COMPARATIVE ECONOMICS OF TRADITIONAL vs. SCIENTIFIC SHRIMP FARMING SYSTEMS: A STUDY OF SMALLHOLDERS SHRIMP CULTURE IN WEST BENGAL

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Abstract

The advent of scientific shrimp farming in India during 1990-91 was a turning point of shrimp production in the country. Though scientific shrimp farming system renders higher level of production than the existing traditional farming system, it is subject to certain criticisms especially for generating negative environmental externalities. The conversion of agricultural lands into shrimp ponds is a widely debated issue in the literature. In this light the present paper aims at a comparative economic analysis of these two farming systems in the context of smallholders shrimp culture in West Bengal. The analysis is based on a survey of 110 traditional and 101 scientific farmers during 2004-2005 who have started household level shrimp farming by converting their agricultural land as well as existing ponds. This paper tries to integrate the sustainability issues related to shrimp culture by incorporating social costs borne by the paddy farmers who are affected by the shrimp culture due to seepage of saline water into their land. Net present value (NPV) has been calculated considering the opportunity cost of converting agricultural lands into shrimp ponds as well as the social costs over a fifteen years time frame under two alternative scenarios - 1) reusing the land for agriculture and 2) using the land for aquaculture with necessary crop holidays and crop rotations by culturing lower value fishes. Results of the study indicate that in the long run net benefit of traditional farming system overrides the net benefit from scientific farming when we take into account the opportunity costs and the social costs. The analysis suggests that enough attention and facilities should be provided to the low yielding small scale traditional shrimp farmers keeping in mind the long term economic viability and environmental sustainability of this system.

KEY WORDS: Shrimp culture, Smallholders, Profitability, Social costs, Conversion, Agricultural land, Opportunity cost, Net present Value

INTRODUCTION

India has a long 811800 sq. Km. of coastline having considerable potential for fisheries development. Fisheries in the East coast of India comprising of the coastal areas of Tamil Nadu, Andhra Pradesh, Orissa and West Bengal are dominated by shrimp culture. Shrimp has become a major export item for India since the last decade, occupying a large share in the total marine product exports. Total shrimp export in India has gradually increased from a growth rate of 0.18% in 1978-79 to 17% in 1990-91.During this period the share of cultured shrimp has become almost double both in quantity and value terms. The farming systems of this important exportable commodity for India as well as other Asian countries can be conventionally classified into four categories. They are- traditional, extensive, semi-intensive and intensive, based on the increasing inputs of feeding and water management as well as stocking density. But there can be country specific deviations from these conventionally defined practices. In India there are five kinds of shrimp culture systems, namely traditional, improved traditional, extensive, semi-intensive[a] and intensive system. In the recent years global demand for environment friendly shrimp and eco-labeling of shrimp products has provided special importance to the low productive traditional, improved traditional and extensive system vis-à-vis the more intensive culture systems. The higher productivity of the intensive systems has a trade off with the negative externality they generate. So, the comparative performance of various culture systems should not only be judged in terms of the profitability of these systems considering the direct costs, but also the social costs they impose on the other section of the society. This paper attempts to provide a comparative economic analysis of traditional shrimp farming system with the scientific shrimp farming[b] not only in terms of its long term profitability accounting for the direct costs, but also the *social costs* in the context of household level small scale shrimp farming in West Bengal , India. This paper addresses the issues in two phases. In the first phase a brief discussion on the profitability of these two systems is furnished. The provides the basis for the second section where the traditional and scientific systems are judged from a long tem perspective considering the externality generated in terms of conversion of agricultural lands into shrimp ponds. The economic viability of the scientific system has been examined under two alternative scenarios-1)The shrimp farmers revert back to agriculture after a continuous culture of shrimp for five years and 2)The farmers follow a sustainable practice of alternative crop rotations. Traditional system gives sustained yield during the time frame under consideration. This analysis helps to identify which of these farming systems is the better option when shrimp culture is promoted at a small scale household level from a long term perspective.

SETTING OF THE STUDY AND DATA SOURCE

West Bengal ranks second in terms of area under shrimp culture and third in terms of production with respect to all India total. The state has a coastline of 158 Km. with rich fisheries activities. The production of shrimp in West Bengal has increased from 6200 metric tones in 1990-91 to as high as 8958 metric tones in 1996-97. But after that, due to frequent disease outbreaks the production started declining and has gone down to 6510 metric tones in 2002-03. Due to large existence of traditional farming, the productivity of shrimp culture is quite low in West Bengal figured as 0.57metric ton per hectare per year. Still West Bengal has the highest potential area for shrimp farming among the states practicing shrimp culture and there are lots of scopes to expand the shrimp culture in the state and to enhance export earnings.

Data have been collected from two shrimp farming districts of West Bengal. Traditional culture system is prevalent in the North 24 Parganas and South 24 Parganas district. The semi-intensive scientific farming is been practiced in Purba Midnapur District. North 24 Pargana district has been selected for the traditional farming system purposively. Sandeshkahli –II and Khejuri –I block has been selected from each of the districts purposively for the survey, keeping in mind the predominance of household level small holders shrimp culture, average soil salinity, low lying lands, similar cropping patterns, and recent change of household occupation from agriculture to aquaculture. From each block two Gram Panchayats have been selected. Stratified Random sampling method has been used to select the farmers, strata being the size holdings of the farmers[c]. Finally data on 100 scientific farmers and 108 traditional farmers have been collected by personal interviews using structured questionnaires, for the culture year 2004-2005.

Before getting into the analysis it is important to have a brief idea about the history of shrimp culture in the study area which gives us lot of insights. In Sandeshkhali-II block there was no brackish water shrimp culture before 1975. Only tank fisheries were there in this area. The local people used to lead a life of immense hardship depending on cultivation of paddy and out-migrating as casual labourers for their livelihood. Before 1990s Bermajur-I Gram Panchayat was fully dominated by agriculture. One-crop paddy cultivation was the major means of land use in this area. In 1992-93 *boro* paddy cultivation started with the help of additional irrigation facilities. But in early 1997 because of low water level, irrigation became a major problem for the paddy cultivators and they reported low returns. The farmers faced a grave situation and as an alternative shrimp culture in owned land started sprouting. On the other hand, farmers who had leased out their land to big fisheries started facing problem of repayment of the lease money or in some cases profit shares. The landholders who could not use their land in other ways, decided to culture shrimp on their own, so that in the years of good production good returns will be ensured. Similar was the case with Darirjangal Gram Panchayat where the large shrimp farms started coming in 1985 and many small farmers had leased-out their river side lands to big fisheries. Recently, after 1996 farmers have started culturing shrimp in their own land.

Scientific farming was first initiated in Digha and Contai region of East Midnapur district in West Bengal. The big corporate houses like Jains, Hindustan Liver etc. ventured into this business in 1990-91. But during 1994-95 due to massive disease outbreaks these companies started incurring huge losses. Seed prices were also hiked during this time. Coupled with these problems, pollution control regulations imposed by Aquaculture Authority of India in 1996 compelled the large corporate bodies to leave the business. Small household level shrimp farming using scientific technique started in this area in 1996-97. The World Bank project also facilitated the development of small scale shrimp culture by either converting agricultural land or existing ponds.

Given this backdrop it is important to know the performance of the farmers who have taken up the risky shrimp farming giving up the agricultural production. Next section makes an attempt compare the returns and profitability of traditional and scientific farming systems in the study area.

PROFITABILITY OF TRADITIONAL AND SCIENTIFIC SHRIMP CULTURE: A COMPARATIVE ANALYSIS

There is quite a lot of literature on the comparative analysis of shrimp culture systems based on the profitability of shrimp culture in Indian context. The profitability of different culture systems were examined under the boom period of shrimp farming in Andhra Pradesh by Shang et al.(1998)[1] which finds that , though cost of production per kg was highest for semi intensive system ($ 5.96) followed by intensive ($5.01) and extensive systems ($4.42), extensive system ranks first in terms of profit per Kg of shrimp, followed by intensive and semi-intensive system. A different result was obtained from the studies by Usharani(1993), Viswavak(1992), Jayaraman(1991)[2,3,4] which reveal that semi-intensive system is much profitable than the other two systems. The extensive and semi-intensive farming also scores better in terms of the labour employment per unit of the area cultured [2]. But none of the studies have incorporated the social and environmental costs associated with these culture practices. Before getting into these issues, the present section gives us a brief idea about the returns and direct costs for both traditional and scientific shrimp farming in the study area which is a prelude to extend our analysis further.

Table I furnishes the returns from traditional and scientific shrimp culture calculated under the Framework of farm management studies[d].

Table I: Returns from Traditional and Scientific Shrimp Farming Systems

	FBI (INR/Acre)		**FLI (INR/Acre)**		**NI (INR/Acre)**	
	T	S	T	S	T	S
Marginal	9627	32069	5101	18158	-514	-2598
Small	14628	88106	9916	73103	7376	69969
Medium	20033	257611	14445	241934	12998	240312
Large	22965	-	15933	-	15509	-
All	15639	70888	10411	56510	7532	42264

Note: FBI: Farm business Income; FLI: Family Labour income; NFI: Net Income[e]. T: Traditional farmers ,S: Scientific farmers; *Source:* Primary survey

It can be observed from table I that the scientific farmers obtain almost 5 times greater value than traditional farmers in terms of farm business income, family labour income and net income which accounts for the imputed value of family labour. The comparison of these incomes across the farmer category reveals that in traditional farming average FBI is lowest for marginal farmers (INR 9627)[f] in contrast to INR14628 for medium farmers, INR 22965 for large farmers. The family labour income is also high for the large and medium farmers and less in case of the small farmers. The relative position of the marginal, small, medium and large farmers do not change in terms of net farm income. As the marginal farmers depend more on family labour, the net income is negative for them. The differences between the returns accrued to different categories do not differ much in case of traditional farming. The table also reveals that medium farmers in scientific system have appropriated highest returns in terms of FBI, FLI and NI and marginal farmers have appropriated the lowest returns. Net farm income is INR -2598 for marginal farmers, INR 66969 for small farmers and as high as INR 240312 for medium farmers. The medium farmers are clearly in the most advantageous position in scientific farming. It is found that the differences in FBI, FLI and NI per acre for marginal and small scientific farmers are not statistically significant. But in case of the small and medium farmers the differences are statistically significant at 1% level.

Table II is much more revealing which provides the returns per unit of cost incurred by the traditional and scientific shrimp farmers. It is interesting to note that , returns per unit of cost is higher in case of traditional farmers who in absolute terms obtain a lower net income than the scientific farmers . The higher costs of scientific farmers especially in feed, fertilizers in order to achieve quick gains can be attributed to their relatively low return-cost ratio. Thus the highly productive scientific farming scores less in terms of returns per unit of cost.

Table II: Return-Cost Ratio for Traditional and Scientific Shrimp Farming Systems

	Return–cost ratio (considering paid out cost)		**Return – cost ratio (considering total cost)**	
Category	Traditional	Scientific	Traditional	Scientific
Marginal	1.73	1.19	1.05	1.07
Small	1.91	1.43	1.39	1.34
Medium	2.17	1.72	1.79	1.20
Large	2.30	-	2.11	-
All	1.98	1.31	1.5	1.20

Source: Primary survey

But analysis of short term net economic returns can not capture the sustainability issues related to these farming systems. As evident from the literature shrimp farming creates several negative externalities in terms of mangrove area destruction, conversion of agricultural land to shrimp culture, the salinization of ground water and nearby water bodies etc. [5, 6,7]. The externality generation, depends on the nature and intensity of shrimp culture and is site specific. As described earlier, shrimp culture has been introduced in both the study areas by converting agricultural land to shrimp ponds. In this context the next section attempts to integrate the opportunity costs of converting agricultural land to shrimp ponds and social costs related to the conversion of agricultural lands with the conventional economic analysis.

PADDY FIELDS TO SHRIMP PONDS: ECONOMIC VIABILITY ANALYSIS OF TRADITIONAL AND SCIENTIFIC SHRIMP FARMING SYSTEMS

Agriculture vs. Shrimp Culture

The debate on conversion of agricultural land to shrimp ponds in India and other Asian countries is well discussed in the literature. Theoretically the debate arises because of the non fulfillment of weak sustainability criteria[g] of an agricultural system, which indicates towards the need for preservation of productive capacity of the resource base for indefinite future. Among many criticisms against shrimp culture[h] a prominent one in the context of developing countries is the conversion of agricultural land into shrimp ponds. But some studies tried to counter this by stating the fact that shrimp farming is generally being developed in the low lying saline lands or waste land. The document on changes in land use pattern by Algarswami [2] about this conversion in India is one of them. There are a few studies which try to reinforce the economic rationale for converting the agricultural land into shrimp ponds both in a descriptive manner and with the help of economic analysis. For example, a recent study by Reddy R. [8] reports that tiger shrimp fetches 10 times of the net income and from groundnut and 13 times that of paddy. Variety scampi fetches 6 times more net income than ground nut and 10 times that of paddy. Selvam and [9] estimated per hectare gross returns of paddy cultivation and brackish water –fed shrimp culture as Rs.15926 per hectare and Rs.5.3 lakhs respectively in Pondichery region of Tamil Nadu. The crisis in the rice market A study by Flaherty and Vandergeest [10] in Thailand states that the growing competition from the rice exporting countries and the stagnant production of rice has increased the pressure on Thai rice farmers to become shrimp farmers. In most parts of Thailand smallholder irrigated paddy could no longer provide a growing or even stable household economy. Even if it is a small size shrimp the average of shrimp farming to rice farming was tempting and high. Gross farm income of rice has been recorded as US$ 4,000 for rice and US$ 60,000 from shrimp. That means the gross farm income from shrimp is almost 15 times greater than that of rice farming, assuming two crops a year and a yield of 3.75 metric ton per hectare. Comparison of shrimp yield with paddy and other crops has revealed that shrimp is obviously a better option in terms of revenue. Thus the farmers behave rationally while converting their agricultural land into shrimp ponds. Now the question is which farming system will maximize the profitability of the farmers in the long run even when they undertake this conversion? Which should be the preferable alternative to the farmers who switch from agriculture to shrimp farming? To rank the shrimp culture systems, comparative economic analyses have been performed by a few studies. These studies give an impression that the ranking of extensive, semi-intensive and intensive shrimp culture in terms of benefit per unit of outlay is country specific [1,2].

The conversion of agricultural land to shrimp culture is also prevalent in the areas covered by the present study. The conversion of agricultural lands to shrimp ponds by village households has started for both the scientific and traditional culture area from 1997 onwards. It has been a common phenomenon in the area that even the farmers who do not have enough capital to invest upon shrimp culture are also ready to take the risk and gamble with shrimp instead of going for rice paddy. So, it is imperative to address a few important questions to in the context of household level small holder shrimp culture where capital is a constraint and farmers are more vulnerable to the losses. Is this decision of change in land use for traditional and scientific shrimp farmers are rational when we judge from a long term perspective? Do the systems remain economically viable in the long run when we consider the opportunity cost and social costs associated with them? Which culture system is more profitable in the long run-the low but sustainable returns of traditional shrimp culture or high but short-lived return from scientific shrimp culture?

Economic Viability Analysis

The assessment has been done taking into consideration the following scenarios. We have considered a fifteen years situation for both the farming systems [i]. The costs and benefits are calculated on per acre basis and are expressed in 2004-2005 prices. The traditional farming system has not reported so far any environmental damage[j] in India ,whereas the scientific shrimp farming system {alternatively termed as semi-intensive system) is alleged to produce a higher yield at the cost of degradation of the quality of land, either fully or partially which requires a high reclamation cost. So we have assumed a situation where the traditional shrimp farming can be continued for 15 years.

But the situation is different for scientific farming system (which is in other way termed as semi-intensive culture system). The allegation raised against the intensive shrimp culture system in most of the Asian countries is the irreversible change of the soil composition of the land leaving the shrimp ponds abandoned and unsuitable for further use. The salinification of the shrimp pond area and overuse of chemicals is cited as the main cause for this irreversible change [5]. But in India a study by CIBA in Tamil Nadu have reported that the main allegation on shrimp farming, i.e., the increase in the salinity level has been nullified [6]. Though no scientific study is available regarding the increase in the soil salinity in the study region, the discussion with fishery experts supports the tested fact in other states like Andhra Pradesh and Tamil Nadu. Abandonment of land where semi-intensive shrimp culture has taken place is not required, provided that the land has to be kept fallow for two years and some soil treatment expenditure has to be incurred to revert back to the agricultural use of that land. Keeping this in mind we have simulated the first situation considering 5 years of continuous shrimp culture and then reverting back to agriculture. So the first 5 years the shrimp farmers are assumed to continue shrimp farming. The sixth and seventh year the land has to be kept fallow. In the sixth year in order to revert back to the paddy production the farmer has to first fill the excavated pond. Then in order to nullify the effect of salinity, the farmer also has to incur some land reclamation cost in terms of applying lime, gypsum etc. From the 8th to 15th year we assume that farmer will resume paddy production but at a 25% reduced rate. [k] The situation is explained in Table III.

Table III: Situation 1 for Scientific Farming System

Period	Activity
First 5 years	Shrimp culture (scientific)
6th and 7th year	Fallow land, land filling and soil treatment
8th to 15th year	Paddy production at a reduced rate of 25 %

The second situation has been simulated according to the prescribed culture practice by the fisheries experts where shrimp farming is performed by giving alternate year crop rotations. That is, shrimp is rotationally cultured with other low yielding brackish water species such as tilapia etc. Though this rotation is possible in various combinations, we consider the most preferred combination as prescribed by the local fisheries experts depicted as follows (Table IV).

Table IV: Situation 2 for Scientific Farming System

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
	S	S	ALF	S	S	ALF	ALF	S	S	ALF	ALF	S	ALF	S	ALF

S: Shrimp culture; ALF: Alternative fish culture.

Under the above described scenarios we have tried to assess the economic viability of scientific shrimp culture system by calculating the viability measures Net Present Value (NPV) and Benefit-cost Ratio (BCR) with alternative discount rates of 8%, 10% and 12 %. The NPV and BCR have been derived using the following formula:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where Bt = Benefit in year t; Ct= Cost in year t;
t = 1, 2, 3,……….., n; n= number of years; i= discount rate

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

In the present context n = 15

The opportunity cost of shrimp culture: Since most of the farmers have converted their agricultural land into shrimp ponds in the study area, we include the opportunity cost of shrimp culture in terms of the forgone income from paddy production.

The opportunity cost per acre of land in terms of forgone income from paddy production has been calculated as follows.

Opportunity cost in terms of forgone income from paddy production (INR per acre) = gross income from paddy (INR. per acre) – cost of cultivation of paddy (INR. per acre)

The social cost of shrimp culture: The opportunity cost mentioned above and the direct costs of shrimp culture are borne by the shrimp farmers. But not only the shrimp farmers, many paddy cultivators whose lands are located adjacent to shrimp ponds suffer loss due to seepage of saline water from shrimp ponds into their lands in case of scientific farming. In the study area an ***internal compensation mechanism*** works between the shrimp farmers and the affected paddy cultivators locally termed as "***damarage***". The compensation can be either paid in cash or kind. In both cases the basis for this compensation is the forgone benefit from paddy production on the part of the paddy cultivator adjacent to shrimp ponds. It has been found that 60 % of the sample farmers are paying this compensation. But for the traditional farming system the situation is different. First of all this compensation system does not exist in one of the gram panchayat we have covered (Bermajur-1 gram Panchayat). The shrimp farms in this gram panchayat are not located near to paddy fields. In the other gram Panchayat Darirjangal, it has been found only four out of the twenty eight sample farmers has paid this compensation to the adjacent paddy fields. This can be explained if we consider the location requirements of traditional farming system. The traditional farms are dependent on tidal water and thus most of the farms are located near the river. The canal system to bring the river water to the ponds is also available to the farmers. So, most of the farms are concentrated near to the canal or the river. A very few farms are located in an area where paddy fields are nearby, because that causes additional cost of excavating a separate canal on part of the shrimp farmers, which the farmers are not willing to incur. So in this case seepage from the ponds to the agricultural farmers is not a prominent problem. The four farmers belong to large farm category, so the NPV and Benefit-cost ratio do not differ much due to incorporation of this cost in case of traditional farmers.

The economic viability of both the farming systems has been assed in the present study with three sets of estimates of NPV and BCR in each case.

1) Without opportunity cost
2) With opportunity cost in terms of forgone benefit from paddy production.
3) Including social cost in terms of lost benefit of the paddy cultivators whose land is being affected by shrimp culture due to seepage of saline water.

The results of these estimates are presented in table V and table VI. It can be observed from the table that the net present value of scientific shrimp culture taking all the farmers together under situation 1 ranges from INR 8.56 thousand to INR 3.88 thousand whereas it ranges from INR143.84 thousand INR 115.06 thousand under situation 2.

Table V also reveals that when we account for the opportunity cost of shrimp culture in terms of paddy income forgone, the NPV is greater than zero for both situation 1 and situation 2 considering all the farmers together. But for the marginal farmers the calculated NPV is reported as negative for both situation 1 and situation 2. This implies that when we account for the opportunity cost, shrimp culture is not a viable option for the marginal farmers if they prefer to revert back to agriculture as an alternative use of the shrimp pond area after a continuous culture of shrimp for five years or follow the prescribed practice by giving alternative crop rotations. The table further unfolds an interesting observation that NPV turns out to be negative in case of situation 1 of scientific shrimp farming when social costs are taken into consideration. This implies, when we account for the social cost in terms of the forgone income of the paddy cultivators whose lands are affected by seepage of saline water due to shrimp culture, the first option is not economically viable. But the NPV for the second situation taking all the farmers together, i.e. the prescribed practice turns out to be positive even if we account for the social cost. It is important to point out that even in the prescribed scenario is not economically viable for the marginal farmers when we account for the social cost.

But the situation is quite different in traditional farming system. The NPV for traditional shrimp farmers taking all the farmers together is positive. For each category of traditional farmers also the NPV is reported to be positive. Moreover, the table also exposes that even after accounting for the opportunity cost; the traditional shrimp farming system is economically viable to all categories of farmers.

Table V: Net Present Value (NPV, in Thousand INR /acre) for Scientific and Traditional Shrimp Farmers

		Scientific shrimp farming Situation 1			***Scientific shrimp farming Situation 2***			***Traditional shrimp farming***		
		8%	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**
NPV without opportunity cost	Marginal	8.56	4.50	3.88	59.98	49.93	46.81	138.98	123.5	110.59
	Small	175.05	171.84	165.23	304.41	273.95	248.61	104.09	92.49	82.82
	Medium	107.77	105.73	64.94	266.96	239.63	217.69	130.83	116.26	150.80
	Large	-	-	-	-	-	-	189.52	168.41	150.80
	all	61.06	50.91	57.47	143.84	126.50	115.06	132.89	118.09	105.75
NPV with opportunity cost	Marginal	-34.73	-33.08	-31.49	-65.37	-50.76	-45.19	117.58	104.49	93.56
	Small	154.62	148.95	109.22	267.19	226.02	203.02	82.69	73.48	65.80
	Medium	78.93	78.91	46.24	226.59	191.87	172.84	109.43	97.24	87.07
	Large	-	-	-	-	-	-	168.12	149.39	133.77
	all	25.11	24.75	12.26	92.49	79.18	71.38	111.50	99.08	88.72
NPV with opportunity cost and social costs	Marginal	-73.96	-61.76	-55.85	-31.75	-27.82	-24.62	117.58	104.49	93.56
	Small	120.26	107.65	103.84	245.11	220.06	200.06	82.69	73.48	65.80
	Medium	41.03	39.84	24.78	190.73	172.23	156.69	109.43	97.24	87.07
	Large	-	-	-	-	-	-	152.12	131.39	121.77
	all	-12.88	-8.10	-7.05	61.94	56.28	51.49	101.50	94.08	82.72

Source: Primary survey

The above results indicate though both the traditional and scientific farming systems are economically viable when we consider only the direct cost of shrimp culture, scientific shrimp farming does not prove to be economically viable when the opportunity costs and social costs in terms of forgone benefit of the affected paddy cultivators are taken into consideration. It can be seen that if the scientific shrimp farmers follow the prescribed practice of crop rotations then shrimp farming is economically viable for them even after accounting for the opportunity cost and the social costs, considering all the farmers together. But it is not a rational decision for the marginal farmers to undertake scientific shrimp farming from a long run perspective.

Table VI is much revealing. In the without opportunity cost situation the benefit-cost ratio for scientific farmers under both situation 1 and 2, are less than that of the traditional farmers. Average Benefit-cost ratio for scientific shrimp farming is calculated as 1.10 and 1.17 for situation 1 and 2 respectively as against 2.1 for traditional shrimp farming system. Thus in the long run low yielding traditional farming system is more profitable for the shrimp farmers. Accounting for social cost, the scientific shrimp farming following situation 1 will be an unprofitable option for the marginal farmers as the benefit cost ratio is recorded as less than one. Even after accounting for the opportunity costs and the social costs traditional shrimp farmers are likely to secure a benefit cost ratio of 1.27 on the average which is quite higher than that of the scientific farmers.

Table VI: Benefit -cost Ratio of Scientific and Traditional Shrimp Farmers

		Scientific shrimp farming Situation 1			***Scientific shrimp farming Situation 2***			***Traditional shrimp farming***		
		8%	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**
BCR without opportunity cost	Marginal	1.04	1.04	1.04	1.08	1.08	1.07	2.17	2.16	2.17
	Small	1.15	1.15	1.16	1.28	1.28	1.28	1.84	1.85	1.84
	Medium	1.38	1.36	1.36	1.46	1.46	1.46	2.10	2.10	2.10
	Large	-	-	-	-	-	-	2.57	2.27	2.57
	all	1.12	1.10	1.10	1.17	1.17	1.17	2.1	2.1	2.1
BCR with opportunity cost	Marginal	1.00	1.00	1.00	1.02	1.02	1.02	1.41	1.41	1.41
	Small	1.18	1.19	1.19	1.23	1.23	1.23	1.20	1.19	1.20
	Medium	1.37	1.38	1.38	1.42	1.42	1.42	1.36	1.36	1.36
	Large	-	-	-	-	-	-	1.70	1.70	1.70
	all	1.11	1.11	1.11	1.12	1.11	1.11	1.37	1.37	1.37
BCR with opportunity cost and social costs	Marginal	.96	.97	.97	1.01	1.01	1.02	1.41	1.41	1.41
	Small	1.10	1.11	1.12	1.22	1.22	1.22	1.20	1.19	1.20
	Medium	1.30	1.31	1.32	1.42	1.42	1.42	1.36	1.36	1.36
	Large	-	-	-	-	-	-	1.54	1.54	1.54
	all	1.04	1.04	1.05	1.11	1.11	1.11	1.27	1.27	1.27

Source: Primary survey

Sensitivity Analysis

A sensitivity analysis of the net present value of the shrimp farmers (Table VII) reveals that even after reducing the benefit by 15% and increasing the cost by 15%, the scientific farming system both in scenario 1 and scenario2 collapse from being economically viable. But, the traditional system continues to secure a positive NPV when the benefits are increased by 15% and costs are increased by 15 %. The table also reveals that even though for the marginal scientific farmers are most affected by the variations in benefits and costs.

Table VII: Sensitivity Analysis of Net Present Value for Traditional and Scientific Farmers

		Scientific shrimp farming Situation 1			***Scientific shrimp farming Situation 2***			***Traditional shrimp farming***		
		8%	**10%**	**12%**	**8%**	**10%**	**12%**	**8%**	**10%**	**12%**
NPV ('000Rs./acre) assuming15 % decrease in benefits	Marginal	-155.57	-150.58	-157.9	-140.34	-133.62	-118.52	98.15	87.22	78.10
	Small	73.03	72.16	57.70	99.63	86.29	79.56	68.82	61.16	54.76
	Medium	119.48	80.71	117.26	270.32	242.7	220.47	91.80	81.57	73.05
	Large	-	-	-	-	-	-	13.9	12.4	111.37
	all	-84.59	-85.69	-86.74	-35.74	-37.42	-38.13	93.03	82.66	74.02
NPV ('000Rs./acre) assuming 15% increase in costs	Marginal	-153.21	-148.38	-115.60	-137.46	-133.62	-188.52	119.03	102.87	91.94
	Small	39.69	37.71	37.83	-139.17	122.52	113.21	84.42	73.00	65.24
	Medium	194.23	165.04	191.26	361.5	326.34	295.8	111.43	96.33	86.09
	Large	-	-	-	-	-	-	168.39	145.5	130.10
	all	-66.76	-65.18	-69.08	-13.4	-17.29	-13.74	112.96	97.65	87.28

Source: Primary survey

Fig. 1 summarizes the above analysis. In Fig.1 for the sake of making the diagram easily explainable we have shown only the NPV of traditional shrimp farmers and scientific shrimp farmers under situation 1 and situation 2 considering all the farmers together and displayed the NPVs at 12 % discount rate
From the figure it can be observed that the scientific shrimp farming under situation 1 fails to remain an economically viable option when we account for the social costs. If the scientific farmers follow the more sustainable practice of shrimp culture with alternative crop rotations it remains an economically viable option but net present value is still lower than the traditional farmers. Most importantly it can be observed from the figure that scientific farming is highly sensitive to the rise in costs by 15 % and decrease in benefit by 15 %. For both situation 1 and 2, a fall in benefit by 15 % from the current situation, the scientific farming becomes economically non-viable. The reduction in benefit is likely by a decrease in price or a reduction in production. This reduction in benefit is not unrealistic given the falling farm gate price of shrimp in the study areas. Moreover, an increase in cost by 15 % of the current cost will lead the scientific farmers to an undesirable situation with negative net present value. But interestingly though the traditional farmers have a lower yield, that yield is sustainable and the traditional farming remains economically viable for all the situations discussed above. The traditional farmers will not end up in an economically non-viable situation even in the case of a fall in the net benefit due to decrease in benefits or rise in costs.

These findings are quite different from an earlier study by Hirasawa (1991) [5] which assess the economics of various shrimp culture system in Philippines. This study finds that if the price of shrimp decreases by 20 %, intensive farming, extensive farming and traditional farming collapse to remain profitable with negative net present value. Only semi-intensive farming was found to be profitable in that case. The reason behind the different results can be attributed to the high per acre cost of semi-intensive farming or scientific farming as we term it in this study, when the culture is performed at a small scale.

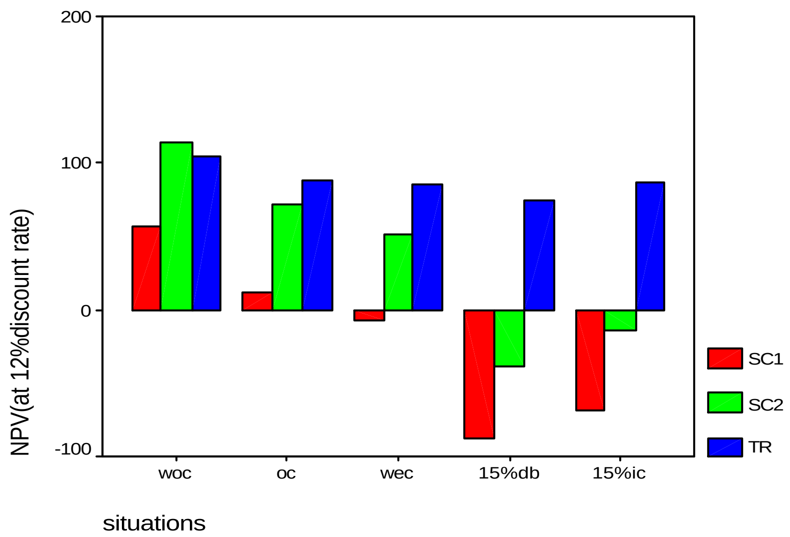

Fig 1. Net present value of traditional and scientific farmers

Explanations:
woc: NPV(thousand INR/acre) without considering opportunity cost;oc: NPV(thousand INR./acre) accounting for opportunity cost; wec: NPV (yhousand INR/acre) accounting for social cost;15 % db: NPV (thousand INR /acre) assuming 15 % decrease in benefit (we have displayed only, without opportunity cost situation);15%ic: NPV (thousand INR /acre) assuming 15 % increase in cost (we have displayed only, without opportunity cost situation);SC1: Scientific farmers under situation 1;SC2: Scientific farmers under situation 1;TR: Traditional farmers

SUMMARY AND CONCLUSION

This paper attempts to provide a comparative analysis of traditional and scientific shrimp farming for small holders shrimp culture in West Bengal, India by addressing the sustainability of the two systems in the long run. The analysis tries to explain the economic viability of the systems across different size classes of farmers using economic viability measures like Net present value and Benefit-cost ratio by incorporating the opportunity cost on the part of the shrimp farmers and the social cost borne by the paddy farmers whose land are adjacent to the shrimp ponds. The results indicate that the high return from scientific farming system is not an economically viable option especially for the marginal shrimp farmers if we consider the social costs associated with it. But even after accounting for the opportunity cost and social cost, traditional farming system records a positive NPV and high Benefit-cost ratio indicating towards the economic viability of the farming system in the long run. Moreover, a sensitivity analysis assuming 15 % increase in costs and 15 % decrease in benefit for both the farming systems, reveals that the scientific farmers record a negative NPV in both the cases whereas traditional shrimp farmers still have a positive NPV implying economic viability of traditional farming systems under such shocks. So, even if the traditional farming system is low yielding, it gives a sustainable return and is economically viable in the long run. In contrast the high yielding scientific shrimp farming fail to remain economically viable when we account for the opportunity cost of converting the agricultural land and the social cost.

Thus, when shrimp farming is undertaken in small scale and at household level the traditional farming seems to be a better option from a long run perspective. In a developing country like India where farmers face severe capital constraints, the aquaculture promotion authority should provide enough emphasis to the traditional shrimp farming also in terms of providing them credit and other extension facilities and should not neglect this farming system because its low yield. The promotion of small scale traditional farming which requires less capital investment will help them to improve rural livelihood which is one of the major goals of sustainable aquaculture.

Endnotes

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[a] As per the guidelines of aquaculture authority of India the traditional system of culture is fully tide fed; salinity variations according to monsoon regime; seed resource of mixed species from the adjoining creeks and canals by auto stocking; dependence on natural food; water intake and drainage managed through sluice gates depending on the tidal effects; periodic harvesting during full and new moon periods, collection at sluice gates by traps and bag nets.
The improved traditional system is different from the traditional system in terms of stock entry control and the supplementary stocking with desired species of shrimp. In fact the traditional farming system as locally known in the study area by its nature is inmproved traditional system.Under semi intensive method of farming (0.25-4.0ha) apart from manuring and fertilization, water exchange, usage of aerators, use of high nutritive feeds, drugs and chemicals, selective stocking with hatchery seeds @6 – 25 PL/m2 are followed

[b] This can alternatively termed as semi-intensive system in the conventional classification

[c] The size holdings are classified as marginal*:* 0-1 acre; *small*: 1-2.5 acres; *medium:* 2.5-5 acres; *large:* above 5 acres. In general the classification of farm size in India is less than two hectares, two to five hectares and greater than five hectares. In the present study the maximum farm size goes up to 1.5 hectares in the study area and is a small holder's shrimp farming. So we have followed local classification for size holdings in shrimp farming.

[d] $A_{1,}A_2$, B and C cost concepts has been calculated for traditional and scientific shrimp farming In traditional farming, cost A_1 comprises of Wages paid to hired human labour; wages paid to permanent labourers; cost of shrimp seed; cost of fertilizers and other inputs including medicine; repairing costs for pond maintenance and sheds and replacement cost of farm equipments; repairing costs of dykes; miscellaneous expenditure incurred for maintaining the pond, license cost, land revenue etc. interest

payment to borrowed capital; depreciation on farm machineries and cost of pond construction pond construction
Cost A_2 consists of A_1 plus rental value of leased land. Cost B consists of A_2 plus rental value of owned land. Cost C includes the imputed value of family labour plus cost B.
As the nature of the farming is different in scientific system, cost A_1 consists of expenditure on hired and permanent labour; expenditure on feed; expenditure on seed; netting cost; tractor cost for sludge removal; other input cost; expenditure on medicine, insecticides and fertilizers; interest payment on working capital; depreciation on farm machineries and equipments viz., pumps, aerators etc.; miscellaneous expenditures including license cost, land revenue etc.; rent of hired equipments; "Damage cost" for compensating the paddy farmers. Rests of the cost components are similar as described in case of traditional farming
[5]The concepts of returns used are as follows:
1. Farm business income(FBI)= Gross farm income-A1
2. Family labour income= Gross farm income - B
3. Net income = Gross farm income – C
The level of yields have been multiplied by the market price of the product (taking care of the grades of the product) in order to obtain the gross value appropriated by the farmers. This is the gross farm income from shrimp culture as termed in Farm Management framework.

[f] 1 USD=44.9 INR;INR implies Indian Rupees
[g] The operational definition of sustainability has been divided into two sub concepts, 'strong' and 'weak' sustainability. Whereas the notion of 'strong sustainability' leads to a concern over resource environment and the ecological basis of development, the 'weak sustainability' indicates the possibility of resource substitution between manmade and natural capital for maintaining the resource productivity.

[h] The criticisms against shrimp culture includes conversion of mangrove areas,salinity of the neaby water bodies, conflict between local farmers and shrimp farm owners from outside etc.

[i] Fifteen years has been taken as the period, because the average age of a traditional shrimp farm (*Gheri)* in the study area is 15 years. So to compare the situation of one acre of land under scientific farming till the period a traditional farm can produce satisfactory yield, 15 years have been taken for the purpose of analysis.

[j] www.mpdea.org , , "Guidelines for Sustainable Shrimp Culture in India"
[k] A study by Selvam and Ramaswamy (2001) has estimated that the gross returns shrimp farm affected paddy land is 25 % less than the normal paddy land, since similar reports are not available in our study area. We consider it as a proxy for the estimated loss in paddy production in the shrimp affected area

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