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An Economic and Environmental Analysis of Shrimp Farming Industry in Sri Lanka

Sampath Jayasinghe

INSTITUTE OF POLICY STUDIES
99 St Michael's Road, Colombo 3, Sri Lanka

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Institute of Policy Studies
99 St Michael's Road, Colombo 3, Sri Lanka
Tel: +94 1 431 368, 431 378 Fax: +94 1 431 395
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Abbreviations

ADB	Asian Development Bank
ASEAN	Association of South East Asian Nations
BOI	Board of Investment
CEA	Central Environmental Authority
DFCC	Development Finance Corporation of Ceylon
EDB	Export Development Board
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization
NWP	North Western Province
NARA	National Aquatic Resources Development Agency
NDB	National Development Bank
NACA	National Aquaculture Center for Asia-Pacific
NGOs	Non Governmental Organizations
PEA	Provincial Environmental Authority
ROW	Rest of the World
SIDA	Swedish International Development Authority
US	United State of America

Abstract

This paper discusses the benefits of intensive farming of the giant tiger prawn Penaeus monodon in Sri Lanka in relation to the environmental costs. Shrimp farming has developed from scratch to a formidable position in terms of the volume and value of output and its contribution to the country's foreign exchange earnings, within a short time span of one and a half decades. The shrimp farming industry has gradually developed into a position of pre-eminence within the fisheries and aquatic resources sector. The industry has generated 8,000 direct employment while around 40,000 people have benefited from indirect employment created by shrimp farming in rural areas. The industry has contributed significantly to the development of the physical and social infrastructure facilities in the coastal villages in the NWP.

The expansion of the shrimp industry in the NWP, while bringing economic benefits, has also created environmental problems. After years of uncurtailed exploitation, the renewable resources and productivity of the coastal ecosystem in the Puttalam district have come under severe strain. Destruction of the mangrove resources, declining water quality of waterbodies in the shrimp farming zones, salinization of soil and water, indiscriminate disposal of solid waste, excessive extraction of groundwater and self pollution have contributed to environmental degradation and a decline in natural productivity of the area.

There is much resentment on the part of the local community, as their traditional user rights are no longer respected and their legitimate beach-based activities have been hampered by the shrimp industry. Consequently, several resource user conflicts have emerged and these have been accompanied by much social strife in the area. The current situation with shrimp farms in the NWP can be seen as yet another example of the state allowing and assisting in common property resources being converted into private property. The paper concludes with recommendations for improving the North Western Province and general recommendation for a national shrimp policy.

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This study owes its conception to the initiative of Dr. Saman Kelegama (Executive Director, Institute of Policy Studies) and sustained by the interest and support of Shamen Vidanage (Head/ Economist, Socio-Economic Division, NARA). The author also wishes to acknowledge the contribution of the research staff of the Institute of Policy Studies who have generously given of their time and insights about the study.

1. Introduction

With the increasing recognition of the decline of the world's fisheries resources (Parfit, 1995), it is apparent that aquaculture will have to expand if the increasing demand for fish and shellfish products is to be met. Aquatic animal husbandry has been growing much faster than capture fisheries and various kinds of livestock husbandry. Cultured finfish, shrimp, mussels, and oysters are increasingly replacing those harvested from marine resources. Farmed shrimp made up only 6 per cent of total world shrimp production in 1980. With the advances in technology, farm shrimp production increased to 920 thousand metric tons, accounting for 30 per cent of world shrimp supply in 1994 (Ling *et al*, 1996).

During the past two decades, shrimp farming has become a multi-billion dollar industry which has created not only hundreds of thousands of jobs but also much needed foreign exchange earnings in many of Asia's developing countries. The tremendous growth of the Asian shrimp farming industry is primarily due to the presence of a large number of natural advantages. These include the availability of suitable coastal sites, appropriate climate, technological breakthroughs in shrimp feed and hatchery, efficiency in the management of grow-out operations, and the governmental supporting promotion and planning programmes. Shrimp farming in countries such as India, Indonesia, Sri Lanka and Thailand has developed because of the relative cheapness of coastal land, the poor regulatory framework governing land use and titling, the eagerness of local and foreign investors to make profit, and the seemingly insatiable desire for shrimp eating among consumers in affluent countries like Japan, the US and the European Union.

The shrimp industry in Sri Lanka has become a promising foreign exchange earner to the country. The private sector, without any government support and an overall development plan, has initiated and established the industry in the North Western Province (NWP) of Sri Lanka. There has been a rapid expansion of the industry in the NWP in the recent past. As with other kinds of development, the boom in aquaculture has been accompanied by questions concerning the social and ecological ramifications of this process. The

dramatic failures of shrimp farms in the NWP within the last five years have raised concerns about the sustainability of shrimp aquaculture, in particular semi-intensive and intensive farming. In fact, the concerned NGOs have often, quite rightly, campaigned against the industry's negative impacts on mangrove systems, its salinisation of waterways, and its transformation of coastal ecologies in both the NWP and the Southern Province.

The economic and environmental analysis of shrimp cultivation in general is well established and numerous research studies have been done in other Asian countries. Primavera (1991 and 1994) and Delwalt *et al*., (1996) provide a good analysis on the issues involved with respect to their countries of concern. Ben Yami (1986), a FAO fisheries expert, points out that commercial shrimp culture, like any other industry, should be evaluated in terms of its economic, social and environmental impact. However, little work on the industry has been carried out in Sri Lanka.

This paper presents an economic and environmental analysis of shrimp farming in Sri Lanka. The paper is in four parts. Chapter 1 gives a background of the shrimp farming industry in Sri Lanka. This includes a review on the different shrimp culture systems, past developments and present status of the shrimp industry in Sri Lanka. Chapter 2 presents a comparative economic analysis of the shrimp industry in Sri Lanka. This includes an analysis of comparative advantage and productivity of shrimp farming in Sri Lanka, as well as an analysis of relative profitability of the farms. Chapter 3 discusses in detail the issues directly connected to the shrimp farming industry in Sri Lanka whose sustainability is at question. Emphasis is placed on the impacts on environmental and socio-economic impacts. Chapter 4 presents concluding remarks. Chapter 5 focuses on recommendations for promoting long-term sustainability of the industry.

Chapter 1: Overview of the Shrimp Industry

1.1 Shrimp Farming Systems

Shrimp and prawns are swimming crustaceans. They inhabit the warm marine waters of the tropics and subtropics. Belonging to the family *Penaeidae*, their complex life history starts in nearshore water where ripe females spawn eggs which hatch into free-swimming larvae. These metamorphose through a series of stages into post-larvae, which move towards nursery habitats along the coastline and estuaries. Here they develop into further juveniles and subadults until they take reverse migration to offshore water. This life cycle is typical for most penaeids although a few species are able to complete the cycle in purely marine or estuarine water. Among 300 species of penaeid shrimp known worldwide, only a few dozen are commercially important in capture fisheries. Among the leading cultured species, the giant or black tiger prawn, *Penaeus monodon* has increased its share in global production from 33 per cent to 56 per cent and the Ecuador white shrimp *P. vannamei* from 14 per cent to 19 per cent, whereas the Chinese white shrimp *P. chinensis* has declined from 28 per cent to 6 per cent in the last five years (Rosenberry, 1993).

The culture of shrimp is basically a two-step process. First, it is composed of a broodstock-hatchery phase for producing seed or post-larvae. Second, there is a grow-out phase usually in earthen culture ponds for ongrowing of post-larvae to marketable size. When industry is highly developed, specialization includes farmers, processors, hatcheries, manufactures of farm equipment, formulated feeds, spawner collectors, private consultants, services for pond cleaning and harvesting, etc. Because of the volumes of shrimp harvested and amounts of water utilized, it is the grow-out phase that generates most of the profits and problems in shrimp aquaculture. Aquaculture is based on the conversion of a low value product (shrimp feed) to a high value product (shrimp meat).

Grow-out or farming systems for shrimp are classified into four categories--traditional, extensive, semi-intensive and intensive. This classification is characterized by increasing stocking density supported by corresponding feed and water management. Extensive

farming technique uses large ponds, low density of Post-Larvae, low level of feed and lesser inputs to grow relatively larger shrimps over a longer period of time (up to six months). The intensive technique uses very high density of Post Larvae, formulated feed, aeration, water management and shorter cropping cycle to grow slightly smaller shrimp. Majority of the shrimp farms in Sri Lanka can be classified under semi-intensive and intensive levels. More than 90 per cent of the farms are operated at semi-intensive levels.

1.2 Past Development Trend

In the fisheries sector, shrimp farming was identified as one of the most promising investment opportunities largely because the shrimp farming industry had proved to be a highly lucrative industry in many developing countries in Asia and Latin America. Until the 1960s, the shrimp industry in Sri Lanka was entirely confined to the capture of wild shrimps from lagoons and estuaries. Commercial shrimp farming in the country actually started in the Eastern Province in the late 1970's, but the civil disturbances in the area totally disrupted it preventing any consolidation of those pioneering efforts. Eventually, the coastal belt in the North Western Province (NWP) became the hub of the shrimp farming industry. This was due to a number of favourable factors such as the very high surface water to land ratio, the desirable salinity levels and regular exchange of fresh and salt water, the availability of fairly large tracts of land generally considered unsuitable for agriculture, and the Dutch Canal and lagoons that serve both as the source of water for shrimp farming, as well as acting as sinks for their waste and effluents.

This industry has been entirely private sector operated. The private developers sought assistance from the government to allocate state-owned land identified by them as being suitable for farming. With the demand for such land on the increase, and in the context of the growing awareness of the government for the protection of the environment, the Ministry of Fisheries and the Central Environmental Authority (CEA) appointed an inter-ministerial committee to carry out a scientific appraisal of the proposed projects in 1986. Under the recommendation of this committee, government started to release lands to developers on a 33-year lease at a nominal lease rent.

The industry grew gradually since 1985. The number of investors kept on increasing steadily as they considered shrimp farming as a very lucrative investment. There was a phenomenal growth after 1990 both in terms of the number of farms as well as the extent of land brought under this activity. Withdrawal of government patronage for inland fisheries during the period 1989-93 and shortcomings of the government mechanism in monitoring the industry in a proper manner led to unplanned development of the industry. A large number of farms set up in this phase were unauthorized farms and most of them were set up in mangrove areas, salt marshes and on the lagoon and canal reservations or whatever state land that was available.

Professional businessmen with high financial standing started the industry with technology from Taiwan and later from Thailand. High secrets of the technology of intensive shrimp farming became open to the people in the coastal belt who had resources to commence farming at both the micro and macro level. Even after the 1994 Elections, with the present government renewing the patronage, the industry continued to expand. Haphazard development coupled with over exploitation of water resources finally resulted in spreading deadly viral diseases such as white spot and yellow head, causing immense financial losses and social problems in the NWP.

1.3 Present Status of Shrimp Farming Industry in Sri Lanka

At present, almost all-existing farms are located in the NWP in the Puttalam District. This district includes Chilaw, Mundel and the Puttalam lagoon (see Figure 1). The main shrimp aquaculture development has taken place in the coastal belt covering an area of around 3940 ha and 70 hatcheries (Siriwardene, 1999). All the shrimp farms in the NWP are operating under semi-intensive farming systems and rely on supplementary feed and the majority of them also resort to aerating the ponds. The only species used for culturing is *Peneaus monoden*. The current status of the shrimp farming industry in the NWP in terms of the number of farm units, their size in terms of the extent of land are given in Table 1.

Table 1
Extent and Size of Shrimp Farms in the Puttalam District -1999

Size	Authorized		Unauthorized	
	No of farms	Extent (ha)	No of Farms	Extent (ha)
> 2 ha	491	547.4	525	792.7
2.0 – 4.0 ha	102	370.8	78	414.6
4.0-10 ha	60	364.4	32	275.3
10.0-20 ha	34	413	06	73
20 ha <	16	688.3	0	0
Total	**703**	**2384.0**	**641**	**1555.6**

Source: Siriwardene, 1999.

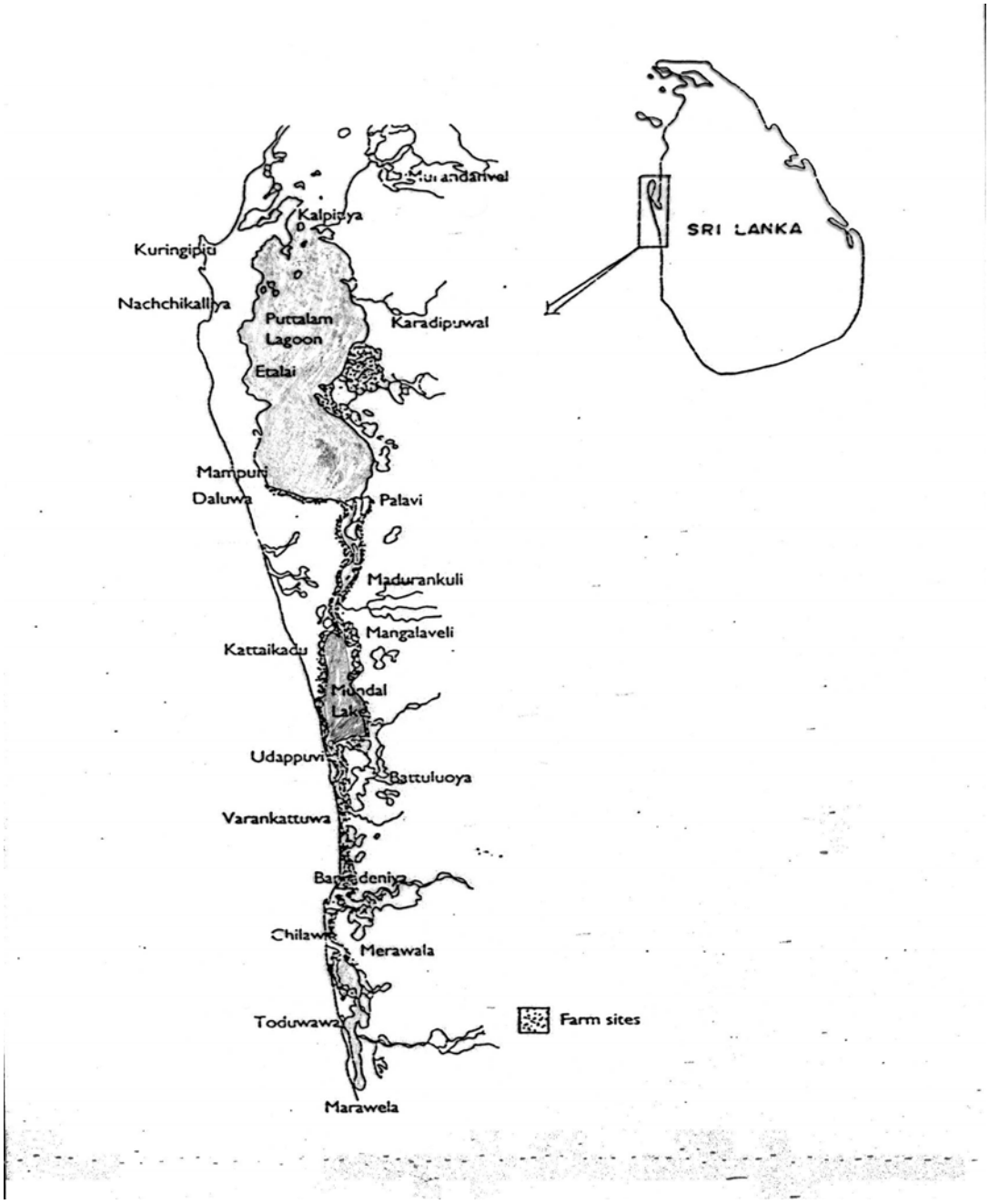
Of the total of 3,940 ha of farm area, ponds occupy an area of 2,760 ha. Of the total 1,344 farm establishments, 47.7 per cent is considered as unauthorized establishments (Table 1). The unauthorized shrimp farms occupy 39.4 per cent of the total area under farming. Of the 641 unauthorized farms, 82 per cent are less than 2 ha in extent. According to Fernando (2000), the shrimp farming in the NWP started on medium scale but has now got firmly established as a predominantly small-scale activity. As nearly 48 per cent of all farms are unauthorized and illegal, their farm lay-outs are not planned on a scientific basis. Furthermore, they have not been subjected to a management oriented appraisal process carried out by the inter-agency Committee of the CEA, the Ministry of Fisheries and Aquatic Resource Development (MFARD), and the Provincial Environmental Authority (PEA).

According to the MFARD, there are at present 70 shrimp hatcheries in operation in Sri Lanka. Up to 1994, there were only eight shrimp hatcheries producing post-larvae required for grow-out farms. When the farming area began to increase, these hatcheries could not meet the requirement of post-larvae. Therefore, the farmers began to import post-larvae, mainly from Thailand. During this period, the white spot disease of shrimp caused by the systemic ectodermal and mesodermal baculovirus (SEMBV) was prevalent in several Asian countries (Hettiarachchi, 2000). In order to prevent the introduction of

this disease, the government banned the import of post-larvae in 1994. Although the disease could not be prevented, the ban had a positive impact on the industry since it catalyzed the development of the domestic shrimp hatchery industry. At present, shrimp hatchery operators have the capacity to produce the country's entire requirement of post-larvae. Almost all hatcheries are located in the farming area. Out of the 70 hatcheries, only about 40 have been approved. With the exception of 5, they can be categorized as small-scale hatcheries. According to Fernando (2000), the hatcheries are said to have an annual installed capacity of around 750 million of post-larvae. However, estimated annual demand from the farms is around 250 million of post-larvae.

According to the Sri Lanka Shrimp Exporters Association, there are 16 marine product-processing establishments primarily in support of the shrimp farming industry. These processing plants are primarily dependent on the production from shrimp farms in the NWP. According Fernando (2000), the total installed capacity available for the processing of shrimp would be around 17,000 metric tons per annum. However, the highest quantity of shrimp processed during last five years was around 5000-6000 metric tons per annum. This alone shows that there is under utilization in capacity of both shrimp hatcheries and processing plants.

Figure 1: Shrimp Farming Area in North Western Province



Source: Senarath and Visvanathan, 2001.

Chapter 2: Comparative Economic Analysis

2.1 Status of World Shrimp Production

As a highly priced seafood delicacy, farmed shrimps are a cash crop grown mainly to cater to the affluent markets in the developed countries. Production of farmed shrimp has grown at a phenomenal rate of 20-30 per cent per year in the last two decades. The major share of the increase in world shrimp production over the past few years was the result of rapid expansion of the world cultured shrimp industry. Cultured shrimp, accounting for only 177 thousand metric tons or 9.2 per cent of the world shrimp production in 1984, had increased to 921 thousand metric tons with a share of 29.9 per cent in 1994 (FAO, 1994). Traditionally, wild catch is the major source of supply. However, the supply trend shows that landings of wild catch shrimp have declined in the past decade. The major concern has been the maximum capacity of wild stock and its harvest close to full capacity (Ling *et al*., 1996). There was a more than 420 per cent increase in aquaculture production from 1984 to 1994. With advances in shrimp farming techniques as well as the growing demand for high value shrimp, the role of aquacuture shrimp in relation to the global supply will become increasingly important.

Table 2: World Production of Shrimp 1998

	Production (Mt)	As % of the World
Asia	**2,694,809**	**70.40**
South Asia	484,656	12.66
Sri Lanka	6900	0.18
ROW	**1,132,528**	**29.59**
World	**3,827,337**	**100**

Source: Aquaculture Production Statistics, FAO, 1998.

The largest increase in aquaculture shrimp production has been in Asia and Latin America, particularly in Thailand, Indonesia, China, the Philippines, and Ecuador. Table 2 presents the world shrimp production by Asia and the Rest of the World (ROW) in 1998. Asia was the largest cultured shrimp-producing region, accounting for 70 per cent

of total world production in 1998. Sri Lanka's contribution to world shrimp production in the same year was less than 0.2 per cent.

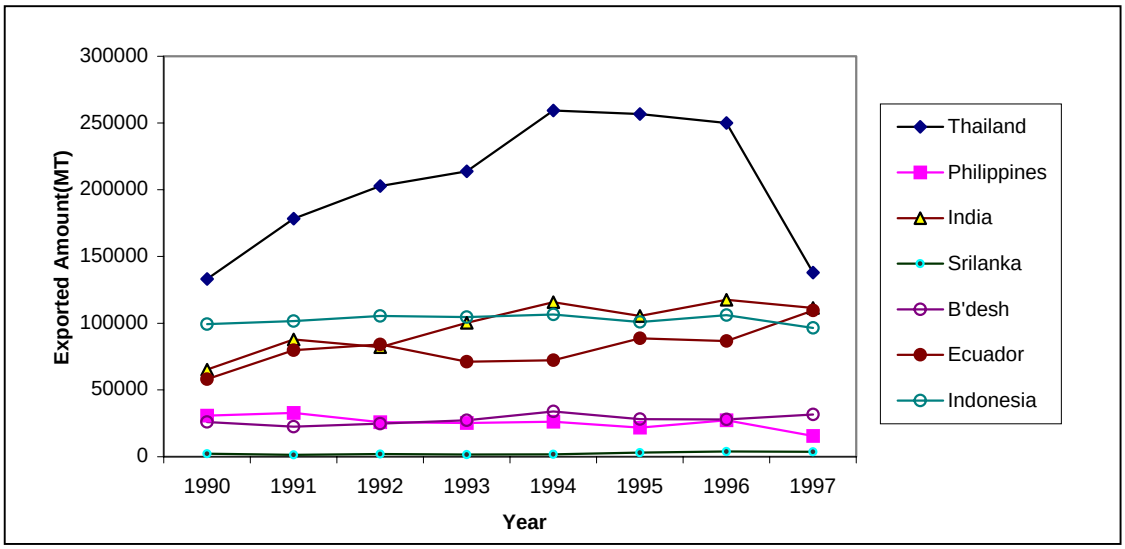
2.2 World Shrimp Trade

Frozen raw shrimp is the most popular commercial product in the international market, and accounted for about 95 per cent of world trade in frozen, fresh, or chilled shrimp products in terms of volume for the past decade. Frozen raw shrimp do not require further value-added processing and are normally exported directly to the international market by producing countries. The global trade of shrimp is a one-way flow, from tropical developing countries to developed industrial countries. For most Asian countries, revenue from shrimp exports was an important source of foreign exchange earnings in the 1980s and 1990s. The leading exporters are in the Asia-Pacific region while the major markets are Japan, US and the European Union.

According to the region of shrimp farming, the ASEAN (the Association of South East Asian Nations) was the most important exporter of frozen shrimp with a market share of 40 per cent in the last decade. Figure 2 presents shrimp export trends in major exporting countries during the period between 1990 and 1998. Within ASEAN, Thailand was the top world cultured shrimp exporter enjoying a very significant market share of around 21 per cent of world exports. Indonesia was the second largest exporter and its market share increased to 12 per cent. Sri Lankan shrimp exports have increased steadily but its export share in the world market is insignificant. Ecuador is the main shrimp exporter in Latin America. However, viral and other diseases have caused severe reduction in shrimp exports in a number of major producing countries, particularly in Thailand and the Philippines during 1995-96.

Around 90 per cent of world frozen shrimp imports in terms of value are by the developed world led by Japan followed by the US and the European Union. Although per capita consumption of shrimp lags behind that of Japan (3.3 kg) and the US (1.3 kg), the European Union as a trading block was the third largest shrimp importer and is the fastest growing market. The most significant change in the import structure of frozen shrimp in the European Union has been the emergence of warm-water cultured shrimp from Asia.

Figure 2: Trends in Shrimp Exports by Major Countries



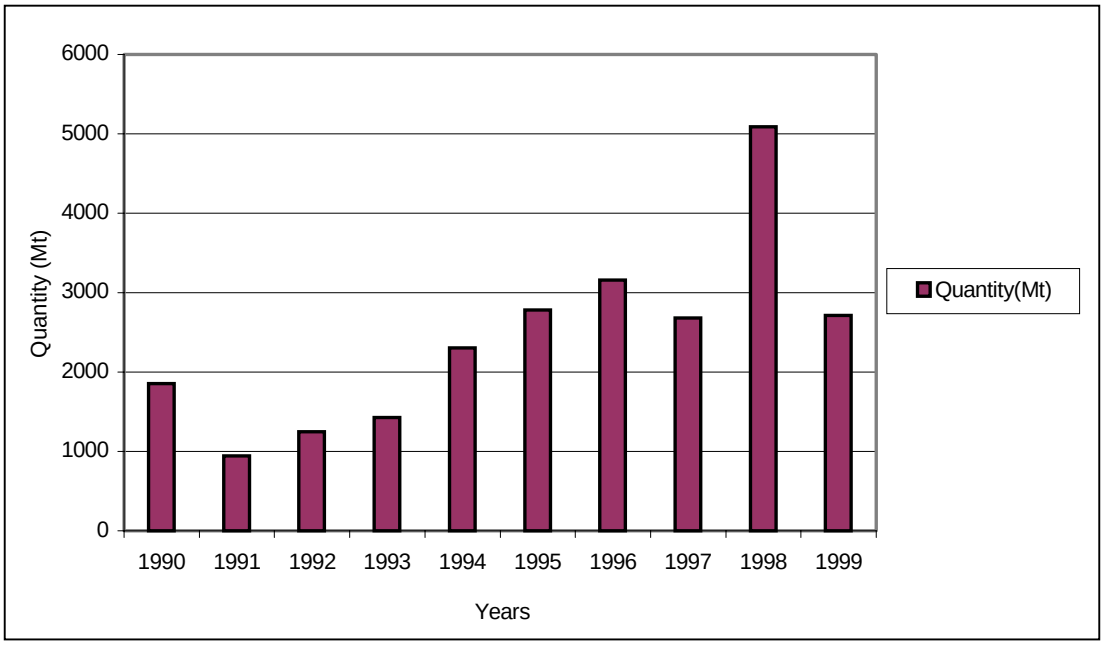
Source: Aquaculture Production Statistics, FAO, 1990-1998.

2.3 Sri Lankan Shrimp Exports

Sri Lanka has gradually increased her shrimp exports and at present well over 90 per cent of the shrimp exported from Sri Lanka is derived from farming. Shrimp exports have increased from 1,855 metric ton in 1990 to 5,092 metric tons in 1998, which generated Rs.4,474 million of export revenue to Sri Lanka. Figure 3 presents the quantity of shrimp exports from Sri Lanka from 1990 to 1999. According to Figure 3, there were two major set backs in the 1996-97 and 1998-99 period. Viral and other diseases have caused severe reduction in shrimp production in 1997 and 1999 in the NWP.

Shrimp farming industry has made a very substantial contribution to the economy of the country. The main contribution of the industry is the generation of a large amount of foreign exchange for the country. Table 3 depicts the contribution of the industry to the country's foreign exchange earnings. It has been estimated that farmed shrimp

Figure 3: Sri Lankan Shrimp Exports



Source: Export Development Board.

contributes, on average, of around 50 per cent of the total export earnings from the fisheries sector. According to Fernando (2000), the shrimp industry has consistently netted in well over Rs. 2000 million in foreign exchange since 1995. Over the past decade, the contribution of shrimp industry to the total export earnings in the fisheries sector has fluctuated between a low of 38 per cent in 1993 to 66 per cent in 1998. Shrimp has a consistent demand in the world market and there has been no difficulty in exporting the large bulk of the country's production.

Figure 4 presents Sri Lankan exports to major markets. Japan is the most important market for Sri Lankan farmed shrimps and it has maintained this position over the last decade. There has been a considerable increase in exports to Japan from 1991 to 1998. In 1998, Japan accounted for 73 per cent of the total exports of Sri Lanka. Apart from Japan, the exports to the US and the European Union in 1998 were 15 per cent and 8 per cent, respectively.In terms of global imports to Japan, Sri Lanka's share is 1.6 per cent. Shrimp

Table 3: Shrimp Exports and Contribution to Export Earnings

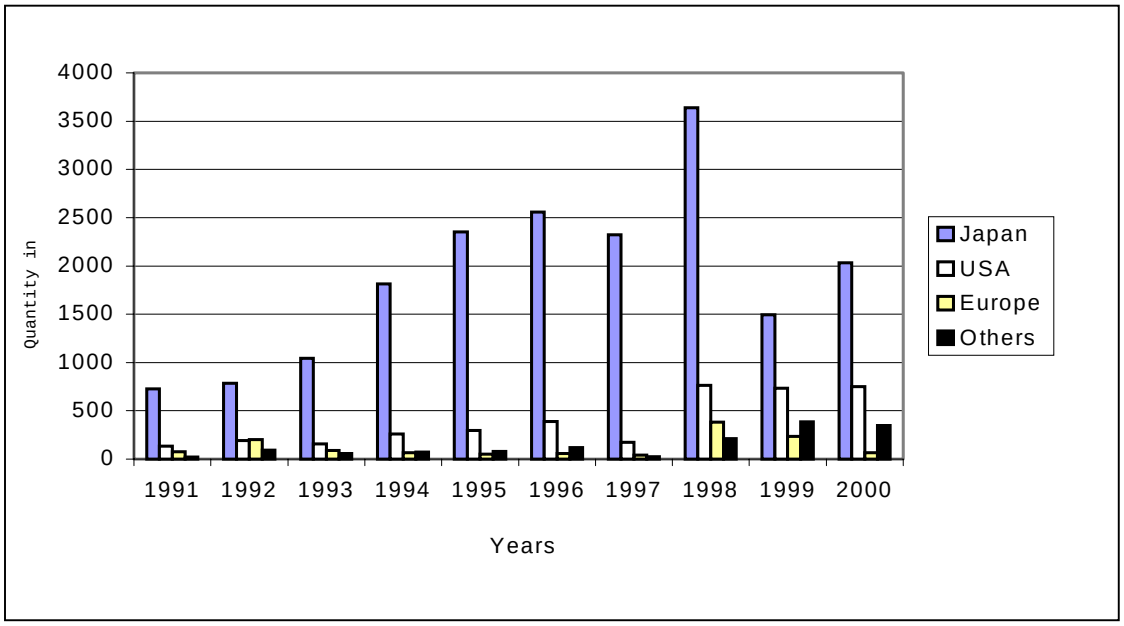
Year	Quantity (Mt)			Value (Rs. million)	Total Export Earnings in the Fisheries Sector (Rs. million)	Contribution of Shrimp to Total Export Earnings (%)
	Earned Shrimp	Captured	Total			
1992	1121	125	1246	613	1304	47
1993	1283	143	1426	808	2145	38
1994	2070	230	2301	1650	3291	50
1995	2503	278	2781	2153	3656	59
1996	3200	355	3155	2365	4125	57
1997	2408	268	2676	2195	4436	49
1998	4588	570	5092	4474	6732	66
1999	2444	272	2719	2275	5130	44

Source: Department of Customs, 1992-1999.

Species, size and country of origin are important features of the international shrimp trade and are reflected in price differences in the shrimp market. Sri Lanka together with Malaysia and Thailand receive relatively high prices in the Japanese market. Sri Lanka's shrimps fetch a high price in the US market too, according to the Export Development Board.

In addition to foreign exchange earnings, the industry has also provided direct employment to 8,000 people in the area who would otherwise have fewer avenues for employment. According to a survey done in the NWP by the MFARD in 1998, 6,388 persons are employed in the processing plants. The industry has generated 40,000 indirect employment in farming related activities. There are over 100 establishments in the NWP alone supplying various inputs and providing supporting ancillary supplies to the shrimp industry such as the supply of lime, fiberglass, shrimp feed, machinery, and repair facilities and hardware stores. The development of the physical and social infrastructure facilities in the coastal area in the NWP can be considered as another positive impact of the industry.

Figure 4: Sri Lankan Exports to Major Markets



Source: Export Development Board

2.4 Comparative Advantage and Productivity of Sri Lanka's Shrimp Farming Industry

In the early 1990s, the rapid expansion of Asian shrimp culture has resulted in increased production of farmed shrimp accompanied by growing competition among shrimp exporters in the international shrimp market. This section presents an analysis of the degree of comparative advantage ranging from shrimp farming techniques to foreign export markets. Bangladesh, China, India, Indonesia, Malaysia, Thailand and Viet Nam are considered as major producing countries and the analysis is carried out according to different farming systems (intensive and semi-intensive).

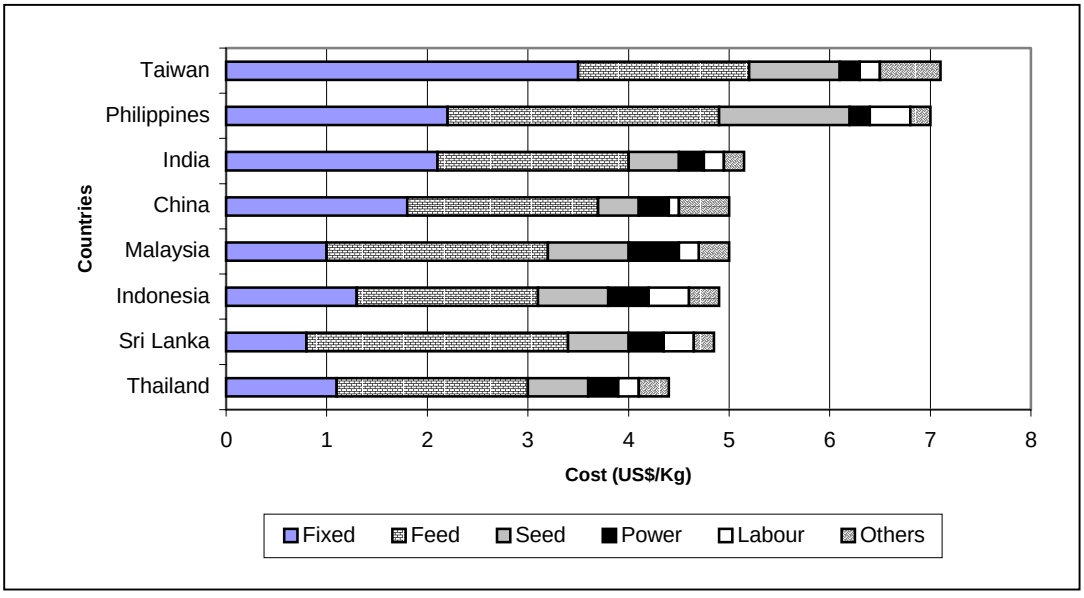
2.4.1 Comparisons of Production Costs

Shrimp farming techniques, farm sizes, stocking density, feed conversion ratio and the number of crop seasons per year are very different both within and between the producing countries. In addition, risks associated with viral diseases during the growing

period also have strong impacts on a country's performance of shrimp yield per hectare (Ling *et al*., 1996). For consistency in inter-country and inter-system comparisons, production cost per kg of shrimp is used as a criterion. Costs are categorized into fixed costs (overhead, depreciation and interest) and operating costs (feed, seed, power, labour and others). The structures of production costs of Asian shrimp farming are presented in Figures 5 and 6. This analysis is based on the farm performance survey conducted by the Asian Development Bank (ADB) and the Network of Aquaculture Center in Asia-Pacific (NACA).

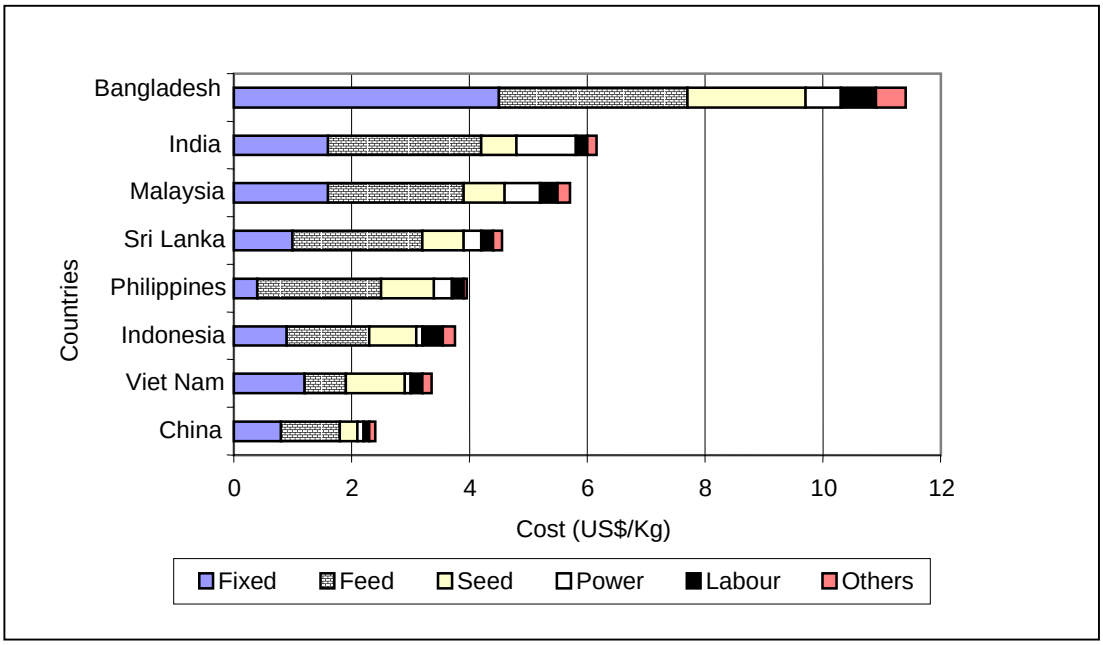
In intensive farming, feed accounts for a high percentage of total costs ranging from 22.6 per cent in Taiwan to 54.2 per cent in Sri Lanka. Feed costs are followed by seed cost which accounts for 9 per cent to 18 per cent. Energy cost which comprises of powering paddle-wheel aeration, generators and pumps accounts for 5-12 per cent of the total cost. The cost to production of one kg of shrimp is highest in Taiwan (US$ 7.33) followed by the Philippines (US$ 6.81). According to Ling *et al*., (1996) production cost per kg is between US$ 4 to US$ 6 among Thailand, Indonesia, Malaysia, and Sri Lanka which have higher comparative advantage than other shrimp farming countries in Asia. Production cost per kg of shrimp (US$ 4.6) in Sri Lanka is lower than that of Indonesia, Malaysia, China, India, the Philippines and Taiwan but higher than that of Thailand.

Figure 5: Cost Structure of Asian Intensive Shrimp Farming



Source: ADB and NACA, 1996.

Figure 6: Cost Structure of Asian Semi-intensive Shrimp Farming System



Source: ADB and NACA, 1996.

For semi-intensive farming, feed costs also dominate production costs (23.1-55.2 per cent of the total) followed by seed costs which form 10-22 per cent of total cost. As a result of the extremely high seed cost, Bangladesh has the highest cost (US$ 12) in producing one kg of shrimp. The overall production cost of semi-intensive shrimp farms is slightly lower as compared to intensive systems. For semi-intensive farming, production cost per kg of shrimp (US$ 4.4) in Sri Lanka is lower than that in India, Malaysia and Bangladesh but higher than the cost in China, Viet Nam, Indonesia and the Philippines. Overall, Thailand, Indonesia and Sri Lanka with lower production costs per kg of shrimp have a higher comparative advantage than the other shrimp farming countries in Asia.

2.4.2 Productivity of Different Shrimp Producing Countries

Shrimp farm productivity depends on the intensity of the inputs, previous land type, soil characteristics, access to water and the level of management skill and technical knowledge. Most of the farms are now semi-intensive and they have stocking density in a range of 10-20 post-larvae per square metre and pond size is from 0.5 to 1.5 ha with farm cycle of 1.5 to 2 per year. Aquacuture Asia (1996) has indicated that Sri Lanka shows

consistently high productivity in the different farming systems followed by shrimp farming countries of the India-Pacific region. When comparing the input uses, labour use (person days/ha) is highest in Sri Lanka. In all culture systems, shrimp farmers in Sri Lanka use relatively high quantity of feed when compared with the regional average (Jayasinghe, 1997). Table 4 presents the average productivity of different countries in Asia. Productivity of shrimp farms in Sri Lanka is higher than in other Asian countries except Thailand and Taiwan. Average productivity of Thailand and Taiwan is relatively high because of the high intensive nature of farming. However, there has been a steady decline in aquaculture productivity as the industry has shifted from an intensive level to a semi-intensive level since 1987. Average productivity was affected by disease outbreaks in 1994 and 1998. Productivity of large-scale farms is estimated to be about 4000 kg/ha/year. Productivity of small-scale farms is estimated to be much lower than 3000 kg/ha/year.

Table 4: Average Productivity of Different Shrimp Producing Countries

Country	Kg/ha/cycle
Sri Lanka	1700-2000
Bangladesh	200-300
China	350-400
India	400-500
Philippines	600-700
Taiwan	3500-4000
Thailand	3400-4000
Vietnam	200

Source: Aquaculture Asia, 1996-97.

2.5 Profitability of Farms in North Western Province

Profitability depends on the price of shrimp, level of production and cost of inputs. Prices for shrimp depend on the quality of shrimp (as measured by weight, size and grade), the country to which the shrimp are exported and the degree of processing. In general, prices

have been increasing for shrimp in all markets over the last ten years though there was a severe drop in prices in 1995. Most farmers in Sri Lanka do not have processing facilities and sell their shrimp to processors receiving only the farm-gate price. This farm-gate price ranges from Rs.300 to Rs.1000 per kg depending on the size and the grade.

Shrimp farm costs include both fixed and variable costs. Fixed costs are those that do not vary significantly with output. The basic capital costs are the ponds and canals, infrastructure (fencing, water and electricity), buildings, equipment and land. The main variable cost item is shrimp feed, which makes up almost 50 per cent of the total. As the feed is imported and is paid in dollars, industry profits are affected by the depreciation of the rupee against the dollar. The other major cost item is seed and labour. The funds for these capital expenses are provided by the National Development Bank (NBD), Development Finance Corporation of Ceylon (DFCC) and major commercial banks. In addition, the Board of Investment promotes development by providing duty free imports, tax concessions and tax holidays.

Table 5: Relative Profitability for Representative Large and Small Farms (assuming maximum productivity)

Features	Large Semi-intensive	Small Semi-intensive
Pond Area	>10 ha	<4 ha
Number of cycles (per year)	2	2
Stocking levels: PL/m2	10	8
Production: kg/ha	7000	5000
Average price of shrimp	520	460
Revenue	3640000	2300000
Capital Cost	560000	460000
Variable Cost	2300000	1400000
Total Cost	2860000	1860000
Profit	780000	440000
Cost of treatment (7% of capital and 3% variable cost	108200	74200
Rate of return (without treatment)	27	23
Profit if proper treatment installed	671800	365800
Rate of return with treatment	23	19

Source: Estimates based on author's calculations.

Profits of a large-scale semi-intensive and a small-scale semi-intensive farms have been estimated using 1999 data in Table 5. A small semi-intensive farm generates a financial rate of return of about 19 per cent whereas a large semi-intensive farm generates 23 per cent. The profitability varies significantly through time as evident from the two recent outbreaks of disease. This suggests that the average profit over the last few years, may be about 20 per cent lower than the figures in Table 5.

Chapter 3: Impacts and Issues Relating to Shrimp Farming Industry in Sri Lanka

3.1 Environmental Impacts

The development of shrimp farming in the NWP has been accompanied by increasing concern about the degradation of the environment in the farming areas. Although the growth of the industry has had obvious social and economic benefits, there has also been significant natural and environmental costs involved in shrimp farming. The rapid and unplanned expansion of shrimp farming has considerably affected the coastal environment and land use pattern.

Significance of these impacts has been established in other countries. A good example of mangrove-to-pond conversion is evident from the Philippines experience where it has led to a decrease in mangrove from approximately 500,000 ha to 132,000 ha in 1990 (Auburn University, 1993). During the last two decades, approximately half of mangrove loss close to 280,000 ha could be attributed to pond development in the Philippines. Similarly, 50 per cent of over 171,000 ha of mangrove loss in Thailand during the last two decades, and most of the mangrove loss of 30,000 ha in Ecuador were mainly due to shrimp pond construction (Aksornkae, 1988; Olsen and Figueroa, 1989). Around 10,000 ha of mangrove area on the border shared by India and Bangladesh have been converted into shrimp ponds (Anon, 1993). So far, little work has been done in Sri Lanka to estimate such losses.

3.1.1 Mangrove Destruction

Mangrove forests constitute the basis of the estuarine tropical system. They provide protection for shorelines in preventing coastal erosion; serve as breeding, nursery and forage ground for many species of fish, animals, and shellfish; and provide habitat for large numbers of migratory and endemic species (Bailey, 1988). In addition to these wide array of ecological functions, mangroves provide a range of economic goods and

services, including materials for fuel, construction, and fishing (Table 6). Mangrove forests[1] provides direct and indirect livelihood to coastal fisher-folk.

Table 6: Direct Products from Mangrove Forests

Uses	Products
Fuel	Firewood for cooking, heating, smoking fish, smoking sheet rubber, burning bricks, charcoal, alcohol.
Construction	Timber for scaffolds, heavy construction, railway ties, mining pit props, deck piling, beams and poles for building, flooring, paneling, boat-building materials, fence posts, water pipes, chipboards, glues.
Fishing	Poles fish traps, fishing floats, fish poison, tannins for net preservation, fish-attracting shelters.
Agriculture	Fodder, green manure.
Paper production	Paper of various kinds.
Food, drugs, and beverages	Sugar, alcohol, cooking oil, vinegar, tea substitutes, fermented drinks, desert topping, condiments from bark, sweetmeats, vegetables, cigarette wrappers, medicines.
Household items	Furniture, glue, hairdressing oil, tool handles, rice mortar, toys, matchsticks, incense.
Textile/leather production	Synthetic fibres dye for cloth, tannins for leather.

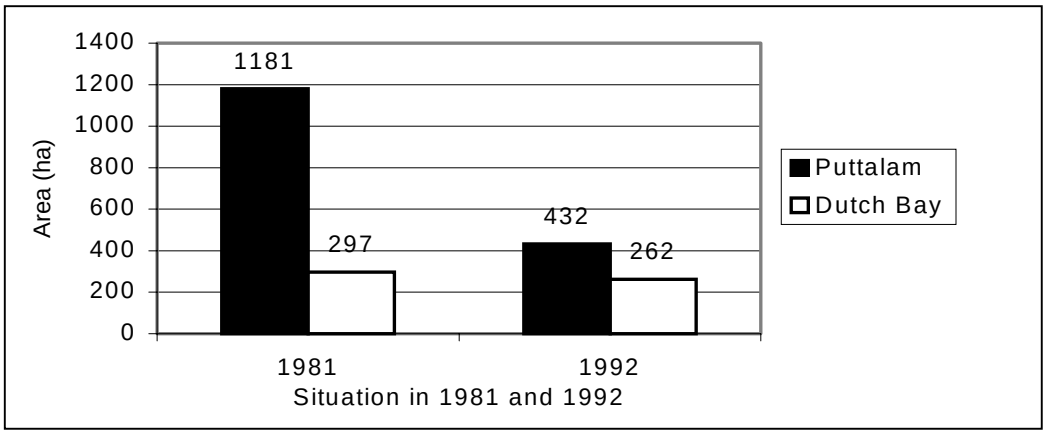
Source: Primavera, 1991.

Shrimp farms can affect mangroves in two ways. First, through the construction of ponds, building and other facilities which directly displace mangroves. Second, through indirect effects, such as alteration in hydrology that may be caused by the construction of a road that alters the mixing of fresh and saltwater. A recent remote sensing survey which estimated the mangrove coverage along the shores of the Puttalam lagoon and Dutch Bay found that as much as 64 per cent and 11 per cent of cover in the respective areas have disappeared (Figure 7).

[1] Rough valuation efforts give maximum figures over $11,000/ha/yr from forestry and fisheries products (see references in Primavera, 1993) for artisan fisheries in mangroves and associated lagoons (Gedney *et al*., 1982).

In 1986 there were around 3,210 ha of healthy mangrove cover in the Puttalam district. This is 25 per cent of total extent of mangroves in the country, which was estimated to be 12,189 ha at that time. Of the total area of 4,000 ha utilized for brackish water shrimp farming on the NWP coast in 1999, 1,200 ha were located in healthy mangrove areas (Fernando, 2000). It is important to note that mangrove soil is typically heavily organic and exist under highly reduced- low oxygen- conditions in their natural system. Pond construction in these areas dries and oxidizes the soil to such an extent that considerable acidity is imparted to overlying water after a new pond is flooded. Shrimps are naturally adapted to the relatively alkaline conditions found in the ponds located over mangrove soil. For this reason, preferred sites for shrimp farms are barren mud flats which are above the elevation of landward perimeter of mangrove stands.

Figure 7: Mangrove Distribution of Puttalam Lagoon and Dutch Bay in 1981 and 1992.



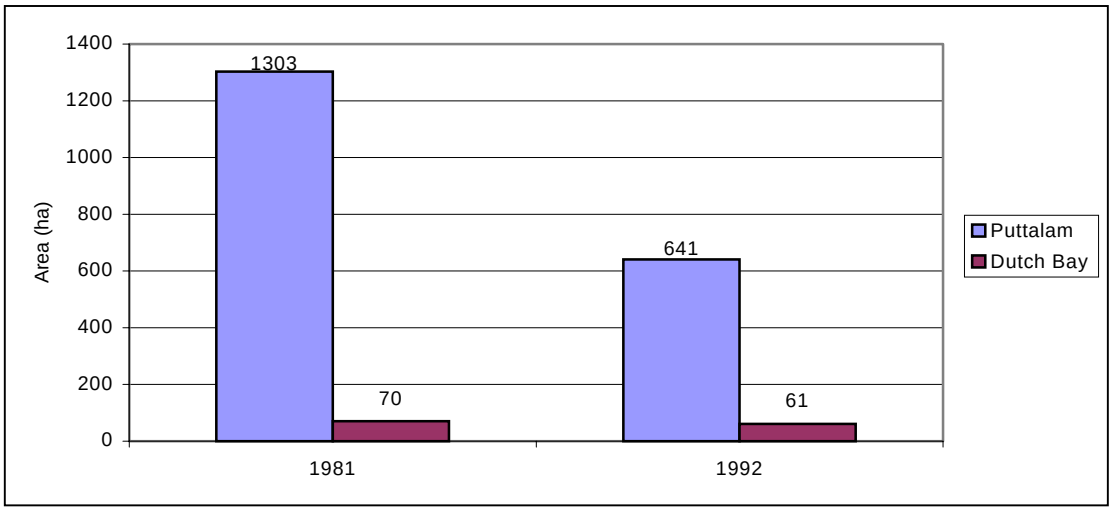
Source: Senarath and Visvanathan, 2001.

3.1.2 Destruction of Other Habitats

Salt marshes are common along the landward side of the mangrove forests in the semiarid Puttalam-Mundel estuarine system, of which 160 ha have been legally approved for shrimp farming (Senarath and Visvanathan, 2001). The extent of destruction is shown in Figure 8. These losses are more critical in the Puttalam Lagoon (51 per cent) than in the Dutch Bay (14 per cent). Wetland ecosystem including sea grassbeds, mud flats, flood

plains, buffer zones around lagoon, seasonal lagoons have been severely threatened by the advent of shrimp farming in the area causing changes in the entire micro and macroclimate of the region. The full extent of destruction has not yet been determined.

Figure 8: Salt Marsh Distribution of Puttalam Lagoon and Dutch Bay in 1981 and 1992.



Source: Senarath and Visvanathan, 2001.

3.1.3 Pollution of Waterbodies

Because shrimp farms rely mainly on natural water and artificial food, intensive culture in ponds place high stress on the environment, aside from the major loss of habitat in the case of mangrove. Intensive farms need large amount of feeds to support high densities of shrimp, and flush correspondingly high loads of wastes into coastal water. Estimates based on digestibility coefficients and feed conversion ratios show that only 17 per cent by dry weight of total feed applied to a pond is harvested as shrimp; 15 per cent is not consumed, 20 per cent becomes faecal material and another 48 per cent goes to energy utilization, metabolites and molted shells. Pond wastes consist of solids --excess food, faecals, plankton, bacteria-- and dissolved matter (e.g., ammonia, urea, carbon dioxide

and phosphorus). Level of nitrogen, phosphorus and other quality parameters are generally high in effluent water.[2]

At least 70 per cent of farmers depend on the Dutch canal for water and to discharge wastewater as receiving water body. Other sources are Chilaw and Mundel Lagoon. The farms discharge wastewater to those water bodies without any treatment. This has had considerable impact on ecological balance and there is much concern that pollution of those water bodies has already reached or perhaps gone beyond critical levels. The Dutch canal has exceeded its carrying capacity due to contamination. The affluent discharged from one farm returns to adjoining farms due to poor planning of inlets and outlets of ponds. In 1996, the discharge of organic matter into water bodies was nearly 3,308 tons per year. High organic load increases the oxygen demand in water bodies, and eventually reduces dissolved oxygen levels. This increases the anaerobic condition in the water, including ecological stress on aquatic organisms. Excessive nitrogen and phosphorous content lead to eutrophication and algae bloom. Water stagnation in the Dutch canal during dry seasons further inhibits the process of natural recovery.

3.1.4 Salinization of Soil and Water

The release of salt water from shrimp ponds has caused salinization of agricultural land. Briggs (1993) points out that 45,000 ha of once productive rice and also shrimp farms in central Thailand have become an ecological desert. The breaking of coastal embankments in search for sea water has led to salinization of rice lands and a drop in rice production from 1.7 to 0.5 tons in the last 10 years in Khulna, Bangladesh (Anon, 1993). A basic feature of the intensive shrimp farming technology in Sri Lanka requires brackish water salinity of 15-20 ppt for rearing of *P. monodon.* This is achieved by pumping large volumes of underground water into ponds. With the emptying of groundwater aquifers, salinization occurs due to intrusion of sea water which results in reducing water supply

[2] Although the pollution potential of shrimp pond effluent is minimal compared to domestic or industrial waste water, problem arise because of the large volumes of water discharged from intensive farms compounded by the high concentration of farm units in areas with limited water supply and inadequate flushing. Intensive shrimp farming as practised in Taiwan and parts of South East Asia has been unsustainable because discharge of effluents has exceeded the assimilative capacity resulting in pollution not only of receiving waters but inside ponds as well (Macintosh and Phillips, 1992).

for domestic and agricultural purposes. This is quite common in the NWP and has been experienced in Thailand and the Philippines as well. Continuous extraction of groundwater eventually leads to land subsidence. Indiscriminate disposal of solid waste from shrimp ponds has polluted groundwater in the area. Solid wastes are generally dumped at the edge of the farms in large heaps. Leaching down of salt from solid waste to land in the vicinity is inevitable and has adversely affected the vegetation. Sediments may contain heavy metals and these can adversely affect human health through ground water contamination.

A major issue in the NWP debate on environmental impacts of shrimp farming is the unique importance of seasonal lagoons[3] to local ecological processes and livelihoods. Shrimp farming has adversely affected these seasonal lagoons. Another environmental problem associated with shrimp farming is soil erosion caused by the alteration of land use system in the area. Soil erosion is reflected in the heavy siltation in certain parts of the Dutch canal, which has significantly restricted water movement. Disturbance to the natural water drainage pattern in the area resulting from the construction of ponds has led to heavy flooding, especially during heavy monsoon rains.

This scenario can be seen as a "tragedy of the commons" situation. Rapidly growing shrimp farms are expanding into a ecological rich but fragile areas. The resources are not subject to private property-rights but are common property resources. The new population occupying this commons does not have social or cultural institutions that could help them to manage the commons for the benefit of everyone. The result is that the growing farm population may be overexploiting the resources, thus leading to potential destruction of productivity and fish stocks.

3.2 Social Implications

The depletion of coastal fisheries due to mangrove conversion into ponds and the discharge of prawn culture byproducts into adjacent lagoons and the Dutch canal marginalizes subsistence fishermen, who are dependent on mangroves. The conflict stems

[3]Seasonal lagoons are fed by rainfall. These pools develop annually on the barren and vegetated mudflats behind mangrove fringe. Seasonal peaks in hightides create brackish conditions in the pools.

from the nature of fishing which is rooted in the communal use of a resource, e.g., mangroves, in contrast to culture which assume control over an area through private ownership or lease. This current situation of shrimp farming can be viewed as another example of the state allowing and assisting in common property resources being converted into private property. Because of concessions granted by the government, these lands are now effectively under the control of private corporations and are being used for private gain.

Shrimp farms illegally deprive fishermen, farmers, and others of access to estuaries, lagoons and other area to which they have rights. Although these areas are normally reserved areas designated by the government, no boundaries or controls have been established. This has adversely affected their livelihoods and has been cited as one of the most critical issues. There is social tension and much resentment on the part of the locals that outsiders exploit their rightful resources.

Employment of local people in shrimp farms is often limited to low-paying jobs such as labourers and guards while technical and managerial positions are reserved for outsiders because shrimp farming is capital intensive rather than labour intensive. Funds invested in pond culture do not trickle down to the residents of the coastal villages, but remain with the farmers, entrepreneurs and traders. Instead of improving living standards and village welfare, shrimp farming brings about social displacement and marginalization of fishermen in the NWP. Shrimp culture in Ecuador has also led to multiple use right conflicts, loss of valuable cultural sites, and increased difficulty in resource management, aside from reduced occupational diversity in coastal communities and inequitable allocation of benefits (Epler, 1992).

The conversion of agricultural land into financial lucrative shrimp farming has resulted in the loss of agri-production in the NWP. It has resulted in loss of income and employment to the people. Shrimp farming has led to increase in land values artificially. The absentee landlords have sold their land to shrimp farmers. In many instances, the tenants who have been living on these lands have been evicted forcibly. Though it has not been properly analyzed, the cost to the economy through loss of eco-tourism development opportunities could be quite considerable. Scenic beauty of the wetland ecosystem in the Puttalam

district has been altered due to the destruction of mangrove forests, degradation of bird habitats and salt marshes, and disturbance of serenity of lagoons.

3.3 Other Issues Relating to the Shrimp Farming Industry in Sri Lanka

3.3.1 Disease Problems

The shrimp industry in Sri Lanka has been suffering from severe outbreaks of viral diseases since 1988. The first disease outbreak that affected shrimp farming occurred in 1988-89 due to an attack of the monodon baculovirous (MBV). About 50 per cent of the farm production was estimated to have been lost. However, the disease was combatted in 1990 and has never re-appeared (Hettarachchi, 2000).

By 1994, there were only eight shrimp hatcheries producing post-larvae required for the farms. These hatcheries could not meet the entire requirement of post-larvae demanded by the industry, as farming areas began to expand at an increasing rate after 1994. Therefore, farmers began to import post-larvae, mainly from Thailand. During that period the white spot disease caused by an acute viral infection was prevalent in South East Asian countries. The white spot disease is thought to be caused by accumulation of waste which increase the susceptibility to the virus. By 1996, it had devastating effects on the industry and the disease affected over 90 per cent of the entire culture area. Cumulative motality up to 100 per cent was reported in farms along the Puttalam Lagoon. The disease spread rapidly to other brackish water systems and many farms became nonfunctional within three months.

In order to prevent further introduction of pathogen, the government banned the import of post-larvae in 1994-95. This ban had positive effects on the industry as the domestic hatchery industry started expanding in numbers as well as in capacities to meet the demand. At present 55 shrimp hatcheries are operating in Sri Lanka. They have the capacity to produce the country's entire requirement of shrimp post-larvae.

In 1996, all shrimp farms were heavily impaired because of "White Spot" disease and there was a virtual collapse of the industry. There were heavy financial burdens falling on farmers. It was estimated that the loss in foreign exchange earnings in 1996 due to

disease was around Rs. 1,000 million (Fernando, 2000). The farmers alleged that State agencies had not extended their full support with regard to technological know-how to combat diseases. The farmers have been facing the threat of legal action from banks against them, due to their inability to pay back the loans, as a result of being adversely affected by the disease.

According to MFARD, the government intervened and immediately appointed a task force to take all possible measures to resolve the problem. This task force implemented an intensive awareness campaign among farmers on the preventive and control measures. At the request of the government, FAO implemented a project with the objective of upgrading shrimp disease diagnostic capabilities of NARA and developing manpower for shrimp health management. Government allocated Rs. 100 million for installation of water treatment or recycling facilities in the farms. To recover this sum, the government has levied a special levy of Rs. 10.00 per Kg on shrimp exports. But the grant was only available to farmers with a minimum of five hectares in extent and possessing a management licence. Therefore, the scheme was not as effective as desired because only 200 of the farms were provided financial support. Also, farms were required to have fulfilled certain criteria as pertaining to obtaining a management licence of operation from the MFARD.

During the early part of 1999, about 75 per cent of the farms were lying fallow due to the outbreak of yellow head disease caused by the yellow head virus. Farmers under the Federation of Association of the Prawn Farming and Exporting Industry of Sri Lanka have made appeals to the government to assist them through a relief package. In collaboration with the DFCC and NDB, the government has offered another financial package to the farmers. This package included the government announcing a moratorium on the repayment of loans, with a state contribution of 25 per cent on accumulated interest and the provision of security free facilities for feed import. In 1999, the government developed guidelines to the industry on good aquaculture farming practices, and emphasized the importance of following them for the prevention and control of disease outbreaks. It is worthy to note that environmental deterioration of brackish water bodies of the coastal belt of the NWP caused by haphazard, unplanned prawn farming without proper monitoring has resulted in continuos crop failure and debt burden for

entrepreneurs. According to Hettiarachchi (2000), MFARD is in the process of making regulations under the Fisheries and Aquatic Resources Act with a view to controlling diseases in aquaculture farms and hatcheries.

3.3.2 Cost of Shrimp Feed

Shrimp feed accounts for 50-60 per cent of the total cost of production of a shrimp farm. The price of shrimp feed has been escalating over the years. Therefore, high price of feed is bound to affect the competitiveness of Sri Lankan shrimp exports in the long run. The high price of feed will have significant impact on working capital requirement in farming. This will lead to a reduction in profitability from shrimp farming. At present, all feed requirements of the industry are imported. The feasibility of production of feed locally has been explored but has not been successful as they are of poor quality. However, it is necessary to develop our own feed production in order to sustain the industry in the long term.

3.3.3 Quality Water Source

One of the major problems that need urgent attention is the quality of water source. The carrying capacity of the Dutch canal has deteriorated and has been exploited in an unsustainable manner by the farmers. There appears to be a general consensus that the Dutch canal is no longer suitable for intake of water to the ponds for farming. It is essential to de-silt and clean the Dutch canal. Further, the Dutch canal should be made available for at least five sea out falls in order to facilitate water exchange with the sea. However, it has not been possible to implement this so far. Cleaning alone will not be an effective solution to the problem of finding a water source. According to Fernando (2000), what is needed is a major development project to provide a system of well-constructed and maintained canals to provide the water requirements of farms and to take the waste water effluent away.

3.3.4 Lack of Technology and Extension Service

Technical know-how and expertise knowledge in the form of qualified personnel is lacking in Sri Lanka. There are no adequate disease diagnostic facilities in the country. Though certain facilities are available, these are not adequate enough to cater to farm

level needs. Moreover, these facilities are not located in the farming areas and therefore cannot respond to the needs of the farmers and breeders on a timely basis. The small-scale farmers generally lack the technology for systematic farm planning, water quality management, pond management, disease control, and feed and seed quality assurance. In order to fulfill these needs, there should be effective extension facilities in that area.

According to Rohitha (1997), information sources to small scale farmers mainly come from other farmers (46 per cent), feed agents (20 per cent), private consultants (20 per cent) and government agencies (14 per cent). It is evident now that on-farm research needs are not met by research institutions sufficiently. NARA is the only national institute with scientists catering to the shrimp industry but it is not equipped with an effective extension mechanism. This situation has created an information gap between farmers and government agencies. There is no systematic information flow between the government agencies and farmers. As a result of weakness in existing institutional framework and lack of information flow, the number of unauthorized small and medium scale farms have increased rapidly.

According to Fernando (2000), numerous ill planned and unapproved farms have affected approved farms. It is clear that unapproved farms, particularly by encroaching on the reservations and buffer zones etc., have undone the outcomes of genuine attempts made by approved farms. The approved farms have gone through the due process of environmental scrutiny and have taken measures to comply with the environmental requirements as prescribed by the project-approving agency. Lack of infrastructure facilities including waste management systems, electricity, telecommunication and roads are causes for concern for the farmers. The large scale poaching by organized groups has become a regular feature in certain areas of NWP. This menace is also the result of the failure on the part of farmers to act as a group to protect their interest.

3.3.5 Issues Relating to Hatcheries

Semi-intensive and intensive farms require hatcheries to produce millions of post-larvae required for stocking in the farms. The majority of giant prawn hatcheries in Sri Lanka depend on either mature female- spawners or immature brood stock caught from the wild.

All hatcheries depend on wild spawners. As a result, the hatcheries are generally unable to meet the demand for post-larvae.

There is increasing concern on the need to develop technology to rear brood stock grown in ponds rather than obtaining them from the wild. The technology is available in other countries such as Thailand and Indonesia. This point was very well highlighted in the ADB project initiated in 1984. One of the major objectives of this project was to promote pond rearing brood stock technology, which involves the production of shrimp post-larvae from brood stock grown in ponds. Obtaining post-larvae from the wild was unsustainable to the industry as well as to the environment. However, with the premature termination of the ADB project in 1990, these objectives could not be achieved.

The cost of production of post-larvae has increased recently. The hatcheries are said to have an annual installed capacity of around 750 million of post-larvae. The estimated annual demand from the farms is said to be 250 millions of post-larvae. The under-utilization of installed capacities of the hatcheries has contributed to the high cost of post-larvae production in Sri Lanka.

The price of *artemia* (feed for post-larvae*)* has greatly escalated in recent years on account of worldwide shortages of artemia production. The high price of artemia has led to increase in the cost of production of post-larvae in the hatcheries. According to Fernando (2000), artemia resources have been identified and located in many parts of Sri Lanka. However, no serious attempt has been made so far to undertake the commercial production of artemia. Scientists have identified the Sri Lankan strain of artemia as of high quality in terms of nutrient composition. The Sri Lankan strain of artemia is said to possess high quality fatty acids and therefore can be a rich resource for aquaculture purposes.

The quality of post-larvae produced in domestic hatcheries is said to be low when compared to those found in other parts of the world. The lack of professional staff in the hatcheries has been a major problem particularly in small and medium scale hatchery operators in the NWP. Some of the large-scale hatcheries have managed to get the services of qualified hatchery personnel from overseas countries. But this method is not

affordable to many. The contribution of present extension and advisory services has been found to be inadequate. All hatcheries totally depend on local private consultants. Currently, the DFCC bank has collaborated with NARA and the EDB to provide technical assistance to breeders. Further, the MFARD and NARA have made significant efforts to upgrade the technical capabilities of the hatcheries and the farms through the FAO Technical Co-operation Project started in 1999-2000.

3.3.6 Product Standard and Quality

Recently, two consignments of ship exports- one to Norway (1999), and the other to Sweden (2000)- were detected to be contaminated with pathogenic organisms. The respective countries discarded these two shipments from Sri Lanka. There are stringent health and environmental product standards that are imposed especially by the European Union to aquaculture exports from South Asia. Processing industry has very little control over the quality of farm production. In addition, self-monitoring on the part of the farms with regard to quality is generally lacking. However, the processors have recently started inspecting farms regularly. Swedish Development Corporation Agency (SIDA) has taken steps to finance a project called "Fish Quality Improvement Programme" to develop and upgrade the quality of exported marine products from Sri Lanka.

3.3.7 Management Issues

Under the government production policy, large extents of state owned land were rented out to investors at a nominal rent. With this incentive, coupled with various other concessions, a number of small-scale entrepreneurs and a few large multinationals have ventured into shrimp farming since 1982. As a result of weaknesses in the existing institutional framework and lack of enforcement of laws and regulations, the number of unauthorized farms continue to proliferate over time. It is estimated that a considerable number of unauthorized small scale farms have been established covering more than 300 ha of encroached land in the Puttalam area. The practices, especially of unauthorized farms, are not systemic and compound adverse social and environmental problems. In some instances, prospective developers who had acquired state land on lease for the purpose of establishing farms had expanded their pond area by encroaching on adjoining

land without any approval. It is imperative that unauthorized use of land for shrimp farming is prevented in the future and the industry should be regulated without delay.

Land allocation for shrimp farming is another major issue in the NWP. According to Fernando (2000), the NARA carried out a study to identify land suitable for shrimp farming and prepared a zoning plan in the area for shrimp farms. NARA had indicated that there are yet another 1,731 acres (692.4 ha) of potential land available for shrimp farming in NWP. However, NARA found that most of above-mentioned lands had already been utilized for illegal cultivation. Fernando stated that only 257 acres (25 per cent) of this were said to be in the zones identified as suitable for shrimp farming. Therefore, the lack of a proper land use plan acts as a bottleneck to any proper land allocation arrangement and zonal planning.

The allocation of land in large parcels has led to improper land transactions such as sub-leasing or even illegal transfer. Authorities who allocated land to private developers on their applications at the initial stages, have not taken much notice and have not made proper guidelines on the extents of land allocation. According Siriwardena (1999), the recommendations made by officials for placing ceilings on extents of land allocated were not given proper attention in the initial stages. Though ceilings were fixed later at 40 ha and then brought down to 20 ha, they were never strictly implemented. The implication of such poor planning is that today there are large extents of abandoned shrimp ponds in the NWP.

3.3.8 Lack of Enforcement, Poor Monitoring and Non-compliance with Conditions of Approval

There are evidences of farms being constructed on large mangrove reserves. It is very clear that there is a lack of monitoring despite an increasing degradation of the environment. Unauthorized farms are reportedly among the highest offenders of environmental pollution in the industry. The necessary regulatory authorities are very often blamed for lack of action being taken on offenders or failing to carry out required awareness programmes for the farmers to be environmentaly friendly. The agencies claim that this is due to the lack of personnel at hand for proper monitoring and enforcing legal

action. Lack of action taken against offenders has been attributed to practical difficulties that provincial administration faces in effecting the legislation pertaining to protection.

There does not appear to be a commitment on the part of the farms towards self-monitoring. This is mainly due to short-run vision of the farmers to reap high profits within a short period. They place emphasis on increasing their harvest in the short-run at any cost. Further, this is also perhaps due to a lack of understanding and appreciation on the part of the farmers. Lack of compliance with guidelines and lack of interest in self-monitoring has caused the industry to be unsustainable which has eventually led to its collapse.

Chapter 4: Conclusions

Shrimp farming industry has developed from scratch to a formidable position in terms of the volume and value of output and its contribution to the country's foreign exchange earnings within a short time span of one and half decades. Shrimp farming industry has gradually developed into a position of pre-eminence within the fisheries and aquatic resources sector. The industry has generated 8,000 direct employment while around 40,000 people have benefited from indirect employment created by shrimp farming in rural areas. The industry has contributed significantly to the development of the physical and social infrastructure facilities in the coastal villages in the NWP.

The expansion of the shrimp industry in the NWP, while bringing economic benefits, has also created environmental problems. After years of uncurtailed exploitation, the renewable resources and productivity of the coastal ecosystem in the Puttalam district have come under severe strain. Destruction of the mangrove resources, declining water quality of waterbodies in the shrimp farming zones, salinization of soil and water, indiscriminate disposal of solid waste, excessive extraction of groundwater and self pollution have contributed to environmental degradation and a decline in natural productivity of the area. There is much resentment on the part of the local community, as their traditional user rights are no longer respected and their legitimate beach-based activities have been hampered by the shrimp industry. Consequently, several resource user conflicts have emerged and these have been accompanied by much social strife in the area. The current situation with shrimp farms in the NWP can be seen as another example of the state allowing and assisting in common property resources being converted into private property.

Aquaculture development is often justified in terms of increasing world food supplies for a growing population. It must be recognized, however, that the products of aquaculture are generally high cost and are likely to be consumed mainly by the middle class and upper income classes, primarily in the developed countries. Even resource-poor people who produce shrimp are much more likely to market them and use the proceeds to purchase less-expensive food. It can of course, be argued that aquaculture in places such

as the Puttalam district can be a profitable and sustainable means of economic activity if it is properly implemented and regulated.

Aquaculture in the NWP can be converted to a very positive force for sustainable development, one that can generate substantial numbers of jobs and foreign exchange. It depends for its survival, however, on an ecological system that provides clean, oxygenated water and a continuous supply of wild shrimp post-larvae. This requires controlled and sustainable aquaculture practices, robust mangrove forest, and a healthy system of estuaries, all of which depend on the cooperation of all stakeholders in the region. Unfortunately, the present state of conflict in the NWP makes such cooperation difficult. The Sri Lankan community needs to continue to take actions designed to balance the benefits and costs to various stakeholders involved in the industry. In cases such as that of the Puttalam district, slowing or eliminating environment degradation can only be achieved through policies that require changes in behaviour by virtually every group, including resource-poor farmers, commercial aquaculturalists, fishermen, and local, regional and national governments.

The most effectual procedures to accomplish sustainable development are those generated for particular environments through (a) appropriate national and regional policy initiatives; (b) productive dialogue and compromise among the various stakeholders in conflict, and (c) informal technical and financial assistance from bilateral and multilateral agencies. These solutions must be based on an understanding of the complex issues relating to environmental problems in local systems. These causes include unequal distribution and access to natural resources, government indifference and/ or ineptitude in enforcing social and environmental policies, and patterns of development based on non-sustainable use of resources.

Chapter 5: Policy Recommendations for Sustainable Development of the Shrimp Farming Industry in Sri Lanka

There are grave constraints on the further expansion of the shrimp industry in the NWP. Thus, early rehabilitation of the industry should be given the highest priority. The main challenge in the NWP is to clean up the mess left by the current unplanned development of the industry. As there is no possibility for expanding the industry any further, diversification or the extension of this industry into other geographical areas of the island is the only possibility to increase the volume of shrimp production. It is unfortunate that it has not been possible to exploit brackish water aquaculture in the North and East due to social conflict. There has been some serious attempts at developing shrimp farms in the southern area at places such as Rekawa, Hambantoa, Bundala. According to Fernando (2000), detail project proposals were formulated in some cases and even environmental impacts studies were conducted. However, none of these projects were proceeded due to public and political protest.

5.1 Need for a National Policy on Shrimp Farming

It is evident that the industry is profitable, particularly the large farm; but uncontrolled shrimp farming does have significant negative impacts. However, the industry is less profitable than sometimes presented, particularly the small farms. The Sri Lankan shrimp industry has to illustrate a new approach to sustainable development to show that it is possible to combine both economic growth and environmental concern. It is the largest, most profitable farms that have the surplus funds to invest in waste management, while the smaller farms with much lower profitability are least able to afford waste treatment. Thus, improving the profitability of the industry will help the environment, and not vice versa and it is then that there will be a win-win solution to the industry.

The recent disease outbreak has heavily affected the industry in the short run. However, this boom and bust cycle has continued throughout the last 10 years of the industry in Sri Lanka and follows the pattern of the industry elsewhere in Asia. Each environmental crisis triggers the industry to be more responsible, but can the industry reform itself without waiting for the next crisis to arise? The threat to the Southern Province is from unplanned shrimp farm growth. Unless a strong policy framework is agreed within the

next year, the boom and bust cycle of the industry will continue in the Southern Province. It is quite possible that with the present state of affairs, in about 5-10 years part of the Southern Province coastline will be much like what the Puttlalam district is now.

A properly managed shrimp industry can provide high export earnings and bring infrastructure to neglected areas. Thus, an attempt to prevent the industry to the Southern Province will simply lead to unplanned development. Therefore, there is a pressing need to develop a clear and coherent national policy on shrimp farming. This need has been argued by many involved in the industry. A clear and coherent policy agreed by all stakeholders is the only way to break the boom and bust cycle explained above. The basic question that must be answered is, does Sri Lanka want to have a well managed shrimp industry in the Southern Province, or to have the same chaos as has developed in the Puttlalam district?

5.2 Policy Recommendations for Improving the North Western Province

The National Environmental Action Plan (NEAP: 1998-2004) states that " *there is a need for a strategic process to rehabilitate the areas of the NWP that have been degraded by shrimp farming and to ensure that the mistakes made there are not repeated in the South, North and the East where considerable extents of land with potential for development of aquaculture are available. The strategy should be implemented both through the existing regulatory framework, but with a greater reliance on economic incentives such as a cess on exports to fund the sustainable management efforts*". The policy recommendations below are aimed at achieving the aforesaid objectives in the future development of the industry.

5.2.1 Moratorium on the Approval of New Farms

An immediate suspension should be placed on the approval of any more new farms in the NWP. It is high time for NARA or MFARD to undertake a comprehensive scientific study to determine the optimum carrying capacity of the system for the use in the future. Adequate publicity should be provided in the media through an awareness campaign directed at the public, state officials, politicians and the NGOs. Further, it is required to reduce the extent of the total culture area of the NWP by at least 20-25 per cent by

implementing the environmental guidelines. A proper monitoring mechanism should be set up and steps should be taken to withdraw aquaculture licences of all defaulters.

5.2.2 Unauthorized Farms Should be Brought into the Management Regimes

The existing unapproved farms in the NWP will be considered for approval provided they comply with the environmental guidelines issued (see Appendix 1) and other relevant conditions. All unapproved farms should be requested to apply for approval by complying with the environmental guidelines. Those unwilling to do so should be penalized withholding any state assistance.

Enforcement and monitoring mechanisms should be strengthened by improving the capabilities of NARA/MFARD and relevant provincial agencies. There is a greater need to set up a fully equipped diagnostic laboratory manned by qualified persons within the farming area and managed jointly by the industry and relevant state agencies. NARA and MFARD should provide technical guidance to the farmers and breeders. The farmers should strengthen their self-monitoring and disease prevention as well as control capacities. The farmers should be provided with the requisite training and the need for self-monitoring should be impressed on them together with assistance to help them launch self-monitoring programmes.

5.2.3 The 'Cluster Concept'

To ease the present situation in the NWP, a cluster concept has been suggested among the small-scale farmers. This will facilitate them to benefit from the assistance available in large-scale farms. Considering the various associated structures that are required for its successful operation, such as reservoir tank and sedimentation tank, the approach of having common facilities for a group or cluster of ponds will bring economic viability. Large sector farms should be encouraged to provide a subsidized technical assistance service to small farmers in the area. This would improve the productivity of the small farmers as well as benefiting the large farmers by reducing pollution from the small farms around. Thus, one important strategy is to prepare designs for the identified potential cluster farms areas in the NWP. Large farms should be licensed on condition that they

provide a clear package of benefits to small farms. Further, high preference should be given for cluster farms in disbursing grants.

5.2.4 Canal System

A system of canals should be developed to allow farms to discharge their effluent into the Dutch canal (where it would be treated) and take in clean sea/ lagoon water from another canal. One option would be to have a sea-fed inland canal running northwards behind most of existing farms for the clean intake water, while the effluent would be discharged into the Dutch canal and treated. This would combine greater productivity and environmental sustainability. Productivity would increase as feeder canals could be constructed which allow much of the abandoned land to be developed, that are now too polluted to be farmed, but do not have enough access to water to be converted to shrimp farms. There would also be a large reduction in disease occurrence, as all farms would take in fresh seawater. Environmental sustainability should be assisted by allowing a large area of land to be devoted to a sedimentation treatment system for the whole Dutch canal so that it would no longer pollute the Chilaw, Puttalam and Mundel lagoons. There would thus need to be about three large treatment sites at the entrance to each lagoon.

The cost of such a project would be very large, but it would be more than covered by the enormous costs of increased land value. Thus, the project could either be financed as a private sector Build Own and Operate Project or government financing capital costs of the project with external assistance and covering costs by selling land. In addition, formation of an infrastructure company by shrimp farmers themselves and taking a soft loan from a development bank would be an ideal option. This approach is being tried by the tanneries industry to finance their proposed common treatment system.

5.2.5 Shift to Alternatives

a) High-density cultivation:

From the viewpoint of efficient land use and nature conservation, high density may be considered. Intensive cultivation requires very large investments in water aeration and purification systems. Maintenance of technically more complicated installations will require continuous and skilful attention. The financial risk in high-density cultivation is

much higher than semi-intensive cultivation. It seems more attractive to improve flourishing farms and, with their profit, gradually convert them to more sophisticated super-intensive farms.

b) Other alternatives:

It is strongly recommended that the farms at a larger distance to the coast be transformed for other use, taking advantage of natural resources (sun and temperature). Culture of algae, tropical fruits, flowers and herbs for the production of soft drinks, fruit juices, teas, wines (unique taste of tropical fruits, flowers, leaves), liquors, perfumes, cosmetic products, odours, food supplements, pharmaceutical products, kelp, shellfish, all purpose wax, etc., do have excellent prospects.

5.2.6 Increase Profitability and Risk Spreading

The industry should decrease the use of imported feed. If imported shrimp feed proves indispensable, they should be encouraged to search for a better supplier. According to Spaargaren (2000), Hainan in China, prepared shrimp feed is available for about 25 RPS/kg, and Callao in Peru fishmeal is sold in bulk for 3 RPS/kg.

To spread the risk of shrimp farming, it is recommended that farmers insure their harvest (crop insurance). It is strongly recommended that extreme care be taken in investing without planning; spread the risk and opt for a safe balance between profit and risk. Further, reduction of the stocking density (down-scaling) decreases the intrinsic losses, phosphate discharge, feed cost and chance for viral infection, etc. Reducing culture cycle to a period of 100 days will reduce the risk and increase profitability, even when the product price of smaller animals is lower.

5.3 General Policy Recommendations for a National Shrimp Policy

5.3.1 Protection and Restoration of Mangrove Habitats and Coastal Ecosystem

Integrated coastal management programs should be developed to address the question of how much mangrove vegetation[4] should be left undisturbed in order to maintain such unique functions. Remaining mangroves should be conserved and existing legislation that prohibits further conversion and requires greenbelts should be enforced. Abandoned ponds should be allowed to regenerate back to mangroves by breaking down dikes. Large-scale reforestation should be undertaken in severely degraded areas. Many lessons can be learnt from the experience of Bangladesh where a total of 120,000 ha have been afforested (Saenger and Siddiqi, 1993).

5.3.2 Management of Pond Effluent

Reduction of wastes means proper site selection, pond design and husbandry--pond preparation, water management and feeding. Since most of the effluent come from feeds, feeding management should be properly done. Therefore, farmers should be educated through an effective extension system. Ecological concerns over chemical use in aquaculture can be addressed by setting up strict guidelines for use of chemicals. The industry will be required to adopt good farming practices in accordance with European Union directives with a view to meeting international standards in regard to consumer safety.

5.3.3 Legislation and Regulation

For shrimp culture to be sustainable there is a need to regulate pond effluent disposal, chemical use, ground water extraction as well as mangrove conversion, if appropriate controls are not in place. The following principles apply to the measures for conservation, amelioration, prevention and protection: a) preventive-government authorizations (licences, permits), EIAs and regulations (quality standards or permissible levels); b) enforcement-criminal prosecutions, and c) economic incentives/disincentives- effluent charges (the polluter pay principle), user charges (e.g., for sea water or ground water),

[4] These mangroves can be managed for silviculture and give annual income up to $11,000/ha/yr (see reference in Primavera, 1993). Integrated forestry, fisheries and aquaculture in mangroves can also be seen in Indonesia and traditional mangrove-shrimp ponds in Viet Nam.

grants or subsidies, e.g., low interest loans to encourage more environment-friendly operation.

As a result of the 1990s shrimp crop failures in Thailand, legislation was set in place to ban the release of salt water into public freshwater resources or other farming areas and the flushing of mud or silt from shrimp farms into natural water sources or public areas, to set a maximum biological oxygen demand in effluents, and to require treatment and sedimentation ponds for farms. Nevertheless, to what extent these measures are implemented remain uncertain. Self-regulation by the industry may be more effective than government regulation. Based on the Ecuador experience in enforcement of laws and policies relating to shrimp culture and mangroves, shrimp farming policies in a developing country like Sri Lanka should take into account the local social and political economy rather than copy integrated coastal management models designed for developed countries with a stable middle class.

5.3.4 Environmental Impact Assessment (EIA)

An Environmental Impact Assessment should also be required for all future additions or new constructions of shrimp farms. Every EIA has become so controversial with fundamental questions being raised as to whether the industry should exist. The EIA should tackle only technical issues, such as whether the shrimp farm should be at location x or location y, not fundamental policy decisions. A social assessment should be required for all future additions or new constructions of shrimp farms. This social assessment should include a determination of how these developments would affect other stakeholders (e.g., communities, fishermen, farmers, etc.) in the region and recommend mitigation measures to minimize negative impacts and enhance positive impacts.

Environmental Compliance must shift to economic intensive issues away from the regulatory approaches. The current focus on a purely regulatory approach has failed. The EIA[5] can be circumvented by dividing land parcels into less than 4 ha. The NARA planning guidelines are simply unimplementable. This is not simply a problem of lack of

[5] The developer of a farm of 4 ha or above in extent has to obtain a site clearance from NARA and requires EIA approval from CEA.

enforcement staff as is often suggested. The pay-offs from flouting the regulations are just too high. The best way to control the industry is through economic incentives since as a dynamic private industry, this is the instrument that the farmers understand. An example of this, is a number of recent applications to the National Development Bank's low interest loans for installing closed system recycling water treatment. About 29 of the medium to large farms have applied this year for waste treatment subsidy.

Possible economic incentive mechanisms include:

1. The Banking industry must take on greater environmental responsibility. It is recommended that banks and other lending agencies should require treatment facilities as a condition of each loan installment. The DFCC and NDB, as the main financiers, do already take environmental concerns seriously. For example, the DFCC requires that the farms get approval from the EIA Scooping Committee chaired by the Ministry of Fisheries in the NWP. However, this is not enough. The DFCC and NDB must actually monitor the farms to make sure that they have a treatment facility and that they use it. If farms do not operate their treatment plants, the DFCC and NDB should suspend their loans. This will be in the long-term interest of the banks, as it will reduce the spread of disease.

2. The government and industry should determine the best mechanisms to finance common wastewater treatment. As demonstrated earlier, treatment is uneconomical for most small farms, mainly due to the relative high capital cost and lack of economies of scale. Possible options include:

    a) Cess on exports, which could be used to install such common waste treatment.

    b) Banks to provide the treatment systems and cover it through leasing out land. This is part of the innovative approach being proposed by the DFCC at the Koholankala Farm proposal to be located in Hambantota. This “site and service” approach is basically like an industrial estate for shrimp farming, with the capital cost of the treatment infrastructure covered by the government and operation and maintenance paid by the private sector.

5.4 Extension of Shrimp Farming Industry

Any organized extension of shrimp farming industry to new areas of the country has to be done taking into experience the very valuable lesson learnt--tremendous cost to the environment -- from the NWP. There is some limited development potential in the southern coast. If the industry has to venture into new areas, there are several issues which need careful consideration;

i. Integration of shrimp farming into the larger Integrated Coastal Management Plan for the area concerned. Priority zones, mangrove area in particularly, for the following activities can be designated: a) preservation and conservation for biodiversity and ecological functions, b) sustained yield of fisheries and silviculture, c) reforestation areas, d) conversion to culture ponds, salt beds, etc.

ii. The preparation of a Zonal Plan for Shrimp Culture should be given high priority. Zoning guidelines should prevent the concentration of farm areas as seen in the NWP where levels of pond effluents eventually exceeded the “carrying capacity” of the environment.

iii. The main focus must be on the site and service approach with a clear development of a planned infrastructure of water intake, discharge points and treatment, before development takes off in a haphazard manner. This can either be done by the development banks as suggested in the Koholankala Project, or through large-scale farmers being allowed only on condition that they also assist smallholders. Thus, large farms are required to develop surrounding land for small farms which will pay a charge to utilize the large farm's treatment ponds. This approach should draw on the experience of the BOI and Ministry of Industries on the lessons learned in developing industrial estates.

iv. Large-scale farms should only be licensed on condition that they provide a clear package of benefits for the local community and potential small shrimp farmers. This would follow the examples in some countries of only allowing luxury housing development on condition that low cost housing is also developed. Such a package

could include access to new electricity, water connections, roads and schools and technical assistance for potential small scale farmers.

v. The small farms must be given greater management and technical assistance. This would significantly reduce both the negative environmental and social effects of the industry. Greater information on the problems of the existing small-scale farmers should be collected and published by the relevant authorities such as EDB, MFARD, DFCC, and NDB. This would guide policy and programmes of assistance for the small-scale industry. Formation of an association of private aquaculture consultants should be encouraged. This should be done due to the number of "cowboy" consultants in the NWP. These cowboy consultants exploit the ignorance of the small farmers, leading to a loss of respect for the consultant, so that even the good consultants are no longer trusted. The association should ideally be set up and policed by the private consultants themselves. However, in the absence of such initiatives, the banks and cooperatives could use the payment scheme to encourage the consultants to register based on minimum standards of experience and qualifications.

vi. In approving shrimp farms in new areas, out-grower farming systems[6] should be given preference. Therefore, appropriate models should be prepared based on the out-grower concept to suit the requirement of specific areas to be opened up for shrimp farming. In the allocation of state land for farming and selection of out-grower farmers, enterprises from the local area will be given priority. Whenever state land is allocated, adequate publicity should be given and the communities must be consulted.

vii. Allocation of state lands should be done with due regard to the needs of traditional land users and the traditional user rights of the local people. There should be a ceiling on the parcels of land allocated and that should be determined on a set of appropriate criteria. Local residents and fisherfolk should be provided with unhindered access to the lagoons and beaches for their legitimate purposes.

[6] Basic arrangement is equivalent to Mother Farm Concept; for more details, see Fernando (2000).

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Appendix 1

Ministry of Fisheries and Aquatic Resources Development

Guidelines for the Shrimp Industry

01. These guidelines are issued for the information of:

(a) the shrimp farmers and hatchery operators – for strict compliance;
(b) extension workers and industry consultants – to provide the required extension and consultancy services;
(c) regulatory officials – to monitor the compliance by farmers and hatchery operators; and
(d) credit institutions – to consider credit facilities only for those farmers and hatchery operators who comply strictly.

02. The objectives of issuing these guidelines are to :

(a) resurrect the industry;
(b) minimize or mitigate the environmental problems associated with the industry;
(c) prevent future shrimp disease outbreaks; and
(d) maximize the production on a sustainable basis.

03. Following are the guidelines:

Design

3.1 Each farm should have a reservoir, the area of which, is not less than 25 per cent of the total area of its culture pond (or ponds). The purpose of this reservoir is to store water taken from the water source for treatment before feeding the culture pond (or ponds). The reservoir should be identified in the plan of the farm. It should not be used as a culture pond for shrimp.

3.2 Each farm should also have a sufficient sedimentation area, a minimum of not less than 10 per cent of the total area of its culture pond (or ponds). This can be either a dugout pond or a natural depression (waterhole). Its purpose is to hold water discharged from the culture pond for sedimentation of suspended matter, and if necessary for treatment, before releasing to the drainage system outside the farm.

3.3 The sedimentation area should also be identified in the plan. No shrimp should be stocked in the sedimentation area.

3.4 It is recommended that as a better option, water-recycling systems be installed in farms, especially in those exceeding 4 ha in extent.

Treatment of Water

3.5 Water taken to the reservoir from the water source should be filtered through a screen containing 576 mesh per square inch. Water should be retained in the reservoir for not less than 7 days before taking into the culture pond. It is recommended that water in the reservoir be treated with chlorine at the rate of 30 ppm on the fourth day, followed by aeration on the fifth day.

Culture Operation

3.6 Ponds should be stocked with post-larvae not less than 20 day old (PL-20). It is recommended that post-larvae used for stocking be screened for viral infection using PCR equipment. The formalin stress test on post-larvae should be performed only on randomly selected samples and not on the entire stock.

3.7 It is recommended that ponds be stocked at a density of 4-6 post-larvae per square meter. However, ponds may be stocked up to 10 per square meter if provided with mechanical aeration. Stocking density should not exceed 10 per square meter under any circumstance.

3.8 Measures should be taken to maintain the pH of water in culture ponds at 7.8-8.5. Hydrated lime should be used to increase the pH of pond water only when it drops below 7.5. Hydrated lime may also be used on soils with a pH of less than 5.0 during pond preparation. In all other cases the use of hydrated lime should be avoided.

3.9 Farmers should ensure that only good quality feed is used for feeding the stock. Consumption of feed should be daily monitored with a view to avoiding excessive feeding.

3.10 When culture ponds are drained for harvesting, water should be discharged through the sedimentation area to facilitate sedimentation of suspended material.

3.11 At least 60 days should elapse after harvesting a pond, before it is restocked under the next culture cycle. Preparatory work of the pond such as drying, removal of organic matter, repairing of dikes, liming, fertilization, etc. can be done during this 60 day period.

3.12 It is recommended that fish be culture in farms in rotation with shrimp.

Disease Situation

3.13 If a disease breaks out in a farm, it should immediately be notified to the National Aquatic Resources Research and Development Agency (NARA) and the Extension Unit of the National Aquaculture Development Authority of Sri Lanka (NAQDA) located a Chilaw. It is recommended that in order to notify the other farms, especially the neighbouring farms, a red flag is displayed prominently close to the affected pond.

3.14 The stock in the affected ponds should be killed by chlorinating the pond water at 30 ppm. Water in the ponds should be allowed to stand for at least 7 days before releasing to the drainage system outside the farm.

3.15 Notwithstanding what is stated in 12 above, if a farmer desires to harvest the stock in an affected pond, he may do so by netting . Should it be necessary to drain the pond to facilitate harvesting, water should be discharge to the sedimentation area or pumped into an empty pond. Any water originating from the diseased pond should be treated with 30 ppm chlorine, and allowed to stand for not less than 7 days before releasing to the drainage system outside the farm.

Hatchery Operation

3.16 Hatcheries should include a reservoir or a tank for storing and disinfecting water taken from the water source, and a receptacle tank to collect and disinfect discharge water before releasing to the drainage system outside the hatchery. Intake water from the reservoir should go through the standard filter system and an appropriate UV light or ozone treatment. Discharged water should be treated with 30 ppm chlorine.

3.17 After every two or three runs, a hatchery should be shut down for a period of not less than one month. Cleaning and disinfecting of hatchery tanks, and repairing of the buildings, water supply and drainage system, etc. can be done during this one-month period.

3.18 It is recommended that hatchery operators avail of the facilities of the phycology laboratory of the NARA for renewal of their algae stocks periodically.

General

3.19 All farmers and hatchery operators are required to maintain a logbook in which all activities in respect of the farming or hatchery operation are recorded. This book should be made available for inspection and if necessary for recording observations by the extension officers, research

officers, and monitoring officers, and representatives of the relevant credit institutions.

3.20 Farmers and hatchery operators may obtain advice of the NARA in regard to usage of chemicals and drugs in farms and hatcheries.

04. Farmers and hatchery operators should permit the officers of the Ministry of Fisheries and Aquatic Resources Development, NARA, NAQDA, North Western Provincial Ministry of Fisheries, and the relevant credit institutions to inspect their farms and hatcheries to monitor the compliance with these guidelines. They should provide the monitoring officers with the required information and assistance.