Economic feasibility of organic and conventional fish farming systems of Indian major carps

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Abstract

In the present study, economic feasibility of culturing Indian major carps (IMC) in conventional culture system (CCS) and organic culture system (OCS) was evaluated considering three consecutive years of culture (2010, 2011 and 2012) in experimental ponds with surface area of 0.015 ha, each measuring 0.015 ha. Highest production to the tune of 19 tonnes of Indian major carps per hectare was obtained in OCS. Further, in case of OCS, apart from fish production, vermicompost to the tune of 45,000 kg ha^{-1} in the first year, and 90,000 kg ha^{-1} from second year is achievable considering a vermicompost unit with capacity of 200 tonnes per annum. Economic analysis of the culture systems showed that highest net present value (NPV) of 1.06 million US$, a payback period of one year and nine months and an internal rate of return (IRR) of 51 % are achievable per hectare of fish culture pond for OCS assuming the project period to be 10 years. Sensitivity analysis of various costs performed for OCS revealed that profitability of the organic fish farming investment is most sensitive to the total fish production and sale price of the organic fishes. In terms of production of fish, vermicomposting, water quality dynamics, quality of fish and economics, organic culture system is proved to be the best available technique.

1. Introduction

During the last few years, aquaculture made significant progress in the food sector as there is increased demand and limited supply for aquaculture products (Demirak et al., 2006). To meet the high demands of the food market, conventional aquaculture system has incorporated increased stocking density, usage of antibiotics, antifungal and other pharmaceuticals (mostly inorganic), heavy application of pesticides and disinfectants (Sapkota et al., 2008, Beg et al., 2016) leading to environmental degradation (Holmer et al., 2008, Pelletier et al., 2007), and food scarcity (Tacon and Metian, 2008 and 2008a).These aspects demand for a sustainable program through which our environment may be protected in addition to fulfilling the demands of fish protein. The sustainability of aquaculture activities is possible through organic farming where ecological balances of natural systems are maintained (Mente et al, 2007, 2011).

The demand for the organically produced fish and fishery products is gradually increasing in the world of aquaculture (IFOAM EU Group, 2010). The production rate of organic fisheries in the world is about 25,000 tons and the contribution according to the continents, 14,000 tons is produced by Europe, Asia has contributed 8,000 tons, and lastly America has produced 3,000 tons (Willer et al., 2015). For sustainable aquaculture growth in the country, a holistic approach of using natural and organic based fish feed and pesticides free materials has to be developed. Three Indian major carps viz. Catla (*Catla catla*, Hamilton), Rohu (*Labeo rohita*, Hamilton) and Mrigal (*Cirrhinus mrigala*, Hamilton) lead the freshwater finfish farming in India and their production has already attained commercial culture position in the Indian subcontinent (Nandeesha et al., 2001; Biswas et al., 2006). They contribute more than 70% of the total inland aquaculture production of India (FAO, 2005; Ramakrishna, et al., 2013) and more than 80% of the world production of Indian major carps (Kalla et al., 2004; ICAR, 2013).

The present study was conducted to evaluate the viability of organic fish production in case of Indian major carps. In the study, Indian major carps comprising Catla, Rohu and Mrigal in the ratio of 4:3:3 were cultured in six experimental ponds following Conventional Culture System (CCS) (with commercial fish feed and organic and inorganic fertilizer and without aeration) and Organic Culture System (OCS) (with organic fertilizer and organic fish feed and without aeration). A Vermicompost unit was established and maize and soybean crops were grown on the periphery of the fish ponds. In case of OCS, vermicompost and liquid vermiwash from the vermicompost unit were utilized as organic fertilizer and the matured earthworms and organically grown maize and soybean were used as organic fish feed. Each of the above culture practices was replicated thrice. Six ponds existing on the experimental farm, each measuring 0.015 ha, were used in the study. Finally, economic analysis was performed to evaluate the applicability of OCS in terms of payback period, net present value (NPV) and internal rate of return (IRR). Further, a sensitivity analysis of various costs was performed for OCS in order to determine the sensitive parameters affecting the financial aspects of the farming project.

2. Materials And Methods

2.1 Conventional and Organic Culture System

In the present study, Indian major carps were cultured following two different management practices - (a) Conventional Culture System (CCS) (with commercial fish feed and organic and inorganic fertilizer) and (b) Organic Culture System (OCS) (with organic fertilizer and organic fish feed). Each of the above culture practices was replicated thrice. Six ponds existing on the experimental farm, each measuring 0.015 ha, were used in the study. A schematic diagram showing the layouts of the culture ponds for CCS and OCS, organic crop fields and vermicompost unit are presented in Fig. 1. A schematic diagram showing the various inputs used in OCS and CCS is presented in Fig. 2.

In CCS, ponds were fertilized with cow dung at the rate of 1,250 kg ha^{-1}, 31 kg ha^{-1} of urea and 16 kg ha^{-1} of triple super phosphate (TSP). In case of OCS, ponds were fertilized with organic compost comprising vermicompost and vermibed-wash at the rate of 12,443 kg $ha^{-1}$and 93.33 liters ha^{-1} respectively (Chakraborty et al., 2009). Fertilization was carried one week before stocking, followed by biweekly application for the entire duration of the study period. Vermicompost as well as vermibed-wash were distributed uniformly over the water surface of the ponds. The fingerlings of three Indian major carps, Catla, (*Catla catla*, Hamilton), Rohu (*Labeo rohita*, Hamilton,) and Mrigal (*Cirrhinus mrigala*, Hamilton) were stocked at the rate of 10,000 fingerlings ha^{-1} with combinations of Catla 40%, Rohu 30%, and Mrigal 30%. Seed stocks of equal size were of good quality and disease free with good growth rate (Xie et al., 2011), while, fish fingerlings were genetic modified organism (GMO) free and genetic engineering free. Stocking was done in the early mornings, generally before 9.30 a.m. when the temperature of water was low. Before stocking, the fish seed was kept in a bath in 2% NaCl solution for 1–2 minute and was well acclimatized to pond water. The mean initial weight of species stocked were – Catla: 25.5 ± 1.09 g, Rohu: 22.5 ± 1.08 g and Mrigal: 21.3 ± 1.06 g. In CCS, commercial feed and antibiotics were used. The commercial fish feed was pelleted feed (2–4 mm diameter) produced by a local commercial fish feed company. In OCS, earthworm and organically grown protein and oil rich crops - soybean and maize were used as ingredients of organic pelleted fish feed. The crude protein content of the organic and conventional feed was maintained at iso-nitrogenous (32% crude protein).

The harvesting of fishes was done through the repeated netting and draining of ponds at the end of 9 months of the culture period. Each species was harvested by draining the ponds. The fishes were recorded for calculation of survival rates and various yield parameters. The harvested fishes from conventional and organic ponds were gathered in different tanks. The sale price of fishes was primarily dependent on weight at the time of harvesting and type of culture provided. The organically grown fish fetched approximately 30% higher price than that of conventionally grown fish. Sale price of conventionally grown fish (non-organic) was US$ 2.17 kg^{-1}, the average weight being above 600 g (Catla: 630 ± 5.6 g, Rohu: 670 ± 5.5g and Mrigal: 504 ± 5.3 g) and for the organically grown fishes, the sale price was US$ 2.75 kg^{-1}, where average fish weight was above 700 g (Catla 709.5 ± 4.3g, Rohu 708.4 ± 4.2 g and Mrigal 547.7 ± 4.2g), in local fish market, Kharagpur, West Bengal, India.

2.2 Economic analysis

The economic analysis included (i) determination of expenditure and income; (ii) profit; (iii) payback period; (iv) net present value and (v) internal rate of return. The field trials were carried out on ponds with 0.015 ha area. The returns on such small pond area are very less and at times can be negative also. Therefore, to compare the economics of different alternatives one hectare pond area has been considered. The cost of various items has been suitably scaled up for 1.0 ha area based on the cost involved in 0.015 ha area and making adjustments wherever necessary. In fact, average weight of fish at the same stocking density and under the same management practice is expected to be more in relatively bigger sized ponds with the same depth. In bigger sized ponds, a fish can traverse a greater distance and therefore, exercise more leading to better growth. Therefore, the analysis made based on the yield of smaller ponds is on the safer side. In case of OCS, the area required for vermicomposting unit and organically grown maize and soybean crop are suitably scaled up to meet the demand for one hectare organic fish pond. The costs of various items were suitably scaled up for 1.0 ha area based on the costs involved in a 0.015 ha area. The profit, payback period, net present value (NPV), and internal rate of return (IRR) were calculated for CCS and OCS using the following formulae (Mal, 1995):

Profit = Income - operating cost … (1)

Payback period = Initial outlay (IO)/cash flow … (2)

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t} - IO \quad \dots (3)$$

Internal rate of return (IRR) was calculated by determining the value of the discount rate at which NPV becomes zero.

The cost analysis of CCS and OCS includes two types of costs: (a) Initial Investment cost for creation of facility of culturing fishes and the (b) variable costs involving the maintenance costs of the fishpond, land lease cost, cost of fingerlings, cost of feed, fertilizer and production cost of field crops.

(a) Initial investment

The initial investment includes the cost of (i) pond construction, (ii) water facilities and (iii) vermicomposting unit.

(i) Pond construction

Earthwork for construction of the ponds was carried out by engaging a contractor who executed the work by engaging daily labourers. The work was carried out according to the requirement of the site. As the soil cannot retain water, it was felt necessary to use lining material on the excavated ponds. Therefore, steps were made from ground level to the bottom of the fishpond for better anchoring of the lining material. Prismoidal formula was used to compute the volume of earthwork. The cost of earthwork was paid to the contractor as per the schedule of rates 2010 of the Public Works Department (PWD), Government of West Bengal, India. As per the schedule, the cost of earthwork for first 1.5 m depth (lift) was US$ 0.29 m^{-3} and US$ 0.40 m^{-3} for next 1.5 m depth. The price of lining includes the cost of lining material and labour wage to spread and bury it with soil. Cross laminated polythene sheet of Sylpaulin make (250 µ thick, 150 g m^{-2} weight, UV ray protectable and green in color) was used for lining of the dugout fishpond. The actual price of the Sylpaulin sheet charged by the authorized dealer was considered to compute the cost of lining material. The price was US$ 0.51 m^{-2} in 2010. Labour wage required to spread the polythene sheet on the bottom and sides, including the embankment and to bury the same with a soil layer of 30 cm thickness was paid as per the schedule of rate of Government of West Bengal, India, 2010. Before laying the cross laminated polythene Sylpaulin material on the bed of the fish ponds, a sand cushioning was provided to a depth of 20 cm to avoid any rupture. After laying the Sylpaulin material, a soil cover of 30 cm thickness was also provided on the lining material to provide stability to the material and create a natural pond bottom environment for fish culture. The number of labourers required for the job was 5 man-days for sand filling, earth filling and providing lining material in one pond.

(ii) Water facilities

A mini deep tubewell along with underground pipe lines and accessories was constructed for regular water supply to the fish ponds as and when necessary.

(iii) Vermicompost unit

The cost for vermicompost unit included the maintenance costs of the land and building, civil works for vermicompost shed and vermicompost tanks, implements and machinery and others work.

(b) Variable cost

The variable cost included maintenance costs of the fishpond, land lease cost, cost of fingerlings, cost of feed, fertilizer and production cost of field crops.

(i) Fishpond maintenance cost

The Maintenance cost of the fishpond involves the expenditure incurred for repair and maintenance of the embankment. The cost has been assumed to be 2% of the initial investment (Palmer et al., 1982 and Mishra et al., 1998).

(ii) Land lease cost

It was thought appropriate to add the annual land lease cost for the area diverted for the construction of fishpond. The cost was decided based on prevailing lease rate under the revenue district of West Medinipore, West Bengal. The cost was found to be US$ 60.71 ha^{-1} $year^{-1}$ as per the rate of 2010.

(iii) Fingerling Cost

Fingerlings were purchased from a nearby farm for stocking in the fishponds. The cost of fingerlings varies depending on the size, weight etc. Fingerlings were purchased at 2.17 US$ $kg^{-1}$and later released to the fishponds after acclimatizing them in an earthen tank for 40 hours.

(iv) Feed and fertilizer cost

The organic fish feed was prepared in the laboratory with due proximate composition of suitable protein, carbohydrate, fat, ash, etc. Conventional feed were bought from the local feed company and the formulated fish feed cost was only US$ 0.51 kg^{-1} at the prevailing cost of inputs in 2010. The chemical fertilizer cost was calculated as per the local market price.

3. Results And Discussion

3.1 Expenditure and income

The common items required in two management systems, i.e., CCS and OCS are soil excavation, polythene sheet, sand and bricks and labour charges for miscellaneous works. Item wise breakup of expenditure is summarized below. For excavation of one hectare pond with a step close to the middle of the slope of the embankment, around 14,300 m^3 soil needs to be excavated for a depth of 1.5 m. At the rate of US$ 0.25 per m^3 of soil excavation, a sum of US$ 3613.88 is required for excavation of the pond. A schematic diagram showing the sectional view of one hectare pond is presented in Fig. 1. The rate of the polythene sheet is US$ 0.49 per m^2. For, 1 ha pond lining the requirement of sheet is about 10,400 m^2. So, the total cost of polythene sheet for pond lining is around US $ 5111.46. Before polythene lining, a 20 cm layer of sand is needed to be spread on the pond bottom to provide cushioning effect to the sheet. For this 2,000 m^3 of sand costing US $ 2023.77 is needed. To prevent sliding of the polythene sheet from the embankment, bricks are to be placed at regular intervals on the steps over the sheet. If the bricks are placed on two steps continuously lengthwise on a 100 m × 100 m pond, about 3,200 bricks costing US $ 231.29 are needed. Construction of polythene lined pond is more labour intensive compared to that of a natural pond. Labour is required for preparation of sand bed, softening of the slope of the embankment with water and sand, sieving of sand and spreading on the pond bottom, laying of the polythene sheet on the pond bottom by joining it as per required length, powdering, cleaning and putting the soil on the bottom, putting the bricks and soil on the step of the embankment etc. For all these purposes, an estimated 500 man days with a total expenditure of US $ 578.22 are needed. A sum of US$ 289.11 is allotted for miscellaneous expenditure for different purposes.

The total capital expenditure on different heads is presented in Table 1. The details of input costs in terms of seed, feed, lime, fertilizers, netting, electricity or fuel for water exchange, labour and prophylactics during culture period and the income generated by selling the fishes are presented in Table 7. In general, the recurring expenditure is found to be more in organic culture system compared to conventional culture systems as shown in Table 2.

Table 1
Initial investment (US$) for construction of one hectare farm for CCS and OCS

Sl. No.	**Particulars**	**CCS**	**OCS**
1.	**Cost of Pond Construction**		
i.	Soil excavation	3613.88	3613.88
ii.	Polythene sheet	5111.46	5111.46
iii.	Brick & Sand	578.22	578.22
iv.	Labour for different works	578.22	578.22
v.	Miscellaneous expenditure	2911.34	289.11
2.	Water facilities (Tube well with water supply facilities, pumps etc)	1373.27	1373.27
3.	Vermicomposting unit	-	17105.19
Total		**14166.39**	**28649.35**

Table 2
Capital cost of vermicomposting unit

Sl. No.	Particulars of item	Amount (US$)
A.	**Land and Building**	
1.	Land (on rent/lease)	-
2.	Levelling and soil filling for vermicompost sheds	343.32
3.	Fencing and gate	596.29
4.	Open shed with brick lined bed bottom & platform with RCC / MS pipe post & truss and thatched /HDPE locally available roof (@US$ 14.46/m^2) for :	
(a)	Vermicompost beds (15 m × 1.5 m × 24 nos = 540 m^2 + 20 m^2 pathways/utility = 560 m^2)	8095.08
(b)	For finished products 30 m^2	433.66
5.	Godown / Store cum office 50 m^2 @ US$ 72.28/-per m^2	3613.88
Sub total		**12612.42**
B.	**Implements and machinery**	
1	Shovels, spades, crowbars, iron baskets, dung fork, buckets, bamboo baskets, trowel	72.28
2	Plumbing and fitting tools	21.68
3	Power operated shredder	361.39
4	Sieving apparatus with 3 wire mesh sieves – 0.6 m × 0.9 m size - power operated with motor	650.50
5	Weighing scale (100 kg capacity)	36.14
6	Weighing machine (platform type)	86.73
7	Bag sealing machine	72.28
8	Culture trays (35 cm × 45 cm) – 4 Nos	23.13
9	Wheel barrows – 2 Nos.	173.47
Sub total		**1497.59**
C.	**Water provision – Borewell with hand pump, pipe, dripper**	1084.16
D.	**Electrical installation**	144.56
E.	**Furniture & fixtures**	361.39
F.	**Earthworms (@1 kg per m^3 and @ 300/kg, total utilized bed volume = 324 m^3)**	1405.07
TOTAL CAPITAL COST		**17105.19**

3.2 Expenditure of vermicompost unit

In case of organic culture system, vermicomposting unit 200 tonnes per annum (TPA) was developed as shown in Fig. 3. The capital cost of vermicomposting unit (200 TPA) is presented in Table 2 (NABARD, 2014). The operational cost and the cost and benefits are shown in Tables 3 and 4 respectively.

Table 3
Operational cost of vermicomposting unit of 200 TPA

Sl. No	Particulars of item	Year 1 Amount(US$)	Year 2 Amount(US$)
1	Agricultural wastes (cost, collection and transportation) @ 320 kg per m^3 and US$ 2.90 / MT (15×1.5×0.6×24×5×320×200/1000) [at 50% in 1st year]	374.70	749.3
2	Cow dung (cost, collection and transportation) @80 kg/$m^3$and US$ 3.61/MT(15×1.5×0.6×24×5×80×250/1000) [at 50% in 1st year]	234.18	468.36
3	Salary pay for 2 stable skilled labourers @ US$ 86.73/month	173.47	173.47
4	Labour pay on day to day basis in development of vermibed with agro-waste, cow dung and worms, watering, stirring, harvesting, sieving, packing, etc., including cost of bags. [at 50% in 1st year]	361.39	722.77
5	Electrical charges for pump, machinery, lighting etc. [at 50% in 1st year]	173.47	346.93
6	Repair and maintenance[at 50% in 1st year]	433.66	867.33
7	Cost of bags and marketing cost[at 50% in 1st year]	216.83	433.66
Sub total		**1967.69**	**3414.96**
8	Lease rent, Miscellaneous etc.	346.92	780.48
Total operational cost		**2314.61**	**4195.56**

Table 4
Cost and benefits of vermicomposting units (200 TPA)

Sl. No.	Cost and benefit	Amount (US$)	
		Year 1	Year 2 onwards
1.	Total Capital cost	17105.19	-
2.	Total Operational cost	2314.61	4195.56
3.	Total cost	19419.81	4195.56
4.	Benefit		
4a.	Sale of vermicompost (200 MT @ 30% conversion) [@US$ 65.05/MT at 60% in 1st year and 90% in 2nd year onwards]	2927.24	5854.48
4b.	Total benefit	2927.24	5854.48

3.3 Economics of soybean

The cost of cultivation and return from soybean were evaluated for all the three experimental seasons. The investment cost incurred for the cultivation of soybean crop is listed in Table 5. The average cost for soybean cultivation was US$ 350.18 ha^{-1}. The farm produced 1 ton yield and selling price of soybean was US$ 578.22 per ton during the experimental season, 5% of the yield is assumed to be spoiled and a net return of 95% of soybean yield was taken as the net income. The net return from the soybean cultivation is presented in Table 6.

Table 5
Average cost of cultivation for soybean and maize

Sl. No.	Input parameters	Soybean cultivation cost per hectare (US$ ha^{-1})	Maize cultivation cost per hectare (US$ ha^{-1})
1.	Land lease cost	60.71	60.7
2.	Land preparation (LS*)	72.28	57.2
3.	Fertilizer	-	-
4.	Seed	43.73	2.0
5.	Plant protection (LS)	28.91	14.5
6.	Labour (man-days)	144.56	144.6
7.	Total cost of cultivation	**350.18**	279
*LS = Lump sum			

Table 6
Net return (US$ ha^{-1}) from soybean and maize cultivation

Treatment	Year	Net yield (t)	Average cost (US$ ha^{-1})	Net return (US$ ha^{-1})	Average net return (US$ ha^{-1})
Organically grown **soybean**	2010	1.02	350.18	210.11	-
	2011	1.48	-do-	462.79	323.63
	2012	1.18	-do-	298.00	-
Organically grown maize	2010	3.705	278.99	150.77	-
	2011	3.90	-do-	172.02	151.20
	2012	3.63	-do-	140.80	-

3.4 Economics of maize cultivation

The average cost for maize cultivation is US$ 279 ha^{-1}. The farm produced 3 ton yield and selling price of maize was US$ 151.20 per ton during the experimental season. The investment cost and the net return incurred in the cultivation of maize is listed in Table 5 and Table 6 respectively.

3.5 Economic Indicators

(a) Profit

The input cost and the income for different culture systems are presented in Table 7. The income from selling of fish for conventional culture system is US$ 13094.63. However in organic culture system, an income of US$ 19770.10 in first year and US$ 22046.86 from second year onwards can be generated from selling of fish. The maximum selling price of fish is received in the organic culture system (US$ 2.75 kg^{-1}) due to their better size and consumer acceptability; whereas the selling price of fish is US$ 2.17 kg^{-1} for CCS. It is seen from Table 8 that in OCS the culture system, a profit of more than US$ 15000.00 per annum and per ha can be obtained. However, the most profitable proposition should be chosen. The maximum profit is obtained in OCS followed by CCS. The % increase in income in CCS and OCS are 181.5% and 337.7% respectively. The profit for different culture systems are presented in Table 8.

Table 7
Input costs (US$) and income for conventional and organic culture system

Items	CCS (US$)	OCS (US$)	
		1st year	2nd year onwards
Input Costs			
Lime	32.50	35.78	2475
Cow dung	21.70	-	-
Urea	2.60	-	-
SSP	2.31	-	-
Fish seed	289	289	289
Feed	4337	-	-
Water filling	43.4	43.4	43.4
Netting	87	87	87
Prophylactics	43	-	-
Labour	289	361	361
Soybean crop	-	350	350
Maize crop	-	279	279
Vermicomposting unit	-	2400	4196
Total Input Cost (US$)	5148	3847	5641
a. Catla	2519 kg/ha/yr @ US$ 2.17 per kg = US$ 5462	2838 kg/ha/yr @ US$ 2.75 per kg = US$ 7795	2838 kg/ha/yr @ US$ 2.75 per kg = US$ 7795
b. Rohu	2009 kg/ha/yr @ US$ 2.17 per kg = US$ 4356.20	2125 kg/ha/yr @ US$ 2.75 per kg = US$ 5835.46	2125 kg/ha/yr @ US$ 2.75 per kg = US$ 5835.46
c. Mrigal	1511 kg/ha/yr @ US$ 2.17 per kg = US$ 3276	1643 kg/ha/yr @ US$ 2.75 per kg = US$ 4512.6	1643 kg/ha/yr @ US$ 2.75 per kg = US$ 4512.6
d. Vermicompost	-	25000 kg @ US$ 0.065 per kg = US$ 1626	60000 kg @ US$ 0.065 per kg = US$ 3903
Total income (US$)	13095	19770	22047

Table 8
Payback period, net present value and internal rate of return in OCS and CCS

Culture systems	Profit (US$)	Payback period (years)	Net Present Value (US$)	Internal Rate of Return (%)
Organic culture system(OCS)	32328	1.75	106219	51.3
Conventional culture System(CCS)	7947	1.82	51117	50.7

(b) Payback period

The payback periods in OCS and CCS culture systems are presented in Table 8.The values of payback period in the CCS culture systems are 1.82 year and OCS culture systems are 1.75 year. The differences in payback period in two culture systems, i.e., CCS and OCS are insignificant ($p > 0.05$). It is the period to get back only the initial outlay. It means that the project gives an actual return to the fisher within 2 year from CCS and OCS out of the expected 10 years of the project life time.

(c) Net present value (NPV)

The NPV estimated in the study are presented in Table 8. As the NPV is greater than zero in all the treatments, all of them may be accepted. However, in the financial theory, if there is a choice between two mutually exclusive alternatives, the one yielding the higher NPV should be selected. NPV were high as US$ 106218.75 for OCS and as low as US$ 51117.03 in CCS obtained.

(d) Internal rate of return

The investment with a higher IRR is usually the better investment. The IRR values calculated in different treatments of the study are presented in Table 8. The IRR values are found to be more than 50% in all the treatments. The highest value of IRR is achieved in OCS (51.3%) followed by CCS (50.7%). The values of IRR in both are quite high and all of these projects are acceptable.

3.6 Sensitivity analysis of various inputs

Among the different items in terms of capital as well as recurring inputs, it is important to identify the items affecting the economy of the project significantly. Special attention needs to be paid for economic utilization of those items during the culture operation. As OCS has been identified as the most suitable for a small or medium fish culturist, the sensitivity analysis was carried out for the said project. The sensitive parameters affecting the economics of the project were identified as cost of soil excavation, input cost, cost of fingerlings, construction cost of vermicompost unit, cost of vermicomposting, cost of cultivation of maize and soybean, sale price of organic fishes and sale price of vermicompost. The variation in the values of NPV and IRR with 20% increase or decrease in the cost of the sensitive parameters is presented in Table 9. The percentage deviation in the values from its original is also estimated for comparison. It can be observed from the above table that except total fish production and sale price of the organic fishes, all other parameters are less sensitive as their variation from their original values are estimated to be less than 5% in terms of NPV and IRR. The sale price of organic fishes are found to be the most sensitive parameters as they increase or decrease the NPV and IRR significantly with 20% increase or decrease of the sale price. With 20% increase in the sale price of organic fishes, the NPV and IRR increase by 28.2% and 7.31% respectively, whereas decreasing those quantities by 20%, the NPV and IRR decrease by 28.2% and 9.5% respectively.

Table 9
Sensitivity analysis of different items for OCS

Item	Particulars	Economic parameter			
		NPV (US$)	% Increase or decrease	IRR (%)	% Increase or decrease
	Actual value	106219	-	51.28	-
Cost of soil excavation	20% (+)	105496	0.70% (-)	50.81	0.92% (-)
	20% (-)	106942	0.70% (+)	51.76	0.94% (+)
Input cost	20% (+)	97225	8.50% (-)	50.03	2.44% (-)
	20% (-)	115212	8.50% (+)	52.43	2.24% (+)
Construction cost of vermicompost unit	20% (+)	102798	3.20% (-)	49.13	4.20% (-)
	20% (-)	109640	3.20% (+)	53.65	4.62% (+)
Cost of vermicomposting	20% (+)	99611	6.20% (-)	50.39	1.74% (-)
	20% (-)	112827	6.20% (+)	52.11	1.60% (+)
Cost of fingerlings	20% (+)	105742	0.45% (-)	51.21	0.136% (-)
	20% (-)	106696	0.45% (+)	51.35	0.136% (+)
Cost of cultivation of maize and soybean	20% (+)	105180	0.98% (-)	51.13	0.29% (-)
	20% (-)	107257	0.98% (+)	51.43	0.29% (+)
Sale price of organic fishes	20% (+)	136160	28.20%(+)	55.03	7.31% (+)
	20% (-)	76277	28.20% (-)	46.41	9.50% (-)
Sale price of vermicompost	20% (+)	112259	5.70% (+)	52.02	1.44% (+)
	20% (-)	100179	5.70% (-)	50.50	1.52% (-)

The sensitivity analysis of the various parameters has clearly shown that profitability of the fish farming investment is most sensitive to the sale price of organic fishes. However, in case of inorganic aquaculture systems, apart from sale price of fishes, feed cost also significantly affects the financial status of the farming project as demonstrated by Okechi and Pall (2004) for African catfish (*Clarias gariepinus*), Bag et al, (2014) for Indian major carps, Mahanand (2014) for Rohu utilizing biofloc technology, and Tanveer et al, (2018) in a recirculating aquaculture system (RAS). Economic analyzed of tiger grouper and humpback grouper for commercial cage culture (Afero et al, .2010). In organic fish culture system, the main advantage is that a part of the vermicomposting is directly used as fertilizer and feed in the culture of fishes and the remaining part can be sold in the market for further income generation.

4. Conclusions

The efficacy of organic aquaculture on Indian major carp culture was established through the study. Based on the results of the present study, the following conclusions are drawn:

I. The fish produced using organic earth worm meal, organic soybean meal and other ingredients following organic guidelines provides a balanced nutritional value and there is no detrimental effect on fish health and aquatic environment.
II. Highest production to the tune of 19 tonnes of Indian major carps per hectare was obtained in organic culture system.
III. In addition to fish yield, production of vermicompost is an additional benefit for organic culture system.
IV. Highest net present value of US$ 1,06,103.37, a payback period of near about two years and an IRR of 51% are achievable for organic culture system assuming the project period to be 10 years.
V. In terms of production of fish, vermicomposting, quality of fish and economics, organic culture system is proved to be the best available technique.
VI. Profitability of the organic fish farming investment is most sensitive to the sale price of the organic fishes.
VII. On the basis of the study, organic culture practice for Indian major carp is strongly recommended for long term benefit in terms of quality product, human health and protection of environment.

Declarations

*Funding: No funding was received for conducting this study.

*Conflicts of interest/Competing interests: The authors have no conflicts of interest to declare that are relevant to the content of this article.

*Ethics approval: N/A.

*Availability of data and material: All data included in the manuscript.

*Code availability: N/A.

*Authors' contributions: Conceptualization: [Mirza Masum Beg, Sanjib Moulick and Subha M Roy], Methodology: [Mirza Masum Beg and Basudev Mandal], Formal analysis and investigation: [Mirza Masum Beg, Sanjib Moulick and Subha M Roy], Writing - original draft preparation: [Mirza Masum Beg], Writing - review and editing: [Sanjib Moulick, Basudev Mandal and Subha M Roy]

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Figures

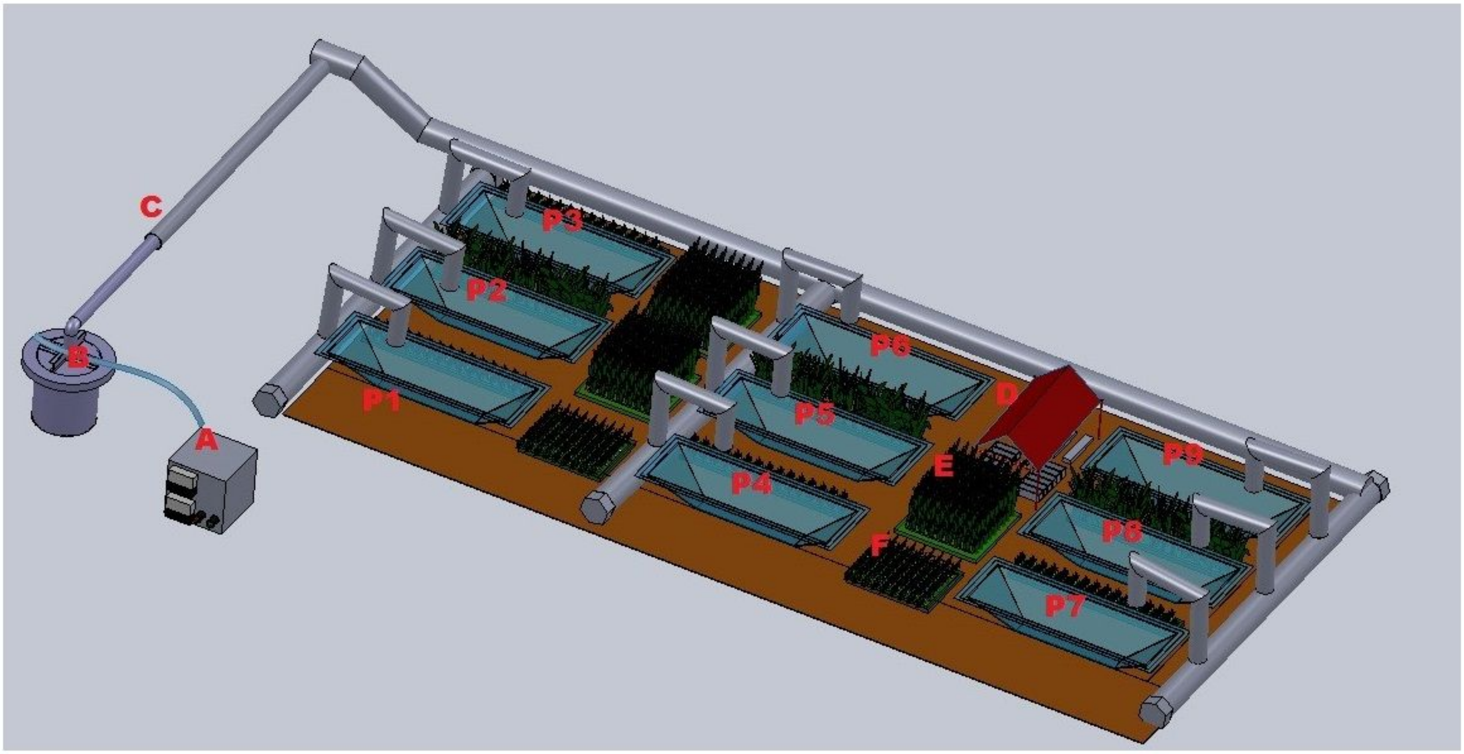

Figure 1

Layout of culture ponds, organic crops fields and vermicompost unit

A - Electric facility, B - Mini deep tube well, C - Water supply pipeline, D - Vermicompost unit, E - Maize crop field, F- Soyabean crop field, Pond-P1, P2, P3, P4, P5, P6, P7, P8 & P9

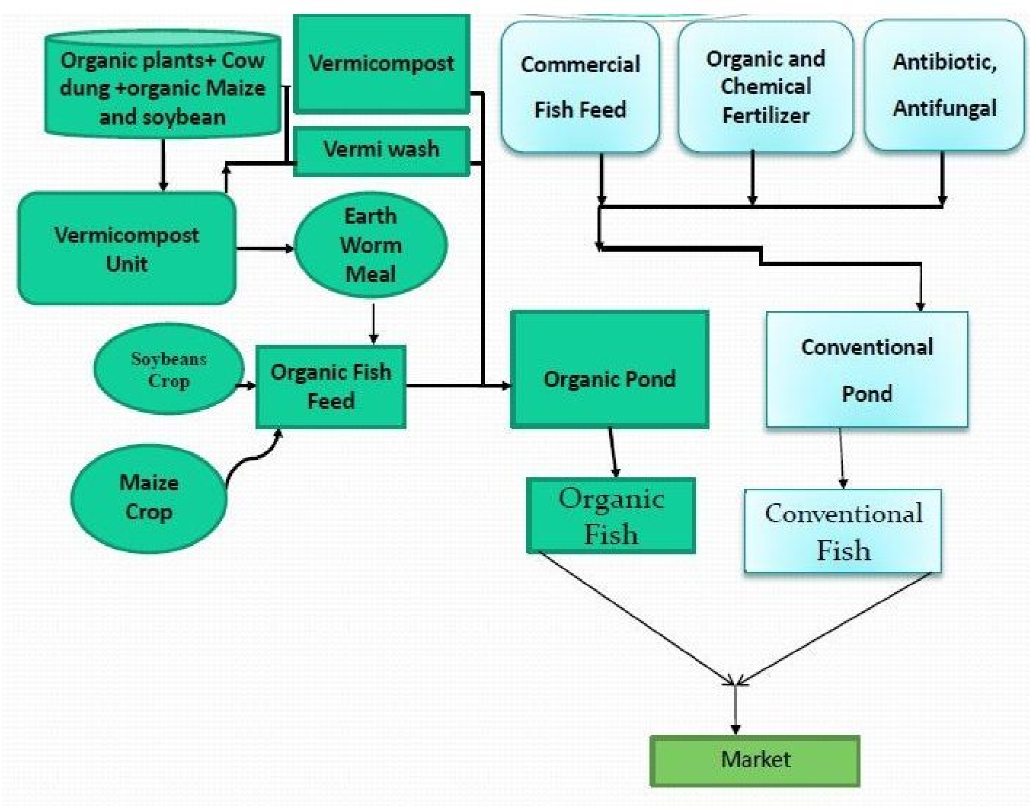

Figure 2

Schematic diagram showing the inputs in OCS and CCS

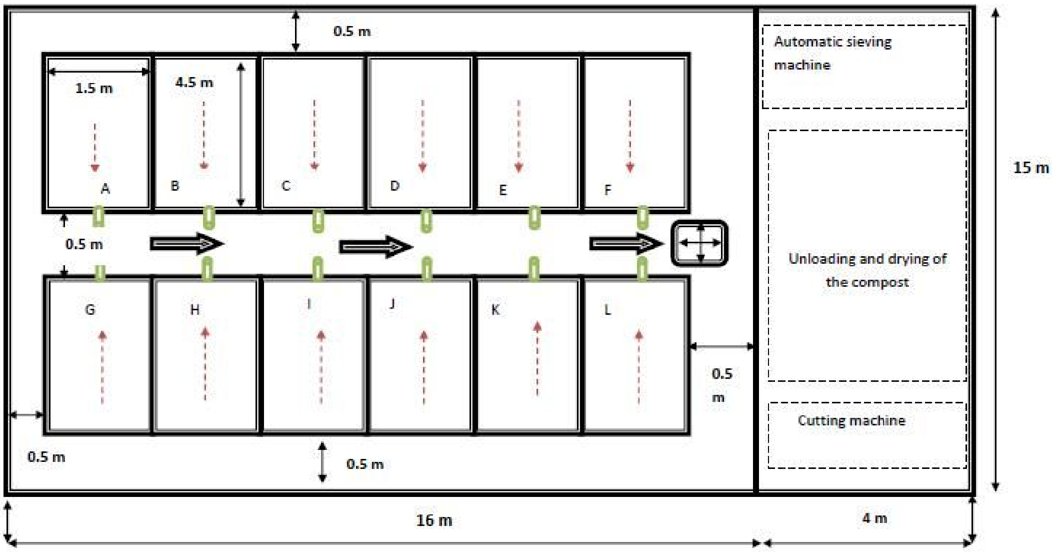

Figure 3

Plan of vermicompost unit comprising 12 nos. of Vermicompost beds (4.5 m × 1.5 m × 0.5 m); and arrangements for automatic sieving, unloading and drying of compost and chopping machine