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Economics of Shrimp Farming: A Comparative Study of Traditional Vs. Scientific Shrimp Farming in West Bengal

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ECONOMICS OF SHRIMP FARMING: A COMPARATIVE STUDY OF TRADITIONAL VS. SCIENTIFIC SHRIMP FARMING IN WEST BENGAL

Poulomi Bhattacharya[1]

Abstract

The advent of scientific shrimp farming in India during 1990-91 not only boosted shrimp production but also attracted criticism on the grounds of generating adverse environmental and social impact challenging the sustainability of the system. Thus while examining the performance of alternative shrimp farming systems incorporating of the cost of negative externalities generated by shrimp farming, the risk associated and the possible fluctuations in the international shrimp market in the economic analysis are also extremely important. The present paper attempts to do so by analyzing the economic viability of alternative shrimp farming systems from a long-term perspective in the context of household level shrimp farming in West Bengal.

Introduction

Shrimp has emerged as an important item in the world seafood production. Asian countries like Taiwan, Indonesia, Thailand and India have emerged as global leaders in shrimp production. In order to bridge the gap between world demand and supply of shrimp, many countries have undertaken intensive shrimp farming with intensive application of fertilizers and chemicals to boost the productivity. This intensified application in production had led to a spurt in production of shrimp till mid-nineties. But such production system has led to degradation of the resource base which resulted in the massive disease outbreak in the shrimp industry especially in 1995-96 and caused subsequent drop in the world shrimp production. Thus, sustainability of shrimp farming is emerging as a major policy concern in the context of further development of shrimp farming as a money spinner. The sustainability issues are intertwined with the environmental and social impacts of shrimp farming. The environmental impacts include conversion of mangrove area into shrimp ponds and consequent loss of the direct and indirect benefits from mangrove ecosystems, conversion of agricultural land, salinisation of the agricultural land, reduction in paddy production in areas where shrimp ponds are located, salinisation of nearby aquifers, deterioration of quality of groundwater and discharge of effluents by shrimp farms to the nearby estuaries and rivers causing deterioration of quality of water both irrigation and potable in the surrounding locality (Primavera 1991, Pillay, 1992, Rajalakshmi, 2002). The expansion of shrimp farming is subject to criticism not only because of the above mentioned off-site environmental factors but also for its on-site adversities. Inappropriate and excess use of chemicals, fertilizers and accumulation of excess feed in the pond bottom makes the soil acidic and unsuitable for any further use either for agriculture or other fish culture, at least in the short run. This leads to the problem of irreversibility (Krutilla and Fisher, 1985) of environmental damage created by a particular economic activity. Moreover, intense use of chemical, fertilizers and antibiotics translate into the disease outbreaks in shrimp ponds and hence pose financial risk to the shrimp farmers. The extent and nature of the above mentioned

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environmental effects depend also on the production system adopted for shrimp farming. For example, the low intensity traditional and extensive shrimp farms are likely to cause a greater destruction of mangroves than the semi-intensive shrimp farms because of the higher spread of those farms. On the other hand, high yielding intensive and semi-intensive shrimp farming are subject to degradation of the quality of land and water which expose the farmers to a higher financial risk. Given the differential nature of externalities generated by shrimp production systems, decisions of aquaculture promotion authorities should not only be guided by the shrimp yield of various shrimp culture systems, but also the sustainability issues associated with such systems. This necessitates the inclusion of cost of negative externalities generated by each production systems in the economic analysis. Such analysis would be helpful to examine whether the shrimp culture by adopting alternative systems can remain profitable when along with the direct costs, costs generated due to onsite and off-site environmental adversities are taken into consideration.

The sustainability of shrimp culture systems does not only refer to the ecological sustainability but also the economic sustainability, which is the capacity of the production system to produce a positive income in the long run. If a production system does not provide sufficient income, farmers will not adopt it even if it scores high in terms of ecological sustainability. The necessity of procuring a stable return from shrimp farming in the long run assumes additional importance in the case of developing countries where the village households invest their scarce resources into shrimp culture and even convert their agricultural lands into shrimp ponds. Thus, an economic assessment of the shrimp culture systems must consider the financial risks associated with them.

A few studies dealt with 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) 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), Viswakumar (1992), Jayaraman(1994) which reveal that semi-intensive system is much profitable than the other two systems. But none of the studies have judged the economics of alternative shrimp farming systems from a long run perspective incorporating the negative externalities generated by such systems and the risks associated with them.

In this backdrop the present paper attempts to examine the economic viability of two alternative shrimp culture systems in the context of household level smallholders shrimp culture in West Bengal, by incorporating the costs incurred due to generation of negative externality and the risks associated with shrimp farming. Such analysis would be helpful to address how far the extension of higher intensity shrimp farming among the small-scale household level shrimp farmers is justifiable from a long term perspective.

The paper is organized in six sections as follows. The following section sketches an overview of the differences of production system of shrimp culture. The third section describes the theoretical and empirical issues related to conversion of paddy lands to shrimp ponds. The data source and approach adopted for the analysis are described in the fourth section. The fifth section presents the results and discussions on the economic viability of traditional and scientific shrimp farming systems. The final section provides the implications of the results and concluding remarks.

Traditional and Scientific Shrimp Farming Systems

Production techniques in shrimp farming are conventionally classified into three main categories based on the level of stocking density, area and yield. They are: traditional, extensive, semi-intensive and intensive (Primavera, 1991). Based on a review of techniques of shrimp culture the typology is further revised and split into five categories namely, extensive, improved extensive or traditional, semi-intensive, intensive and super-intensive (Raux and Bailly, 2002) [for details see Table A1 in Appendix 1]

Keeping the basic characteristics unaltered there can be country specific variations in the practices followed under traditional, semi-intensive and intensive shrimp farming systems and thus the features of each of these production systems vary across countries. In India, as per the guidelines of Aquaculture Authority of India (AAI), the **traditional system** of culture is fully tide-fed; salinity varies according to monsoon regime; seed resource of mixed species from the adjoining creeks and canals by auto stocking; depends on natural food; water intake and drainage are managed through sluice gates, depending on the tidal effects; periodic harvesting is done during full and new moon periods, the product is collected at sluice gates by traps and bag nets and sometimes there are seasonal alterations with rice-paddy. **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. Extensive method includes tidal fed water bodies of 2 –5 ha area with natural food and supplementary feeds and stocking density @ 2 PL/m2. These farming systems formed main activities of small farmers. In the modified extensive method, ponds are manured and fertilized, water filling and exchange by pumping, feeding with formulated feeds and selective stocking with hatchery seeds @ 5 PL/m2. 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. Intensive method is similar to semi- intensive method but with higher stocking density @ 25-35 PL /m2, better water exchange, drainage and removal of sludge. Apart from the above mentioned classification, depending on the extent of scientific techniques used, shrimp culture systems also are classified as traditional or improved traditional methods and scientific methods, in certain states of India including West Bengal. The scientific shrimp farming system in its strict sense not only restricts to higher intensity shrimp farming techniques but even low intensity, low input shrimp farming can also be undertaken using suitable scientific methods. But in this study we have used the common definition of traditional and scientific shrimp farming. The term *traditional shrimp farming* used in the present study has the following features as described in Table 1.

Table 1: Characteristics of Traditional and Scientific shrimp farming

Traditional shrimp farming	Scientific shrimp farming
▪ Fully tide fed ▪ Salinity varies according to monsoon regime ▪ Seed of mixed species from the adjoining creeks and canals by auto stocking ▪ Additional stocking of natural seeds ▪ 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.	▪ Ponds are manured and fertilized, water filling and exchange are done by pumping ▪ Selective stocking with hatchery seeds @6–25 PL/m^2 ▪ Use of high nutritive feeds ▪ Usage of aerators ▪ Harvesting at the end of one crop season, normally 120 days.

Traditional and scientific shrimp farming are closer to the improved traditional and semi-intensive shrimp farming in the conventional classification. The systems not only differ in terms of the intensity of production and productivity but also the on-site and off-site environmental effects. This paper concentrates on the effects generated by shrimp farms developed in paddy lands. These externalities encompass the salinization of the nearby agricultural land as well as the unsuitability of the shrimp ponds for agricultural use.

Paddy Fields to Shrimp Ponds: Empirical and Theoretical Issues

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[I] 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[II], conversion of agricultural land into shrimp ponds is a prominent one especially in the context of developing countries. But some studies tried to counter this criticism by citing examples of shrimp farms developed in the low lying saline lands or waste lands. Algarswami (1999) reports about such change in land use in case of India. There are a few studies which try to reinforce the economic rationale for converting agricultural lands into shrimp ponds and compare the net income from shrimp with the other agricultural crops especially paddy. Studies by Flaherty and Vandergeest (1999), Selvam and Ramaswamy (2001) and Reddy et al. (2004) report that net income from shrimp is more than ten times than the crops like paddy and groundnut. Such comparisons indicate that farmers behave rationally while converting their agricultural land into shrimp ponds.

But, shrimp farming by converting agricultural lands has different on-site and off-site effects as evident from the literature. These include crop loss due to salinization of land and water resources and thus the income loss of the local farmers other than shrimp farmers, reduction in paddy yield, reduced milk production due to reduction in grazing lands etc. The on-site effects are, the degradation of the quality of land and water resources. For example, in case of intensive shrimp culture, application of high doses of fertilizer and chemicals leaves the shrimp ponds abandoned and unsuitable for further use. This is the problem of irreversibility (Krutilla and Fisher, 1985) of environmental damage created by a particular economic activity, in this case shrimp culture. The economic viability analysis of different shrimp culture systems should also account for the above mentioned effects and the costs generated by such effects, in order to understand the potential of each culture systems to generate sustainable profit.

So, the viability measure like Net Present Value (NPV) and Benefit - Cost Ratio (BCR) should take the on-side and off-site effects of shrimp farming into consideration and can be expressed as,

$$NPV = \sum_t \frac{B_{dt} + B_{et} - C_{dt} - C_{et}}{(1+r)^t}$$

Where NPV: Net present value

B_{dt}: Direct benefit at period t

C_{dt}: Direct costs at period t

B_{et}: External benefits at period t

C_{et}: Costs generated by on-site and off-site environmental effects of shrimp culture (at period t)

In the present study we have included only the direct benefits of shrimp farming, as the external benefits are difficult to identify and measure. Apart from direct costs of production this paper attempts to capture costs of some on-site and off-site negative impact generated by traditional and scientific shrimp culture in the context of household level shrimp culture in West Bengal.

Data and Approach

West Bengal ranks second and third in terms of area and production under shrimp culture respectively, among the Indian maritime states. The state has a coastline of 158 Km. with rich fisheries activities. Production of shrimp in West Bengal has increased from 6200 metric tonnes in 1990-91 to as high as 8958 metric tonnes in 1996-97. But after that, due to frequent disease outbreaks the production started declining and has gone down to 6510 metric tonnes in 2002-03. Due to large existence of traditional shrimp farming, the productivity of shrimp farming is quite low in West Bengal figured as 0.57metric tonnes per hectare per year (MPDEA). Still, West Bengal has the highest potential area for shrimp farming among the maritime states and the state has huge potential for development of shrimp culture to enhance the export earnings.

Data for the present study are collected from two shrimp farming districts of West Bengal. Traditional shrimp farming is prevalent in the North 24 Parganas and South 24 Parganas district. The scientific farming is practiced in East Midnapur District. As the North 24 Parganas district covers higher area under shrimp culture than South 24 Parganas and the percentage of utilization of the potential area in this district is also more, we chose North 24 Parganas district for studying traditional shrimp farming. For studying scientific shrimp farming we have considered east-Midnapur district. Since, the present study looks into the economics of small- scale household level shrimp culture, first we have identified the blocks where household level small-scale shrimp culture exists in the selected districts. Sandeshkhali – 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 shrimp farming households, strata being the size holdings of the shrimp farmers. Finally data on 101 scientific and 110 traditional shrimp farming households have been collected by personal interviews using structured questionnaires, for the culture year 2004-2005.[III] The sample used for the present analysis consists of 29 marginal,40 small,21 medium and 18 large traditional shrimp farmers. In case of scientific shrimp farming, we have covered 64 marginal, 25 small and 11 medium shrimp farmers. In the villages selected for scientific shrimp farming we did not find any shrimp farmers culturing shrimp in greater than or equal to 5 acres. Thus there are no large scientific shrimp farmers in our sample.

As mentioned earlier the on-site environmental degradation of land and water quality due to overuse of feed and fertilizer in shrimp culture posed a serious concern in the recent years. But the degradation of land and water depends upon the production system adopted for shrimp culture. It is said that traditional shrimp culture causes lesser degradation of the pond, and subsequently shrimp can be cultured in same piece of land for a longer period of time. But the intensive shrimp farming needs artificial feed and the shrimp farmers often overuse shrimp feed and chemicals. Such practices lead to salinification of the pond and soil, leaving the land unsuitable for shrimp culture as well as agricultural use at least in the short run. In order to capture the effects such degradations in the economic analysis we have tried to assess the economic viability of shrimp culture under alternative scenarios in a fifteen years time span. The average age of a traditional shrimp farm (*Gheri)* in the study area is 15 years. So to compare the returns from one acre of land used for scientific shrimp farming till the period a traditional shrimp farm can produce satisfactory yield, 15 years have been taken for the purpose of analysis. The degradation of soil and water quality due to scientific shrimp farming depends on the intensity of use of artificial feed, chemicals and fertilizers. Though no scientific study is available related to increase in the soil salinity due to scientific shrimp culture in the study region, discussion with fishery experts revealed that shrimp culture is not an activity, which leads to irreversible change in the land as far as the study region, is concerned. The land used for shrimp culture can be reused for agriculture provided that it is kept fallow for two years and some land reclamation cost is incurred. Keeping this in mind we have simulated the first situation considering 5 years of continuous shrimp culture by the shrimp farmers and then reverting back to agriculture. So the first 5 years[IV] 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 fill the excavated pond. Then 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 reduced rate of 25%.[V]

The second situation has been simulated according to the prescribed culture practice by the fisheries experts where scientific 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*. Though this rotation is possible in various combinations, we consider the most preferred combination as prescribed by the local fisheries experts depicted as follows:

1st and 2nd year ⟶ Shrimp; 3rd year ⟶ Alternative fishes; 4th and 5th year ⟶ Shrimp; 6th and 7th year ⟶ Alternative fishes; 8th and 9th year ⟶ Shrimp; 10th and 11th year ⟶ Alternative fishes; 12th year ⟶ Shrimp; 13th year ⟶ Alternative fishes; 14th year ⟶ Shrimp; 15th year ⟶ Alternative fishes

Under the above described scenarios we have tried to assess the economic viability of scientific shrimp farming system. The assessment is done by calculating the viability measures like Net Present Value (NPV) and Benefit-Cost Ratio (BCR). The costs and benefits are calculated on per acre basis and are expressed in 2004-2005 prices. The NPV and BCR are derived using the following formula:

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

Where Bt = Benefit in year t; Ct= Cost in year t;

t = 1, 2, 3,..........., n; n= number of years; i= discount rate

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}} \quad \text{..(2)}$$

In the present context n = 15

The discount rate (i) is the rate of time preference. There has been a lot of debate related to discount rate in the literature. Opportunity cost of capital is often chosen as the discount rate for cost-benefit analysis (Farber, 1993). To arrive at a figure of opportunity cost of capital is a difficult task. The opportunity cost of capital for shrimp farmers implies how much return the farmers would have gotten had they invested the money in some other projects. The current structure of interest rate in India for the year 2003-2004 suggests that the interest rate of long term deposits in commercial banks range from 5.6% to 6.5 %. Moreover, a recent estimation of social discount rate in the context of projects for agricultural development in India by Kula (Kula, 2004) has proposed that a discount rate of 5.2 % is appropriate for India. Most of the agricultural and livestock cost-benefit analysis conducted by FAO (Food and Agricultural Organization) a discount rate ranging from 8% to 15 % (Acharya and Murray, 1997, cited in Shaw, 2003). Following these lines we have conducted the analysis with respect to a range of discount rates - 5%, 8% and 10 %.

The analysis involves direct benefits of shrimp culture, i.e., returns from shrimp culture in time period t. In this paper economic viability is judged without accounting for the imputed costs of production. Thus the resulting figures provide us the upper limit of the economic viability of the traditional and scientific shrimp farming systems without accounting for the imputed costs.

It should be noted that for situation 1 for scientific shrimp farming, the effect of degradation of pond water and soil quality due to intensive use of fertilizers, chemicals and artificial feed is reflected in three ways. They are the reclamation cost of the land for re-using it for paddy cultivation, zero return from the land for keeping it fallow for two years and the reduction in the production of paddy compared to production before shrimp culture was initiated in the area. In the second situation, the shrimp farmers are advised to give crop holidays, since culturing shrimp continuously in the same pond using high doses of artificial feed and fertilizers will expose the shrimp farmers to a higher risk of disease out break. Thus, in this situation the effect of degradation of pond water and soil quality due to intensive use of fertilizers, chemicals and artificial feed is reflected in the lower returns from culture of low yielding brackish water fish species during the crop holidays.

Apart from the direct costs we have also included the opportunity cost of shrimp culture. In fact, paddy cultivation was the main activity in the study areas before shrimp culture was started. Most of the sample shrimp farmers have converted their paddy lands for shrimp ponds. Thus the opportunity cost of shrimp culture in the study area is assessed in terms of the paddy income foregone. The opportunity cost per acre of land in terms of forgone income from paddy production (OCS) is calculated as follows.

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

In study areas for scientific and traditional shrimp farming average OCS is estimated as Rs.7719 per acre and Rs. 6745 per acre respectively. It is important to mention that, only paid-out costs of paddy cultivation are considered here. If we consider the imputed costs of paddy cultivation (imputed value of land and family labour), the return from paddy becomes negative in case of study area for traditional shrimp culture and negligible in case of study area for scientific shrimp culture. Thus we have accounted only paid-out costs of paddy cultivation in our analysis.

Compensation to paddy farmers whose paddy lands are adjacent to the shrimp ponds (CPA):

Shrimp farmers also incur costs due to negative externality generated by shrimp farming besides the production cost. 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, especially in the case of scientific shrimp farming. In the study area an ***internal compensation mechanism*** works between the shrimp farmers and the affected paddy cultivators locally termed as "***damarage***". This compensation is the cost due to off-site environmental effect of shrimp farming. The compensation can be either paid in cash or kind (paddy). The basis for compensation is forgone income of paddy cultivators whose lands are adjacent to the shrimp ponds.

It is found that 60 % of the sample farmers are paying this compensation. The average amount of compensation paid to paddy farmers by shrimp farmers is estimated as Rs. 1855 per acre. But for the traditional farming system the situation is different. In case of traditional shrimp farming the compensation system do not exist in one of the Gram panchayats covered. This is because the shrimp farms in that Gram Panchayat does not exist near to the paddy farms. In the other gram panchayat Sandeshkhali, it has been found that only four out of the twenty-eight sample farmers have paid this compensation to the owners of adjacent paddy fields. This can be explained if we consider the locational requirements of traditional farming system. The traditional farms are dependent on tidal water and thus most of the farms are located near the river. Canals are there also to bring the river water to the ponds and facilitate the water exchange system. So, most of the farms are concentrated near to the canal or the river. A few farms are located in an area close to paddy fields, because that causes extra burden to the shrimp farmers in terms of excavating a separate canal, which the shrimp farmers are not willing to incur. So, because of the nature of shrimp culture system adopted the problem of seepage of saline water in the area is less prominent.

The economic assessment of shrimp culture in this paper is done with three sets of estimates of NPV and BCR.

1) Excluding OCS and CPA
2) Including the opportunity cost borne by shrimp farmers in terms of the forgone income from paddy cultivation (OCS).
3) Including compensation paid to paddy cultivators whose lands are affected by shrimp culture due to seepage of saline water from shrimp ponds and opportunity cost in terms of the forgone income from paddy cultivation.

The first set of estimates attempt to assess profitability of alternative shrimp culture systems before accounting for the opportunity costs under the assumption that shrimp farmers do not create any loss to the paddy farmers in the vicinity. The second set of estimates depict the profitability of shrimp farming when opportunity costs of shrimp farming in terms of paddy income foregone is accounted for. The third set of estimates judge the profitability of shrimp culture including opportunity costs and by relaxing the assumption of no damage to the adjacent paddy farmers.

Shrimp culture is not only exposed to the externalities mentioned above but also is subject to high financial risks. In general it is believed that higher the intensity higher would be the financial risk of shrimp farming. The financial risk in shrimp culture stems from four sources. They are - input factors (price of Post larvae, water quality, availability of brood stock, credit, etc.); output factors (shrimp price, future supply to the market, etc.);design factors (site selection, etc.) and factors based in nature (naturally occurring risks, such as shrimp disease, typhoons, floods,etc.) (World Bank,2000).

Among these factors decline in shrimp prices as well as the rise in the input prices are quite likely. The GLOBEFISH report on shrimp price in the world shrimp market in the recent years exhibit a declining trend (Jusupeit,2004). The price competition faced by Asian countries due anti-dumping measures taken by the major importers of Asian shrimp can also be a reason for declining shrimp prices in the international market. The present study attempts o accommodate such fluctuations with the help of a sensitivity analysis, assuming 15 % increase in costs of production, 15 % reduction in benefits (which can stem from reduction in shrimp prices) and a simultaneous reduction in the benefits and reduction in costs.

Frequent outbreak of shrimp diseases is another source of financial risk in shrimp farming. The risk of disease outbreak depends on the quality of shrimp seed used as well as the pond water management practices. In the states like West Bengal there are many reasons for such shrimp diseases. The main problem is supply of shrimp seed in this state is dependent on other states for shrimp seeds. So there is no proper mechanism to check the quality of the seeds. The lack of training for proper water management also lead to higher application of feed, antibiotics also lead to higher disease outbreak. In order to account for the incidence of disease in our analysis of economic viability of shrimp farms, we have adjusted shrimp output with the incidence of disease occurrence. In order to account for the incidence of disease in our analysis of the economic viability of shrimp farms, we have adjusted shrimp output with the incidence of disease occurrence. The expected output has been calculated as follows.

Let, Y_i be the shrimp output for the i^{th} shrimp farmer (i=108 for traditional farming system and i=100 for scientific farming system). P_i is the probability of disease occurrence for the i^{th} shrimp farmer. P_i is calculated as the number of times of disease occurrence in the past five years, if the shrimp farmer has experience of shrimp culture equal to or greater than five years. In case of the shrimp farmer who has less experience in the shrimp farming P_i is calculated as the number of incidence of disease occurrence out of total years of farmers' experience in shrimp culture .

Thus, the expected shrimp output of the i^{th} shrimp farmer = $Yi\ (1-P_i) + (1-a)\ Yi\ P_i$

Where 'a' is the proportion of loss of total shrimp output due to disease. The value of 'a' could not be estimated exactly due to lack of scientific data. As most of the scientific shrimp farmers are having a single crop and a single harvest in a year, we consider a=1. This implies a complete loss of crop once the pond is affected by disease. In the case of traditional farming there are multiple cropping and harvesting systems depending on the high and low tide. Thus, even if one crop is affected by disease, a new crop cycle can be started in the next high tide after disposing the disease-affected shrimps and treating the pond water. So, in a year even if a shrimp farmer faces disease outbreak, the entire yearly output would not be lost. It is assumed that a traditional shrimp farmer who has experienced disease outbreak in a year loses 50% of the yearly shrimp output (a=0.5).

Following the above mentioned framework the present paper seeks to judge the profitability of alternative shrimp culture systems in the long run taking into account the negative externality generated by such culture practices, the risk of disease outbreak as well as possibility of fluctuations in the international shrimp market. Before moving into the long-term analysis of profitability of shrimp culture systems in the long run, a brief discussion on the comparative economics of traditional and scientific shrimp farming is also furnished.

Costs and Returns of Shrimp Farming: A Comparative Picture of Traditional Vs. Scientific Shrimp Farming

The profitability of any production system depends on the underlying cost structure and the returns. The cost of shrimp culture can be divided into paid-out and imputed costs. The paid-out costs include the value of shrimp seed, value of hired human labour, cost on other inputs like rice bran, lime etc., miscellaneous costs (e.g. repair and maintenance, netting of the pond); cost of tractor to plough the pond bottom (fuel), interest on working capital, value of farm machineries and implements rent on hired land and machineries, rent for land leased-in for shrimp farming, land revenues. In case of scientific shrimp farming expenditure on diesel (or fuel), expenditure on medicines and fertilizer, cost of inputs to maintain water quality like rice bran, east, dolomite, slaked lime, bleaching etc. are also components of paid-out costs. The imputed costs include the imputed value of family labour, imputed interest on land rent less land revenue and the imputed interest on fixed capital. In case of traditional shrimp farming shrimp seed account for the major portion of paid-out costs followed by leasing rent. Shrimp feed occupies more than 40% of the total paid out costs followed by interest on working capital in the case of scientific shrimp farming. The distribution of paid-out costs, total costs, gross revenue, net income over paid-out costs and net income over total costs are presented in table 2. It can be observed that in case of traditional shrimp farming the average paid-out costs does not vary much across the marginal, small and medium shrimp farmers, though for the large shrimp farmers it is a little higher. But the totals costs of traditional shrimp farmers are quite different across size classes. It can be seen that the marginal traditional shrimp farmers have the highest total cost of Rs. 24893per acre followed by small, large and medium traditional shrimp farmers. This is can be attributed to higher use of family labour by the marginal shrimp farmers. In case of scientific shrimp farmers the paid-out costs of shrimp farming is highest for the medium shrimp farmers (Rs. 333450 per acre) and lowest for the small shrimp farmers (Rs. 224135). In this case after accounting for the imputed costs the total cost of shrimp production ranges from Rs.275561 per acre for marginal scientific shrimp farmers and highest for the medium shrimp farmers amounting to Rs. 348168 per acre.

From table 2 it is evident that the returns per acre has direct association with the size of class of the farmer in case of both traditional and scientific shrimp farming systems. The net income over paid-out costs from traditional shrimp farming ranges from Rs.2842 per acre for marginal shrimp farmers to Rs. 19979 per acre for large shrimp farmers. It can be noted that the net income from scientific shrimp farming taking all the farmers together is almost four and half times higher than that of the traditional shrimp farmers. But a closer look at the net income over paid-out costs across size classes of shrimp farmers state that for marginal scientific shrimp farmers, shrimp farming is not so profitable as the other categories. The average net returns of the marginal scientific shrimp farmers do not differ much from their counterparts in traditional shrimp farming. It is also interesting to observe that net return over total cost is negative for the marginal scientific shrimp farmers.

Table 2: Returns and Costs of Traditional and Scientific Shrimp Farming Across Farmer Categories

(Rs. / acre)

	Traditional Shrimp Farming					Scientific Shrimp Farming				
Categories of shrimp farmers	Gross returns (Rs. /acre)	Paid-out Costs (Rs. /acre)	Total costs (Rs. /acre)	Net income Over Paid-out costs (Rs. /acre)	Net income Over total costs (Rs. /acre)	Gross returns (Rs. /acre)	Paid-out Costs (Rs. /acre)	Total Costs (Rs. /acre)	Net income Over Paid-out costs (Rs. /acre)	Net income Over Total Costs (Rs. /acre)
Marginal	31801	16151	24893	11584	2842	273477	248623	275561	24854	-1690
Small	27464	15909	20977	11555	6487	292062	224135	239026	67923	53881
Medium	30226	15535	18455	14821	11939	580408	333450	348168	246958	233871
Large	38603	17416	18624	21187	19979	-	-	-	-	-
All	31030	16152	21456	13803	8817	311885	251833	274414	60053	38115

Source: Primary survey.

Economic Viability of Traditional and Scientific Shrimp Farming in the long run

After discussing the economics of traditional and scientific shrimp farming in the short run let us now discuss about the long run economic viability of the two shrimp farming systems following the methodology described earlier. The three sets NPV and BCR estimates are presented in table 3.

Net Present Value (NPV) of traditional and scientific shrimp farming excluding OCS and CPA

The first set of NPV estimates in Table 3 excluding OCS and CPA assess the profitability of alternative shrimp culture systems excluding opportunity costs in terms of the forgone paddy income and assuming that the farmers have not caused any loss to the adjacent paddy cultivators. The estimates reveal that shrimp culture following scientific system is profitable for all the categories of shrimp farmers at all the discount rates when only paid-out costs are taken into consideration. The NPV of scientific shrimp farming taking all the shrimp farmers together under situation 2 ranges from Rs. 2.6 lakhs per acre to Rs. 3.2 lakhs per acre which is higher than the NPV figures for situation 1 which range from Rs. 1.9 lakhs per acre to Rs. 2.2 lakhs per acre. This suggest s that, continuous shrimp farming with intensive use of fertilizers and chemicals without giving crop holidays would provide a lower profit to the scientific shrimp farmers than the profit generated by them following the practice of alternative crop rotations. The NPVs across the shrimp farmer categories denote that the medium scientific shrimp farmers got the highest benefit from shrimp culture before accounting for the opportunity cost of shrimp culture in terms of foregone benefit from paddy cultivation, despite the highest cost of production incurred by them.

The estimates of NPV for traditional shrimp farming shows that, this farming system is also profitable for all the categories of farmers for all the discount rates before accounting for the opportunity costs as well as assuming that shrimp farming does not cause any loss to the paddy farmers in the vicinity. The NPVs across the shrimp farmer categories denote that the large shrimp farmers have the highest NPV of Rs. 2.0 lakhs per acre. It is interesting to note that in the long run the profitability of marginal shrimp farmers over paid-out costs in the case of traditional shrimp farming is almost same as that for small and medium shrimp farmers.

A comparison of the NPVs of traditional and scientific shrimp farming reveals that in the long run scientific shrimp farming generates approximately double the profit than that from traditional shrimp farming before accounting for the opportunity costs taking all the farmers together. But it is important to point out that the profitability of marginal shrimp farmers in scientific shrimp farming is less than their counterparts in traditional shrimp farming, even when the scientific shrimp farmers follow the prescribed practice of alternative crop rotations. For instance, at 10% discount rate the NPV of marginal scientific shrimp farmers under situations 1 and 2 are Rs. 0.5 lakhs per acre and Rs. 1.1 lakhs per acre respectively as compared to Rs 1.2 lakhs per acre for traditional shrimp farmers.

Net Present Value (NPV) of traditional and scientific shrimp farming including OCS and excluding CPA

The figures in Table 3 indicate that that scientific shrimp culture is still economically viable for all the categories of shrimp farmers in both situations 1 and 2 when we account for paid-out costs only. It is notable that after accounting for the opportunity cost in terms of the foregone income from paddy cultivation, the Net Present Value (NPV) of scientific shrimp culture under situation 1 drops from Rs. 1.9 lakhs per acre taking all the shrimp farmers together to Rs. 1.1 lakhs per acre at 10% discount rate considering only paid out costs. Under situation 2 the NPV shows a decline from Rs. 2.6 lakhs to Rs.1.9 lakhs per acre. After the opportunity costs in terms of the forgone benefit from paddy cultivation are accounted for, the NPV taking all the shrimp farmers together exhibit a decline from Rs. 1.2 lakhs per acre to Rs. 1.0 lakhs per acre at 10% rate of discount in the case of traditional shrimp farming.

The difference between the extent of variations in the NPVs of the two shrimp culture systems before and after accounting for the opportunity costs should not be interpreted merely as the difference between the opportunity costs in terms of paddy income in the two different study areas. This has a wider implication. Given the dependence of traditional shrimp farming on tidal waters, the traditional shrimp farms are generally established in the low lying coastal lands where the productivity of paddy is not so high. But as the water exchange in scientific shrimp farming depends on pumping and water can be brought to the ponds from the river by connecting pipes, the scientific shrimp farms can be established even in areas which are having higher productivity of paddy, leading to higher opportunity cost of shrimp farming.

Table 3: Net Present Value (NPV) and Benefit-Cost Ratio (BCR) across different categories of Shrimp Farmers in Traditional and Scientific Shrimp Farming Systems

	Categories of shrimp farmers	NPV ('00000 Rs. per acre)									BCR		
		Scientific shrimp farming Situation 1			Scientific shrimp farming Situation 2			Traditional shrimp farming			Scientific shrimp farming Situation 1	Scientific shrimp farming Situation 2	Traditional shrimp farming
		5%	8%	10%	5%	8%	10%	5%	8%	10%	10%	10%	10%
NPV excluding OCS and CPA	Marginal	0.7	0.6	0.5	1.5	1.2	1.1	1.5	1.4	1.2	1.16	1.19	2.17
	Small	2.5	2.2	2.2	4.1	3.3	3.0	1.6	1.0	0.9	1.32	1.36	1.84
	Medium	10.6	10.1	9.8	14.0	11.6	10.2	1.5	1.3	1.2	1.66	1.68	2.10
	Large	-	-	-	-	-	-	2.0	1.9	1.7	-	-	2.57
	All	2.2	2.0	1.9	3.2	2.9	2.6	1.6	1.3	1.2	1.25	1.29	2.1
NPV including OCS	Marginal	0.3	0.2	0.1	0.9	0.7	0.6	1.3	1.2	1.0	1.13	1.17	1.41
	Small	2.3	2.1	2.0	3.6	3.2	2.7	1.1	0.8	0.7	1.29	1.35	1.20
	Medium	9.9	9.8	9.6	12.2	10.9	9.8	1.3	1.1	1.0	1.64	1.69	1.36
	Large	-	-	-	-		-	1.9	1.7	1.5	-	-	1.70
	All	1.6	1.4	1.1	2.5	2.1	1.9	1.4	1.1	1.0	1.22	1.24	1.37
NPV including OCS and CPA	Marginal	-0.1	-0.1	-.08	0.5	0.3	0.2	1.3	1.2	1.0	1.0	1.04	1.41
	Small	2.0	1.8	1.7	3.3	2.7	2.4	1.1	0.8	0.7	1.26	1.32	1.19
	Medium	9.5	9.1	8.8	12.0	10.4	9.6	1.3	1.1	1.0	1.59	1.38	1.36
	Large	-	-	-	-			1.8	1.5	1.3	-	-	1.54
	All	1.4	1.3	0.9	2.4	2.0	1.7	1.4	1.0	0.9	1.18	1.21	1.3

Note: 1) Cash flows are summed up over 15 years at 2004-05 prices, 2) The values of Benefit –Cost ratio (BCR) are calculated at 5%, 8% and 10% discount rates. But here we present only the values at 10% discount rate, as there is little variation of BCR across discount rates, 3) Situation 1 indicates continuous scientific shrimp farming in the initial years without giving crop holidays and situation 2 indicates the prescribed practice of scientific shrimp farming by giving crop holidays.

Source: Primary survey.

Net Present Value (NPV) of traditional and scientific shrimp farming including OCS and CPA: Relaxation of the assumption that the shrimp farmers do not cause any loss to the nearby paddy farmers through seepage of saline water, has not turned the scientific shrimp culture unprofitable activity in the long run considering all the shrimp farmers together. But, for the marginal scientific shrimp farmers following situation 1, NPV over paid-out costs turns out to be negative after inclusion of the cost of compensation to the adjacent paddy farmers. This indicates that if the shrimp farmers following scientific shrimp farming system, produce shrimp continuously in the initial years, they would end up in an unprofitable situation. But, if the marginal scientific shrimp farmers follow the prescribed practice by giving crop holidays, they still can retain a positive profit in the long run, even after accounting for the opportunity costs in terms of paddy income forgone and cost of damage created by them to the adjacent paddy farmers.

It is noteworthy that even after accounting for the cost of compensation to the adjacent paddy farmers, traditional shrimp farming remains profitable for all the categories of shrimp farmers including the marginal shrimp farmers when only returns over paid-out cost are considered. But, in unlike the short term situation where the scientific shrimp farming reported about four times higher profit than the traditional shrimp farming, in the long the profitability of scientific shrimp farming is only 1.7 times that of the traditional shrimp farming. Table 3 reveals another interesting observation. Even though scientific shrimp farming taking all the shrimp farmers together and following the prescribed practice of alternative crop rotations registers higher profitability than traditional shrimp farming, the shrimp farmers who culture shrimp on smaller pieces of land by scientific method are worse-off as compared to their counterparts in traditional shrimp farming.

Benefit-Cost Ratios (BCR) of alternative shrimp farming systems: Table 3 also depict the Benefit-Cost Ratios(BCR) at 10% discount rate for the alternative shrimp farming systems. The estimates of BCR taking all the scientific shrimp farmers together (under situation 1) excluding OCS and CPA, including OCS and including both OCS and CPA are 1.25, 1.22 and 1.18 respectively. Similar set of BCR estimates range from 1.29 to 1.21 for situation 2 in scientific shrimp farming. These BCR figures clearly suggest that even if situation 1 is economically viable, but has a lesser BCR than that of situation 2, indicating higher profitability of situation 2. The BCRs for scientific shrimp farming are lower than those of traditional shrimp farming which is 2.1 when OCS and CPA are excluded and 1.3 when both OCS and CPA are included. This implies a given investment in traditional shrimp farming produce a relatively higher benefit than that in the scientific shrimp farming.

Sensitivity analysis:

The sensitivity analysis would reflect the profitability of shrimp farming under the risk of decrease in the shrimp price and increase in the costs of production of shrimp. Table 4 presents the results of the sensitivity analysis. The table reveals that after assuming a reduction in benefits by 15 per cent [VI] and an increase in costs by 15 per cent, the scientific farming system will not be profitable if the farmers culture shrimp continuously in the initial years and then use the shrimp land for agricultural purposes taking all the shrimp farmers together. If the shrimp farmers follow the prescribed practice of alternative crop rotations, so that the degradation of on-farm environmental quality is minimized, the shrimp farming by scientific method remain profitable even if benefits drop due to the drop in shrimp prices in the international market. But even scientific shrimp farming with alternative crop rotations will not remain profitable if there is a drop in the shrimp prices by 15 per cent and the cost of production raises by 15 per cent simultaneously, taking all the farmers together. It can be observed from the table that the marginal scientific shrimp farmers irrespective of the practice they adopt would not be able to sustain their profit in the long run if the benefits drop by 15% from the present situation. Thus the scientific shrimp farmers who cultivate shrimp in a land less than one acre are more susceptible to the risk of drop in prices in the international shrimp market. The inclusion of opportunity costs of shrimp farming in terms of forgone paddy income turns the NPV figures negative considering all the categories of farmers together, if there is a drop in prices and increase in costs of production by 15%. It is interesting to note that traditional shrimp farming system qualifies as profitable under the conditions of distortions in the shrimp market when there is a drop in the prices as well as an increase in the costs of production. Moreover the traditional farming system remains economically viable under these situations even after accounting for the opportunity cost (OCS).

Table 4: Sensitivity Analysis of Net Present Value (NPV) [in'00000 Rs.] and Benefit -Cost Ratio (BCR) for Traditional and Scientific Shrimp Farmers

	Categories of shrimp farmers	***Scientific shrimp farming Situation 1***				***Scientific shrimp farming Situation 2***				***Traditional shrimp farming***			
		NPV		**BCR**		**NPV**		**BCR**		**NPV**		**BCR**	
		WOC	OC	WOC	OC	WOC	OC	WOC	OC	WOC	OC	WOC	OC
Assuming15 % decrease in benefits	Marginal	-1.1	-1.46	0.99	0.95	-0.8	-1.2	1.01	0.95	0.9	0.5	1.98	1.35
	Small	0.6	-0.35	1.07	1.03	1.2	0.8	1.18	1.13	0.7	0.2	1.75	1.23
	Medium	4.4	4.19	1.29	1.26	5.4	4.7	1.47	1.43	0.9	0.5	1.94	1.40
	Large	-	-	-	-	-	-	-	-	1.4	1.0	2.45	1.95
	All	-0.4	-0.39	1.04	1.00	0.4	-0.8	1.11	1.05	0.9	0.4	1.95	1.36
Assuming 15% increase in costs	Marginal	-1.0	-1.36	1.00	0.97	-0.7	-1.0	1.05	0.99	0.9	0.4	2.10	1.76
	Small	0.9	0.71	1.10	1.06	1.6	1.1	1.26	1.16	0.7	0.2	1.85	1.59
	Medium	4.5	4.25	1.33	1.30	5.9	5.1	1.49	1.45	0.9	0.4	2.01	1.64
	Large	-	-	-	-	-	-	-	-	1.3	0.8	2.22	1.72
	All	0.01	-0.04	1.07	1.04	0.6	0.1	1.12	1.07	0.9	0.4	2.02	1.58
Assuming15 % decrease in benefits and 15% increase in costs	Marginal	-2.7	-3.16	0.87	0.83	-2.1	-2.5	1.00	0.94	0.8	0.1	1.89	1.28
	Small	-1.0	-1.11	0.96	0.91	0.01	-0.4	1.06	1.01	0.5	-0.1	1.6	1.09
	Medium	2.4	1.93	1.13	1.11	3.6	2.7	1.28	1.25	0.7	0.6	1.82	1.23
	Large	-	-	-	-	-	-	-	-	1.2	0.4	2.24	1.54
	All	-1.6	-2.09	0.93	0.8	-0.9	-1.4	1.01	0.96	0.7	0.5	1.83	1.24

Note: 1) Cash flows are summed up over 15 years at 2004-05 prices, 2) The values are for 10 % discount rate, 3) WOC indicates NPV excluding opportunity costs and compensation to paddy farmers whose paddy lands are adjacent to the shrimp ponds; OC indicates NPV including opportunity costs, 4) Situation 1 indicates continuous scientific shrimp farming in the initial years without giving crop holidays and situation 2 indicates the prescribed practice of scientific shrimp farming by giving crop holidays.

Source: Primary survey.

The sensitivity analysis conveys that under the uncertain scenario of international shrimp market scientific shrimp farming system would not be profitable whereas the traditional shrimp farming system would be a profitable option. The findings of our study differs from that of an earlier study by Hirasawa which assesses the economics of various shrimp culture system in Philippines (Primavera, 1991). The above - mentioned study finds that if the price of shrimp decreases by 20 per cent, intensive farming, extensive farming and traditional farming fail to remain profitable with negative net present value. Only semi-intensive farming was found to be profitable in that case. The difference between the shrimp farming systems are attributable to the difference in the relative cost positions of the farmers across the countries and also the scale of operations. A very low cost might have helped the traditional shrimp farmers in the present study to retain positive profits under the worse condition of price fall and increase in cost of production.

Net Present Value of Shrimp culture considering the risk of disease outbreak: Frequent disease outbreak is also a source of financial risk of shrimp farming which needs to be accommodated in the economic viability of shrimp farming. Table 6 presents the estimates of NPV after adjusting the output with the risk of disease incidence following the methodology described earlier. But, before presenting those results of net present value due to disease outbreak, a brief idea about the incidence of disease out - break for traditional and scientific shrimp farmers is furnished in table 5. The incidence of disease outbreak has been calculated as the ratio of number of years in which the shrimp farmers faced disease to the years of farmers' experience of culturing shrimp. It can be observed that on an average the traditional shrimp farmers are likely to get affected by disease 45 times out of 100 as against 36 times for the scientific shrimp farmers. It is interesting to observe that the marginal farmers in the case of traditional shrimp farming are more likely to get affected by diseases than the marginal farmers in the scientific shrimp farming. The incidences of disease for small and medium shrimp farmers are almost same for traditional and scientific shrimp farming.

Table 5: Incidence of Shrimp Disease in Traditional and Scientific Shrimp Farming

Categories of Shrimp farmers	Traditional shrimp farming	Scientific shrimp farming
Marginal	0.51	0.30
Small	0.39	0.38
Medium	0.57	0.57
Large	0.43	0.35
All	0.45	0.36

Note: The figures in the table indicate the incidence of disease outbreak which has been calculated as the ratio of number of years in which the shrimp farmers faced disease to the years of farmers' experience of culturing shrimp if the shrimp farmer has less than five years of experience in shrimp farming, other wise the figures indicate the ratio of number of years in which the shrimp farmers faced disease divided by 5.

Source: Primary survey

Table 6 reveals that scientific shrimp farming registered a negative NPV taking all the shrimp farmers together for all the discount rates. It is important to note that even if the incidence of disease was higher in the case of traditional shrimp farmers than that of the scientific shrimp farmers, the loss of revenue due to disease was higher in case of the latter. In case of any disease outbreak, the high magnitude of the gross value from scientific shrimp farming lead to high losses also. Thus, in the long run considering the disease adjusted output, the scientific shrimp farming is not profitable, whereas the traditional shrimp farming qualifies as a profitable option even after adjusting for the risk of disease outbreak taking all the farmers together.

Table 6: Net Present Value (NPV) of Traditional and Scientific (situation 1 and 2) Shrimp Farming Excluding and Including Opportunity Cost in Terms of Paddy Income Forgone (considering disease adjusted output)

Shrimp Farming Systems	NPV of shrimp culture excluding opportunity cost in terms of paddy income forgone (Rs./ acre)	NPV shrimp culture including opportunity cost in terms of paddy income forgone (Rs. /acre)
Situation 1, Scientific shrimp farming	-151897	-200239
Situation 2, Scientific shrimp farming	-114672	-198318
Traditional shrimp farming	52360	2842

Note: Cash flows are summed up over 15 years at 2004-05 prices.
Source: Primary survey

Conclusion

This paper attempts to provide a comparative analysis of traditional and scientific shrimp farming for small holders' shrimp farming in the state of West Bengal by addressing the sustainability of the two shrimp farming systems in the long run. The analysis explains the economic viability of the systems across different size classes of shrimp farmers using economic viability measures like Net Present Value (NPV) and Benefit-cost Ratio (BCR) by incorporating the opportunity costs in terms of forgone paddy income, risk of disease outbreak and the costs of adverse on-site and off-site impacts generated by shrimp farms.

Assessment of economic viability of shrimp farming shows that on the whole scientific shrimp farming is a profitable option in the long run where the effect of degradation of water and soil quality due to shrimp culture are considered. But the NPV estimates across the size class of the shrimp farmers reveal that the marginal scientific shrimp farmers who culture shrimp in less than one acre of land are in a disadvantageous position in terms of profitability than their counterparts in traditional shrimp farming. This indicates that the promotion of scientific shrimp farming in order to achieve high profitability of shrimp farming should be not be undertaken irrespective of the size of the shrimp farms. In a state like West Bengal where the availability of better quality shrimp seed and feed and seed is limited, scientific shrimp farming is not advisable especially to the farmers who culture shrimp at very small pieces of land.

The inclusion of opportunity costs in terms of paddy income forgone in the analysis has not turned the shrimp culture unprofitable to shrimp farmers belonging to any of the size classes for either traditional or scientific shrimp farming system. But the inclusion of costs of negative externality in terms of production loss of the adjacent paddy farmers due to seepage of saline water in their paddy lands makes the scientific shrimp farming unprofitable to the marginal scientific shrimp farmers when they opt for continuous farming with out giving crop holidays. This again poses a caution for promoting scientific shrimp farming at a very lower farm size. The higher benefit cost ratio of traditional shrimp farming than the scientific shrimp farming suggests that emphasis on the proper extension facilities for traditional shrimp farming amongst the resource constrained rural households would be more useful to promote shrimp farming as a means to improve rural livelihood. The sensitivity analysis indicates that the scientific shrimp farming would not remain profitable for the shrimp farmers in case they face the adverse situation of shrimp price decline in the international shrimp market as well as rise in the costs of production of shrimp. But the traditional shrimp farming continues to remain profitable under such adverse situation for all the categories of shrimp farmers. Moreover The NPV estimates after incorporating the risk of disease outbreak suggests that the scientific shrimp farming is unprofitable when the shrimp output is adjusted with risk of disease outbreak. But the traditional shrimp farming remains a profitable option under such risk adjustments. This result conveys an important message. In the absence of proper crop insurance and risk covering facilities, the expansion of scientific shrimp farming can lead to undesirable situations. Thus, in order to avoid a massive loss following uncertainties in the international market as well as the disease outbreaks in the shrimp industry, the concerned authority should give enough emphasis on traditional shrimp farming by extending better farm management practices, rather than neglecting the farming system for its lower yield.

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Endnotes

I 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.

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

III In the analysis 100 scientific and 108 traditional shrimp farmers are considered dropping the outliers and questionnaire with incomplete sets of information.

IV We have considered five years because, after five years of continuous shrimp farming majority of shrimp farmers have stared incurring loss due to disease outbreaks if they continue to culture shrimp in the same land. The average age of scientific shrimp farming depends on the extent of stocking density, water management practices, avoidance of anti-biotic use etc. A well managed scientific shrimp ponds can give profit to the farmers for more than five years also. But in the study area, the small sale farmers do not have enough training and resources for such pond management. Thus the farmers get enough profit to continue shrimp culture only till five years if they continue to culture shrimp in the same land without giving crop rotations.

V 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.

VI The price of shrimp received by the farmers has gone down from Rs. 350 per kg. for grade 'A' shrimp to Rs. 300 in the past four years as reported by the farmers. This is a reduction of price approximately by 15 %. So, we have considered a possibility of 15 % reduction in benefits.

Appendix 1

Table A 1. Technical Criteria for Shrimp Farming

	Traditional	Semi-intensive	Intensive
Stocking density	$<2/m^2$	$4\text{-}6/\ m^2$	$>10/\ m^2$
Feed (artificial pellets)	No	Yes	Yes
Usual Feed conversion ratio	-	1-1.5	>1-1.5
Liming	Yes	Very less	Yes
Fertilizers	100-150 kg/ha	Yes	Yes
Pesticides	Yes	Yes	Yes
Other inputs	Corn,Rice bran etc.	no	Feed complement, fertilizers
Paddle wheel	no	<10hours/day	>20 hours/day
Pumping	no	Yes	Yes

Source: Raux and Balliey, 2002

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