Coastal processes in Tamil Nadu - [1980-2010]

[Analysis of shore line oscillation between the year 1978 to 2010 by considering the shore line oscillation reading in thirteen observation sites]

[Region between Cuddalore and Valinokkam]

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Chapter one

Introduction

1.1. The renewable living aquatic resources of the sea represent a unique gift of nature to Mankind. Sea and its coast is an aesthetic gift of God, only comparable with the majestic mountains. The sound and serenity provided by the sea is one of the most sought after endowments of nature. Therefore, aesthetic considerations should play a significant role in development of the coastal areas.

1.2. Tamilnadu with an area of 1,30,000 Sq.km. is situated on the South East portion of Peninsular India. It has got a coastline of about 950 km. along Bay of Bengal, Indian Ocean and Arabian sea. About 46 rivers draining a total catchment of about 1,71,000 Sq.km. empty along this coast line. These rivers being fairly long and traveling the plateau and carry considerable sediment, which is fed into the seas affecting the shore, processes, very significantly.

1.3. The coastal areas are also the place where natural disasters are also experienced. The entire East coast of, the coast along the West coast and the islands of Lakshadeep and Andaman and Nicobar face frequent cyclonic conditions which sometimes cause large scale destruction of life and property. The Super Cyclone had caused massive destruction along the coast of in 1999 and its impact was felt several kilometers inland. The tsunami, which occurred on 26th December, 2004 was one of the most serious and unexpected natural catastrophes to occur along the Indian coast. The major destruction caused by this tsunami was to the life and property located along the coast of Andaman and Nicobar, Tamil Nadu, and Kerala. It would take several years to restore the damages caused by this natural catastrophe

1.4. In the Bay of Bengal and cyclonic disturbances and storms are quite frequent, the annual frequency of disturbances being 16 in an average and storms being 6. Cyclonic disturbances are five to six times more frequent over the Bay of Bengal than over the Arabian sea.

1.5. There are two definite monsoon seasons during which rain fall is concentrated. The South West monsoon is active from mid June to mid September during which period the West coast (along Arabian sea) experiences heavy rainfall and the East coast (along) has its share as scanty to moderate scales. The East coast experiences heavy rainfall during North-East monsoon period spreading about from mid September to mid January. During these periods and in the calm weather period (from mid January to mid June) the shore line undergo significantly deep changes, which at times affect the shorelines by way of loss of land and properties.

1.6. These shore processes are known to result in massive littoral drift too along the East coast from South to North during the period of March to October and from North to South during the rest of the year, the latter being only a fraction of the former. Even though the general trends of these phenomena are known detailed information were to be collected.

1.7. Nearly 250 million people live within 50 km from the coast. Over 25 % of India's population will live in the coastal areas during this century. Therefore an integrated and economically and socially sustainable coastal zone management should be put in place jointly by Government agencies and coastal communities, their behavior should be evolved properly. India's coastline undergoing physical changes through the geological past, although the last tectonic phase in the Indian peninsula has been one of the general emergences, the present coastal geomorphology of has evolved largely in the background of the past glacial transgression over the pre-existing topography of the shore, coast and Offshore zones. The Tamil Nadu (including) coast is straight and narrow without much indentation except at Vedaranyam. Fringing and patch reefs are present near Rameswaram and Gilf of Mannar. Pichavaram,Vedaranyam and Point Calimere have well developed mangrove systems. In Tamil Nadu about 46 rivers drain into Bay of Bengal forming several estuaries adjoining coastal lagoons. The other landforms

of the Tamil Nadu coast are rocky outcrops, mudflats, beaches, spits, coastal dunes and Strand features whenever a major cyclone or tides or men made mistakes lead erosion and consequent damages to the habitats on the beach is sudden, colossal, drastic and often irreversible.

1.8.Beaches and estuaries have been the first to feel the impact of growing population and its civilizations. At present about two thirds of the world population lives within a narrow belt along the coasts. In Tamil Nadu also, the average density of population in coastal districts is 417/Sq.Km. when compared to the average density of 338 Sq.km. Ocean and its nearby environments are becoming inevitably-great resources in terms of land, food energy and as recreational beach resorts. Hence harassing the ocean behavior and coastal processes, after an in-depth study, to suit the human requirements is a must.

1.9 To design certain coastal structures properly or to evaluate the effect of certain flood control structure on the stability of a coastline an estimate of the annual amounts of sand supplied to or lost from the coast is necessary. Therefore the study related to investigations of the factors of shoreline features which prevent the movement of sediment into and out of the shore area may be called, in simple terms, as study of 'Coastal Processes'

1.10.So our works and studies centre on this orientation of 'Coastal Processes'. Accordingly, though data are available on many factors and phenomena. We have restricted ourselves for analyzing erosion and accretion problem only in this report.

1.11.The selection of sites and the data collected have been briefed in Chapter-2. It will be of interest to note that the sites selected for study are situated mostly near river mouths, so as to facilitate the characteristic features of the littoral transport.

1.12 Chapter-3 outlines the geology and geomorphology of coastline of Tamil Nadu to have a glimpse of it in relation to coastal processes.

1.13.A General narration has been given in Chapter 5 for the methodology adopted in analyzing the data. Though so many techniques have been mentioned, all have not been adopted for all the sites; according to the data base, requirements of the site problems, man power involved, data have been analyzed.

1.14.Chapter-5 deals the coastal hazards of this region and the general details.

1.15.Chapter 6 deals with the individual sites with their history, data problem and conclusive remarks about the shoreline behavior.

1.16.The Chapter 7 gives the derived opinions and conclusions regarding the shore's behavior, remedial measures the cares to be adopted in execution etc. in broad outlines.

Chapter Two
Data Collection

2.1.Generally the coastlines are supposed to undergo severe changes during monsoon periods and these changes will disappear and the shorelines will regain their original position during non-monsoon periods. Such a situation makes one to think that the particular shorelines behavior is stable. But in real situation, mostly, the shore line behavior is not so. On the other hand, one cannot also attribute a definite trend of advances or recession of

season waters against the land forms. Even if continuous erosion or accretion is noticed at one particular place, we cannot also find readily a pattern of behavior without analyzing considerably a long data.

2.2 Therefore on the basis of importance of place, significant changes reported in shoreline behavior, channels and rivers affecting the shoreline etc., suitable sites have been selected for study.

2.3.At present thirty two sites are under active study along the coastline of Bay of Bengal, Indian Ocean and Arabian sea. Out of these 32 sites, 25 sites lie in the East coast and the rest along west coast. The length (reach) of each site varies from about 250 metres to 6000 metres according to the significance of the phenomena noticed and studied. The total length of all the 32 sites is about 89 Km. This Ramanathapuram section is monitoring the shore line oscillation in 13 sites comprise to a length of 35 Km.

2.4.
COLLECTION OF DATA: At first, in each site, a base line is fixed in such way that the references in the base line are not expected to be destroyed by the ocean waters for about 10-15 years in the future. On this line, reference pillars are erected each separated by a distance of about 200m. The distance between the reference pillars may also vary according to site conditions.

2.5 Each site is observed once a month based on the lunar phase namely new Moon, first quarter, full moon and third quarter days, based on the dates found in Indian Tides Tables. For short of staff strength and financial implications involved in traveling allowance and Dearness Allowance etc., closer time interval observation seems to be a constraint on this.

2.6.Ramanathapuram Section collects observations at thirteen sites. All the sites are in East Coast with nature of Coast varying from sandy, sand stone, rock out crops, etc. Each site is analysed separately and brief discussion is made in this report. The following table shows the sites with their locations for observation are detailed in this table

Sl. No.	Name of Observation Site	Location		Coastal length of study	No. of Reference Pillars
		Latitude	Longitude		
1.	Devanampattinam	11°44’37.61”	79°47’14.32”	750 m	6
2.	Cuddalore North & South	11°40’52.99”	79°46’17.09”	1538 m 180 m	3 3
3.	Poompuhar	11°8’26.08”	79°51’26.42”	1905 m	7
4.	Tranquebar (Tharangambadi)	11°1’28.81”	79°51’22.10”	760 m	6
5.	Nagapattinam	11°1’28.81”	79°51’22.10”	4270 m	5
6.	Velankanni	10°40’48.95”	79°51’6.18”	1549 m	6
7.	Point Calimer	10^0 17’ 00”	79^0 53' 00”	966 m	6

	(Kodiakkarai)				
8.	Ammapattinam	10º0’55.15”	79º13’57.94”	3700 m	15
9.	Nambuthalai	9º9’50.40”	78º38’54.64”	1200 m	7
10.	Mandapam	9º17’3.01”	79º9’38.74”	2165 m	9
11.	Rameswaram	9º17’50.16”	79º19’36.61”	3295 m	13
12.	Keelakkarai	9º13’42.32”	79º47’12.13”	5140 m	8
13.	Valinokkam	9º9’50.40”	78º38’54.64”	7360 m	10
Total				**34778 m**	**104 Pillars**

2.7 In all, there are 104 numbers of reference pillars form which the observations are made for shoreline oscillations. From these reference pillars the horizontal distance of crest of berm of the shoreline is measured every month.

2.8 Apart from this crest of berm measurement, the fore shore distance and the slope of it are also measured. The other measurements taken on each observation site are.

1. The average wave height, wave period, wave length and the wave angle.
2. The wind speed and direction.
3. Beach material sample as and when required.
4. Bathymetric surveys as and when required at place of interest and necessity.
5. Storm track details when required.
6. Details of stream in falls affecting the site of observation.
7. Historical data on the ecological and environmental aspects etc.
8. Behavior of existing coastal structures.
9. Currents and Tides and
10. Geomorphologic features.

The proforma for collection of coastal data has been appended

APPENDIX-1

PROFORMA FOR COASTAL INSPECTION

Name of Officer and Designation		:	
Date of Inspection		:	Time :
Place		:	Nearest prominent rail head or bus terminus.
Name of the sea		:	
Latitude		:	Longtitude
I. SEA			
a)	State of sea	:	Rough/Calm/Moderate
b)	Waves	:	Height Period Directions
c)	Tide	:	High/Low

			Rising/Falling
d)	Wind	:	Directions Calm/Breezy/Windy
a)	Width of beach	:	Backshore plus Foreshore
b)	Soil classification	:	Backshore Foreshore
c)	Foreshore	:	Eroding/accreting Distance of crest of berm from baseline. Slope of Foreshore Whether there is littoral drift: Yes/No if so, direction.
d)	Backshore	:	Scrap line visible/not visible if visible distance from baseline. Is the sand is backshore protected by Vegetation: Yes/No.
e)	Water table	:	M.Below sea level/in metre above/
a)	Approximate orientation		
b)	Present condition	:	Eroding/Accreting/Stable
c)	Is the erosion recurring or infrequent?	:	Is the accretion Temporary/ Permanent.
d)	Distance of if any from the sea?	:	
e)	Are there sand dunes? Yes/No. If so approximate height.		
f)	Are they protected by Vegetation?		

IV. INLET			
a)	Is there a coastal inlet in the vicinity?	:	
b)	If so position with reference to locality, whether closed or open	:	
c)	Name of stream and hydraulic particulars.	:	Width/Velocity of flow (if there is stream flow)
d)	Tidal limit	:	Depth Approximate Distance from shore
e)	Approximate period of functioning of inlet (by local enquiry).	:	
V. CONSTRUCTIONS			
a)	If the beach/coast affected by coastal constructions. (legal enquiry)	:	South/North/East/West of erosion site.
b)	If so details location, type.	:	
VI. OTHER ADDITIONAL INFORMATIONS.			

Signature and Designation of the Section Officer.

Chapter three
Geology and Geomorphology

3.1.1. GEOLOGY: The entire coastal belt of Tamil Nadu consists of recent alluvium and beach sands overlying sedimentary formation such as laterite and limestone, Clays and sandstones and shoals of different geological age formations which rest on crystalline rocks made up/of mostly of granites and gneisses. The area is characterized by a plain topography with prominent deltaic and estuarine formations. There is a number of sand dunes of various dimension also, developed along the fringe of the coast.

3.1.2. The oldest rock types exposed along the coast belong to the archaism age of formation (more than 250 million years ago) and are chiefly made up of granites and gneisses (rocks made up of quarts and feldspar). There are a few other occurrences of upper Gondvana formation (of age between 140 and 220 million of years) intervening the Achaean are the later Tertiary formations (30-65 million years). Thus there is a transition from the oldest rock in the west to the most recent formation on the East.

3.1.3. The coastal belt from to Marakkanam consists of Achaean unclassified crystalline rocks overlain by sedimentary and alluvial formations. The unclassified crystalline rock includes granite granodiorites, gneisses consisting of harrslend, biotires and minor accessories besides their main constituents of quartz and feldspar.

3.1.4 The coastal belt from Marakanam to the mouth of River Coleroon consists of Cuddalore sand stones (Tertiary), shell limestone mals and clays (Crataceous) and clays and shales (Gondwana). The upper Gondwana rocks rest on the crystallines and/in ocean as detached outcrops within the Archnean and at the contact of the cretaceous Tertiary formations. They consist of micaceous shales, gray sand stones and grits. The crataceous formations are separated from the upper Gondwana. The crataceous rocks generally consist of calcareous shales, sandy clays, sand stones and limestones.

3.1.5. Sand stone and alluvial are the main formations from the mouth of Coleroon to Ramanathapuram. The alluvial formations occupy much of the coastal belt. The crataceous formations are absent in this belt, and the tertiary directly rests on the upper Gondwana formations. Out of this belt the region from Thalainayaru to Mimisal belt is of the recent origin deltaic formations well delineated by satellite imagery observations.

3.1.6 The belt from Ramanathapuram to Kanyakumari consists of alluvial formations mostly of beach sands and sand dunes that rest directly on the Archaean crystalline rocks. The crystalline rocks are mostly granites and Kankar, and turfaceous limestones, marir sands, Red sands, recent soils are also found in the coastal area. Loosely commented paramassive sand stone is common occurrence near the beach South of Tiruchendur down to Kulasekarapattinam. The sand stone along the beach is made up of compacted breach sand with shells of recent age. Shell limestone of marine origin are also common in the Tiruchendur area. Marine sand stone with commented shells are found along the wide beach. Red ‘Teri’ sands are common feature in this area. The sand is silica rich and reddish in colour, Dark gray clayey soil associated with caleareous nodules (Kankar) occur fairly wide spread to the West and North West of Tiruchendur.

3.1.7. From Kanyakumari to Kollengodu beach and are underlain by partially consolidated fessiliferrous limestone or sandstone laterite or clayey beds. Many coastal areas have good exposures of crystalline rock. The entire coastal belt is covered by formations of recent origin, like semi consolidated sands and leached beds of clayey composition covered by wind blown red soils which in some places reach thickness of over 30 to 35 metres

3.2.1.GEMORPHOLOGY: The East coast originated much earlier than the West coast and has maintained very much its present position since lower cretaceous times as shown by the fringes of cretaceous and Tertiary marine sediments. This coast has marginal lakes and recently acquired alluvial fringes like Vedaraniyam, Point Calimere

belt. The is subjected to severe cyclonic storms which move South-West and dissipate themselves in land after crossing the coast.

3.2.2. There is evidence of past tertiary upheaval on the East coast whereas signs of depression are seen on the West. The Peninsular India is having the tendency of changing its structural formation with intermittent uplift or warp, which may not be uniform over the entire region. Such changes lead to geomorphological evolutions.These may result in the formation of sedimentary basins and coastal flexing. Physiographical of the long and broad East coast is one of the fine coastal regions of Southern India. This region extends to a width of about 80 Km. to less than a km. at places, where most of the East flowing rivers join the Bay of Bengal.

3.2.3. The presence of coral reef and marine deposits raised above the present level of the sea testify to sub-recent evolution. Shells belonging to the recent species are found from 2 to 3 m. depth beneath the surface at, Mahabalipuram, Cuddalore, Thanjavur and Tiruchendur etc. A bed of estuarine shells is noticed about the present flood level in the lower part of the near Pertonovo. These shells are of estuarine form, such as now live in the creeks and backwaters of the coast, but in several cases true marine, species are found. The sub soil shells are available in plenty at and Pulicat and they are being collected for lime burning. Pascoe has stated that in his book “a geology of the Manual of India and Burma” that on the North of Rameswaram an old coral reef has been raised several feet above sea level. The gentle slope of older rocks on which lies the low level laterite of the East coast is one such formed by the sea unaffected by the sub acriat erosion, and the laterite material must have been deposited either before or shortly after this plain was raised above sea level.

3.2.4. Besides the changes by rise and fall of the sea level, there have been minor modifications of the shore line due to erosion or accretion of land forms. The town of, Poombuhar are said to have been overwhelmed by the sea. Erosion of beach is noticed by the evidence of destruction of old temples and parts like that happened in Tranquebar (Tharangampadi) and Dhanuskkodi. Evidence of advance of land is found near Korkai in Tirunelveli District, which is 8 km. inland, yet no well defined erosion surface are seen along the East coast.

3.2.5. It is reported that physiographical changes have taken place in Southern India, resulting in coastal flexing which may be due to a major cynatogency i.e., upwards of lesser magnitude with asymmetric arch. This resulted in the sea advancing in the West coast and land formation in the East coast due to sedimentation. Because of this uplift, Eastern land of the got dissented and East flowing rivers carried lot of sediments to the sea thereby creating beaches, along the East coast.

3.2.6. There might have occurred a few minor changes along or partly along the same axis which might have played a role in creating gorges, waterfalls, piracies and wind gaps. From this it is apparent that rivers that now flow East bound might not have flown towards East right from their inceptions. The present courses are the results of river piracies brought about by the headword erosion for example; the present course of Cauvery might have been formed after the river piracies, the rivers being Palaru and Pennaiaru due to subsequent erosion following uplift.

Chapter four

Analysis

4.1.Though data on various aspects have been collected for a long time, all data have not been collected simultaneously. As far as crest of berm distance is concerned, the data suitable for a time series analysis is available only from 1978 onwards.

4.2 When behavior of the individual pillars of a site with respect to each other compared, it is found that the behavior in most cases are significantly different. This is comprehensible for the fact that within a short distance of about 200 m. to 500 m. breakers lying in the sea bed or the shoals present might not have been truly parallel to the shore line crest. The crest line of waves (orthogonal to the wave length) might not have been long enough to cover distances between pillars. Therefore each pillar point may behave individually.

4.3. It was tried to find out the Auto correlation function of each pillar point of the shoreline.The results were not encouraging. This reveals that (i) the time lag namely one lunar month might be too long a period for such decisions to arrive at and/or (ii) whatever energy impinged upon the shoreline, which makes the shore eroded or accreted, it has got no effect on the part or future deposition. That means, the system has get no residual memory over the past occurrences. Due to non cohesive nature of the beach material and destabilizing nature of the impinging wave energy, the role of replenished material for stability is much less over the originally available naturally consolidated shore line materials. Therefore the auto correlation co-efficient is conspicuously much less.

4.4. Since statistical analysis for this type of behavior and data were not much useful, visual analysis was made.From this observation, the points of most advanced condition of the sea are connected in the time series. Thus connected line of the most eroded condition of the shoreline reveals the quantity of erosion in terms of distance of crest of berm for the observed length of record. In case of failure to visualize this line by this method, the second degree equation line will give a better spectrum over this.

4.5. Each site has been analyzed separately and the report on them compiled.

4.6. Co-efficient of Oscillation: Now our experienced difficulty is that, whenever an untoward incident occurs in coastline causing loss of lives and properties, the occurrence with its entirety in its vigour and style cannot be expected to recur in the near future to be studied in detail, as such, the problem is a many folded one. This is because (a) the causative factors are many and complex and, so often the causes go unidentified.
(b) The actual processes that cause the resultant damages cannot be visually observed because of the severe weather conditions.
(c) Hence, only the resultant damages are there to be studied for the causes and processes.
(d) Mostly the process is continuous whether they cause significantly appreciable resultants or not.
(e) Because of the above nature of the problem, to identify, analyze and to suggest the causes, processes and remedial measures, substantially, one has to do some work on the predictive lines. Here again, for prediction one has to resort to visual predication and statistical predictions. Mostly the affected site has little historical record over the coastal processes. If one is provided a record of data on wind, wave, tide, geography, soil, hydrology etc., it may be possible to analyze the scene of occurrence for suggesting remedial measures. Unfortunately, these are not readily available. So, if one has to wait for date collection, there are instances that even a systematic collection of a lengthy record does not lead us for a conclusive comprehension. Even a record of 10-15 years, may not show any symptom of meaningful stochastic properties. On such a situation, we have to try an year's record compared to a full length of record of the same site. For this purpose, the measurement of crest of berm with respect to the reference pillars came a handy tool for analysis.

4.7. In this method of analysis, year wise maximum oscillation of the shoreline for a particular reference pillar is calculated.Average yearly oscillation is calculated and the standard deviation is also found.The total oscillation for the pillar for the entire period of record is found. Then the ratio of this total oscillation over the average one year oscillation is found. Thus coefficient of point oscillation is found. This coefficient of point oscillation is calculated for other pillars of the site too an average is taken. This is the coefficient of oscillation for the site in consideration. This coefficient can be considered to contain the following situations.

(a) The length of record for about 30 years may be considered as a representative one in the absence of an optimal length of record, but at the same time, this coefficient is expected to change a little over or lower the present values in a long record of data by an amount not exceeding the averages of the standard deviations of these present coefficient.
(b) The changes of the oscillations were dynamic in character, for the factors that caused the change such as wind, wave, tide, storms, rainfall, human interferences etc.,
From this coefficient, one can arrive at the possible oscillation range, provided one year record of observation made.
This can be considered as a workable form of prediction since in planning and decision making and year can pass through very easily during which period the observations can be made for design purposes.
This work of finding coefficient of oscillation has been done for all the 13 sites. From these coefficients for any other sites in between, the same can be computed by interpolation.

4.8.Annual average of the crest of berm distances have been computed for each ref. pillar of all the sites. These have been plotted as graphs. The spectrum of the oscillation can be visualized for the entire site as a hole from these graphs. The degree of natural replenishment or erosion by on shore off-shore littoral transport may be decided from this graph. The unique pattern of behavior found in these figures suggests that the shore line between these pillars showing such pattern may be a straight beach or/and the forces acting on this reach are not varying within this stretch. By these graphs we can also ascertain whether there were any observational errors
As mentioned earlier above, attempts were made in analyzing the behavior of the shorelines by the characteristic temporal changes in their configurations themselves.

Chapter five
Coastal hazards

5.1. The coastal areas of the country experienced tropical climate and are having a diverse geological geomorphologic set up which favour a multipurpose of coastal and off shore marine ecosystem. The coastal areas are also the place where natural disasters are also experienced.

5.2. The entire East coast of India, the Gujarat coast along the West coast and the islands of Lakshadeep and Andaman and Nicobar face frequent cyclonic conditions, which sometimes cause large-scale destruction of life and property. The Super Cyclone had caused massive destruction along the coast of in 1999 and its impact was felt several kilometers inland. Tropical cyclones that are severe storm spun off from the intertropical convergence zone, may affect thousands of Indian living in the coastal regions.

5.3.Each year an average of eight storms with sustained wind speed greater than 63 kmph form; of eight storms with sustained wind speed greater than 63 kmph form; of these two strengthened into time tropical cyclones, which have sustained guts greater than 117 kmph , on an average a major cyclone develops every year. During summer, the is subject to intense heating, giving rise to humid and unstable air masses that morph into cyclones. Cyclone 05B a super cyclone that struck Orissa on 29thOctober 1999, was the deadliest in more than a quarter-century, with peak wind speed of 257 kmph, it was equaling of a category of a five hurricane.

5.4. Tamilnadu falls mostly via region of low seismic hazard with the exception of the western border areas that are link low to moderate hazard zone; as per the 2002 Bureau of Indian standards (BIS) map, Tamilnadu falls in zone II 2 III.

5.5. Almost all the countries situated around the were affected by the tsunami waves in the morning hours of 26 December 2004 (between 0900 – 1030 hrs IST). The killer waves were triggered by an earthquake measuring 8.9 on the Richter scale that had an epicenter near the west coast of Sumatra in Indonesia. The first recorded tsunami in dates back to 31 December 1881. An earthquake of magnitude 7.5 on the Richter scale, with its epicenter believed to have been under the sea off the Coast of Car Nicobar, caused the tsunami. The last recorded tsunami in India occurred on 26 June 1941, caused by an earthquake with magnitude exceeding 8.5. This caused extensive damage to the Andaman Islands. There are no other well-documented records of Tsunami in India.

(Tsunami damage in India)

Tsunami damage in [1]						
Factor	**Andhra Pradesh**	**Kerala**	**Tamil Nadu**	**Pondcherry**	**Total**	
Population affected	211,000	2,470,000	691,000	43,000	3,415,000	
Area affected (Ha)	790	Unknown	2,487	790	4,067	
Length of coast affected (Km)	985	250	1,000	25	2,260	
Extent of penetration (Km)	0.5 - 2.0	1 - 2	1 - 1.5	0.30 - 3.0		
Reported height of tsunami (m)	5	3-5	7-10	10		
Villages affected	301	187	362	26	876	
Dwelling units	1,557	11,832	91,037	6,403	110,829	
Cattle lost	195	Unknown	5,476	3,445		

5.6. The state of Tamil Nadu has been the worst affected on the mainland, with a death toll of 7,793. Nagapattinam district has had 5,525 casualties, with entire villages having been destroyed. Kanyakumari district has had 808 deaths, Cuddalore district 599, the state capital Chennai 206 and Kancheepuram district 124. The death tolls in other districts were Pudukkottai (15), Ramanathapuram (6), Tirunelveli (4), Thoothukudi (3), Tiruvallur (28), Thanjavur (22), Tiruvarur (10) and Viluppuram (47).Those killed in Kanyakumari include pilgrims taking a holy dip in the sea. Of about 700 people trapped at the Vivekananda Rock Memorial off Kanyakumari, 650 were rescued. In Chennai, people playing on the Marina beach and those who taking a Sunday morning stroll were washed away, in addition to the fisher folk who lived along the shore and those out at sea. The death toll at Velankanni in Nagapattinam district is currently 1,500. Most of these people were visiting the Basilica of the Virgin Mary for Christmas, while others were residents of the town. The nuclear power station at Kalpakkam was shut down after sea water rushed into a pump station. No radiation leak or damage to the reactor was reported.

It was all quiet on the waterfront on the Sunday morning after Christmas in 2004 at Kanyakumari, the famous

Marina Beach in Chennai and elsewhere on the Kerala coast and Andaman Nicobar Islands. There was the excitement of a holyday with an offbeat mood with swarms of people on the sea front: children playing cricket and man and women on their morning work at the . Elsewhere, fishermen were putting out to sea for the day's catch. Then all on a sudden, a curious thing happened. The holidaymakers at Kanyakumari were awestruck when the sea receded from the shores.
In the present tsunami, was the third country severely battered after and Srilanka. In the State severely affected by tsunami are Tamilnadu, Pondichery, Andhra Pradesh, Kerala and Andaman and Nicobar islands

Chapter six
Coastal processes

6.0. In the literatures on coastal Engineering, much has been discussed about the concept upon which the wave theories have been constructed and evaluated. Most of the theories are approximated for two dimensional motions of the water particles constituting the wave form. But realities, most of the waves do not function as sine or cosine function and fluid dynamics is three dimension. Therefore the shore processes can be approximated and analyzed through the shore line changes themselves. Hence much reliance has been made on the behaviour of the coastal changes in response with wind and tidal characteristics etc., of the ocean water. Coastal observation of each site between Devanampattinam to Vallinokkam has been analyzed for the coastal processes.

6.1.DEVANAMPATTINAM

6.1.1.This site is situated to the Northeast of Cuddalore town. This site located between two river mouths, Pennaiyar in North and Gadilam river at South in cuddalore district.

6.1.2. This is a new site in which observations are commenced from April 2000 only. Though this place was getting eroded for a long time, it attracted the attention of all during the end of 1998, when severe sea erosion had damaged more than 25 houses and uprooted a number of coconut trees. Hence as per the instructions of higher authorities, 6 new reference pillars site stretch of 750 m were erected and observations made from April 2000.

6.1.3. This coast configuration in North South direction. Wave height ranges from 0.90m to1.5m.Wave current 1.80mto 3.6ms-1 to north. This site experiences two monsoon viz., South west monsoon and North East monsoon as any other site of the East coast. The behaviour of the shore line with respect to monsoon periods are of eroding nature, but in the fair weather the accretion takes place. Tourism activity named the beach as "Silver beach".

6.1.4. The Government of Tamil nadu had constructed a coastal defensive structure RMS wall in this observation site in the year 2007 to protect the habitations of this shore. It further transfer the erosion in the down drift side of North of this shore. Long shore littoral drift is seems to be more in this region.

6.1.4. Studying the site, it is seen that just to the South of the mouth of river Gadilam the erosion is severe and its intensity reduces towards the North. The reason for this may be due to any submerged sand/rock or any other barrier in the sea in front of the river mouth, which obstructs the littoral drift, thereby causing erosion in this site. A detailed study of the site including bathymetric survey will only reveal the actual cause of erosion.

6.1.5. The behaviour o f shore line does not obey any mathematical rule, because of the complexity and interaction of factors causing and affecting the behaviour. The behaviour between the pillars too seems to be not correlating much. So the time series analyses by statistical method are not encouraging. Behaviour of the shore line for crest of berm was plotted for a span of five years and visual analysis was made. This seems to be much encouraging inferring the overall behaviour of the beach.

6.1.6. It is inferred that a beach width of about 35 m was lost during this period of observation. The range of oscillation for the entire site is about 10 mts. The spectrum of oscillation can be seen for the entire site as a whole. All the pillars are unique trend of erosion.

6.2.0 .CUDDALORE (NORTH & SOUTH):

6.2.1.This site is situated at a distance of 40 km South of Puducherry on the shoreline of Bay of Bengal. This site is split into Cuddalore North and Cuddalore South. The two rivers Gadilam and Paravanar (a drainage carrier carrying flood and irrigation water of Perumal Eri and its basin) join together and fall into the sea. There is one port maintained by Port Trust Authority. Previously fertilisers, fertiliser raw materials, minerals for SIPCOT industries were imported Rice, onions, and marine products were also exported from this port.

6.2.2. The total length of each site of Cuddalore North and Cuddalore South are 1538 meter and 180 meter respectively. Each site is having three observation points. .In this site sand dunes have formed due to accretion and displacement of sand by wind and waves. At this site there are no habitations near the sea. Only coconut farms are on the beach soil.

6.2.3. The back shore is formed as island in both the site and top soil is beach sand. The shore lays North South and such of observation is about straight.

6.2.4. This site experiences two monsoon viz., South west monsoon and North East monsoon as any other site of the East coast. The behavior of the shore line with respect to monsoon periods are of eroding nature, but in the fair weather the accretion takes place.

6.2.5. The wind and wave are characterized by monsoon of the coast. Major part of the year wind blows from South West in this site. During North East monsoon period the wind blow from north east & north direction .So also the characteristics of wave too. The average wave height is about 0.50 to 1.2 and its wave period is 6 to 18 seconds. fore shore slope observed varies from 1:1 to 1:25.

6.2.5 .The behaviour of shore line does not obey any mathematical rule, because of the complexity and interaction of factors causing and affecting the behaviour. The behaviour between the pillars too seems to be not correlating much. So the time series analyses by statistical method are not encouraging. Behaviour of the shore line for crest of berm was plotted for a span of five years and visual analysis was made. This seems to be much encouraging inferring the overall behaviour of the beach.

6.2.6. It is inferred that there is an erosion found in cuddalore North about 50m and accretion in cuddalore South about 60m. This phenomenon is due to the gryone field of port navigational channel. This man made obstruction of this groyne disturbs the littoral drift, hence this erosion in down drift side and accretion in up-drift side of south.

6.3.POOMBUHA

6.3.1. Poompuhar is a small coastal village located 22Km Northeast of in Nagapattinam District. It is situated at about 11^0 8' N Latitude and $79^0$52' E Longitude. This village was once aflourishing major and capital place for and was called as Kaveripoompattinam. There is is ample evidence that this sea port had trade link with European port and cities in those days. State archeological department conducted under coastal water survey and found sunken city about 5 km away from the present shore. Now it is a tourist place with buildings and monuments depicting the famous epic Silapathikaram, which has been constructed in this coastal village.

6.3.2.The Poompuhar shoreline is fairly straight for a few Km in length and backshore is moderately flat. River Cauvery joins the sea at a distance of about 400m South of this village. The soil in the shore consists of alluvium of Cauvery delta. The site has 7 pillars covering a stretch of 1905 m. Two pillars are in south of Cauvery confluence point and remaining in north.

6.3.3. Considering the second lap of period of observation i.e.1988 to 1995, pillar observation at P3 reveals the highest erosion and the reach between pillars P7, P6, P5, and P4 shows erosion of an average of 2.40 m/year. At pillar P2 there is erosion. From the plan it can be seen that the heavy erosion at P3 may be due to Cauvery river

flow entering into sea and due to this, accretion is taking place at P2 due to North East monsoon winds and drift taking place. The reach between P4 to P7 experiences a steady rate of erosion. Since erosion is a steady state in this coast, immediate coastal defensive structure RMS wall was carried out for the reach between P7 to P4 to save the beautiful monuments and structures constructed here which in turn promotes tourists attraction.

6.3.4. The wind and wave are characterized by monsoon of the coast. Major part of the year wind blows from South West in this site. During North East monsoon period the wind blow from north east & north direction .So also the characteristics of wave too. The average wave height is about 0.50 to 1.2 and its wave period is 6 to 18 seconds.fore shore slope observed varies from 1:1 to 1:25.

6.3.5. .The behaviour of shore line does not obey any mathematical rule, because of the complexity and interaction of factors causing and affecting the behaviour. The behaviour between the pillars too seems to be not correlating much. So the time series analyses by statistical method are not encouraging. Behaviour of the shore line for crest of berm was plotted for a span of five years and visual analysis was made. This seems to be much encouraging.

6.3.6.It inferred that the oscillation range of the entire site is about 30m. A beach width of about 100m was lost slowly. The average estimated erosion is about 1.50m per year.The spectrum of oscillations are not unique. The erosion is due the submerged structures, which affect the littoral drift of this shore. The sub marine canyon may also be the reason for this erosion.

6.4.0.THARANGAMBADI (TRANQUEBAR):

6.4.1. Tharangambadi is a small village about 30 Km East of Mayiladuthurai in Nagappattinam district. It has historical and archaeological importance. It is situated at about 11^0 03' N Latitude and 78^0 85' E Longitude. This village was once under the control of Danish administration in the pre-independence period to protect their trade in during the time of 15^{th} century A.D. Only fishing is the major activity in this area. There is no river mouth at the site observation. However, flows at a distance of about 3 Km South of this village.

6.4.2. The data of Coastal observation is collected for a length of 760 m with six observation pillars, two in the South of Masilanathaswami temple and four in the North of it. According to the storm tract details, this coastal region which is very near to Nagapattinam has been exposed to severe Cyclonic storms in the years such as 1972, 1977, 1993, etc. Due to Northeast monsoon, this shoreline gets eroded mainly during the period October to January. This shore was much evaded by 2004 TSUNAMI.

6.4.3. From the study of shoreline changes from 1978 to 2010, it is found that the shoreline suffered cumulative erosion. The sea has advanced towards land nearly 30 m to 40 m within a period of 30 years. However it is

interested to note that there is comparatively less erosion at the observation points P1 & P2 which are to the South of the damaged massive brick wall, when compared to the erosion at the observation points P3 & P4 which are on the Northern side of the massive brick wall. But since 2005, accretion is seen at pillars P1 & P2. This shows that the massive brick wall acts as a groyne or as a littoral drift barrier and is also contributing factor for the heavy erosion on the Northern side.

6.4.4. By visual inspection, it is seen that extensive damage has been caused by erosion to the Masilanathaswami temple which, was constructed 600 years back by the Pandian king "Kulasekara Pandian". The houses to the North of the temple and the village Pattinacheri were also eroded sevearly. Presently coastal defensive structure RMS wall has been put off to protect these shore habitants.

6.4.5.The shore line lies north south and the beach observation is a zig-sag line.Fore shore area is of beach mineral sand with a slope varies from 1:10 to 1:30.Wave height observed from 0.50m to 1.10m at an interval from 6 sec to 12 sec.

6.4.6. The wind and wave are characterized by monsoon of the coast. Major part of the year wind blows from South West in this site. During North East monsoon period the wind blow from north east & north direction .So also the characteristics of wave too.

6.4.7. The behaviour of shore line does not obey any mathematical rule, because of the complexity and interaction of factors causing and affecting the behaviour. The behaviour between the pillars too seems to be not correlating much. So the time series analyses by statistical method are not encouraging. Behaviour of the shore line for crest of berm was plotted for a span of five years and visual analysis was made. This seems to be much encouraging.

6.4.8. The spectrum of oscillation as whole was seen for the entire site. The pillars behaviors are uncertain and their fluctuation is different, this may be due to sunken structures in the in shore of this beach which disturb the littoral movement.The average beach width is about 50 m.The oscillation range for the entire site is about 10 m.The average estimated erosion is 1.0 percent.

6.5.0.Nappattinam

6.5.1.Nagapattinam is a district headquarters of Nagapattinam district. Its geographical location is 10^0 46' N Latitude and 79^0 51' E Longitude. This is a coastal town having a small port and customs office. The port is situated in the river mouth of . Fishing is the main activity now carried out through this river mouth.

6.5.2. The shoreline lies North to South and almost a straight one. The total length of observation is 4270 m and the total numbers of observation pillars are six. The backshore of this site is almost flat. This coast is the target point for most of the cyclones crossing the shore. Hence, the shoreline gets affected during the cyclones and especially during the Northeast monsoon. However, it gets restored afterwards by accretion.

6.5.3. The shore is almost flat compared to the fore shore area. The topsoil is only beach sand and the earth crest will be alluvial deposits. The surrounding land forms are also flat, So during North East monsoon months there is a sheet of back water stretching to 2 Km south of port in Accarapet village.

6.5.4. In the month of Nov. 1995 due to heavy monsoon rain the river course was about to change from its original curved path. It was about to cut its course (into sea) at the right of pillar point P4. Urgent protection works by the public, fishermen and officials have saved it from doing so. If it had happened, the function of the port would have been affected. Nagapattinam district was the worst affected, with an estimated 6,063 people were killed. The Tsunami uprooted their routine lives and left a trail of profound human tragedy. The disaster has imposed a huge burden on the community, not only in physical terms but also in the psychological trauma experienced. The tsunami devastated coastal communities, killing thousands of people, the majority being fisher folk. In addition the waves destroyed houses, boats, fishing equipment, agricultural land and salt pans, thereby wiping out many thousands of livelihoods. It is estimated that 196184 people of this district was affected, 36860 houses were damaged.

6.5.5.From the observations made so far, this shoreline is a stable one irrespective of erosion due to North East monsoon winds, cyclones and heavy floods in the river Koduvaiyaru. However in the post monsoon period the erosion was restored by the way of accretions and forms a stable shoreline. The sea in this area is comparatively deeper than other places in this district. The shore has been protected by RMS sea wall except in the reach observation pillar p1.There is two groynes to facilitate the marine vessels navigation channel to the port. By this there is an accretion in south of navigational channel.

6.5.6.The wave height observed is 0.40 to 1.0m with an interval 6 sec to 15 sec. fore shore slope is 1:10 to 1:25.The winds are characterised by monsoon of this coast.

6.5.7. The spectrum of oscillation was seen as a whole. The pillars behaviour are unique. Beach width of this site is 70m.The range of oscillation is observed to about 15 m. Rate of erosion is 0.50 m.

6.6.0. VELLANKANNI.

6.6.1. This site is situated at a distance of about 10km from Nagapattinam and its geographical location is 10^0 45' N latitude and 79^0 51' E longitudes. The observation site is about 1549 m with a total of six observation pillars.

6.6.2.River Vellaiyar joins the sea at this place. The backshore of the seacoast of this site is almost flat and hence forms a sandy beach for the devotees coming to worship Mary Madha. The shore lies North to South and the river Vellaiyar runs perpendicular to the coast. Since this river drains a major area of inland and carries lot of sediment. Hence the river mouth often gets changed leading to erosion of shore. Sand dunes to a height of 6 to 8m have been formed at the river mouth and a village called Kilcheruvai is also located in one of these sand dunes.

6.6.3. The site has been added since 1988. The area between P1 to P2 is relatively unaffected. Between P3 to P7 there is a lot of variation in shoreline, which is mainly due to the entry of the river Vellaiyar into the sea in this area. Erosion takes place in the Northeast monsoon period and it will be compensated by accretion in the later period.

6.6.4.This shore was severely invaded by 2004 Tsumami. Fortunately this was happened next day of Christmas events, on that day more than a lakh of people have had their bath in this shore in front of Virgin Mary church. However during the period of July 2005, due to a cyclone that crossed near Andhra Pradesh the sea waves went high causing serious erosion at pillar P5. The village named Kilcheruvai which was located on a huge sand dune was seriously affected with about 10 to 12 houses washed away by the backwaters. The river Vellaiyar has taken a curved path towards Southern side thereby eroding this sand dune. However, now there is accretion takes place.

6.6.5. Like other sites this site is also experiencing two monsoons.The wind and wave are characterized by monsoon of the coast. Major part of the year wind blows from South West in this site. During North East monsoon period the wind blow from north east & north direction .So also the characteristics of wave too. The wave heights visually observed, it varies from 0.40m to 0.70m with an interval of 3sec to 6 sec. Fore shore slope is 1:10 to 1:20.

6.6.7. The graphical configuration of observed readings shows an average beach width of 150m and the range of oscillation is 20m in this site. Rate of erosion is 0.70m.

6.7.0.KODIAKARI(POINT CALIMERE)

6.7.1 This site is situated 11Km South of Vedaranyam town. Its geographical location is 10^0 17' N latitude and 79^0 53' E longitudes. The shoreline of this site lies east to West and the reach of observation is exactly in a straight line. The total length of observation is 966m. Six nos. of observation pillars have been erected with three pillars on either side of the fishing port jetty located here. The intervals between the pillars are approximately 200m.

6.7.2. This shore lull the National marine zoological park sea. This coast is famous for wild animals and bird's sanctuary for all along the forest surrounded in this area. Bird's migration during monsoon will be a interesting one. The people make their living by collecting salt and fishing in small boats.

6.7.3. The back shore is slightly reverse slope compared with fore shore. The top soil is fine sand along the fore shore. The surrounding land forms level permits the sea water to ingress; this pattern is useful for salt pans in manufacturing the food salt. The beach sand size varies for 0.2mm to 1.8mm D50 size is from 0.3mm to 0.5mm.

6.7.4. This sea is very calm in all periods except during monsoon. During north east monsoon the sea water enters the village and disturb the salt pans. The wind and wave characterized by the monsoon of the coast. Major part of the year, winds blow from south west. During North east monsoon period, the wind blows from

North East and north directions. The average wave height is about 0.20m to 0.70m with an interval of 6sec to 12 sec. The fore shore slope varies from 1:20 to 1:40.

6.7.5. Visual interpretation is made on the graphically plotted values of observations of crest and berm at each pillar. The average width of beach is about 100m and the range of shore line oscillation is 15m.The spectrum of oscillation was seen as a whole, it shows continuous trend of accretion. The rate of accretion is 1.5m percent

6.8.0.AMMAPATTINAM.

6.8.1. This site is Ammapattinam site is situated at a distance of about 90 km Northeast of Ramanathapuram on the shoreline of . Its approximate geographical location is 10^0 1' N latitude and 79^0 13' E longitudes. The people make their living on fishing activities. This site is vulnerable for depressions and storms in the . The total width of the site observation is 3700 m. The total numbers of pillars are fifteen. The average wind speed is about 10 to 29 Km/hr in this site.

6.8.2. Generally the prawn farm owners pump sea water for prawn culture disturbing the shoreline. Also the salt producers encroaching the shore lands and produce salt in a high quantity. Peoples of this site make their life by fishing and salt manufacturing. The sea is very calm. This shore environs with coconut trees and salt pans. This experiencing monsoon as like that of other shore of this coast. South west tidal current contributes more marine wealth to this shore people. The near shore sea floor is very shallow in this region. Fore shore slope observed is 1:7 to 1:10. Beach is with the sediments of fine sand mean value varying from 2.63 to 3.45 in both fore shore and back shore regions.

6.8.3. The wave action is baffle by the adjoining Palk bay and the island Srilanka. During cyclonic weather the wave dynamics often increase the southerly drift, sediments from the northern part are carried by the currents to the south and accretion takes place. There is no riverine discharge in this site.

6.8.4. Wave height was visually observed it varies from 0.10 m to 0.30 m with an interval of 4 sec to 15 sec. The wind direction is characterised by monsoon.

6.8.5. The behaviour of shore line does not obey any mathematical rule, because of the complexity and interaction of factors causing and affecting the behaviour. The behaviour between the pillars too seems to be not correlating much. So the time series analyses by statistical method are not encouraging. Behaviour of the shore line for crest of berm was plotted for a span of five years and visual analysis was made. This seems to be much encouraging.

6.8.6. The spectrum of oscillation of shore line was seen as a whole by plotting the observed crest of berm values of this site. Accretion trend continuing at the rate 0.20m per year. The beach width observed is about 25 m. The oscillation range is 5 m in this site

6.9.0.NAMBUTHALAI

6.9.1. This site Nambuthalai is a new site. The observations were taken from January 2005 only. It was proposed to construct a rubble mound sea wall in this sea shore in the National Coastal Protection Project (NCPP) work. Hence the Chief Engineer, Design Research & Construction Support, Chennai had inspected the site on January 2005 and given instructions to take coastal observation reading in this site from January 2005 onwards. This site is located at a distance of 50 Km from Ramanathapuram near Thondi in the shoreline of . Its approximate geographical location is 9^0 3' N latitude and 79^0 2' E longitudes. The total length of observation is 1200 m and seven reference points has been marked to take readings.

6.9.2. The sea advances towards the village and touch the road side. During the monsoons the sea water intrudes into the buildings and huts situated along the shoreline. Most of the people in this area make their livelihood by fishing activities and they built their house jut on the shore.

6.9.3. There is no riverine system drains in this shore. The sea is calm and experiencing north east monsoon, on those days sea water flux into salt pans and into the houses in the near shore region. The visual observation of wave height is varies from 0.10 m to 0.30 m with an interval of 5 sec to 20 sec. Fore shore slope is 1:5.

6.9.4. The beach spread with fine sand and flat shore The wave action is baffle by the adjoining Palk bay and the island Srilanka. During cyclonic weather the wave dynamics often increase the southerly drift, sediments from the northern part are carried by the currents to the south in addition to the northerly drift from Palk Bay located to south. This stretch of coast is very swampy, with wave shadow conditions and no riverrine discharge, the sediments carried by eaves and long shore are continuously being mixed. The combination of various mode of transport may lead to poorly sorted sediments.

6.9.5. The graphical configuration of observed crest of berm detail was seen to assess the spectrum of shore line oscillation, it is better to understand than mathematical calculations. The average beach width observed is about 30 m and the range of oscillation is 5 m. Rate of accretion of this site is 0.50 m percent per year.

6.10.0.MANADAPAM.

6.10.1. This site is situated at a distance of 40 km East of Ramanathapuram on the shoreline of . Its approximate geographical location is 9^0 16' (N) latitude and 79^0 12' (E) longitudes. This is a coastal town where the and meets. On either side of the road there is beach. The total length of the site of observation is 2165 m. The total number of observation pillars is nine.

6.10.2. This shoreline experiences both monsoons namely Southwest monsoon and Northeast monsoon. The wind and wave are characterised by the monsoon of this coast. Major part of the year, wind blows from south west in the site. During northeast monsoon it blows in north east and north directions. The behaviour of the shore line during north east monsoon is of the eroding nature and during the south the south west monsoon is of accretion nature. The wind speed in south east monsoon is 8 to 10 knots and in north east in 11 to 14 knots. The visual observation reveals the wave height varies from0.30 m to 0.60m with an interval of 5 to 15 sec. The fore shore slope observed 1:10 to 1:50.

6.10.3. The sediments are the finest in the entire site, with mean value varying 2.63 to 3.45 □ in both fore shore and back shore. Beaches are gently slope with muddy clay. This configuration of shore is useful for this area people in the boat construction. This stretch of coast line wave action has been baffled by the and the island Srilanka.

6.10.4.The observations were taken from 1978 onwards. The data for this site is taken monthly once during the First Quarter based on the Lunar Phase guided by Indian Tide Tables compiled at Dehradun. The sea shore is polluted by the waste disposal of some fish food producing companies.

6.10.5. The observed crest of berm details were plotted graphically and interpretation were made on shore line oscillation of this site. Average beach width is about 30 m. The range of oscillation is 5 m. The rate of accretion is 0.35 m per year.

6.11.0.RAMESWARAM.

6.11.1 This site is situated at a distance of 56 km East of Ramanathapuram on the shoreline of Palk Bay. Its approximate geographical location is 9^0 17' N latitude and 70^0 19' E longitudes. Rameswaram is a coastal town and a revered, sacred pilgrimage centre surrounded by sea forming. Lord Ramanathaswamy temple has been visiting by the peoples from different corners of and for holy bath in this sea. This place was very important in Epic literature Ramayana now one of the famous tourism centre in .

6.11.2. The peoples of this site make their live hood by fishing and mainly depend on the famous temple. More number of launch occupying this coast in fishing activity. The port of this shore is used to link the Thalaimannar of Srilanka.

6.11.3.The back shore area is with mild slope comparing with coastal front. The top soil in the nearby vicinity is only beach sand and the crest will be of alluvial deposits. This shore lays North East- South East and the reach of observation is not straight but slightly curves.

6.11.4. This shore line experiencing North East as well as South West monsoon. The eroding nature envisaged during north east monsoon and accretion in southwest monsoon.
6.11.5. The wind and waves are characterized by the monsoon of the coast. South west blow takes place in this site except North East monsoon, in that period wind blows from northeast and north directions. The visual observation of wave height of this site is varies from 0.30 m to 0.80 m with an interval of 5 to 20 sec. Fore shore slope is 1:10 to 1:50.

6.11.6. Graphical representation of crest of berm details was visually analyzed and conclusion was arrived. The beach width observed to an average of 30 m. The spectrum of oscillation was seen as a whole, it shows the pillars behaviour is unique. The range of oscillation is 8 m. Observation of shore line oscillation reveals the erosion in north east shore reach at a rate of 0.15 m per year and accretion trend in south east stretch beach at the rate of 0.6 m per year.

6.12.0.KEELAKKARAI

6.12.1. The Keelakkarai site is situated at a distance of about 17 Km South of Ramanathapuram on the shoreline of . Its approximate geographical location is $9^0$14' latitude and 78^0 49' longitudes. The people living here are employees in abroad and depend upon mainly foreign exchange. Handsome of people involved in fishing activity.

6.12.2. The total length of the site of observation is 5140 m and the total numbers of pillars are 8.The shore lies North East to South West and the reach of observation is almost straight. The sea seems to be shallow here. The shore area top soil is with beach sand and crest of alluvial deposits. Coconut forms on this beach extended up to shoreline. This site is more vulnerable for depressions and storms. Fishing jetty and light house is embracing this shore.

6.12.3. This shore experiencing two monsoons viz., South West monsoon and North East monsoon. During North East monsoon shoreline tending towards accretion and in South West monsoon erosion is happening. During fair weather season the building up takes place.

6.12.4. The winds and wave are characterised by the monsoon of this coast. Most of the days of a year south west wind blows in this shore. During North East monsoon wind blows in north east and north direction.
These phenomenon hold the wave action too and align with this. The wave height is 0.20 m to 0.50 m with an interval of 7 sec to 20 sec. Fore shore slope observed is 1:10 to 1:8.

6.12.5. Graphical representation of crest of berm details was visually analyzed and conclusion was arrived. The beach width observed to an average of 20 m. The spectrum of oscillation was seen as a whole, it shows the pillars behaviour is unique. The range of oscillation is 3 m. Observation of shore line oscillation reveals the erosion in north east shore reach at a rate of accretion trend 0.30 m per year

6.13.0.VALINOKKAM.

6.13.1.The Valinokkam site is located at a distance of 50 Km Southwest of Ramanathapuram on the shoreline of Gulf of Mannar. Its approximate geographical location is 9^0 13' N latitude and 78^0 46' E longitudes. The people's profession in this area is only fishing. This site is more vulnerable for storms and depressions. The sea water

depth immediately increases nearly 60 feet even within 10 mts from the shore. The total length of the site of observation is 7360 m and the total number of pillars is ten.
6.13.2.The Director, Institute of Hydraulics and Hydrology, Poondi has inspected the site during 1992 and given instruction to collect the data from this site. Based on the Director's order the reference pillars were fixed and the observation was started during 1992. The ship wrecking works are being done only here next to . But now the wrecking works are stopped due to the non availability of old damaged and auctioned ships. In this village the Tamil Nadu salt corporation unite and Tamil Nadu Magnesium unite are functioning.

6.13.3. The beach sand spread in back shore and nearby vicinity and the earth's crest will be of alluvia deposits. This site is vulnerable for depression and storms. This shore experiencing two monsoons viz., South West monsoon and North East monsoon. During North East monsoon shoreline tending towards accretion and in South West monsoon erosion is happening. During fair weather season the building up takes place.

6.12.4. The winds and wave are characterised by the monsoon of this coast. Most of the days of a year south west wind blows in this shore. During North East monsoon wind blows in north east and north direction. These phenomenon hold the wave action too and align with this. The wave height is 0.20 m to 0.50 m with an interval of 7 sec to 20 sec. Fore shore slope observed is 1:10 to 1:8.

6.12.5. Graphical representation of crest of berm details was visually analyzed and conclusion was arrived. The beach width observed to an average of 20 m. The spectrum of oscillation was seen as a whole, it shows the pillars behaviour is unique. The range of oscillation is 3 m. Observation of shore line oscillation reveals the erosion in north east shore reach at a rate of accretion trend 0.30 m per year

Chapter Seven
Conclusion

7.1 Sea and its coast is an aesthetic gift of nature, only comparable with majestic mountains. The sound serenity provided by the sea is one of the most sought after endowments of nature. The renewable living aquatic resources of the sea represent a unique gift of nature to mankind.

7.2.0.Diverse stakes increasingly for coastal and marine source. Rapid economical growth in recent past propelled newer and larger use of coastal zone with more ports set up. The numerous unplanned competitive economic activities have resulted in conflicts among stake holders misuse, abuse and overuse of resource and degradation of ecosystem with some pockets of coastal landscapes destroyed by commercial aquaculture.

7.3.0.The coastal area are the place where the natural disasters are also experienced. The entire East and West coast face frequent cyclonic conditions, which sometimes cause large scale damages to the coast and inland. The Tsunami, which occurred on 26th December 2004 was one of the most serious and unexpected natural catastrophes occur along the coast. The major destruction caused by this Tsunami was to the life and property located along the coast. It would take several years to restore the damages caused by this natural catastrophe. Over twenty-five percent of population living along the cost. Hence it is innovative to have a integrated sustainable coastal processes study at this time.

7.4.0.The equilibrium of the shore line configuration and coastal processes will be affected by
i) Sea level rise due to deglaciations, which cause in an increase of average sea level rise by 3.4 mm per year.
ii) Not less of beach materials due to off shore part in the on shore-Off shore transport processes.
iii) Deficiency of littoral material supply which may be due to (a) a natural barrier like coastal inlet, head lands (b) a man made barrier like groyne field jetty, navigation entry channel and sand traps (c) a large

value of materials having the coast than arriving it due to a more in sense wave climate prevailing on the coast than on the updrift beach. (d) Drying up of the source of sediment supply, ex-construction of irrigation structures discharging into count (f) Effect of different agents like waves, storm, tides, littoral current, off shore relief and beach re-action to structure.

7.5.0. So, all the factors prevailing in the coastal environments have to be studied in every possible detail to arrive at, a prediction, conclusion or remedial measures for the undesirable changes to be stopped in the shoreline. One of the methods to achieve this, in this report of shoreline changes itself has been studied in the light of elementary mathematics and statistics.

7.6.0. It is learnt that Pondichery to Cuddalore () the sediments size ranges from 0.70 to 0.99 in the low tide, mid tide and high tide zones. Because of the prevailing high wave-energy environment strong winnowing must have removed the fine sediments, leaving the coarser sediments behind on the shore. This is also evidenced by the presence of a wave cut cliff to a height of 0.75 m. formed by the erosive action of the waves. The sudden deepening and the steeply sloping nature of the steep slope of the shelf and open sea condition must have made the composition of beaches coarser in the fore shore region. However, the presence of finer sediments in the beach shore region. (2.34 to 2.68 Ó in the berms and 2.14 to 2.69 Ó in the dune is attributable to the activity of the wind, which will have carried fine sediments in suspension to the back shore from the beach ridges. The high wave energy condition is also attributable to the presence of submarine canyons in Pondichery and Cuddalore regions.

7.7.0. The observation sites from Poompuhar to Kodiakarai is in Cauvery sub basin. In this region the mean size of sediments on the foreshore ranges from 1.51 to 2.95 Ó indicating the predominance of fine sediments with an admixture of medium grained sands. The preponderance of such fine sediments is probably due to the deposition by fluvial system reworked Mesozoic and Tertiary sediments. In the backshore region the sediments are very fine, indicating the influence of Aeolian activities in transporting fine sediments in suspension and of saltation from the adjoining coastal landforms. In this region all the rivers of cauvery sub basin confluence into sea. They don't have sufficient flow and sediments. Most of the esturies are reverse esturies. In the coastal region subjected to erosion there was an olden day arrangement with two mouth channel in the shore to dissipate the high energy waves. This channels facilitate the sea water ingression during high tides and drain in low-tide. This backwater flow (the water course called as uppanar) restricted the erosion and used for navigating the marine vessels. But now the closure of mouth discarded the intended function.

7.8.0. In the region, Kodiakarai to Valinokkam sediments are the finest with mean valves from 2.63 Ó 3.45 Ó in both foreshore and backshore. Beaches are gently sloping with muddy clay. This stretch of coastline is sheltered from wave-action by the adjoining and the , the sediments there are predominantly very fine. During monsoon Southerly drift carried the fine sediments and deposited in this region in addition to the Northerly drift from located to south.

Sl. No.	Name of the site	Location		Observation Length of Beach (M)	width (M)	(M)	Co-efficient of Shoreline Oscillation	Rate of Oscillation per year (m)	
		Latitude	Longitude					Erosion	Accretion
1.	Devanampattinam	11’44’37.61”	79’47’14.32”	750	35	10	1.84	0.60	
2.	Cuddalore North & South	11’40’52.99”	79’46’17.06”	1538 180M	200	25	1.57	1.50	
3.	Poompuhar	11’8’26.08”	79’51’26.42”	1905	100	30	2.13	1.50	
4.	Tharangambadi	11’1’28.81”	79’51’22.10”	760	50	10	2.20	1.00	
5.	Nagapattinam	11’1’28.81”	79’51’22.10”	4270	70	15	2.04	0.50	
6.	Velankanni	10’40’48.95”	79’51’6.18”	1549	150	20	2.91	0.70	
7.	Kodiakarai	10’17’00”	79’53’00”	966	100	15	2.16	-	
8.	ammapattinam	10’0.55’15”	79’13”57.94”	3700	25	5	2.03	-	
9.	Nambuthalai	9’9’ 50.40”	78’38’54.64”	1200	30	5	1.56	-	
10.	Mandapam	9’17’3’01”	79’9’38.74”	2165	30	5	3.15	-	
11.	Rameswaram	9’17’50.16”	79’19’36.61”	3295	30	8	2.02	-	
12.	Keelakarai	9’13’42.32”	79’47’12.13”	5140	20	5	3.08	-	
13.	Valinokkam	9’9’50.40”	79’38’54.64”	7360	40	10	2.34	-	

Coastal processes study on shore line oscillation

7.9.0. The co-efficient of shoreline oscillation were analyzed for varies sites, it is seen that whenever the man made interference is high, the coefficient of oscillation are also high. It does not vary with the width of beach but it varies in its range according to the wind and wave climate and to the man made activities.

By this it is concluded that the study of shoreline oscillation has to be conducted with new sites until the data behaves for the properties of an optimal length of record. An integrated field study on the evaluation coastal protection works and post effects on shoreline; off-shore study on wave climate, wind set up and littoral zone to be done. Behavior of submarine canyon between Pondichery to Nagapattinam has to be studied in detail.