SOCIAL COST-BENEFIT ANALYSIS OF SCIENTIFIC VERSUS TRADITIONAL SHRIMP FARMING: A CASE STUDY FROM INDIA

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Abstract

This paper attempts a social cost-benefit analysis of scientific versus traditional shrimp farming in West Bengal, India. Using primary data, the paper shows that although intensive or scientific shrimp farming yields high returns as compared to traditional shrimp farming, when the opportunity costs and environmental costs of shrimp farming including disease risk are accounted for, scientific shrimp farming loses its advantage. In fact sensitivity analysis shows that if expected benefits were to fall short by 15% and costs rise by a similar proportion, scientific shrimp farmers report higher losses than traditional shrimp farmers. But large traditional shrimp farmers continue to report positive net returns. These results are also most pronounced for small and marginal scientific shrimp farmers. Further if the probability of disease risk is also accounted for, scientific shrimp farming reports significant losses whereas traditional shrimp farming in most cases shows positive net returns. In the light of the high social and environmental costs, and risks, this paper questions the rationale behind promoting intensive or scientific shrimp farming, especially among small and marginal holdings as an income-generating activity or poverty alleviation measure. It also suggests that policy makers need to factor in sustainability concerns while formulating policies to promote intensive shrimp farming.

Key Words: Shrimp Farming; Social Cost-Benefit Analysis; Net Present Value, Benefit-Cost ratio; Environmental costs, Opportunity cost; Risk

JEL classification: Q22, Q51

Social Cost-Benefit Analysis of Scientific versus Traditional Shrimp Farming
A Case Study from India

Introduction

Shrimp has emerged as an important item in world seafood production and trade, accounting for about 20 and 30 per cents respectively. Realising its potential for growth and income, and especially in earning foreign exchange, many Asian countries such as Taiwan, Indonesia, Thailand and India have promoted shrimp farming involving intensive application of chemicals, fertilisers and artificial feeds to boost shrimp output. Evidences from Thailand and India suggest that the net income from shrimp is more than ten times that from paddy and groundnut (Cf. Flaherty and Vandergeest, 1999; Selvam and Ramaswamy, 2001; Reddy et al, 2004). This, however, does not account for the adverse social and environmental costs of shrimp farming such as the destruction of mangroves, conversion of agricultural land into shrimp ponds, salinization of nearby agricultural lands and aquifers, deterioration of quality of groundwater, irrigation and drinking water in the vicinity of shrimp ponds, etc.(Primavera,1991; Pillay,1992;Rajalakshmi,2002). Moreover, inappropriate and excessive use of chemicals, fertilizers and feed makes the pond soil acidic and unsuitable for any further use (agriculture/fisheries) 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. The intensive use of such inputs also makes shrimp farming vulnerable to disease outbreaks and financial risks as witnessed in the mid-nineties which led to a slump in world shrimp production.

Unlike scientific shrimp farming which relies on chemicals, fertilizers and artificial feeds to sustain shrimp production, traditional shrimp farming which relies on natural feeds and other environmentally less harmful practices is assumed to be more sustainable (Table 1). Studies that examine the comparative economics of different shrimp farming systems have, however, focused exclusively on analysing their profitability, to the neglect of their long term social and environmental consequences (Cf. Shang et al, 1998; Usharani et al, 1993; Viswakumar, 1992; Jayaraman, 1994). This paper, therefore, attempts a social cost-benefit analysis of scientific versus traditional shrimp farming in West Bengal, India by accounting for the opportunity costs of shrimp farming in terms of the foregone paddy benefits, environmental costs, and the probability of risks due to diseases. Such analysis would also be helpful to address how far the extension of higher intensity shrimp farming among the small-scale household level shrimp farmers is justified from a long term perspective.

Objectives

In the light of the above the specific objectives of the study are as follows:

1. To analyse the comparative economics of scientific versus traditional shrimp farming.
2. To attempt a social cost-benefit analysis of scientific versus traditional shrimp farming both excluding and including the opportunity cost in terms of the foregone paddy (rice) benefits as well as the cost of damages paid to farmers adjoining shrimp farms due to the negative externalities caused by shrimp farming.
3. To analyse the net benefits from scientific versus traditional shrimp farming after accounting for the probability of disease and other risks.

Data and Approach

The study is based on an in-depth survey of 208 shrimp farmers, i.e.100 scientific and 108 traditional shrimp farmers from West Bengal, which accounts for major share of shrimp area and output in India. Two districts, North 24 Parganas and East-Midnapur where traditional and scientific shrimp farming are predominant, and one block from each district, namely, Sandeshkhali –II and Khejuri were purposively selected for the survey. From each block two village (Gram) panchayats have been selected randomly to choose the households for the survey. Stratified random sampling method has been used to select the shrimp farming households, covering different strata of holdings. The reference year for the study is the shrimp culture year 2004-2005.

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.

To undertake the social cost-benefit appraisal we have assumed a life span of 15 years. This is because in the study area the average age of a traditional shrimp farm (*Gheri*) over which it yields satisfactory returns is 15 years. The adverse on-site and off-site environmental consequences of shrimp farming depend upon the production system adopted for shrimp culture. It is said that traditional shrimp culture causes lesser degradation of the pond, and therefore shrimp can be cultured in the same piece of land for a longer period of time. But the same cannot be said about scientific shrimp farming which relies on artificial feeds and fertilisers that shrimp farmers tend to overuse resulting in salinification of the shrimp pond, which makes the land unsuitable for shrimp culture as well as agricultural use at least in the short run. However, as per local fisheries experts the land used for shrimp culture in the study area can be reused for agriculture but at reduced yields provided that it is kept fallow for two years and some land reclamation cost is incurred. Alternatively scientific shrimp farming can be rotated with other low yielding brackish water species such as *tilapia*. Keeping this in mind for our analysis we have simulated two situations for scientific shrimp farming. In the first the shrimp farmers are assumed to continue shrimp farming for the first five years[1] following which in the sixth and seventh year the land has to be kept fallow. In order to revert back to paddy production thereafter the farmer has to incur land reclamation costs such as filling the excavated pond, applying lime and gypsum to nullify the effect of salinity, etc. From the 8th to 15th years we assume that the farmer will resume paddy production but at a reduced rate by 25%.[2] In the second situation scientific shrimp farming is rotated with other fish culture such as *tilapia* as follows:

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

S: Shrimp farming, AF: Alternative fish culture

For assessing costs we have two sets of estimates – one accounting for only paid out costs and the other all costs i.e. paid out costs plus the imputed value of owned inputs including family labour. The conversion of agricultural lands or rice fields into shrimp farms has an opportunity cost in terms of the foregone benefits from paddy. Besides as stated earlier, shrimp farming has both on-site and off-site environmental costs. During the survey many paddy cultivators having lands adjacent to shrimp ponds reported losses due to seepage of saline water into their lands from adjoining shrimp ponds, especially in the case of scientific shrimp farming. In the study area an ***internal compensation mechanism*** operates whereby the shrimp farmers compensate the affected paddy cultivators either in cash or kind for the environmental damages caused. Hence for our analysis we take note of the opportunity costs (OCS) and compensation paid for environmental damage (CPA) caused by shrimp farming. Thus for assessing benefits we consider three alternate scenarios: (1) excluding both OCS and CPA, (2) including the opportunity cost of shrimp farming in terms of the

[1] 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.

[2] A study by Selvam and Ramaswamy (2001) has estimated that the gross returns of 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.

forgone benefits from paddy (OCS), but excluding CPA; and (3) including both OCS and CPA.

To assess the economic viability of scientific versus traditional shrimp farming we have used two measures, namely Net Present Value (NPV) and Benefit-Cost Ratio (BCR). The costs and benefits are calculated on per acre basis and expressed in 2004-2005 prices. We have used three alternate discount rates - 5, 8 and 10 per cents to check for the robustness of our estimates

Apart from opportunity and environmental costs, shrimp farming is also exposed to high financial and other risks. These may stem from a rise in input prices, or a decline of shrimp prices in the international market, and the risk of disease outbreak. Hence, we need to account for the possibility that expected benefits may not be realized or that costs may rise. Thus as part of sensitivity analysis, we assume that costs may rise by 15 %, or expected benefits may fall short by a similar proportion, and alternatively both a reduction in expected benefits and a rise in costs by 15%. Furthermore, in order to account for the risk of disease outbreak on shrimp output, we have also assessed the net benefits from shrimp farming, using a disease-risk adjusted shrimp data series which is derived as follows (see also footnote 3).

The expected disease-risk adjusted shrimp output of the i^{th} shrimp farmer has been calculated as

$Yi\ (1-P_i) + (1-\ a)\ Yi\ P_i$[3].

[3] Where, Y_i = shrimp output for the i^{th} shrimp. 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. Here, 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).

Comparative Economics of Traditional Vs. Scientific Shrimp Farming

Before attempting the social cost-benefit appraisal we may examine the comparative economics of traditional versus scientific shrimp farming using a single year's data. This clearly shows that scientific shrimp farming is more profitable than traditional shrimp farming (Table 2). The net income over total costs from scientific shrimp farming is almost five times higher than from traditional shrimp farming taking all the farmers together. The net income also varies positively with farm size in the case of both shrimp farming systems. However, what is most significant to note is that while marginal traditional shrimp farmers report profits even after all costs are reckoned, marginal scientific shrimp farmers report negative returns.

Table 2: Costs and Returns from Traditional and Scientific Shrimp Farming across Shrimp Farmer Categories (Rs. /acre)

Source: Primary survey.

	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

Social Cost-Benefit Analysis

The NPVs and BCRs corresponding to the alternate scenarios depicted above are presented in Tables 3, 4 and 5. Table 3 shows that excluding the opportunity cost of shrimp farming in terms of the foregone paddy benefits (OCS) and the compensation paid for environmental damage (CPA), the NPVs of scientific shrimp farming under the two alternative scenarios, situations 1 and 2 are conspicuously higher than the same for traditional shrimp farms, taking all farmers together. Also the NPVs of scientific shrimp farming under situation 2 (i.e. shrimp farming alternated with other low yielding brackish fish) are higher than the same under situation 1. It is significant to note that the NPVs for large traditional shrimp farmers are much higher than the same for small and marginal scientific shrimp farmers under both situations 1 and 2. Furthermore, the NPV for marginal scientific shrimp farmers is negative after accounting for the imputed costs and if they don't alternate shrimp farming with crop holidays (situation 1). In terms of BC ratios it is seen that traditional shrimp farming fares better than scientific shrimp farming under both situations 1 and 2. For instance, at 10% discount rate the BC ratio for traditional shrimp farmers for all farmers as a whole was 1.60 as against 1.13 and 1.14 for scientific shrimp farmers under situations 1 and 2 respectively. In fact the BC ratios for all categories of traditional shrimp farmers are higher than the same for scientific shrimp famers under the two situations.

Table 3: Net Present Value (NPV) and Benefit-Cost ratio (BCR) across different categories of Shrimp Farmers in Traditional and Scientific Shrimp Farming System-excluding OCS and CPA

		NPV ('00000 Rs. per acre)						BCR at 10% rate of discount	
	Categories	5% discount rate		8% discount rate		10% discount rate			
		P	T	P	T	P	T	P	T
Scientific Shrimp Farming Situation 1	Marginal	0.7	-0.3	0.6	-0.2	0.5	-0.2	1.16	1.05
	Small	2.5	2.1	2.2	1.7	2.2	1.7	1.32	1.22
	Medium	10.6	9.7	10.1	9.1	9.8	8.2	1.66	1.43
	Large	-	-	-	-	-	-	-	-
	All	2.2	1.4	2.0	1.2	1.9	1.1	1.25	1.13
Scientific Shrimp Farming Situation 2	Marginal	1.5	0.2	1.2	0.2	1.1	0.1	1.19	1.08
	Small	4.1	3.3	3.3	2.7	3.0	2.4	1.36	1.29
	Medium	14.0	13.0	11.6	10.7	10.2	9.6	1.68	1.46
	Large	-	-	-	-	-	-	-	-
	All	3.2	2.4	2.9	1.9	2.6	1.7	1.29	1.17
Traditional Shrimp Farming	Marginal	1.5	0.7	1.4	0.6	1.2	0.5	2.17	1.29
	Small	1.6	0.6	1.0	0.5	0.9	0.4	1.84	1.23
	Medium	1.5	1.2	1.3	1.0	1.2	0.8	2.10	1.67
	Large	2.0	1.9	1.9	1.6	1.7	1.4	2.57	2.25
	All	1.6	1.0	1.3	0.8	1.2	0.7	2.1	1.60

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) P and T implies considering paid-out and total costs respectively; 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 NPVs and BC Ratios of scientific versus traditional shrimp farming after accounting for the opportunity cost in terms of the foregone paddy benefits but excluding the compensation paid for environmental damage (CPA) are presented in Table 4. As evident, scientific shrimp farmers report higher NPVs under both situations 1 and 2 compared to traditional shrimp farmers for all farmers as a whole. However, it is significant to note that marginal scientific farmers under both situations 1 and 2 report negative returns after these opportunity costs are accounted for. The same is also true of marginal and small traditional shrimp farmers who report negative NPVs after these opportunity costs are accounted for. However, in terms of BC ratios we find that even after accounting for the opportunity cost traditional shrimp farmers (except for small shrimp farms) fare better than scientific shrimp farmers under both situations 1 and 2.

Table 4: Net Present Value (NPV) and Benefit-Cost Ratio (BCR) across different categories of Shrimp Farmers in Traditional and Scientific Shrimp Farming System- including OCS and excluding CPA

		NPV ('00000 Rs. per acre)						BCR at 10% discount rate	
Shrimp Farming Systems	Categories of shrimp farmers	5% discount rate		8% discount rate		10% discount rate			
		P	T	P	T	P	T	P	T
Scientific Shrimp Farming Situation 1	Marginal	0.3	-0.7	0.2	-0.7	0.1	-0.6	1.13	1.00
	Small	2.3	1.7	2.1	1.6	2.0	1.5	1.29	1.19
	Medium	9.9	9.4	9.8	8.7	9.6	8.1	1.64	1.4
	Large	-	-	-	-	-	-	-	-
	All	1.6	1.0	1.4	0.9	1.1	0.7	1.22	1.09
Scientific Shrimp Farming Situation 2	Marginal	0.9	-0.4	0.7	-0.4	0.6	-0.3	1.17	1.02
	Small	3.6	3.1	3.2	2.5	2.7	2.3	1.35	1.23
	Medium	12.2	12.0	10.9	10.3	9.8	9.4	1.69	1.43
	Large	-	-		-	-	-	-	-
	All	2.5	1.7	2.1	1.5	1.9	1.3	1.24	1.12
Traditional Shrimp Farming	Marginal	1.3	-.05	1.2	-.04	1.0	-.04	1.41	1.09
	Small	1.1	-0.1	0.8	-.08	0.7	-.07	1.20	0.99
	Medium	1.3	0.5	1.1	0.4	1.0	0.3	1.36	1.19
	Large	1.9	1.3	1.7	1.0	1.5	0.9	1.70	1.54
	All	1.4	0.4	1.1	0.3	1.0	0.3	1.37	1.22

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) P and T implies considering paid-out and total costs respectively; 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.

If we account for both the opportunity cost and environmental costs of shrimp farming we find that the NPVs from scientific shrimp farming under both situations 1 and 2 have drastically declined as compared to earlier, although they are still around twice that from traditional shrimp farming (Table 5). Scientific shrimp farming turns out to be unprofitable for marginal farmers under both situations 1 and 2 when both these costs are accounted for. For marginal and small traditional shrimp farmers too these NPVs are negative. In terms of BC ratios, however, we find that except for small shrimp farmers, traditional shrimp farmers fare better than scientific shrimp farmers under both situations 1 and 2.

Table 5: Net Present Value (NPV) and Benefit-Cost Ratio (BCR) across different categories of Shrimp Farmers in Traditional and Scientific Shrimp Farming System- including OCS and CPA

Shrimp Farming Systems	Categories of shrimp farmers	5% discount rate		8% discount rate		10% discount rate		BCR at 10% rate of discount	
		P	**T**	**P**	**T**	**P**	**T**	**P**	**T**
Scientific Shrimp Farming Situation 1	Marginal	-0.1	-1.0	-0.1	-0.9	-.08	-0.8	1.0	0.96
	Small	2.0	1.5	1.8	1.4	1.7	1.3	1.26	1.13
	Medium	9.5	9.1	9.1	8.4	8.8	7.9	1.59	1.35
	Large	-	-	-	-	-	-	-	-
	All	1.4	0.8	1.3	0.8	0.9	0.6	1.18	1.0
Scientific Shrimp Farming Situation 2	Marginal	0.5	-0.8	0.3	-0.7	0.2	-0.6	1.04	1.01
	Small	3.3	2.6	2.7	2.2	2.4	2.0	1.32	1.21
	Medium	12.0	10.2	10.4	9.4	9.6	8.5	1.38	1.41
	Large	-	-		-		-	-	-
	All	2.4	1.2	2.0	1.1	1.7	1.0	1.21	1.10
Traditional Shrimp Farming	Marginal	1.3	-.05	1.2	-.05	1.0	-.04	1.41	1.12
	Small	1.1	-0.1	0.8	-.08	0.7	-.07	1.19	0.97
	Medium	1.3	0.5	1.1	0.5	1.0	0.4	1.36	1.17
	Large	1.8	1.3	1.5	1.0	1.3	0.9	1.54	1.49
	All	1.4	0.4	1.0	0.3	0.9	0.3	1.3	1.19

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) P and T implies considering paid-out and total costs respectively; 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.

If expected benefits were to fall short or costs were to rise, this will impact on the net benefits from shrimp farming. Results of a sensitivity analysis presented in Table 6 reveal that if expected benefits were to fall by 15% and costs likewise rise by 15%, scientific shrimp farming under both situations not only reports losses but also these are much higher than for traditional shrimp farmers. Both excluding and including the opportunity cost and environmental costs, except for medium farmers, all categories of scientific shrimp farmers report negative returns. It is significant to note that even after accounting for all these costs large traditional shrimp farmers continue to report positive benefits and they even fare better than medium scientific shrimp farmers (BC ratios being 1.15 and 1.01 respectively).

If we account for disease risk we find a dramatic change in the performance of scientific versus traditional shrimp farming. Table 7 which presents the NPVs using the disease-risk adjusted shrimp output series clearly shows that even accounting for only the opportunity costs of shrimp farming, and without accounting for the environmental costs, scientific shrimp farming reports losses under both situations 1 and 2. As against this traditional shrimp farming reports positive NPVs except when total costs including opportunity costs are reckoned. Unlike scientific shrimp farming where only one crop can be harvested in a year, traditional shrimp farming, despite its comparatively lower productivity, has the advantage of giving more number of crops per year. Thus the foregoing analysis clearly shows that when one takes note of the social and

Table 6 : Sensitivity Analysis of Net Present Value (NPV) [in'00000 Rs.] and Benefit-Cost Ratio (BCR) for Traditional and Scientific 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
	Categories of shrimp farmers	P	T	P	T	T	T	P	T	P	T	T	T	P	T	P	T	T	T
Assuming15 % decrease in benefits	Marginal	-1.1	-1.9	-1.46	-2.2	0.89	0.86	-0.8	-1.7	-1.2	-2.1	0.81	0.77	0.9	0.8	0.5	0.2	1.19	0.93
	Small	0.6	0.1	-0.35	-0.08	1.01	.99	1.2	0.7	0.8	0.3	1.04	1.02	0.7	0.5	0.2	0.1	1.10	0.84
	Medium	4.4	3.9	4.19	3.7	1.12	1.05	5.4	4.9	4.7	4.3	1.05	1.02	0.9	0.7	0.5	0.2	1.42	1.03
	Large	-	-	-	-	-	-	-	-	-	-	-	-	1.4	1.1	1.0	0.8	1.81	1.31
	all	-0.4	-0.7	-0.39	-1.0	.94	0.91	0.4	-0.3	-0.8	-1.3	1.00	0.94	0.9	0.7	0.4	0.3	1.30	0.98
Assuming 15% increase in costs	Marginal	-1.0	-1.9	-1.36	-2.3	0.84	0.81	-0.7	-1.6	-1.0	-2.1	1.02	0.97	0.9	0.3	0.4	-0.2	1.21	0.95
	Small	0.9	0.4	0.71	0.2	1.02	.98	1.6	0.7	1.1	0.3	1.58	1.11	0.7	0.3	0.2	-0.3	1.13	0.86
	Medium	4.5	5.0	4.25	4.7	1.13	1.01	5.9	4.2	5.1	3.1	1.25	1.22	0.9	0.7	0.4	-0.1	1.45	1.06
	Large	-	-	-	-	-	-	-	-	-	-	-	-	1.3	1.2	0.8	0.7	1.85	1.34
	all	0.01	-0.6	-0.04	-0.9	0.97	0.92	0.6	-0.5	0.1	-0.9	1.04	1.00	0.9	0.5	0.4	-.05	1.34	1.00
Assuming15 % decrease in benefits *and* ***15% increase in costs***	Marginal	-2.7	-3.2	-3.16	-3.9	0.85	0.78	-2.1	-3.3	-2.5	-3.8	0.89	0.86	0.8	-0.1	0.1	-0.6	1.03	0.80
	Small	-1.0	-1.2	-1.11	-1.4	0.94	0.85	0.01	-0.6	-0.4	-1.0	1.00	0.99	0.5	-0.07	-0.1	-0.5	0.96	0.74
	Medium	2.4	2.2	1.93	1.7	0.97	0.91	3.6	3.1	2.7	2.5	1.11	1.01	0.7	0.5	0.6	-0.2	1.23	0.94
	Large		-	-	-	-	-	-	-	-	-	-	-	1.2	1.0	0.4	0.2	1.57	1.15
	all	-1.6	-2.1	-2.09	-2.6	0.87	0.84	-0.9	-1.9	-1.4	-2.4	0.97	0.94	0.7	0.31	0.5	-0.4	1.14	0.94

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 famers whose paddy lands are adjacent to the shrimp ponds; OC indicates NPV including opportunity costs, 4) P and T implies considering paid-out and total costs respectively, 5) 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

Table 7: Net Present Value (NPV) of Traditional and Scientific (situation 1 and 2) Shrimp Farming Excluding and Including Opportunity Cost in Terms of the Foregone Paddy Benefits (considering disease adjusted output)

Shrimp Farming Systems	NPV of shrimp culture excluding opportunity cost in terms of the foregone paddy benefits (Rs./ acre)		NPV shrimp culture including opportunity cost in terms of the foregone paddy benefits (Rs. /acre)	
	Paid-out costs	Total costs	Paid-out costs	Total costs
Situation 1, Scientific shrimp farming	-151897	-159209	-200239	-203901
Situation 2, Scientific shrimp farming	-114672	-125929	-198318	-216907
Traditional shrimp farming	52360	18497	2842	-1913

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

environmental costs including risks of shrimp farming, scientific shrimp farming is not as remunerative as is made out, when compared to traditional shrimp farming. The rationale for encouraging intensive or scientific shrimp farming, especially among small and marginal farmers, therefore, needs to be questioned. Policy makers therefore need to factor in sustainability concerns while promoting intensive shrimp farming.

Conclusion

Evidences presented in this paper show that although intensive or scientific shrimp farming yield high returns compared to traditional shrimp farms, when the opportunity costs and environmental costs of shrimp farming including disease risks are accounted for scientific shrimp farming loses it advantage. In fact if expected benefits were to fall short by 15% and costs rise by a similar proportion, scientific shrimp farmers report losses as compared to traditional shrimp famers who continue to report positive returns. Further if the probability of disease risk is also accounted for scientific shrimp farming reports significant losses whereas traditional shrimp farming in most cases shows positive returns. The results are especially pronounced for small and marginal scientific shrimp farmers. In the light of the high social and environmental costs and risk factors, the rationale for promoting intensive or scientific shrimp farming, especially among small and marginal holdings as an income-generating activity or poverty alleviation measure in developing countries needs to be questioned. Policy makers also need to factor in sustainability concerns while promoting shrimp farming.

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