Indian J. Fish., 64(3): 100-105, 2017
DOI: 10.21077/ijf.2017.64.3.31439-14

Evaluation of economic viability and sensitivity analysis of Indian major carp culture

NARAYAN BAG[1], SANJIB MOULICK[2] AND BIMAL CHANDRA MAL[3]
[1]*Fishery Extension Officer, Uluberia-I Dev. Block, Uluberia R.S. P.O., Howrah - 711 316, West Bengal, India*
[2]*School of Civil Engineering, KIIT University, Bhubaneswar - 751 024, Odisha, India*
[3]*Swami Vivekananda Technical University, Bhilai - 490 009, Chhattisgarh, India*
e-mail: ns8nov2003@yahoo.co.in

ABSTRACT

Indian major carps *viz.*, catla *Catla catla* (Hamilton); rohu *Labeo rohita* (Hamilton) and mrigal *Cirrhinus mrigala* (Hamilton) were cultured with a stocking density of 50000 fingerlings ha^{-1} for a period of 300 days with all possible best management practices. Sensitivity of different fixed and operating cost variables, production and sale price involved in the experiment were analysed. All the above costs varied by ±10%, ±20% and ±30% respectively and the net present value (NPV) and internal rate of return (IRR) were determined. Among all the inputs, feed cost was found to be the most sensitive. NPV and IRR values ranged from 7 to 20% and 5 to 15% respectively with varied feed cost ranging from 10 to 30%. Increases either in the production or in the sale price by 10, 20 and 30%, led to increase in the NPV by around 22, 43 and 65% and IRR by around 17, 33 and 49% respectively from their original values. Present study suggests that proper feeding and marketing strategy should be emphasised to get maximum economic benefit from Indian major carp culture.

Keywords: Fixed cost variables, Indian major carps, Internal rate of return, Net present value, Operating cost variables, Sensitivity

Introduction

Demand of fishery products is increasing worldwide to meet the nutritional requirements of the increasing human population (Banas *et al.*, 2007). As the natural supply of fishes both from marine and freshwater sources has reached sustainable limit, aquaculture is the only way of increasing world supply of fishery products (Boyd, 2003; Sugiura *et al.*, 2006; Banas *et al.*, 2007). In India, aquaculture is almost synonymous to carp culture since carps contribute to more than 80% of the total aquaculture production of country (Jena and Das, 2006).

The Indian major carps *viz.,* catla *Catla catla* (Hamilton); rohu *Labeo rohita* (Hamilton) and mrigal, *Cirrhinus mrigala* (Hamilton) are the dominant species in freshwater aquaculture in India (Nandeesha *et al.*, 2001; Biswas *et al.*, 2006) contributing more than 82% of the total inland aquaculture production (FAO, 2003). Though large numbers of literature are available on carp culture with the stocking densities varying from 690 to 35,000 fingerlings ha^{-1} with recorded production levels ranging from 600 to 25000 kg ha^{-1} $year^{-1}$ in different culture systems (Alikunhi *et al.*, 1971; Lakshmanan *et al.*, 1971; Das *et al.*, 1975, 1977, 1980; Chaudhuri *et al.*, 1974, 1975, 1978; Chakrabarty *et al.*, 1979a,b; Jhingran, 1991; CIFA, 1998; Tripathi *et al.*, 2000; Jena *et al.*, 2002a,b; Reddy *et al.*, 2002), the most important aspect of economic analysis has generally been ignored in these studies. Moreover, the sensitivity of different fixed as well as operating cost variables involved in a carp culture system has not been studied earlier. In the present study, different economic parameters like capital expenditure, input costs, income, profit, net present value (NPV) and internal rate of return (IRR) were calculated and the sensitivity analysis of different variables involved in Indian major carp production system was carried out.

Materials and methods

Study area and experimental design

The field experiment was conducted from 20 June 2008 to 16 April 2009 for a period of 300 days at the aquaculture farm of the Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, India. Three numbers of polythene (Silpauline, 150 g m^{-2} in weight, 250 µm thick, UV ray protected, blue in colour) lined ponds of average water area 0.015 ha and water depth 1.2 m were used for the experiment to avoid high seepage loss of the project site. Loamy soil was provided over the lining at the pond bed to a thickness of about 30 cm to simulate natural pond environment. The ponds were stocked with fingerlings of catla

(16.78±1.84 g), rohu (16.82±1.69 g) and mrigal (16.65±1.83 g) at a stocking density of 50000 fingerlings ha^{-1} with a species combination of catla 40%, rohu 30% and mrigal 30%. Pelleted feed containing 35% crude protein prepared at the Aquacultural Engineering Processing Laboratory was fed to the fishes. The pH of water was maintained within its ideal range (6.5 -9.0) through intermittent application of agricultural lime. The concentration of major influencing inorganic water quality parameters particularly the total ammonia nitrogen (TAN) was maintained within the acceptable range through water exchange. The experiment was conducted within an integrated aquaculture and irrigation system (IAI) where the pond effluent was used as a source of enriched water for irrigation as it contained inorganic nutrients which were useful to the agricultural crops. So, no expenditure was considered for the purpose of water exchange. Supplementary aeration was provided to maintain dissolved oxygen concentration of the pond water above 4 mg l^{-1}.

Economic analysis techniques

The field trials were conducted using ponds of 0.015 ha area each. To analyse the economic benefit of the experiment, one hectare (ha) pond area was considered. The cost of various items was suitably scaled up for 1ha area based on the cost involved in 0.015 ha area. Considering the durability of the polythene lining and other machineries, the life time of the project (n) was assumed as 10 years. Depending on the recurring expenditure and income of the present study, cash flows (CF) for 10 years were decided considering a discount (k) rate of 10%. Fixed cost variables of the system *viz.,* soil excavation, polythene sheet, labour for miscellaneous works at the time of pond construction and aeration facility and the key operating cost variables *viz.,* feed, fingerlings and electricity for aeration and finally, the fluctuations in sale price and the production were included in the sensitivity analysis. All the above costs varied by ±10%, ±20% and ±30% and the NPV and IRR were determined to enable a direct comparison.

Inputs, costs and income

A sum of ₹990700 was estimated to be invested as the capital expenditure (Table 1). The details of recurring costs for various items, the income by selling fish and the profit (cash flow) are presented in Table 2. A sum of ₹607964 was required as the recurring expenditure for

Table 1. Initial outlay for construction of 1 ha farm

Particulars	Expenditures (₹)
Soil excavation	386100
Polythene sheet	353600
Brick and sand	86000
Labour for different works	40000
Miscellaneous expenditure	25000
Aerators (4 paddle wheel aerators of 1.12 kW) with accessories	100000
Total	990700

₹44.50 = 1.00 $ (Approximate)

Table 2. Cost and returns in 1 ha farm

Particulars	Amount (₹)	% to total
A. Investment costs		
Lime	3600	0.59
Cowdung	1500	0.25
Urea	180	0.03
SSP	160	0.03
Fingerlings	50000	8.22
Fish feed	407733	67.06
Aeration cost	74600	12.27
Netting	8000	1.32
Prophylactics	8000	1.32
Labour for monitoring, feeding, water exchange and aeration	30000	4.93
Maintenance	24191	3.98
Total input costs (₹ha^{-1} $crop^{-1}$)	607964 ± 12708	100.00
B. Income from different treatments		
Total production (kg ha^{-1} $crop^{-1}$)	14814 ± 143	
Sale price	₹90 kg^{-1}	
Total income (₹ha^{-1} $crop^{-1}$)	1334224 ± 11291	

SSP - single super phosphate; ₹44.50 = 1.00 $ (Approximate). Data are means (± standard deviation) of three replicates the culture operation and ₹1334224 was recorded as the income by selling fish at @ ₹90 per kg.

Calculation of net present value and internal rate of return

Net present value (NPV) analysis applies the time value of money to cash inflows and outflows over the life of the project so that the management can evaluate the project's benefits and costs at one point in time (Larson *et al.*, 2002). NPV is computed by discounting the future net cash inflows at the project's required rate of return, and then subtracting the initial amount invested (Larson *et al.*, 2002). Hence, a positive NPV highlights that the present value of the net cash inflows to be received over the project's life exceeds the amount of the initial investment, and hence is an indicator of economic viability. The value of NPV was calculated using the following formula:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+K)^t} - IO \qquad \text{........................ (1)}$$

where, CF = cash flow over the life of the project; IO = initial outlay; k = discounted rate or cost of capital and n = life time of the project.

Internal rate of return (IRR) is the rate used to evaluate an investment's feasibility which reflects the rate of return the project earns (Petty *et al.*, 1996; Larson *et al.*, 2002). Mathematically, IRR is the discount rate that yields an NPV of zero for an investment (Larson *et al.*, 2002). Hence, a project evaluated according to IRR is accepted if its IRR is greater than or equal to the required rate of return (Petty *et al.*, 1996). A minimum discount rate of 10% was used in the present study. IRR was calculated by determining the value of discount rate at which NPV becomes zero.

$$IO = \sum_{t=0}^{n} \frac{CF_t}{(1+K)^t} \qquad \text{........................ (2)}$$

Analysis of key variables affecting profitability

Key operating cost variables *viz.,* feed, fingerlings and electricity for aeration were identified as the main operating costs of the aquaculture system and subsequently were included in the sensitivity analysis. Fixed cost variables of the system *viz.,* soil excavation, polythene sheet, labour and aeration facility and finally, the large fluctuations in production and sale price were also addressed. All the above costs were varied by ±10%, ±20% and ±30% and the NPV and IRR were determined to enable a direct comparison. The deviation (%) in the values from its original was also estimated for comparison.

Results and discussion

The net present value (NPV) of ₹5612161 and the internal rate of return (IRR) of 82.86% were obtained in the present study. These figures of NPV and IRR clearly indicate that the project is highly acceptable from economic point of view. Among the different items in terms of capital as well as recurring inputs, production and sale price, it is important to identify the items affecting the economy of the project significantly. Special attention needs to be paid for economic utilisation of those items during the culture operation. The variations in the values of NPV and IRR with 10, 20 and 30% increase or decrease in the cost of the items are presented in Tables 3, 4 and 5 respectively.

The percentage deviation in the values from its original was also estimated for comparison. It is seen from the tables that the labour charge for miscellaneous works during pond construction, cost of aeration facilities with accessories, cost of fingerlings and the cost of electricity for aeration are less sensitive since variations in costs of these items with their original values as high as 30%, cause less than 5% variations both in NPV and IRR.

It is also seen from the tables that a variation of ±10% in the costs of soil excavation and polythene sheet is not sensitive either to NPV or to IRR. However, with variations of ±20% and ± 30%, they were found to be sensitive to IRR but not to NPV. The variation in the cost of capital expenditure as a whole is found to have more influence on IRR compared to NPV.

On the other hand, the input cost as a whole, is found to have very significant effect compared to capital expenditure, especially on the NPV and less on IRR. Among all the inputs, feed is found to be the most sensitive as it increases or decreases the NPV and IRR at a faster rate compared to any other inputs. The variations in NPV and IRR ranged from about 7 to 20% and 5 to 15% respectively for variations of feed cost in the range of 10 to 30%. However, the production and the sale price of the fish are identified as the two most influential factors among all the items. As expected, variations either in production or in sale price influence the NPV and the IRR by the same degree. The increases either in the production or in the sale price by 10, 20 and 30%, increase the NPV by about 22, 43 and 65% respectively and IRR by about 17, 33 and 49% respectively from their original values. Similar trends were also recorded by Ionno *et al.* (2006) in a recirculating aquaculture system (RAS).

Therefore, it is clear from the sensitivity analysis that special attention should be paid to the production cost of feed and its optimum utilisation. Also proper marketing strategy, such as, harvesting at lean period of supply and period of maximum demand as well as identification of good market should be followed to earn maximum profit. In the present study, the feed ingredients were

Table 3. Sensitivity analysis of different variables with ±10% variation in cost

Item	Particulars	Economic parameter			
		NPV (at 10% discount rate) (₹)	% Increase or decrease	IRR (%)	% Increase or decrease
	Original value	5612161	-	82.86	-
Soil excavation	+10%	5573554	- 0.69	80.05	- 3.39
	- 10%	5650774	+ 0.69	85.88	+ 3.64
Polythene sheet	+10%	5576804	- 0.63	80.28	- 3.11
	- 10%	5647524	+ 0.63	85.62	+ 3.33
Labour charge	+10%	5608164	- 0.07	82.56	- 0.36
	- 10%	5616164	+ 0.07	83.16	+ 0.36
Aeration facility with accessories	+10%	5602164	- 0.18	82.11	- 0.90
	- 10%	5622164	+ 0.18	83.62	+ 0.92
Capital investment	+10%	5513094	- 1.76	76.04	- 8.23
	- 10%	5711234	+ 1.76	91.13	+ 9.98
Fingerlings	+10%	5566706	- 0.81	82.34	- 0.63
	- 10%	5657622	+ 0.81	83.37	+ 0.61
Feed cost	+10%	5241469	- 6.60	78.65	- 5.36
	- 10%	5982859	+ 6.60	87.04	+ 5.04
Electricity for aeration	+10%	5544341	- 1.21	82.09	- 0.93
	- 10%	5679987	+ 1.21	83.62	+ 0.92
Input cost	+10%	5059428	- 9.85	76.58	- 7.58
	- 10%	6164901	+ 9.85	89.09	+ 7.52
Production	+10%	6825187	+ 21.61	96.51	+ 16.47
	- 10%	4399141	- 21.61	69.03	- 16.69
Sale price	+10%	6825187	+ 21.61	96.51	+ 16.47
	- 10%	4399141	- 21.61	69.03	- 16.69

Table 4. Sensitivity analysis of different variables with ± 20% variation in cost

Item	Particulars	Economic parameter			
		NPV (at 10% discount) rate) (₹)	% Increase or decrease	IRR (%)	% Increase or decrease
	Original value	5612161	-	82.86	-
Soil excavation	+ 20%	5534944	- 1.37	77.44	- 6.54
	- 20%	5689384	+ 1.37	89.15	+ 7.59
Polythene sheet	+ 20%	5541444	- 1.26	77.86	- 6.03
	- 20%	5682884	+ 1.26	88.58	+ 6.90
Labour charge	+ 20%	5604164	- 0.14	82.26	- 0.72
	- 20%	5620164	+ 0.14	83.46	+ 0.72
Aeration facility with accessories	+ 20%	5592164	- 0.36	81.38	- 1.79
	- 20%	5632164	+ 0.36	84.39	+ 1.85
Capital cost	+ 20%	5414024	- 3.53	70.32	- 15.13
	- 20%	5810304	+ 3.53	101.42	+ 22.40
Fingerlings	+ 20%	5521248	- 1.62	81.83	- 1.24
	- 20%	5703080	+ 1.62	83.88	+ 1.23
Feed cost	+ 20%	4870774	- 13.21	74.43	- 10.17
	- 20%	6353553	+ 13.21	91.22	+ 10.09
Electricity for aeration	+ 20%	5476517	- 2.42	81.32	- 1.86
	- 20%	5747811	+ 2.42	84.39	+ 1.85
Input cost	+ 20%	4506691	- 19.70	70.26	- 15.21
	- 20%	6717637	+ 19.70	95.31	+ 15.02
Production	+ 20%	8038210	+ 43.23	110.09	+ 32.86
	- 20%	3186118	- 43.23	54.86	- 33.79
Sale price	+ 20%	8038210	+ 43.23	110.09	+ 32.86
	- 20%	3186118	- 43.23	54.86	- 33.79

Table 5. Sensitivity analysis of different variables with ±30% variation in cost

Item	Particulars	Economic parameter			
		NPV (at 10% discount rate) (₹)	% Increase or decrease	IRR (%)	% Increase or decrease
	Original value	5612161	-	82.86	-
Soil excavation	+ 30%	5496334	- 2.06	75	- 9.48
	- 30%	5727994	+ 2.06	92.71	+ 11.89
Polythene sheet	+ 30%	5506084	- 1.89	75.6	- 8.76
	- 30%	5718244	+ 1.89	91.78	+ 10.76
Labour charge	+ 30%	5600164	- 0.21	81.96	- 1.09
	- 30%	5624164	+ 0.21	83.77	+ 1.10
Aeration facility with accessories	+ 30%	5582164	- 0.53	80.66	- 2.65
	- 30%	5642164	+ 0.53	85.18	+ 2.80
Capital cost	+ 30%	5314954	-5.29	65.44	- 21.02
	- 30%	5909374	+ 5.29	114.59	+ 38.29
Fingerlings	+ 30%	5475790	- 2.43	81.31	- 1.87
	- 30%	5748538	+ 2.43	84.39	+ 1.85
Feed cost	+ 30%	4500080	- 19.81	70.19	- 15.29
	- 30%	6724248	+ 19.81	95.38	+ 15.11
Electricity for aeration	+ 30%	5408694	- 3.62	80.55	- 2.79
	- 30%	5815634	+ 3.62	85.15	+ 2.76
Input cost	+ 30%	3953954	- 29.55	63.88	- 22.91
	- 30%	7270374	+ 29.55	101.5	+ 22.49
Production	+ 30%	9251233	+ 64.84	123.62	+ 49.19
	- 30%	1973095	- 64.84	39.95	- 51.80
Sale price	+ 30%	9251233	+ 64.84	123.62	+ 49.19
	- 30%	1973095	- 64.84	39.94	- 51.80

collected from local market and fish feed (35% crude protein) was prepared. The production cost of feed was ₹12.70 kg^{-1} at the market price of 2008. If the feed containing 35% protein was purchased from the market, the cost would be more than ₹20 kg^{-1}. Therefore, it is advisable that the farmers should prepare the fish feed in their own farm after undergoing some preliminary training on feed preparation. It is not necessary to prepare pelleted diet when moist feed is supplied in gunny bags. It only needs mixing of the ingredients proportionately to get the desired level of protein and the feed is supplied using the gunny bags just after steam boiling for about 10-15 min.

Acknowledgements

Authors are highly obliged to the Indian Council of Agricultural Research (ICAR), SMD Sanction No. 16-9/2004-AFC, dated 28.12.2004 for providing the necessary fund.

References

Alikunhi, K. H., Sukumaranan, K. K. and Parameswaran, S. 1971. Studies on composite fish culture: Production by composite combinations of Indian and Chinese carps. *J. Indian Fish. Ass.*, 1(1): 26-57.

Banas, D., Masson, G., Leglize, L., Usseglio-Polatera, P. and Boyd, C. E. 2007. Assessment of sediment concentration and nutrient loads in effluents drained from extensively managed fishponds in France. *Environ. Pollut.*, 20: 1-7.

Biswas, G., Jena, J. K., Singh, S. K. and Muduli, H. K. 2006. Effect of feeding frequency on growth, survival and feed utilisation in fingerlings of *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) in outdoor rearing systems. *Aquac. Res.,* 37: 510-514.

Boyd, C. E. 2003. Guidelines for aquaculture effluent management at the farm level. *Aquaculture*, 226(1&4): 101-112.

Chakrabarty, R. D., Rao, N. G. S. and Sen, P. R. 1979a. Culture of fish in ponds with fertilisation. In: *Proceedings of the Seminar on Inland Aquaculture.* Central Inland Fisheries Research Institute, Barrackpore, India, p. 5-6.

Chakrabarty, R. D., Sen, P. R., Rao, N. G. S. and Ghosh, S. R. 1979b. Intensive culture of Indian major carps. In: Pillay, T. V. R. and Dill, W, A. (Eds.), *Advances* *in aquaculture*, Fishing News Books Ltd., England, p. 153-156.

Chaudhuri, H., Chakrabarty, R. D., Rao, N. G. S., Janikiram, K., Chatterjee, D. K. and Jena, S. 1974. Record fish production with intensive culture of Indian and exotic carps. *Curr. Sci.*, 43(10): 303-304.

Chaudhuri, H., Chakrabarty, R. D., Sen, P. R., Rao, N. G. S. and Jena, S. 1975. A new high in fish production in India with record yields by composite fish culture in freshwater ponds. *Aquaculture*, 6: 343-355.

Chaudhuri, H., Rao, N. G. S., Rout, M. and Kanaujia, D. R. 1978. Record fish production through intensive fish culture. *J. Inland Fish. Soc. India*, 10: 19-27.

CIFA 1998. Intensive carp culture utilising biotechnological tools for achieving fish production levels of 25 t ha^{-1} $annum^{-1}$. *Project completion report.* Central Institute of Freshwater Aquaculture, Bhubaneswar, India,115 pp.

Das, P., Kumar, D. and Guha Roy, M. K. 1975. National demonstration on composite fish culture in West Bengal. *J. Inland Fish. Soc. India*, 7: 112-115.

Das, P., Kumar, D., Ghosh, A. K., Chakraborty, D. P. and Bhaumik, U. 1980. High yield of Indian major carps against encountered hazards in a demonstration pond. *J. Inland Fish. Soc. India*, 12(1): 70-78.

Das, P., Sinha, M., Kumar, D., Chakraborty, D. P. and Guha Roy, M. K. 1977. Culture of Indian major carps with record yield in a demonstration pond. *J. Inland Fish. Soc. India*, 9: 105-110.

FAO 2003. FAO yearbook of fishery statistics and aquaculture production, vol. 92/2 2001. Food and Agriculture Organisation of the United Nations, Rome, 186 pp.

Ionno, P. N. D., Wines, G. L., Jones, P. L. and Collins, R. O. 2006. A bioeconomic evaluation of a commercial scale recirculating finfish growout system - An Australian perspective. *Aquaculture*, 259: 315-327.

Jena, J. K. and Das, P. C. 2006. Carp culture. In: Verma, S. A., Kumar, A. T. and Pradhan, S. (Eds.), *Handbook of fisheries and aquaculture*. Indian Council of Agricultural Research, New Delhi, India, p. 265-282.

Jena, J. K., Ayyappan, S. and Aravindakshan, P. K. 2002a. Comparative evaluation of production performance in varied cropping patterns of carp polyculture systems. *Aquaculture*, 207: 49-64.

Jena, J. K., Ayyappan, S., Aravindakshan, P. K., Dash, B., Singh, S. K. and Muduli, H. K. 2002b. Evaluation of production performance in carp polyculture with different stocking densities and species combinations. *J. Appl. Ichthyol.,* 18: 165-171.

Jhingran, V. G. 1991. *Fish and fisheries of India.* Hindustan Publ. Corporation, Delhi, India, 727 pp.

Lakshmanan, M. A. V., Sukumaranan, K. K., Murty, D. S., Chakraborty, D. P. and Philipose, M. T. 1971. Preliminary observations on intensive fish farming in freshwater ponds by the composite culture of Indian and exotic species. *J. Inland Fish. Soc. India*, 3: 1-21.

Larson, K. D., Wild, J. J. and Chiappetta, B. 2002. Fundamental accounting principles, 16th edn. McGraw-Hill Irwin Publishing, USA.

Nandeesha, M. C., Gangadhara, B., Manissery, J. K. and Venkataraman, L. V. 2001. Growth performance of two Indian major carps catla (*Catla catla*) and rohu (*Labeo rohita*) fed diets containing different levels of *Spirulina platensis*. *Bioresour. Technol.*, 80: 117-120.

Petty, J. W., Peacock, R., Martin, P., Burrow, M., Keown, A. J., Scott, D. F. and Martin, J. D. 1996. *Basic financial management.* Prentice Hall Publishing, Sydney, Australia.

Reddy, P. V. G. K., Gjerde, B., Tripathi, S. D., Jana, R. K., Mahapatra, K. D., Gupta, S. D., Saha, J. N., Sahoo, M., Lenka, S., Govindassamy, P., Rye, M. and Gjedrem, T. 2002. Growth and survival of six stocks of rohu (*Labeo rohita*, Hamilton) in mono and polyculture production systems. *Aquaculture*, 203: 239-250.

Sugiura, S. H., Marchant, D. D., Kelsey, K., Wiggins, T. and Ferraris, R. 2006. Effluent profile of commercially used low-phosphorus fish feeds. *Environ. Pollut.*, 140: 95-101.

Tripathi, S. D., Aravindakshan, P. K., Ayyappan, S., Jena, J. K., Muduli, H. K., Suresh, C. and Pani, K. C. 2000. New high in carp production in India through intensive polyculture. *J. Aquac. Trop.*, 15: 119-128.

Date of Receipt : 13.07.2013
Date of Acceptance : 24.07.2017