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Economics of Fresh Water Cultured Fish Production in Odisha and Bihar, India: A Comparative Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Fisheries and aquaculture are important sectors that provide nutritional security, contribute to agricultural exports, and provide livelihoods to about 28 million fishermen, fish farmers, and other value-chain actors. The study was conducted in two states of Eastern India, i.e. Odisha and Bihar, to estimate the comparative economics of freshwater fish production and its profitability. The results showed that the cost of fish production was estimated to be Rs. 346943.45/ha of pond, constituting Rs. 208582.74 as a variable cost and Rs.138360.71 as a fixed cost in Odisha. In Bihar, the per hectare fish production for an average pond size was estimated to be Rs. 318445.47, comprising variable cost as Rs 188061.82 and fixed cost as Rs. 130383.64. On average, per hectare, fish production in Odisha from all ponds was estimated to be 45.69 quintals, while in Bihar, it was 35.67

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quintals. The profitability analysis revealed that in Odisha, per hectare gross income, on average, for all ponds was Rs. 717763.06. In the case of Bihar, the gross income for all the ponds was calculated to be Rs. 540352.02/ha. It was concluded that returns on investments in all pond categories were comparatively higher in Odisha than in different pond size groups of Bihar.

Keywords: Fisheries; aquaculture; freshwater; production; profitability.

1. INTRODUCTION

Fisheries and aquaculture are among the fastest-growing industries in India and worldwide [1]. The fisheries sector contributes to national income and exports, ensures nutritional security, generates employment, and provides livelihood options [2]. It provides livelihood to about 28 million fishermen, fish farmers, and other value chain actors. India's position in aquaculture is second and ranked third globally in fisheries production. The fisheries sector contributed about 1.24% to the nation's total gross value added (GVA) and shares about 7.28% of the GVA from the agricultural sector during 2020-21. Two types of aquaculture, i.e. freshwater and brackish water, are practised in the country. The breeding and cultivation of freshwater fish like carp, catla, rohu, magur, freshwater prawn, freshwater pearl culture, and ornamental fish are part of freshwater aquaculture. India is ranked second at the global level in terms of production of fish through aquaculture. India's contribution to global fish production is about 7.96%. India stands fourth in the export of fish products worldwide during 2021-22. The sector has a prospect of enhancing the farmers' income by boosting production and productivity, improving production quality and reducing wastage. The "Blue Revolution", a scheme sponsored by the Central government, was started in December 2015 to develop the sector.

To augment the fish production to 22 million metric tonnes by 2024-25, *"Pradhan Mantri MatsyaSampada Yojana" (PMMSY)* was launched on 10th September 2020. The estimated investment was Rs. 20,050 crores for five years, i.e., from 2020-21 to 2024-25. The second most important aim of this scheme was to create employment opportunities for about 55 lakh people. The scheme's prime thrust was the infusion of new and emerging techniques to boost the production and productivity of fisheries and aquaculture. Besides, the scheme's other main goals were the socio-economic development of fishermen and fish farmers, ensuring private sector participation, entrepreneurship development, creation of ease of fishing, and motivating people to come forward with innovative ideas to establish start-ups. The "Fisheries and Aquaculture Infrastructure Development Fund (FIDF)", was launched during 2018-19 with a budget of Rs.7522.48 crores to create fisheries infrastructure facilities in both marine and inland fisheries sectors to boost fish production in the country. Apart from these facilities, the government has also provisioned to provide Kisan Credit Cards (KCC) to fishers and fish farmers to credit working capital.

Fish is considered the "Rich Food for Poor People" and contains both macronutrients and micronutrients, making it a nutrient-rich source. Fish is low-fat and contains high-quality protein with Omega-3 fatty acids and other micronutrients such as Vitamins A and D, as well as thiamine, riboflavin, and niacin (vitamins B_1, B_2, and B_3). Vitamin D, found in fish liver and oils, is essential for bone formation, metabolism, and calcium absorption. Fish is also known as "Brain Food" and "Heart Food" as it helps in brain development and reduces the risk of heart attacks and strokes. Fish has a substantial amount of protein, around 18-20% by fresh weight.

Odisha is one of the major fish-producing states in India and ranks 4th in production after Andhra Pradesh, West Bengal and Gujarat [3]. Odisha is one of the best maritime states in India; it has an excellent scope for fisheries development. Odisha has 6.86 lakh hectares of freshwater resources, 4.18 lakh hectares of brackish water and 480 Km of coastline for fisheries production (Annual Activity Report of Fisheries Sector 2020-21). The total amount of fish produced in the year 2019-20 was 8.16 Lakh tonnes, and the per capita fish consumption was about 16.2 kg (Annual Activity Report of Fisheries Sector 2020-21).

The vibrancy of the fisheries sector is reflected in its compound annual production growth rate of 6.38% from 2015-16 to 2019-20 in Bihar. During 2021-22, fish production in Bihar was 7.62 lakh tonnes. The fisheries sector provides employment and is essential in enhancing the

per capita income of people experiencing poverty, particularly in the rural areas of Bihar. Freshwater resources are a natural gift for the development of this sector. About 3.8 per cent of the total geographical area of Bihar comes under water resources, which offer a conducive ecosystem for the development of fisheries and aquatic biodiversity in the state. The share of fisheries and aquaculture in gross state domestic product (GSDP) was about 8% during 2019-20. The prominent fish-producing districts in Bihar are Madhubani (0.76 lakh tones), East Champaran (0.60 lakh tones) and Darbhanga (0.59 lakh tones), contributing about 30.4% of the total fish production of the state. The state government has initiated providing high-quality seeds to enhance fish production. Training for setting up hatcheries is being imparted to the fish farmers to intensify quality fish production in the state.

Fishing has been a vital livelihood option for human beings since ancient times. This sector provides livelihood to a large proportion of the population, generates employment, fetches foreign exchange, and enhances nutritional security not only in India but also across the globe. There has hardly been any comparative study on fisheries and aquaculture to understand the spatial differences between different states of India, particularly between the states of Bihar and Odisha. While Odisha is ranked 4th in terms of fish production in the country, Bihar too is quite rich so far as water bodies are concerned and has enormous potential to harness these water bodies by setting up fish and aquaculture to boost the income of fish farmers of the state and in uplifting socio-economic conditions. Hence, the present study intends to study the comparative economics of producing freshwater cultured fish in both states.

2. METHODOLOGY

2.1 Source of the Data

The research study was based on primary data. The primary data were collected through the survey method by using pre-tested schedules during 2021-22. Two states of Eastern India, Bihar and Odisha, were selected purposively: Balasore district from Odisha and Darbhanga district from Bihar, with the maximum number of fish farmers present in the study area kept in mind. Balasore Sadar block was selected from Balasore district, and from Darbhanga district, Biraul block was selected purposively. From Balasore Sadar block, Nuagan and Bhimpura villages were selected randomly, and from each village, 30 fish farmers were selected, and from Biraul block, Manikpur and Itwa Shivnagr villages were selected, from each village, 30 fish farmers were selected. For the study, the total sample size was 120 fish farmers.

The data thus collected and summarized were primarily analyzed by a simple tabular method. The pond-wise data, at first, were used to categorize the operators of the fish ponds. The data relating to fish production and cost of production, including costs of different inputs used in the production of fish, production level, and profitability, were tabulated for the various categories of ponds separately. The ponds were categorized based on area, as small ponds (less than 0.5 ha), medium ponds (0.5 to 0.8 ha) and large ponds (above 0.8 ha).

Estimation of costs of production of fish: The fish production process requires various types of investments. The investments made in production were divided into two categories, i.e. variable and fixed costs.

(a) Fixed costs:

Fixed costs are overhead expenses that remain the same irrespective of production level. It included

Rent paid: The rent paid was calculated only in the case of the leased-in ponds.

Land revenue: The land revenue was included as per the government rates.

Interest on fixed capital: This was calculated by taking 7.5% as the interest rate on fixed capital.

Depreciation: The depreciation cost was calculated on machinery, fish nets, boats, and buckets using the straight-line method.

Table 1. Kinds of fish produced in the study area

Particulars	Selected study area of Odisha	Selected study area of Bihar
Indigenous	Catla, Rohu, Mrigal, Bhetki, Midha	Catla, Rohu, Mrigal, Naini etc
Exotic	Pangasius, Roopchand, Grass carp, Amur Carp, Bighead carp,	Grass Carp, Silver Carp, Common Carp, etc

(b) Variable costs

Cost of seed: The price paid by the fish farmers for fingerlings.

Cost of feed: Two types of feed, artificial and supplementary, were considered to calculate feed costs. The feed costs, such as oil cakes, rice bran, etc., were calculated.

Cost of manure and chemicals: The manures and chemical fertilizers, whether purchased or home-produced, were evaluated at the prevailing market price, including costs incurred on transportation were included in the manure and fertilizer cost. Other chemicals used, like medicines, potash, and oxygen tablets, were calculated at the market price. Lime was used in ponds to clean the ponds; hence its cost was included in this head.

Human labour charges:

Hired human labour: The actual payment to hired labour was considered as the cost of hired labour. No permanent labours were found in the study areas of both states; hence, no calculation was made for permanent labours.

Family labour: Family labour was the main source of labour utilized in different production processes, especially on small and medium ponds. Despite wide variation in wage rates for various operations, the family labour was calculated at the prevailing average wage rate in the study areas of the states under investigation.

Interest on working capital: To estimate interest on working capital, 7.5% for six months on the cost of seed, feed (artificial feed and supplementary feed), manure, chemicals used and labour was used.

Financial measures:

Net income

Net income= Gross income - Total expenses

Family labour income

Family labour income= Net income + imputed value of family labour

Farm business income

Farm business income= Family labour income + Interest on own capital (Fixed + Variable) + Imputed value of pond

3. RESULTS AND DISCUSSION

3.1 Cost of Fish Production in the Study Area of Odisha and Bihar

Farmers are primarily concerned with profitability from any enterprise, which can only be ascertained if the related costs of different components are estimated. Per hectare, costs of various cost components have been computed for various size groups of ponds in the study areas of the states under investigation. The details of the cost incurred on various cost components are presented in Table 2.

It may be observed from the table that per hectare pond, the average cost of fish production in the study area of Odisha was estimated to be Rs. 346943.45, constituting Rs. 208582.74 as variable cost and Rs.138360.71 as a fixed cost. The total production costs exhibited increasing trends among the different size groups of ponds under investigation in the study area of Odisha, i.e. production costs for small, medium and large ponds were estimated to be Rs 299872.63, Rs. 351175.96 and Rs. 389781.76 per hectare, respectively. Trends of total variable costs and fixed costs were also observed to be the same. The increasing cost trends may be due to comparatively more expenses incurred on feeds, manure, and chemicals used by medium and large ponds. Makadia et al. [4], Kumar et al. [5] reported similar findings. Supplementary feeds such as groundnut cakes, mustard cakes, and jaggery may be used in higher quantities in medium and large ponds than in small ponds. Lime was used in ponds to maintain pH and keep pond water clean occasionally. For the growth of planktons, farmers were found using manures every month. Most of the medium and large fish farmers were also observed applying some chemicals regularly, such as potash and medicine called ecospot, to protect the fish from diseases. The small pond holders were also found using chemicals and medicines but not regularly.

On average, fish production in all ponds was estimated to be 45.69 quintals per hectare. Whereas the per hectare production of fish for different categories of ponds, i.e. for small, medium and large, were estimated to be 39.08 quintals, 44.48 quintals and 53.50 quintals, respectively.

Further, gross returns and net returns were also estimated for various sizes of ponds under

investigation. It was observed that the average Gross and net returns for all the ponds were computed to be Rs.717763.06 and Rs.370819.61. In the case of Small, medium and large ponds, gross returns were calculated to be Rs. 609576.24, Rs.698409.79 and Rs. 845303.16, respectively. Net returns were observed to be Rs.309703.61, Rs.347233.83 and Rs. 455521.40.

From the above discussion, it may be inferred that fish farming was a profitable enterprise in the study region of Odisha. The findings revealed that large fish farmers earned the highest total returns per hectare compared to medium and small fish farmers. It was also evident that the net profit per hectare was the highest for large producers compared to small and medium producers. Similar findings were reported by Ravikesh, [6] and Sharma & Singh [7].

Further, the results revealed that fish production cost in the study area of Bihar for an average pond size was estimated per hectare to be Rs. 318445.47, which expenses incurred on variable cost components were Rs. 188061.82 and fixed cost expenses Rs. 130383.64. In the case of pond size-wise analysis, it was observed that the total cost of production per hectare was higher in medium size ponds, i.e. Rs 356514.98/ha, followed by large Rs. 338961.48/ha and small Rs. 259859.96/ha.

The variable and fixed cost components also exhibited the same trend as the average of all ponds. The medium farms exhibited a variable cost of Rs. 215422.83/ha, and the variable costs for small and large ponds were estimated to be Rs 147879.76/ha and Rs. 200882.85/ha. The fixed costs for small, medium and large ponds were computed to be Rs. 111980.19, Rs. 141092.16 and Rs. 138078.63 per hectare.

The production of fish per hectare of the pond was comparatively high in the case of medium ponds, i.e. 38.14 quintals per hectare, followed by large ponds at 37.67 quintals/ha and small ponds at 31.20 quintals per hectare. The reason for the better performance of medium-sized fish farms may be the major proportion of fish farms belonged to the medium-sized group (51.67%), and they could have utilized more feeds, manures and chemicals in the production of fish in the area under study and also have used their acquired patriarchal skills in fish farming.

It was also evident from the findings that medium pond cultivators earned more gross returns than small and large pond cultivators. The gross returns earned by the medium pond cultivators were estimated to be Rs.581586.20/ha, followed by large ponds Rs. 572546.00/ha and small, Rs. 467941.50. But the net returns were found high in the case of large ponds (Rs.233584.52/ha) followed by medium (Rs.225071.22/ha), and small (Rs.208081.54/ha) as the investments of medium farmers were comparatively high.

From the above discussion, it may be concluded that per hectare, the cost of fish production was comparatively high in all the pond sizes in Odisha compared to the study region of Bihar. It was also pointed out that output per hectare of fish and profitability were comparatively high in Odisha compared to that of Bihar. The reason may be the better economic status of fish farmers in Odisha than in Bihar. In Odisha, the state government launched the Odisha Fisheries Policy in 2015 to reach an average productivity of 5 tonnes/ha. Higher fish productivity in the study region of Odisha may be due to the impact and the successful implementation of the scheme. Besides this scheme, other schemes for promoting fish cultivation and improving the socio-economic conditions of the fishing community in the states are Matsya Pokhari Yojana and Matsyajibi Unnayan Yojana.

3.2 Factor-wise Analysis of Fish Production

The essential cost components utilized in the fish production in the study area of both states have been presented in Table 3.

The share of different cost items incurred on fish production in the study region of Odisha was assessed, and the results revealed that feed cost shared a major proportion (22.16%), followed by labour cost (19.15%), manure, lime and chemical application (8.16%) and fingerlings (6.45%) in case of an average of all the ponds under investigation. Thus, variable cost constituted about 60.12% and fixed cost 39.88%. Among fixed costs major share of rental value (35.09%) was observed.

Ponds category-wise analysis exhibited the same pattern. The shares of major cost components on small ponds were feed (22.56%) followed by labour charge (15.10%), manure, lime and chemical application (8.93%) and fingerlings (7.36%). Similarly, the shares of different cost components were 22.05%, 20.22%, 7.54% and 5.94% on feed, labour, manure, lime and

chemical applications and fingerlings on medium ponds. The shares of different components on large ponds were feed (21.96%), human labour (21.32%), manure, lime and chemical application (8.11%) and fingerlings (6.21%). Thus, total shares of variable costs were 60.12% for all ponds, small ponds (58.00%), medium (59.92%) and large (61.92%). The variable cost was observed to increase with the increase in pond size. Fixed cost exhibited a reverse trend, i.e., with the rise in pond size, the fixed cost decreased in Odisha's study area.

Further, In the case of Bihar, the results revealed that the percentage value of feed cost in the total value of fish production was the highest (21.58%) in the case average for all ponds. The other component, human labour share, was estimated to be 21.16, followed by a share of the cost for manure, lime and chemical application (7.64%) and fingerlings (6.68%) in the costs of an average of all ponds.

The pond size-wise percentage shares of different cost components were also estimated. It was observed that feed cost shared 21.71%, followed by human labour (16.30%), manure, lime and chemical application (8.38%) and fingerlings (7.59%) for small ponds size and medium ponds the shares of feed cost, human labour cost, manure, lime and chemical application cost and fingerlings cost were 21.28%, 23.22%,7.58% and 6.30% and for large ponds feed cost, human labour cost, manure, lime and chemical application and fingerlings cost shared 21.02%, 22.73%, 7.13% and 6.38%. It is evident from the findings that in the case of medium and large ponds, human labour shares were observed highest in the study region of Bihar.

The variable cost constituted about 59.06% in the case of an average of all ponds, and for different pond size groups, the shares were 56.91%, 60.42% and 59.26% for small, medium and large ponds respectively. The higher variable cost in medium ponds was due to higher investment in labour costs and feed costs. The fixed cost shares about 40.94% of the total cost of fish production. The pond size-wise share of the fixed cost was observed to be 43.09% for small, 39.58% for medium and 40.74% for large ponds. Among fixed costs, rent paid for leased-in ponds/rental values constituted a huge proportion of the total cost of fish production, i.e. for an average of all ponds (36.74%) and the category-wise 38.77% for small ponds, 35.35% medium ponds and 36.65% for large ponds.

Both states exhibited the same trends in shares of various components of variable cost. In the study area of Odisha variable costs were found to increase with the increase in pond size, and a reverse trend was observed in fixed costs. However, in the study area of Bihar, neither variable nor fixed costs showed any definite pattern in different pond size categories.

3.3 Financial Measures of Fish Production

Four financial measures, i.e. gross income, net income, family labour income and farm business income, were worked out for various pond categories under study (Table 4).

The findings revealed that per hectare gross income, on average, was Rs. 717763.06. A comparatively high gross income was found in large ponds (Rs. 845303.16), followed by medium (Rs. 698409.79) and small (Rs. 609576.24). The net income also showed the same trend, i.e. with the increase in pond size, the net income increased [8]. The reason might be that the larger ponds may have cultivated high-priced fetching demanding fishes in their ponds like Rohu, Catla, and Bhetki, and they could grow fishes with their proper weight and low mortality rates.

Similar trends were noticed in family labour and farm business income in the study region of Odisha. The family labour income from the small pond was 324733.46 Rs/ha, from the medium pond 368091.36 Rs/ha, and the large pond 460120.22 Rs/ha. The reason might be that the small pond holders did most of the work using family labour, but medium and large pond holders used more hired labour. The farm business income was the highest in large ponds, followed by medium and small ponds, i.e. Rs. 605944.48Rs/ha, 508303.36Rs/ha, 451073.25 Rs/ha respectively. The reason may be that many large pond operators may have utilized resources optimally.

The gross income in the study area of Bihar for all the ponds was calculated to be Rs. 540352.02 per hectare. The gross income on medium ponds was comparatively more than that of large and small ponds. Net income was computed to be Rs. 233584.52 for large farmers, medium (Rs. 225071.22/ha) and small (Rs. 208081.54/ha). The large ponds earned more due to cultivating high-priced fetching species like catla and rohu in their ponds.

Table 2. Per hectare cost incurred on different operations in fish production in the study area (Rs/ha)

Particulars	Odisha				Bihar			
	Small	Medium	Large	All pond size	Small	Medium	Large	All pond size
Fingerlings cost	22083.33	20846.70	24217.88	22382.64	19711.84	22464.16	21614.06	21263.34
Total feed cost	67656.66	77427.09	85610.50	76898.08	59026.21	75859.88	71251.60	68712.56
Artificial feed cost	13178.34	48676.78	53268.81	38374.64	38178.17	46528.63	45853.08	43519.97
Supplementary feed	43116.32	17556.27	23042.63	27905.07	14426.04	22847.50	20379.48	19217.66
Rice bran cost	11362.00	11194.04	9299.06	10618.37	6422.00	6483.75	5019.04	5974.93
Potash cost	14654.51	12955.64	17557.39	15055.85	10892.70	13514.73	12091.14	12166.18
Cow dung cost	2000.70	1857.44	1847.56	1901.90	1506.70	1185.60	1358.50	1350.27
Oxygen Tablets cost	7862.83	8127.41	8446.93	8145.72	7311.20	8795.05	7581.91	7896.05
Lime cost	2272.97	3549.17	3755.64	3192.59	2074.80	3534.08	3150.73	2919.86
Total Cost of manure, lime and chemical Application	26791.00	26489.66	31607.52	28296.06	21785.40	27029.46	24182.29	24332.39
Labour charges	45272.85	70994.35	83093.81	66453.67	42355.56	82784.52	77041.77	67393.95
Variable costs	161803.85	195757.80	224529.71	194030.45	142879.00	208138.01	194089.71	181702.24
Interest on working capital	12135.29	14681.83	16839.73	14552.28	5000.76	7284.82	6793.14	6359.58
Total Variable cost	**173939.13**	**210439.63**	**241369.44**	**208582.74**	**147879.76**	**215422.83**	**200882.85**	**188061.82**
Fixed Cost								
Rental paid (owned)	113324.84	124389.69	127527.46	121747.33	100746.11	126045.71	124224.50	117005.43
Land revenue	534.48	583.71	604.33	574.18	366.55	383.59	376.68	375.61
Interest on fixed capital	879.67	1140.47	1457.08	1159.07	1436.53	1744.34	1706.42	1629.09
Depreciation	11194.51	14622.45	18823.45	14880.14	9431.00	12918.52	11771.03	11373.51
Total fixed cost	**125933.49**	**140736.33**	**148412.32**	**138360.71**	**111980.19**	**141092.16**	**138078.63**	**130383.64**
Total Cost (Variable +Fixed)	299872.63	351175.96	389781.76	346943.45	**259859.96**	**356514.98**	**338961.48**	**318445.47**
Total Fish Production(q/ha)	39.08	44.48	53.50	45.69	31.20	38.14	37.67	35.67
Gross return (Rs/ha)	609576.24	698409.79	845303.16	717763.06	467941.50	581586.20	572546.00	540352.02
Net Return(Rs/ha)	309703.61	347233.83	455521.40	370819.61	208081.54	225071.22	233584.52	221906.55

Table 3. Cost incurred on important components of fish production in the study area (%)

	Odisha				Bihar			
Cost Components	**Small**	**Medium**	**Large**	**All pond size**	**Small**	**Medium**	**Large**	**All pond size**
Fingerlings	7.36	5.94	6.21	6.45	7.59	6.30	6.38	6.68
Feed	22.56	22.05	21.96	22.16	22.71	21.28	21.02	21.58
Manure, lime and chemical Application	8.93	7.54	8.11	8.16	8.38	7.58	7.13	7.64
Human Labour	15.10	20.22	21.32	19.15	16.30	23.22	22.73	21.16
Total Variable cost (Rs/ha)	58.00	59.92	61.92	60.12	56.91	60.42	59.26	59.06
Rental paid	37.79	35.42	32.72	35.09	38.77	35.35	36.65	36.74
Total fixed Cost(Rs/ha)	42.00	40.08	38.08	39.88	43.09	39.58	40.74	40.94

Table 4. Per hectare gross income, net income, family labour income and farm business income on different categories of ponds in the study area

	Odisha				Bihar			
Particulars	**Small**	**Medium**	**Large**	**All ponds**	**Small**	**Medium**	**Large**	**All ponds**
Gross return (Rs/ha)	609576.24	698409.79	845303.16	717763.06	467941.50	581586.20	572546.00	540352.02
Net income (Rs/ha)	309703.61	347233.80	455521.40	370819.61	208081.54	225071.22	233584.52	221906.55
Family Labour income (Rs/ha)	324733.46	368091.36	460120.22	386915.49	242300.92	270924.30	245484.98	252564.19
Farm Business income (Rs/ha)	451073.25	508303.36	605944.48	524374.18	357478.80	417173.34	388273.65	387302.72

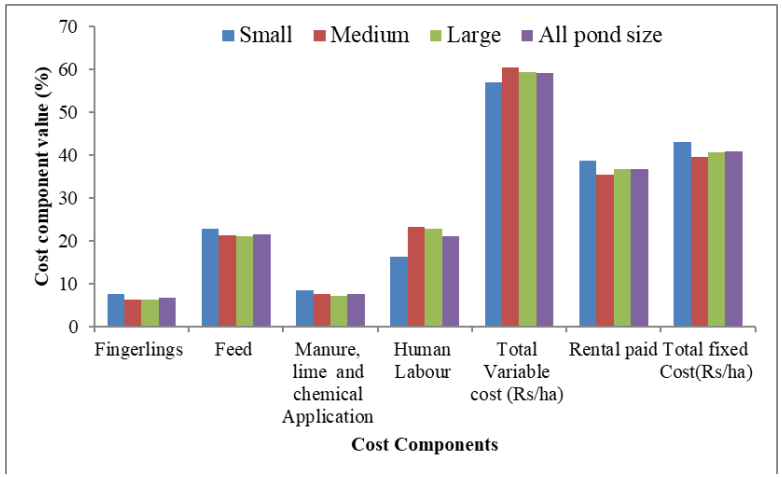

Fig. 1(a). Cost incurred on important components of fish production in Odisha

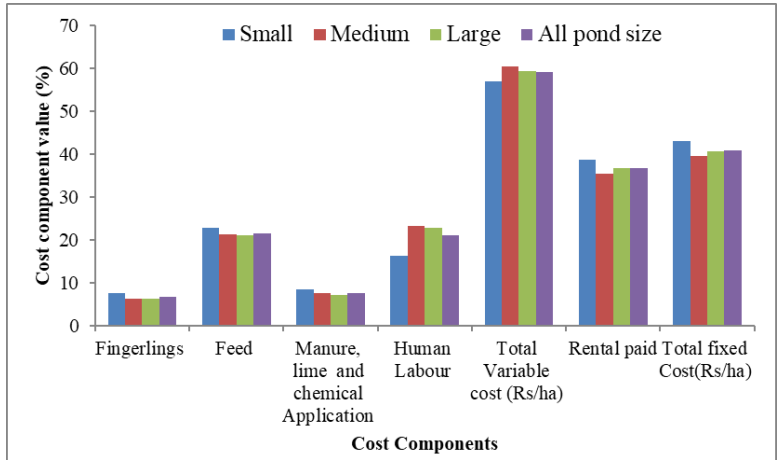

Fig. 1(b). Cost incurred on important components of fish production in Bihar

Table 5. Returns on investment on different categories of ponds in the study area

	Odisha			Bihar		
Pond categories	**Total investment (Rs/ha)**	**Gross return (Rs/ha)**	**Return on investment (%)**	**Total investment (Rs/ha)**	**Gross return (Rs/ha)**	**Return on investment (%)**
Small	299872.64	609576.24	103.28	259859.95	467941.5	80.07
Medium	351175.95	698409.79	98.88	356514.98	581586.2	63.13
Large	389781.75	845303.16	116.87	338961.48	572546	68.91
All ponds	17347.18	35888.16	106.88	318445.46	540352.02	69.68

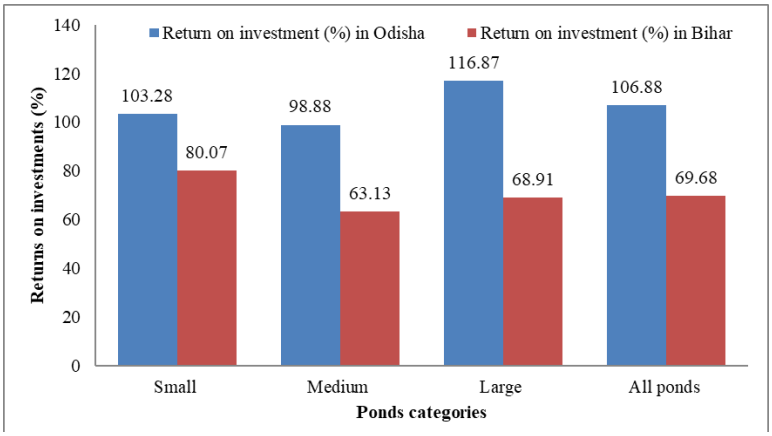

Fig. 2. Returns on investment on different categories of ponds in the study area

The family labour income was higher in the case of medium ponds (Rs. 270924.30/ha) followed by large ponds (Rs. 245484.98/ha) and small (Rs. 242300.92/ha). The farm business income followed the trend of family labour income. The family labour income may be high due to the utilization of comparatively more human labour in fish production on medium farms.

From the above findings, it was inferred that in the study area of Odisha, gross income, net income, family labour income and farm business income increased with an increase in pond size. In contrast, in the case of Bihar, gross income was recorded as highest in the case of medium ponds, followed by large and small, whereas net income was higher in the case of large ponds. The findings revealed that medium ponds had the highest family labour and farm business income. The reason may be due to the comparatively high utilization of human labour in fish farming compared to small and large ponds in the study area of Bihar.

3.4 Ratio Measures

Returns on investment have been estimated by comparing the relative efficiency of different fish ponds under investigation. It would help the farmers decide whether to increase or decrease the investment in the production process. Returns on investments for various types of ponds in the study areas of the states are presented in Table 5.

The results revealed that the return on investment obtained from dividing net income by total expenses and expressed as a percentage was comparatively high in large ponds (116.87%), which declined with an increase in the pond size group, i.e. 103.28% for small ponds and 98.88% for medium ponds. It may further be observed from the table that, on average, returns on investment in fish production in all the ponds under investigation in the study region of Odisha was 106.88%, indicating that investment of one rupee on fish production generated Rs. 1.07 in sample households. As mentioned, the return on large ponds was comparatively high and was lowest on medium farms. Similar findings were reported by Devi et al. [9]. The reason was that medium ponds had utilized a relatively large proportion of human labour charge. It is worth mentioning that returns on investment on medium ponds were more than the prevailing interest rate of bank deposits, suggesting scope for further investment in fish production.

Returns on investment percentages for various types of ponds in the study region of Bihar were worked out, and the findings revealed that net returns decreased with an increase in pond size. More income generation by small fish farmers in the state may be due to the rational use of inputs by the farmers on small ponds, and the small farmers of the study region were also observed to be resource-poor. However, returns on investment were more than prevailing bank interest. Hence, fish farming investments may increase in Bihar's study area [10].

From the above findings, it may be inferred that returns on investments across all pond categories were comparatively higher in Odisha than different pond size groups in Bihar.

4. CONCLUSION

The foregoing discussion revealed that the cost of fish production for one hectare of the pond was estimated to be Rs. 346943.45, constituting Rs. 208582.74 as variable cost and Rs.138360.71 as a fixed cost in Odisha. For different categories of ponds production costs were Rs 299872.63, Rs. 351175.96 and Rs. 389781.76 per hectare for small, medium and large. In case of Bihar, the per hectare production of fish for an average pond size was estimated to be Rs. 318445.47, in which expenses incurred on variable cost components were Rs 188061.82 and fixed cost expenses Rs. 130383.64. For small, medium and large ponds the total cost of production per hectare was Rs. 259859.96/ha, Rs 356514.98/ha and Rs. 338961.48/ha. On average, per hectare, fish production in Odisha from all ponds was estimated to be 45.69 quintals while in Bihar it was 35.67 quintals.

From the profitability point of view, the average gross and net returns for all the ponds were computed to be Rs.717763.06 and Rs.370819.61 in Odisha. While in the case of Bihar the average gross and net returns for all the ponds were estimated to be Rs.540352.02 and Rs. 221906.55 per hectare, respectively. The major cost components of fish production in Odisha, was feed (22.16%) followed by human labour (19.15%). While in Bihar, the major cost contributor was the rental paid for leased-in ponds (36.74%) of the total cost of production. Feed cost constituted 21.58% of the total cost of production.

The profitability analysis revealed that in the study area of Odisha, per hectare gross income, on average, for all ponds was worked out to be Rs. 717763.06. There was higher gross income from larger ponds followed by medium and small ponds. The farm business income was highest in the case of large ponds, as the number of large pond holders was more in Odisha. In Bihar, the gross income on medium ponds was comparatively more than that of large and small ponds. Net income was computed to be Rs. 233584.52 for large farmers, followed by medium (Rs. 225071.22/ha) and small (Rs. 208081.54/ha). The large ponds earned more due to the cultivation of high price fetching species like catla and rohu in their ponds. The family labour income was more in the case of medium ponds (Rs. 270924.30/ha) followed by large ponds (Rs. 245484.98/ha) and small (Rs. 242300.92/ha). The farm business income was highest in the case of the medium pond. The ratio measures revealed that in Odisha, the return on investment was highest for large pond at 116.87% and lowest for medium pond at 98.88%. In Bihar, net returns decreased with an increase in pond size. The higher income generation by small fish farmers in the state may be due to the rational use of inputs by the farmers of small ponds.

There is further need to augment the fish production to enhance the income of fishing community and meet the targeted per capita availability of fish to 15 kg in India by 2030.

5. POLICY IMPLICATIONS

Fish production was found to be profitable in both the states under investigation. Hence, the governments of both the states should adopt and implement the policies like

- Fish feed is an essential components of fish farming; hence, the government should encourage local entrepreneurs to set up of fish feed plants in the area to ensure regular and cost effective supply of quality feed in time at affordable prices.
- To make credit availability easy and adequate, and to manage risks involved, credit and insurance agencies should be encouraged to extend adequate lending and insurance coverage to fish farmers as fish production requires significant investments.
- The government should also encourage and support the establishment of certified hatcheries in order to ensure the supply of good quality fingerlings on time.

- Adequate training support to fish farmers on different aspects of fish farming technologies would help boost the fish production and productivity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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