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ARTICLE

A Unit Study of Externality of Shrimp Farming on Provisioning Services (Paddy Farming)

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ABSTRACT

Externality; the term can define as a positive or negative impact from either production or consumption of goods or services. Services provided by particular location have very specific dependency on spatial characteristics of that region. A region's distinct characteristics make it ecologically unique from other such regions. Ecosystem services are offered by these regions thus differ according to these unique ecological features. In this particular study, artificially imposed expansion of coastal shrimp farming towards the inland and its impact over paddy cultivation have been addressed. Optimization of the extent of this manipulative coastal expansion has been supported by little modification of a previously described model. Here the investment prediction for both shrimp and paddy farming has been investigated by calculating net present value (NPV). Shrimp farming has very specific externality on local ecosystem services. In this particular case, some contradictory results are presented and with respect to positive or negative externality; but the externalities are strong. NPV results indicate that there is no long-term profitability in case of shrimp farming. Hence, an overall externality of shrimp farming has been described in context of this study.

1. Introduction

Externalities (also called "spill-over effects") arise when one valuable objective function, like profits from any investment or personal happiness of any person, is directly or indirectly dependent on the unintentional or accidental "by-product" of other's activity [1, 2]. Therefore, whenever any investment (may be short-term or long-term) or any infrastructures are established, the investors always try to minimise externality. Externality is either positive or negative. For internalising the externality, investors or government or institute take extenuation steps. When environmental cost, caused by any industries or activities is not included in policies then no internalisation happened [3]. For dealing with the problem where environment is involved, recovery cost of negative externalities on environment incorporated in decision making and "compromise business community in a long term" [4].

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From the point of view of externality; shrimp farming industries are most controversial one. Huge profit within short period of time and high demand in national and international market is the main driving force behind the ever-expanding shrimp farming industry. Specially, brackish water shrimp culture is a major boost up for coastal economic prosperity. The expansion of shrimp farming has risen as a major trade-off product since 1975. Before that only 2% of the world market was occupied by this major 'blue revolution' agent (shrimp) [5]. In coastal India, different states viz. Gujrat, Andhra Pradesh, West Bengal etc. are emerging their economy by shrimp farming (especially brackish water shrimp farming). The presence of suitable ecological and environmental supports acts as main driving force for this emerging shrimp farming in these states. Though a huge manipulation, in terms of maintenance is needed to succeed in shrimp culture. This maintenance differs according to culture species and culture processes.

In this particular study, the study area is at Paschim Shitalpur village, at Nandakumar subdivision of Purba Medinipur district, West Bengal, India. Major trend of Purba Medinipur district is to convert paddy cultivation land into low depth saline water bodies. As per present statistics there are more than 25000 shrimp farms, most of these farms did not measure any externality. Here, externality comes mainly in negative measures.

In order to investigate the impact of outward expansion of coastal boundary by canalizing the brackish or salt water directly from source to the inward fertile land for shrimp culture on paddy farming; some sort of key objectives have been reached both in qualitative and quantitative aspects. Inward extension of salt water has a huge impact on spatial variabilities. The variation range which occurs in between coastal and non-coastal region is being diminished day by day by this kind of activities. These activities may lead to the alteration of directly or indirectly ecosystem services which are extensive result of these kinds of variabilities. Here, the ecosystem services and optimum expansion range of coastal region are considered. This consideration is very relevant for conservationist for making policy to conserve coastal region as well as mitigate the confliction between coastal expansion and fertile inland conservation. The Net Present Value (NPV) has been calculated and compared by categorising the paddy farming system in different groups with each other's groups and with shrimp farm. From investors perspective in both such choices (paddy farming and shrimp farming) the comparison of NPV value is effective for the projection in long run. Externality in terms of qualitative impacts assessment for intensive or semi-intensive shrimp culture, at the study location, on ecosystem services; act as holistic conclusion of this study.

2. Materials and Methods

2.1 Study Area

The entire study has been conducted at shrimp farming region of Shitalpur Paschim village, Nandakumar block, Purba Medinipur, West Bengal. Shrimp farms are located along a canal which is canalized from River Haldi at a point of 22°08'18.72'' N and 88°53'24.35'' E and routed in a northward direction for 6.5 km inland of Shitalpur Paschim (Figure 1). The canal is on 25 km upstream or inland from the mouth of River Haldi, where it meets and River Hooghly which is finally draining into Bay of Bengal. Data from paddy farms were collected from adjacent paddy farms of this particular shrimp farm. The location map (Figure 1) is prepared using ArcMap by digitisation of scanned map and data point collected during field survey by author.

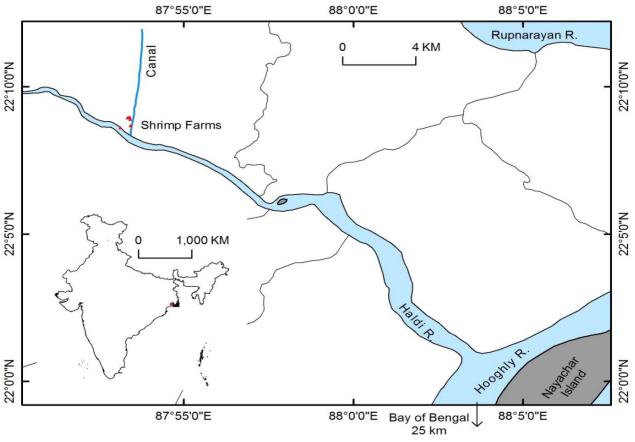

Figure 1. Location Map of Shrimp Farming and Adjacent Paddy Farms (Source: Prepared by ArcMap)

2.2 Data Collection

For collecting data, a primary survey was conducted with the help of interactive face to face questionnaire. Costs and benefits data were collected from a shrimp farm from their previous record books from the year of 2009 to 2018. Paddy farms which are situated beside the particular shrimp farms are considered for the study of externality of brackish water shrimp farming. Lots of other paddy farms have been converted into brackish water low depth ponds from paddy after leasing for shrimp farming. Production cost, benefits and other data (total production, market price, amount of production utilised for their own needs

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etc.) were collected from paddy farmers who are still cultivating at Shitalpur Paschim beside this shrimp farm. Here, these paddy farms are categorised according to their distance from the shrimp farms as follows:

(1) Proximal farm: Near to shrimp farm - within 100 meters and

(2) Distal farm: Far from shrimp farm - more than 100 meters.

2.3 Analysis

First of all, it has been tried to address the spatial pattern of the farm lands and their relationship with ecosystem services. This relationship has been described using a simple mathematical model described by Barbier (2012) with little modification in perspective of this study. By this model, the optimum width of coastal expansion can be measured theoretically, along with the difference of ecosystem services between coastal and inner land (non-coastal area) with respect to spatial variabilities.

By the production cost and benefits data from shrimp farm, Net Present Value (NPV) has been calculated at different discount rates. NPV is an economic methods dealing with discounting of future cash flows [6]. Net present value is the yield from goods or services of time series by subtracting the cost by discount rate. Discount rate is very vital and specific for each decision makers for projection of particular investment. Discount rate is rate of return at which the investor wants to derive the cost of money. Initially, the paddy farms were divided according to distance from shrimp farm, then the NPV calculation for paddy farms, average cost of production, average benefit of production have been estimated by calculating arithmetically according to year wise MSP (Minimum Support Price) of government.

The NPV of shrimp farm and both categories of paddy farms were detected to measure and compare their long lasting approach towards economic profitability [7]. NPV defines the net contribution to the economy of a particular investment. NPV is measured by the sum of year wise net benefit in term of the present value [8]. The formula of NPV is as follow:

$$NPV = [(B_0 - C_0) + \frac{(B_1-C_1)}{1+r} + \frac{(B_2-C_2)}{(1+r)^2} + \ldots\ldots + \frac{(B_n-C_n)}{(1+r)^n}] > or < 0 \quad (1)$$

Where, B is the category specific benefits over the year; C is the category specific cost over the year and r is the discount rate. For determine the social, environmental cost and benefit; discounting the events for the 'distant future' is very important for economic or eco-economic analysis. For this research with the concern with externality caused by shrimp farming has been tried to focus on discounting the payoffs of distant future. This is tricky task to standardise the discounting for the distant future with considering all right and wrong intuitionism [9]. The value of NPV can be greater than or less than 0. The greater than and less than value signifies investment prediction.

3. Observations & Discussions

3.1 Spatial Variability and Ecosystem Services

Derived gains of human society; from ecosystem functions, features and from cumulative interactions of these are known as Ecosystem Services [10] All the dimensions of human society from economic to political, from agricultural to cultural, from religious to developmental are directly or indirectly dependent or interconnected with various ecosystem services.

The characteristic features of an ecosystem are defined by different components, their properties, their assemblage and functioning. If all those ecological and environmental specificity determining factors are compared between different spatial locations, then spatial variability arises. From this context, it can be said that spatial variability depends of different physical properties (e.g. thermal conditions, humidity, soil texture, soil chemistry etc.), biological conditions (e.g. presence of different flora and fauna, microbes, planktons etc.), availability of different nutrients (e.g. litter deposition, nitrogen contents, and mineralization etc.) and others (e.g. weather history, anthropogenic activities etc.). Therefore, the distinctive services provided by any ecosystem differ from other ecosystems as variabilities exists in between all ecosystems from spatial to others determining sectors for example the brackish water shrimp farming flourishes in coastal parts of Purba Medinipur district of West Bengal due to its spatial location (presence of Bay of Bengal and suitable environmental conditions) but it cannot flourish at the inner most region of the same district (due to further distance from the Bay of Bengal and other spatial conditions which are not suitable for brackish water shrimp farming).

From the above-mentioned consequences of spatial variabilities it is clear that the different ecosystem services of different spatial location are intermingled outcome with spatial variabilities. In these aspects, the ecosystem services depend on spatial variability. Even spatial variability differs according to the temporal variations, i.e., the variations of ecosystem services are equally dependent on both spatial as well as temporal variabilities. The services provided by a particular ecosystem were previously considered as followed the linear pattern. Now it has been cleared that ecosystem services follow nonlinear pattern with relation to spatial and temporal

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variabilities [11]. In some consecutive effects, loss of ecosystem services and gradual shrinking of habitats create high risk of collapse on ecosystem.

Amendment in the Indian coastal Aquaculture Authority Act 2005, which stated that "area of land within a distance of two kilometres from the high tide line of seas, rivers, creeks and backwaters," would be classified as a coastal area. But the problem is that the saline water is canalized far beyond the coastal boundary to the inland fertile non-coastal regions at study area, Shitalpur. The canal beside the particular shrimp farm has been shown in Figure 1.

Therefore, it is very pertinent to understand up to which distance the coastal expansion can be optimum. The optimum level can be set by considering persistency of ecosystem services. Considering ecosystem services (*ES*) is the function of spatial variability (S_v).

$$ES=fS_v \quad (2)$$

From the proposed model [12], the idea of optimization of this expansion can be estimated. Suppose, if any social planner tries to preserve any landscape area which is denoted as (a). The expansion of boundary of the landscape toward sea defined as 0 and toward the main land as A. Considering maximum ecosystem services toward sea, social planner can estimate the optimal width of coastal landscape (W_a).

$$W(a) = \int_0^a (v-m)S(i)di + R(A-a) \quad (3)$$

Where, *(v-m)S(i)* is net benefit [v = value of the ecosystem service *S(i)*, m = cost of maintaining the ecosystem service *S(i)*] of ecosystem service *S(i)*. *R(A-a)* is opportunity cost of remaining location.

The Environmental and Ecological uniqueness of Purba Medinipur, which is exclusively suitable for shrimp culture, is majorly defined by convergence of freshwater rivers plains with Bay of Bengal. The presence of Bay of Bengal makes this area distinct from others region and the favourable condition for brackish water shrimp culture is also an ecosystem-services out-come of this region. Though ever-expansion growth of shrimp farming and manipulative semi intensive culture method are major detrimental agents of natural services, hence uncertainty exists in future of shrimp culture and drastic spatial variability with favourable ecosystem services out-come.

3.2 Comparison of NPV of Different Types of Investment

NPV is one of the major indicators for investment. It considers relativity of performances of investors. When the time horizon is fixed, depending on the discount rate a specific magnitude of NPV can be reached. What will be the future value of the money invested today? Or what amount of money should be invested to get certain future value? To answer this question, an investor should always measure present value. Present value can be estimated by discounting the future amount by certain interest rate. This interest rate is called discount rate. To set a perfect discount rate is crucial for NPV calculation.

Here, for comparison between the two categories of paddy farming systems NPV of both farms for equal time periods have been calculated. The basic similarity between two farms is with increasing farming shifting from paddy to shrimp industries; still they are doing paddy farming practice. The distance from shrimp farm is main dissimilarity among these.

In paddy farming, the maximum discount considered is 7%, as the farmers get government's loan with some other suitable subsidies at 7% interest rate. Here, to understand the reliability of nature of NPV, the entire calculations were carried out from minimum to maximum discount rate with some regular interval (at discount rate 1%, 3%, 5%, 7%) and the comparative result presented in Table no. 1. The time period has been considered 10 year unto 2018 and cost and benefits were standardised in equal margin of land amount and market price.

Table 1. NPV of two categories of farming system at different discount rate

Categories of paddy farms system	NPV at different discount rate in Indian currency (Rupees ₹)			
	1%	3%	5%	7%
Proximal farm system	130827.812	125198.633	120226.898	115812.345
Distal farm system	-27298.546	-21610.287	-16812.987	-12754.67

NPV has been calculated for the particular shrimp farm for same time horizon and equally standardised to maintain equality with paddy farms but here the maximum discount rate is 30%. As the shrimp farmers take loan from unauthorised sector (not have government authorisation). Here, the NPV of shrimp farming system has been estimated with maximum 30% rate and minimum 7% rate (the minimum rate is the maximum rate of paddy culture industry).

Table 2. NPV of shrimp farming system

Shrimp farming system	NPV at different discount rate in Indian currency (Rupees ₹)	
	7%	30%
	-17827189.43	-8441325.967

From above mentioned results of NVP, some of contradictory conclusion may be arisen. First of all, in case of shrimp farming system the NPV shows it is less

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than zero in both maximum and minimum discount rate. Hence, from this result it can be very clearly predicted that there is no such future profitability. In case of paddy farming system, the proximally located farm system has positive NPV values at all of the different discount rates but the distally located farm system has completely opposite result. The distally located farm has negative NPV at all of the different discount rates.

It is wide spread that intensive or semi intensive culture of brackish water shrimp culture always have some negative externality towards the native provisioning services [13]. Here, this unit study come up with completely contradictory results. With consideration of previously studied results, it was very natural prediction that due to the some detrimental effects of shrimp culture like saline water intrusion, unwanted exposure of certain chemicals used in shrimp farms etc., the NPV of proximal farming system should be negative and lower than the distal one. Here, the opposite and the contrast between the NPV results of these two farming systems indicate some probable possibilities behind this occurring:

(1) Might be some sort of positive externality of shrimp farming present on proximal farming. Or

(2) The proximal farming land or culture land of shrimp farming are itself much more fertile than the other parts but the lands are converted into low depth saline water bodies.

In support of first possibilities, it can be assumed that nutrients from shrimp farms which intrudes in adjacent paddy cultivation land along with water. This nutrients which are deposited, might have some enhancing effects on paddy production and which is yet to be explained by ecologically.

The second assumption has great chance of possibilities and can be easily supported by previous works which had been carried out at different parts of world. In this respect most suitable explanation was come by the following statement of J H Primavera (1997):

"When intensive farming is practised, the life span of ponds does not exceed 5-10 years because of attendant problems of self-pollution and disease. In some cases, entrepreneurs have moved on to other areas in a pattern called 'rape-and-run' and the sterile lands are no longer available for agriculture or aquaculture."

When any one compare different services values including all trading and non-trading values with before and after shrimp culture period of a particular ecosystem, then we can make some conclusions.

3.3 Externality and Shrimp Culture

The perception of externalities deals with analysis of connectivity of economic welfare. In existence of externalities costs and benefits of each individual may vary in respect of consequences of true social cost action in them. According to Pigou, externalities seem as one of the principal reasons of deviation among "private net product" and "social net product" [14]. In case of shrimp farming the holistic externality concept lies with assembling both social and ecological interfaces with economic welfare. Negative externality of shrimp culture had been repeatedly reported from different leading countries of aquaculture since after blue revolution occurred in the World. In south-east Asian countries (Sri Lanka, Bangladesh, India etc.) have been reported salinization and hardening of shallow well for domestic and farm land water supplies [13,15].

The trend of shrimp farming has negative externalities in terms of enrichment of nutrients in marine water and lead marine eutrophication, long term exposure of chemicals and toxic products cause changes in abundance of local non- target species, chance of creation of some invasiveness by introduction of exotic species, creation of extreme threats on mangrove ecosystem etc. The wide spread expansion of coastal shrimp culture is altering the multiservice functions provided by mangrove into fragmented ponds which has given some artificially driven production services and at the same time degrade the ecosystem [16].

The sustainability of shrimp culture as well as sustainable aquaculture refers the both ecological and economic sustainability. Both these sustainability scenarios are centred to the long run goal. In case of the semi-intensive or intensive method of shrimp farming the farmers adopted this practice because its high income is short period. For the illusion of high-income farmers neglected their farsightedness to measure its longevity. They are courageous to take the risk of huge investment and huge loss.

In this particular study, it is very difficult to draw any strong conclusion of positive or negative externality on the basis of assessment of the contradictory NPV values of both farming systems. To make such conclusion different ecological and environmental parameter and their interactive nature with all socio-economic behaviour must be investigated. Concept of sustainability with incorporation of shrimp culture and its externality must be studied with some implications of strong or weak sustainability concept.

4. Conclusion

This is a unit representation of entire ever-growing shrimp farming of Purba Medinipur. It stretches a scenario

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of condition of shrimp farming and paddy culture in future. In further extension of this study to understand the externality of shrimp farming NPV data of paddy farms adjacent to the shrimp farming region would be compared with the NPV of paddy farming region, situated completely out of the externality of shrimp farms. The value added by the altered practice from paddy to brackish water shrimp farming would be compared in next face of this work with the value added by the previous paddy culture practice. Ultimately the social cost would be estimated and incorporated in determination of actual cost and benefits of shrimp farming. In terms of social cost the ecological and environmental damages, ecosystem services alterations all would be integrated. Therefore, the holistic measurement actual cost and actual benefits of shrimp farming would be assessed. In the mean times; the externality of shrimp farming weather it causes negative externality or positive externality; would be cleared by this incorporation of social and ecological and environmental costs. Different ecosystem services valuation methods to measure both altered and actual service value is pertinent steps of this aspect.

Finally, this study and its extension would be the basic footsteps for implementation of policy which addresses the all externality of shrimp farming in this location to mitigate the problems.

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