Pakistan J. Zool., pp 1-7, 2026. DOI: https://dx.doi.org/10.17582/journal.pjz/20250925164913

Economic Performance and Productivity of Cultured Species in Farmed Ponds: Implications for Sustainable Intensification in Tamil Nadu

S. Dawood Ibrahim[1], V. Senthilkumar[2]*, Thavasiyandi Umamaheswari[1], R. Durairaja[3] and Ishani S Gowda[1]

[1]*Department of Fisheries Extension, Economics and Statistics, Fisheries College and Research Institute, Thoothukudi, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu, India - 611001*
[2]*ICAR-Krishi Vigyan Kendra, Sikkal, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu, India - 611001*
[3]*Department of Fisheries Biology and Resource Management, Fisheries College and Research Institute, Thoothukudi, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam, Tamil Nadu, India - 611001*

Article Information
Received 25 September 2025
Revised 03 October 2025
Accepted 10 October 2025
Available online 26 February 2026 (early access)

Authors' Contribution
DIS: Gathering both primary and secondary data and drafting the initial version of the manuscript. VS: Evaluator of the research project, data interpretation, and technical support. TU: Verified the findings and proof-read the manuscript. RD: Examined the manuscript before submission. ISG: Provided valuable recommendations for the manuscript and evaluated the paper.

Key words
Pond fish production, economic performance, cost-benefit analysis, freshwater aquaculture, species composition

ABSTRACT

The study evaluates the economic performance and productivity of pond fish farming across three districts in Tamil Nadu. Using data from 120 farms categorized by pond size, the research employs cost-return analysis and a Cobb-Douglas production function with inputs such as feed, seed, labour, electricity, fertilizer and transportation. Statistical test assesses differences in costs and returns between districts. Results reveal that feed constitutes the largest share of variable costs followed by labour and seed. Small ponds generate the highest total returns per acre, while medium ponds exhibit superior cost efficiency as indicated by the benefit-cost ratio. District-level analysis shows significant variation in total costs and returns, with one district performing others in net returns and efficiency. The production function identifies feed and seed as primary drivers of output, with labour and electricity also significantly influencing productivity. Transportation costs negatively affect the returns. Species analysis indicates that major carp species dominate production, with tilapia and murrel contributing notable market value and varied productivity across districts. Findings highlight the importance of targeted input management and pond-size specific strategies for optimizing profitability. The study underscores the potential for sustainable intensification in freshwater aquaculture through efficient resource use, supporting rural livelihoods and food security in the region.

INTRODUCTION

Fish, as an affordable and high-quality source of animal protein, stands out as one of the healthiest dietary options to combat hunger and address nutrient deficiencies, especially in developing region (FAO, 2020). Recognizing its nutritional and economic value, the fisheries sector in India has been identified as having remarkable potential for expansion, particularly in export markets. With advisable policy measures and targeted financial support from the union government, sustainable efforts are being made to accelerate the sector's development in a sustainable, responsible, inclusive and equitable manner (PIB, 2023).

Over the past twenty-five years, the sector has witnessed a significant transition, especially in inland fisheries, from traditional capture fisheries to aquaculture practices. This shift has been pivotal in increasing productivity and ensuring the sustainability of aquatic resources. Notably, freshwater aquaculture constituted around 34% of inland fish production in the mid-1980s, now accounts for approximately 75% of inland fisheries output– a evidence to its growing importance and technological advancements in the sector (Sofia, 2022). This transformation is not only aiding food security and rural livelihoods but also positioning India as a major player in the global fish trade (DOF, 2024).

Tamil Nadu, with its 1076 km coastline ranking second longest in India.it has emerged as leading maritime

* Corresponding author: senthilkumar@tnfu.ac.in
0030-9923/2026/0001-0001 $ 9.00/0

state achieving 6.37 lakh MT of marine fish production in 2023-24 and generating Rs 6854.22 crore through exports of 1.34 lakh MT of fish and fishery products (CMFRI, 2024). While the state possesses vast inland water resources covering 3.85 lakh hectares including reservoirs, rivers, lakes, ponds and irrigation infrastructure under multiple departmental management, the current inland fish production of 2.47 lakh MT in 2023-2024 significantly underperforms against the estimated potential of 4.50 lakh tonnes, achieving merely 54.9% resource utilization (Tamil Nadu Fisheries Policy Note, 2023).

The state government is addressing this production deficit through multifaceted interventions including the river ranching programme for major rivers, systematic fingerling stocking in reservoirs to promote the intensive aquaculture system like bio-floc and RAS and establishment of seven Centres for Sustainable Aquaculture (CeSAs) under Tamil Nadu Dr. J. Jayalalithaa Fisheries University (DOF, 2024). The infrastructure development is supported by 13 government and 46 fish seed rearing centres complemented by private facilities, with substantial investment through 64 FIDF projects worth Rs. 1,573.73 crores and 96 RIDF projects valued at Rs 1,664.39 crores (NFDB, 2024). These comprehensive strategies targeting modern aquaculture adoption, infrastructure enhancement and optimal resource utilization are designed to maximize the sector's economic potential while sustaining livelihoods for 2.36 lakh inland fisherfolk and addressing the growing consumption demand of 10.83 kg per capital (Economic Survey of Tamil Nadu, 2024).

The need for comprehensive economic information regarding the fish production is globally recognized (Singh, 2007). Pillay (1990) observations highlighting a crucial paradox where economic sustainability forms the foundations of successful aquaculture ventures, yet the sector's advancement has been consistently hampered by inadequate data collection systems and poor documentation practices. The optimization of resource utilization in pond based fish farming represents another persistent challenge, as Inoni's (2007) research emphasized the ongoing uncertainty surrounding input efficiency in aquaculture operations, questioning whether available resources are being maximized or underutilized in fish production systems, while Kumar (2010) findings demonstrated the potential for enhanced marketing efficiency in India's aquaculture sector through the integration of scientific methodologies and traditional cultural approaches combined with improved price information systems and adequate infrastructure development.

This research initiative seeks to address these identified knowledge gaps by conducting a comprehensive examination of freshwater fish production system, with primary objectives encompassing detailed assessments of existing fish production pathways to determine their cost-effectiveness, profit margins, and overall operational efficiency, investigating the economic dynamics of pond fish production by examining costs, profitability metrics, and financial viability across various farm categories, and systematically examining the key variables that affect pond fish production outcomes, including technological, management, and market related factors that contribute to productivity variations thereby providing actionable insights that can inform policy development, improve producer decision-making and enhance the overall sustainability of freshwater aquaculture system in the study area.

MATERIALS AND METHODS

Among the diverse practices in freshwater aquaculture, excavated ponds (previously referred to as tanks) have emerged as dependable source of fresh fish and present significant potential for further development within Tamil Nadu's aquaculture sector. This study primarily examines fish production through pond-based aquaculture in Tamil Nadu, focussing on both privately owned ponds and those managed by Gram Panchayats. Typically, Panchayat-managed ponds are leased to fish farmers through the Department of Fisheries and the Fish Farmers Development Agency (FFDA). The district fisheries office provided the list of farmers who had leased panchayat ponds.

The research was concentrated in the three delta districts of Thanjavur, Thiruvarur and Nagapattinam-regions that collectively account for the highest share of pond-based fish production in the state. From each district, 40 pond fish farmers were randomly selected and subsequently grouped into three categories based on the size of their operational holdings. Comprehensive primary data relating to production costs were collected from each group using a structured survey schedule. To address the objectives of the study, the gathered data were analyzed utilizing a range of analytical methods, as follows.

Cost and return analysis

The cost structure was estimated by aggregating variable and fixed costs. Profitability indicators including total returns (₹/acre), total cost (₹/acre), net returns (₹/acre) and benefit cost ratio were computed following standard farm management techniques.

Gross Returns = Physical production × Price per kg

Net Returns = Gross Returns – Total Cost

Benefit Cost Ratio (TC) = Net Returns/ Total Cost

Benefit Cost Ratio (TVC) = Net returns/ Total variable cost

Species-wise production analysis

Species-wise production and farm-gate prices of rohu, mrigal, catla, tilapia and murrel were documented, and average productivity (kg/acre) was calculated to assess comparative performance across districts.

Econometric and statistical analysis

To identify determinants of gross returns, a Cobb-Douglas production function was specified in double-log form, with inputs (feed, seed, labour, electricity, fertilizer and transport) as explanatory variables. Coefficients were estimated using Ordinary Least Squares (OLS) in R software. The significance of input variables was tested at 1%, 5% and 10% probability levels. The double log production function of the following model was used

$$\log(Y) = \beta_0 + \beta 1 \cdot \log(X_1) + \beta_2 \cdot \log(X_2) + \beta_3 \cdot \log(X_3) + \beta_4 \cdot \log(X_4) + \beta_5 \cdot \log(X_5) + \beta_6 \cdot \log(X_6) + \varepsilon$$

where; Y= Returns (₹), β_0= Intercept (constant), X_1= Feed (₹), X_2= Seed (₹), X_3= Labour (₹), X_4= Electricity (₹), X_5= Fertilizer (₹), X_6= Transport (₹), ε= Error term (assumed to have a zero mean and constant variance), β_1 to β_6= Regression coefficient for input variables.

To compare mean differences across districts and operational categories, non-parametric Kruskal-Wallis tests were applied, followed by Bonferroni-adjusted pairwise comparisons. This was complemented with descriptive statistics (mean, percentage share, ratios) to highlight relative input use and cost-return efficiency.

Statistical analyses including regression modelling and non-parametric tests were performed using R statistical software (version 4.4.2) through R Studio (Version 2025.5.1.513), while descriptive statistics, percentage analysis and basic computation were carried out in MS Excel.

RESULTS AND DISCUSSION

Pond size is a pivotal factor in fish production, as it shapes how resources are used, influences farmers' decisions to adopt new technologies, determines the level of production achieved, and affects overall revenue generation. Larger ponds typically enable more efficient input use, facilitate higher production levels, supports a wider range of technologies, and are associated with greater economic returns for fish farmers (Singh *et al.*, 2015). The examination of Table I revealed the distribution of pond holding sizes among the surveyed farmers in the study area. A majority of the fish farmers (53.33%) possessed small ponds of less than 3 acres, followed by medium-sized farms ranging from 3 to 6 acres (34.16%), while 12.5% owned large ponds exceeding 6 acres. The findings concurred with the observations by Nayak *et al.* (2023). The average sizes of small, medium and large ponds were recorded at 1.37 acres, 3.6 acres and 8.33 acres, respectively. It was further observed that 25.83% of freshwater ponds were under the leased-in category, with the highest lease-in proportion among small farmers (34.37%) followed by large farmers (26.66%) and medium farmers (12.19%). This indicates that leasing of ponds is a prevalent practice in the study area particularly among small and large-scale fish farmers, whereas medium scale fish farmers tend to operate independently and are largely self-reliant (Makadia *et al.*, 2015).

Table I. Size of operations for sample fish farmers.

Particulars	Small (less than 3 acres)	Medium (3-6 acres)	Large (more than 6 acres)	Over-all
Sample farms (No.)	64	41	15	120
Sample farms (%)	53.33	34.16	12.5	100
The average size of the pond (acres)	1.37	3.6	8.33	3.45
Leased farms (No.)	22	5	4	31
Leased in the pond to the total pond (%)	34.37	12.19	26.66	25.83

Table II. Economics of pond fish culture according to operational holdings.

Variable cost	Per acre per culture			
	Small	Medium	Large	Overall
Feed (₹)	93296.88 (47.47)	81783.74 (49.29)	87273.15 (45.64)	88610.25 (47.79)
Seed (₹)	26273.44 (13.36)	21136.18 (12.74)	20566.67 (10.76)	23804.86 (12.83)
Labour/wages (₹)	40992.19 (20.86)	32947.15 (19.85)	48830.56 (25.53)	39223.26 (21.15)
Electricity/fuel (₹)	17304.69 (8.80)	14075.2 (8.48)	14767.2 (7.72)	15884.09 (8.57)
Fertilizer (₹)	8785.15 (4.47)	8205.28 (4.94)	10366.14 (5.42)	8784.65 (4.73)
Transportation (₹)	9867.18 (5.02)	7755.69 (4.67)	9421.42 (4.92)	9090.04 (4.90)
Total variable cost (₹)	196519.5 (100)	165903.3 (100)	191225.1 (100)	185397.2 (100)

Economics of pond fish culture among the operational categories

The economic analysis of pond fish aquaculture (Table II) showed that feed was the largest expense across small (47.47%), medium (49.29%) and large (45.64%)

pond categories, followed by labour (20.86%,19.85% and 25.53% respectively and seed (13.36%, 12.74% and 10.76% (Singh *et al.*, 2015). Operational costs for electricity/fuel, fertilizer and transportation remained stable at 17-19%. Total variable costs were ₹196519.00 for small ponds, ₹165903.30 for medium ponds and ₹191225.10 for large ponds. Medium farms benefited from economies of scale, while large farms incurred higher labour costs due to greater management needs (Islam *et al.*, 2023). The dominance of feed and labour in cost structure, consistent with earlier studies (Nayak *et al.*, 2023) highlights the need for pond-size-specific optimisation strategies to improve profitability.

Profitability estimates of pond fish production among the operational categories

The profitability analysis of pond fish production (Table III) showed that the small ponds achieved the highest total returns (₹434353.9/acre) followed by large (₹420936.1/acre) and medium ponds (₹360558/acre). Cost of cultivation was greatest in small ponds (₹196519.5/acre) and lowest in medium ponds (₹165903.3) with total cost also following the same pattern. Net returns were slightly higher for small ponds (₹103256.3) than large (₹101778.2) while medium ponds recorded lower returns (₹91425.2). The benefit-cost ratio (BCR) was highest in medium ponds (1.41) reflecting superior cost efficiency compared with small (1.37) and large ponds (1.32). These results consistent with earlier findings (Makadia *et al.*, 2015; Nayak *et al.*, 2023) confirms that pond aquaculture is profitable across all scales with small farms excelling in per-acre profitability through intensive management, medium farms optimizing resource use for higher efficiency and large farms requiring targeted labour and input optimization to enhance returns.

Table III. Output-input analysis of pond fish production among operational categories.

Particulars	Per acre per culture			
	Small	**Medium**	**Large**	**Overall**
Total returns (₹)	434353.9	360558	420936.1	407082.1
Cost of cultivation (₹)	196519.5	165903.3	191225.1	185397.2
Total cost (₹)	330827.7	269132.8	319157.9	305660.8
Net returns (₹)	103526.3	91425.2	101778.2	101421.3
Benefit-cost ratio (TC)	1.37	1.41	1.32	1.39
Benefit-cost ratio (TVC)	2.38	2.34	2.07	2.36

Table IV. Output-input analysis of pond fish production among three districts.

Particulars	Per acre per culture			
	Thanja-vur	**Thiru-varur**	**Nagapat-tinam**	**Overall**
Feed	79923.95 (46.74)	103591.1 (50.24)	83563.84 (46.66)	88610.25 (47.79)
Seed	20391.96 (11.92)	28667.26 (13.90)	22355.36 (12.48)	23804.86 (12.83)
Labour/wages	39007.74 (22.81)	39359.52 (19.09)	39302.53 (21.94)	39223.26 (21.15)
Electricity/fuel	15580.56 (9.11)	16258.04 (7.88)	15813.69 (8.83)	15884.09 (8.57)
Fertilizer	8895.33 (5.20)	9345.536 (4.53)	8113.09 (4.53)	8784.65 (4.73)
Transportation	8409.82 (4.91)	8939.167 (4.33)	9921.13 (5.54)	9090.04 (4.90)
Cost of cultivation (variable cost)	170961.3 (100)	206160.6 (100)	179069.6 (100)	185397.2 (100)
Total cost	274810.1	336739.9	305432.5	305660.8
Total returns	375056	457858	388332.4	407082.1
Net returns	100245.9	121118.2	82899.91	101421.3
Benefit-cost ratio (TC)	1.41	1.42	1.35	1.39
Benefit-cost ratio (TVC)	2.28	2.36	2.43	2.36

Cost structure and profitability of pond fish production among the districts

The economic analysis of pond fish production across Thanjavur, Thiruvarur and Nagapattinam districts (Table IV) revealed feed as the dominant variable cost, accounting for 46.74%, 50.24% and 46.66% of total variable costs, respectively with an overall average of 47.79%. Seed costs contributed 11.92-13.90%, while labour and wages formed 19.09-22.81% of expenses, alongside other operational costs (electricity/fuel, fertilizer, transportation) comprising about 17-19%. Total variable costs ranged from ₹170961.3 in Thanjavur to ₹206160.6 in Thiruvarur, while total costs (including fixed costs) were highest in Thiruvarur (₹336739.9) and lowest in Thanjavur (₹274810.1). Profitability analysis showed Thiruvarur achieving the highest total returns (₹457858), net returns (₹121118.2) and BCR (1.42) followed by Thanjavur (BCR 1.41) and Nagapattinam (BCR 1.35). The consistently high BCR values on variable costs (>2.28) highlight the strong economic viability of pond aquaculture when inputs are efficiently managed. The superior returns and efficiency observed in Thiruvarur suggest that optimized resource use and targeted management practices significantly enhance profitability, supporting earlier findings that effective input allocation and intensification improve aquaculture sustainability (Ayyapan and Jena, 2003; Makadia *et al*., 2015; Nayak *et al*., 2023).

Comparative analysis of Cost, Returns, BCR and ROI between Thanjavur, Thiruvarur and Nagapattinam

Given the non-normal distribution of all financial indicators, the Kruskal-Wallis rank sum test (Table V) revealed significant differences in total Cost (χ^2=15.992, df=2, p<0.001) and total Returns (χ^2=15.877, df=2, p<0.001) across the Thanjavur, Thiruvarur and Nagapattinam districts. No significant differences were found for benefit-cost ratio (BCR) and returns on investment (ROI) (χ^2=1.492, df=2, p=0.474 for both), indicating consistent relative profitability and investment efficiency. Dunn's post-hoc test with bonferroni adjustment identified that nagapattinam differed significantly from Thanjavur and Thiruvarur in both total cost (Z=-3.108, p_adj = 0.0056; Z=-3.733, p_adj<0.001) and total returns (Z=-3.098, p_adj=0.0058; Z=-3.719, p_adj<0.001), while thanjavur and thiruvarur did not differ. These results indicate that Nagapattinam consistently exhibited lower costs and returns, yet comparable efficiency to Thanjavur and Thiruvarur, suggesting that lower production scale or input expenditure in Nagapattinam is offset by proportionally lower returns. This aligns with previous findings documenting regional differences in cost structures with corresponding changes in probability ratios, likely due to unbalanced market, resource and operational factors across locations (Allison and Ellis, 2001; Conover, 1999).

Table V. Comparative analysis between Thanjavur, Thiruvarur and Nagapattinam districts.

Variable	Kruskal Wallis X^2 (df=2)	p value	Pairwise comparison	Z value	Adjusted p-value (Bonferroni)	Significance
Total cost	15.992	<0.001	NP-TJ	-3.108	0.0056	Yes
			NP-TR	-3.733	0.0006	Yes
			TN-TR	-0.625	1.0000	No
Total returns	15.877	<0.001	NP-TJ	-3.098	0.0058	Yes
			NP-TR	-3.719	0.0006	Yes
			TJ-TR	-0.620	1.0000	No

Note: Significance is based on adjusted p-values (p<0.05)

Estimated production function for pond fish production

Among the three functional forms evaluated -linear, semi-log and double-log model-the double log model, grounded in the cobb-douglas production function was selected for its superior statistical performance and theoretical appropriateness. The double-log specification yielded an adjusted R^2 of 0.9262, indicating the approximately 93% of the variation in gross returns is explained by feed, seed, labour, electricity, fertilizer and transportation inputs (Table VI). Most input coefficients were statistically significant at the 5% level, affirming the robustness of the model. Specifically, feed (0.315) and seed (0.274) had the largest positive elasticities, underscoring their central role in driving productivity. Labour (0.158) and electricity (0.225) also contributed significantly to the returns, while fertilizer (0.092) showed marginal significance. In contrast, transportation exhibited a negative elasticity (-0.131, p<0.05), suggesting that increased transportation costs diminish gross returns, likely due to logistical inefficiencies or market access constraints. Notably, the positive and significant effects of human labour and feed on gross returns are consistent with earlier findings in fish farming reported by Kumar and Singh (2013) and Rahaman *et al*. (2015). Collectively, these results highlight the relative importance of input factors in aquaculture systems, demonstrate the utility of the double-log functional form for elasticity interpretation and inform targeted strategies for optimizing input use and reducing cost burdens to enhance overall production efficiency.

Table VI. Regression coefficients of various inputs.

Independent variables	Coefficients
Intercept	3.209
Feed	0.315^{***}
Seed	0.274^{***}
Labour	0.158^{**}
Electricity	0.225^{**}
Fertilizer	0.092^{NS}
Transport	-0.131^{*}
Adjusted R^2	0.926

***Highly significant (p<0.01), **Significant (p<0.01), *Significant (p<0.05), ^{NS} Non-significant.

Production analysis of cultured species in the study area

The production analysis of cultured species across the study area (Table VII) revealed that Indian major carps dominated aquaculture output, with Rohu recording the highest total production (317011kg), average productivity (809.48 kg/acre) and a farm gate price of ₹148.29/kg, followed by Mrigal (306350 kg; 753.86 kg/acre; ₹143.70/kg) and Catla (276310 kg; 673.69kg/acre; ₹137.12/kg), consistent with earlier findings that carps remain the backbone of inland aquaculture due to high consumer

Table VII. Production analysis of the cultured species among the districts.

Districts/ Species	Per culture		
	Total production (kg)	Average farm gate price (₹)	Average production per acre (kg)
Thanjavur			
Rohu	120900	144.25	732.11
Mrigal	123500	140.25	703.36
Catla	104100	132.25	616.27
Tilapia	128200	93.25	807.38
Murrel	13700	332.81	50.99
Thiruvarur			
Rohu	121500	149.75	882.11
Mrigal	113500	143.75	810.29
Catla	107500	141.5	754.97
Tilapia	112500	103	842.29
Murrel	13800	357.14	55.51
Nagapattinam			
Rohu	74611	150.87	814.23
Mrigal	69350	147.12	747.93
Catla	64710	137.62	649.84
Tilapia	53990	96.37	556.78
Murrel	6590	373.66	32.60
Overall			
Rohu	317011	148.29	809.48
Mrigal	306350	143.70	753.86
Catla	276310	137.12	673.69
Tilapia	294690	97.54	735.48
Murrel	34090	354	46.37

preference (Ayyappan and Jena, 2003). Tilapia emerged as an important secondary species with a substantial production of 294690 kg and high productivity (735.48 kg/acre), through commanding a lower price (₹97.54/kg), reflecting its growing role in enhancing household food security and income diversification. Murrel, through contributing only 34090 kg in output, fetched the highest price (₹354/kg), underscoring its potential as a high-value niche species (Nayak *et al.*, 2022). District-wise, Thiruvarur outperformed both Thanjavur and Nagapattinam in yield and productivity of major carps and tilapia, recording the highest Rohu productivity of (882.11 kg/acre) and tilapia productivity (842.29 kg/acre), while Nagapattinam lagged in overall production, particularly for Tilapia and Murrel, pointing to differences in farm level management and input efficiency. Overall, the results highlight a species-diverse production structure with carp species forming the production base, Tilapia strengthening its role as a food fish, and Murrel offering high-value market potential, thereby suggesting that optimizing species composition alongside improved management practices could enhance productivity, profitability and sustainability of freshwater aquaculture systems in the region (Singh *et al.*, 2015).

CONCLUSION

The study assessed the economic performance and productivity of pond fish farming in Tamil Nadu. Feed and Labour were identified as key cost drivers. Small ponds yielded the highest returns per acre, while medium ponds showed greater cost efficiency. District analysis revealed significant differences in costs and returns. Major carps dominated production, with tilapia and murrel contributing significant market value. Results underscore the need for targeted management strategies to optimize profitability and support sustainable aquaculture development in the region.

DECLARATIONS

Acknowledgement

This research was part of the first author's postgraduate program. The authors gratefully acknowledge the Honourable Vice-Chancellor, Dr. N. Felix, Tamil Nadu Dr. J. Jayalalithaa Fisheries University in Nagapattinam, Tamil Nadu, India, and the Dean of the Fisheries College and Research Institute in Thoothukudi, for their unwavering guidance and support throughout the research process. Additionally, the author thanks the fish farmers in the study area for their cooperation during the data-collection period.

Funding

The research was funded by Tamil Nadu Dr. J. Jayalalithaa Fisheries University under the TNJFU PG Merit Fellowship.

Consent for publication

After reviewing the manuscript, all authors have agreed to submit it for publication.

Generative AI and AI-assisted technology statement

During the preparation of this work, the authorsused ChatGPT (OpenAI) for grammar correction and language editing. After using this tool, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the publication.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Allison, E.H. and Ellis, F., 2001. The livelihoods approach and management of small-scale fisheries. *Mar. Policy*, **25**: 377–388. https://doi.org/10.1016/S0308-597X(01)00023-9

Ayyappan, S. and Jena, J.K., 2003. Grow-out production of carps in India. *J. appl. Aquacult*., **13**: 251–282. https://doi.org/10.1300/J028v13n03_04

CMFRI, 2024. Annual marine fish production statistics 2023-24. Kochi: *Cent. Mar. Fish. Res. Inst*., **1**: 12.

Conover, W.J., 1999. *Practical nonparametric statistics*. 3rd edn. Wiley, New York.

Department of Fisheries, 2024a. *Annual report on inland fisheries and aquaculture*. Govt. India, New Delhi.

Department of Fisheries, 2024b. *Initiatives in fisheries and aquaculture 2023-2024*. Deptartment Fish., Chennai, Govt. Tamil Nadu.

Economic Survey of Tamil Nadu, 2024. *Economic Survey of Tamil Nadu 2023-24*. Dept. Econ. Statistics, Chennai, Govt. Tamil Nadu.

FAO, 2020. *The state of world fisheries and aquaculture 2020*. Food Agric. Organ, United Nations, Rome.

Inoni, O.E., 2007. Allocative efficiency in pond fish production in Delta State, Nigeria: A production function approach. *Agric. Trop. Subtrop*., **40**: 127–134.

Islam, S., Mitra, S. and Khan, M.A., 2023. Technical and cost efficiency of pond fish farms: Do young educated farmers bring changes? *J. Agric. Fd. Res*., **12**: 100581. https://doi.org/10.1016/j.jafr.2023.100581

Kumar, B.G., Datta, K.K., Reddy, G. and Menon, M., 2010. Marketing system and efficiency of Indian major carps in India. *Agric. Econ. Res. Rev*., **23**: 105–113.

Kumar, H. and Singh, R., 2013. Economic analysis of freshwater aquaculture production: A comparative analysis of different production systems. *Russ. J. agric. Soc. Econ. Sci*., **13**: 49–55. https://doi.org/10.18551/rjoas.2013-01.06

Kumar, S. and Singh, R.K., 2013. Productivity analysis of carp farming in India. *Appl. Biol. Res*., **15**: 112–119.

Makadia, J.J., Ahir, N.J. and Mistry, H.H., 2015. Economics of leased out ponds of fish in Navsari district of South Gujarat. *Trends Biosci*., **8**: 3907–3910.

National Fisheries Development Board, 2024. *Project Funding Status Report FIDF and RIDF Projects*. Natl. Fish. Dev. Board, Hyderabad.

Nayak, A.K., Panigrahy, S.R., Pundir, R.S. and Kumar, H.M., 2022. Status of fisheries sector in Gujarat: An overview. *Indian J. Econ. Dev*., **18**: 381–387. https://doi.org/10.35716/IJED/22043

Nayak, A.K., Panigrahy, S.R., Pundir, R.S. and Kumar, M.H.V., 2023. An economic evaluation of freshwater fish production and marketing in Gujarat. *Indian J. Econ. Dev*., **19**: 202–208. https://doi.org/10.35716/IJED/22263

Pillay, T.V.R., 1990. *Aquaculture: Principles and practices*. Fishing News Books.

Press Information Bureau, 2023. *Government's policy initiatives for fisheries sector development*. Ministry of Fisheries, Govt. India, New Delhi.

Rahaman, S.M., Ghosh, A., Pal, S. and Nandi, S., 2015. A comparison of resource use efficiency and constraints of wastewater and freshwater fish production system in West Bengal. *Econ. Affairs*, **60**: 249–256. https://doi.org/10.5958/0976-4666.2015.00037.6

Singh, D.R., Vasisht, A.K. and Kumar, S., 2015. Profitability and technical efficiency of aquaculture in Punjab, India. *Indian J. Fish*., **62**: 49–55.

Singh, K., 2007. Economics and determinants of fish production and its effects on family income inequality in West Tripura district of Tripura. *Indian J. agric. Econ*., **62**: 1.

Sofia, 2022. *State of fisheries and aquaculture inland fisheries statistics report*. Food Agriculture, Organ. United Nations, Rome.

Tamil Nadu Fisheries Policy Note, 2023. *Policy Note 2023-2024*. Dept. Fish., Chennai, Govt. Tamil Nadu.