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Technical efficiency and economic viability of fish culture under cold water production environment of Kashmir

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Fishing has been a significant source of livelihood for the economically weaker section in Kashmir, Jammu and Kashmir (Baba *et al*. 2019). Despite a steady growing dependence on this sector (http//www.JKfisheries.nic), its contribution to states' domestic product has drifted below 1% (Baba *et al.* 2018). It is often argued that fishers are not receiving the due care they deserve (Rahman *et al*. 2002) and their miseries are getting worse with declining fish catch (Anonymous 2017). The labour mobility in favour of lucrative options is restricted to a small proportion of their young generation (Malik *et al*. 2013). The encouragement of aquaculture is expected to revamp fisheries sector of the territory and would uplift living standard of the fisher community. Aquaculture is profitable with better BC ratio (Mog *et al*. 2018, Baba *et al*. 2019) and is believed to enrich values and reduce dependence on natural water resources (Naylor *et al*. 1998). However, fish culture is a capital intensive activity largely adopted by economically better section of the society (Ahmed and Lorica 2002). The emphasis would certainly be on the role of institutions towards encouragement of fish culture. This backdrop made it imperative to investigate the economic aspects of culture of fish to get lessons for expansion of production capacities on supply side by encouraging culture of fish in private domain and promotion of consumption of less costly fish based nutrients on demand side. The available references in the literature on culture of fish speaks much about other production environments of the country and evidence of such studies for cold water conditions for Kashmir appears scanty. Hence this study focuses on the economic feasibility of the fish culture under private domain in Kashmir valley of Jammu and Kashmir.

The secondary data were obtained from the official website of Directorate of Fisheries, Government of Jammu and Kashmir (www.jkfisheries.com) and for the primary data, the valley was stratified into north, central and south Kashmir, and one district representing each stratum was selected randomly. Out of each selected district, 40 fish farmers (20 each for carp and trout culture) were selected randomly thus forming a total sample of 120 fish farmers. The primary data were collected through personal interview method employing a pre-tested schedule during 2019–20 under. For comparison, the selected fish farmer households were categorized into two groups on the basis of participation in any extension programme, viz. households who have participated in any extension programme at least once (FF-I) and households who have never participated in any such programme (FF-II).

The comprehensive cost of production (C) was calculated by using formula adopted by Mog *et al*. 2018. Technical efficiency of input use in fish culture was estimated by employing an output-oriented framework by employing Data Envelopment Analysis Package (DEAP) (Wani *et al*. 2013).

Regression models: Regression functions (I) & (II) was developed to estimate the contribution of different inputs in the yield levels in carp and trout fish culture, and to analyze the determinants of technical efficiency of input use at farm level, respectively. The models were estimated in a log-linear form separately for carp and trout fish cultivation.

$$Y = f(Fc, FDc, FYMc, FERc, LMc, LBRc, TRNc, FXDc, U) \quad ... (1)$$

$$TE = F(AGE, EXT, LIT, FMW, CFR, AHS, U) \quad ... (II)$$

where *Y,* fish yield (kg/kanal); *Fc,* cost of fingerlings (₹/kanal); *FDc,* cost of feed; *FYMc,* cost of FYM (₹/kanal); *FERc,* cost of inorganic fertilizers; *LMc,* cost of lime (₹/kanal); *LBRc,* cost of human labour (₹/kanal); *TRNc,* cost of transport/marketing/watch and ward; *FXDc,* fixed cost (₹/kanal); *TE,* technical efficiency of input use; *AGE,* age of family head (yrs); *EXT,* extension participation (0 for no and 1 for participation); *LIT,* literacy of fish farmers (0 for illiterate, 1 for education of middle level, 2 for education of secondary school level, 3 for education of graduation level and 4 for above); *EXP,* experience in fish farming

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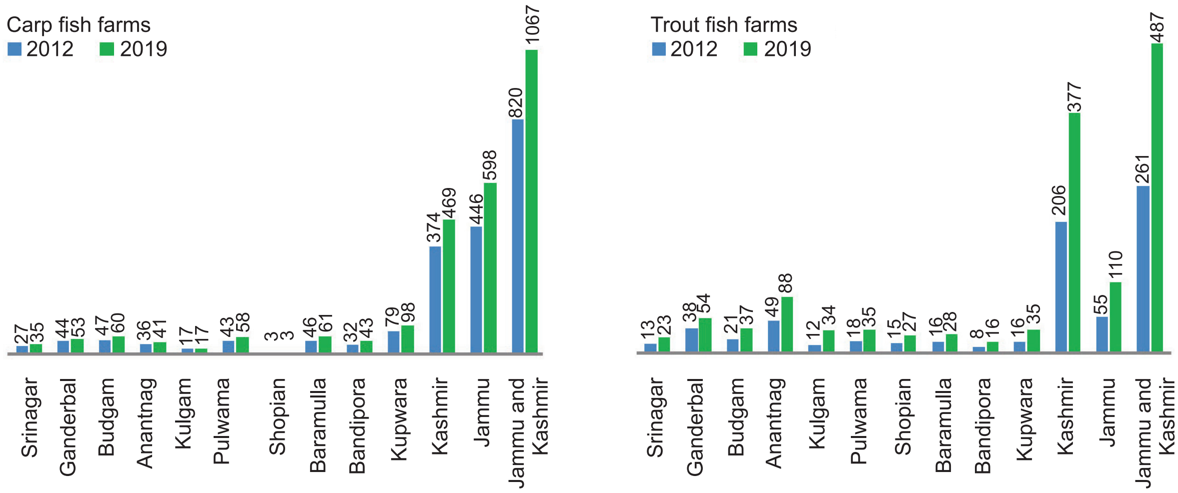

Fig. 1. District-wise private fish farms in Kashmir *vis-à-vis* Jammu and J&K-2012 and 2019 (No.).

Table 1. Economics of carp fish culture (₹/kanal)

Particular	FF-I		FF-II		Average	
	Amount	%	Amount	%	Amount	%
Variable costs						
Fingerling	1,600	3.6	1,200	3.5	1,400	3.5
Liming	107	0.2	77	0.2	92	0.2
FYM	693	1.6	675	2.0	684	1.7
Fertilization	98	0.2	90	0.3	94	0.2
Feed (rice bran, fish meal, etc)	15,960	35.7	9,000	26.0	12,480	31.5
Grass (Oats)	925	2.1	600	1.7	763	1.9
Labour (hired + family)	10,665	23.9	10,265	29.7	10,465	26.4
Transport and marketing costs	889	2.0	932	2.7	911	2.3
Miscellaneous	500	1.1	500	1.4	500	1.3
Working capital	31,436	70.3	23,339	67.4	27,388	69.1
Interest on working capital @10%	3,144	7.0	2,334	6.7	2,739	6.9
Total variable costs	34,580	77.4	25,673	74.2	30,126	76.0
Fixed costs						
Fixed cost*	9,193	20.6	8,121	23.5	8,657	21.8
Interest on fixed capital @10%	919	2.1	812	2.3	866	2.2
Total fixed cost	10,112	22.6	8,933	25.8	9,523	24.0
Total costs (A+B)	44,692	100.0	34,606	100.0	39,649	100.0

* Prorated establishment costs + Rental value of land + Depreciation on fixed asset + land revenue

(yrs); *FMW,* workers (% members); *CFR,* capital formation at fish farm (₹/farm); *AHS,* average holding size (ha); *U,* error term.

J&K Government has been launching a number of schemes to introduce fish culture in the private sector and has realized satisfaction in the work progress (Anonymous 2018). At the end of 2019, there were 1067 carp and 487 trout private fish farms in the UT and there has been a significant growth in their number between 2012 and 2019 (Fig. 1).

Economics of carp fish culture: The cost of carp culture at two categories of fish farms indicated that the total cost was estimated at ₹ 39,649 per kanal and 76% of this amount goes on variable inputs of which the feed cost comprises a higher proportion (31.5%) (Table 1). Carp culture is a labour intensive venture and the cost on this item accounts for over 26% of variable cost. Majority of fish farmers were

Table 2. Returns from carp fish culture (Per kanal)

Particular	FF-I	FF-2	Average
Yield (kg)	415	320	367.5
Mortality (kg)	55	50	52.5
Effective yield (kg)	360	270	315
Gross return (₹)	72000	54000	63000
Net return (₹)	27308	19394	23351
Per rupee return	1.61	1.56	1.59
Cost of production (₹/kg)	124	128	126

Table 3. Economics of trout fish culture (₹/kanal)

Particular	FF-I		FF-II		Average	
	Amount	%	Amount	%	Amount	%
Variable costs						
Fingerling	60,480	18.9	51,100	17.8	55790	18.3
Feed	74,000	23.1	62,500	21.7	68250	22.4
Labour	104,500	34.1	95,020	33.1	99760	32.8
Transport/marketing	2,900	0.9	2,910	1.0	2905	1.0
Miscellaneous	1,100	0.3	1,130	0.4	1115	0.4
Working capital	242,980	75.7	212,660	74.0	227820	74.9
Interest on working capital @10%	24,298	7.6	21,266	7.4	22782	7.5
Total variable costs	267,278	83.3	233,926	81.4	250602	82.4
Fixed costs						
Fixed cost*	48,700	15.2	48,702	16.9	48701	16.0
Interest on fixed capital @10%	4,870	1.5	4870.2	1.7	4870	1.6
Total fixed cost	53,570	16.7	53572.2	18.6	53571	17.6
Total costs (A+B)	320,848	100.0	287,498	100.0	304173	100.0

*Prorated establishment costs + Rental value of land + Depreciation on fixed asset + land revenue.

seen to sell their produce within the village, therefore, only 2.3% of costs were spent on transportation (to arrange input, etc) and marketing. FYM was applied to the ponds to encourage growth of zooplanktons and phytoplankton and the cost on this item was around 2% of total production cost. The cost estimates for two categories of carp farms revealed that FF-I not only stocked more but also applied more feed and other inputs that yield them more body weight gain of fishes. Accordingly, the cost on almost all the factors of production at these farms was higher compared to FF-II but the difference appears wider for feed, labour and fingerlings. On an average, a farm of one kanal area yields 350 kg fishes and after accounting for losses due to mortality, they have a marketable surplus of 315 kg (Table 2). The additional expenditure on the culture of carp fishes at FF-I farms expectedly yield better returns and marketable surplus of 360 kg/kanal to them which is higher than FF-II. The increase in cost of culture of carps more or less on scientific lines resulted in the more surplus of fishes available at FF-I farms that in turn enhanced net returns and reduced cost per unit of produce.

Economics of trout fish culture: Rainbow trouts are better suited for cultivation in Kashmir valley because this fish species are easy to domesticate and acclimatize with the cold water conditions. Trout culture is highly cost intensive compared to the carp culture. On an average over ₹3 lakh are incurred to manage 3 race ways on one kanal of land though the expenditure at FF-I was relatively higher owing to fish culture more on scientific lines (Table 3). The culture of trout is highly labour intensive and the cost on labour constitutes about 33% of total cost of managing three raceways in a kanal of land. Following this, cost of feed and fingerlings are the major cost items in the culture of rainbow trout. About 18% cost goes on fixed items. FF-I farm spent more on culture of trout fishes compared to FF-II and the increase in cost was on account of fingerlings and feed, indicating that they are intensively stocking the raceways with better feeding practices. Study indicated an average yield of 1375 kg/kanal with just 3 race ways and the yield level at FF-I was significantly better (Table 4). Clearly, the culture of trout more or less on scientific lines could potentially increase fish yields at FF-I compared to FF-II. The scenario indicated that although the culture with relatively better feeding and rearing practices raised the cost of culture but it also benefits farmers in terms of improved productivity and less cost of production.

Economic viability of fish production compared to competing crop enterprises: Fish production was highly capital intensive compared to competing crop enterprises (Table 5). The net returns from trout culture (which has been calculated on 3 raceways/kanal basis) is almost 20 times the net returns from apple and yet more than walnut. The returns from carp culture are also encouraging.

Regression estimates (*for input use efficiency*): The regression coefficient of expenditure made on fingerlings indicated that this cost has contributed significantly in the improvement of yield levels of carp and trout fishes (Table 6). While the feed cost was a positive and significant determinant of trout yield, it negatively affected carp yield. It emphasize upon rationalization of feed expenditure. There are scopes for the improvement of trout yield by using more

Table 4. Returns from trout fish culture (Per kanal)

Particular	FF-I	FF-II	Average
Yield (kg)	1500	1250	1375
Mortality (kg)	188	175	181
Effective yield(kg)	1313	1075	1194
Gross return (₹)	557813	456875	507344
Net return (₹)	236965	169377	203171
Per rupee return	1.74	1.59	1.67
Cost of production (₹/kg)	244	267	255

Table 5. Economic feasibility of fish production compared to field crops

Enterprise	Gross returns (₹/kanal)	Total cost (₹/kanal)	Net returns (₹/kanal)	BC ratio	Per 100 g			
					Calories (kcal)	Fat (g)	Carbohydrates (g)	Proteins (g)
Carp fish	63000	39649	23351	1.59	127	5.6	0.0	17.83
Trout fish	507344	304173	203171	1.67	138	5.4	0.0	20.87
Rice	6277	4213	2064	1.49	130	0.30	28.0	2.70
Apple	25766	9201	16565	2.80	52	0.2	14.0	0.3

Source: Field survey 2018 and 2019; Baba 2018.

Table 6. Regression estimate of fish yield

Variables	Carp		Trout	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	–2.121	1.210	–2.717	0.347
Fingerlings	0.061*	0.003	0.055*	0.001
Feed	–0.034*	0.111	0.042*	0.011
Lime	0.113	0.006	–	–
FYM	0.103*	0.012	–	–
Fertilization	0.160	0.560	–	–
Labour	–0.012	0.030	–0.011*	0.001
Transport and marketing	0.121*	0.001	0.121*	0.002
Fixed cost	–0.001	0.021	0.003	0.003
Adjusted R^2	0.5915		0.6612	
F cal.	112.23*		199.03*	

*Denote significance at 0.05 or better probability level.

Table 7. Technological gaps and technical efficiency in fish culture (%)

Particular	Carp			Trout		
	FF-I	FF-II	Average	FF-I	FF-II	Average
Technical efficiency						
0–30	16.0	23.0	19.5	6.0	12.0	9.0
31–75	70.0	64.0	67.0	58.0	43.0	50.5
>75	12.0	15.0	13.5	36.0	45.0	40.5
Technological gaps						
Seed	–9.4	20.8	5.6	–3.00	4.40	0.70
Feed	–33.2	18.5	–7.3	–12.14	–1.43	–6.79
Lime	–24.0	9.9	–7.0	–	–	–
FYM	–10.0	–7.6	–8.8	–	–	–
Fertilization	–20.0	–10.0	–15.0	–	–	–
Average	–19.3	6.3	–6.5	–7.57	1.49	–3.04

feed on scientific lines. The expenditure made on transport for arranging inputs and marketing of produce has turned significant contributor of revenue generated in fish culture.

Technical efficiency and technological gaps: Using DEAP statistical package, the technical efficiency of input use in carp and trout culture was estimated. Technical efficiency of majority of fish farmers ranged from 31 to 75% (Table 7). A less proportion of fish farmers were seen to use inputs beyond 75% efficiency though their proportion was relatively more for trout farms. About 20% carp fish farmers and only 9% of trout fish farmers were observed to use inputs up to 30% technical efficiency. Further technical efficiency at FF-II farms was relatively better in both trout and carp culture.

Technological gaps in the input use were calculated (Table 7). Within carp culture, FF-II farms were seen to stock a little more intensively as they applied about 21% more fingerlings and 18.5% more feed. Same scenario for this group of carp farmers was seen in case of lime application. Contrary to this, negative technological gaps were seen for the application of inputs at FF-I category of carp fish farmers. For the trout culture except for fingerling application by FF-II, there were negative technological gaps in the application of fingerlings and feed at the farm level.

Regression estimates (*for technical efficiency*): The regression estimates revealed that literacy of fish farmers, participation in extension programmes and working family members were positive determinants of technical efficiency in both trout and carp culture. Capital formation in the form of fisheries assets like net, etc turned significant determinant of technical efficiency in carp culture though this variable has insignificant relationship with input use efficiency in trout culture. An important observation of this analysis is that the possession of more land holding holds negative relationship with dependant variable in carp culture which may be owing to the interest in cultivation of other crops and least attention given to the management of fish culture (Table 8).

Table 8. Determinants of technical efficiency

Variable	Carp	Trout
Intercept	–0.100	0.100
AGE	–0.016 (0.029)	0.017 (0.023)
EXT	0.013* (0.007)	0.010* (0.001)
LIT	0.33* (0.11)	0.41* (0.02)
FMW	0.013* (0.003)	0.022* (0.001)
CFR	0.001* (0.000)	–0.005 (0.005)
AHS	–0.025* (0.005)	0.003 (0.004)
Adjusted R^2	0.6704	0.6271
F cal	97.971	101.10

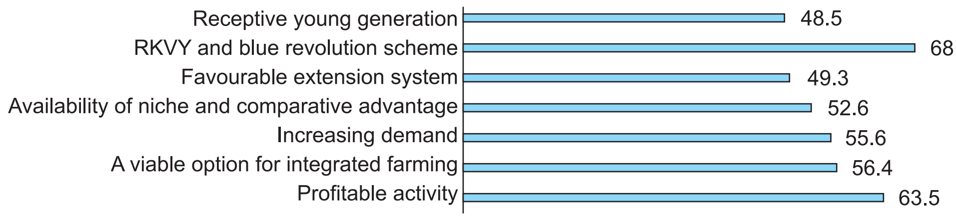

Fig. 2. Farmers' perception regarding encouraging factors of fish culture.

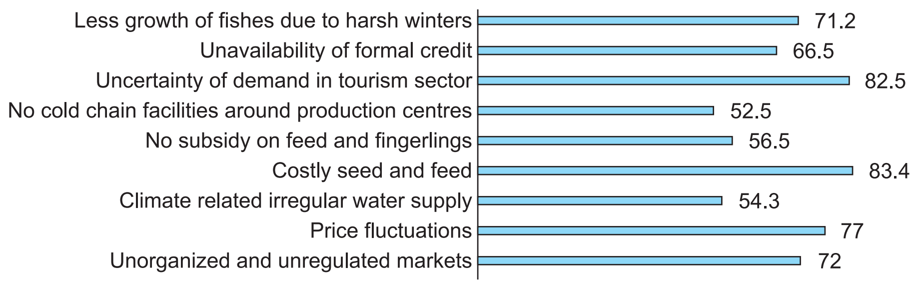

Fig. 3. Farmers' perception regarding discouraging factors of fish culture.

Farmers' perception on pushing and pulling factor of fish culture: Fish farmers were asked about the various factors which support or suppress their decision to take up fish culture as an economic activity and their perceptions are depicted in Figs 2 and 3.

Policy options for the encouragement of aquaculture in the valley: Given meagre land holdings with fishers, institutional support for strengthening cooperatives for collectivization of various activities of fish culture would indeed raise their livelihood status. Provision of development and seed/feed subsidy subsidies for race ways, ponds, etc and provision of low cost feeds has to go long way. Encouragement of entrepreneurship in breeding and cost effective feed formulations are needed to rationalize costs on fingerlings and feed and it is expected to increase employability of the unit. Formal education and capacity building of fish farmers on scientific practices of fish culture would enhance yield and enable them to harness full benefits from available capital and labour. The market space for fish sale is thin and unorganized across the territory which demands institutions role in the market development and provision of formal loans at cheap rates with easy formalities to supplement their resources for investing in fish culture. Long term income growth of farmers is possible by encouraging fish processing and in this way farmers are also able to achieve various utilities. Protected culture under poly-houses with necessary logistics is expected to improve feeding and body weight gain during winters. Besides, the study recommends strengthening of R&D efforts in this sector to enhance the area and production under fish culture for ensuring sustainable livelihood and income to the farmers of the state.

SUMMARY

This study examines the progress and economic viability of trout and crap fish culture under cold water environment of Kashmir valley. Results revealed a significant progress in the encouragement of fish culture especially in Kashmir. Trout and carp culture is capital intensive but their production is highly profitable compared to cultivation of commercial crops. Regression estimates revealed that the expenditure on fingerlings has contributed significantly in the improvement of yield levels of fishes while as the feed cost has been a positive and significant determinant of trout yield. There are wide technological gaps in the input use in both trout and carp culture though the gap was relatively lesser for farm category who have participated in extension events. A majority of fish farmers falls between 31 to 75% technical efficiency level. Regression analysis indicated important role of literacy, extension participation and female workers in the enhancement of technical efficiency in fish culture. Fish farmers brought out number of pushing and pulling factors associated with fish culture in Kashmir valley. Based upon findings, this study put forth few policy options for the encouragement of aquaculture in the valley including need for HRD and institutional role for the creation of marketing logistics.

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