Chapter One

Quality of Life in Sirkazhi Coast: An Introduction to the Problem and Review of Literature

1.1 Introduction

Aquaculture refers to "*the farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants*", when restricted to fish culture alone, it is frequently called "fish-farming". Shrimp and prawns, the decapods crustaceans of the families *Penaeidae* and *Palaemonidae* are popular in fish farming. In the recent aquaculture literature, a distinction is drawn between the two groups; the name prawn is used for freshwater forms of *Palaemonids* and shrimp for the marine *Penaeidae*. According to FAO guidelines for the Promotion of Environmental Management of Coastal Aquaculture Development, it is "the land based and water-based brackish and marine one", called as "coastal aquaculture". Aquaculture has developed rapidly over the last three decades to become an important economic activity worldwide. It has confronted many of the developmental problems in this relatively short period including sector competition, over production, trade restrictions, overcapitalization and concerns over environmental impacts.

The proposed research would study the Morphological Changes along the East coast river mouth. The river mouths are greatly affected due to impact of Tsunami. East coast is severely affected due to Tsunami of 26th December 2004 and several morphological changes along the coast happened. There are numerous Major and Minor rivers that mixes with the sea in this region. All the mouths of the rivers are affected due to Tsunami.

Apart from the river mouth affected there has been severe impact throughout the World. In India sever impact is felt at Nagapattinam district that caused a death of about 6000 lives and loss of several millions. Next to Nagapattinam district, Cuddalore district is worst affected district. Tsunami has caused extensive damages in Andaman and Nicobar Island, Andra Pradesh, Kerala and Pondicherry State. The death toll had exceeds about ten thousand in India. The Tsunami disaster also raised important question about the effectiveness of human societies in dealing with such extreme high magnitude in terms of preparedness, the effectiveness of warning system and the ability of the international community to act unilaterally to guide and organize an effective response. River mouths are usually covered with sand, Mangrove forest, Vegetation cover, Swamps and in some cases settlement. The river mouth, which could not resist the force of Tsunami wave, had suspected greater changes. This necessitates a several changes along the coast and various destructions by using optical remote sensing technology. The GPS would used to map the changes at the river mouth through survey method. The study would suggest measures to overcome the problem due to changes in the river mouth due to Impact of Tsunami. Using the optical remote sensing data and the filed data to create a Geographical information system model for disaster reduction in future would generate a geo-spatial data.

1.2 Aquaculture: Definition

Aquaculture is the farming of aquatic organisms such as fish, shellfish and even plants. The term aquaculture refers to the cultivation of both marine and freshwater species and can range from land-based to open-ocean production. The jurisdiction of The Maine Department of Marine Resources (DMR) and the focus of this is the farming of marine species within the coastal waters of Maine. Mari-culture is another term used for the farming of marine organisms in their natural habitats.

1.3 History of Aquaculture

Aquaculture has been used in China since circa 2500 BC. When the waters lowered after river floods, some fishes, namely carp, were held in artificial lakes. Their brood was later fed using nymphs and silkworm feces, while the fish themselves were eaten as a source of Protein. By a fortunate genetic mutation, this early domestication of carp leads to the development of goldfish in the Tang Dynasty. The Hawaiian people practiced aquaculture by constructing fish ponds (see Hawaiian aquaculture). A remarkable example from ancient Hawaiian is the construction of a fish pond, dating from at least 1,000 years ago, at Alekoko. According to legend, it was constructed by the mythical Menehune. The Japanese practiced cultivation of seaweed by providing bamboo, poles, later, nets and oyster shells to serve as anchoring surfaces for spores. The Romans often bred fish in ponds.

The practice of aquaculture gained prevalence in Europe during the middle Ages, since fish were scarce and thus expensive. However, improvements in transportation during the 19th century made fish easily available and inexpensive, even in inland areas, causing a decline in the practice. The first North American fish hatchery was constructed on Dildo Island, Newfound land Canada in 1889; it was the largest and most advanced in the world.

Americans were rarely involved in aquaculture until the late 20th century, but California residents harvested wild kelp and made legal efforts to manage the supply starting circa 1900, later even producing it as a wartime resource. (Peter Neushul, Seaweed for War: California's World War I kelp industry, Technology and Culture 30 (July 1989), 561-583), In contrast to agriculture, the rise of aquaculture is a contemporary phenomenon. According to professor Carlos M. Duarte About 430 (97 per cent) of the aquatic species presently in culture have been domesticated since the start of the 20th century, and an estimated 106 aquatic species have been domesticated over the past decade. The domestication of an aquatic species typically involves about a decade of scientific research. Current success in the domestication of aquatic species results from the 20th century rise of knowledge on the basic biology of aquatic species and the lessons learned from past success and failure. The stagnation in the world's fisheries and overexploitation of 20 to 30 per cent of marine fish species have provided additional impetus to domesticate marine species, just as overexploitation of land animals provided the impetus for the early domestication of land species.

In the 1960s, the price of fish began to climb, as wild fish capture rates peaked and the human population continued to rise. Today, commercial aquaculture exists on an unprecedented, huge scale in the 1980s, open-net cage salmon farming also expanded; this particular type of aquaculture technology remains a minor part of the production of farmed finfish worldwide, but possible negative impacts on wild stocks, which have come into question since the late 1990s, have caused it to become a major cause of controversy.

1.4 Types of Aquaculture

1.4.1 Alga culture

Alga culture is a form of aquaculture involving the farming of species of algae. The majority of algae that are intentionally cultivated fall into the category of microalgae, also referred to as phytoplankton, microphysics or plank tonic algae. Micro algae, commonly known as seaweed, also have many commercial and industrial uses, but due to their size and the specific requirements of the environment in which they need to grow, they do not lend themselves as readily to cultivation on a large scale as microalgae and are most often harvested wild from the ocean.

1.4.2 Fish farming

Fish farming is the principal form of aquaculture, while other methods may fall under mare culture. It involves raising fish commercially in tanks or enclosures, usually for food. A facility that releases juvenile fish into the wild for recreational fishing or to supplement a species, natural numbers is generally referred to as a fish hatchery. Fish species raised by fish farms include salmon, catfish, tilapia, cod, carp, trout and others. Increasing demands on wild fisheries by commercial fishing operations have caused widespread overfishing. Fish farming offers an alternative solution to the increasing market demand for fish and fish protein.

1.4.3 Fresh water prawn farming

A freshwater prawn farm is an aquaculture business designed to raise and produce freshwater prawn or shrimp for human consumption. Freshwater prawn farming shares many characteristics with and many of the same problems as, marine shrimp farming. Unique problems are introduced by the developmental life cycle of the main species (the giant river prawn, *Macro brachium Rosenberger*). The global annual production of freshwater prawns (excluding crayfish and crabs) in 2003 was about 280,000 tons, of which China produced some 180,000 tons, followed by India and Thailand with some 35,000 tons each. Additionally, China produced about 370,000 tons of Chinese river crab.

1.4.4 Integrated multi-trophic aquaculture

Integrated Multi-Trophic Aquaculture (IMTA) is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another. Fed aquaculture (e.g. fish, shrimp) is combined with inorganic extractive (e.g. seaweed) and organic extractive (e.g. shellfish) aquaculture to create balanced systems for environmental sustainability (bio mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

"Multi-Trophic" refers to the incorporation of Species from different treopic or nutritional levels in the same system. This is one potential distinction from the age-old practice of aquatic poly culture, which could simply be the co-culture of different fish species from the same trophic level. In this case, these organisms may all share the same biological and chemical processes, with few synergistic benefits, which could potentially lead to significant shifts in the ecosystem. Some traditional poly culture systems may, in fact, incorporate a greater diversity of species, occupying several niches, as extensive cultures (low intensity, low management) within the same pond. The "Integrated" in IMTA refers to the more intensive cultivation of the different species in proximity of each other, connected by nutrient and energy transfer through water, but not necessarily right at the same location. Ideally, the biological and chemical processes in an IMTA system should balance. This is achieved through the appropriate selection and proportions of different species providing different ecosystem functions. The co-cultured species should be more than just bio filters; they should also be harvestable crops of commercial value. A working IMTA system should result in greater production for the overall system, based on mutual benefits to the co-cultured species and improved ecosystem health, even if the individual production of some of the species is lower compared to what could be reached in monoculture practices over a short term period.

Sometimes the more general term "Integrated Aquaculture" is used to describe the integration of monocultures through water transfer between organisms. For all intents and purposes however, the terms "IMTA" and "integrated aquaculture" differ primarily in their degree of descriptiveness. These terms are sometimes interchanged. Aguaponics, fractionated aquaculture, IAAS (integrated agriculture-aquaculture systems), IPUAS (integrated peri-urban-aquaculture systems) and IFAS (integrated fisheries-aquaculture systems) may also be considered variations of the IMTA concept

1.4.5 Mari culture

Mari culture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater. An example of the latter is the farming of marine fish, prawns, or oysters in saltwater ponds. Non-food products produced by Mari culture include: fish meal, nutrient agar, jewelries (e.g. cultured pearls) and cosmetics.

1.4.6 Shrimp farming

A shrimp farm is an aquaculture business for the cultivation of marine shrimp for human consumption. Commercial shrimp farming began in the 1970s, and production grew steeply, particularly to match the market demands of the U.S. Japan and Western Europe. The total global production of farmed shrimp reached more than 1.6 million tons in 2003, representing a value of nearly 9,000 million U.S. dollars. About 75 per cent of farmed shrimp is produced in Asia, in particular in China and Thailand. The other 25 per cent is produced mainly in Latin America, where Brazil is the largest producer. The largest exporting nation is Thailand.

Shrimp farming has changed from traditional, small scale businesses in Southeast Asia into a global industry. Technological advances have led to growing shrimp at ever higher densities and brood stock is shipped worldwide. Virtually all farmed shrimp are penaeids (i.e., shrimp of the family Panaeidae), and just two species of shrimp the Penaeus vannamei (Pacific white shrimp) and the Penaeus monodon (giant tiger prawn) account for roughly 80 per cent of all farmed shrimp. These industrial monocultures are very susceptible to diseases, which have caused several regional wipe-outs of farm shrimp populations. Increasing ecological problems, repeated disease outbreaks and pressure and criticism from both NGOs and consumer countries led to changes in the industry in the late 1990s and generally stronger regulation by governments. In 1999, a program aimed at developing and promoting more sustainable farming practices was initiated, including governmental bodies, industry representatives and environmental organizations.

1.4.7 Types of Shrimp Farming

1.4.7.1 Static freshwater ponds

Ordinary fresh water fish culture ponds are still-water ponds. They vary a great deal in water spread area and depth. Some are seasonal and some perennial. The ponds may be rain fed (also called sky ponds) and/or may have inlet and outlet systems. The water supply may be from a stream or a canal or from an underground source such as wells, tube wells etc. The water retentively of the ponds depends on soil composition of the pond bottom and subsoil water level. The natural biological productivity of such ponds depends on soil and water qualities. Homestead ponds are usually small and shallow. Commercial freshwater ponds have to have an assured water supply, inlet and drainage systems. In organized aquaculture, the carrying capacity of still water ponds is enhanced by maturing and/or fertilizing and exercising water quality control. Fish are also fed from an extraneous source for obtaining fast growth.

Science of freshwater pond fish-culture has made great strides in recent years and there is a fast advancing frontier of knowledge on every aspect of pond culture starting from farm designing and construction up to production of marketable fish of a wide variety of cultured fresh water species of finfish and shellfish. Examples are: carp culture systems in India, China, Israel, Germany, etc; catfish culture in U.S.A. There is considerable competition with agriculture and other land-use agencies in this system of aquaculture and its success would, by and large, depend on comparative economics of land use. But much also depends on national policies on land use and the encouragement government gives to aquaculture as a means of producing fish protein.

1.4.7.2 Brackish water ponds

The species different from those cultured in freshwater ponds but the principle of operation of brackish water ponds is different from those of freshwater ponds. Here the pond or the farm is essentially located on a tidal creek or stream and there is a system of sluices to control the ingress and egress of water into and from the ponds. Examples are: Milkfish farms in Philippines, Taiwan and Indonesia etc. Brackish water fish farming is a fast growing science. Here also there is competition with other land use agencies, especially forestry, but the extent of competition with agriculture is relatively less because coastal land is generally not suitable for agriculture. The ARAC farm at Buguma is tidally fed and the salinity range is 5 – 21 ppt.

1.5 World aquaculture

As world population continues to expand, with current projections being for an increase from 6 billion people in the year 2000 to 9-10 billion by 2050, fisheries products are one of the many food groups that will come under increasing pressure just about all the world's natural fisheries resources are fully exploited (many being already over exploited) and the challenge for aquaculture is to expand to meet the future shortfall in fish supplies. A key way forward has been demonstrated over the last decade in China, where a substantial expansion of production has been grounded on small-scale pond culture. Similar growth in other countries could help alleviate poverty and improve the livelihoods and food security of the poor.

Although aquaculture has been practiced for many centuries, its expansion and intensification is a modern phenomenon. It is important that, as the industry expands to meet future needs, it does so in an environmentally positive way. This is easier with the production of herbivores than with carnivores. The major potential to meet future human food demand is with herbivorous and omnivorous fish like carps and tilapias, and expansion of this sector needs to be nurtured. Not only are fish such as carps suited to the regions where food for the human population is likely to come under the greatest pressure, but they also can be fitted more readily into a nutrient recycling scheme. Their production additionally avoids the question we have to face with the farming of carnivorous fish: whether it makes sense to use fish (processed into meal) as a key feed ingredient for the fish we are growing for human consumption. In fact the aquaculture sectors using fish protein, the farming of shrimp in ponds and of sea fish in coast cages represent less than 10 per cent of total world aquaculture production. Worldwide, most fishmeal is used in the production of pigs and chickens. However, the production of species like shrimp, salmon and bream are their demand for fishmeal, is likely to continue growing because of their commercial profitability.

Fish farming can provide livelihoods, not only for small scale farmers, but also through larger scale commercial operations. When properly balanced with social and environmental needs, commercial aquaculture can bring benefits of poverty reduction and hunger elimination to the disadvantaged, through the generation of employment and stimulation of the economy. The commercial sector is also better placed to bring about technical innovation, reduce operating costs and grow products acceptable to a wider range of consumers.

The challenge for aquaculture in the new millennium is to expand sustainable aquaculture to achieve enhanced food security and economic development for the world's people. There is every prospect that this can be realized if the mechanisms can be found to improve support to existing producers, spread successful methods to new regions and boost the regional aquaculture has shown rapid expansion in recent years, equivalent to growth year on year close to 10 per cent since the late 1980s. In comparison, livestock meat production has been growing at around 3 per cent per year over the same period and the output from capture fisheries has actually fallen.

In 1998, total world production of finfish, crustaceans, (shrimps, prawns, crabs etc.), and mollusks, (e.g. clams, oysters, mussels), from capture fisheries and aquaculture reached 117.2 million metric tons. A quarter of the fish eaten in the world now comes from aquaculture. The inclusion of aquatic plants raises total production by a further 9.6 million metric tons to 126.8 million metric tons, an overall increase of 19.9 million metric tons in the 10 years since 1989. While total production from the capture fisheries sector had fallen 3.4 per cent during that 10 year period, the supply from aquaculture had more than doubled, from 16.5 million metric tons in 1989 to a total of 39.4 million metric tons in 1998. 4.4 million metric tons of this increase was of aquatic plants. Aquaculture by 1998 was providing 31 per cent of total fisheries supply, compared to only 15 per cent in 1989. The total value of aquaculture production reached US$ 52.5 billion in 1998 - double the figure of a decade earlier - and much of this increase originated from the Low Income Food Deficit Countries (LIFDCs), in particular China. This reflects the continuing trend in LIFDC countries of increased use of aquatic resources to further diversify food production.

1.6 Regional growth of aquaculture

Regional, cultural and historic factors have played major roles in influencing both the size of the production base and the rate of expansion of aquaculture in different parts of the world. An historic tradition of growing fish in Asia has provided the background for the region's dominant role in the sector in modern times. Asia accounted for over 90 per cent of world aquaculture output in the late 1990s, regional production having increased from 14.3 million metric tons to over 35.8 million metric tons between 1989 and 1998, equivalent to growth of nearly 11 per cent per year. Much of this expansion was in China where the year on year increase was around 15 per cent. In the rest of Asia, growth has been closer to 3 per cent per year, similar to that in Europe and North America (3 - 4 per cent). In Africa and Latin America the aquaculture production base a decade ago was considerably smaller and so there has been added potential for higher rates of expansion. Aquaculture output in Africa has been growing at around 8 per cent per year, while the boom of shrimp and tilapia fish farming in Latin America enabled growth to average 18 per cent per year during the 1990s.

1.6.1 Aquaculture presence in India

India is a land of diversity. The climate ranges from tropical heat in the south to temperate in the north. The landscape includes towering mountains, extensive alluvial plains, riverine wetlands, plateaus, deserts, coastal plains and deltas. The main soil types are alluvial, deep and medium black, red and yellow, late rite, saline desert, forest and hill. Almost all conceivable forms of vegetation, including tropical evergreen, littoral and swamp, tropical moist deciduous, tropical thorn, subtropical, Himalayan and Alpine are present in various parts of the country. The major physiographic divisions are the Himalayas, the Indo-Gangetic plains, the Vindhyas, the Satpuras, the Western Ghats, the Eastern Ghats, coastal plains, deltas and the riverine wetlands.

1.6.2 Aquaculture development Tamil Nadu

Tamil nadu has a total of 56,000 ha. of potential shrimp farming area. On the direction of Hon'ble Supreme Court of India, the Aquaculture Authority has been constituted to regularize the shrimp aqua farms. To assist the Aquaculture Authority, the State Level Committee and District Level Committees have been constituted. For issue of licenses to the aqua farms, the State Level Committee scrutinize the applications received from the farmers and processed by the District Level Committees and forward these applications to the Aquaculture Authority with recommendations. As on date there are 2086 shrimp farms functioning in all the 12 coastal districts of Tamil Nadu (except Chennai). Out of this, 852 shrimp farms got approval from the Aquaculture Authority. Steps are being taken to regulate all shrimp farms functioning without the approval of Aquaculture Authority.

In the "Fisheries Development Mission", coastal aquaculture has been identified as a thrust area and it is proposed to develop 1000 ha. of coastal saline land every year under aquaculture utilizing low intensive traditional and improved traditional shrimp farming practices with the support of other agencies like Marine Product Export Development Agency (MPEDA). During the past three years (i.e. from July 2002) aquaculture farming has been undertaken over an area of about 3100 ha. in the State with the approval of the Aquaculture Authority, Chennai. Coastal Aquaculture has been recognized as an important tool for employment generation and a vital source of food supply for meeting the food security and nutritional requirements of our growing population. In the context of increasing food security in the modern world, fish and fishery products are considered to be among the safest foods of animal origin. Tamil Nadu is having the second longest coastline in the country with rich natural resources in coastal areas for coastal aqua farming. The total estimated brackish water area of Tamil Nadu is about 56,000 ha. The total area under shrimp farming is 4,455 ha. out of which 3,178 ha. areas are creek based and 1,277 ha. area sea based. The composition based on the sea holdings revealed that 16 per cent of farmers having less than 2 ha culture area; 32 per cent are having 2 to 5 ha and 35 per cent are having above 5 ha. of culture areas. The corporate sector is having only 17 per cent of total culture area. The present culture is 4,455 ha. This is only 30 per cent of the estimated potential area of 14,880 ha. readily available for shrimp farm development. Hence there is a wide scope for land based costal aquaculture development in Tamil Nadu.

1.6.3 Aquaculture in Nagapattinam

The shrimp farms in the coastal areas of Nagapattinam district, which was the worst hit district in Tamil Nadu by the devastating tsunami tidal waves, have vanished due to the natural calamity. Environmentalists and farmers in the region have been long seeking a ban on operation of shrimp farms in the region which they claimed was losing its fertility due to use of chemicals by the farm owners. They claimed that the farms impeded flow of rain water through canals to the sea during monsoon. About 200 shrimp farms, many of them illegal, along the coastal belt of Thirumullaivasal near Sirkazhi to Vedaranyam near here have been destroyed. Farm equipments such as pumps, motors and aerators were devoured by the tidal waves.

1.7 Shrimp Farming - Production and Consumption (World level)

1.7.1 The Basics of Shrimp Farming

Cultivating edible fish and other marine species in both freshwater and marine environments is a traditional food production method, particularly in Southeast Asia where 'backyard' fish ponds provided valuable protein to complement vegetables, rice and other grains produced on the surrounding lands. In some countries, such as India, Bangladesh and Thailand, there is a tradition of a rice/shrimp rotating system, with rice grown part of the year shrimp and other fish species cultured the rest of the year. In such low-yielding, 'natural' ponds the harvest was small but sustainable over long periods. The 'catch' most likely, was for family consumption or sold in local markets. Such systems have become known as extensive systems and contrast starkly with the modern mode of production which rely heavily on chemicals, antibiotics and processed feeds.

Long standing, sustainable tradition is being transformed by modern, commercially oriented, high-output, intensive culture processes that are causing severe environmental damage. Although there are still many of the more traditional style aquaculture farms in production in such countries as India, Indonesia, Vietnam, Bangladesh, the dominant trend during the past decade has seen most farms built as either semi-intensive or intensive operations. As the extensive style has given way to intensification and industrialization, the degree and extent of environmental damage intensifies too. Because the species of shrimp being mass-cultivated on farms live naturally in warm-water marine environments, commercial shrimp farms are located along tropical and sub-tropical coastlines within easy pumping distance from the ocean or tidal inlets. Indeed, site selection is one of two principal management considerations in shrimp farming, the other being concerned with how to maximize the efficiency of rearing juvenile shrimp to market size. The outcomes of both these decisions have tremendous effects on the type and extent of consequent environmental damage.

Shrimp are farmed in large ponds, usually dug to a depth of at least one meter and the pond levees are formed either by hand or by earth moving equipment. Normally the site will be on an estuary or next to a coastline to provide a source of brackish or saltwater. A shrimp culture pond can be a converted extensive coastal fish pond, a large rice paddy area or land producing other agricultural crops, salt flats, or a newly excavated site in a clear-felled mangrove forest. It is in situations like these where the construction of shrimp ponds does the initial damage to the environment, stripping natural or existing farmed landscapes bare.

Lured by profits, investors in shrimp farming have been moving to even greater levels of intensification in order to dramatically increase rearing of juvenile shrimp to market size. Instead of relying on natural tidal flows to stock ponds, as the traditional aquaculture systems have, the more intensive methods of shrimp farming rely on industrialized processes for example, the manual stocking of ponds with either wild caught or hatchery produced 'post-larvae'. Shrimp post-larvae are crammed into these intensive ponds at density rates up to 100 times greater than the stocking rates of the lower-yield, systems. The higher intensification requires ponds to be 'fertilized' with urea and triple superphosphate to stimulate algae growth as food for growing shrimp, but supplemental feeds have become the norm. Maintaining favorable water quality is an essential aspect of pond shrimp aquaculture. Shrimp are particularly sensitive to low concentrations of dissolved oxygen in the water. In order to maintain favorable dissolved oxygen concentrations, intensively cultivated ponds must undergo frequent flushing. Sea and ground water must be also continuously pumped into the intensive ponds, and polluted water flushed out. Intensive pond systems may need water exchange rates of between ten to fifty five per cent of the pond volume each day just to keep dissolved oxygen concentrations above critical levels. This water demand places a tremendous burden on local ground water supplies, rapidly depleting local freshwater resources. The flushing of brackish and polluted pond waste-water ends up contaminating adjacent lands and coastal waters.

1.7.2 The Producing Countries

The world's production of farmed shrimp is dominated by developing countries located in the tropical latitudes. Seven countries produced about 86 percent of the farmed shrimp production in 1995 - six Asian and one Latin American. Regionally, Asia produces nearly four-fifths of the world's farmed shrimp output, with Latin American countries providing most of the remainder. Shrimp farms throughout Asia harvested 558,000 tons in 1995, accounting for 78 per cent of the world's farmed shrimp production. By comparison, the shrimp farming industry in the western hemisphere, led by Ecuador's annual output of 100,000 tons, produced a regional total of 154,000 tons. In total, about 712,000 tons of shrimp were produced in farms in 1995, roughly 26 percent of the world's total shrimp production, from by capture fisheries and farming combined, which exceeded 2.6 million tons in 1995. Thailand has been the world's leading producer of farmed shrimp for the past few years, producing 220,000 tons of farmed shrimp in 1995, twice as much as it produced in 1990, and nearly one-third of the world's entire 1995 farmed shrimp production. The people along Thailand's coastline, however, have paid an enormous price in terms of environmental loss, however. With production space along Thailand's coastline now at a premium, there are a number of countries in Latin America and Africa that are being eyed by greedy investors as the "sleeping giants", seen to possess enormous potential for building shrimp farms in the next few years.

1.7.3 The Consuming Countries

Roughly one third of the global shrimp harvest (from capture and culture) is traded internationally about 900,000 tons. That's less than one percent of global fisheries production by weight, yet shrimp is the single most valuable seafood product that enters into world trade today. Worth about seven billion dollars a year, shrimp traded internationally contributes about 18 percent of the value of all global fisheries exports which are valued at about 40 billion dollars a year. The value of shrimp imports into the United States in 1995, for instance (valued at $2.7 billion), accounted for 40 percent of the value of America's total edible seafood imports and although farmed shrimp represents about one-quarter of all shrimp harvested each year, it constitutes nearly half of all shrimp traded internationally. Over 90 percent of all shrimp traded on the international market is consumed by just a few importing countries - Japan, the United States and countries comprising the European Union (EU). Japan and the U.S. are the major consumers of farmed tropical shrimp. While European consumers still prefer coldwater species harvested from the wild they are warming to tropical, farm reared shrimp varieties.

While Japan is the largest warm water shrimp importer, the U.S. is the world's leading consumer of shrimp. The U.S. consumes some 600,000 tons round weight, or 360,000 tons processed weight of shrimp each year. This compares to a Japanese consumption of about 318,000 tons (processed weight), while shrimp consumers in the European Union buy close to 200,000 tons (processed weight) annually. Between one-half and two thirds of the shrimp consumed in the U.S. comes from shrimp farms located in Asia and Latin America. Wild caught shrimp makes up the rest, and most of this comes from the US domestic shrimp fishery in the southeastern U.S. and the Gulf of Mexico or from the neighboring Latin American or Caribbean countries. Shrimp has a high profile with American consumers, due to substantial promotion and advertising by the seafood industry, and growth in demand for farmed shrimp in the short term is expected to be significant. Europe should experience the most substantial long term growth since current low consumption levels of farmed, tropical shrimp have great expansion potential. With an anticipated doubling of farmed shrimp production forecast over the next decade there is justifiable concern that past mistakes made in the stampede to shrimp farming will be replicated as investors rush to profit from this the growing market demand.

India is a South Asian country situated between the Himalayas in the north and the Indian Ocean in the south and flanked on either side by Pakistan and Burma. India is a federal republic made up of 25 states and covers a total area of 32,87,728 Sq.km. One-half of India's national territory lies above the

Tropic of Cancer and the rest is within the tropics. India's population of over 900 million is the second largest in the world and the population density is also very high with more than 70 per cent of the people living in rural areas. The economy is agriculture-based. Although rich in natural resources and self-sufficient in food grains, India has many unresolved problems relating to poverty, unemployment and malnutrition.

1.8 Fish production trends in India

1.8.1 Fishery resources

With a long 8,129-km coastline, 0.5 million Sq.km. of continental shelf and 2.02 million Sq.km. of exclusive economic zone (EEZ), India is a major marine fish producer ranking seventh in the world. The warm, fertile inshore waters of India are among the most productive fishing grounds in the world, yielding shrimps, sardines, mackerels, Bombay ducks, carangids, croakers, soles, and a variety of other marine fish. Marine products are a major component of India's overseas trade. However, inland fisheries resources are equally rich and varied.

1.8.2 Fish production

Fish and fisheries form important economic activities in India. The total fish production in the country increased six fold from 0.75 million ton in 1950-51 to 4.95 in 1994-95. During the same period, inland fish production increased from 0.22 million ton to 2.09 million ton registering a near tenfold increase. Over the last four and one-half decades, the annual growth rate in inland fisheries was 11 per cent and that of the marine segment was 9.0 per cent. The contribution from inland fisheries to national fish production has been consistently increasing. While in the 1950s it supplied less than one-half the volume of marine catch, it now contributes almost an equal quantity. Despite being a marine-fish producer traditionally, India is one of the few countries in the world which has substantially exploited its inland fisheries potential.

1.8.3 Inland fisheries resources

India's inland fisheries resources are as diverse as they are plentiful, comprising rivers, floodplains, estuaries, mangroves, estuarine impoundments, lagoons, upland lakes, reservoirs and ponds. In India, inland fisheries is classified as follows: freshwater aquaculture, including the pond culture of carp; brackish water aquaculture, involving mostly shrimp culture; and capture fisheries in rivers, estuaries, lakes, reservoirs, etc.

1.8.4 Freshwater and brackish water aquaculture

Ponds are among the most important inland fisheries resources of India, in terms of both surface area and the volume of fish produced. The country is believed to have a surface area of more than 2.21 million ha that can be developed for freshwater aquaculture, only a fraction of which is currently utilized about 0.4 million ha. are being supervised by government sponsored aquaculture promotion agencies. Carp culture, traditionally restricted to the States of West Bengal, Bihar and Orissa, and has recently spread to almost all the states of the country. Private fish farmers of the southern state of Andhra Pradesh have only recently engaged in carp culture and have made great progress. The growth of brackish water aquaculture has been most successful in the maritime states. Focusing on export-oriented shrimp culture, industrial giants of the corporate and multinational sectors are also involved. A more detailed account of reservoir fisheries and freshwater aquaculture is given in the following paragraphs.

1.8.5 Reservoir fisheries

In India, reservoirs are considered the prime resource as regards capture fisheries and extensive aquaculture. The river estuaries and other natural water bodies are threatened by increasing environmental degradation. With the great emphasis on conservation, there is little scope for a substantial increase in yields. The available estimates made by various agencies are conflicting and inaccurate. The most recent study (Sugunan, 1995) estimated the combined surface area of all reservoirs, irrespective of size, as 3135366 ha. Enumeration of the medium and large reservoirs in India is a relatively easy task as there are fewer of them and the details are readily available from the irrigation, power and public works authorities. However, compilation of data on small reservoirs is a tedious task as they are ubiquitous and too numerous to count.

1.9 Land use patterns and aquaculture

Agriculture contributes to a great degree to the utilization of land, both in the states surveyed in this report and in the country as a whole. Net sown-area and current fallows accounted for 48.7 per cent of total geographical area in 1958-59 and for 51.3 per cent in 1995-96. Within the broader agricultural sector, the proportion of land under crop cultivation has declined and that for livestock and aquaculture has increased. However, actual data for areas serving capture and culture-based fisheries and land-based aquaculture farms are not available. Surveys from a few states indicate that there has been a significant increase in areas under aquaculture. Available statistics show that the area under aquaculture production has increased from 18 500 ha in 1990-91 to 28 550 ha. States have significant, yet various, shares in total inland fisheries: Orissa (13.56 per cent), Tamil Nadu (12.60 per cent), Andhra Pradesh (11.85 per cent), Karnataka (8.30 per cent), West Bengal (7.92 per cent), Kerala (7.54 per cent), Uttar Pradesh (6.47 per cent), Gujrat (5.95 per cent), Madhya Pradesh (5.93 per cent) and Maharashtra (4.67 per cent). However, the contribution of these states to total inland fish production is almost equal to their percentage share in total water area. The details of estimates of aquaculture production in India by species during 1986 to 1995 Data indicate that out of the total estimated quantity of aquatic production, catla, marigal and rohu contributed major shares, followed by other species. Cultured shrimps contributed nearby 97 000 t in 1995.

Total aquaculture production increased from 686,260 tons to 1,608,938 tons during the ten-year-period, indicating that production more than doubled. In terms of total value, the figures show an increase of more than three times above the previous level. We attribute this growth in production to higher prices in the international market for cultured shrimps. During 1996, the United States imposed a ban on captured shrimps under the United States Endangered Species Act to protect turtles. India, along with 30 other countries, was prohibited to export marine captured shrimps to the United States, which led to a sharp rise in the price of shrimps.

Sunder aquaculture is expected to grow to 238,500 ha with a financial outlay of Rs 119,300 million. Similarly, a massive sum of Rs 27,340 million is proposed to be invested by 2002 in the construction of new ponds. The investment plan also gives priority to freshwater prawn-farms. The plan envisages development of new prawn hatcheries with an area-increase from 200 ha in 1998-99 to 300 ha. in 2002 and a proposed investment of Rs 440 million. The IX five-year-plan proposes to increase the number of carp-hatcheries to 1 700 by the end of 2002 with a proposed investment of Rs 119 million. Of total investment, more than 66 per cent is allocated for freshwater aquaculture. The other two fisheries sectors are marine and brackish water aquaculture.

1.10 Exports of products from aquaculture

Agricultural exports accounted for 27 per cent of total exports from India during 1986-87 but dropped sharply to 20 per cent during the post-reform period in 1996-97. However, the share of seafood exports was 16 per cent of total agricultural exports and is steadily growing in absolute terms. The absolute value of total seafood exports, which includes freshwater prawns and fish, has increased from US$ 549 million in 1990-91 to US$ 1 038 million in 1998-99, which constitutes an increase of 89.07 per cent. However, between 1995-96 and 1998-99, a marginal decline in marine exports occurred from US$ 1,129 million to US$ 1,038 million due to a decline in cultured shrimp production and a ban on Indian shrimp by the European Union. One of the main concerns of India in augmenting exports is the non-tariff barrier imposed by developed importers, such as the United States of America and the European Union. For example, the United States applies domestic legislation outside its borders and forces exporting countries to comply with it. Some of the non-tariff barriers are: Environmental and health factors as in the cases of shrimp and turtle; Ban on Indian processed shrimp on grounds of poor sanitary conditions; Pre-clearance inspections, etc. The contribution of cultured shrimp to total shrimp exports from India from 1988-89 to 1998-99. Share of products from aquaculture increased from 33 per cent in 1988-89 to 52 per cent in 1998-99. The spectacular progress of aquaculture in real value terms is worth noting. Within a period of ten years, the value of cultured shrimp increased from 48 per cent to 74 per cent. Although the major part of export of cultured products is shrimps, the contribution of carps, such as rohu, has been increasing over the years. Production in aquaculture and exports continue to be sectors of great importance during the IX five-year-plan, from 1996-97 onwards, the country started to export negligible quantities of other products from freshwater aquaculture in filleted form India exports too many foreign markets, and that India's trade partners are changing. Major buyers of Indian freshwater fishes are China and Bangladesh, followed by Near Eastern countries.

Analysis of freshwater fish exports shows that the quantity and value of cultured shrimps, as a proportion of total shrimp exports, has been rising steadily. Further, a small quantity of Indian major carps was also exported from 1996-97, indicating that export potential exists to absorb higher levels of production at times when the domestic market cannot absorb increased production at current domestic prices. Regulations governing export of aquatic products are covered by section six of the Export (Quality Control and Inspection) Act of 1963. Standard specifications for each type of fish and fish products have been identified by the government. Most export items from India are sent in bulk packs. Consumer packaging is available and exporters have not yet come across any stringent requirements regarding environmental considerations.

1.11 Definition of Disaster

Definition for Disaster: "Any incidents that causes a severe disruption to the organization's ability to function or to provide service to internal or external customers".

1.11.1 Tsunami: Definition and Basic Concept

The term **Tsunami** is a series of waves with a long wavelength and period. Time between crests of the wave can vary from a few minutes to over an hour. Tsunamis are often incorrectly called tidal waves; they are not related to the daily ocean tides. Tsunami (soo-NAH-mee) is a Japanese word meaning harbor wave. Tsunamis can occur at any time of day or night.

1.11.2 Causes of Tsunami

Tsunami is caused by vertical displacement of the water column owing to earthquakes, volcanic eruptions, and submarine mudslides. Though they are almost undetectable in the open sea owing to their low amplitude, the tsunami waves can reach heights exceeding 10 m in the vicinity of a coast. The high impact they have on a coast is due to high water velocity and wave height. A Tsunami can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Such large vertical movements of the Earth's crust can occur at plate boundaries. Subduction earthquakes are particularly effective in generating Tsunami.

1.11.3 Historical Events of Tsunami in India

The Indian coastal belt has not recorded many Tsunamis in the past. Waves accompanying earthquake activity have been reported over the North Bay of Bengal. During an earthquake in 1881, which had its epicenter near the centre of the Bay of Bengal, Tsunamis were reported. The earthquake of 1941 in Bay of Bengal caused some damage in Andaman region. This was unusual because most Tsunamis are generated by shocks, which occur at or near the flanks of continental slopes. During the earthquakes of 1819 and 1845 near the Rann of Kutch, there were rapid movements of water into the sea. There is no mention of waves resulting from these earthquakes along the coast adjacent to the Arabian Sea, and it is unlikely that Tsunamis were generated. Further west, in the Persian Gulf, the 1945 Mekran earthquake magnitude 8.1 generated Tsunami of 12 to 15 meters hight. This caused a huge deluge, with considerable loss of life and property at Ormara and Pasi. The estimated height of Tsunami at Gulf of Combay was 15m but no report of damage is available. The estimated hight of waves was about 2m at Mumbai, where boats were taken away from their moorings and casualties occurred. Above facts indicate the coastal region of Gujarat is vulnerable to Tsunamis from great earthquakes in Mekran coast. Earthquake of magnitude 7 or more may be dangerous. It may be noted that all earthquake do not generate Tsunami. For the Indian region, two potential sources have been identified, namely Mekran coast and Andaman Island.

1.12 Physiography of East Coast

The Eastern Coastal Plain is a wide stretch of land lying between the Eastern Ghats and the Bay of Bengal. It stretches from Tamilnadu in the south to West Bengal in the north. Deltas of many of India’s rivers form a major portion of these plains. The Mahanadi, Godavari, Kaveri and Krishna rivers drain these plains. The region receives both the Northeast and Southwest monsoon rains with its annual rainfall averaging between 1,000 mm and 3,000 mm. The width of the plain varies between 100 to 130 km. The plains are divided into six regions: The Mahanadi delta; the Southern Andra Pradesh plain; the Krishna Godavari deltas'; the Kanyakumari coast; Coromandel Coast and sandy littoral.

1.13 Impact of Tsunami

An earthquake of magnitude 9.0 occurred off the coast of Sumatra on 26 December 2004 at 00:58:50 (UTC)/ 06: 28: 50 AM (IST). The epicenter of the earthquake was located at 3.29°N and 95.94°E. The focal depth of the earthquake was 30 km. This earthquake generated huge Tsunami waves, which devastates the Andaman and Nicobar Islands, east coast of India, south Kerala in India and several other countries like Sri Lanka, Indonesia, and Thailand and Somalia in the Indian Ocean. The Tsunami claimed more than 250,000 human lives in these countries. The aftershocks of this earthquake, numbering more than 250 in the magnitude range $5 \leq M < 7.3$, were located for a length of 1,300 km from Sumatra in the south to the Andaman and Nicobar islands in the north, till 30th January 2005.

1.13.1 Tsunami Hazard Assessment

Preparation of database of historical and archival information of relevant Indian Tsunamis, with the emphasis clearly on the December 26, 2004 event supplement the data from computer based simulations. Analyses of these data, to define the scenario Tsunamis from various earthquake sources, prepare the Tsunami hazard map.

1.13.2 Tsunami Vulnerability Assessment

The exposure inventory with vulnerability to Tsunami impact for both the built and natural environments will need to be developed for shores and harbours. Potential damages are related to the hydrological controls of wave action, flooding and debris deposition, and consequent geotechnical controls to damage by liquefaction, cracking and slumping. This result in structural damages to buildings, water damage to contents, flooding damage to infrastructure and damages to navigational aids and reef damage. There is a potential for “sleighing” in the shallow harbour areas where, alternately water is drained from the harbour and then flooded to depths greater than high tide levels. This has the potential for threat to human life from people collecting fish from the harbour seafloor. In the Harbour, waves are a threat to shipping and fishermen. The vulnerability assessment is expressed as details of elements of the built, natural and human environments vulnerable to potential tsunami-related damage. These need to be considered in terms of the Tsunami Hazard Zones for the terrestrial environments around the shore and the marine environments.

1.13.3 Tsunami Risk Assessment

By integrating the hazard and vulnerability assessments, the tsunami risk assessment is to be developed in terms of zonation, inundation maps and associated affects.

1.14 Mangroves types

Red Mangrove (Rhizophora Mangle): The Red Mangrove - also known as the “Walking Tree” - can be identified by the trunk roots which have a reddish color to the bark. They have shiny deep green leaves which are lighter on the underside. The leaves measures 1-5 inches in length are broad and blunt at the tip. Their prop roots - arching out from the trunk and the branches, produce additional roots and give the tree the appearance that it is walking into the water. The survival of this tree in brackish water is a direct result of the tree’s ability to adapt to its environment by using its roots to remove 99/100ths of the salt from the water it drinks. Red Mangrove tissue samples, when analyzed, revealed that the salt content of the water in those samples had approximately 1/100th of the salt found in the water in which the trees were growing. The Red Mangrove produces bud-like growths which grow into torpedo-shaped seedlings known as propagules. These seedlings eventually fall into the water and either takes root in the ground below or floats and drift with the tides until suitable ground is found. A red mangrove propagule can drift for a year before rooting and producing a tree.

Black Mangrove (Avicennia Germinans): Black Mangroves, larger and taller than the Red and White Mangroves because of their age, they are found upland of the Red Mangroves at higher elevations. These old timers are the most cold tolerant of the three species found in Florida. They can readily be identified by: Looking at the ground. These trees are surrounded by Pneumatophores (pronounced "new-mat-afores") – stick-like structures (growths) - pointing skyward from the soil surrounding the trunk of the tree. Pneumatophores come from the roots of the Black Mangroves and help the tree to breathe. This species of mangrove generally grows in areas where the soil is saturated with water – without the pneumatophores, which act like a diver's snorkel; the tree would lack the oxygen it needs to survive. The bark of a Black Mangrove is dark. The leaves are shiny dark green on the top, oblong and pointed at the tip. The undersides of the leaves are a dull green color with short dense hairs glands which excrete salt the leaves serve as a back-up system for ridding the Black Mangrove of the salt that has not been excreted by the roots. When early settlers came to Florida they harvested salt from the

Black Mangrove leaves. The seedlings produced by these trees are light green in color and shaped like large coins.

White Mangroves (Laguncularia Racemosa): White Mangroves, usually found at higher elevations (further upland than the red or black mangroves) can easily be identified by: Their leaves which are light green in color, approximately 3 inches long, rounded at both ends – often having a notch in the tip. At the base of their leaves, where the leaves meet the stems, you will find two bumps. These bumps are glands which excrete the salt found in the water. The seedlings of the White Mangrove are pod-shaped, about the size of a nickel and whitish in color.

General Characteristics and Adaptations: Most dicotyledons of mangal form as small trees. In some Old World mangrove swamps, trees may reach 40 meters, but most mangal rarely exceeds 10 meters. Except for epiphytes, which are not restricted to mangal, herbaceous species are absent. Zones of mangal are often fairly easy to distinguish because a zone will be dominated by only one or two species. Monocultures are produced when vigorous growth of one species, such as Nypa fruticans or Rhizophora mangle, prevents other species from becoming established. The major plant species forming the mangrove tangle have aerial roots**,** commonly prop roots or even stilt roots (Examples: red mangrove and its root tip). These serve, of course, to anchor the plants, but also are important in aeration, because the mangrove mud tends to be anaerobic. Special vertical roots, called pneumatophores**,** form from lateral roots in the mud, often projecting above water. These are particularly well developed in species of Avicennia, Sonneratia less so in Laguncularia and as knee-like structures in Xylocarpus mekongensis, Bruguiera, and Ceriops, permitting some oxygen to reach the oxygen-starved submerged roots. Roots also can exhibit development of air cavities in root tissues, designs that aid oxygenation of the tissues. Aeration occurs also through lenticels in the bark of mangrove species, e.g., species of Rhizophora.

Leaves of typical mangrove plants are evergreen, relatively tough and very similar in size across the species that belong to different families. Acanthus, Aegiceras, Ceriops, Intsia, Lumnitzera, Rhizophoraceae, Xylocarpus. Mangrove plants have salt resistance. This may involve cytoplasmic tolerance of high solute concentrations and many of the common species have in leaves sodium and chloride ion levels that each exceed 250 millimoles, about half that of sea water. In addition, the most salt-resistant species also tend to show avoidance to salt stress. Avoidance can be achieved by excretion of crystalline salt from glands or hairs of leaves. Examples of salt excretion are Avicennia, Aegialitis annulata (family Plumbaginaceae), Aegiceras, and Acanthus ilicifolius (family Acanthaceae). Another mechanism to avoid toxic levels of ions is to produce succulence, i.e., dilution of salts via having watery tissues. Salt dilution is said to be the reason for having large hypodermal cells on the upper (adaxial) side of leaves, covering the photosynthetic tissues, e.g., in Avicennia and Rhizophora, or large, vacuolate cells in the middle tissue in Sonneratia and Laguncularia. Germination of seeds while still attached to the mother plant is called vivipary**.** Vivipary and cryptovivipary (not visually obvious) are exceedingly rare among plants, but these are found in many early colonizing, pioneer species on mangal, including Avicennia, Rhizophora and all other Rhizophoraceae, Aegiceras, Pelliciera, Aegialitis, and the aggressive estuarine species Nypa fruticans. The classic example of vivipary is Rhizophora mangle, which is able to traverse broad ocean regions by producing large seedlings that float horizontally, undamaged by salinity. These seedlings can be washed up on sand or mud flats, where they settle to establish new populations. In this case, the hypocotyl develops as a long, stiff axis, sometimes exceeding a foot in length. Vivipary is alleged to be a strategy not only for seawater flotation, a dispersal mechanism, but to avoid the toxic effect that chlorides have on germination. By germinating while on the mother plant, and thereby drawing nutrients under lower salt stress, the young plant can increase its salt resistance before falling into the seawater environment.

a) Examples of vivipary in Rhizophoraceae one and another
b) Examples of seedlings from viviparous embryos one and another
c) Mangrove trees appear to have special mechanisms to permittem to take upwater from the very saline muddy soil without making their water conduits salty.

1.15 Mangroves function and values

Mangroves trap and cycle various organic materials, chemical elements, and important nutrients in the coastal eco-system. Mangroves provide one of the basic food chain resources for marine organisms. The leaves of mangroves last for approximately a year before falling into the water where bacteria and fungus decompose the leaves – these leaves form the base of the food chain. The mixture of decaying plant material, soil, water, fungus and bacteria makes up Detritus (pronounced “di-tri-tes”) which provides food for marine organisms – i.e. crabs, shrimps, oysters, claims, anchovies, mullets. These marine species in turn provide food for larger species, i.e. Snook, Sea trout, Red Drum and Pinfish, Mangrove Snapper, Tarpon, which in turn provide food for Bottle Nosed Dolphins, Bull Sharks, Alligators, pelicans, Great Blue Herons, Egrets, Wood Storks, Eagles, Osprey and humans. Mangroves provide physical habitat and nursery grounds for a wide variety of marine organisms, many of which have important recreational or commercial value. For example, the Pneumataphores of the Black Mangrove provide safety for many marine animals, sheltering crabs, shrimp, fish and clams, protecting many from predators. Mangroves serve as storm buffers by reducing wind and wave action in shallow shoreline areas. Mangrove seedlings unlike other plants whose seedlings need to be germinated, are alive and ready to grow. The moment they are dropped from the parent plant they have the ability to take root and produce tree. An estimated 500,000 acres of mangroves remain in the coastal areas of Central and South Florida. It is estimated that approximately 80percent are under governmental or private ownership or control for conservation and preservation purposes.

1.16 Spatial Information Technology

Remote Sensing: Remote Sensing is the Science and art of obtaining information about an object, area or phenomenon through the analysis of the data acquired by the device that is not in contact with it. This device can be a camera or a bank of sensors operated form an airplane or a satellite.

Geographical Information System: A GIS is “an organized collection of computer hardware, software, geographical data, and personnel designed to efficiently capture, store, update, manipulate and display all forms of geographically referenced information”.

Global Positioning System: GPS is a satellite-based system that uses a constellation of 24 satellites to give a user an accurate poison. It is important at this point to define ‘accurate’.

1.17 Literature Review

Studies discussed in this section include several site-specific studies related to aquatic ecosystem effects of effluent discharges from aquaculture facilities. Loch et al. (1996) examined the effects of three large trout flow-through facilities in North Carolina on macro invertebrate species diversity. Their data showed that species richness was significantly decreased below the outfalls of the facilities. Samples did show that richness did increase further downstream. These data indicate that effluents did reduce water quality, even at 1.5 km further downstream, although to a lesser extent. The authors noted that impacts were seasonal, that water quality and taxis richness improved during the winter. The authors also noted that sewage fungus (which they defined as a community of organisms that consist mainly of bacteria and ciliated Protozoans and is the product of concentrated organic matter) "was present in great abundance at Site 2 of each trout farm". In contrast, Fries and Bowles (2002) examined aquatic impacts associated with a large CAAP facility located on the San Marcos River in Texas, which is designated by the Texas National Resource Conservation Commission as exceptional for aquatic life and recreation. On average, this CAAP facility produces four million largemouth bass fingerlings, one million channel catfish fingerlings, 12,000 kg live forage for captive brood stock, and 67,000 rainbow trout (winter only) each year. Based on the data covering a period from October 1996 to July 1998, the authors concluded, "the hatchery effluent did not substantially affect downstream water quality and benthic communities, despite the relatively high total suspended solids and chlorophyll-a levels in the effluent". The authors noted that sport fish hatchery operations can have negligible effects on receiving waters, even in environmentally sensitive systems". In the 1970s, Big Platte Lake in Michigan, which is fed by the Platte River, was experiencing periods of calcium carbonate formation that were reducing lake transparency (also called "whiting"), as well as other symptoms of eutrophication including reduced macro invertebrate communities and disappearance of sensitive vegetation. Because the watershed is mostly undeveloped, a possible explanation of these changes in lake conditions was phosphorus loadings from nonpoint sources, effluents from the Platte River State Fish Hatchery, salmon smolts dying in outmigration and returning adult salmon deaths in the river. It was estimated that the hatchery was contributing approximately 33 per cent of the phosphorus load into the lake in the late 1970s (Whelan, 1999). In its 1980 NPDES permit, the hatchery was required to take steps to reduce phosphorus loads in its effluent. However, subsequent court cases found that significant changes in facility operation would be required to mitigate the impairment of Big Platte Lake. Beginning in 1998, the hatchery took further actions to improve lake conditions. The hatchery's 1988 NPDES permit restricted water use to 166 million liters per day, with a maximum discharge of 200 kg of phosphorus per year, and TSS limits of 1,000 kg/day. Through the use of low phosphorus fish food, improvements in waste removal, deepening of treatment ponds, and changes in fish migration, the hatchery now contributes only 5 per cent of the annual phosphorus loading to the lake. Maximum transparency in the lake has increased from an average of 3.5 meters to 5 meters or greater. Severe whiting events continue to occur during the summer months, although these losses of transparency problems are less frequent since 1988. Studies and renovations of the hatchery are estimated to further improve water conditions in the future (Whelan, 1999). Other releases from facilities include materials related to maintenance activities, loss of fish via decomposition of carcasses, and escapes. In some cases, escaped cultured organisms may not be native to the receiving water and at certain levels may pose an environmental risk. Scientists and resource managers have recognized aquaculture operations as a potential source of concern with respect to non-native species issues (ADFG, 2002; Carlton, 2001; Goldburg et al., 2001; Naylor et al., 2001; Lackey, 1999; and Volpe et al., 2000). It is important to note, however, that many non-native fishes are introduced intentionally. For example, non-native sport fish species are a large and important component of a number of state recreational fishery programs. Horak (1995) reported that "[forty]-nine of 50 state recreational fishery programs use nonnative sport fish species and some states are almost totally reliant on them to provide recreational fishing". This section does not address such intentional releases. In addition, scientists have also highlighted the need for careful assessment of potential environmental risks associated with the possible future use of genetically modified organisms in aquatic animal production (e.g., Hedrick, 2001; Reichardt, 2000; Howard et al., 2004). Many states have developed requirements specific to potential escapes of non-native organisms from aquaculture facilities and/or have developed aquatic nuisance species (ANS) management plans to address non-natives in their state. ANS management plans identify goals or objectives for addressing ANS and strategic actions or tasks to accomplish the goals or objectives. For example, an objective might be to prevent the introduction of new ANS into state waters. A strategic action to accomplish this might be to identify those ANS that have the greatest potential to infest state aquatic resources. As part of this effort, states might identify existing and potential pathways that facilitate new ANS introductions. A task that might be used to accomplish the strategic action might be to develop a regional listing of ANS and evaluate the potential threat posed by these organisms to aquatic resources in the state. The following sections describe general issues relating to effects of non-native aquatic organisms and specific discussions relating to non-native issues specifically related to aquaculture operations.

Non-native aquatic organisms in North America can alter habitat, change trophic relationships, modify the use and availability of space, deteriorate gene pools, and introduce diseases. Non-native fish introduced to control vegetation, such as carp or tilapia can destroy native vegetation. Destruction of exotic and native vegetation can result in bank erosion, degradation of fish nursery areas, and acceleration of eutrophication as nutrients are released from plants. Common carp (*Cyprinus carpio*) reduce vegetation by direct consumption and by uprooting as they dig through the substrate in search of food. Digging increases turbidity in the water. Non-native species may also cause complex and unpredictable changes in community trophic structure. Communities can be changed by explosive population increases of non-native fish or by predation of native species by introduced species. Spatial changes may result from overlap in the use of space by native and non-native fish, which may lead to competition if space is limited or of variable quality. Genetic variation may be decreased through inbreeding by species being produced in a hatchery. If these species are introduced to new habitat, they may lack the genetic characteristics necessary to adapt or perform as predicted. There is also a possibility that native gene pools may be altered through hybridization from non-native species. However, hybridization events in open waters are rare (AFS, 1997; Kohler and Courtenay). Finally, diseases caused by parasites, bacteria, and viruses may be transmitted into an environment by non-native species. For example, transfer of diseased non-native fish from Europe is believed to be responsible for introducing whirling disease in North America (Blazer and LaPatra, 2002).

Black carp (*Mylopharyngodon piceus*) provide a cheap means for controlling trematodes in catfish ponds, but they feed on many different mollusks when released to the environment. Silver carp (*Hypophthalmichthys molitrix*) were discovered in natural waters in 1980, "*probably a result of escapes from fish hatcheries and other types of aquaculture facilities*" (Freeze and Henderson, 1982, as cited in Fuller et al., 1999). Bighead carp (*Hypophthalmichthys nobilis*) first appeared in open waters (Ohio and Mississippi rivers) in the early 1980s, "likely as a result of escapes from aquaculture facilities (Jennings 1988, as cited in Fuller et al., 1999). Both carp have been identified as species of significant concern to aquatic resource managers (Schomack and Gray, 2002). Again, however, it is important to stress that carp are mainly raised in pond aquaculture systems, and that pond systems are not in the scope of EPA's final regulation. *Atlantic salmon* Escapement of Atlantic salmon (*Salmon salar*) from net pens off the East and West Coasts of the United States and in British Columbia has been well documented. Potential concerns associated with Atlantic salmon escapes include possible impacts on wild salmon from disease, parasitism, interbreeding, and competition. In areas where the salmon are exotic, most concerns do not focus on interbreeding with other salmon species. Rather, they center on whether the escaped salmon will establish feral populations, reduce the reproductive success of native species through competition, alter the ecosystem in some unpredictable way, or transfer diseases (EAO, 1997). However, a comprehensive evaluation of risks has concluded that the escape of Atlantic salmon pose very little or no risk to the environment of the Pacific Northwest, including through the mechanisms of colonization of salmonid habitat, competition with native species for forage, predation on indigenous species, and hybridization with other salmonids (Nash, 2001).

Victor Rajamanickam (2004) has briefly investigated light minerals along the beaches between Valinokkam and Tuticorin has been carried out for the first time along the Southern Tamilnadu coast in order to discover the provenance of the sediments. The study spotlights a wide variation in light mineralogy along the three zones of the investigated area (Valinokkam, Vaippar and Tuticorin). A higher percentage of quartz is reported from the Valinokkam (48.34 to 68.63 per cent) and Tuticorin zones (55.66 to 73.05 per cent) than from the Vaippar zone (40.24 to 60.77 per cent). The trend with regard to the maturity index is similar, with appreciably higher values in Valinokkam (1.15 to1.89) and Tuticorin (1.61 to 1.94) than Vaippar (0.79 to 1.39). Morphological analysis of quartz grains shows a higher order of sphericity and roundness values in Valinokkam and Tuticorin as compared to Vaippar Moreover, the surface texture.

According to Rahul Prakash Srivastava (2006) the Tsunami event of December 26, 2004 in the Indian Ocean that rocked the Sumatra Island in Indonesia had a profound impact on the south-eastern coast of India. In general, the state of Tamil Nadu in India suffered maximum damage in terms of life and property. The present study focuses its realm on the extent of inundation and damage to various land cover classes in the Nagapattinam area that suffered 6065 casualties, the maximum anywhere in India. The research takes into its gamut the model simulation of tsunami waves using a numerical model, *Tsunami N2*. Fumihiko-Imamura from Tahuko University, Japan authors the model Tsunami N2. It has been used for the generation, propagation and amplification of the tsunami waves. The model results show the propagation of the sea waves for the event of December 26, 2004 taking into account the fault geometry, bathymetry and initialization conditions for running the model. The model incorporates ETOPO-5 and near-shore bathymetry data that is an important parameter in the model. It shows the arrival time of the tsunami waves at the south-eastern coast of India. The tsunami waves reach the Indian coast in 180 minutes that is in agreement with the real tsunami event of December 26, 2004. It also gives the amplitude of the tsunami waves. The model results are validated with the field observations and tide gauge measurements.

J.P. Narayan, M.L. (2005) indicates the effects of Medu (naturally elevated landmass very close to the seashore and elongated parallel to the coast) and coastal topography on the damage pattern during the deadliest Indian Ocean tsunami of December 26, 2004 is reported. The tsunami caused severe damage and claimed many victims in the coastal areas of eleven countries bordering the Indian Ocean. The damage survey revealed large variation in damage along the coastal region of Tamilnadu (India). The most severe damage was observed in the Nagapattinam district on the east coast and the west coast of Kanyakumari district. Decrease of damage from Nagapattinam to Kanchipuram district was observed. Intense damage again appeared to the north of Adyar River (from Srinivaspuri to Anna Samadhi Park). Almost, no damage was observed along the coast of Thanjavur, Puddukkotai and Ramnathpuram districts in Palk Strait, situated in the shadow zone of Sri Lanka. It was concluded that the width of continental shelf has played a major role in the pattern of tsunami damage. It was inferred that the width of the continental shelf and the interference of reflected waves responsible for intense damage in Nagapattinam and Kanyakumari districts, respectively. During the damage survey authors also noted that there was almost no damage or much lesser damage to houses situated on or behind the Medu. Many people observed the first arrival. The largest tsunami amplitude occurred as the first arrival on the eastern coast and in the second arrival on the western coast.

Hakan Alphan (2004) describes a methodology that relies upon digital processing of remotely sensed satellite images to detect coastline changes in Cukurova Deltas, south east Mediterranean coast of Turkey. Two winter images of Landsat MSS and ETM+, acquired in 1972 and 2002, were clustered into “water” and “non-water” classes using the ISODATA algorithm prior to pixel-based comparison of land and water areas in two dates. The results of the study showed that significant changes occurred especially around river mouths, in the form of accretion and erosion. More than half of the total erosion along the seacoast, 153 of 347 ha, was detected to have occurred at the mouth of river Seyhan. The amount of accretion in Ceyhan delta was calculated as 203 ha. Importance of landscape-level characterization and monitoring that provide a basis for more detailed research and finer change detection was also highlighted.

R. M. Westaway, S. N. Lane, D. M. Hicks (2005) has studied the use of conventional survey methods to monitor large, gravel river beds has traditionally led to a reliance on repeat measurements of cross-sections which, unless very closely spaced, may give unreliable information about three-dimensional channel morphology and morphological change. Provided certain technological limitations can be overcome, remote survey techniques, such as digital photogrammetry and airborne laser scanning, remove the spatial and temporal constraints typically associated with ground-based surveys, allowing high spatial resolution, distributed, elevation mapping of gravel river beds. This paper develops the use of digital photogrammetry for the survey of a 3.3 km reach of the braided Waimakariri River, New Zealand, which, when combined with image analysis of water colour to infer water depth, provides a Digital Elevation Model (DEM) of the entire river bed. Central to the successful application of this method is DEM post-processing. Errors take two forms: (i) individual point errors associated with incorrect stereo-matching during automated data collection; and (ii) spatially-variable systematic errors that are associated with uncertainties in sensor position and orientation as determined during the bundle adjustment. An automated post-processing procedure is developed to deal with individual point errors and this improves DEM surface based on surveyed photo-control point elevations reduced systematic errors in the final DEM surface.

N. Chandrasekar, S. Saravanan, J. Loveson Immanuel, M. Rajamanickam (2006) implies that the prevention of natural disasters is not feasible but the destruction it conveys could be minimized at least to some extent by the postulation of reliable hazard management system and consistent implementation of it. With that motive, the beaches along the study area have been classified into various zones of liability based upon their response to the tsunami surge of 26 December 2004. Thereby, the beaches which are brutally affected has been identified and the beaches which are least. Based on the seawater inundation with relative to their coastal geomorphic features, we have classified the tsunami impact along the coast and the probability of the behavior of the beaches in case of similar havoc in future. The maximum seawater inundation recorded in the study area is 750 m as in the case of Colachel and the minimum is 100 m as in the case of Kadiapatanam, Mandakadu and Vaniakudy. Beaches like Chinnamuttom, Kanyakumari, Manakudy, Pallam and Colachel are under high risk in case of similar disaster in future and the beaches like Ovari, Perumanal, Navaladi, Rajakkamangalam,

Kadiapatanam, Mandakadu, Vaniakudy, Inayam and Taingapatnam are under least viability. Kenneth Pye and Simon J. Blott (2006) have studied the Suffolk coast around Dunwich and Sizewell has experienced major changes during the past 2000 years with significant loss of land caused by marine erosion. Against a background of projected acceleration in sea level rise and storminess resulting from global climate change, concern has been expressed that present coastal defenses may become unsustainable in the medium to longer term, and that the survival of internationally important wildlife habitats is under threat. This paper examines the past coastal evolution in the light of natural processes and provides a discussion of future management options.

Based on analysis of historical maps, charts, air photographs, and ground survey. It is shown that rates of coastal erosion have actually been much lower in the last 50 years than historically and at present there is little scientific evidence to support a case for large-scale managed realignment or abandonment of flood and coastal defense. However, in some areas, notably the very northern end of the Minsmere barrier and the middle part of the Dunwich-Walberswick barrier, local realignment and/or construction of stronger secondary flood defenses are required to establish a coastal condition that is more in equilibrium with current processes, and to provide adequate protection against marine flooding even under present climatic and sea level conditions.

N. P. Kurian, T. N. Prakash, M. Baba, N. Nirupama (2004) research was about the tsunami generated by the December 2004 Sumatra-Andaman earthquake had a devastating effect on some parts of Kerala coast, which is a coast located in southwest India. Results of post-tsunami field surveys carried out to understand the changes in coastal morphology and sediment characteristics in the worst affected Kayamkulam region of Kerala coast are documented in this study. Analysis of offshore bathymetric data indicates the shifting of depth contours towards shore, indicating erosion of sediments and deepening of inner shelf due to the tsunami. Depth measurement along the backwater (T-S canal) in the hinterland region indicates siltation due to the inundation of the canal.

Chamhuri Siwar, Mohd Zaki Ibrahim, Siti Haslina Md Harizan and Roslina Kamaruddin (2005) highlighted the socioeconomic impacts of the 26th December 2004 Tsunami on fisheries, aquaculture and livelihoods of coastal communities in Malaysia. Data for the discussion were collected in the months on January to February 2005, based on a rapid assessment survey of communities impacted by the tsunami in the states of Kedah (including Langkawi Island) and Penang. In March 2005, and recently in September 2006, another rapid follow-up survey was conducted in Kedah to assess recent progress, development and remaining issues facing the impacted communities. The socioeconomic analysis focuses on accounting the loss and damages to human lives, properties, fishing equipments and aquaculture enterprises. Financial estimates of damages are provided. Impacts on livelihoods cover loss of employment, income and psychological trauma experienced by the impacted populations. Issues, responses and disaster management by various assisting agencies and NGOs are also discussed and recommendations for better disaster management are provided.

K. S. R. Murthy et al, (2005) have studied the Tamil Nadu margin, in particular the Nagapattinam–Cuddalore shelf was the worst affected by the tsunami surge and inundation caused by the great Sumatra earthquake of 26 December 2004 (*M*w 9.3). Surge heights in this part were of the order of 2 to 5 m, with inundation of the order of few hundred meters into the interior coast, thus causing huge loss of human life and property. Several reasons were attributed to the unusual surge in this part of the Tamil Nadu margin, the main reason being its relative proximity to the origin of the event, apart from the concave nature of the shelf with a gentle gradient. A detailed analysis of geophysical data of the Nagapattinam–Cuddalore shelf is presented. The results indicate that the structure of the underlying basement, the morphology and the land–ocean tectonics are the main guiding factors for the run-up heights in case of the Nagapattinam–Cuddalore shelf. The fault controlled basement structure, and a straight coastline with narrow and gentle shelf have helped in rapid transgression of the surge inundating the coastal area.

1.18 Problem Statement

A major portion of the conflicts arising from the expansion of shrimp farming is the result of environmental and social degradation that is not included in the costs of shrimp production. Where the industry assumes no responsibility for damages to other groups arising from its activities, economists call them "externalities". For example, abandoned ponds are usually virtually unusable for other purposes for indefinite periods without costly rehabilitation, which is seldom undertaken. Mangrove destruction, flooding of crops, salinization or pollution of land and water associated with the expansion of shrimp farming all affect the local people depending on these resources. Natural resource and ecosystem degradation the shrimp industry is polluting and degrading water, forests and soils. Public health, biodiversity, and the sustainable productivity of ecosystems are endangered. Deterioration of local livelihoods shrimp aquaculture is changing customary patterns of natural resource use by appropriating these resources for its own purposes while abrogating or restricting rights of local users. This in turn affects livelihoods more widely by disrupting earlier systems of production, distribution and social relations.

Water Pollution: The waste water from aquaculture pond let out to the nearby areas caused surface and sub surface water pollution. Estuarine waters are the recipients of urban, industrial, agricultural and aquaculture pollution. Shrimp aqua culturists consider their crop failures to be mainly due to organic and inorganic pollution coming from other sources. Waste and sewage from urban and industrial centers from modern agriculture frequently pollute shrimp ponds with heavy metals, pesticides and other toxic products. In areas densely covered with intensive shrimp farms, however, the industry is responsible for considerable self-pollution particularly for bacteriological and viral contamination. Each hectare of pond produces tons of undigested feed and fecal wastes for every crop cycle. These ponds discharge ammonia, nitrites and nitrates. The latter is fatal to fish when it binds with the hemoglobin of their blood.

Biodiversity losses: The impacts of shrimp aquaculture on biodiversity (the totality of genes, species and ecosystems in a region) are multiple. Shrimp aquaculture affects biodiversity for many reasons already mentioned. Shrimp ponds cover vast coastal land areas and they pollute large volumes of water. Modified water circulation systems are altering wild fish and crustacean habitats. The risks of disease spreading out of the ponds into wild stocks are increasing. Pollution from shrimp farms contributes to the increasing frequency of "red tides" and endangers other native fauna and flora.

Health hazards: Health hazards to local populations living near or working in shrimp farms have been observed in several places. For instance, in Tamil Nadu (Quaid-e-Milleth district near Pondicherry) an approximately 1,500 acre shrimp farm has been reported to have caused eight deaths from previously unknown diseases within a period of two months following the installation of the aquaculture farm (Naganathan et al., 1995:607). There are numerous hazards to public health along the shrimp production chain, from the farmers through the various processors to the often distant consumers. The workers employed on shrimp farms handle several potentially dangerous chemicals, and may be exposed to unsanitary working conditions.

Changing Natural Resource use and Deteriorating Livelihoods: Shrimp aquaculture is expanding in many areas that in the past had been managed under some kind of common property régime. This is particularly the case in coastal zones where fisher folk require easy access to beaches and where multiple uses by different users of land, water and forest resources have made exclusive control by individuals untenable. Several case studies mention that due to the expansion of modern shrimp ponds in coastal areas, local fishermen can only reach the beach by trespassing at great risk on shrimp farms or by taking a long detour. Local people have not only lost access to their fishing grounds and to their sources of riverine seafood and seaweed, but they have also relinquished social and recreational activities that they traditionally enjoyed on their beaches. Moreover, many coastal communities for the extensive farming of fish and crustaceans use coastal lowlands and mudflats during the rainy season practices which have traditionally been regulated through customary common property régimes. Since the latter have frequently had no formal legal status, the customary holders of areas appropriated for shrimp farms have been easily dispossessed, usually without compensation. With these caveats in mind, let us look at a few cases where modern shrimp farming has had some rather serious negative consequences for many people as well as for their environment. We attempt here to cite cases that bring out several of the contradictions associated with divergent social and economic contexts.

Mangrove deforestation: Mangrove forests constitute an important component of coastal ecosystems in tropical regions of both hemispheres. They thrive in tidal estuaries, salt marshes and muddy coastlines. Trees and shrubs of the Rhizophor genus dominate mangroves. Some species have the peculiar faculty of rooting from the seed still attached to the tree. Colonial settlers and urban dwellers regarded mangroves as being practically worthless, but coastal indigenous populations had been using them sustain ably for many centuries as sources of firewood, construction materials, nursery beds for fish and crustaceans and as protection against storms and floods. During recent decades mangroves have disappearing rapidly, victims of urbanization, commercial logging, unrestricted fuel wood collection, charcoal making, and river impoundment and more recently shrimp pond construction.

Encroachment upon agricultural land: The increasing need for land by shrimp entrepreneurs has meant a dramatic rise in land prices in many areas. When extensive shrimp farming is combined with paddy cultivation, it should not always be viewed as a multi-cropping pattern advantageously replacing the fallow period of a seasonal mono crop production. In Bangladesh, for instance, the land previously used for the production of rice and paddy during the wet season was often used in the dry season for pasture and cultivation of beans, melons, pumpkins, jute and other less water-demanding crops (Sultana, 1994). According to this case study, the average number of cows and buffalo per household prior to shrimp farming was 11, but afterwards it dropped to 3. Share cropping becomes less interesting when the land is under water for several months. Indeed, sharecroppers receive land for the cultivation of rice paddy for shorter periods than before in order to leave more time for shrimp growth. Rice yields are falling with the increasing salinity of the land. After the farming of shrimp, the harvests of paddy and local rice varieties average only one to two thirds of yields recorded prior to shrimp cultivation.

Polluted waters: As seen earlier, shrimp farms use both sea- and fresh-water to replenish their ponds. This heavy demand on water brings shrimp enterprises into competition with other users of these water resources. In areas where commercial shrimp ponds have been constructed there is frequently insufficient fresh-water left to meet customary needs for irrigation, drinking, washing or other household and livestock related uses, and water supplies may be contaminated. Ground water salinization has been reported in several places. This often means that people most of the time women have to bring water from more distant wells in Tamil Nadu.

The present study is about the impact of December 2004 Tsunami waves, destructing the coastal landscape with particular reference to the sand erosion and deposition of river mouths along the rivers in the Nagapattinam coast. Field investigation in this region reveal that huge quantity of sand particles were removed by the giant waves and deposited on the lee ward side of the coast which ranges from 300 meters to 1 kilometer. Majority of the shrimp aquaculture farms, which are present inside the river as well as near the vicinity, have been severely affected due to the tsunami impact. The estuary's which confluences with the Bay of Bengal, particularly the river mouth which is close to the sea has been widened and though which the surface sea level intrusion have been wide spread prevalence in almost all the river confluence segments in this coastal region. This would also affect the economic activity such as aquaculture farming, coastal agriculture, and coastal forestry and so on. The present study has been focused to analyze the problem of pre and post tsunami conditions of river estuaries along the specific rivers, which are existence along the Nagapattinam coast using spatial information technology.

1.19 Objectives

The present research has a focus on the following objectives:

a) To study the development of aquaculture ponds along the estuaries and trace their environmental impact for the past decades,

b) To collect the water samples from the selected aquaculture farms physically and analyze the bio-geo-chemical components to find out the nature of contaminants/ abnormal limits to the environment that affect the quality of life in this region,

c) To compare the bio-geo-chemical analysis results to enable the dominating or depending variable that affects the one on the other and also to study the causal relationships,

d) To study the changing pattern of mangrove forests during pre and post tsunami using optical remote sensing data,

e) To select sample ponds along the Nagapattinam coast zone to analyze pre and post tsunami impacts and their implications using GPS and GIS.

1.20 Methodology

The present research is about the geo-chemical and biological qualities of surface waters in the shrimp farm zones of Sirkazhi and their estuaries on the ecological point of view, which is situated in the Nagapattinam District, which was bifurcated from the old Thanjavur District. This region has majority of shrimp farms in when compared to the other coastal areas in Tamil Nadu and the topography plays a dominant role for the establishment of shrimp farms in this zone. Majority of the agricultural lands were converted into shrimp farms due to its vast income in the shrimp culture business activities. Though it has been considered as a good income for the farmers, the quality of the surface and sub-surface water is a major question that determines the majority of the life in and around this region. Basically the shrimp farm requires enormous water with the required characteristics in which the shrimp is being cultured. During the harvest the water is being let out to the nearby wastelands and thus again makes a soil polluted land that affects the environment of this region in an adverse manner. A field investigation in these regions reveals that most of the land nearby shrimp culture ponds is polluted due to this type of activity. Though the lands are found away from the settlements it would have a definite impact on the surface and subsurface water quality and there must be a proper treatment is required before the waste water from the shrimp farm is being let off. This necessitates a careful examination of waters that are let out of from the shrimp farms and to study and analyze the results of the bio-geo-chemical qualities of the surface waters in this region.

To assess the problem along the estuaries Indian Remote Sensing Digital Data for the pre and post tsunami periods, for Nagapattinam coast the digital data pertaining to the time period of 18-12-2004 (Pre-tsunami) and 6-1-2005 (Post-tsunami) have been obtained from the National Remote Sensing Agency, Hyderabad. The data covers the Kollidam river estuaries and the digital data were cropped for in-depth analysis. The data were analyzed using ENVI 4.1 to find the morphological changes along the river mouth using the pre and post tsunami data. The analysis performed to find the change is the unsupervised classification method with GPS field checks to identify the samples. The processed data have been tabulated by calculating pixel-by-pixel method and derived the values of changing character of the region of interest.

To study the impact of post tsunami for the selected forty two ponds, the environmental conditions that affected during the tsunami and the aggravated environmental conditions were mapped using GPS and field survey methods. All the sample ponds were mapped using GPS and different shape files were created using ArcGIS 9.0. All the forty two ponds, the inlet of salt water and out let of contaminant water have been tracked using GPS and mapped at micro-level to study the pond character at in depth level. Stagnant water level maps for all the 42 ponds were devised using GPS and mapped. As an example one sample pond has been taken for the analysis. The inlet and outlet for the sample point has been considered to show the flow pattern. The surrounding land characters in the sample ponds were also mapped to study the category of lands.

To study the pond characteristics, forty two ponds of seven ownerships in the selected village of Pappakoil (in the estuary) have been taken for the study along the Nagapattinam coast and these ponds are two kilometers away from the coast. They were worst affected during December tsunami due to its locational character, which are located along the river Uppanar and Kaduvaiyar river course. During tsunami the destruction waves carried sea water through the river course and the post tsunami study indicate that the intrusion of salt water through surface and subsurface levels.

1.21 Chapterization

The present research has been classified into five major chapters: The first chapter deals with the general introduction of the problem globally and domestic with few references, literature review, objectives and methodologies. The second chapter is about the study area described in various aspects. The third chapter has been devoted to go an in depth analysis of ecological destruction due to aqua culture farms due to water pollution and Quality of Aquaculture Farm practice in Kollidam Estuary: Surface water quality and Environmental land degradation, The fourth is impact of natural disasters and the role of mangrove forests to protect the structure. Pre and post tsunami conditions of Mangrove forests and a sample study of how safe culture practice is possible in the coastal estuaries and how the natural environment rejuvenates the ponds for higher growth. The final chapter is the summary, conclusion and recommendation for the improvement of the coastal ecosystem.