28: 2111–2120.

Antti Kause, Antti Nousiainen, Heikki Koskinen (2022): Improvement in feed efficiency and reduction in nutrient loading from rainbow trout farms: the role of selective breeding. *Journal of Animal Science*. 100(8). https://doi.org/10.1093/jas/skac214.

Ayyappan, S., J.K. Jena, A. Gopalakrishnan and A.K. Pandey (2006): *Handbook of Fisheries and Aquaculture.* Indian Council of Agricultural Research, New Delhi.

Bhat, S. U., & Pandit, A. K. (2009): Limno-chemistry of three fresh water springs of Kashmir Himalaya. *Hydro Nepal-Journal of Water, Energy and Environment.* 7: 54–59.

Bhat, S. U., & Pandit, A. K. (2018): Hydrochemical characteristics of some typical freshwater springs - a case study of Kashmir Valley springs. *International Journal of Water Resources and Arid Environments.* 7(1), 90–100.

Bombeo-Tuburan, E.B. Coniza, E.M. Rodriguez and R.F. Agbayani (2001): Culture and Economics of Wild Grouper (*Epinephelus coioides*) using Three Feed Types in Ponds. *Aquaculture.* 201(3): 229-240.

Bozoğlu, Mehmet and Vedat Ceyhan (2009): Energy Conversion Efficiency of Trout and Sea Bass Production in the Black Sea, Turkey. *Energy*. 34(2): 199-204.

Cobb, C. W.; Douglas, P. H. (1928): A Theory of Production" (PDF). *American Economic Review*. 18 (Supplement): 139–165.

d'Orbcastel ER, Blancheton JP, Aubin J (2009): Towards environmentally sustainable aquaculture: comparison between two trout farming systems using Life Cycle Assessment. *Aquacult Eng*. 40:113–119.

David Stankovic, Alain Jean Crivelli and Ales Snoj (2015): Rainbow trout in Europe: Introduction, Naturalization and Impacts. *Reviews in Fisheries Science and Aquaculture*. 23 (1): https://doi.org/10.1080/23308249.2015.1024825.

Edo D'Agaro, PierPaolo Gibertoni and Stefano Esposito (2022): Recent Trends and Economic Aspects in the Rainbow Trout (*Oncorhynchus mykiss*) Sector. *Appl. Sci.* 12(17): 8773; https://doi.org/10.3390/app12178773.

Ele, I.E., O.W. Ibok, E.A. Antia-Obong, I.E. Okon and E.S. Udoh (2013): Economic Analysis of Fish Farming in Calabar, Cross River State, Nigeria. *Greener Journal of Agricultural Sciences*. 3(7): 542-549.

Engle CR (2010): Aquaculture economics and financing: management and analysis. John Wiley & Sons, Ames

FAO (2020): Cultured Aquatic Species Information Programme. *Oncorhynchus mykiss*. http://www.fao.org/fishery/culturedspecies/Oncorhynchus_mykiss/en#tcNA0078. Acessed in 05 April 2020.

Food and Agriculture Organization of the United Nations (FAO) (2013): *Statistical Yearbook 2013*, World Food and Agriculture, Food and Agriculture Organization of the United Nations, Rome.

Ganesh Kumar, Carole Engle, Jonathan vanSenten, Lianqun Sun, Shraddha Hegde, Bradley M. Richardson (2023): Resource productivity and costs of aquaculture practices: Economic-sustainability perspectives from U.S. catfish farming. *Aquaculture*. 574: 739715.

Government of Jammu and Kashmir (2023): *Achievements in Fisheries Sector*, Official website of Department of Fisheries, Jammu and Kashmir http://jkfisheries.in/achievements.htm.

Hassan, Abdul, Muhammad Ishaq, Arshad Farooq and Shaukat Hayat Sadozai (2007): Economics of Trout Fish Farming in the Northern Areas of Pakistan. *Sarhad Journal of Agriculture*. 23(2): 407–408.

Hinshaw, J.M. (1990): *Trout Production - Handling Eggs and Fry,* Southern Regional Aquaculture Centre, (*SRAC)* Publication, No. 220, U.S.A. (Available at http://www2.ca.uky.edu/wkrec/ TroutEggsFry.pdf).

Hinshaw, Jeffrey Maynard, Lindsay E. Rogers and James E. Easley (1990): *Budgets for Trout Production: Estimated Costs and Returns for Trout Farming in the South,* SRAC Publication, U.S.A., No. 221.

Lazard, J. (2010): Aquaculture System Diversity and Sustainable Development: Fish Farms and their Representation. *Aquatic Living Resources*. 23: 187–198.

Oluwemimo, Oluwasola, and Ajayi Damilola (2013): Socio-Economic and Policy Issues Determining Sustainable Fish Farming in Nigeria. *International Journal of Livestock Production*. 4(1): 1-8.

Olaoye, O. J , Ashley-Dejo, S. S, Fakoya, E. O., Ikeweinwe, N. B., Alegbeleye, W. O., Ashaolu, F.O & Adelaja, O. A (2013): Assessment of Socio-Economic Analysis of Fish Farming in Oyo State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary.* 13(9): 45-55.

Ragnar Tveteras Ragnar Nystoyl Darryl E. Jory (2019): Annual survey data shows farmed fish production increased 73% over past decade. GOAL 2019: Global finfish production review and forecast.

Sabarathnam, V.E. and S. Vennila (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): 87-90.

Sami Ullah Bhat, Suraya Mushtaq, Umara Qayoom & Inam Sabha (2020): Water Quality Scenario of Kashmir Himalayan Springs—a Case Study of Baramulla District, Kashmir Valley. *Water Air and Soil Pollution*. 231:454.

Shahnawaz Ali, C. Silva, Nityanand Pandey and Pramod Kumar Pandey (2023): Status and prospects of Rainbow trout farming in the Himalayan waters. *Fisheries and Aquaculture of the Temperate Himalayas*. Pp. 113-129.

Sneha Mahale (2021): Trout swims to success in Jammu and Kashmir. Mongabay. http://www.mongabay.com.

Sodhi, A.S., J.D. Saroch, and Jyoti Verma (2013): Fisheries Resources of Kashmir: A Case Study of River Jhelum. *Journal of Chemical, Biological and Physical Sciences* (JCBPS). 3(2): 1194.

Stanzin Gawa, Nalini Ranjan Kumar, Swadesh Prakash, Vinod Kumar Yadav, Vinay Maruti Hatte and Navghan Mahida (2017): Economic analysis of trout feed production in Jammu and Kashmir, India. *Journal of Applied and Natural Science.* 9 (4): 2385 – 2390.

Ugwumba, C.O.A. (2010): Resource Use Efficiency and Determinants of Catfish Production Output in Anambra State, Nigeria. *Multi J. Res. Devel.* 15: 143-150.

Valenti WC, Moraes-Valenti P (2010): Production chain of aquaculture. *World Aquaculture.* 41:54–58.

Woynarovich, András, Gyorgy Hoitsy and Thomas Moth-Poulsen (2011): *Small-Scale Rainbow Trout Farming*, Food and Agriculture Organization of the United Nations, Rome.