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Economic feasibility of Roopchand (Pacu, *Piaractus brachypomus*) farming in HDPE lined farm ponds in Belagavi district

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Abstract

The increasing adoption of HDPE-lined farm ponds in Belagavi district, Karnataka, has opened opportunities for aquaculture diversification beyond irrigation use. This study evaluated the economic feasibility of Roopchand (*Piaractus brachypomus*) culture in comparison with carp farming in lined farm ponds. Data were collected from 72 farmers (36 carp and 36 Roopchand growers) across 12 taluks through structured interviews. Cost-return analysis, financial indicators net present value (NPV), internal rate of return (IRR), benefit-cost (B:C) ratio, and payback period—as well as sensitivity analysis and statistical testing (Welch's t-test) were applied to assess profitability and resilience. Results revealed that Roopchand farming, though more input-intensive (₹3.59 lakh/acre vs. ₹1.74 lakh/acre for carps), generated substantially higher gross returns (₹5.25 lakh/acre vs. ₹2.36 lakh/acre) and net returns (₹1.66 lakh/acre vs. ₹0.62 lakh/acre). Financial viability was stronger for Roopchand, reflected in higher NPV (₹1.45 lakh), IRR (30.02%), and B:C ratio (1.31) compared to carp culture (₹13,560; 15.65%; 1.21, respectively). Sensitivity analysis indicated greater resilience of Roopchand to feed price increases and market downturns. Welch's t-test confirmed significantly higher profitability for Roopchand farming ($p < 0.001$). Overall, the findings highlight Roopchand as a superior candidate species for lined pond aquaculture in Belagavi, offering faster investment recovery, higher profitability, and better adaptation to pond conditions. Adoption of best aquaculture practices, strengthened seed supply, and farmer training could further enhance the viability and regional impact of Roopchand culture.

Keywords: HDPE lined farm ponds, economic feasibility, roopchand

1. Introduction

Belagavi district located in the northwestern part of Karnataka, shares its boundaries with the Western Ghats alongside Maharashtra and Goa. This advantageous geographical positioning has endowed the district with rich water resources, including eight rivers, four major reservoirs, and more than 300 natural tanks. A well-developed canal network further strengthens Belagavi's irrigation status as one of Karnataka's most water-abundant districts (Karnataka District Census Handbook, Belagavi; censusindia.gov.in)^[7].

In last decade, Belagavi district has witnessed a remarkable rise in the establishment of HDPE-lined farm ponds. These ponds are primarily designed to store water for critical irrigation, supporting both agricultural, horticultural, animal husbandry and allied activities. The initiatives have been implemented under various schemes such as the Krishi Bhagya Scheme, the National Horticulture Mission, and MNREGA. In addition, many progressive farmers in rainfed areas have independently invested in constructing larger farm ponds to ensure irrigation facility to their agriculture needs (Adarsha *et al.*, 2025)^[5].

The scale of development is significant. Till date more than

22,000 such structures have been established across the district. The size of farm ponds is ranging from 200 square meters to as large as 8,000 square meters. Beyond irrigation, these ponds have unlocked new livelihood opportunities like fish farming. Many farmers are now diversifying their income streams by adopting fish farming practices with different fish species, thereby ensuring more sustainable and profitable farming systems (Yang *et al.*, 2024)^[12].

These HDPE-lined farm ponds in Belagavi district, primarily designed for water storage and irrigation, are increasingly being used for aquaculture. Farmers commonly stock Catla, Rohu, and Common carp in these ponds. However, limited soil-water interaction and frequent water withdrawals reduce primary productivity and hinder plankton growth, leading to lower fish yields (Smith *et al.*, 1938)^[10]. Despite these challenges, the easy availability of carp seed locally sustains their dominance in farm pond aquaculture.

Roopchand is a native of Amazon and Orinoco River basins of South America and belongs to the family: Serrasalminae; order Characiformes. The fish has been cultivated in many countries around the globe namely including Colombia, Brazil, Peru, Venezuela, Central America, Vietnam,

Thailand, Malaysia, Bangladesh and China. Notably, Roopchand is often mischaracterized as a carnivorous fish. However, it is primarily a herbivore and, at times, an omnivore. In its early life stages, it feeds mainly on plankton. As it matures, the diet broadens to include a mix of plant and animal matter, but in adulthood, the species is predominantly vegetarian, preferring leaves, flowers, fruits, and seeds. (Sipauba *et al.*, 1999) [9].

The culture of pacu (*Piaractus brachypomus*) in India commenced around 2005, and since then, the species has gained considerable popularity among farmers owing to its rapid growth rate. Despite this, concerns have been raised regarding its ecological implications and overall impact on pond production systems. To address these uncertainties, the National Fisheries Development Board (NFDB) supported a study entitled “*Risk and Benefit Assessment of an Illegally Introduced Fish Species, Pacu (Piaractus brachypomus)*”. This investigation was carried out by ICAR-National Bureau of Fish Genetic Resources (NBFGGR), Lucknow, across three major states where pacu culture is prominent—Andhra Pradesh, Kerala, and West Bengal and findings were used for guidelines (Guidelines for culture of Pacu, 2024).

ICAR-BIRDS Krishi Vigyan Kendra, Belagavi-1 has introduced Roopchand fish farming in 2020-21 at HDPE lined farm ponds which are basically confined waterbodies and safe to introduce considering there is no threats to native biodiversity. Fish seeds are sourced from Kolkata and Chhattisgarh. Pelleted feeding was practiced for the culture. Due to attractive body colour, good meat quality and faster growth, Roopchand farming has taken rapid expansion in the district. In this study, economic feasibility of Roopchand in farm ponds were studied in comparison with Carps. The study aims to support farmers in making informed decisions by identifying and prioritizing suitable candidate fish species for farm pond aquaculture.

Materials and Methods

The study was conducted among farmers from 12 taluks of Belagavi district, Karnataka. Only HDPE-lined farm ponds with an area exceeding 400 m² were considered for inclusion. A total of 72 farmers participated in the study, consisting of 36 carp farmers and 36 Roopchand farmers. Since the total number of pangasius farmers in the district is fewer than 40, the sample size was fixed at 36, following the Krejcie and Morgan sample size determination formula. An

equal number of carp farmers were selected as a control group for comparison.

Primary data were collected directly from respondents through personal interviews using a structured schedule. The interview schedule was prepared in alignment with the objectives of the study, focusing on two main aspects: (i) the socio-economic background of the respondents, and (ii) the economic feasibility of farm pond aquaculture.

Socio-economic information collected from the respondents was analyzed using tabular presentation and descriptive statistics. Production parameters, including yield, cost of production (segregated into fixed and variable costs), and returns, were estimated on a per-acre basis. Economic feasibility of farm pond aquaculture was assessed through standard financial indicators such as break-even analysis, payback period (PBP), net present value (NPV), benefit-cost ratio (B:C ratio), and internal rate of return (IRR). To evaluate the resilience of the enterprise under fluctuating market conditions, sensitivity analysis was performed by simulating a 10% increase in feed cost and a 10% reduction in fish market price.

Statistical analysis

The statistical significance of the of the profitability among Carps and Roopchand were studied by testing following hypothesis.

(H₀): The mean profitability of Roopchand farming is equal to that of Carp farming in lined farm ponds

(H₁): The mean profitability of Roopchand farming is greater than that of Carp farming in lined farm ponds

To evaluate the profitability difference between Roopchand and Carp farming, an independent samples t-test (Welch's t-test) was performed.

Results & Discussion

The economic aspects of fish farming in HDPE-lined farm ponds in Belagavi district were analysed in conjunction with the socio-economic profile of the respondents. This approach provided insights into the farmers' capacities, resources, constraints, and overall potential in farm pond aquaculture. Table No.1 presents the key socio-economic characteristics of the respondents, including age distribution, family size and composition, educational status, landholding patterns and resource availability.

Table 1: Socio-economic characteristics of sample fish farmers (n=72)

Sl. No	Particulars	Number	Percentage to total
A.	Age Group		
	Young (≤40 Years)	40	55.56
	Middle (41-50 years)	16	22.23
	Old (above 50 years)	16	22.23
B.	Family Size		
	Small (<4 members)	2	2.78
	Medium (4-6 members)	31	43.06
	Large (above 6 members)	39	54.17
C.	Family Composition		
	Male	148	28.41
	Female	160	30.71
	Children	213	40.88
	Average number of family members		

D.	Family Members available for Agriculture activities		
	Male	133	38.33
	Female	121	34.87
	Children	93	26.80
E	Educational qualification		
	Illiterate	1	1.39
	Primary education	5	6.95
	Highschool education	17	23.60
	Pre-University	13	18.06
	Graduation	36	50.00
F	Occupation		
	Agriculture	67	93.06
	Agriculture + subsidiary	5	6.94
G	Land holdings		
	Marginal farmers (<2.5ac)	10	13.89
	Small farmers (2.5-5ac)	21	29.17
	Medium farmers (5-10ac)	19	26.39
	Large farmers (>10 ac)	22	30.56
H	Source of Irrigation		
	Bore well	81	29.67
	Open well	143	52.38
	Canal / Stream/ River	49	17.95

A. Age Group

More than half of the respondents (55.56%) were young (≤ 40 years), while the remaining were equally distributed between middle-aged and older groups (22.23% each). This indicates that fish farming in farm ponds is largely adopted by younger farmers, especially in adaption of new technologies and breeds like Roopchand for aquaculture.

B. Family Size

Most households were large (54.17%), followed by medium-sized (43.06%), while only 2.78% had small families. The predominance of larger families suggests greater availability of family labour, which can support aquaculture day-to-day activities.

C. Family Composition

Children accounted for the largest share of household members (40.88%), followed by females (30.71%) and males (28.41%). This structure indicates higher dependency ratios, though it also reflects potential future labour force for aquaculture.

D. Family Members in Agriculture and allied activities

Male members (38.33%) contributed most to agricultural and allied activities, followed by females (34.87%) and children (26.80%). The active involvement of women highlights their significant role in supporting farm-based livelihoods.

E. Education

Half of the respondents (50%) were graduates, 23.60% had completed high school, while only 1.39% were illiterate. This comparatively high educational level suggests strong potential for adoption of scientific aquaculture practices.

F. Occupation

Agriculture was the primary occupation for 93.06% of respondents, with only 6.94% combining it with subsidiary activities. The dominance of farming as the main livelihood indicates high dependency on agriculture-based income streams of respondent farmers.

G. Land Holdings

Around 30.56% were large farmers (>10 ac), while 29.17% were small, 26.39% medium, and 13.89% marginal farmers. The balanced distribution shows participation from all landholding groups. The large farmers were slightly more interested in adaption of aquaculture as they are rich in resources.

H. Source of Irrigation

Open wells (52.38%) were the most common irrigation source, followed by bore wells (29.67%) and canals/streams/rivers (17.95%). This reliance on groundwater highlights both the importance of farm ponds as supplementary water sources and the need for sustainable water management. It is important to note that majority of the respondent farmers having more than one source of irrigation as fish farming demands for frequent water exchanges.

Economic Performance of Fish Farming in HDPE-Lined Farm Ponds

The economics of production were assessed through analysis of cost of production, returns, and overall economic feasibility. The cost structure for carp and Roopchand culture is presented in Table No. 2 and Table NO. 3 respectively, with a detailed breakdown of fixed and variable cost components.

Table 2: Cost of production of Carps in farm ponds at the study area (per acre)

Sl. No	Particulars	Quantity	Unit Price (₹)	Total amount (₹)	Percentage to total cost
A	Variable Cost				
1	Cost of fish seeds	~5000 - 8000 No.s	0.3	2126.72	1.22
	Cost of feeding	3058.75 Kgs	30.67	61,123.75	35.03
	Cost of manure & fertilizers	574.21 Kgs	08	4593.75	2.63
	Cost of lime and medicines	54.23	50	2711.54	1.55
	Cost of labour	83.00 No.s	300	24,901.62	14.27
	Cost of electricity	-	-	Nil	
	Cost of transportation	-	-	2138.55	1.23
	Cost of marketing	-	-	5058.75	2.90
	Miscellaneous	-	-	3432.29	1.97
	Interest on working capital @ 7%	-	-	7426.09	4.26
I	Total variable cost			1,13,513.06	65.05
B	Fixed Cost				
	Depreciation of farm assets	-	-	29,691.03	17.02
	Land revenue	-	-	20.00	0.01
	Rental value of land	-	-	24,740.52	14.18
	Interest on fixed capital @12%	-	-	6534.19	3.74
II	Total fixed costs	-	-	60,985.73	34.95
	Total cost (I + II)			1,74,498.79	100

The total cost of carp farming in farm ponds was estimated at ₹1,74,498.79 per acre. Variable costs constituted the major share (65.05%) of the total expenditure, while fixed costs accounted for 34.95%. Within the variable cost structure, feed was the single largest component (₹61,123.75), representing 35.03% of the total cost, followed by labour charges (14.27%). Seed expenses were comparatively low owing to subsidized supply from

government hatcheries. Most carp farmers relied on locally available feed ingredients such as rice bran, maize/jowar flour, and groundnut oil cake, which are more economical than commercial pelleted feed. Among fixed costs, rental value of land (14.18%) and depreciation of farm assets (17.02%) were the most prominent, highlighting the capital-intensive nature of farm pond aquaculture.

Table 3: Cost of production of Roopchand in farm ponds at the study area (per acre)

Sl. No	Particulars	Quantity	Unit Price (₹)	Total amount (₹)	Percentage to total cost
A	Variable Cost				
1	Cost of fish seeds	~8000 No.s	5	39317.70	10.94
	Cost of feeding	5968.98 Kgs	32.5	183661.19	51.11
	Cost of fertilizers	1211 Kgs	8	9688.19	2.70
	Cost of lime and medicines	68.43 Kgs	50	3421.90	0.95
	Cost of labour	88.96	300	26690.75	7.43
	Cost of electricity	0	0	0	0
	Cost of transportation	-	-	5813.44	1.62
	Cost of marketing			5904.48	1.64
	Miscellaneous			4453.74	1.24
	Interest on working capital @ 7%			19526.60	5.43
I	Total variable cost			2,98,478	83.06
B	Fixed Cost				
	Depreciation of farm assets			28994.59	8.10
	Land revenue			20	0.005
	Rental value of land			25242.81	7.02
	Interest on fixed capital @12%			6524.10	1.82
II	Total fixed costs			60,891.63	16.94
	Total cost (I + II)			3,59,369.6	100

The total cost of Roopchand farming in farm ponds was estimated at ₹3,59,369.60 per acre, of which variable costs accounted for the major share (83.06%), while fixed costs contributed 16.94%. Among the variable expenses, feed cost was the dominant component (₹1,83,661.19), representing 51.11% of the total cost, followed by seed cost (10.94%) and labour charges (7.43%) and interest on working capital (5.43%). Other variable expenditures such as fertilizers, lime and medicines, transportation, and marketing together

formed a relatively small proportion of the total.

On the fixed cost side, depreciation of farm assets (8.10%) and rental value of land (7.02%) were the major contributors, while land revenue and interest on fixed capital accounted for minimal parts. The high proportion of feed and seed costs within the variable component highlights the input-intensive nature of Roopchand aquaculture. This cost structure suggests that profitability is highly sensitive to fluctuations in feed price and seed availability, both of

which are not locally available.

Returns from fish farming in farm ponds

The comparative economic analysis of carp and Roopchand farming in farm ponds revealed clear differences in cost structure and profitability (Table No.4). The total cost of cultivation was substantially higher for Roopchand

(₹3,59,369.60/acre) compared to carps (₹1,74,498.79/acre). However, this higher investment was offset by superior yield performance, with Roopchand producing 5.70 tonnes per acre against 2.45 tonnes for carps. Despite a slightly lower market price per tonne for Roopchand (₹88,472.3) compared to carps (₹89,388.9), the greater volume of harvest translated into higher gross returns.

Table 4: Returns from fish farming in farm ponds (per acre)

Sl. No.	Particulars	Carps	Roopchand
1	Total cost of cultivation (₹)	1,74,498.79	3,59,369.6
2	Total Yield (tonne)	2.45	5.70
3	Market price (₹/ tonne)	89388.9	88472.3
4	Gross returns (₹/acre)	236419.61	525314.81
5	Net returns (₹/acre)	61920.82	165945.28
6	Returns per rupees of expenditure (₹)	0.35	0.46

*Returns per rupees of expenditure= Net Returns / Total Expenditure

Gross returns from Roopchand farming (₹5,25,314.81/acre) were more than double those of carp culture (₹2,36,419.61/acre). Consequently, net returns were markedly higher in Roopchand (₹1,65,945.28/acre) compared to carps (₹61,920.82/acre). The return per rupee of expenditure also favoured Roopchand (0.46) over carp farming (0.35), indicating greater economic efficiency. These findings suggest that although Roopchand culture is more cost-intensive, it offers higher profitability and better returns on investment, thereby presenting itself as a more

viable candidate species for farm pond aquaculture.

Economic feasibility study

The economic feasibility of farming Carps and Roopchand was evaluated using multiple financial indicators over a 4-year time frame at a 12% discount rate (Table No. 5). The indicators include Payback Period, Time to Break-Even Output, Break-Even Output, Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost (B:C) Ratio.

Table 5: Feasibility of investment for fish farming in farm ponds

Sl. No.	Feasibility indicators	Units	Value	
			Carps	Roopchand
1	Payback period	Years	2.82	2.17
2	Break even output	Kg	1419.72	1685.29
3	Net Present Value for 4 years @ 12%	₹	13,560.29	1,44,638.24
4	Internal Rate of Returns	Percent	15.65	30.02
5	Benefit-Cost Ratio for 4 years @ 12%	-	1.21	1.31

The economic feasibility of carp and Roopchand culture in farm ponds was evaluated using multiple financial indicators over a four-year period at a 12% discount rate (Table 5). The payback period analysis revealed that Roopchand farming recovered the initial investment more rapidly (2.17 years) compared to carp farming (2.82 years), indicating a shorter risk exposure. A similar observation was reported by Beg *et al.* (2024) ^[1], where species with higher growth rates achieved quicker capital recovery.

Break-even output was estimated at 1,419.72 kg for carps and 1,685.29 kg for Roopchand. Although the requirement is higher for Roopchand due to greater investment, its yield potential offsets this threshold, ensuring higher gross returns. Net present value (NPV) further substantiated this finding, with Roopchand culture generating a significantly higher NPV (₹1,44,638.24) compared to carps (₹13,560.29). Since positive NPV values indicate profitability, both systems were economically feasible, though Roopchand demonstrated superior long-term gains (Khan *et al.*, 2021). Internal rate of return (IRR) was also favorable for both farming systems, exceeding the discount rate of 12%. Carp farming achieved an IRR of 15.65%, while Roopchand

farming showed nearly double at 30.02%, reflecting more efficient capital utilization (David *et al.*, 2017). Finally, the benefit-cost (B:C) ratio was greater than unity for both species, confirming economic viability, but Roopchand (1.31) again outperformed carp (1.21)

It is evident that all key economic parameters, Roopchand farming has outperformed Carp farming in terms of profitability, investment recovery time and financial sustainability. These results underscore the economic advantage of Roopchand farming for farmers to take slightly more risk and aiming to maximize returns in shorter production cycles.

Sensitivity Analysis: To evaluate the financial resilience of farm pond aquaculture under changing economic conditions, a sensitivity analysis was performed. Two adverse scenarios were simulated: (i) a 10% increase in feed cost and (ii) a 10% reduction in fish market price. The impact of these scenarios on carp and Roopchand culture was assessed using Net Present Value (NPV) and Benefit-Cost (B:C) ratio, calculated at a 12% discount rate. The results are summarized in Table No. 5.

Table 6: Sensitivity analysis of fish farming in farm ponds

Sl. No.	Project indicators	Units	Value	
			Carps	Roopchand
1	10% increase in fish feed cost			
	NPV @ 12%	₹	-11,088.92	70,546.60
	BC Ratio @ 12%	-	1.1687	1.1891
2	10% fall in fish market price			
	NPV @ 12%	₹	-1,05,838.36	-72,339.27
	BC Ratio @ 12%	-	1.0085	1.1276

Impact of 10% Increase in Fish Feed Cost

The sensitivity analysis revealed notable differences in the economic resilience of carp and Roopchand farming under adverse market conditions (Table 6). A 10% increase in feed cost resulted in a negative NPV for carp (₹-11,088.92), indicating marginal infeasibility, while Roopchand continued to show positive returns (₹70,546.60). Nevertheless, both farming systems maintained B:C ratios above unity (1.16 for carps and 1.18 for Roopchand), suggesting that production remains financially viable despite higher input costs. Similar findings were highlighted by Kapil *et al.* (2017) ^[6], who emphasized that species with better feed efficiency, such as Roopchand, are more resilient to rising feed prices.

Impact of 10% Decrease in Fish Market Price

In contrast, a 10% decline in fish market price exerted a stronger impact on profitability. Both carp and Roopchand farming exhibited negative NPVs (₹-1,05,838.36 and ₹-72,339.27, respectively), reflecting significant vulnerability to revenue shocks. However, roopchand demonstrated relatively greater resilience, with a higher B:C ratio (1.1276) compared to carp (1.0085). This suggests that while both systems are sensitive to market downturns, roopchand culture offers a comparatively stronger buffer against reduced returns. Similar observations were reported by Sonvanee *et al.* (2021) ^[11], who noted that species with higher yield potential and stronger consumer demand are less affected by market price fluctuations.

Results of Statistical Analysis

The mean profitability of carp farming was ₹61,920.8 per acre with a standard deviation of ₹58,565.9, indicating relatively lower and more variable returns. In contrast, Roopchand farming showed a substantially higher mean profitability of ₹165,945.2 per acre with a standard deviation of ₹85,714.4, reflecting both greater profitability and wider variability among farmers.

An independent samples t-test (Welch's t-test) was performed to compare the profitability of carp and Roopchand farming in HDPE-lined farm ponds. The analysis revealed a highly significant difference between the two systems ($t = -6.01$, $p < 0.001$). The mean profitability of Roopchand farming (₹165,945.2/acre) was markedly higher than that of carp farming (₹61,920.8/acre). These findings lead to the rejection of the null hypothesis (H_0), confirming that Roopchand culture generates significantly greater economic returns compared to carp culture under the studied conditions.

Conclusion

HDPE-lined farm ponds provide an alternative environment

for aquaculture, enabling farmers to generate subsidiary income from existing water resources. Species selection emerged as a critical determinant of economic performance. The greater depth and frequent water exchange in these ponds limit plankton productivity, thereby reducing the yield potential of carps. In contrast, species such as Roopchand, which readily utilize artificial feeds, are better suited to these conditions. The comparative economic analysis clearly demonstrates that Roopchand culture offers a more viable and profitable option for farm pond aquaculture than carp farming.

The findings of this study highlight the economic potential of utilizing HDPE-lined farm ponds for fish farming in Belagavi district. Stocking of appropriately sized fingerlings, biomass-based feeding protocols and proper water quality management are essential to enhance yield and profitability. Hence, it is important that farmer should be trained on best aquaculture practices by central and state agencies. Establishing dedicated Roopchand hatcheries under the State Department of Fisheries would further strengthen seed availability and support farmer adoption. A focused and systematic approach to farm pond aquaculture can substantially contribute to improving fish production and rural livelihoods in the Belagavi region.

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