Table 8. Contribution of Cultured Shrimp in Total Shrimp Exports

Year	Total shrimp exports			Contribution of cultured shrimps				
					Product exported			
	Annual shrimp landings**	Quantity (mt)	Value (Rs. millions)	Total production (mt)	Weight (mt)	% of total weight of shrimp exported	Value (in Rs. millions)	% of total value of shrimp exported
1990-91	253 626	62 396	6 633.2	35 500	23 075	36.98	3 764.0	56.77
1991-92	290 267	76 107	9 661.6	40 000	26 000	34.16	5 447.6	55.81
1992-93	281 766	74 393	11 802.6	47 000	30 550	41.06	7 662.5	64.93
1993-94	266 727	86 541	17 707.3	62 000	40 300	47.14	12 889.3	72.79
1994-95	321 234	101 751	25 102.7	82 850	53 853	52.92	18 662.3	74.35
1995-96	265 284	95 724	23 560.0	70 573	47 922	50.96	15 316.9	64.09
1996-97	315 153	105 426	27 017.8	70 686	45 945	43.58	16 425.6	60.80
1997-98	291 590	101 318	31 405.6	66 868	43 454	42.90	20 860.0	66.42
1998-99	304 541	102 484	33 449.0	82 634	53 816	52.41	25 110.0	75.07
1999-00	—*	110 275	36 452.2	86 000	54 000	48.96	27 820.0	76.32

*Source: MPEDA; * Figure not available; ** Figures for calendar year*

Note: 1. From capture resource, only around 50 000 metric tonnes (product weight) of shrimp contributes to the export market, which is almost equivalent to around 100 000 metric tonnes by live weight (i.e. 33% of the total shrimp landings) is exported, leaving behind about 200 000 metric tonnes (67%) for the domestic consumption.

2.Though the cultured shrimps contributed about 41.0% to the total shrimp exports (by weight), its contribution by value is around 76% because of the production of high value shrimps.

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4.0 Environment (Protection) Act, 1986 and Coastal Regulation Zone, 1991

4.1 Introduction

In the 42nd amendment to the Constitution in 1976, India made provisions for the protection and improvement of environment and in the process became the first country in the world to do so. In Chapter IV of the Constitution (Directive Principles of State Policy), Article 48-A was inserted which enjoins the State to make endeavour for protection and improvement of the environment and for safeguarding the forest and wild life of the country. Another landmark provision in respect of environment was also inserted, by the same amendment {Article 51 -A (g)}, which stipulates that it shall be the duty of every citizen of India *to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.*

While provisions for regulation and legal action for some specific environmental issues were existing in various enactments (e.g. The Indian Penal Code, The Criminal Procedure Code, The Factories Act, The Indian Forest Act, The Merchant Shipping Act), these were found either inadequate or being not effectively applicable to check the degradation of the environment due to the fast pace of industrialisation in the post-independence era. The Stockholm Conference on Human Environment in June, 1972 accelerated our actions on environmental safeguards and it was considered appropriate to have uniform laws all over the country for broad environmental problems endangering the health and safety of people as well as of the flora and fauna. The Water (Prevention and Control of Pollution) Act, 1974, was the first enactment by the Parliament in this direction and also the first specific and comprehensive legislation institutionalising simultaneously the regulatory agencies for controlling water pollution. The Pollution Control Boards at the centre and in the states owe their genesis to this act.

This chapter brings out salient excerpts from the Environment (Protection) Act, 1986 and the Coastal Regulation Zone, 1991, since both these legislations have vital bearing on the matters related to the sustainable development of shrimp aquaculture in the coastal areas of the country*.

4.2 The Environment (Protection) Act, 1986

Consequent upon the decisions taken at the United Nations Conference on Human Environment held at Stockholm in June 1972, the Government of India took appropriate steps and enacted the Environment (Protection) Act in 1986 to provide for the protection and improvement of environment and for matters connected therewith. This Act came into force on 19th November, 1986 *vide* Notification No. G.S.R. 1198 (E) dated 12.11.1986, published in the Gazette of India No. 525 dated 12.11.1986 and it extends to the whole of India.

Chapter 2 of that Act deals with the General Powers of the Central Government. Section 3(1) provides the Central Government the power to take *all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution.*

* For full details, the said legislations should be referred

Section 3 (2) has the following provisions:

(i) Co-ordination of actions by the State Governments, Officers and other authorities;

(ii) Planning and execution of a nation-wide programme for the prevention, control and abatement of environmental pollution;

(iii) Laying down standards for the quality of environment in its various aspects;

(iv) Laying down standards for emission or discharge of environmental pollutants from various sources whatsoever;

(v) Restriction of areas in which any industries, operations or processes or class of industries, operation or processes shall not be carried out or shall be carried out subject to certain safeguards;

(vi) Laying down procedures and safeguards for the prevention of accidents which may cause environmental pollution and remedial measures for such accidents;

(vii) Laying down procedures and safeguards for the handling of hazardous substances;

(viii) Examination of such manufacturing processes, materials and substances as are likely to cause environmental pollution;

(ix) Carrying out and sponsoring investigations and research relating to problems of environmental pollution;

(x) Inspection of any premises, plant, equipment, machinery, manufacturing or other processes, materials or substances and giving, by order, of such directions to such authorities, officers or persons as it may consider necessary to take steps for the prevention, control and abatement of environmental pollution;

(xi) Establishment or recognition of environmental laboratories and institutes to carry out the functions entrusted to such environmental laboratories and institutes under this Act;

(xii) Collection and dissemination of information in respect of matters relating to environmental pollution;

(xiii) Preparation of manuals, codes or guides relating to the prevention, control and abatement of environmental pollution;

(xiv) Such other matters as the Central Government deems necessary or expedient for the purpose of securing the effective implementation of the provisions of this Act;

Section 3 (3) empowers the Central Government to - "*constitute an authority or authorities by such name or names as may be specified in the order for the purpose of exercising and performing such of the powers and functions (including the power to issue directions under section 5) of the Central Government under this Act and for taking measures with respect to such of the matters referred to in sub-section (2) as may be mentioned in the order and subject to the supervision and control of the Central Government and the provisions of such order, such authority or authorities may exercise the powers or perform the functions or take the measures so mentioned in the order as if such authority or authorities had been empowered by this Act to exercise those powers or perform those functions or take such measures*" (Aquaculture Authority has been set up under this Section of the Act).

Section 5 of the Act deals with the Power to give Directions – "*Notwithstanding anything contained in any other law but subject to the provisions of this Act, the Central Government may, in the exercise of its powers and performance of its functions under this Act, issue directions in writing to any person, officer or any authority and such person, officer or authority shall be bound to comply with such directions*"

4.3 Coastal Regulation Zone, 1991

The Government of India, issued a Notification on February 19, 1991 notifying the Coastal Regulation Zone and regulating activities in this zone under Sections 3(1) and 3(2) (v) of the Environment (Protection) Act, 1986. According to the said Notification, *the Central Government declared the coastal stretches of seas, bays,* *estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 meters from High Tide Line (HTL) and the land between the Low Tide Line (LTL) and the HTL as Coastal Regulation Zone and imposed with effect from the date of this Notification, certain restrictions on the setting up and expansion of industries, operations, processes, etc. in the said Coastal Regulation Zone (CRZ).*

The High Tide Line (HTL) was defined as *the line up to which the highest high tide reaches at spring tide.* It was clarified that the distance from the High Tide Line (HTL) to which the CRZ regulations will apply in the case of rivers, creeks and backwaters may be modified *on a case by case basis for reasons to be recorded while preparing the Coastal Zone Management Plans; However, this distance shall not be less than 100 meter or the width of the creek, river or backwater whichever is less.*

This definition was further amended by a Notification dated August 18, 1994, as " *the High Tide Line means the line on the land up to which the highest water line reaches during spring tide and shall be demarcated uniformly in all parts of the country by the demarcating authority so authorised by the Central Government in consultation with the Surveyor General of India."*

Under Section 2 of the Notification, the following activities are declared as prohibited within the Coastal Regulation Zones, namely:

(i) Setting up of new industries and expansion of existing industries, except those directly related to water front or directly needing foreshore facilities;

(ii) Manufacture or handling or storage or disposal of hazardous substances;

(iii) Setting up and expansion of fish processing units including warehousing (excluding hatchery and natural fish drying in permitted areas);

(iv) Setting up and expansion of units/ mechanisms for disposal of wastes and effluents, except facilities required for discharging treated effluents, into the water course with approval under the Water (Prevention and Control of Pollution) Act, 1974; and except for storm water drains;

(v) Discharge of untreated wastes and effluents from industries, cities or towns and other human settlements. Schemes shall be implemented by the concerned authorities for phasing out the existing practices, if any, within a reasonable time period not exceeding three years from the date of Notification;

(vi) Dumping of city or town waste for the purposes of land filling or otherwise; the existing practice, if any, shall be phased out within a reasonable time period not exceeding three years from the date of Notification;

(vii) Dumping of ash or any wastes from thermal power stations;

(viii) Land reclamation, bunding or disturbing the natural course of sea water with similar obstructions, except those required for control of coastal erosion and maintenance or cleaning of waterways, channels and ports and for prevention of sandbars and also except for tidal regulators, storm water drains and structures for prevention of salinity ingress and for sweet water discharge;

(ix) Mining of sands, rocks and other substrata materials, except those rare minerals not available outside the CRZ area;

(x) Harvesting or drawal of ground water and construction of mechanisms therefor within 200 m of HTL; in the 200 m to 500 m zone it shall be permitted only when done manually through ordinary wells for drinking, horticulture, agriculture and fisheries;

(xi) Construction activities in ecologically sensitive areas;

(xii) Any construction activity between the Low Tide Line and High Tide Line except facilities for carrying treated effluents and waste water discharges into the sea, facilities for carrying sea water for cooling purposes, oil, gas and similar pipelines and facilities essential for activities permitted under this Notification; and

(xiii) Dressing or altering of sand dunes, hills, natural features including landscape changes for beautification, recreational and other such purposes, except as permissible under this Notification.

Section 3 deals with the regulation of permissible activities and sub-section (3) deals with the preparation of the coastal zone management plans.

3(3) (i) The coastal States and Union Territories have been asked to prepare, within a period of one year from the date of Notification, Coastal Zone Management Plans identifying and classifying the CRZ areas within their respective territories in accordance with the guidelines and obtain approval of the Central Government in the Ministry of Environment & Forests;

3(3) (ii) Within the framework of such approved plans and guidelines, all development and activities within CRZ other than those not permitted and activities which require environmental clearance from the Ministry of Environment and Forests shall be regulated by the State Government, Union Territory Administration or the local authority as the case may be.

3(3) (iii) In the interim period till the Coastal Zone Management Plans are prepared and approved, all developments and activities within the CRZ shall not violate the provisions of the Notification. State Governments and Union Territory Administrations shall ensure adherence to these regulations and violations, if any, shall be subject to the provisions of the Environment (Protection) Act, 1986.

In Annexure I, Section 6(1) of the Notification, classification of Coastal Regulation Zone is detailed. For regulating development activities, the coastal stretches within 500 meters of High Tide Line of the landward side are classified into four categories namely:

Category – I (CRZ – I)

(i) Areas that are ecologically sensitive and important, such as national parks/ marine parks, sanctuaries, reserve forests, wildlife habitats, mangroves, corals/ coral reefs, areas close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty/ historical/ heritage areas, areas rich in genetic diversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such other areas as may be declared by the Central Government or the concerned authorities at the State/ Union Territory level from time to time.

(ii) Area between the Low Tide Line and the High Tide Line.

Category – II (CRZ – II)

The areas that have already been developed upto or close to the shore-line. For this purpose, “developed area” is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

Category – III (CRZ-III)

Areas that are relatively undisturbed and those which do not belong to either Category I or II. These will include coastal zone in the rural areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

Category – IV (CRZ-IV)

Coastal stretches in Andaman & Nicobar, Lakshadweep and small islands except those designated as CRZ-I, CRZ-II, or CRZ-III.

Section 6 (2), details with the norms for the regulation of development or construction activities in different categories of CRZ. Under CRZ – III, the area up to 200 meters from the High Tide Line is to be earmarked as ‘No Development Zone’. No construction shall be permitted within this zone except for repairs of authorised structures not exceeding existing FSI, existing plinth area and existing density. However, the following uses may be permissible in this zone – agriculture, horticulture, gardens, pastures, parks, play fields, forestry and salt manufacture from sea water.

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5.0 Coastal Environment

5.1 Introduction

Coastal area is commonly defined as the interface or transition area between land and sea, including large inland lakes. Coastal areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. There are no exact natural boundaries to delineate coastal areas and they can best be viewed in their entirety as special geographical areas wherein the productive and natural defense functions are intimately linked with the physical and socio-economic conditions far beyond the physical boundary.

According to the 1994 distribution of population in relation to the distance from the nearest coastline, 20.6% of the world's population lives within 30 km of the coast, and 37.0% within 100 km[30]. The potential for economic opportunities in coastal cities is a strong attractive force, fuelling immigration, often from economically depressed rural areas. As a result, in future much larger, younger populations can be expected in the coastal areas of developing countries. These future coastal residents will demand employment, housing, energy, food, water and other goods and services, thus presenting a substantial development challenge. Against this demographic backdrop, coastal areas are extremely important for the social and economic welfare of current and future generations, as coastal resources support key economic and subsistence activities.

Coastal areas are also important ecologically, as they provide a number of environmental goods and services. Marine, estuarine and coastal wetland areas often benefit from flows of nutrients from the land and also from ocean upwelling which brings up nutrient-rich water to the surface. They thus tend to have particularly high biological productivity. Moreover, coastal areas frequently contain critical terrestrial and aquatic habitats, particularly in the tropics. Such habitat together comprise unique coastal ecosystems, support a rich biological diversity and frequently contain a valuable assortment of natural resources. Examples of such habitats are estuarine areas, coral reefs, coastal mangrove forests and other wetlands, tidal flats and seagrass beds, which also provide essential nursery and feeding area for many coastal and oceanic aquatic species.

Typically, the coastal zone includes all the intertidal and supratidal areas of the water's edge; specifically all the coastal floodplains, mangroves, marshes and tidal flats as well as beaches and dunes and fringing coral reefs. This is the zone where some of the richest aquatic habitat is found. It is the core of the coastal zone.

Five main zones can be identified in the coastal-marine spectrum: *inland areas*, which affect the oceans mainly *via* rivers and non-point sources of pollution; *coastal lands*—wetlands, marshes, and the like—where human activity is concentrated and directly affects adjacent waters; *coastal water*—generally estuaries, lagoons, and shallow waters—where the effects of land-based activities are dominant; *offshore waters*, mainly out to the edge of national jurisdiction (200 nautical-miles offshore); and *high seas*, beyond the limit of national jurisdiction.

The coastal ecosystem is influenced by the oceanographic, climatic and demographic factors. The ecosystem has tremendous pressure from its varied users. The major activities in the ecosystem include agriculture, horticulture, livestock, industries, salt production, fisheries, aquaculture, tourism, recreation, transport and waste disposal. With such multifarious users, there is bound to be conflict among the different users.

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[30] Gommes, R. 1997. Sea level, agriculture and population : some issues. Paper presented at the Staring Symposiuim on Sea Level and Science Fiction, Amsterdam, 22 October, 1997, organised by the Royal Netherlands Academy of Arts and Sciences, 20pp

5.2 Coastal Environment

India has a vast coastline of 8 118 km distributed in nine coastal states and four union territories. The state-wise distribution of the coastline and the associated continental shelf area is presented in Table 9. Apart from this, India has a total estuarine area of 3.9 million ha and backwaters of 3.5 million ha. Mangroves contribute about 0.4 million ha area[31] .

Table 9. State-wise Details of Coastline and Continental Shelf [32]

State/ Union Territory	Approximate length of coastline (Kms)	Continental shelf (‘000 sq. km)
East Coast		
West Bengal	158	17
Orissa	480	26
Andhra Pradesh	974	33
Tamil Nadu	1 076	41
West Coast		
Kerala*	590	40
Karnataka	300	27
Goa	104	10
Maharashtra	720	112
Gujarat	1 600	184
Union Territories		
Andaman & Nocobar islands*	1,912	35
Daman and Diu*	27	-
Lakshadweep*	132	4
Pondicherry	45	1
Total	**8 118**	**530**

**Provisional;*

India has a variety of natural coastal ecosystems. The Indian coastline can be divided into the Gujarat region, the west coast, the east coast and the Islands. The major portion of the west coast is dominated by a scarped slope resulting in a well-drained, flood free hinterland. The east coast is low-lying with lagoons, marshes, beaches and deltas. The east coast is flatter and wider and tends to be better cultivated and more densely populated than the west coast. The islands of Lakshadweep are composed of atolls while the Andaman and Nicobar Islands are volcanic in origin, arising from a submerged mountain chain. The coastal areas are productive and rich in natural resources. They support a significant proportion of India’s population as well as several important urban centres and ports.

The Indian coastal zone is used for multifarious activities and the main activities listed by the MOEF are presented in the following Table 10.

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[31] WWF. 1992. India’s Wetlands, Mangroves and Coral Reefs. Prepared by World Wide Fund For Nature, India, for the Minsitry of Environment and Forests

[32] FAO/BOBP.2001. Report of the National Workshop on the Code of Conduct for Responsible Fisheries. BOBP/REP/90

Table 10. Main activities along the Indian Coastal Zone[33]

Land Based	
I. Coast Dependent	Ports and Harbours Oil Terminals Paper and Pulp mills Metallurgical plants Fish Processing Power Plants
II. Coast preferring	Urban, commercial and residential development Tourism and beach recreation Agriculture
III. Coast independent	Defence
Water Based	
	Offshore oil and gas Offshore placer mining Navigation Naval defence Water sports Fishing Dredging and Land reclamation

5.3 Threats to Coastal Environment

All developmental activities, irrespective of their scale, nature and magnitude affect the environment. The impacts of these developmental activities may have short-term as well as long-term implications. The short-term implications may be negligible as compared to the benefits of the developmental programmes, but the long-term implications may further create new ecological and environment problems, the solutions for which may not be easy to find. Some of these implications may be summarised in terms of vast areas of deforested lands, denudation of slopes, soil erosion and silting rivers, regular occurrence of floods and droughts, impoverishment of important fauna and flora, changed climate, polluted water unfit to drink and contaminated air unfit to breathe.

Coastal ecosystem is considered as fragile and the coastal resources and natural habitats are influenced by various human activities. The important factors responsible for the degradation of coastal resources are the pollution from land as well as water-based sources and competing, often conflicting, demands placed on coastal resources by different stakeholders.

5.3.1 Pollution

The exponential growth of population, the rapid pace of industrialization and urbanization, and the increasing use of fertilizers and pesticides in agriculture are mainly responsible for pollution along the Indian coast. The coastal waters are exposed to pollution from various sources – inland, coastal, offshore, and atmospheric. Pollutants from inland areas find their way to coastal waters through rivers and streams. The main sources of pollutants are:

- Domestic wastes
- Industrial wastes from textile mills, chemical plants and pharmaceutical, plastic, detergent, food processing, jute and tyre factories, etc.
- Pesticides and insecticides used in agriculture and healthcare, including chlorinated hydrocarbons like DDT, BHC, Endrin and Dieldrin and organophosphates such as Malathion, Parathion, Diazinon, etc.

[33] The State of Environment, 1995. Ministry of Environment and Forests

- Petrochemical substances, from oil exploration, refineries, oil tankers, ships, fishing vessels, etc.
- Heated effluents discharged from thermal (coal-based) power stations.

The major source of pollution are discussed below.

Industry

It is estimated that about 390 million tonnes of industrial effluents are released annually into Indian coastal waters. Though strict standards have been prescribed for industrial effluents under Environment (Protection) Act and monitoring is carried out by Central and State Pollution Control Boards, the pollution load reaching the coastal environment is enormous. Polluting industries include leather tanneries, textiles, chemical and other allied industries. Among the coastal states, industrial pollution is high in West Bengal, Tamil Nadu, Gujarat, Maharashtra and Andhra Pradesh. The mining industry also contributes to pollution of coastal waters as, for example, off the coasts of Goa and Orissa. In addition, atmospheric and other pollutants from non-coastal states are also washed into coastal waters. Toxic chemicals and heavy metals are of major concern. Apart from affecting the various marine organisms, these pollutants may harm human beings through bio-accumulation and bio-magnification through the food chain.

Domestic Sewage

Sewage from inland and coastal urban centres, is dumped directly into coastal waters or through rivers and estuaries. The estimated pollution load is as follows:[34]

Domestic sewage added to the sea by coastal population per year - 4 100 million tonnes
Sewage and effluents added by the rivers to the sea per year -50 million tonnes
Solid waste and garbage generated by coastal population per year -33 million tonnes

Excessive nutrients from the sewage leads to eutrophication of waters, a decline in photosynthetic activity and a reduction in dissolved oxygen. These changes will often affect the coastal ecosystem. Negative impacts are especially evident in estuaries and creeks near cities, as in the Mahim area off Mumbai. Further, bacterial and viral pathogens released along with sewage may reach the human beings through marine food items.

Agricultural Run-off

The "green revolution" in India has also brought in along with it an increased use of fertilizers and pesticides in agriculture operations. It has been estimated that atleast 25.0 % of the following reach the coastal waters.

Fertilizers used per year[35]	-	*5.0 million tonnes*
Persticides per year	-	*75 000 tonnes*
Synthetic detergents used per year	-	*125 000 tonnes*

Pesticides, especially organochlorine pesticides which are non bio-degradable accumulate in the marine organisms and subsequently, bio-magnify through the food chain.

Oil Pollution

Pollution due to oil exploration and mining, oil refining, oil transportation, oil spills and bilge discharge from ships and fishing trawlers, as well as from petrochemical industries, is also present in some regions, such as in Tamil Nadu, Gujarat, Maharashtra, Andaman and Nicobar and the Lakshadweep Islands.

Coastal Aquaculture

Coastal aquaculture practices can also lead to organic pollution as well as nutrient loading in coastal waters. This form of pollution is different from that of industrial pollution, since the waste materials are biodegradable. Unlike agricultural wastes no toxic material like pesticides are used in aquaculture. The cultivated aquatic organisms, especially shrimps are more susceptible to coastal pollution rather than contributing to the pollution

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34 Qasim, S.Z. *et al.*, 1988. Pollution of the seas around India. Proc. Indian Acad. Sci., (Anim. Sci.) Vol 97(2): 117-131

35 Qasim, S.Z. *et al.*, 1988. Pollution of the seas around India. Proc. Indian Acad. Sci., (Anim. Sci.) Vol 97(2): 117-131

load. Aquaculturists are the first to be affected by coastal pollution. They may lose their total crop or end up with poor growth of the cultivated organisms due to the poor quality of water. In China and Korea, the administration actively helps shrimp farmers to obtain compensation from the polluting industry, whose action had led to the poor production in the shrimp ponds[36].

5.3.2 Siltation

Increased siltation and sedimentation of coastal water is consequence of deforestation, mining and inappropriate agricultural practices in upstream and coastal areas. The Chilka lake in Orissa, the largest brackishwater lake in Asia, is shrinking due to siltation.

5.3.3 Coastal Erosion

The Indian coastline for instance, along the coasts of the western states of Kerala and Karnataka, is vulnerable to erosion. The construction of inappropriate designed coastal protection structures such as sea walls has, in many cases aggravated the problem.

5.3.4 Degradation and Destruction of Natural Habitat

Natural coastal habitats such as mangrove forests are being degraded by human activities which will lead to overall degradation of the coastal area with erosion, tidal waves and other natural calamities.

5.4 Potential Hot Spots

In Indian coastal zone there are many areas where the pollution levels are alarming and these are identified as "Potential Hot spots" and the state-wise detail of the "Potential hot spots" are listed below in Table 11 [37].

Table 11 "Potential Hot Spots" in the Indian Coast

States	Coastal cities/ towns
Gujarat	Okha, Veraval
Maharashtra	Bassein, Bombay Harbour, Thane,
	Trombay, Versova, Ulhas creek, Mahim
Goa	Marmagao
Karnataka	Karwar, Mangalore
Kerala	Kochi, Thiruvananthapuram
Tamil Nadu	Ennore, Madras Harbour, Cooum, Point Calimere
	Koodankulam, Arumuganeri, Tuticorin
Andhra Pradesh	Vishakhapatnam
Orissa	Gopalpur, Paradeep, Puri
West Bengal	Indo-Bangladesh border, Sandheads, Diamond Harbour

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36 Kutty, M.N. 1995. Aquaculture Development and Sustainability in Southeast Asia, pp 91-108. In: Bagarinao.TU, and Flores EEC (eds.) Towards Sustainable aquaculture in Southeast Asia and Japan. SEAFDEC Aquaculture Department, Ilo-ilo, Philippines

37 The State of Environment, 1995. Ministry of Environment and Forests

6.0 Shrimp Aquaculture and the Coastal Ecosystem

6.1 Introduction

Aquaculture, as with all agricultural enterprises, is dependent on natural resources. The optimum and sustainable use of natural resources for aquaculture (and agriculture) can lead to profitable economic gains, although if badly planned and managed, it can also lead to short and long-term economic loss[38]. Aquaculture can be considered as an integral part of the natural environment, and the interactions between aquaculture and the environment are inevitable. The major natural resources required for aquaculture are land, water and biological inputs such as seed and feed. The manner in which the natural resources are used for aquaculture are the key to its economic success and sustainability.

In considering the interaction between aquaculture and the environment, it is essential to consider the environmental impacts related to aquaculture. These include the probable impact(s) of aquaculture operations on water, land and other resources required by other aquaculturists or other user groups. It is important to recognise that the impact(s) may be negative or positive. *It may also be mentioned here that aquaculture can certainly contribute positively to environmental improvement in many ways, a fact often not recognised in many discussions on environmental impacts of aquaculture*[39].

The level of environmental impacts of shrimp aquaculture are dependent on the site conditions, geographical locations, tidal characteristics, species cultured, type of farming practices, degree of intensification, quality of inputs, management methods used and the level of human awareness regarding the ecosystem. The major impacts of shrimp farming can be broadly categorised as follows:

a) Impact on land resources
b) Impact on water resources
c) Impact on biological resources
d) Social
e) Economical

In an attempt to assess the probable environmental impacts of shrimp farming, the categories listed above have been discussed at length in this chapter. To provide an objective assessment and portray a balanced picture of the impacts, a large number of published documents - from India and other countries were referred to and their findings presented hereunder. Reports specific to the Indian scenario (e.g., Report of NEERI, Nagpur submitted to this Court) have been analysed in greater details and the observations summarised in the following paragraphs.

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[38] Phillips. M. J. 1995. Aquaculture and the Environment – Striking a balance. Proc. INFOFISH-AQUATECH '94 Conference Aquaculture towards the 21st Century, Colombo, Sri Lanka, 29-31 August 1994

[39] Phillips. M. J. 1995. Aquaculture and the Environment – Striking a balance. Proc. INFOFISH-AQUATECH '94 Conference Aquaculture towards the 21st Century, Colombo, Sri Lanka, 29-31 August 1994

6.2 Impact on Land Resources

Since shrimp farming requires good, clean, saline or brackishwater, shrimp farms have to be located near the sea or creek. These areas are generally also the habitat of wetland ecosystems like mangroves, marshy lands, etc. Multifarious activities take place in the coastal areas and shrimp farming has to compete with these activities for land and other resources. The major activities that take place in coastal areas are - fisheries, horticulture (plantations such as coconut, cashew nut), salt production, industries, urban development and tourism. Apart from competition for land and other resources, aquaculture may also interact with the other user groups. The following paragraphs discuss the impact and interaction of shrimp aquaculture on major coastal resources.

6.2.1 Mangrove Resources

Mangrove forests constitute the most productive ecosystems along the tropical and sub-tropical coastal zones and islands and are ecologically important in many ways. They provide direct and indirect social, economic and ecological benefits. Traditionally, mangrove forests have served various daily needs of coastal communities and the following major uses, functions and attributes can be assigned to mangroves (Table 12).

Table 12. Summary of the Uses, Functions and Attributes of Mangroves

Uses	Forestry, agriculture, food, drugs, beverages, fuel wood, recreation, tourism, water supply, mineral production, wildlife, research and education, energy production, fishing and aquaculture inputs and materials, household items, textiles and leather, construction material and transport.
Functions	Flood mitigation, prevention of saline intrusion, storm protection, sediment trap, removal of nutrients and toxicants, ground water recharge, nutrient export, wildlife habitat, fish and shell fish habitat (especially as nursery areas)
Attributes	Biological diversity, social, economic and cultural value, aesthetic value, wilderness value, education value.

The various goods and services of the mangrove forests benefit the communities living in coastal areas and the removal of mangroves can lead to far reaching economic and social impacts, particularly when the removal leaves the local communities without alternative means of employment or sustenance. This is one of the reasons why removal of mangroves for various activities commonly leads to social conflicts and declining living conditions for traditional communities deriving their sustenance from mangrove areas[40] .

General Pattern of Mangrove Exploitation

Mangrove resource utilization takes several forms, which have collectively contributed to the decline in mangrove areas in many parts of the world during the last 3 – 4 decades. The basic forms of exploitation arising from human utilization of mangroves include:

- over-exploitation by traditional users;
- commercial mangrove wood utilisation;
- conversion to other natural resource uses – such as agriculture, salt production, aquaculture. The extent of conversion varies with population pressures, government policies and incentives and the extent and quality of mangrove available;

[40] Tobey. J. and J. Clay . 1997. Shrimp Mariculture in Latin America and the Caribbean. Production, Trade and the Environment. Working paper presented by the Coastal Resources Centre, University of Rhode Island

- conversion to other activities generally unrelated to the coastal ecosystem, which completely destroy the mangrove resource, such as urban and industrial development, harbours, mining; and
- off-site activities unrelated to the mangrove ecosystem but which are detrimental such as offshore dredging, mining, coastal oil pollution, and diversion of upstream freshwater resources for irrigation.

Conversion of Mangrove Forests for Shrimp Farming

Shrimp culture is often regarded as the most obdurate destroyer of mangroves, but the development of shrimp culture is not as closely related to the availability of mangroves as often perceived. It has been observed that if all the shrimp ponds in the world were located in mangrove regions, they would occupy less than five percent of global mangrove resources. It has also been reported that sustainable development of shrimp culture is closely inter-related with mangroves, as "shrimp culture cannot be sustainable without mangroves and clean water"[41] .

Analyses on depletion of mangrove cover in Asia point towards the fact that shrimp ponds have recently been and/ or now being constructed, either on former mangrove areas that were cleared long ago (and considered degraded) or on more recently cleared areas for which the primary purpose of clearance was timber abstraction (logging, wood chip industries or charcoal production) or by adopting traditional trapping ponds or on areas inland from the mangrove belt. Aquaculturists in Asia are therefore more often than not the end users of already degraded or destroyed mangroves rather than the primary culprits of mangrove destruction[42] .

Modern scientific shrimp farming is not carried out in mangrove areas owing to the following disadvantages :

- mangrove lands are mostly potential acid sulphate soils characterised by acidic nature which is not suitable for shrimp culture
- clearing of the mangrove forests is cost-prohibitive
- high organic content of the mangrove forest soil is unusable for dyke construction, and the cost of construction escalates many fold if the soil is brought from outside
- reclamation of acid sulphate soil and pre-conditioning of the pond bottom requires heavy application of lime and several months are required for the purpose

The paucity of information on mangroves in India has resulted in discrepancies between various estimates published on their original extent and subsequent depletion due to anthropogenic activities, including shrimp aquaculture. Deltaic environment of the Indian east coast supports extensive mangrove formations due to gentle intertidal slope and siltation. The largest stretch of mangroves in the country lies in West Bengal (the Sunderbans) and in Andaman and Nicobar Islands. The Ministry of Environment and Forests had estimated a total area of 6 680 sq. km of mangroves in the country in 1987[43] and 4 256 sq. km of mangroves in 1994[44] .The National Institute of Oceanography (NIO), Goa has estimated about 4 943 sq. km of mangroves from remote sensing imageries of 1992[45] . A recent estimate (1997) by the Forest Survey of India (FSI), Dehradun shows an area of 4 824 sq. km of mangrove forests in the country[46] . The details of the available estimates are shown in Table 13.

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41 Lassen, T.J. 1997. Environmental Extremes vs. Sustainable Policies in Aquaculture, published in World Aquaculture, Sept. 1997

42 Pullin. RSV. 1993. International Centre for Living Aquatic Resources Management, Metro Manila, Philippines – Discussion & Recommendations on Aquaculture & the Environment in Developing Countries

43 MOEF, 1987. "Mangroves in India - Status report", Ministry of Environment and Forests, Government of India, New Delhi, p. 150

44 MOEF, 1994. "Wetlands of India - A Directory", Ministry of Environment and Forests, Government of India, New Delhi, p.150

45 National Institute of Oceanography. Data from 1992 imagery. From web site http://www.mangroveindia.org

46 FSI, 1997. Annual Report 1997. From web site http://envfor.nic.in/fsi/sfr97/A2.HTML

Table 13. Extent of Mangrove Systems in India

State/ Union Territory	Area in Sq. Km			
	MOEF 1987	**NIO 1992**	**MOEF 1994**	**FSI 1997**
Andaman and Nicobar Islands	1 190	771	966	966
West Bengal (Sundarbans)	4 200	2 300	2 119	2 123
Orissa (Bhitarkanika and Mahanadhi)	150	193	195	211
Andhra Pradesh (Godavari and Krishna)	200	330	378	383
Tamil Nadu (Pitchavaram and Muthupet)	150	30	21	21
Kerala	_	25	5	_
Karnataka	-	13	-	-
Goa	200	20	3	5
Maharashtra	330	209	155	124
Gujarat	260	1 052	414	991
Total	**6 680**	**4 943**	**4 256**	**4 824**

An analysis of the estimates made by government agencies in the country indicates that about 2 424 sq. km of mangroves were lost between 1987 and 1994, of which 2 081 sq. km were lost in West Bengal; 197 sq. km in Goa; 129 sq. km in Tamil Nadu; and 175 sq. km in Maharashtra. The time-series data show that maximum mangrove cover has been lost in West Bengal (31.15%). The traditional shrimp farms *(bheries)* in West Bengal covering an area of approximately 33 000 ha were in operation much before 1987 and shrimp farms developed in West Bengal during the period 1984 – 1997, covered an area of 15 444 ha only. On the contrary, the mangrove loss reported is to the extent of 2 424 sq. km or 242 400 ha. Assuming that the entire 15 444 ha of the new shrimp farms were developed in mangrove area, the balance 226 956 ha loss of mangrove cover in West Bengal during the same period must have been due to other human activities.

The mangrove forests in India are very rich in bio-diversity and the mangrove species available in India and their families are listed in Table 14.[47]

In India, mangrove forests have been traditionally exploited by the coastal communities for fuel wood except in the Indian Sunderbans and the Andaman Islands where selective system of rotational felling has been practiced. Further, an analysis of the remote sensing data on the status of the different mangrove systems has showed that except for the mangroves in Andaman and Nicobar Islands and Gujarat, all others were highly degraded and the reasons attributed were conversion for agriculture, human dependency, aquaculture, harbour development, salt industries, cattle grazing, geomorphological changes, fuel wood use and industrial development[48] .

Besides making a general assessment on the probable causes of mangrove cover in the country as a whole, the time-series data available on some of the specific mangrove sites were analysed in more details to get a clearer picture of the impact of shrimp farming on mangroves.

Muthupet Mangrove Forests, Tamil Nadu

The Muthupet mangrove was declared as Reserve Forest in 1911 and the total area of the wetland is about 11 800 ha divided into six Reserve Forest Blocks for administrative purpose. In 1960s, an area of 1 300 ha of mangrove wetland was denotified and given to the Salt Corporation, Government of India, for construction of salt pans and in the same year 370 ha was also dereserved for the settlement of the repatriates from Myanmar (Burma)[49] .

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[47] National Institute of Oceanography. Data from 1992 imagery. From web site http://www.mangroveindia.org

[48] Krishnamoorthy, R. and S. Ramachandran. 2000. Application of remote sensing in mangrove wetland studies. In: Ramachandran.S. (ed.) Marine Remote Sensing Applications. Institute for Ocean Management, Anna University, Chennai – 25. pp 168-208

[49] MSSRF, 1995. Coastal Wetlands: Mangrove Conservation and Management. Project proposal submitted to India-Canada Environment Facility, New Delhi. September 1995

Table 14. Species of Mangroves Available in India

Family	Species
Acanthaceae	*Acanthus ilicifolius* L. *A. Volubilis Wall. A. Ebracteatus*
Aizoaceae	*Sesuvium portulacastrum* L.
Apocynaceae	*Cerbera manghas* L. *C. odollam* Gaertn.,
Aracaceae (Palmae)	*Nypa fruticans* (Van.) Wurumb. *Phoenix paludosa* Roxb.
Asclepiadaceae	*Finlaysonia maritima* (Bl.) Backer ex Heyna *Sarcolobus carinatus* Wall. *Tylophora tenuis* Bl.
Asteraceae	*Pluchea indica* Less.
Avicenniaceae	*Avicennia alba* Bl. *A. marina* (Forsk.) Vahl *A. marina* (Forsk.) Vahl var. acutissima Stapf & Mold *A. officinalis* L.
Barringtoniaceae	*Barringtonia racemosa* Roxb.
Bignoniaceae	*Dolichandrone spathacea*
Boraginaceae	*Helioptropium curassavicum*
Caesalpiniaceae	*Caesalpinia bonduc* (L.) Roxb.
Chenopodiaceae	*Arthrocnemum indicum* (Wild.) Moq. *Salicornia brachiata* Roxb. *Suaeda maritima* (L.) Dumort. *S. monoica* Forsk. Ex. Gmel. *S. nudiflora* (Willd.) Moq.
Combertaceae	*Lumnitzera* (Jack.) Voigt *L. racemosa* Willd.
Convolvulaceae	*Ipomoea tuba* (Schl.) G. Don. *Stictocardia tiliifolia* (Desr.) Hall. f.
Cyperaceae	*Fimbristylis ferruginea* (L.) Vahl *Scirpus littoralis* Schrad.
Euphorbiaceae	*Exceocaria agallocha* L.
Fabaceae	*Cynometra ramiflora* L. *Cynomitra iripa Dalbergia spinosa* Roxb. *Derris hetereophylla* Willd. *Intsia bijuga* (Colebr.) Kuntze
Hippocrataceae	*Salacia chinensis* L.
Malvaceae	*Hibiscus tiliaceus* L. *Thespesia populnea* (L.) Sol. ex Correa *T. populneoides* (Roxb.) Kostel
Meliaceae	*Xylocarpus granatum* Koen. *X. molluccensis* (Lamk.) Roem. *X. mekongensis* Pierre
Myrsinaceae	*Aegiceras corniculatum* (L.) Blanco
Pandanaceae	*Pandanus odoratissimus* Linn. F.
Plumbaginaceae	*Aegialitis rotundifolia* Roxb.
Poaceae	*Aeluropus lagopoides* (L.) Trin. *Myriostachya wightiana* Hook. F. *Porteresia coarctata* (Roxb.) Tateoka *Urochondra setulosa* (Trin.) Hubb.
Polypodiaceae	*Stenochlaena palustre* (Burm.) Bedd.
Pteridaceae	*Acrostichum aureum* L.
Rhizophoraceae	*Bruguiera cylindrica* (L.) Bl. *B. gymnorrhiza* (L.) Lamk. *B. parviflora* (Roxb.) Wt & Arn. ex Griff. *B. sexangula* (Lour.) B. Poir. *Ceriops decandra* (Griff.) Ding Hou *C. Tagal* (Pers.) Robin *Kandelia candel* (L.) Druce *Rhizophora apiculata* Bc. *R. mucronata* Lamk. *R. stylosa* Griff.
Rubiaceae	*Scyphiphora hydrophyllacea* Gaerin f.
Rutaceae	*Merope angulata* (Willd.) Swingle
Salvadoraceae	*Salvadora persica* L.
Sonneratiaceae	*Sonneratia alba* J. Sm. *S. apetala* Buch. - Ham. *S. caseolaris* (L.) Engl. *S. griffithii* Kurz
Sterculiaceae	*Heritiera fomes* Buch. -Ham. *H. kanikensis* Banerjee & Majumdar *H. littoralis* Dryand. ex. Ait. *H. macrophylla*
Tamaricaceae	*Tamarix troupii*
Verbenaceae	*Clerodendrum inerme* Gaertn.

Change detection studies conducted in Muthupet mangrove area, in Tamil Nadu using remote sensing data for 1989, 1990 and 1996 indicated that mangroves have degraded in density at some places and have disappeared in several other places (Table 15). The degradation has occurred mostly in sparse mangrove forests due to expansion of salt pan and human activities. The mangrove forest at Point Calimere is also found to be degraded in density. However, dense mangrove forests have increased from 706 ha to 958 ha. In total, nearly 87 ha of total mangrove forest have been degraded. As Muthupet area is dry for most of the year, human activity like cutting the wood for fuel, grazing by cattle, etc., have caused the degradation of mangroves. Agriculture areas, habitation with vegetation and salt pan areas have increased at the expense of mangrove vegetation and mudflat areas[50] .

Table 15. Change in the Status of Mangroves at Muthupet During 1989 – 1996

Category	Area (ha)			% Change
	1989	1990	1996	
Mudflat	21 913.40	21 258.08	21 998.78	+0.39
Sandy area/beach	664.10	741.44	229.68	- 65.41
Mangrove (Dense)	706.38	648.48	958.99	+35.76
Mangrove (sparse)	1 163.70	1 068.59	524.32	-54.94
Total Mangroves	1 570.08	1 417.02	1 483.31	-5.53
Scrub	3 112.10	2 837.09	2 146.57	-31.03
Lagoon	4 239.20	4 365.09	4 839.36	+14.16
Natural forest	2 673.50	1 970.47	2 511.61	-6.06
Man-made forest	541.96	521.31	425.31	-21.52
Salt affected land	220.75	362.89	153.18	-30.61
Reclaimed area	237.94	358.44	118.32	-50.27
Saltpan	3 128.87	3 359.75	3 497.37	+11.78
Agricultural land	1 101.47	2 126.30	1 469.50	+33.41
Habitation with vegetation	232.80	289.00	712.37	+206.00

Pichavaram, Tamil Nadu

The Pichavaram mangrove forest area was declared as a Reserve Forest in 1897. The total area of the wetland including the forest area, water spread area, barren mud flat, etc., is about 1 100 ha. Subsistence fishing is the main activity within the mangroves. Agriculture is the main land use in the area around the mangrove wetland and in recent years a large number of small-scale shrimp farms are being constructed very close to the mangroves[51].

The studies carried out in Pichavaram area of Tamil Nadu by M S Swaminathan Research Foundation, Chennai showed that the degradation of mangroves is largely due to biophysical factors such as changes in topography and tidal water flow pattern[52]. Further, remote sensing studies conducted by the Institute of Ocean Management, Anna University in Pichavaram, have shown that the mangrove forests have increased from 461.98 ha in 1987 to 475.99 ha in 1998; while the degraded mangroves have reduced from 152.93 ha to 120.25 ha. During the same period, area under aquaculture increased from 6.99 ha to 331.27 ha. It is also reported that 6.0 ha of mangrove area has been converted into shrimp farms and fallow lands have reduced from 1 045 ha to 425.88 ha[53].

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[50] Ramachandran, S., S. Sundaramoorthy, R. Krishnamoorthy, J. Devasenapathy and M. Thanikachalam. 2000. Application of remote sensing and GIS to coastal wetland ecology of Tamil Nadu and Andaman and Nicobar group of Islands with special reference to mangroves. Curr. Sci., 75(3): 236 - 244

[51] MSSRF, 1995. Coastal Wetlands: Mangrove Conservation and Management. Project proposal submitted to India-Canada Environment Facility, New Delhi. September 1995

[52] MSSRF, 1996. “Integrating conservation with development in mangrove ecosystems in Tamil Nadu.” Final report submitted to Canadian International Development Agency by the M.S. Swaminathan Research Foundation (MSSRF), Chennai, p. 70

[53] Jayanthi.M. and S. Ramachandran. 2000. Remote Sensing and Geographical Information System for Aquaculture Management. In: Ramachandran.S. (ed.) Marine Remote Sensing Applications. Institute of Ocean Management, Anna University, Chennai. pp 304 – 315

Sundarbans, West Bengal

The history of Gangetic Sundarbans is nothing but the reclamation of mangrove forests for agriculture. The reclamation process was initiated by the British rulers during 1770, and it continued till recently. The whole district of 24–Parganas is a delta area formed by the action of the Ganga, bringing down alluvial soil from the Himalayas through Bagirathi and Padma[54]. It has been reported that approximately 585 sq. km of mangrove forests have been distributed for agricultural purposes during the period 1901 to 1964[55].

Studies conducted on Sundarban Forests in West Bengal during the late eighties have reported that large areas of the mangroves have gone for urban development, besides being converted for agriculture, salt production and industrial uses[56].

Andhra Pradesh

In Andhra Pradesh, it has been reported that about 2 838 ha of mangroves have been converted for shrimp farming[57]. Out of this, a major chunk of mangrove (Polekerru) in Godavari estuarine system was dereserved in the late 1970s when the importance of mangroves was not recognised fully. Considering 78 702 ha of area presently under shrimp farming in the state, the 2 838 ha of mangrove area accounts for only 3.6 % of the total area under shrimp farming today.

A study conducted by National Remote Sensing Agency in 1993 in Guntur and Krishna districts of Andhra Pradesh showed that the development of shrimp farming in these districts was not related to the level of mangrove destruction (Table 16)[58]. In Guntur district the total mangrove loss during the 20 year period 1973 to 1992 was 952 ha of which 752 ha was lost during 1973-1985. Only 200 ha was lost between 1985 to 1992 which is 5.0 % of the total area developed for shrimp farming (4 048 ha) during the period. In Krishna district, 405 ha of mangrove was lost during the said period and shrimp culture development was about 6 005 ha.

Table 16. Extent of Mangrove and Shrimp Farms in Guntur and Krishna District During the Period 1973 – 1992

Year	Guntur District (area in ha)		Krishna District (area in ha)	
	Shrimp aquaculture	Mangroves	Shrimp aquaculture	Mangroves
1973	Nil	4 411	Nil	5 884
1985	472	3 659	327	5 789
1990	2 569	3 360	3 371	5 498
1992	4 520	3 459	6 005	5 479

Source: Interface, NRSA Bulletin, Volume 4 (2); April 1993.

[54] Untawale, A.G. 1987. Country Report – India. Mangroves of Asia and the Pacific: Status and Management. Technical Report of the UNDP/UNESCO Research and Training Pilot Programme on Mangrove Ecosystems in Asia and the Pacific (RAS/79/002)
[55] Banerji. A.K. 1964. Forests of Sundarbans.Centenary Commemoration volume. West Bengal Forests 1964: 166 – 175
[56] Silas. E. G. 1987. 'Mangroves & Fisheries – Management Strategies. In: Proceedings of the National Seminar on Estuarine Management, 4 – 5, June 1987, edited by Prof. N Balakrishnan Nair
[57] Government of Andhra Pradesh, January 2001
[58] Interface, NRSA Bulletin, Volume 4 (2); April 1993

Further, as per the recent information provided by some of the coastal state governments and union territory administrations, about 25.8 ha of mangroves have been converted into shrimp farms in Kerala[59] and no mangrove land has been converted to shrimp farms in West Bengal[60], Orissa[61], Gujarat[62], Pondicherry[63] and Goa[64].

From the above discussions, it is evident that the destruction of mangroves in India is mainly due to urban development, wood cutting, development of salt pans, agriculture and traditional brackishwater farming and the destruction due to commercial shrimp farms is insignificant.

6.2.2 Conversion of Agricultural Land

Conversion of coastal agricultural land into shrimp farms is widely practiced in Asia. A study on the land-use types of shrimp farming in 12 Asian countries based on 5 000 farms revealed that about 30.0 % of the intensive farms were located in erstwhile rice fields, while it was 15.0 % for the semi-intensive farms and 14.1% for the traditional/ extensive farms[65]. It is evident that semi-intensive and intensive farms are located in supra-tidal areas where rice cultivation is being done.

In most of the coastal states and the union territories in India, the extent of different habitats used for shrimp farming is not documented and the revenue records of land classification are also outdated. Algarswami[66] while reporting on the changes in land use patterns related to shrimp farming, observed that *"Paddy fields are being converted to shrimp farms, as in some parts of Andhra Pradesh (e.g. Bhimavaram). Some paddy lands along the fringe of Chilka Lake have been lost to shrimp farming"*. However, the report does not give any quantified data. Similarly, Justice Suresh Committee observed that in Nagapattinam, Tuticorin and Kancheepuram districts of Tamil Nadu, *most of the shrimp ponds are constructed on fertile agricultural land or on marginal lands where one crop is raised. Owing to the recent shortage of Cauvery water, the yield of crops has been affected. Taking advantage of this, shrimp industries have been buying up agricultural land through inducement, persuasion and high pressure on revenue authorities. It is estimated that 10 000 acres (about 4 000 ha) of agricultural land has been purchased by prawn farm owners*[67]. However, there was only 2 000 ha area (5 000 acres) under shrimp farming in entire Tamil Nadu during 1994-1995.

A joint study conducted in 1997 by the Central Institute of Brackishwater Aquaculture (CIBA), Chennai and the Central Institute of Fisheries Education (CIFE), Mumbai, in Andhra Pradesh and Tamil Nadu has revealed that:

(i) 75 - 80% of the farms are constructed in coastal saline soils,

(ii) 12.5 - 15% of the farms are constructed in lands earlier classified as agricultural land and

(iii) 7.5-10% of the farms are constructed on sandy soils, and mud flats[68].

Another study conducted by CIBA in Nellore district of Andhra Pradesh revealed that all the sea-based farms, comprising a total of 483 ha in the district were constructed on coastal wastelands[69].

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59 Government of Kerala, April 2001
60 Government of West Bengal, April 2001
61 Government of Orissa, January 2001
62 Government of Gujarat, January 2001
63 Government of Pondicherry, January 2001
64 Government of Goa, January 2001
65 ADB/ NACA. 1998. Final report on the regional study and workshop on aquaculture sustainability and the environment (RETA 5534). Asian Development Bank and Network of Aquaculture Centres in Asia-Pacific, NACA, Bangkok, Thailand
66 Alagarswami, K. 1995. Country Report – India. In FAO/NACA 1995 "Report on a Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development"
67 Justice H. Suresh 1995. Report on Impact of shrimp farms along the coast of Tamil Nadu and Pondicherry. *Campaign Against Shrimp Industries*
68 CIFE/CIBA, 1997. Final report: Assessment of ground realities regarding the impact of shrimp farming activities on environment in coastal areas of Andhra Pradesh and Tamil Nadu. Mimeo
69 CIBA 1996. Comprehensive survey of impact assessment of shrimp farms in Nellore district. *Mimeo*

The information provided by the state and union territory governments show that in Andhra Pradesh, 31 082 ha of land classified as agricultural land in revenue records have been converted into shrimp farms. It is stated that these lands are mostly unproductive, shallow and tail-end land[70]. In Orissa about 4 520 ha of agricultural land has been converted into shrimp farms[71]. In Goa all the 110.38 ha of area developed so far for shrimp farming were converted from agricultural land[72]. No agriculture land has been converted into shrimp farms in West Bengal[73], Gujarat[74] and Pondicherry[75]. Detailed information on the conversion of agricultural land is not available from the states of Tamil Nadu, Karnataka, and Maharashtra. In Kerala, shrimp farming and paddy cultivation are practiced in the same field alternatively.

A case study conducted by the Central Marine Fisheries Research Institute in Nagapattinam District (Tamil Nadu) analysed the soil maps prepared by Soil Survey and Land Use Organization in 1984 and observed that the coastal soils are affected by surface and sub-surface salinity and alkalinity. In Thiruthuraipoondi, Nagapattinam and Sirkazhi taluks, where most of the shrimp farms are located, the saline soils to the extent of 4 814 ha, 1 502 ha and 13 807 ha respectively were reported even during 1984 when shrimp farming was not developed in the district[76]. It has been reported that *"all the shrimp farms are located in cultivable waste lands where crops have not been raised for the last 20 years"*[77]. It was also reported that in the coastal areas of Thanjavur district, *"Owing to the influence of the coastal tides and low land setting, the soils of coastal region are generally saline. The magnitude and degree of salinity varies with topographic setting and the intensity of sea water intrusion"* The coastal lands in Thanjavur district were not put to agriculture mainly due to three important reasons: salinity of the soil, non-availability of water for irrigation and poor quality ground water aquifers.

In view of the above situation, it is opined that conversion of agricultural lands has taken place in several states. However, most of the converted land was poor in nutrients, salinity affected and located close to brackishwater areas. While non-availability of water for crop irrigation is the main reason for the conversion of agricultural land in Tamil Nadu, it is salinisation by tidal water, poor nutrient status and low profit from agriculture for conversion in Andhra Pradesh and Orissa. Some fertile agricultural land also seem to have been converted in certain states because of the high profit associated with shrimp farming. Presently, a clearance from the district authorities indicating that the farm is not constructed on agricultural land is mandatory for obtaining license from Aquaculture Authority.

6.2.3 Soil Salinisation

The total area of salt affected soils in India is about 8.0 million ha, out of which 3.1 million ha are coastal saline soils including 0.5 million ha of mangrove areas. The details of the extent of saline soils in the coastal belt (Table 17)[78] shows that even in 1983, hundreds and thousands of hectares of salt affected soils were present in all the coastal states.

In West Bengal and Kerala traditional types of farms are constructed in low-lying inter-tidal zone that is generally inundated by saline water during spring tides. Being low lying areas, there is no scope of salt water seeping to adjacent lands which are located at elevated levels.

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70 Report of the Study Team on Shrimp Aquaculture in the Coastal Areas of the Country- 22 July 1997, Ministry of Agriculture, DOAC, GOI.

71 Government of Orissa, January 2001

72 Government of Goa, January 2001

73 Government of West Bengal, April 2001

74 Government of Gujarat, January 2001

75 Government of Pondicherry, January 2001

76 Paulraj, R., M. Rajagopalan, M. Vijayakumaran, E. Vivekanandan and R. Sathiadhas. 1998. Environmental and social issues in coastal aquaculture - A case study. *Bay of Bengal News,* **II(11)** : 15-18

77 Special report No. 85 (1994), Soil Salinity and Land Use Organisation (SS and LUO) and Soil Testing Laboratory, Aduthurai, Tamil Nadu Agricultural University

78 Yadav. J. S.P, A.K. Bandopadhyay and B.K. Bandopadhyay. 1983. Extent of coastal saline soils of India. J. Ind. Soc. Coastal Agric. Res., 1(1); 1- 6

Table 17. Extent of Saline Soil in the Coastal States of India in 1983

State	Extent of saline Soil (in ha)	soil salinity (mmhos/cm)
West Bengal	820 448	4 - 35
Gujarat	714 000	9 - 20
Orissa	400 000	2 - 50
Andhra Pradesh	276 000	0.5 - 17
Tamil Nadu	99 950	2 - 10
Karnataka	86 000	3 - 10
Maharashtra	63 537	4 - 14
Kerala	26 400	1 - 20
Goa	18 000	4 - 15
A & N Islands	15 000	-
Pondicherry	1 000	1-50
Total	**2 520 335**	

Notwithstanding the extent of inherent soil salinity in the coastal areas, it is generally perceived that *"prawn culture activity requires pumping of seawater into ponds, since the majority are marine prawn species which require a salinity between 25 – 30 ppt. The growing period for prawn is between 120 – 150 days, meaning sea water is also on the land for this period of time which is sufficient to allow salt water to seep into the neighbouring agricultural farm areas and as well as into the water table."*[79] However, in India, only 3.0% of the total shrimp farm area is directly dependent on sea water for farming. All the other areas are based on creek water, where the salinity ranges in between 0 – 35 ppt depending on the tidal flow and the intensity of monsoon.

NEERI in its study on Environmental Management of Prawn Farming Activity has reported that there was no change in soil salinity of the adjoining lands beyond 25 m distance from the shrimp farms in Tuticorin, Sirkali and Killai in Tamil Nadu, Nellore in Andhra Pradesh, and Palghar in Maharashtra[80].

To enable a better understanding of the impact of shrimp aquaculutre on soil salinisation, detailed studies were initiated by CIBA, Chennai during 1996 – 1999 in Tamil Nadu, Andhra Pradesh and West Bengal.

In Nellore district of Andhra Pradesh, soil samples were collected at distances of 50, 100, 250 and 500 m around the farms and electrical conductivity of soil was estimated as an indicator of soil salinity[81]. The data (Table 18) show that no major soil salinization has taken place and the soil is suitable for most of the agricultural crops. It was also observed that soil salinity levels decreased with the increase in the distance from the farm and the Buckingham canal, which runs through the major shrimp farming areas in Nellore district. The higher salinity levels seen near the farm could not be attributed to the shrimp farms since Buckingham canal, a saline water canal, also flows in between the farms and the land.

Based on the classification of Arakeri and Donahue (1987)[82], common varieties of rice have a maximum tolerance limit of 6.0 mmhos/ cm. However, salt resistant paddy varieties do have a higher tolerance limit and can be raised in saline soils.

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79 Vandana Shiva. 1999. Who pays the price? The shrimp industry, rich consumers, and poor coastal communities. In. Sustainable Aquaculture, Bukema, Rotterdam

80 NEERI, January 1995 Report on Study on Environmental Management of Prawn Farming Activity. Submitted to MPEDA

81 CIBA 1996. Comprehensive survey of impact assessment of shrimp farms in Nellore district. *Mimeo*

82 Arakeri, H. R. and R. Donahue. 1987. Principles of soil conservation and water management, Oxford & IBH Publishing Co. P. Ltd., New Delhi, pp. 238-239

Table 18. Electrical Conductivity of Soil Samples Collected from Sites around Shrimp Farms in Nellore District, Andhra Pradesh

Farm	Site No.	Electrical Conductivity (mmhos/cm) Distance from farm			
		50 m	100 m	250 m	500 m
Farm 1	1	2.18	1.36	1.18	0.66
	2	3.20	2.90	1.60	0.30
	3	3.80	3.20	1.40	0.60
	4	2.10	1.80	1.10	0.30
Farm 2	5	3.06	1.93	0.57	0.25
	6	2.22	1.72	0.82	0.18
	7	3.52	1.21	0.81	0.16
	8	2.84	1.11	0.62	0.11
Farm 3	9	4.24	3.20	0.70	0.54
	10	4.80	3.90	2.00	0.70
	11	4.60	3.62	2.52	0.61
	12	4.20	1.82	0.68	0.18
Farm 4	13	3.15	2.72	1.26	0.94
	14	3.60	2.20	1.30	0.70

Coastal districts of Tamil Nadu

The soil salinity profile of lands adjacent to shrimp farms in three coastal districts of Tamil Nadu was studied and the data showed that the soils in the three districts were highly saline compared to that of Nellore district of Andhra Pradesh (Table 19)[83]. A survey conducted in 1984 by Soil Survey and Land Use Organisation, government of Tamil Nadu, reported that a total of about 20 000 ha in Nagapattinam district was affected by surface, sub-surface and complete salinity and alkalinity. Salinity levels were up to 250 m from shrimp farms in Nagapattinam district while in Thanjavur and South-Arcot districts, the salinisation was seen only up to 100 m. Soil salinity levels are generally higher nearer to the creek than away from it. In Nagapattinam district, no agricultural activity was seen near the creeks irrespective of the presence or absence of shrimp farms, indicating that the soil salinisation was not due to shrimp culture alone. In South Arcot district, the salinisation effect was not felt much, as cereals, mulberry and vegetables were grown near the shrimp farms with good yields.

However, the negative impact of soil salinisation due to shrimp aquaculture has been reported on agriculture lands near Vedaranyam channel at Mahili village in Nagapattinam district and coconut trees on the banks of Mudiyanar river in Thanjavur district of Tamil Nadu[84].

Soil salinisation studies carried out in the World Bank assisted shrimp farming sites at Canning in West Bengal has not shown any effect of shrimp farming in the area (Table 20). There is a general variation in the soil salinity during summer and monsoon seasons. Soon after monsoon, paddy is cultivated in Canning area. Data collected from other three sites in West Bengal – Digha, Dighirpar and Dadanpatra[85] also showed that there is no salinisation effect in lands adjacent to the farm.

The foregoing studies clearly show that salinisation of soils due to seepage from shrimp farms is very site-specific. It also depends on the soil quality, the level compaction of the dykes, the elevation of the shrimp farm and the distance and location of the neighbouring agricultural field. Seepage will occur if the soil is sandy and

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[83] CIBA. 1997. Impact Assessment of Ground realities of shrimp farming. Final Report. Mimeo
[84] Government of Tamil Nadu, March 2001
[85] CIBA Consultancy on Environment Monitoring Programme in World Bank assisted shrimp farming sites. Unpublished data. 1999-2000

Table 19. Electrical Conductivity of Soil Samples Collected from Sites around Shrimp Farms in Three Districts of Tamil Nadu

District	Site No.	Electrical Conductivity (mmhos/cm)			
		50 m	100 m	250 m	500 m
Nagapattinam	1	8.96	9.46	5.76	2.66
	2	7.70	6.13	4.76	2.00
	3	8.00	7.10	4.80	2.67
	4	6.60	3.90	4.03	2.60
	5	5.63	3.50	3.50	2.13
	6	6.33	4.16	3.66	2.83
Thanjavur	1	7.66	4.83	2.66	2.00
	2	6.26	3.93	2.30	1.66
	3	6.90	4.16	1.93	2.30
South Arcot	1	8.66	3.63	2.76	1.76
	2	7.90	3.70	1.73	1.76
	3	5.26	2.86	1.93	1.73

enough compaction or protective measures are not undertaken by the shrimp farm operator. Presently, permission by Aquaculture Authority is not accorded to shrimp farms that are located in areas with poor soil quality and prone for seepage. In areas with clayey soil, the seepage effects are negligible and aquaculture farms and paddy fields are in close proximity without any problem of soil salinisation.

Table 20. Land Salinisation Studies at Canning, West Bengal

Distance (m)	Depth (cm)	Electrical Conductivity (ds/m)					
		SITE A			SITE B		
		SEPT'98	OCT'98	NOV'98	SEPT'98	OCT'98	NOV'98
0	0	1.68	1.24	1.26	3.11	1.68	1.83
	50	1.27	1.30	1.21	2.64	1.79	1.77
	100	1.29	1.22	1.33	1.96	2.32	1.96
50	0	0.40	1.05	1.28	2.41	2.21	1.25
	50	0.47	1.45	1.96	0.42	1.65	1.36
	100	0.41	1.23	1.67	0.56	1.83	1.45
100	0	1.23	1.07	2.16	3.33	2.97	2.76
	50	0.99	1.17	2.07	2.02	2.28	2.98
	100	1.11	1.11	2.32	1.87	2.03	2.32
250	0	0.58	0.90	1.06	2.78	1.29	1.32
	50	0.37	1.04	1.38	2.28	1.45	1.48
	100	0.39	1.00	1.45	1.34	1.10	1.63
500	0	0.40	0.75	0.98	3.41	2.08	1.72
	50	0.41	0.68	0.73	2.53	1.76	1.96
	100	0.46	0.67	0.82	2.51	0.99	1.32

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6.3 Impact on Open Water Resources

6.3.1 Nutrient and Sediment Loading

The problem of nutrient loading in sea/ creek due to the discharge of shrimp aquaculture wastes has been studied extensively in many countries. Shrimp aquaculture wastewater comprises both living and dead plankton, bacteria, feed waste, faecal matter, and other excretory products of shrimps. Though all these nutrients and organic wastes are biodegradable, the soluble nutrients such as nitrogen, ammonia and phosphorus, beyond a reasonable limit, can result in nutrient enrichment in the open water where the wastes are released. The suspended solids, when in high level, can also create problems of siltation and physical and chemical changes in the sediment.

To regulate discharge of wastewaters with higher nutrient levels, standards have been prescribed for the waste water from shrimp aquaculture ponds in the Guidelines issued by the Ministry of Agriculture (Table 21). These standards have been fixed at much lower level than the General Standards for discharge of environmental pollutants prescribed under Environment (Protection) Act vide Gazette Notification dated May 19, 1993.

In general, nutrient loading from low production shrimp culture systems (traditional) which are characterized by low stocking with little or no fertilization and supplementary feeding, is not significant. In high production systems (semi-intensive and intensive), where input levels are moderate and high respectively, the nutrient loading will also be moderate and significant, respectively. However, in cases where traditional farms get concentrated, the impact of wastewater can be as conspicuous as in the case of other shrimp aquaculture practices.

A comparison of shrimp farm effluent with wastes from other potential sources of pollution (Table 22), shows that the shrimp farm wastewater is considerably less polluting than that of domestic and industrial effluents[86].

Table 21. Standards for Shrimp Aquaculture Wastewater

Sl.No.	Parameters	Guidelines issued by the Ministry of Agriculture		General standards for discharge of environmental pollutants[87]
		Coastal marine waters	Creek	Marine Coastal areas
1.	pH	6.0-8.5	6.0-8.5	5.5 – 9.0
2.	Suspended solids (mg/l)	100	100	100
3.	Dissolved oxygen (mg/l)	not less than 3	Not less than 3	-
4.	Free Ammonia(as NH3-N) (mg/l)	1.0	0.5	5
5.	Biochemical oxygen Demand- BOD(5 days @ 20 c)	50	20	100
6.	Chemical Oxygen Demand-COD (mg/l)	100	75	250
7.	Dissoved Phospate (as P) (mg/l max)	0.4	0.2	-
8.	Total Nitrogen (as N) (mg/l)	2.0	2.0	-

Source: Guidelines for Sustaninable Development and Mangement of Brackishwater Aquaculture, Ministry of Agriculture, GOI.

The quality of shrimp farm wastewater is far less polluting than most of the other sources of wastewater. However, water pollution problems may arise because of the large volumes discharged, particularly when shrimp farms become too concentrated in areas with limited water supplies or poor flushing capacity. Unfortunately, it has been all too common in Asia for many investors to rush into the same area, such that one farm's discharge becomes another farm's intake.

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[86] Macintosh, D.J. and M.J. Phillips.1992. Environmental issues in shrimp farming pp 118 – 145. In: de Saram, H. and T. Singh (eds) Shrimp '92: Proceedings of the 3rd Global Conference of the Shrimp Industry, Hong Kong, 14 – 16 Sept. 1992. INFOFISH, Kuala Lumpur, Malaysia

[87] Gazette Notification G. S. R. No 422 (E) dated May 19, 1993. General Standards for Discharge of Environmental Pollutants Part – A: Effluents

Table 22. Comparison of Wastewater from Different Sources

Parameter	Wastewater			
	Shrimp Farm (untreated)	Domestic (untreated)	Domestic (treated)	Fish Processing Unit (untreated)
BOD (mg/l)	4.0 – 10.2	300	200	10 000 – 18 000
Total Nitrogen (mg/l)	0.03-1.24	75	60	700 – 4 530
Total Phosphorus (mg/l)	0.01- 2.02	20	15	120-298
Solids (mg/l)	30-225	–	500	6 880-7 475

Source: Macintosh and Phillips (1992) [88]

Note: The shrimp farm wastewater is the least polluting among all others

Table 23. Water Quality in Kandaleru Creek at Different Points from Sea Mouth

Distance (km)	Point	Dissolved oxygen (mg/l)	BOD (ppm)	COD (ppm)	NH_3 (ppm)
5	PO	-	-	-	1.38
	MS	5.1	33	120	1.38
12	PO	3.2	98	128	0.08
	MS	4.3	42	110	-
15	PO	3.8	97	50	0.2
	MS	4.5	43	80	-
18	PO	3.1	102	348	0.24
	MS	5.6	53	305	-
25	PO	2.3	100	260	0.58
	MS	3.5	55	365	-
32	PO	1.2	162	100	0.24
	MS	3.5	63	128	-
40	PO	2.0	160	130	3.08
	MS	3.8	52	310	-
45	PO	2.0	162	210	0.52
	MS	3.9	69	98	-
50	PO	2.3	160	280	0.53
	MS	3.9	42	430	-

PO – Pond outlet point; MS – mid stream; (Source: Document on Aquaculture Industry, South Zonal office, CPCB)

Note: Since intake (MS) water itself has high values, the pond outlet value is also high

In India, concentration of shrimp farms have been observed in certain areas of Andhra Pradesh and Orissa. These concentrations have occurred mainly due to the availability of land from private holdings, delay in the development of land lease policy by some of the state governments and availability of infrastructure facilities such as road and electricity.

The water quality parameters in Kandaleru creek in Nellore district of Andhra Pradesh was studied by the College of Engineering, Andhra University[89] . The creek is about 50 km in length and at the time of study about 2 500 ha of shrimp farms were dependent on the creek for intake and discharge. The study indicated that the

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[88] Macintosh, D.J. and M.J. Phillips.1992. Environmental Issues in Shrimp Farming pp 118 – 145. In de Saram, H. and T. Singh (eds) Shrimp '92: proceedings pf the 3 rd Global conference of the Shrimp Industry, Hong Kong, 14 – 16 Sept. 1992. INFOFISH, Kuala Lumpur, Malaysia

[89] College of Engineering, Andhra University, as quoted in Document on Aquaculture Industry. South Zone Office, Central Pollution Control Board, Bangalore. Mimeo

flushing of the creek by sea water occurs only upto a distance of 10 to 12 km and beyond that there is a general build up of contaminants as indicated by BOD and COD values (Table 23).

The study showed that the dissolved oxygen levels were critical in pond outlet beyond 18 km, but the mid-stream values were all above critical levels for the whole length. BOD values were high in both creek and the pond outlet, but the creek level was within the permissible levels. Since the intake point in the creek have higher values of nutrients, the values at the time of release of the wastewater will have still higher values. COD values are higher in the creek than the pond outlet in some of the points. In most of the creek-based systems, the farms draw water from the creek and releases the wastewater into the same creek. Since the discharge from one farm becomes the intake of the neighbouring farm, the gradual build up of nutrients takes place and it affects the shrimp farms foremost. Moreover, in creeks where tidal flow is low, the nutrients remain in the creek system for longer period of time. To overcome these problems, farmers have already been advised to set up wastewater treatment units/ sedimentation tanks to minimise discharge of nutrient loads into open water bodies, both as a self protective device and for environmental sustainability.

The National Institute of Ocean Technology, Chennai has conducted a preliminary survey on environmental impact of shrimp culture during the year 1995 in Andhra Pradesh in association with the Andhra University, Visakhapatnam. The study focussed on the nutrient load arising from aquaculture farms and their impact on nearby coastal waters. The study did not reveal any excessive nutrient load arising from the aquaculture farms and therefore concluded that there is no impact of shrimp farming on the water quality of coastal waters.[90]

CIBA is presently engaged in the Environmental Monitoring of World Bank assisted Shrimp Farm Projects in West Bengal[91], Orissa and Andhra Pradesh. The water quality charactersistics at the outfall of the creek during the first crop in Digha and Canning in West Bengal is presented in Tables 24 and 25.

The study in respect of Digha[92] and Canning[93] farms in West Bengal with total area of 36 ha and 132 ha respectively, shows that none of the parameters were higher than the levels prescribed for wastewater indicating that the shrimp farm wastes are not leading to nutrient loading in the ecosystem when low density culture (6 nos/ m^2) is practiced.

Studies carried out by NEERI, Nagpur

A team of scientists from NEERI, Nagpur, inspected shrimp farms in Andhra Pradesh and Tamil Nadu during April 10 to April 19, 1995 at the direction of this Court and a report was submitted[94]. The report detailed the physico-chemical and biological conditions of water and sediment in the sea/ creek/ estuary in different areas of Andhra Pradesh and Tamil Nadu. A summary of the data is presented in Tables 26 and 27.

Based on an examination of the study conducted by NEERI and the environment impact assessment investigations conducted subsequently by various other organisations, the following observations are made:

- During the inspection of shrimp farms by NEERI in April 1995 *"all the shrimp farms were non-functional"* due to the crop holiday announced in view of the outbreak of viral disease of the cultured shrimps.
- More than 50.0% of the data presented by NEERI in its report submitted to this Court, is from the earlier studies – out of 38 tables presented on physico-chemical parameters in the report submitted in April 1995, 20 tables are adapted as such from the earlier report submitted by NEERI to MPEDA during January 1995.

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90 Personal Communication to Aquaculture Authority from Dr. B. R. Subramanian, Project Director, Integrated Coastal and Marine Area Management (ICMAM) Project, Chennai

91 CIBA.1998. Report on the consultancy on Environmental Monitoring Programme of World Bank assisted Shrimp Farming at Digha and Canning

92 CIBA 1998. Report on the Consultancy on Environment Monitoring Programme: Digha I crop. Mimeo

93 CIBA 1998. Report on the Consultancy on Environment Monitoring Programme: Canning I crop. Mimeo

94 NEERI, April 1995. Investigation Report on Impacts of Aquaculture Farming, and Remedial Measures in Ecologically Fragile Coastal Areas in the States of Andhra Pradesh and Tamil Nadu. Report Submitted to Hon'ble Supreme Court

Table 24. Water Quality Parameters in the Creek at the Outfall in Digha, West Bengal

Parameters	Pre-stocking May'98	July '98	Aug'98	Sept '98	Oct '98
pH	7.15	7.63	7.3	7.36	7.6
Salinity (ppt)	31.0	31	28	9	6
Total suspended solids (mg/l)	51.5	15.1	26.1	16.9	19.4
Turbidity (NTU)	28	4	4	10	17
Chemical Oxygen Demand (ppm)	6.0	34.4	46.2	32.5	29.73
Hydrogen sulphide (ppm)	BDL	BDL	BDL	BDL	BDL
Total ammonia Nitrogen (ppm)	0.110	0.102	0.137	0.076	0.135
Nitrite (ppm)	0.070	0.052	0.057	0.041	0.039
Nitrate (ppm)	0.020	0.02	0.016	0.02	0.019
Total Nitrogen (ppm)	0.811	0.521	0.501	0.512	0.501
Phosphate (ppm)	0.013	0.016	0.015	0.015	0.013
Total Phosphorus (ppm)	0.109	0.104	0.072	0.101	0.094
Iron (ppm)	0.734	0.724	0.616	0.387	0.791
Biochemical Oxygen Demand (ppm)	2.31	13.2	15.4	10.1	10.4
Alkalinity (ppm)	–	–	91.4	94.6	81.6

Note: Though there was a slight increase in the COD/ BOD levels, but they are well within the standards prescribed

Table 25. Water Quality Parameters in the Creek at the Outfall in Canning, West Bengal

Parameters	Pre-stocking May'98	Sept'98	Oct '98	Nov'98
pH	7.09	7.91	7.49	7.13
Salinity (ppt)	25	7	8	5
Total suspended solids (mg/l)	53.5	20.2	19.1	24.2
Turbidity (NTU)	29	7	11	10
Chemical Oxygen Demand (ppm)	1.90	34.8	26.58	28.5
Hydrogen sulphide (ppm)	BDL	BDL	BDL	BDL
Total ammonia Nitrogen (ppm)	0.051	0.151	0.104	0.219
Nitrite (ppm)	0.035	0.059	0.053	0.044
Nitrate (ppm)	0.007	0.011	0.057	0.048
Total Nitrogen (ppm)	0.271	0.238	0.198	0.267
Phosphate (ppm)	0.006	0.013	0.015	0.016
Total Phosphorus (ppm)	0.201	0.059	0.051	0.054
Biochemical Oxygen Demand (ppm)	0.71	11.4	9.4	8.2
Alkalinity (ppm)	–	105.4	99.0	96.2

- The study analyses only the creek/ sea water and the quality of the wastewater discharged was not studied. However, distinct conclusions have been drawn regarding the wastewater also. Levels of suspended solids or the nutrients in the creek or sea water cannot be taken as criteria for indicating the contamination from shrimp farms since the pollutants could have come from many other sources, either upstream or down stream depending on the tidal flow. The study of this kind should clearly indicate the quality of intake water, pond water, water discharged from the farm and the creek water. Such a data would have clearly shown the actual accumulation of nutrients in the farm and their release and contamination of the open water. Absence of such data in the study indicates lack of scientific protocol in the NEERI report and also the fact that any inferences drawn from such data can lead to erroneous conclusions.

- The study has listed heavy metal and pesticide concentrations which are not connected with shrimp farming activities. Heavy metals and pesticides are harmful to shrimps and their presence beyond the 'safe level' leads to the mortality of the shrimps or for that matter most of the farmed fin and shellfish species.

- A perusal of Table 27 wherein the data of NEERI study is summarized, show that the total nitrogen and suspended solids values for Sirkali and Killai creek are higher during April 1995 (no culture period) than during September 1994 (culture in progress), thereby showing that shrimp farm wastes do not lead to nutrient or sediment loading.

Table 26. Summary of the Physico-Chemical Parameters of Creek/ Sea Water in Andhra Pradesh as presented in NEERI Report

Source of data	Range of Physico-chemical parameters						Remarks
	Suspended solids (mg/l)	Dissolved oxygen (mg/l)	Free ammonia (mg.l)	BOD_5 (mg/l)	Dissolved phosphates as P (mg/l)	Total nitrogen (mg/l)	
Table 2.8 Kakinada and Visakapatinam creek/ sea	70 – 100	5.0 – 5.7	0.1 – 0.8	12 – 16	0.02 – 0.15	2.13 – 3.5	April 1995. No culture period. (n = 4)
Table 2.9 Kakkinada and Visakapatinam creek	90 – 850	1.8 – 5.4	0.56 – 1.00	-	0.56 – 1.00	2.47 – 5.76	September 1994* (n = 7)
Table 2.20 Nellore sea/ creek	48 – 50	5.80 – 6.3	0.15 – 0.17	10 –12	0.02 – 0.03	2.00-2.30	April 1995* No culture period (n = 2)
Table 2.21 Nellore creek/sea	76 - 150	3.84 – 6.0	0.28 – 1.44	-	0.05 – 0.46	2.29 – 3.62	September 1994* (n = 8)
Table 2.20 Buckingham canal	170	4.8	0.06	80	0.13	3.00	April 1995* (n=1)
Table 2.21 Buckingham canal	104	1.76	0.34	-	0.16	ND	September 1994* (n = 1)

Note: Except suspended solids and dissolved phosphorus in some cases, other parameters are well within the prescribed limits

** Data pertains to an earlier study undertaken by NEERI for MPEDA; n = number of sampling sites under the group*

Table. 27. Summary of the Physico-chemical Parameters of Creek/ Sea Water in Tamil Nadu as Presented in NEERI Report

Source of data	Range of Physico-chemical parameters						
	Suspended solids (mg/l)	Dissolved oxygen (mg/l)	Free ammonia (mg/l)	BOD_5 (mg/l)	Dissolved phosphates as P (mg/l)	Total nitrogen (mg/l)	Remarks
Table 2.30 Sirkali and Killai creek	200 – 400	4.0 – 5.5	0.68 – 1.20	15 – 33	0.08 – 0.18	5.90 – 7.60	April 1995. No culture period. (n = 4)
Table 2.31 Sirkali sea / creek	57 – 148	7.8 – 9.8	0.6 – 1.08	–	0.08 – 1.12	1.56 – 3.52	September 1994* (n = 3)
Table 2.32 Killai creek/ estuary	90 – 192	6.0 – 8.7	0.60 – 1.26	–	0.02 – 0.16	1.32-1.94	September 1994* (n =5)
Table 2.44 Tuticorin seawater	108- 120	6.5 – 6.6	0.56 – 0.76	12 – 15	0.12 – 0.14	2.16 – 2.48	(n = 2) April 1995. No. culture period
Seawater near proposed farm	140	6.8	0.94	16	0.09	3.31	(n=1)
Table 2.45 Tuticorin sea/creek	99.5 - 246.5	5.4 - 7.7	0.26 – 1.84	–	0.15-0.25	0.485-3.68	July-August 1994* (n=7)

Note: Excepting suspended solids in few cases all the other parameters are well within the prescribed standards

** Data pertains to an earlier study undertaken by NEERI for MPEDA; n = number of sampling sites under the group*

- Further, the bacterial load in different creek water samples in Andhra Pradesh (Table 2.12 of NEERI Report) were reported from 15 to 12 000 CFU/ml. However, the comment on the table is a simple *"total bacterial count indicates organic contamination of creek water"*.

- Similarly, for plankton population it is merely reported that *higher levels of algal count and dominance of chlorophyceae and cyanophyceae indicate organic contamination*, when the total count varied between 22 054 to 7 537 689 nos/100 ml and the chlorophyceae levels varied between 0 to 73.3%; cyanophyceae between 0 to 88.5 %. It is the same case with the zooplankton population: the generalised statement at the bottom of the tables given states *'zooplankton count and Shannon-weaver index values indicate organic contamination'*.

- Besides, glaring factual errors have also been noticed in the data presented. For example in Table 2.8 on page 13 of NEERI report, the total dissolved solids (which includes dissolved salt represented as salinity) are less than the salinity (dissolved salt content) mentioned –

  Sl.No. 2 TDS – 4 000 mg/ l while salinity is 32 g/ kg *i.e.*, 32 000 mg/ l
  Sl. No. 3 TDS – 26 000 mg/ l and salinity is 29 000 mg/ l

From the foregoing account it is evident that the nutrient and sediment load from the traditional and improved traditional farming systems are negligible and they generally conform to the standards prescribed. However, the process of intensification is likely to lead to higher levels of nutrients and sediments if untreated wastewater is released to the creek/ sea. Further, the level of nutrient loading in natural waters is dependent on the site and environmental characteristics like tidal amplitude, tidal current, wind velocity, width and depth of the creek, the type of culture system, stocking density, the quality and the quantity of feed used and the level of water exchange. In West Bengal where the tidal amplitude is high and the tidal current is swift, the retention time of the wastewater in the creek system is low. As the retention time increases, the level of nutrient loading in the creek or sea will also be high. Further, various remedial measures are available for reducing the nutrient and sediment loading such as i) minimal water exchange; ii) zero effluent discharge, iii) sedimentation ponds, iv) bio-remediation ponds, and v) recirculation farms[95]

6.3.2 Chemicals used in Aquaculture

The most common substances applied in shrimp culture ponds are fertilisers, liming materials, and feeds. These materials can cause nutrient and organic enrichment, but they are not toxins. Even the magnitude of enrichment of nitrogen and phosphorus due to shrimp farming is comparatively low than that of their usage in agriculture. A comparative account of fertilizer usage in shrimp farming and agriculture is presented in Table 28.

Table 28. Use of Fertilizers in Agriculture and Aquaculture

Fertilizer Nutrient	Application in Kg per ha per crop		
	Agriculture		Aquaculture
	Paddy	Sugarcane	Shrimp
Nitrogen (N) (kg/ ha)	125	275	46
Phosphorus (kg/ha)	62	62	12
Potassium (kg/ ha)	62	112	Nil

In Asia, chlorination is widely used to disinfect pond waters and bottom soils suspected of containing disease vectors. The common form of chlorine used in ponds is calcium hypochlorite, the same compound widely used to disinfect public water supplies and swimming pools. Chlorine has a demonstrable history of safe use, and its use in shrimp ponds will not harm the environment outside ponds since treated water is used for the culture and not let off. Zeolite is also widely used in ponds in Asia for ammonia removal. Zeolite has no benefits to pond water quality, but it is a natural mineral that is neither toxic nor bio-accumulative.

Many Asian shrimp farmers use a variety of bactericides, enzyme preparations, bacterial amendments, and other products in ponds. The benefits of these products to shrimp farming are unproven. Nevertheless, all of these products have a history of safe use in other types of agriculture, and they do not have negative impacts on natural ecosystems[96] .

Liming and fertilisation is generally followed by most of the shrimp farmers in India. Chlorination is also widely used by farmers for killing the vectors of pathogens prior to stocking. But since it is costly, most of the farmers cannot afford it. Instead, they filter the water through fine mesh nets to prevent the entry of the vectors.

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95 Robertson, C. 2000. Sustainable prawn farming. Prawn farm effluent treatment and recirculation systems. QI00021 DPI, Government of Queensland.

96 Global Aquaculture Alliance, 1999. Code of Practice for Responsible Shrimp Farming

6.3.3 Salinisation of Freshwater Resources

During the early development of commercial shrimp aquaculture, farmers in Taiwan, the Philippines and Thailand, resorted to abstraction of freshwater from underground aquifers for use in intensive shrimp farming. This practice is reported to have resulted in salt-water intrusion and salinisation of freshwater aquifers. Adjustment of salinity using freshwater is non-existent in India and hence such problems have not occurred.

In India, there were reports regarding salinisation of drinking water in coastal areas due to seepage of saline water from shrimp farms. While discussing the impacts of "industrial shrimp farming" in India, it was observed that "The massive extraction of freshwater from underground aquifers for salinity control in the ponds also intensifies the problem of salinity. Estimates show that roughly 6 600 m^3 of freshwater are needed to dilute full sea water in a one hectare pond at one meter water depth over a cropping period of four months. Emptied aquifers are subject to salt water intrusion. Seepage from the tanks also increases salinisation of ground water"[97]. In India, out of the total shrimp farming area, seawater is used in only 3.0% area *i.e.*, 4 366 ha (Andhra Pradesh – 3 077 ha; Tamil Nadu – 1 277 ha; and Pondicherry – 12 ha) [98] while all the others are dependent on brackishwater creeks where the salinity ranges between 0 – 30 ppt. The use of freshwater for reducing the salinity is not practiced in the seawater – based farms. Hence the question of emptying the aquifers does not arise.

There have been reports of ground water salinisation from the coastal villagers, but most of these reports were not substantiated with scientific data on the quality of water prior to the development of shrimp farming. A study on the quality of borewell water was carried out in the vicinity of seawater-based shrimp farms in Nellore district of Andhra Pradesh. The details of the water quality are presented in Table 29.

Table 29. Total Dissolved Solids and Chloride Content in the Borewell Water Located in the Vicinity of Shrimp Farms in Nellore, Andhra Pradesh

Farm (Village)	Distance from farm (m)	Total Dissolved Solids (ppm)	Chloride (ppm)
Farm 1 (Venkateswara Pattapalem)	200	1 171	500
	350	1 060	480
	500	960	420
Farm 2 (Gavallapalem)	100	1 650	680
	200	868	460
	500	800	410
Farm 3 (Thupillipalem)	200	9 600	4 900
	400	4 749	1 800
	600	4 012	1 600
Farm 4 (Pattupalem)	100	1 700	700
	350	1 200	520
	500	1 010	460

As per the standards for potable water, the water near farm 3 is not suitable for drinking. In the remaining three farms, the water is potable. In the study area it was observed that water is generally brackish upto a depth of 20-30 m. Freshwater table is available at a depth of about 60 - 200 m. At such depths, the salinisation cannot

97 Vandana Shiva. 1999. Who pays the price? The shrimp industry, rich consumers, and poor coastal communities. In. Sustainable Aquaculture , Bukema, Rotterdam

98 Information provided to Aquaculture Authority by the Directorate of Fisheries of all the coastal states/ union territories

occur due to shrimp farms. Further, the sea-based farms in Nellore are located between the sea and the Buckingam canal, which is a saline drainage canal, connected to the sea during monsoon months. The canal is in existence even before the aquaculture activity started and it is likely that any salinisation effect could have been due to the saline water flowing in the canal[99] .

NEERI (January,1995) in their study also observed no deterioration in the ground water quality at three sites located one km from the shrimp farms.

The Department of Fisheries, Government of Andhra Pradesh in Nellore district of Andhra Pradesh, collected 87 samples from the villages in the coastal area adjoining shrimp farms, to study the water quality conditions, during 3.2.1995 to 18.4.1995. The water samples were analysed by the Ground Water Department, Cuddapah. According to Rangwala (1990), for potable water the highest desirable level of chloride content is 200 mg/l and its maximum permissible level is 600 mg/l; and for total solids the highest desirable levels is 500 mg/l and its maximum permissible level is 1 500 mg/l. The details of the analytical data based on the two important parameters for establishing potability of the drinking water, namely Total Dissolved Solids and Chlorinity (Table 30) show that 40 –50% of the wells had good potable water and 83-86% of the wells had potable water with TDS and Chloride within permissible levels, while 14 –17% of the wells had water, which is not potable, in the shrimp farming area. Since the quality of water is not uniform in all the samples analysed, it indicates that the salinisation of groundwater is a complex phenomenon where various other factors such as soil quality, distance from the farm, depth of the borewells, salinity of the farm water and the quantity of water drawn from the wells are also involved apart from the seepage from the shrimp farms.

Table 30. Quality of Borewell Water in the Vicinity of Shrimp Farms in Nellore District, Andhra Pradesh

Parameter	Standards for drinking water[100]	No. of wells	Percentage
TDS (mg/l)	Highest desirable level (less than 500)	24	40
	Max. permissible level (between 501 – 1 500)	26	43
	Above permissible level (Above 1 501)	10	17
Total		**60**	**100**
Chlorides (mg./l)	Highest desirable level (less than 200)	29	50
	Max. permissible level (between 201 – 600)	21	36
	Above permissible level (Above 601)	8	14
Total		**58***	**10**

** No data in two cases due to highly saline water*
(Data Source: State Fisheries Department, Nellore, Andhra Pradesh)

However, as per the information available with the Department of Fisheries, Government of Andhra Pradesh, establishment of shrimp farms have affected drinking water availability in nine coastal villages (there are about 409 coastal fishing villages in Andhra Pradesh).

NEERI[101] reported the physico-chemical characteristics of well waters in South Arcot (Sirkali) and Nagai-Quaid-e-Milleth (Killai) districts of Tamil Nadu and the details are presented in Table 31.

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99 CIBA. 1996. Comprehensive survey of impact assessment of shrimp farms in Nellore district. *Mimeo*
100 Rangwala. S.C. 1990. Water Supply and Sanitary Engineering (Environmental Engineering) , Charotar Publishing House, Anand, India
101 NEERI April 1995. Investigation Report on Impacts of Aquaculture Farming, and Remedial Measures in Ecologically Fragile Coastal Areas in the States of Andhra Pradesh and Tamil Nadu. Report Submitted to Hon’ble Supreme Court

Table 31. Quality of Drinking Water in Andhra Pradesh in the Vicinity of Shrimp Farms

Sl. No	Parameters	Kuchipalam Village		Pudukuppam Village	
		100 m from farm	500 m from farm	100 m from farm	500 m from farm
1	pH	7.9	7.8	8.0	8.2
2	Total solids	860	830	900	840
3	Chlorides	490	230	510	240
4	Ammonical Nitrogen	0.90	0.35	0.60	0.30

(Source: Table No. 2.29: NEERI Report, April 1995, Page No. 37)

As per the standards of drinking water discussed earlier, the total dissolved solids and chlorides levels are well within the permissible levels for drinking water. However, NEERI report states that “well waters are brackish due to seepage from aquafarm”. Without the baseline data on the quality of borewell water before initiation of the shrimp farms, there is no basis to conclude that the shrimp farms were responsible for the water becoming “brackish”. Further, the total solids show more or less same values in wells located 100m and 500 m from the farm, indicating that it could not be due to seepage since the level of seepage will be reduced as the distance increases. Unfortunately, there is no reliable data on the rate of seepage under different water holding capacities and the distance upto which salinisation extends.

The foregoing discussions indicate that the salinisation of freshwater resources due to seepage from shrimp farms could occur. But several aspects have to be looked into before assessing the extent of salinisation. Many coastal villages are not getting protected water supply in states such as Andhra Pradesh and Tamil Nadu mainly because there are no freshwater aquifers in the coastal areas. Wherever limited resources of subsoil water is available it is being exploited by village panchyats for supply of drinking water. Consequently, attempts have been made by the state governments to dig tanks for storing rain water or to convert sea water into freshwater by desalinisation plants. This proves that there is a scarcity of drinking water in coastal areas. Most of the reports pertaining to salinisation were specific to certain belts where farms are built in sandy soil and the drinking water source was available at lower depths. After setting up of the Aquaculture Authority licenses are not being issued for locating shrimp farms in seepage prone areas.

6.4 Impact on Biological Resources

6.4.1 Exploitation of Natural Seed

During the late eighties shrimp aquaculture in India was totally dependent on wild seed collected from the estuaries, backwaters and the creeks. Exploitation of natural seed was at its highest in West Bengal, Orissa and Andhra Pradesh. Banerjee and Singh (1993)[102] reported that over 50 000 fry collectors operated in West Bengal. During the course of collection of cultivable shrimp seed, a large number of other shrimp and fish seed were caught as bycatch and destroyed. This practice caused wanton destruction of juveniles of other fin and shell fish species. However, during the nineties, hatcheries were set up and wild seed collection was reduced. Later, collection of wild seed was banned by the Government of India and some state governments.

Presently, hatcheries are mainly dependent on wild spawners (brood stock) for the supply of nauplii and there are over 260 hatcheries with a total production capacity of 10.8 billion postlarvae. This capacity is more than sufficient to supply stocking material for over 150 000 ha of shrimp farms. There has been some apprehension regarding reduction in shrimp catch from sea due to capture of mother shrimps in large number. Since the cost

102 Banerjee, B.K. and H. Singh 1993. The Shrimp Fry Bycatch in West Bengal, BOBP/ WP/ 88

of the wild spawner is very exorbitant, the hatchery operators are using nauplii purchased from other hatcheries. Nauplii suppliers have also been successful in induced maturation of wild caught immature shrimps.

6.4.2 Biodiversity

There is an apprehension that shrimp aquaculture wastes cause changes in the biodiversity of the natural ecosystem. However, it is clear from the foregoing account that the level of nutrient loading from shrimp farms is negligible to cause any major change in the ecosystem. Change(s) in biodiversity could occur because of the large-scale loss of fish and shrimp larvae along with the collection of wild shrimp seed over a long period of time. However, hatchery production of quality shrimp seed to cater to the need of the shrimp farmers has also eliminated this risk

6.4.3 Marine Capture Fisheries

The country has a long coastline of 8 118 kms and an equally large area under estuaries, backwaters, lagoons, etc. highly amenable for developing capture as well as culture fisheries. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the area available to India is estimated at 2.02 million sq. km comprising 0.86 million sq. km on the west coast, 0.56 million sq. km on the east coast and 0.60 million sq. km around the Andaman and Nicobar Islands. With the absolute right on the EEZ, India has also acquired the responsibility to conserve, develop and optimally exploit the marine living resources within this area.

The fisheries sector occupies a very important place in the socio-economic development of India. The sector has been recognised as a powerful income and employment generator as it stimulates growth of a number of subsidiary industries and is a source of cheap and nutritious food. At the same time it is an instrument of livelihood for a large section of economically backward population of the country. The fisheries sector has also been one of the major contributors of foreign exchange earnings through export. The earnings from export of fish and fishery products crossed US $ one billion mark in 1995-1996 and has reached the figure of Rs 46 270 million* in 1998-1999.

The marine fishing fleet[103] comprises about 0.226 million traditional craft (including about 44 578 motorised traditional craft), 53 684 mechanised craft and about 170 large fishing vessels of 2l meter overall length (OAL) and more. As seen by the number of traditional craft and small mechanised vessels, the major fishing activities are still concentrated in the areas within 0 to 70-80 m depth zone. Trawling by larger vessels is confined to the north-east coast. As compared to the west coast, concentration of traditional craft (including motorised) is more on the east coast (about 57 % of the total). In the case of mechanised vessels, the trend is reverse. The scale of mechanisation is also reflected in the total fish landings of the two coasts. There has been a marked increase in the traditional fleet during the nineties (from 191 207 in 1994-1995 to 225 862 during 1998-1999). Similarly, the number of mechanized vessels (below 20 meter OAL) have also increased from 46 918 to 53 684 during the corresponding period. Although this increase in the fishing fleet has brought in additional harvest from the marine sector (mainly in-shore water), the per boat catch has gone down. Further, the increased effort has also exceeded the harvest levels from inshore waters *(0-50 m depth) vis-à-vis* the harvestable potential of about 2.20 million tonnes from this area.

It has been generally recognised that the Indian ocean has the best-developed fisheries, but coastal resources in this ocean are under stress in many areas and require effective management, even though the potential for expansion may exist offshore. In India, while inshore waters have been almost exploited to the sustainable levels, the contribution from deep sea has been insignificant. The current (1998-1999) annual fish production has been estimated at 5.26 million tonnes (mt) – 2.696 mt from the marine sector against a potential of 3.9 mt and 2.566 mt from the inland sector against a potential of 4.5 mt. The provisional figures for 1999-2000 have been estimated at 5.66 mt (2.834 mt from the marine sector and 2.823 mt from the inland sector).

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* *One US $ = INR 46.50*

[103] *Department of Animal Husbandry & Dairying, Ministry of Agriculture, Government of India*

The marine fisheries scenario, as seen from the above analyses do not point towards reduction in the catches or any adverse impact of shrimp aquaculture wastewater on fish stocks, etc. The impact assessment made at micro-level has also shown a similar picture. In a case study in Nagapattinam district in Tamil Nadu it was observed that there was no major change in the fishing effort and in the annual fish landings during 1991-1994 when the shrimp culture in the district was at its peak (Table 32) [104].

Table 32. Annual Fishing Effort ('000 hours) and Catch (t) from Major Gear in Nagapattinam District, Tamil Nadu

Gear	1991		1992		1993		1994	
	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
Gill net	1387	15400	1030	12911	1213	5108	1549	17244
Bag net	20	2785	16	5649	12	3346	27	3385
Hook& line	29	196	45	262	18	157	39	264
Other gears	-	634	-	1910	-	1933	-	510
Total	**-**	**19015**	**-**	**20732**	**-**	**20544**	**-**	**21403**

The fish landing data from the major shrimp producing states and union territories in the country is presented below (Table 33).

Table 33. Marine Fish Production by States/ Union Territories, 1989-1990 to 1998-1999[105]

(in '000 t)

State/ Union Territory	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99
Andhra Pradesh	111.35	120.35	125.79	113.07	154.32	150.26	151.99	152.05	146.55	150.00
Goa	52.65	53.18	47.11	101.49	102.11	98.46	84.21	93.76	88.81	65.84
Gujarat	432.36	500.00	516.85	589.00	619.84	645.26	600.00	660.07	745.71	550.00
Karnataka	186.13	183.83	181.41	174.19	174.52	173.75	217.51	222.78	189.86	160.61
Kerala	535.71	514.24	524.76	496.24	559.20	548.37	532.55	578.92	526.34	583.34
Maharastra	393.00	325.00	390.86	387.55	350.40	357.00	387.00	481.00	453.00	394.88
Orissa	77.89	78.00	87.88	119.38	103.93	122.89	123.20	133.46	156.08	124.33
Tamil Nadu	289.00	288.95	301.00	308.00	317.72	330.50	340.00	350.79	355.10	359.55
West Bengal	89.00	125.00	142.00	145.00	153.00	151.20	153.00	172.00	164.00	171.50
A & N Islands	13.60	15.15	25.19	24.17	25.08	26.12	25.68	26.40	27.23	27.40
Daman & Diu	7.73	7.73	15.94	13.43	11.53	11.50	15.28	15.28	18.81	26.85
Lakshadweep	6.97	7.60	5.81	9.73	9.41	9.75	9.82	11.75	10.55	13.54
Pondicherry	29.51	30.62	32.68	35.00	37.78	36.75	36.82	38.55	38.42	38.60
Deep Sea Sector	50.00	50.00	50.00	60.00	30.00	30.00	30.00	30.00	30.00	30.00
TOTAL	**2 274.90**	**2 299.65**	**2 447.28**	**2 576.25**	**2 648.84**	**2 691.81**	**2 707.06**	**2 966.81**	**2 950.46**	**2 696.46**

104 Paulraj, R., M. Rajagopalan, M. Vijayakumaran, E. Vivekanandan and R. Sathiadhas. 1998. Environmnetal and social issues in coastal aquaculture - A case study. *Bay of Bengal News,* II(11) : 15-18

105 Department of Animal Husbandry & Dairying, Ministry of Agriculture, Government of India, New Delhi, 1999

6.4.4 Shrimp Diseases

In nature, the host, the pathogen and the environment are in an equilibrium and because of the equilibrium, disease do not manifest on the host. However, if the equilibrium is disturbed, the disease occurs. The microorganisms which cause disease constitute a part of the natural microflora in the aquatic ecosystem, but they cause disease only when the host organism is stressed. Hence, changes in weather conditions, environmental perturbations, and bad management practices can cause stress to shrimp leading to disease outbreaks. A similar situation prevails in crop and animal husbandry also, inspite of the fact that these two sectors have an evolutionary history of many centuries. The recent outbreak of foot and mouth disease (FMD) in livestock in Great Britain is an example. After having been certified as FMD-free, the disease re-surfaced in the country causing immense loss to the livestock and dairy industry. On the contrary, commercial shrimp farming is only 2 – 3 decades old and the best management practices are still under trial and field testings. It may also be mentioned that disease eradication is one of the biggest challenge before mankind since disease causing organisms (virus, bacteria, etc.) display much faster genetic manifestations than their hosts. So it is in the shrimp farmers' own interest, that they maintain a clean environment, both within the farm and outside it.

6.5 Socio-Economic Impacts

In the wake of the fast development witnessed during the nineties, shrimp farming has led to many debates and discussions on issues revolving around the socio-economic fabric of the coastal communities. Some of these issues examined in the impact assessment can be broadly compartmentalized into impediments to access, loss of employment, flooding and human health.

Socio-economic impacts of shrimp farming have been generally studied based on the survey of public opinion and the data indicate public perceptions on shrimp farming. A study conducted by the Depatment of Economics, University of Madras in Sirkali Taluk in Tamil Nadu showed that increase in the land price (61.1% of the responses), improvement in road facilities (32.2%), improved employment oppurtunities (31.1%), and improved export earnings (25.5%) were the benefits expressed by the local population. In the same study, 60.5% of the sampled population felt that employment opportunities have reduced[106]. Such wide variation in the responses of the public makes it very difficult to interpret the data. The following account gives more detailed observations on the socio-economic impacts of shrimp farming.

6.5.1 Access

Coastal zone is being used for various purposes – agriculture, horticulture, fishing, salt-pan, tourism, etc. Construction of large farms in the coastal areas may affect accessibility to coast leading to conflicts among various user groups. In India, farms of above 10 ha are very few in number and most of the small farmers have holdings of less than 2.0 ha. It has been reported that some of the large farms in Andhra Pradesh have fenced their area and it requires a long detour for the local population. A few of these farms have made provision of a public road through their farm.[107] Large farms, with more than 50 ha farm area, should be advised to split their holdings into smaller segments with provision of access to others to the sea/ creek.

In Sirkali Taluk of Tamil Nadu, only 1.0 % of the responses felt that shrimp farms are affecting the access to the seashore[108].

In Andhra Pradesh, people from 6 villages have reported problem of access to the sea because of the jetties constructed to the seas for drawing water for the large shrimp farms. However, in Andhra Pradesh, less than 5.0 % of the total area of shrimp farming is based on sea water which need coastal facilities and, therefore, this problem is localized.

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106 Prof. Dr. N. Rajalakshmi, Department of Economics, University of Madras, information sent to Aquaculture Authority 2001

107 CIBA, 1996. Comprehensive Survey of Impacts of Shrimp Farming in Nellore District, Andhra Pradesh. Mimeo

108 Prof. Dr. N. Rajalakshmi, Department of Economics, University of Madras, information sent to Aquaculture Authority 2001

6.5.2 Employment

Coastal aquaculture generates a wide range of employment, bringing in people from diverse backgrounds, social groups and traditions. Data analysed from the eastern and western hemisphere indicate that investment and economic output from shrimp aquaculture generates considerable employment in developing as well as developed countries. In Thailand, more than 150 000 people are directly employed in shrimp farming[109]. In Ecuador, 195 000 people were engaged directly and 17 000 people on part-time basis in 1 567 farms involved in shrimp farming, processing and hatcheries[110]. A survey of 5 000 diverse shrimp farms in Asia showed intensive and semi-intensive shrimp farming provided employment for an average of 558 person-days/ha/yr; but traditional and extensive farming systems provided a much lower employment of 192 person-days/yr. Rice farming employment figures are commonly reported at around 200 – 250 person-days/ha/yr.[111]

In India, a study conducted in Nagapattinam district of Tamil Nadu showed that the employment opportunities have increased due to shrimp farming. The average labour requirement for paddy cultivation is 180 labour days/ crop/ ha, whereas in shrimp farming it is about 600 labour days/ crop/ ha. In contrast to paddy cultivation where only one crop is feasible, in shrimp culture two crops are possible. Further, where agricultural labourers on an average earn an annual income of Rs. 7 500, shrimp farm labourers earn about Rs. 12 000 per annum.[112]

Studies conducted in the sea-based farms of Nellore district of Andhra Pradesh indicated that there was an increase of 2.0-15.0 % in employment after the establishment of the shrimp farms in the vicinity and 6.0-22.0 % increase in income of the farm labourers. Several infrastructure facilities such as roads, electricity, sanitation and housing have improved in many villages due to aquaculture development in the area.[113]

Apart from direct employment, employment oppurtunities have also been created due to shrimp farming in the allied sectors such as hatchery, broodstock and spawner supply, supply of equipments and other materials for hatchery and the farm, supply of seed, feed manufacturing units, feed supply, ice plants, processing plants, etc.

In Andhra Pradesh, it is observed that *scientific shrimp farming generates maximum number of man-days per hectare per annum – to the extent of 650, as against 225 mandays/ ha provided by agricultural operation in one year. (Commissioner of Fisheries, Andhra Pradesh, Hyderabad).*

In Sirkali Taluk in Tamil Nadu it has been observed that 75.0 % of the employees in the shrimp aquafarms are getting monthly salary of Rs. 1 000 and above and 83.0 % of the employees felt that they are receiving increased wages in aquafarms[114].

In West Bengal, a total of 242 000 people are directly employed in coastal aquaculture and about 1 416 persons are employed in allied sector[115]. In Andhra Pradesh, there are about 72 000 farmers involved in the farming activities. Presently, there are 142 shrimp hatcheries, 28 feed mills and 36 processing plants as ancillary activities associated with shrimp farming and it has been reported that about approximately 40 000 people are employed in the ancillary activities[116]. The total number of farmers involved in shrimp farming is estimated as 92 591 for the total area of 140 936 ha of farms.

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109 Phillips, M. and U. Barg. 1999. Experiences and Opportunities in Shrimp Farming. Sustainable Aquaculture. Balkema, Rotterdam

110 Robadue, D. Jr. 1995. Managing shrimp mariculture development. Eight years in Ecuador: The Road to Integrated Coastal Management. CRC Technical Report No. 2088. Coastal Resources Centre, Universityof Rhode Island

111 ADB/NACA, 1998. Final Report on the Regional Study and Workshop on Aquaculture Sustainability and the Environment (RETA 5534), Asian Development Bank and NACA, Banghok, Thailand

112 Paulraj, R., M. Rajagopalan, M. Vijayakumaran, E. Vivekanandan and R. Sathiadhas. 1998. Environmental and social issues in coastal aquaculture - A case study. *Bay of Bengal News*, II(11) : 15-18

113 CIBA, 1996. Comprehensive survey of impact of shrimp farming in Nellore District, Andhra Pradesh. Mimeo

114 Prof. Dr. N. Rajalakshmi, Department of Economics, University of Madras. Information furnished to Aquaculture Authority 2001

115 Government of West Bengal, April 2001

116 Government of Andhra Pradesh, January 2001

However, on the contrary, there are reports that *"conversion of agricultural land has resulted in untold unemployment and only a few of these displaced workers were employed for short period as construction workers. Shrimp farms employ 0.6 labourers per ha.*[117]*"*

The employment potential of traditional system where large water bodies are involved is minimal. But in case of scientific extensive farming, the technology requirements in pond preparation, feed management, water exchange, regular monitoring of growth and health of the shrimps are high and one technical person and 2 – 4 farm hands are required on regular employment for farms of 2.0 ha size (1-2/ ha) apart from the labor requirements during pond preparation and harvesting. Since 65.0 % of the total water spread area under shrimp farming is constituted by farms of less than 5.0 ha size, the employment potential is high. Further, shrimp farming can even generate employment in salt affected areas where no other activity is possible.

6.5.3 Infrastructure Facilities

Shrimp farming has improved the infrastructure facilities available in the remote coastal villages. In the coastal belts, where shrimp farms are set up, the much needed electricity, roads and even telephone lines have been developed, which were never thought of by the villagers. Aquaculture has augmented the earnings of the villagers through increased wages and expanded job opportunities[118]. A detailed study conducted in Tamil Nadu and Andhra Pradesh showed significant development of infrastructural facilities in shrimp cultivation areas. According to the survey, improvement in infrastructure facilities took place in new roads (40.0 –46.0 %); construction of new houses (48.0–96.0%); transport facilities (4.0-32.0%); communication linkages (22.0-32.0%); and market facilities (22.0-82.0 %)[119].

6.5.4 Human Health

On the impact of shrimp farming on human health, most of the information available is based on opinion survey of the local population, but there are no direct evidences to substantiate the basis of this information. For example in a survey conducted in Sirkali Taluk of Tamil Nadu, the local population claimed that they are affected by malaria, typhoid, cough and cold, dysentery, cholera and viral fever due to shrimp farms[119] . Another study in Tamil Nadu indicated that *"the effluents discharged into the sea contain more pollutants like phosphorus, nitrogen which are consumed by the adult fish population. Ultimately, when these fishes are consumed by human beings, the phosphorus and nitrogen will act as a chemical irritant inside the intestines of the human beings leading to a dreadful disease 'Narcotizing Enteritis'. ……… the villagers are being affected by diarrhea, skin diseases, and a particular type of gastro-infection because of the effluent from the prawn farms mixing in the channel water, which is also used for domestic purpose. Eight persons inclusive of children have died during July-August 1994 alone of acute stomach disorder*[120]*"*. The report further stated that, *"grazing lands have been affected by the effluent and the water used for livestock is contaminated. In June – July 1994, when people died due to acute stomach disorder even cows, goats and poultry also died"*. These claims do not have any proof since for each of these ailments there are different pathogens and vectors, which are not related in anyway to the shrimp farming practice. Nitrogen and phosphorus are not toxicants, but are nutrients which are always found in open waters. Further, the reports of the state governments of Orissa, Gujarat, Goa, West Bengal, Andhra Pradesh, Maharashtra and Pondicherry have indicated that there are no human health hazards reported from shrimp farming areas. If shrimp farming is affecting the human health, then the farmer and the farm workers will be the first to be affected.

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117 Justice H. Suresh, 1995. Report on Impact of shrimp farms along the coast of Tamil Nadu and Pondicherry. *Campaign Against Shrimp Industries*

118 Personal Communication from Commissioner of Fisheries, Government of Andhra Pradesh

119 Prof. Dr. N. Rajalakshmi, Department of Economics, University of Madras, 2001

120 Justice H. Suresh Committee. Report on Impact of shrimp farms along the coast of Tamil Nadu and Pondicherry, 1995. *Campaign Against Shrimp Industries*

6.5.5 Flooding

Algarswami in his Report[121] mentioned that *" huge cyclone protection dykes and peripheral dykes are constructed by shrimp farmers. In many cases, as in Kandaleru creek (Andhra Pradesh), the farm area is the natural drainage area for floods. Due to physical obstruction caused by the dykes, the natural drain is blocked and floodwater accumulates in the hinterland villages. Protest is being made by people in some of the villages against such dykes. The ponds are constructed right on the bank of the creeks without leaving any area for draining of flood water".* The information available from the state governments indicated that no such complaints have been received from any of these areas[122]. Only large farms have lengthy dykes without any break. With small farms such problems do not generally arise. No such problem was encountered in other states as well.[123]

6.5.6 Cost of Environmental Damage

NEERI in its report presented to this court, has shown an assessment of socio-economic status of aquaculture in coastal areas of the states of Andhra Pradesh and Tamil Nadu (Table 4.2 and Table 4.3). According to its assessment a total damage of Rs. 6 305 crores and Rs. 423 crores have been estimated for the two states respectively, and the earnings from the states are shown as Rs. 1 498 crores and Rs. 280 crores. These calculations are based purely on 29 assumptions (Table 4.1). Out of these, the following assumptions do not have any valid scientific evidence or reliable data.

- Loss of land (with casuarina plantation) - 30% of the total land under cultivation .
- Loss of grazing grounds – 5% of the total area under cultivation
- No. of persons requiring medical assistance due to shrimp farming – 2 persons/ ha
- Total damages caused due to cyclonic effects in the coastal areas – Rs. 1000 million/ year
- Damage due to cutting of casuarina plantation – 2%
- Loss due to desertification – Rs. 47 000/ ha
- Loss of potable water – 360 m^3/ ha/ yr
- Water treatment cost – Rs. 30/ m^3
- Total damage to coastal areas from destruction of mangrove plantation -equivalent to casuarina plantation.
- Fish catch from the coastal area – 3 boats equivalent to one hectare of aquaculture
- Loss of fishing nets 9 fishing net/ ha/ year
- Loss of mandays for fish catch activity due to construction of aquaculture unit – 1 fisherman/ boat.

These assumptions are totally unscientific and without any basis. Even with these assumptions, the calculations are erroneous. For example, annual loss due to 'dessertification' in Andhra Pradesh was estimated as Rs. 4 022.20 million, which according to their assumption (annual loss Rs. 47 000/ ha) works out to annual desertification of 85 578 ha of farms, where as the total area under farming at that time was 34 500 ha only.

The loss due to fishing income in Tamil Nadu is shown as Rs. 1123.20 million. However, the time-series data of fish landing from Tamil Nadu has not shown any reduction in the total landings for the last ten years (Table 33). Similarly, the assessment shown for Tamil Nadu is also erroneous on various accounts due to unscientific assumptions.

6.5.7 Review of Responses Received from Public

In connection with the preparation of the Environment Impact Assessment report, the Aquaculture Authority issued a Public Notice in English and vernacular languages in leading newspapers in coastal states and union territories on 10.2.2001 inviting representations from interested parties and individuals. In response to the public notice, 1 130 representations were received which comprised: English – 99; Tamil – 247; Oriya – 4; Marathi – 2; and Telugu – 778.

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[121] Alagarswami. K. 1995. India – Country Report. FAO/NACA Report on a Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development. 1995.pp 141 – 186

[122] Government of Andhra Pradesh, January 2001

[123] Governments of West Bengal, Orissa, Maharashtra, Goa, Gujarat, Pondicherry, 2001

The responses received have listed various positive and negative impacts of shrimp farming in their respective local areas. A summary of the impacts mentioned with number of responses in each are listed in Table 34. The responses showed that the positive responses far outweigh the negative responses.

Among the other responses received, a number of experts in the field of aquaculture and fisheries have made various observations which will be useful while considering the development of sustainable shrimp farming. A summary of the responses received are presented below:

1. Aquaculture in brackishwater areas should be done by farmers, in small holding which should not exceed 10 ha each. This will ensure environment-friendly and sustainable farming.
2. The farms should not be clustered together.
3. The farms should be located very close to the estuaries, brackishwaters, backwaters, lagoons, river mouth areas and delta regions to avoid pollution of water, sedimentation, salinisation of soil and water. To this extent, the CRZ rules will have to be modified.
4. Agricultural land, mangroves, coconut groves, casuarina plantations should not be converted into aquaculture farms. However, derelict salt pans can be used. No aquaculture should be permitted around salt water lakes.
5. Laying of long distance pipelines for pumping sea water, construction of jetties into the sea, usage of ground water, fencing of farms should be prohibited.
6. Capture of wild seed for shrimp culture should be prohibited.
7. Use of drugs, chemicals and antibiotics in shrimp farming should be prohibited.
8. The principles of social equality, nutritional security, environmental protection and economic development should be integrated with shrimp farming.
9. Species, other than tiger prawn should also be cultured.
10. Farmers have to be educated and trained in sustainable shrimp farming. Institutions concerned with shrimp aquaculture and extension should be given this responsibility.
11. A total review of shrimp farming at village, district and state level should be conducted by empowered technical committees for each state and re-organise the present system. Based on this review, a long-term plan of action for orderly and sustainable growth of shrimp farming should be drawn.
12. Realising the potential of shrimp culture in the rural economy, responsible shrimp culture practices should be introduced for food security, clean environment, improved socio-economic conditions of the rural communities and increased national income.
13. The corporate sector should come forward to share the benefits of shrimp farming with local people instead of alienating them.
14. The shrimp pond system should be suitably designed to accommodate ponds to grow aquatic species like sea weed, mollusc, milk fish, mullet, tilapia. This would serve as waste utilization rather than simple disposal.
15. Unfortunately, not much data are available on the environmental impact of shrimp farming and little effort has been made to define criteria for sustainability. Hence R&D efforts should be targeted to evolve suitable methods for sustainable and eco-friendly coastal shrimp culture programmes.
16. Compared to the effluents of other industries, aquaculture wastewater should be considered as less harmful and be treated through bio-ponds.
17. Farmers should be given adequate inputs to go for crop rotation *i.e.* one crop of shrimp and one crop of fish, which is the answer for sustainable production.