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Cost-benefit analysis of rohu (*Labeo rohita*) reared in in-pond raceway system and commercial earthen pond

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Abstract

The present study was conducted to determine the cost and benefits of a commercially important major carp *Labeo rohita* (Rohu), reared under In-pond Raceway System (IPRS) and Commercial Earthen Pond (CEP) for 90 days from 1 October to 30 December 2021. Rohu is considered to be one of the widely available and highly favorable cultured fish in Bangladesh. However, this is the first comparative study on the cost-benefit analysis of rohu in these two aquaculture systems. In total, 13,000 individuals of healthy *L. rohita*, weighing from 180 to 190 g were stocked in an IPRS cell having an area of 220 m^3 of each cell and the area of pond is 1.38 acre, while in the CEP of 1.38 acre was stocked with 5,500 individuals of the same species and same size. A commercial Afil fish feed was used during the experiment. The fishes were fed 3 times at 4 hours of interval in the IPRS cell and 2 times at 12 hours of interval in CEP, respectively during day times. After stocking, all fishes in the IPRS cell were fed at the rate of 5.5-6.0% of body weight for the first 15 days, 5.0-5.5% for the next 15 days, 4.5-5.0% for the next 15 days, 4.0-4.5% for the next 15 days, 3.5-4.0% for the next 15 days and 3.0-3.5% for the last 15 days, while fishes in the CEP were supplemented with the same feed at 4.5-5.0% for the first 30 days, 3.5-4.0% for the next 30 days and 2.5-3.0% for the remaining 30 days. The mean water quality parameters such as temperature, pH, DO and ammonia-nitrogen were 25.34±4.56°C, 7.8±0.34, 6.62±0.34 mg/L and 0.03±0.01 mg/L in IPRS, and 26.04±4.53°C, 7.57±0.28, 5.41±0.20 mg/L and 0.39±0.26 mg/L in CEP, respectively. At the end of the 90-day rearing experiment, total production of rohu fish was obtained to be 9,295 kg and 2,814 kg in IPRS and CEP, respectively. The estimated total costs and net benefits were BDT 9,20,059 and 5,20,665, and BDT 3,52,679 and 69,473 in IPRS and CEP in this order. The cost-benefit ratio in IPRS and CEP was found to be 1.66 and 1.28, respectively. The findings from our study revealed that IPRS is

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better than CEP for the rearing of *L. rohita* in respects of higher production and net benefits.

Keywords: Labeo rohita, IPRS, CEP, production, costs, benefits

1 Introduction

The concept of the in-pond raceway (IPR) was simple. It would be a system, like cages, that could be adapted to almost any body of water but with the advantage of controlled water movement to improve the water quality and allow for increased stocking density, thereby increasing total production per unit area. Many researchers and aquaculture entrepreneurs have looked at the vast amount of water impounded or potentially available in rivers, bays, and estuaries and have seen opportunities to produce fish. Flow-through systems, such as raceways tend to have fewer water quality issues than most of the other culture systems. The constant exchange of water removes metabolites from the culture area and allows increased stocking rates and production rates per unit area compared to cages and open ponds. Traditional raceways have to be located on springs or creeks with sufficient gradient, and these constant flowing water sources are exceedingly site limited. The largest drawback of traditional raceways, aside from limited suitable locations, is the constant discharge of wastes into the receiving surface waters of the state. The discharge of these wastes has caused public concern and led to the enactment of strict environmental regulations. Additionally, the high water flow rates common in raceway systems reduce the concentration of these waste products making them difficult to capture or mediate before leaving the site. In the early 1990s, an IPR design was developed at Auburn University. The design used airlift pumps to move water through a box-like culture area. The raceway was rectangular and suspended from a floating pier. Airlifts were placed at one end of multiple raceways and water was pumped through the airlifts into the raceways at the surface. Water was discharged from the raceways along the bottom on the opposite end from the airlifts. The water discharged through a solids-settling chamber and then flowed back into the impoundment (Masser and Lazur, 1997).

The commercially important major carp *Labeo rohita* (Hamilton, 1822) commonly referred to as 'Rohu' fish, is abundantly found in the freshwater sections of the rivers of north India, Pakistan, Bangladesh, Burma and the Tera region of Nepal. It has been transplanted into some of the rivers of Peninsular India and Powai Lake, Bombay, Sri Lanka and to Mauritius. Mixed along with the seed of catla and mrigal, rohu has been exported to USSR, Japan, Philippines, Malaysia, Nepal and some countries of Africa. Rohu is both a bottom and column feeder and prefers to feed on plant matter including decaying vegetation; it is less adapted to take zooplankton than even mrigal. Rohu fingerlings subsist on unicellular and filamentous algae, rotting vegetation, rotifers and protozoans and crustaceans. The rotten vegetation component in the food increases in bigger fish. Rohu is a quick-growing fish and generally spawns during monsoon (Jhingran and Pullin, 1985).

Bangladesh is gradually rising to the top of the aquaculture business, but due to our country's large population, we have limited land properties for aquaculture. In general, our people culture fish in the improved extensive or sometimes semi-intensive system, but

Bangladesh has lately developed the In-pond Raceway System (IPRS) as a representative of intensive aquaculture. The primary motivation for introducing this technology in our country is to expand intensive aquaculture under these resource constraints as well as to provide an alternative technology to meet rising protein demand, particularly for fish protein. By using the same amount of land, IPRS can produce nearly ten times better than traditional culture methods. It has the potential to produce a large profit in a short cultural time. However, this method requires big capital.

In this study, we have attempted to determine which culture system had better outcomes in terms of water quality, total production, cost-benefit ratio, and net benefit. The experimental species in this study was *Labeo rohita* (Rohu). The entire project was installed at Afil Aqua Fish Ltd. in Sharsha, Jashore, with technical assistance from World Fish. The Jashore region, which is an aquaculture zone in Bangladesh, is located in the southwest of the country.

2 Materials and Methods

2. 1. Structure of pond

The total area of the CEP was approximately 1.38 acres. It was a classic or normal clay pond with little water circulation. The pond was used to raise commercial fish. The IPRS pond, on the other hand, was same in size, with 880 m^3 allocated to four production cells, each measuring 220 m^3. Four high-pressure air blowers controlled the water flow or circulation. In IPRS, having access to electricity 24 hours a day is crucial. As a result, a Diesel Generating Set has been erected. Each cell has an additional ventilation system called bottom ventilation. Booster ventilation is provided throughout the system, allowing for consistent water quality along the raceway. This system includes high-quality blower metal hose, PVC hose, bottom, and arrow tube ventilation tubing. On each side of the cells, there are 12 aerator tubes. The trash collection system serves as a drainage system, storing and removing garbage mechanically. The sludge unit is another name for this equipment. This device collects all racetrack garbage and removes it on a regular basis.

2. 2. Collection and stocking

Rohu (*Labeo rohita*) were collected from the Afil fish hatchery and some fishes were purchased from a private hatchery of Jashore. In CEP, 5,500 pieces of rohu were stocked, while one IPRS cell was stocked with 13,000 pieces of rohu, having an average weight of 180 g and price of BDT 22.73.

2.3. Feeding management

The experimental fishes were fed with the commercial fish feed, manufactured by Afil Group of Industries, which enhanced the growth performances and production efficiency due to its high nutritive values and quality. The stocked fishes of CEP were fed manually 2 times at 12 hours of intervals in the daytime. After stocking, all fishes in the CEP were fed at 4.5-5.0% of body weight for the first 30 days, 3.5-4.0% for the next 30 days and 2.5-3.0% for the remaining 30 days. On the other hand, fishes in IPRS were sampled 15 days of intervals using a seine net to assess their growth and health. The stocked fishes were fed by auto-feeder 3 times at 4 hours of interval. After stocking, all fishes in the IPRS cell were fed at the rate of 5.5-6.0% of body weight for the first 15 days, 5.0-5.5% for the next 15 days, 4.5-5.0% for the next 15 days, 4.0-4.5% for the next 15 days, 3.5-4.0% for the next 15 days and 3.0-3.5% for the last 15 days.

2. 4. Sampling

The data were collected through the regular samplings of water and fish species, which were organized every 15 days of interval and several parameters (weight, mortality, water temperature, pH, DO, ammonia-nitrogen) were measured. The maintenance of water quality parameters is very important for pond management. Poor quality water increases the chance of pathogenic and parasitic infection to the fish. Different physicochemical parameters including temperature (°C) and pH was measured with a digital multi-meter (Model No HI9814, Hanna, made in Romania), Dissolve-oxygen (mg/l) was measured by Digital DO meter (YK-22D0, made in Taiwan), Ammonia-nitrogen was measured with a multi-meter (Model no. HI98191, Hanna instruments, made in Romania) in this experiment.

2. 5. Cost-benefit analysis

The cost-benefit analysis is an important aspect of any farm operation. The detailed cost and benefits were analyzed based on the production obtained and expenses incurred during the 90-day culture of *L. rohita* in IPRS and CEP as follows:

2. 5. 1. Capital cost

A capital cost means the costs during the hatchery construction and setup.

2. 5. 2. Operating cost

The operating cost refers to costs involved to run the hatchery operation e.g., labor, feed, etc.

2. 5. 3. Depreciation cost

Annual depreciation cost was calculated, using the following formula (Biswas, 2021):

$$\text{Annual depreciation cost} = \frac{\text{Capital cost}}{\text{Project life}}$$

$$\text{Monthly depreciation cost} = \frac{\text{Annual depreciation cost}}{12}$$

$$\text{Depreciation cost for 1 cell} = \frac{\text{Monthly depreciation cost}}{4}$$

2. 5. 4. Total cost

Total cost was calculated, using the formula (Biswas et al., 2021) as follows:

Total cost (BDT) = Total operating cost (BDT) + (Depreciation cost for 1 cell × 3) (BDT)

2. 5. 5. Revenue income

The revenue income is the total sale during the experimental period

Revenue income (BDT) = Total production (Kg) × Unit price (BDT)

2. 5. 6. Net benefit

Net benefit was calculated by the following formula:

Net benefit (BDT) = Total revenue income (BDT) – Total cost (BDT)

2. 5. 7. Cost-benefit ratio

The cost-benefit ratio was calculated, using the formula as below:

$$\text{Cost benefit ratio} = \frac{\text{Total benefit}}{\text{Operating cost}}$$

2. 6. Data analysis

The results obtained in the experiment were subjected to statistical analysis. Qualitative and quantitative analysis of all kinds of data were carried out. Microsoft Office Excel 2013 was used for the data analysis. One-way analysis of variance (ANOVA) was performed using the Microsoft excel 2013. Significance was assigned at the 0.05% level.

3 Results and Discussions

3. 1. Water quality parameters

Various types of water quality parameters were observed throughout the study period. Water temperature (°C), dissolved oxygen (mg/1), pH, and ammonia-nitrogen (mg/l) were measured at 15 days of interval. The water parameters of both ponds have been presented in Table 1 as below:

Table 1. Mean (±SD) values of water parameters recorded from IPRS and CEP.

Pond / Parameters	IPRS	CEP
Water temperature (°C)	25.34±4.56	26.04±4.53
pH	7.8±0.34	7.57±0.28
Dissolved oxygen (mg/l)	6.62±0.34	5.41±0.20
Ammonia nitrogen (mg/l)	0.03±0.01	0.39±0.26

3. 1. 1. Temperature (°C)

Water temperature was measured at 15 each days of intervals from the sub-surface of water in IPRS and CEP, and the mean temperature was found to be 25.34±4.56°C and 26.04±4.53°C, respectively (Table 1). There was no significant difference found between IPRS and CEP. The highest temperature of 31.5°C and 32.1°C was recorded in IPRS and CEP, respectively in October, while the minimum temperature of 20.3°C and 20.5°C was recorded in IPRS and CEP in December (Figure 1).

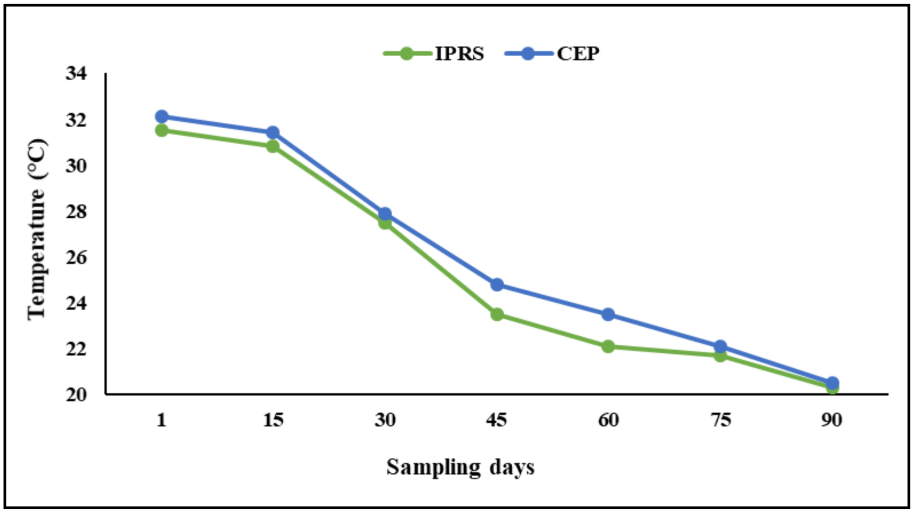

Figure 1. Per 15 days variations of water temperature in IPRS and CEP during the 90-day culture of *Labeo rohita*.

3. 1. 2. pH

PH of the sub-surface waters of IPRS and CEP was measured at 15 days of intervals, and the values in two systems are presented in Figure 2. In the IPRS, the range of pH was 7.3 to 8.2 with an average value of 7.8±0.33 and in the CEP, range of pH was 7.2 to 8.0 with an average value of 7.57±0.28 during the experimental period from 1 October to 30 December.

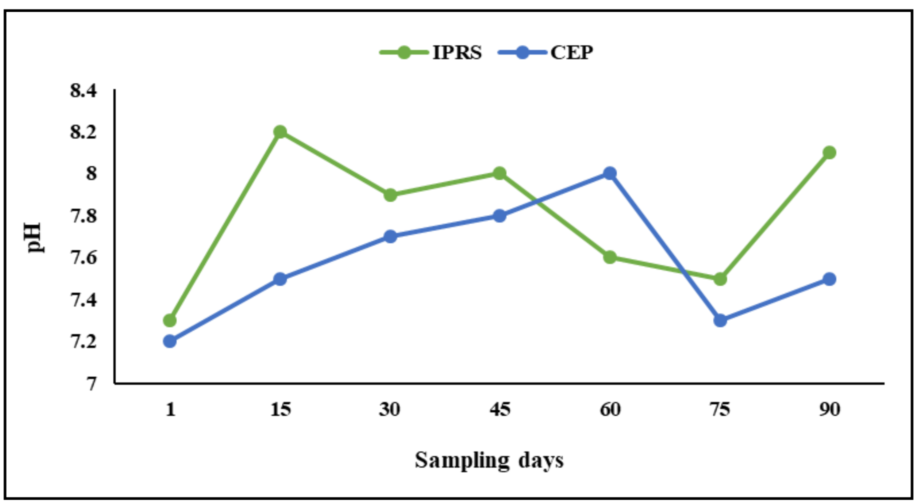

Figure 2. Per 15 days variations of pH in IPRS and CEP during the 90-day culture of *Labeo rohita*.

3. 1. 3. Dissolved oxygen (mg/1)

Dissolved oxygen was measured at 15 days of intervals in both the IPRS and CEP systems and the variations are shown in Figure 3. During the observation, the mean values of dissolved oxygen in IPRS and CEP were found to be 6.62±0.34 mg/l and 5.41±0.20 mg/l, respectively (Table 1). Dissolved oxygen was higher than the CEP.

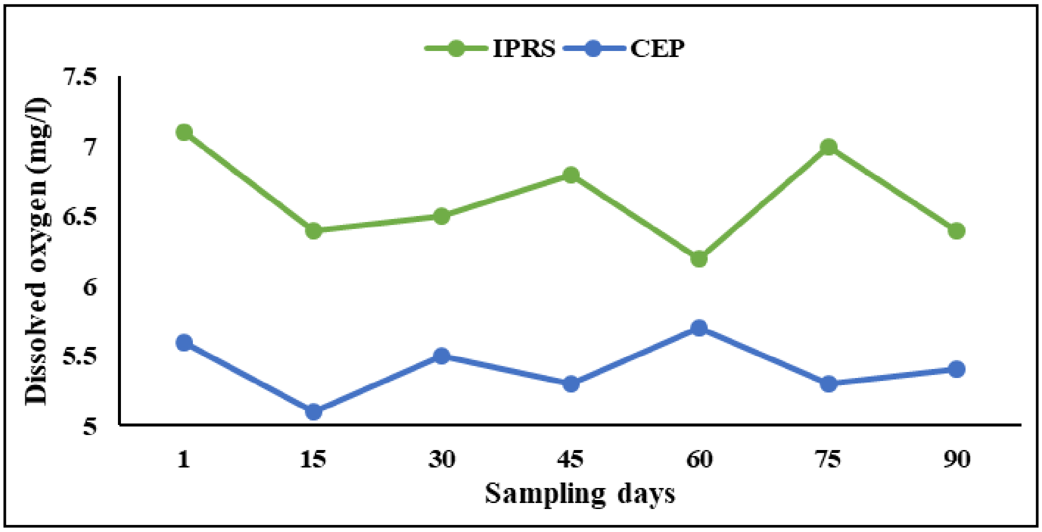

Figure 3. Per 15 days variations of dissolved oxygen in IPRS and CEP during the 90-day culture of *Labeo rohita*.

3.1.4. Ammonia-nitrogen (mg/l)

The mean values of ammonia-nitrogen were 0.03±0.01 and 0.39±0.26 in IPRS and CEP, respectively (Table 1). The mean values were significantly different between the systems; the highest value of ammonia-nitrogen (0.05) was found in IPRS in November and the lowest value (0.01) was found in IPRS on 1st October. The highest value of ammonia-nitrogen (0.7) and the lowest value of ammonia-nitrogen (0.05) was found in the CEP. Per 15 days variations of ammonia-nitrogen in IPRS and CEP are presented in Figure 4.

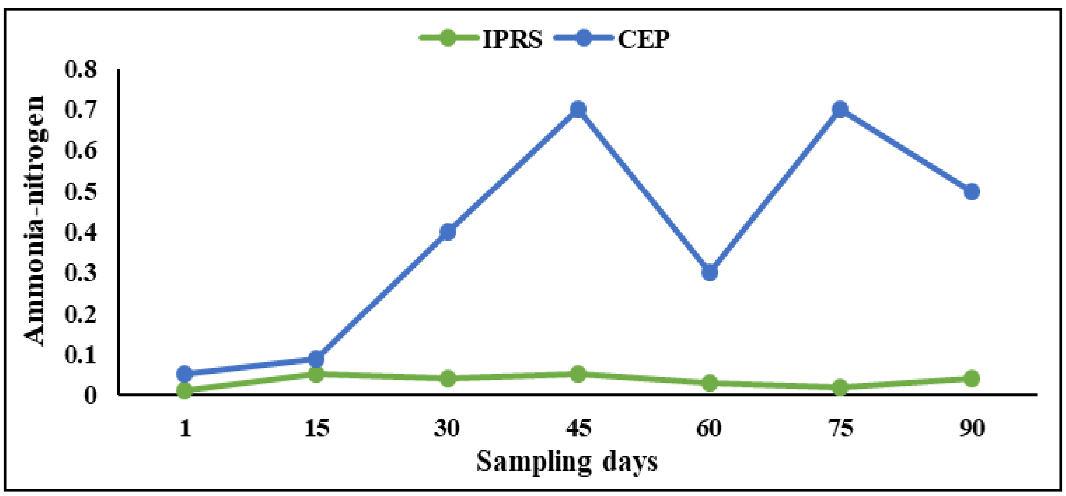

Figure 4. Per 15 days variation of ammonia-nitrogen in IPRS cell and CEP during the 90-day culture of *Labeo rohita*.

3. 2. Cost-benefit analysis of IPRS

3. 2. 1. Capital and monthly depreciation costs in IPRS

The capital and depreciation costs of the 4 experimental IPRS cell during the 90-day culture are summarized in Table 2. The estimated annual capital cost was BDT 1,43,76,010, while the annual depreciation cost was BDT 8,30,877 with a monthly expenditure of BDT 69,239.

Table 2: Estimated capital and depreciation costs for the 4 cells of IPRS.

Items	Estimated capital cost (BDT)	Useful project life (year)	Annual depreciation cost (BDT)	Monthly depreciation cost (BDT)
Land lease	54,00,000	20	2,70,000	22,500
Pond construction	12,43,260	10	1,24,326	10,360
Civil construction	46,59,300	20	2,32,965	19,413
IPRS equipment	12,07,325	15	80,488	6,707
SS mesh gate	1,59,250	15	10,616	884
Stand by power generator	5,42,750	10	54,275	4,522
Electrical wire and control system	7,46,325	20	37,316	3,109
Installation & project management cost	4,17,800	20	20,890	1,740
Total	1,43,76,010		8,30,877	69,239

3. 2. 2. Operating costs in IPRS cell

The operating cost for rearing of *L. rohita* in IPRS cell from 1 October to 30 December is shown in Table 3. The highest amount of cost (BDT 4,62,455) was incurred for the first month (October) followed by December (BDT 2,31,375) and the lowest in November (BDT 1,74,300). The reason behind these might be due to the fish seed cost, which was incurred only in the first experimental month (October) and the fish selling cost that was incurred in December.

Table 3: Estimated operating costs for the rearing of *Labeo rohita* in 1 IPRS cell.

Items	Estimated cost (BDT) in October	Estimated cost (BDT) in November	Estimated cost (BDT) in December
Labor salary	40,000	30,000	35,000
Seed cost	2,95,455		
Feed cost	1,40,000	1,50,000	1,60,000
Electricity	7,500	7,300	7,400
Medicine	1,500		
Selling cost			46,475
Total	4,62,455	1,74,300	2,31,375

3. 3. Cost-benefit analysis of CEP

3. 3. 1. Capital and monthly depreciation costs in CEP

The capital and depreciation costs of the experimental CEP system during the 90-day culture period of *L. rohita* are shown in Table 4. The total annual capital cost was estimated to be BDT 17,78,000 and the annual depreciation cost was BDT 1,11,650 with a monthly cost of BDT 9,304.

Table 4: Estimated capital and depreciation costs for the rearing of *L. rohita* in CEP

Items	Estimated capital cost (BDT)	Useful project life (year)	Annual depreciation cost (BDT)	Monthly depreciation cost (BDT)
Land lease	13,50,000	20	67,500	5,625
Pond construction	3,50,000	10	35,000	2,916
Equipment	60,000	10	6,000	500
Electrical wire cost	3,000	20	150	12
Management cost	15,000	5	3,000	250
Total	17,78,000		1,11,650	9,304

3. 3. 2. Operating cost

The operating cost of *L. rohita* during the three-month (1 October–30 December) rearing in CEP system in given in Table 5. The highest of cost (BDT 1,77,860) was incurred during the first month (October) followed by that of December (BDT 1,78,875) and the lowest cost was in November (BDT 58,930). The reason behind these might be due the fish seed cost, which was incurred only in October and the fish selling cost in December.

Table 5. Estimated operating costs for the rearing of *Labeo rohita* in CEP.

Items	Estimated cost (BDT) in October	Estimated cost (BDT) in November	Estimated cost (BDT) in December
Labor salary	2,000	2,000	2,000
Feed cost	50,000	55,000	60,000
Electricity	260	280	250
Medicine	600	650	500
Netting cost		1,000	
Selling cost			28,140
Seed cost	1,25,000		
Total	1,77,860	58,930	90,890

3. 4. Total production

The details of the culture system, stocking density, stocking size, harvesting density, harvesting size, survival rate and total production of rohu in IPRS and CEP during the study period are summarized in Table 6. In the present study, stocking size of rohu fingerlings in both the culture systems was 180 g. At the end of the 90-day culture period, the highest survival and harvesting size of *L. rohita* were obtained in IPRS (99.1% and 721.6 g) than those in CEP (98.5% and 519.5 g), respectively. It was also found that production in IPRS (9,295.4 kg) was more than 3 times higher than that obtained in CEP (2,814.4 kg) (Figure 5).

Table 6. Details of the culture system, stocking density, stocking size, harvesting density, harvesting size, survival rate and total production of rohu (*L. rohita*) in IPRS and CEP during the 90 days of culture.

Name of pond	Stocking density	stocking size (g)	Survival (%)	Harvesting density	Harvesting size (g)	Total production (kg)
IPRS	13,000	180	99.1	12,881.7	721.6	9,295.4
CEP	5,500	180	98.5	5,417.5	519.5	2,814.4

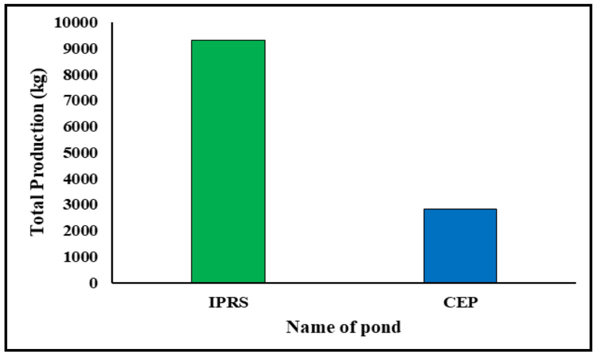

Figure 5. Comparison of total production between IPRS and CEP at the end of the 90-day culture of *L. rohita*.

3. 5. Total cost and revenue income

The total cost and revenue income obtained from the present study were BDT 9,20,059 and 3,52,679, and 14,40,725 and 4,22,152, respectively in IPRS and CEP (Figure 6). Total revenue income was two times higher, when *L. rohita* was cultured in IPRS than that in CEP.

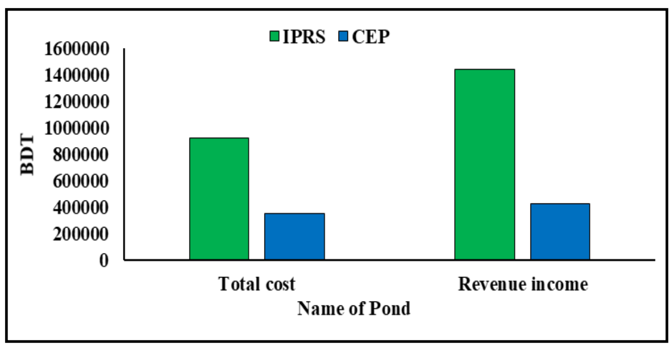

Figure 6. Comparisons of total cost and revenue income between IPRS and CEP during the 90-day culture of *L. rohita*.

3. 6. Cost-benefit ratio

The estimated cost-benefit ratio after the 90-day culture of *L. rohita* was found to be 1.66 and 1.28 in IPRS and CEP, the values of which was the highest in the former and the lowest in the later culture system (Figure 7).

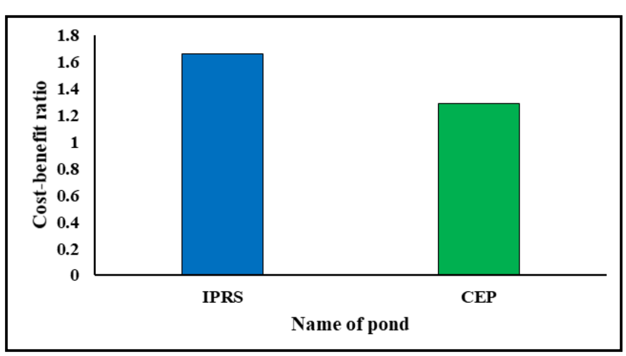

Figure 7. Comparison of cost-benefit ratio between IPRS and CEP during the 90-day culture of *L. rohita*.

3. 7. Net benefits

The net benefits obtained from the present experiment were BDT 5,20,665 and BDT 69,473 in IPRS and CEP, respectively (Figure 8). After the 90 days rearing of *L. rohita*, the results showed that IPRS was almost 7.5 times more profitable than CEP.

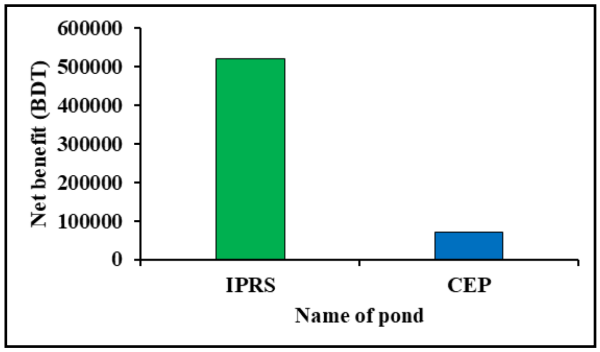

Figure 8. Comparison of net benefits between IPRS and CEP during the 90-day culture of *L. rohita*.

The results of the present study showed the comparisons of water quality parameters, production, cost and benefits of the rearing of rohu fish between two different pond culture systems. This result indicated that the cost-benefit ratio and net benefit of IPRS were more than CEP. The findings of the present study are discussed with available references on the IPRS and CEP culture systems of rohu (*L. rohita*).

1. Water quality parameters

The maintenance of good water quality is essential for both the survival and optimum growth of culture organisms. The suitable range of water quality parameters ensures the better management of aquatic organisms as well as the aquatic environment. Although there was little fluctuation in the parameters of water temperature, pH and dissolved oxygen concentration from the morning hours of two different culture systems (IPRS and CEP), the ranges of these values were still suitable for the growth of rohu (Khan et al., 2000).

2. Temperature

Temperature has a direct effect on the physical, chemical and biological condition of the water body. The water temperature is one of the most important water quality parameters that influence the growth, food intake, reproduction and other biological activities of aquatic organisms. A 1°C rise in water temperature metabolic rate becomes double (Moncrief and Jones, 1977).

During the present 90-day experiment, the result of water quality parameters such as the range of water temperature was (20.3~31.5)°C and (20.5~32.1)°C, and the mean value was 25.34±4.56°C and 26.04±4.53°C in IPRS and CEP, respectively. Boyd (1982) reported that the range of water temperature from 26.06 to 31.97°C is suitable for fish culture. Wahab *et al*. (1995) also reported the surface water temperature is ranged from 30.2 to 34ºC in polyculture of Indian and Chinese carps. Ali and Baggs (1982) observed the water temperature ranged from 20.5 to

30.5ºC in pond during their study. Hossain *et al*. (2000) reported water temperature of ponds ranged from 26.0 to 32.4°C.

3. pH

pH is considered as an important factor in fish culture. It indicates the acidity and alkalinity conditions of a water body. It is also called the productivity index of a water body. The present study showed that the range of pH was 7.3~8.2 and 7.2~8.0, and the mean value was 7.8±0.34 and 7.57±0.28 in IPRS and CEP, respectively in the 90 days of culture. Hossain *et al*. (2000) found a good relationship between the pH of pond water and fish culture, and also obtained satisfactory results of pH from 6.5 to 9.0. Swingle (1968) suggested that neutral to slightly alkaline pH has been found to be most favorable for fish ponds. The pH values obtained in this study (7.6-8.2) fell within the suitable range according to Boyd *et al*. (2000).

4. Dissolved oxygen

Successful fish culture depends on the careful management of dissolved oxygen at an optimum level. The present study showed that the range of dissolved oxygen was varied bewteen 6.2~7.1 mg/1 and 5.1~5.7 mg/1, and the mean value was 6.62±0.34 and 5.41±0.20 in IPRS and CEP, respectively during the 90 days of culture trial. Wahab *et al*. (1995) recorded dissolved oxygen to be ranged from 2.2 to 7.1 mg/l in nine ponds of BAU campus, Mymensingh in their study. Ali and Baggs (1982) considered 5.0 to 7.0 mg/l of the dissolved oxygen content of water as fair or good in respect of productivity.

5. Ammonia-nitrogen

A high level of ammonia is toxic to fish. In the 90 days of experimental period, the range of NH_3-N was between 0.01~0.05 and 0.05~0.7, and the mean value was 0.03±0.01 and 0.39±0.26 in IPRS and CEP, respectively. Hossain *et al*. (2000) found that lower than 1 mg/l of NH_3 gas content in ponds was good for fish culture. Our results are more or less similar to Ali and Baggs (1982) who recorded ammonia nitrogen values was ranging from 0.2 to 0.37 mg/l. So, in the present study, ammonia-nitrogen value was suitable for rohu culture in the experimental rearing systems.

However, all these reports are more or less in agreement with the results of the present study and are suitable for fish culture in captive rearing systems.

6. Cost and benefit of IPRS

Cost is a big fact in IPRS. The present experiment showed that the cost-benefit ratio was 1.66, the net benefit obtained was BDT 5,20,665, where the total cost was BDT 9,20,059, total production was 9,295 kg and revenue income was obtained to be BDT 14,40,725. However, when the IPRS unit density was selected to the recommended 2.47 cells/ha, there was a profit between 9,772 and 15,688 US$ per pond (Fullerton, 2016). Brown *et al*. (2014) told that the break-even price per pound to cover fixed costs was greater in all IPRS production scenarios than for the traditional farm. This was due to the initial construction cost of the IPRS ($113,279 or $18,880 per acre).

7. Cost and benefit of CEP

In CEP, the cost was lower than IPRS. The present experiment showed that the cost-benefit ratio was 1.28, the net benefit was BDT 69,473, where the total cost was BDT 3,52,679, total production was 2,814 kg and revenue income was BDT 4,22,152. Biswas *et al*. (2021) documented the cost-benefit ratios of 1.59, 1.51, and 1.46 were in May, June, and July, respectively. Islam *et al*. (2016) documented that the cost-benefit ratios were 1.54, 1.32, and 1.23 in the month of January, February, and March in that order.

8. Better culture system

The present study demonstrated that the cost-benefit ratio was 1.66 and 1.28, and the net benefit was BDT 5,20,665 and BDT 69,473 in IPRS and CEP, respectively from 1 October to 30 December 2021 in Afil Aqua Fish Ltd., Sharsha, Jashore. From the findings of this experiment, it was revealed that the IPRS is more profitable than the CEP.

4 Conclusion

In the case of high-density stocking of fish, farmers face some general problems. These are: ammonia toxicity, requires large volume of water body, feeding competition, size variations due to malnutrition, stressed condition and disease. IPRS is a great solution for this kind of problems. The findings from this study revealed that In-pond Raceway System (IPRS) is better than Commercial Earthen Pond (CEP) for the rearing of *Labeo rohita* in respects of higher production and net benefits.

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Conflict of interests

The authors declare that they have no conflict of interest.

References

Ali, A., & Baggs, R. D. (1982). Seasonal changes of chironomid populations in a shallow natural lake and in a man-made water cooling reservoir in central Florida. *Mosquito News, 42*(1), 76-85. https://www.biodiversitylibrary.org/content/part/JAMCA/MN_V42_N1_P076-085.pdf

Biswas, A., Choudhury, M., Farid, M. A., Rahman, M. A., & Rahman, M. A. (2021). Induced breeding of freshwater fishes and cost benefit analysis of a selected fish hatchery in Jashore, Bangladesh. *Annual Research & Review in Biology*, *36*(11), 15-25. doi: 10.9734/arrb/2021/v36i1130446

Boyd, C. E. (1982). Water quality management for pond fish culture. Amsterdam, *Elsevier Science* (No. 639.3 D48/9).

Boyd, P.W., Watson, A.J., Law, C.S., Abraham, E.R., Trull, T., Murdoch, R., Bakker, D.C., Bowie, A.R., Buesseler, K.O., Chang, H., & Zeldis, J. (2000). A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. *Nature*, *407*(6805), 695-702. https://doi.org/10.1038/35037500

Brown, T. W., Hanson, T. R., Chappell, J. A., Boyd, C. E., & Wilson Jr, D. S. (2014). Economic feasibility of an in-pond raceway system for commercial catfish production in west Alabama. *North American Journal of Aquaculture*, *76*(1), 79-89. https://doi.org/10.1080/15222055.2013.862195

Fullerton, G. (2016). Economic viability of floating in-pond raceway systems for commercial hybrid catfish production. http://hdl.handle.net/10415/5403

Hossain, M. M., Rahman, M. K., & Rahman, S. S. (2000). Hydraulic fracture initiation and propagation: roles of wellbore trajectory, perforation and stress regimes. *Journal of Petroleum Science and Engineering*, *27*(3-4), 129-149. https://doi.org/10.1016/S0920-4105(00)00056-5

Islam, M. M., Hassan, R., Sharif, B. N., Rahaman, M. M., Islam, M. A., & Amin, M. R. (2016). Water quality, feeding management and cost-benefit analysis of a fish hatchery in Jessore district of Bangladesh. *Asian Journal of Medical and Biological Research*, *2*(3), 414-421. https://doi.org/10.3329/ajmbr.v2i3.30112

Jhingran, V. G., & Pullin, R. S. (1985). *A Hatchery Manual for the Common, Chinese, and Indian Major Carps* (No. 252). WorldFish.

Khan, M. A., Gul, B., & Weber, D. J. (2000). Germination responses of *Salicornia rubra* to temperature and salinity. *Journal of Arid Environments*, *45*(3), 207-214. https://doi.org/10.1006/jare.2000.0640

Masser, M. P., & Lazur, A. (1997). In-pond raceways. *Aquaculture Production Systems*, 387-394.

Moncrief, J. W., & Jones, W. H. (1977). Water quality management for pond fish culture. Department of Fisheries and Allied Aquaculture (ed. CE Boyd). Agricultural Experiment Station, Auburn, Alabama.

Swingle, H. S. (1968). Biological means of increasing productivity in ponds. *FAO Fisheries Report*, *44*(4), 243-257. http://www.nativefishlab.net/library/textpdf/15116.pdf

Wahab, M. A., Ahmed, Z. F., Islam, M. A., Haq, M. S., & Rahmatullah, S. M. (1995). Effects of introduction of common carp, *Cyprinus carpio* (L.), on the pond ecology and growth of fish in polyculture. *Aquaculture Research*, *26*(9), 619-628. https://doi.org/10.1111/j.1365-2109.1995.tb00953.x