

## ECONOMICS OF SUSTAINABLE AQUACULTURE IN ASIAN REGION: ISSUES REVISITED

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### ABSTRACT:

Empirical evidence shows that aquaculture plays a crucial role in ensuring food security, increased household income, alternative employment generation and increased foreign exchange earning in developing countries, especially in the Asian region. However, several issues relating to shrimp-aquaculture such as, risk and uncertainty of investment in shrimp culture, the issues related to the labour absorption and debate related to the possibility of local employment generation through shrimp culture, the institutional mechanisms and its role to promote sustainability of shrimp aquaculture, warrant for proper economic analyses. This being the case, the present paper looks into identifying and addressing some of these important issues, especially in the context of Asian aquaculture. The paper has two parts. The first part highlights the importance and implications of the issues discussed both at the theoretical and empirical levels. The discussion has been substantiated by results from case studies from Asian region in particular. Second part of the paper concentrates on the debate that has recently been raised on the negative environmental impacts of aquaculture especially shrimp culture in the developing countries. Some of the empirical evidences support that the negative externalities generated by the shrimp culture overrides its benefits and some literature contradicts it. But the core issue is how to estimate the social cost and benefits so that one could decide about who benefits or suffers and by how much. With the view to address this particular debate, the focus of the second part of the paper is devoted to the economic issues in estimating the social costs and benefits, issues related to compensation and sustainability issues associated with the shrimp culture within the environmental economics framework.

**Keywords:** Aquaculture, Asian region, employment generation, negative externality, social costs, economic valuation.

### INTRODUCTION:

Aquaculture has emerged as a means of alternative food security, employment generation and source of providing nutrition to the poorer section of the society especially in the developing world. Empirical records show that World aquaculture production has increased by 11% in quantitative terms and by almost 50% in value terms over the time period 1988 to 1997 [1]. Asian region occupies a major share in world aquaculture. The region provides 91 percent of global aquaculture production, where the top 10 Asian aquaculture producers are China, India, Japan, Republic of Korea, the Philippines, Indonesia, Thailand (also the top seven producers in the world), Bangladesh, Viet Nam and Korea[2]. In most parts of Asia, the aquaculture have been developed as a commercial activity. The possibility of higher yield has attracted higher private sector participation and the potential of this sector to act as a means of alternative employment generation, food security and rural development has encouraged state patronage towards this sector. The promotion of aquaculture has got a new dimension in the recent years. That is the sustainability issues related to this sector. The concept of sustainable development has emerged as one of the most discussed issue after the Brundland commission. 'Sustainability' is considered to be the long-term and difficult to achieve goal of reaching an environmentally socially and economically sustainable state. The processes by which this goal is approached are encompassed by the term 'sustainable development' [3]. Like any other economic activities aquaculture also has several negative and positive environmental and social impacts which demand attention towards sustainable development of that sector. The sustainability issue is more important in the context of commercial aquaculture rather than rural and traditional aquacultural practices, because they apply more intensified technologies and thus creating

more social and environmental unrest. In the context of aquaculture we can think of three kinds of sustainability.

**The economic or financial sustainability:** This should be achieved at the farm level by providing adequate and stable returns to the investment.

**The social sustainability:** In broader terms, the social sustainability reflects the relationship between the development and the current social norms. An activity is called socially sustainable if it conforms to the social norms or does not stretch them beyond the tolerance level of the society[4]. In case of aquaculture the social sustainability implies the culture practice should be acceptable to meet the general cultural, gender and social norms. That means the benefits should accrue to a wide socio-economic spectrum, not only to a small numbers of elites [5]

**Ecological sustainability:** the commercial aquaculture should be environmentally friendly.

But these three sustainability concepts are interlinked. In case of many development activities maintenance of ecological sustainability becomes complementary to economic sustainability and social sustainability. On the other hand in some cases the efforts to maintain economic sustainability hampers the social and environmental sustainability. The later case can be supported by the theory of externality<sup>1</sup> generated by economic activities. The unidirectional externalities<sup>2</sup> are more prone to create problems in the social and ecological spectrum associated with that particular economic activity. In this paper we will bring out the important economic and environmental issues pertaining to the shrimp aquaculture in Asian region and examine the debates related to these issues as evident from empirical evidences from the main shrimp producing countries in Asia. The issues involve the employment generation and the whole bunch of environmental and social impacts of shrimp aquaculture that are recently being highlighted. Moreover; the paper explores the possibility and importance of the economic valuation techniques to address these debates as well as serving the basis of policies promoting sustainable shrimp aquaculture.

#### **SHRIMP CULTURE IN ASIAN REGION:**

Asia plays a major role in farmed shrimp by producing almost 80% of the farmed shrimp in the total shrimp culture production [6]. Thailand, China, Indonesia and India are among the top ten producers of shrimp (Table I. shows the country wise picture of shrimp production in Asia). The production trend of shrimp continued to increase starting from 1980s driven by the high trade possibilities and high demand for shrimp from US and Japan. But in early 90s and late 80s several Asian countries faced collapse in their production. Taiwan in 1988 and China in 1993 faced this problem. The reason identified were the deterioration in farm water quality and poor farm management practices. Now the question is, did the farmers do any economically irrational farm behaviour in these countries by not adopting proper farming practices? The answer is evident in the global trade scenario of the shrimp. If Japan is excluded, Asia is a net exporter of shrimp and most of the shrimp exports are coming from the developing countries in Asia [2], fetching high export earnings. So, the farmers are inclined towards the short term gains which are in some cases high enough to ensure sufficient return to venture into some other occupations than shrimp farming. In the macro level also, governments promoted supports for expansion and intensification of these farming practices. But in the recent years the concern is shifting in Asia. The degradation of environmental quality both at the farm level and at the ecological level is becoming one of the major focuses of the policies towards shrimp sector. With the high level of importance in trade, commercial shrimp farming warrants attention in terms of the trade off between high level of economic gain and social and environmental negative externalities generated by the sector.

**Table I: The Country Wise Details of Shrimp Production in Asian Region**

Country	Production (tons)	Grow out area (ha)	Average production	Estimated no. of farms
Thailand	1,50,000	70,000	2134	25,000
China	80,000	160 000	500	8000
Indonesia	80000	350 000	229	60 000
India	40 000	100 000	400	100 000
Bangladesh	34 000	140 000	243	32 000
Vietnam	30 000	200 000	150	8000
Taiwan	14000	4500	3111	2500
Philippines	10 000	20,000	500	2000
Malaysia	6000	2500	2400	800
Sri Lanka	1200	1000	1200	800
Japan	1200	300	4000	135

From, Jory .D (1998), World Shrimp Farming in 1997. Aquaculture Magazine Buyer's Guide, 27: 32-41

## **THE ECONOMIC AND ENVIRONMENTAL ISSUES IN SHRIMP AQUACULTURE: REVISITED**

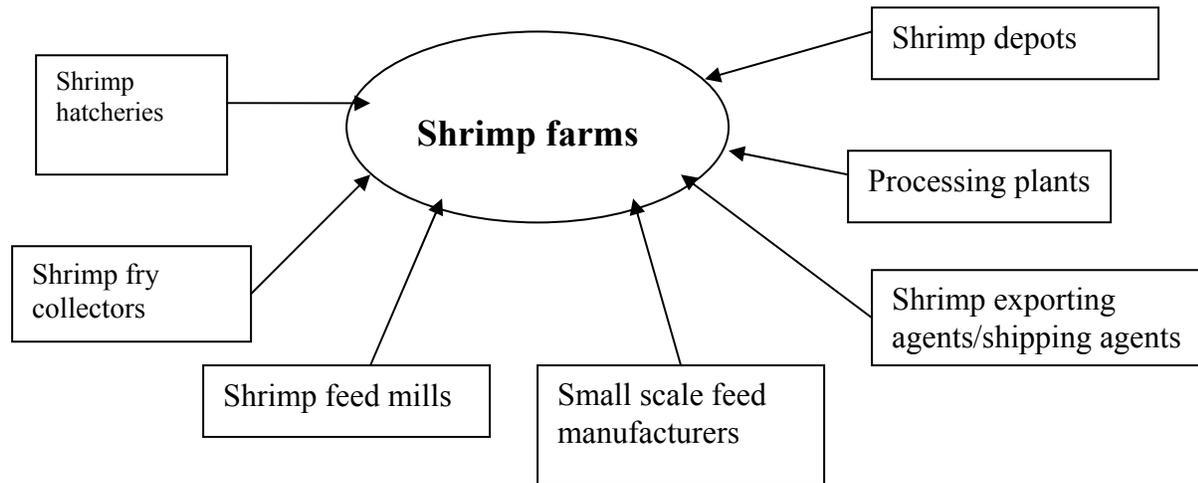
### **The Employment and Livelihood Issues:**

The economic benefits from shrimp industry can be manifold both for the national and local economy. At the national level the foreign exchange earnings and employment generation is much important. But at the local and regional level the socio-economic impacts together are the matters of concern. To understand the impacts on employment, we need to look into the sectoral components of this industry and the stakeholders associated with the industry. Though it varies across countries and farming practices, in general the sector consists of the sub-sectors and stakeholders as shown in the Figure 1.

Given this strong sectoral linkages the shrimp farming is expected to generate considerable amount of employment through backward linkage. The sector has indeed generated considerable amount of employment as evident from the literature.

The world wide commercial shrimp culture employs about one person per ton of produce i.e., approximately one million persons [7]. But this is the direct employment. The employment effect will be larger if multiplier effect is added. In many countries this multiplier effect has been calculated. Among the Asian countries, in Sri Lanka, the multiplier is one; for each direct job one indirect job is created [8]. The employment multiplier is quite higher in the developed countries like US where the secondary sectors are much more developed. The employment generation basically depends on the labour output ratio. The shrimp farming industry can have positive effect on the employment generation if it absorbs more labour per unit of output as compared to the other economic activities and if it offers considerably higher wages compared to other competing economic activities. A survey in Asia found that, wages on shrimp farms are two or three fold higher than the minimum rural wage [9]. Some specific studies in Thailand (which ranks first in world shrimp export) have revealed that the returns from the shrimp farming are more than

some alternative occupations. A survey in southern Thailand has placed shrimp farming in the second place in terms of the source of income [10]. In 1994, the Thailand shrimp culture



**Figure 1. The sectoral linkage in shrimp industry: A schematic diagram.**

industry employed around 97,000 people directly and 53,000 indirectly [11]. Scattered empirical evidences in the country level as well as in the regional level on employment generation provide a rationale to the policy-makers to promote and encourage the intensive shrimp farming in these regions as a means of alternative source of employment and reducing poverty by enhancing the living standards of the population as a whole.

But the debate revolves around the equity issues in this context. Contesting with the positive employment generation and wage increase the problem of social disparity exists. Large-scale evidences on the creation of social disparity due to shrimp farming practices are there in Asian countries. The disparity can be in terms of the increasing differences in income of the small and large scale farmers or in terms of increase in landlessness of the marginal farmers who can't invest in the highly capital intensive farming practices. Shrimp culture in various countries supports this argument. In Vietnam the farmers have reported increased landlessness and vulnerability due to the repeated crop failures and encroachment of the land by large farmers [12]. In Bangladesh the problem has been considered in terms of the centre-periphery framework by Rahman et al.[13]. They identified two kinds of conflicts between the outsiders and local people.

\*conflict between local and outsider shrimp farmers

\*conflict between local self employed and hired labourers

\*conflict between local and outsider labourers

The intrusion of outsiders in the local economy creates some positive effects as well. Those positive effects come in terms of the increase in land rents because of the increase in the demand for land. There are also long-term economic benefits. Land values often increase in areas where shrimp farming has gone ahead, providing added investment incentive and 'insurance' against financial losses in the event of crop failure. Land prices in Thailand Chant-aburi rose from 200 –500 baht/rai prior to shrimp farming, to 5,000 –10,000 baht/rai by 1990[14]. In spite of the demand driven increase in the land price the dominance of the outsider shrimp farmers both politically and economically sometimes compel the small farmers to give their land in a lesser rent [13].

Another important issue is the substitution of other agricultural activities by shrimp farming and loss of livelihood associated with that. Conversion of coastal agricultural land into shrimp farms is widely practiced in Asia. A study on the land-use types of shrimp farming in 12 Asian countries based on 5 000 farms revealed that about 30.0 % of the intensive farms were located in erstwhile rice fields, while it was 15.0 % for the semi-intensive farms and 14.1% for the traditional/ extensive farms[15].The alternative activities may be manifold. In Indonesia the shrimp farms were constructed by replacing milkfish production [16]. In some cases the local subsistence economy has been lost (as in Bangladesh) [17]. In Thailand, the salt production was the economic activity substituted by shrimp production. In general the investors consider the comparative economic returns of shrimp farms and other agricultural activities in the short run. But in case of intensive cultural practices, due to use of excessive chemicals and artificial feeds the irreversibility problem occurs. In this case the land sometimes becomes unsuitable for other uses especially for agricultural crops. This has caused the abandonment of large areas in Thailand, Indonesia and Vietnam where these intensive practices were mostly used. From an economists perspective one should look into the problem from the point of view of irreversibility of the land resource and develop methodologies to decide whether this kind of alteration in land use is economically viable in a long term perspective. The widely used cost -benefit analysis of alternative land use itself can take into account the irreversibility criteria as suggested by Krutilla- Fisher model[18].<sup>3</sup> In the context of the conversion of agricultural fields into intensive shrimp farms, adjustments for irreversibility of the agricultural land to its current use if developed as shrimp pond can be done by adjusting the net present value of shrimp culture. In this case, the development activity has to be considered as shrimp- farming and the conservation benefits should be as the benefits from the agricultural land overtime.

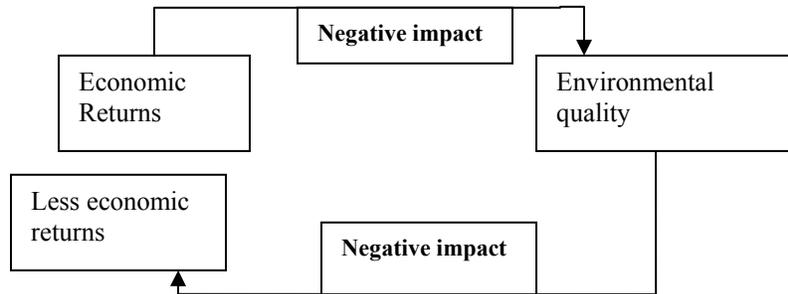
#### **The Interaction between Environment and Development: Evidences and Issues in Shrimp Aquaculture:**

The interaction between environment and development has widely been discussed in the environmental economics literature. Any economic activity has its own effects on the natural environment. On the macro-level the relation between the activities related to economic development of a country and its environmental quality has been tested with the environmental Kuznets curve as the base. At the local level, a large stream of debate relates with the conservation of natural ecosystems and its development for different economic activities. In the case of shrimp aquaculture especially in the developing country context, the conversions of natural ecosystems like mangrove and other wetlands <sup>4</sup> has become a major concern, which follows the second stream of debate mentioned above.

In order to discuss the interaction between aquaculture and the environment, it is essential to consider the environmental impacts related to aquaculture. These include the probable impact(s) of aquaculture operations on water, land and other resources required by the aquaculturists or other user groups. It is important to recognize that the impact(s) may be negative or positive. It may also be mentioned here that aquaculture can certainly contribute positively to environmental improvement in many ways, a fact often not recognized in many discussions on environmental impacts of aquaculture [19].

Aquaculture, as all agricultural enterprises, is natural resource based. The optimum and sustainable use of natural resources for aquaculture (and agriculture) can lead to profitable economic gains, although if badly planned and managed, it may also lead to short and long-term economic losses. Aquaculture can be considered as an integral part of the natural environment, and the interactions between aquaculture and the environment are inevitable. The major natural resources required for aquaculture are land, water and biological inputs such as seed and feed. In shrimp aquaculture also there is no exception and the impact comes from both the use of biological inputs and the land and water resource use. We can link the impacts using these natural resources with the issue of economic sustainability and the ecological sustainability. There is a strong linkage between the farming practices and environmental quality in aquaculture. It is so sensitive to environment that it can not sustain in degraded sites [20] .To maintain the high yield and return the farmers are not adopting the proper management practices. That deteriorates the inside environmental quality of the farm itself and thus affects the production of the farm in the long run in the

form of outbreak of shrimp disease etc. Thus there is a bidirectional relation between the economic returns and environmental quality as created by the problem of self-pollution, which can only be corrected through proper government intervention and standard setting for maintaining the environmental quality of the farms (Figure 2).



**Figure 2. Interlink between environmental quality and economic returns in intensive culture systems without proper management practices.**

The shrimp culture intervenes in the issue of maintenance of ecological sustainability (the effects of which are economically important) mainly in two ways. First, by the destruction of mangrove ecosystems due to conversion of these areas into shrimp farming and the problems related to degradation of land and water. Among them the non-availability of potable water for irrigation and drinking purposes due to over pumping of ground water and the pollution of the water bodies due to the effluent discharge by intensive shrimp farming practices are important.

The extent of mangrove area destruction due to establishment of shrimp farming is widespread in Asian region [21]. Though the empirical data on the destruction are scattered, but the problem is quiet evident. The mangrove area destruction due to shrimp farming is closely associated with the livelihood issues of the local people who sustain their livelihood by collecting timbers from mangrove forests, subsistence fisheries, honey collection, etc. The loss of these subsistence occupations due to conversion of mangrove areas has been a matter of concern because the mangrove areas are sometimes densely populated and the source of subsistence of the poor migrants. The other developmental activities also distort the mangrove forest ecosystems. But if the forestland is converted to agricultural use that does not hamper the subsistence population whose livelihoods are challenged by the capital-intensive shrimp culture.

The conversion of mangrove forests has other ecological implications as well. Mangroves act as a buffer to floods, cyclones, hurricanes, tidal waves and protect the life and property loss in the coastal zone. It functions as a nursery to the off shore fishery, the pollutants generated by upstream industries is also recycled in the mangrove ecosystems [21, 12]. Severe floods are often reported in Bangladesh and Vietnam. But one should reconsider the effect of the flourishing shrimp industries as a cause of that. That is why several agitations against the shrimp faming in developing countries are upcoming by non-shrimp farmers, which are also supported by the non-governmental organizations. Evidences are there from India, Bangladesh, Vietnam and Thailand [21, 12, and 14].

In Thailand saline effluent water and seepage from ponds have contributed to year-round salinisation of canals that were previously saline only in the driest periods. Though so many other reasons contribute to the land salinization, the main blame comes to the shrimp farmers [22]. There is a lack of scientific studies in this context to support this argument [23]. Empirical evidences from the coastal districts of India have nullified the shrimp farming on the salinity of the soil and water and proved that the effect of the domestic effluents are far more than the agricultural and domestic effluent discharge. This scientific

study reveals that the salinity problems are very less prevalent in India. Even the drinking water sources are not severely saline [23]. The social impact associated with the salinization problems are two fold - the non-availability of potable water for drinking as well as irrigation purposes and the salinization of the agricultural fields in the vicinity of the shrimp farms. Table II summarizes some of these impacts.

**Table II: The Negative Social and Environmental Impacts of Shrimp Farming**

<b>Action</b>	<b>Impacts</b>	<b>Results</b>
Shrimp products are exported	*Most benefits do not accrue locally	*No improvement in local diet, perhaps net protein loss  *Local communities do not develop employment or improve infrastructure
Coastal wetlands are declared national patrimonies	*Claims outstrip government's capacity to manage resources or even ensure that claims are honored	*Widespread encroachment on public-sector property leads to displacement of artisan fishermen and others dependent on fisheries resources
Excessive collection of post-larvae and egg-laden female shrimp	*Declining shrimp population along coastline  *By-catch is reduced	*Loss of income for fishermen  *Massive loss of shrimp and fish stocks
Clearing mangroves	*Loss of natural mangrove Products (fuel wood, poles, fish etc.)  *Destruction of shrimp and fish nursery grounds	*Loss of income and subsistence products for local population  *Lower productivity, lack of seed stock
Construction of shrimp ponds in former mangrove areas	*Displacement of rural coastal communities	*Loss of income for those who traditionally depend on mangrove resources

From Clay (1996)

**The Methodologies in Environmental Economics: How Helpful they are to Estimate the Economic Losses due to Shrimp farming?**

The empirical literature provides mixed evidence of the damage from shrimp farms via its negative impact on environment. But still the unresolved issue where economics can look into is the question of compensating the losses. To decide the compensation the quantification of these losses are important which can be dealt with economic valuation. The assessment of the environmental impacts and the methodologies adopted to assess them should be area specific. The methodologies should consider the types of farming practices and the size of the holdings as well. For example- in the countries like India and Thailand small farmers own most of the farms. So in this case the farm wise environmental impact

assessment may not serve the purpose. Instead, an overall system assessment is required either taking the shrimp farming regions as a whole or by ecological zones; for example the mangrove areas or coastal zones. Some studies have done this and come out with important decisions in the Asian region. An important example is the cost-benefit analysis conducted in Thailand in the mangrove areas of Surat Thani. The study had used the opportunity cost approach to calculate the money value of income lost by the local inhabitants due to mangrove destruction. The study also had included the indirect valuation of the indirect use values of the mangrove ecosystems in the calculation. Taking into account the marketable products only net present value (NPV) per rai (6.25 rai = 1 ha) of a commercial shrimp farm was far higher than the NPV of a rai of mangrove forest - US\$ 3 734 against US\$ 666. But after including the indirect benefits, the NPV of mangrove forest far exceeded the NPV of commercial shrimp farms [22]. The result is highly dependent on the discount rate chosen. In India based on the Supreme Court's order a cost-benefit analysis on the shrimp farms of Andhra Pradesh and Tamil Nadu was conducted. The study revealed that in Andhra Pradesh, the social and environmental costs outweighed the economic benefits by a ratio of four to one whilst in Tamil Nadu the losses were one and a half times greater than the economic gains [24]. In Bangladesh by comprehensive cost-benefit analysis the opportunity loss in terms of the alternative house hold alternative has been captured [17]. The study reveals that while shrimp farming brings fortunes to some, it incurs significant loss of opportunities for almost every household. The opportunities lost include those for rearing poultry and livestock, growing fruit trees, kitchen gardening, culturing fish in homestead ponds, availability of cow dung and firewood for fuel, and access to fresh drinking water. A study in Malaysia has concentrated on the loss of the fishermen community and recorded a loss of 1/6<sup>th</sup> of their total income due to mangrove destruction within 2-3 years of large-scale mangrove clearance. In Thailand, it has been estimated that for every kg of shrimp produced, 434g of fisheries are lost due to habitat conversion alone. While in the Chokoria region of Bangladesh, fishermen have reported 80% decline in catches since mangrove destruction and creation of dykes for shrimp farming [12].

From the above review it is clear that most of the studies have attempted the estimation of economic loss either from a particular stakeholder's perspective or focused on a particular problem. But an integrated approach to consider the overall estimation of the net benefit of shrimp farming by social cost benefit analysis is necessary. This necessitates the identification of each subcomponent of the benefits and costs on local basis and appropriate choice of discount rate. In this kind of analysis demands special weight attached to each of the economic benefits i.e., the benefits should be evaluated at social prices.<sup>5</sup> For example: to evaluate the employment benefit from shrimp culture in terms of the accounting price of labour to account for the level of unemployment in that particular region. In the cost-benefit analysis conducted by Supreme Court of India, the foreign exchange earnings were given special premium. But still the cost-benefit analysis has its own limitation and it should not be a decisive criterion to choose between alternatives. The cost-benefit analysis despite having its foundation on the welfare economics, do not take into account the distributive and equity aspect of the problem. In the context of impact of shrimp farming, the equity aspects are quite important as evident from the literature because it hampers the interest of different stakeholders in different manner. So, one has to find alternative methodologies for taking policy decision. In the literature the preference based methodologies are quite popular now a days for addressing environmental problems. The multi-criteria analysis is one of them.

Cost-benefit analysis follows the priorities of the market. The costs and benefits are derived either from the direct market prices or by indirect market prices elicited by the contingent valuation technique. The maximization of economic efficiency remains as the baseline policy objective of the policies designed on the basis of cost-benefit analysis. But multi-criteria analysis is based on the preferences of the decision makers. The decision-making regarding environmental problems involves conflicting interest of different groups. The multi-criteria methods are preferable in the question of addressing the sustainability issues as well. Cost-benefit analysis assumes substitution between manmade and natural capital [25]. If the substitution is not possible in case of irreversible effects, cost-benefit analysis will always lead to the unsustainable solutions. But the weak and strong sustainability concepts can be operationalized in the

aggregation procedures of multi-criteria analysis [26] Keeping these points in mind, one may advocate the multi-criteria analysis as an alternative for policies to promote sustainable shrimp culture. The shrimp culture leads to the deforestation of mangroves, which is an irreversible change. The destruction of mangroves also leads to conflicting interests of the stakeholder. In this case the multi-criteria matrix can be framed as suggested by Alier [22]. The matrix is as follows:

*Criteria*

<b>Bio-mass Production</b>	<b>food security</b>	<b>cultural values</b>	<b>coastal defense</b>	<b>landscape values</b>
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*Alternatives*

- 1) **Keep mangroves**
- 2) **Grow shrimp**
- 3) **Other alternatives**

The above discussion deals with the methodologies helpful to address the sustainability issues from a holistic point of view. Various valuation techniques are applicable to estimate the effects of externalities separately. These estimates can be assembled together in the holistic analysis. For example: if the problem is the salinization of agricultural land in the vicinity of shrimp farms the hedonic pricing method can be applied along with the valuation of direct loss in agricultural productivities. The basic logic behind applying this method is to test whether the property value decreases as a result of increase in the salinity level of the agricultural farm. In order to apply this method the data on the land prices of the plots in the vicinity of the area concentrated on shrimp farms are required. The salinity levels of the plots are also necessary. In case we don't get the salinity data, the level of salinity can be used as a dummy variable in the estimation of the hedonic price function<sup>6</sup>. In fact the use of this methodology can help us to estimate the loss due to increase in salinity of land due to shrimp cultivation. Similarly the water contamination of the freshwater sources can be addressed by applying contingent valuation technique. In the following table (Table 3) the nature of the problem and the techniques to measure them under environmental economics framework has briefly been chalked out.

**Table III: Externalities Generated by Shrimp Farming and the Tools to Measure Them**

<b>The nature of the problem</b>	<b>Possible tools that can be used</b>
The mangrove area destruction 1) loss of income to the local people 2) bio-diversity loss 3) the loss in terms of off-shore fisheries(because mangrove acts as a nursery ground to the offshore fisheries) 4) loss of indirect-use values of mangroves (e.g. buffer to floods, typhoons etc.)	*Opportunity cost approach *Contingent valuation method *Production-function approach  * Averting expenditure method , by measuring the costs to prevent those natural calamities
Non availability of safe drinking water due to effluent discharge from the shrimp farms	*The averting expenditure method *Contingent valuation method applied in the context of better quality water
Loss due to salinization of adjacent land 1) loss in agricultural productivity 2) change in the value of land	*Money value of the reduction in agricultural produce *Hedonic price method,

**CONCLUSION:**

The paper brings out various economic, social and environmental dimensions of shrimp aquaculture and the controversies revolving around them. The empirical evidences of these effects vary across countries and across culture practices. Though there are policy decisions to promote sustainable aquaculture through zoning and banning of the shrimp farming practices in Asian countries, the basis for undertaking these policies are to be strengthened by adopting economic valuation techniques. In this context the paper critically evaluates the alternative methodologies like cost benefit analysis and multi-criteria analysis as a basis for policies. The paper also gives an insight on the use of different environmental economic tools to take care of the various kinds of externality problems created by shrimp farming practices.

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## ENDNOTES:

<sup>1</sup> Externality is broadly defined as the side effect that occurs when people undertake activities without mutual agreement

<sup>2</sup> Externality has been classified by Dasgupta in two categories-the unidirectional and the reciprocal. Unidirectional externality is characterized by one sided externalities. For example the pollution created by the upstream factories to the down stream farmers. Whereas the reciprocal externality pertains to the common property resource extractions, like over fishing in the sea etc. See Dasgupta ,P.Shaymsundar and Maler,2004,The Economics Of Environmental Change And Pollution Management-Issues And Approaches From South Asia *Environment And Development* 9,pp.9-18.

<sup>3</sup> The Krutilla-Fisher model treats the irreversible cost as a financial perpetuity. The present value of such perpetuity is found by multiplying it by inverse of the discount rate. Thus the preservation benefit foregone into perpetuity are included into the net present value expression. The net present value of an irreversible development with initial cost C, development benefits  $D_t$  and preservation benefits foregone of  $P_t$  is given as

$$NPV_D = -C + \frac{D_t}{i - g} - \frac{P_t}{i - r}$$

The denominators contain the discount rates. Where  $i$ = Discount rate,  $g$  is the growth or decay rate of development benefits and  $r$  is the rate of growth or decay in the preservation benefits foregone.

<sup>4</sup> Wetland whose ecosystem balance and biodiversity loss due to shrimp culture has become a matter of concern includes Chilika lagoon in India and Tam Giang lagoon in Vietnam.

<sup>5</sup> In an economy characterized by market imperfection, monopoly profits, institutional constraints, fiscal policies and other regulatory measure, also distort factor prices. So, market prices do not reflect the scarcity value of the inputs or the social value of output. Though actual computation of the social or shadow price is difficult, some usable estimates can be provided

<sup>6</sup> The hedonic pricing is included in the revealed preference methods in the environmental economics literature. This method uses property value data as a source of information in order to estimate the benefits from controlling the environmental disseminates like air pollution, water pollution etc.

Suppose A is a site with higher environmental quality than site B

Then , it is expected that  $PLA(X,N) > PLB(X,N)$

The hedonic pricing function can be written as:

$$PL = PL(X, N)$$

Where PL: Price of the property

X: vector containing the variables related to the structural characteristics

N: vector containing variables related to the environmental quality associated with the property

The two basic steps in hedonic pricing method:

a) To estimate the implicit price of the particular environmental quality.

b) To estimate the demands function for that environmental quality by regressing the implicit price on the variables like income etc.