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Spatial and Temporal Deviation of Morphology in the South Eastern Beaches of Tamil Nadu (SE India)

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Abstract

The EOF analysis has identified most stable point (pivot point) along the beach profile about which the seasonal movement of sand in the onshore offshore direction takes place. In order to appreciate the change in beach configuration, monthly beach profile survey was carried out by the method described by Lafond and Prasada Rao (1954) and Emery (1961) between Tiruchendur and Kanyakumari beach. Based on the Beach profile measurements the changes were also critically examined and also the impact of intensive extraction of beach sand minerals along the beach profiles was investigated in order to know the morphological variation using EOF analysis. To isolate the spatial and temporal variation of beach profiles, Empirical Orthogonal Function (EOF) analysis has been carried out. The set of beach profiles was analyzed by using Empiric Orthogonal Functions (EOF) which provides quantitative results showing the spatial and temporal changes of the profiles. In order to establish the predominant causes of these variations, the relationships existing between the temporal eignfunction and the spatial eignfunction was investigated. It was found that a 99.32% of the mean square value of the profile can be explained by the first three autofunctions.

At certain locations of the study area the beaches experience erosion during the southwest and northeast monsoon seasons. The period of maximum erosion almost coincides with the onset of southwest monsoonal wave climate. The EOF analysis has identified most stable point (pivot point) along the beach profile about which the seasonal movement of sand in the onshore offshore direction takes place.

Keywords: Waves, Beach Profile, morphology, EOF analysis, SE India.

1. Introduction

The zone of land-water interface i.e., the nearshore environment forms one of the most dynamic parts on the earth's surface. Because of the proximity to ocean and land, a coast is subjected to natural events and processes common to both realms. The shape of a coast is the product of many processes; uplift and subsidence, the wearing down of land by erosion, and the redistribution of materials by sediment transport and deposition. In order to appreciate these processes, a study of beach morphology is vital. Investigations on such processes will provide basic data for formulating and evaluating beach sediment supply and coastal erosion. Devoid of such study, comprehensive coastal zone management is preposterous. The morphology of a beach is mainly controlled by wave climate, tide and sediment characteristics. An equilibrium beach results from a balance of destructive and constructive forces acting on the beach (Bagnold, 1940; Bascom, 1951; Bruun, 1954; Johnson, 1956; King, 1972; Strahler, 1966; Eliot and Clarke, 1988; Komar, 1998). Copper et al (2000) suggested that beach profiles are an important tool for understanding the long-term trends of erosion, accretion and predicting the future evolution of coastal landforms. Inman et.al, (1993) and Larson, et.al, (1999) divided a beach profile into two independent portions separated at the breaker point on realizing the fact that the forcing mechanisms landward and seaward of the breaker line area significantly different. However the state of our understanding with regards to seasonal variation and heavy mineral has lacked in quantification. An attempt has been made in this paper to establish the relation between the morphological changes in the profile responses to morphodynamic processes.

Empirical orthogonal function analysis also known as empirical eigen function technique or eigen analysis which is a powerful tool for statistical analysis and interpretation of morphological variability of beaches. The EOF analysis is an offshoot of the classical eigen value problem which arises when one tries to solve an ordinary differential equation subjected to specific boundary conditions. This technique has been applied to beach profile data by Winant et. al., (1975); Aubrey (1978); Aranuvachapun and Johnson (1979); Prasannakumar (1985); Mahadevan and Fernades (1985); Shenoi et. al., (1987); Nayak and Chavadi (1988); Hsu et.al and Hanamgond and Chavadi (1993) and helps in (i) separating the temporal and spatial dependence of the data set in which one can express as a linear combination of corresponding factors of time and space, (ii) delineation in space of the spatial location at which greater variability occurs, (iii) identification of seasonal or any other periodic variations of specific nature which is otherwise less obvious from conventional graphic analysis, and (iv) identification of the processes responsible for the beach profile changes, i.e., the presence of any specific events and their relative importance. In a way, this analysis would indicate clearly several characteristic patterns of sediment movement on the beach face, e.g., the crossshore and longshore direction (Aubrey et. al., 1980; Aubrey, 1979). Above all, the eigen functions have a physical analogue when applied to beach profile data (Winant et .al., 1975 and Aubrey, 1978).

2. Study Area

The study area is located along the southern coast of Tamilnadu State, India (Fig.1) and the southeast coastline borders the Bay of Bengal. The backshore of the beach is limited by urban infrastructures. The Mean Sea Level (MSL) is 2m above the 0m depth chart datum (CD). The local mean tidal range is 0.5m and the maximum tidal level above CD is 1m. The net longshore transport is directed to the north. The drainage pattern along the study area is controlled by minor streams like Palaiyar, Namiyar, Hanuman Nadhi and seasonal streams like Nilapparai channel and Puttanar channel. Cliffs are along the Kanyakumari coast which projects towards the Indian Ocean forming a promontory. Coastal areas of Rasthakadu and Kuttapuli have sandy beaches and some areas are rocky in nature. The study area includes a fishing harbor, mining sites, salt pans and other developmental projects like a power plant project in Kudankulam. Break waters were also constructed long ago along in the study area. Sand mining is also actively pursued along the coast (Photo.1).

Saravanan and Chandrasekar (2010) reported the monthly and seasonal variation in beach profile along the coast of Tiruchendur and Kanyakumari, India. Chandrasekar and Immanuel (2005) insisted that the recent Indian Ocean Tsunami (26 December 2004) induced sudden erosion unlike seasonal variations along the southeast coast of India. Sheik Mujabar et.al (2007) reported that the tsunami induced large amount of beach erosion along the study area. Angusamy (1998) made a panoramic classification of the beaches between Mandapam and Kanyakumari, TamilNadu based upon the beach composition, beach gradient and beach configuration. Anil Cherian (2003) reported both monthly and seasonal variation in beach profile along the coast between Valinokkam and Tuticorin, TamilNadu. Chandrasekar et al, (2001) proposed that unsystematic garnet sand mining affected the beach morphology especially the littoral zone along the coast between Periyathalai and Navaladi, TamilNadu.

3. Shoreline Configuration

In the study region, shoreline configuration is appeared to have been controlled and influenced by the predominant monsoonal wind directions of both NE and SW. Waves and longshore currents have also played an important role for shaping the shoreline. The shoreline of the study region displays a varying trend in E - W, N - S, NE - SW and NNE - SSW directions (Fig.4).

a. NE -SW Direction

This part of the coast is higher than that of any other areas in Gulf of Mannar with undulating sand hills and the hinterland mostly of reddish soil. In due south, from Periyathalai to Vatakkottai the NE - SW trend is represented by minor zigzag patterns at few places.

b. N -S Direction

The other direction of configuration is in N-S direction from Vembar - Tuticorin. Otherwise the N-S configuration is seen in the study area as a very narrow strip to fill up the gap developed between the two different configurations of NNE - SSW and NE - SW in places like Kanyakumari, Tuticorin, Navaladi and Valinokkam.

c. NNE - SSW Direction

The next prominent configuration is from Tuticorin - Manappad in the direction of NNE - SSW. The river mouth of Thamirabharani is indented with numerous creeks with a chain of backwaters running parallel to the coast. Thiruchendur is a low rocky headland projecting into the sea where, well developed marine terraces are exposed, depicting the events leading to the formations of Quaternary landform developments.

d. NE - SW Direction

From Vattakkottai - Kanyakumari, once again the coastal configuration reverts back to EW direction and finally enjoins with west coast by showing a trend of N-S direction for a smaller distance. Various natural processes are found to prevail in the coastal segment between Vattakottai and Kanyakumari.

In short, major part of the study area is aligned in the direction of NE-SW. It is worth to note that economically viable heavy minerals are found to get segregated only in this configuration. It may probably due to the role played by the NE-SW monsoons.

4. Materials and Methods

a. Beach Profile

Beach profile surveys have been carried out using graduated poles and measuring tape as described by Lafond and Prasada Rao (1954) and Emery (1961). Beach profiling was carried out every month before the full moon day at the time of lowtide to beyond the low water level as far as wading depth (photo.2). Beach morphology was monitored monthly for 12 months and seasonally from February 2005 to December 2006 at 10 locations selected in the study area. Altogether 876 surface samples were collected from dune (if present), backshore (berm), hightide zone (high water line), midtide zone and lowtide zone (low water line). From the data collected during these surveys, the monthly and seasonal beach profile variations are graphically represented to appreciate the variability in beach profile configuration. From these data, changes in the volume of sediments are calculated using a computer package to scrutinize the temporal variation.

A graduated staff of 3 m length and marked in centimetres was designed for beach profile measurements. The beach levels were taken at every 5 m interval. In this method, the horizon is viewed through a slot in a rod of convenient length (1m) and this line of collimation makes an intercept on the graduated staff held vertically at 5 m distances. The sand level of the beach was calculated after doing the necessary corrections with benchmark level. The graduated staff was moved to the next point that was at 10 m away from the station and the process was repeated. The profiles were drawn for 5 m intervals to understand the change in beach morphology across the shoreline direction.

b. Variation in Beach Profile

The monthly variation in the beach profiles along the study area is given in Table.1. Record of monthly and seasonal beach profile obtained at the 8 beaches along the study area during the period between 2005 and 2006 yield an extensive dataset that could be used to determine the variations in the beach morphology and processes responsible for the changes. The steep slope of the beach denotes long term erosion while the gentle slope point out gradual accretion. In general, these changes in beach profile configuration are related to the onshore-offshore transport of sand by waves. This onshore-offshore movement of sand was reflected in the beach morphology by the construction and destruction of the sub aerial berm growth and migration of near shore sand bars in the surf zone. The development of sand bar in the low water line during monsoon and pre-monsoon indicates the onshore-offshore sand transport.

Beach profiles respond to the overall physical energy imparted by waves and currents. There are essentially two general shapes assumed by the beach; a low energy, accretional profile and high energy erosional profile (Shepard, 1960). The accretional profile is characterised by a flat, gently landward sloping back-beach zone, a prominent berm, and a fairly steep foreshore zone. The erosional profile displays a nearly uniform and gently sloping, slightly concave upward profile. Some suffer destruction in beach morphology due to mining and other anthropogenic activities and some are free from those eco-threatening aspects. The chief factors which determine the beach profile variation are the wave climate, coastal configuration, cross shore/long shore sediment transport and mining activities in particular. The unexpected event of Tsunami on 26th December 2004 modified the coastal land forms of various parts of Indian coast. Few beaches like Kanyakumari and Vattakottai experienced the force of tsunami but due to their elevation and rocky exposure along the coastline.

c. Empirical Orthogonal Function Analysis (EOF)

The empirical orthogonal function (EOF) method is a descriptive tool which can be applied to examining the variations in the beach profiles as well as heavy mineral distribution. The theory behind the EOF analysis is proposed by (Jeroskov, 1963). The technique has been applied to beach profile data by (Winant et. al., 1975, Shenoi et. al 1987, Nayak and Chavadi 1988). The greatest benefit of the analysis is that often a huge spatial variability of the field data can be reproduced using only a few of the space vectors (Jackson 1991, Svensson 1999). Following subsection described detail mathematical description of EOF analysis. For better understanding, the entire mathematical description explained with respect to beach profile analysis.

Let P be an maximum matrix of monthly beach profile data, where m is the months and n is the profile points. It can be decomposed into linear functions of n temporal and n spatial vectors, so that the profile observation P_{ij} on a month i at the station point j as

$$P_{ij} = \sum_{k=1}^{n} a_{ik} e_{kj} \leftrightarrow P = ae^{1} \qquad \text{----------} \quad 1$$

Where a_{ik} is the element for month i in the kth time vector, and e_{kj} is the element for profile point j in the kth space vector. The space vector may be found using the correlation or the covariance matrix. The larger profile variances in the beaches have been less clear when the covariance matrix was used. Therefore, the correlation matrix was used for further analysis. Beach profile data is standardized by

$$A_{ij} = \frac{P_{ij} - \overline{P_j}}{\sigma_j} \qquad \text{----------} \quad 2$$

Where, A_{ij} is standardized data and $\overline{P_j}$, σ_j are mean and standard deviation respectively. Correlation matrix calculated with respect to time series is

$$C = \frac{A'A}{(m-1)} \qquad \text{----------} \quad 3$$

Where, C is the symmetric nxn correlation matrix. The correlation matrix can be decomposed into eigenvectors, e, and associated eigenvalue, λ (Green, P. E., 1978, Kaplan, W., 1981).

The eigenvectors are the space vectors described in equation 1, and the corresponding eigenvalue are measures of the explained variance accounted for by each eigenvector. The eigenvalue are obtained from

$$|C - \lambda I| = 0 \qquad \text{----------} \quad 4$$

and the eigenvectors through solving

$$(C - \lambda I)e = 0 \qquad \text{----------} \quad 5$$

d. EOF analysis of Beach profile data

In order to appreciate the change in beach configuration, monthly beach profile survey was carried out. The monthly fluctuation in sand volume was calculated from the profiles to understand the erosion/accretion nature of the coastal zone. To isolate the spatial and temporal variation of beach profiles, Empirical Orthogonal Function (EOF) analysis has been carried out. The monthly beach profile data at 8 locations along the study area are tabulated (Table .1), while the results of the EOF analysis are accessible from the beach profile data. The monthly variations in the volume of beach material have been documented in the Table.2.

The eigen functions are ranked according to the percentage of mean square value of the data. These percentages are accounted by each function based on the observed beach variability. The first eigen function comprehends the greatest portion of the mean square value. For example, in the present investigation, the first eigen function accounts for more than 97% of the mean square value of the data, while the second and third functions comprises the residual part (Table. 3). This implies that the contribution from the higher order functions becomes negligible and hence they have not been considered in the present study.

5. RESULT AND DISCUSSION

The first three eigenfunction accounted for 99.5% of the total variability in the beach profile data. Therefore, first three eigenfunction considered for spatial and temporal analysis. The first spatial eigenfunction (U1) represents the mean beach profile of the original data. The second spatial eigenfunction (U2) represents the seasonal cyclic moment of sediments from back shore to foreshore and offshore regions. The third spatial eigenfunction represents mean grain size variation. Similarly, the first temporal eigenfunction (V1) points out an overall accretion tendency along the profile over the study period. The second function represents maximum sediment storage along the entire period, and third eigenfunction represents moving average of the profile data.

The eigenfunctions are ranked according to the percentage of mean square value of the data. These percentages are accounted by each function based on the observed beach variability. The first eigenfunction comprehends the greatest portion of the mean square value. The second and third eigenfunction comprises the residual part. Remaining eigenfunctions have only less information ($\geq$0.01). This implies that the contribution from the higher-order functions became negligible and the data could be reliable for spatial, temporal and textural analysis.

The first three eigenvalue obtained from the EOF analysis for the data of all the profile station are listed in **Table 3**, with the numbers in parentheses representing the ratio of the eigenvalue to the maximum eigenvalue ($\lambda 1$). These data show that $\lambda 1$ is dominant over any of the other eigenvalue. Hence it is sufficient to use the spatially-and temporally-related eigenfunctions to represent the original data. The results for all the locations (Ovari, KuttanKuli, Navaladi, Perumanal, Kuttapuli, Vattakotai, Arokiapuram and Kanyakumari) are graphed (**Figure 3.a to 10.b**). EOF results of Spatial and Temporal variations of each location is interpreted and discussed.

a. Ovari

The first spatial eigenfunction (U1) at Ovari exhibits the berm, and foreshore is not presented whereas the existence of a wider low tide region can be attested. The allied temporal eigenfunction (V1) demonstrates the general trend and overall stability which indicate the possibility of the buildup of beach. The second spatial eigenfunction (U2) at Ovari indicates maximum erosion occurred from the berm to foreshore area. The distribution of second temporal eigenfunction (V2) indicates largest sediment concentration during May 2004, September to November 2004, May to July 2005 and Postmonsoon of 2006 seasons. The maximum erosion observed during June to August 2004, January to March 2005, September to November 2005 and Premonsoon 2006 seasons.

The third spatial eigenfunction (U3) shows variability in shape between profile locations. However, this function has an influence on the mean grain size along the profile line. The mean grain size in this zone shows maximum variability along the berm and foreshore regions. The inverted 'V' shape in the foreshore region represents the medium grained sediments. Third temporal eigenfunction (V3) shows monthly and seasonal changes in mean grain size between a berm and offshore regions. The Inter-annual variation is much higher during April to May 2004, August to November 2004. This may be endorsed to the irregular changes in monsoonal climate, degree of waves and hence, more dynamic changes in terms of beach sand volume and grain size.

b. Kuttankuli

The first spatial eigenfunction (U1) at Kuttankuli indicates well developed berm at the 4m and foreshore bar at 35m away from the reference point. The temporal function associated with the mean beach function (V1) points out an overall accretion tendency along the profiles over the study period. The second spatial eigenfunction (U2) perceptibly brings out the presence of erosion from a berm to foreshore regions. The second temporal function shows the maximum accretion during June to Augest 2004, November 2004 to January 2005 and pre monsoon 2006 seasons. The third spatial eigenfunction (U3) represents medium grained sediments at berm and fine grained sediments at foreshore regions. Third temporal eigenfunction (V3) indicates mean grain size irregularity varied over the study period.

c. Navaladi

The first spatial eigenfunction (U1) is given a gently sloped plot. The berm and foreshore bars are not presented. The first temporal eigenfunction (V1) demonstrates irregular variations over the entire study period. The second spatial eigenfunction (U2) shows an accretion at berm region and erosion at the foreshore region. The second temporal eigenfunction (V2) shows the maximum accumulation in premonsoon and monsoon seasons. On the other hand, erosion occurred in Post monsoon season. The third spatial eigenfunction (U3) provide positive slope, which means the entire region have fine grained sediments. Beyond the foreshore region moderate grained sediments deposited. The third temporal eigenfunction (V3) shows greatest variability of mean grain size along the total study period.

d. Perumanal

The first spatial eigenfunction (U1) represents a sand bar present at 24m from the reference point. This is due to the degree of waves and dynamic changes in terms of manmade materials. The first temporal eigenfunction (V1) exhibits irregular variations from the berm to the foreshore region. The second spatial eigenfunction (U2) shows maximum erosion in a nearshore region and increasing accretion from the berm to foreshore regions. The second temporal eigenfunction (V2) shows that erosion at pre monsoon season and accretion at post monsoon season. The third spatial eigenfunction (U3) represents moderate grained sediments occurred at the berm to the foreshore region and beyond the foreshore fine, sediment occurred. The temporal eigenfunction (V3) reflects the maximum positive variation in mean grain size during January to October and negative variation during December to March on the entire study period.

e. Kuttapuli

The result of first spatial eigenfunction (U1) shows. Kuttapuli has gently sloped beach. The first temporal eigenfunction (V1) represents the moderate variations along the study period. The second spatial eigenfunction (U2) shows the maximum accumulation at the berm (3m to 10m), and maximum erosion occurred at foreshore regions. The second temporal eigenfunction (V2) represents maximum accretion during the monsoon season, and erosion occurred during the post monsoon season. The third spatial eigenfunction (U3) exhibits the presents of moderate grained sediments at berm and fine grained sediments at foreshore regions. Beyond the foreshore have moderate grained sediments. The third temporal eigenfunction (V3) shows irregular changes during the entire study period.

f. Vattakotai

The first spatial eigenfunction (U1) represents the presence of a sand bar in 4m to 6m at berm and 28m at the foreshore region. The temporal eigenfunction (V1) shows an irregular mean sand level. The second eigenfunction (V2) indicates the maximum erosion at nearshore to lowtide region followed by accretion occurred in the entire stretch. The second temporal eigenfunction (V2) shows the maximum erosion occurred during April to August, and accregation occurred during December to March on the entire period. The third spatial eigenfunction (U3) represents fine grained sediment deposition upto the berm region and moderate grained sediments deposited occurred in between berm and foreshore regions. The third temporal eigenfunction (V3) shows the irregular mean grain size variation over the study period.

g. Arokiapuram

The result from first spatial eigenfunction (U1) indicates sand accumulation at the berm region, and the remaining beach stretch has been gently sloping environment. The first temporal eigenfunction (V1) shows the normal distribution over the entire study period. The second spatial eigenfunction (U2) exhibits the presents of erosion at nearshore to berm region and maximum accretion at the foreshore region. The temporal eigenfunction (V2) shows pre monsoon and post monsoon has erosion as well as monsoon has the accretion. The third spatial eigenfunction (U3) represents alternate changes of fine and moderate grained sediment deposition. The temporal eigenfunction (V3) shows monsoon have inverse mean grain size variation.

h. Kanyakumari

The first spatial eigenfunction (U1) at Kanyakumari shows the sand bar accumulation at the foreshore region and remaining stretch are gently sloped manner. The temporal function (V1) shows normal variation and possibility of the built up of beach. The second spatial eigenfunction (U2) shows the steep erosion at nearshore region and steep erosion in between the berm and foreshore regions. The temporal eigenfunction (V2) reveals the alternate steep variation of erosion and accretion over the entire study period. The third eigenfunction (U3) represents the fine-grained sediments at nearshore to berm region and moderate grained sediments at the berm to the foreshore region. The third temporal eigenfunction (V3) shows the irregular mean grain size variation over the entire study period.

6. CONCLUSIONS

The set of beach profiles was analyzed by using Empiric Orthogonal Functions (EOF) which provides quantitative results showing the spatial and temporal changes of the profiles. In order to establish the predominant causes of these variations, the relationships existing between the temporal eignfunction and the spatial eignfunction was investigated. It was found that a 99.32% of the mean square value of the profile can be explained by the first three autofunctions. The shape of a coastal profile can be calculated using the first spatially related eigenfunction. The equilihrium slope-elevation curves of profiles may have spatial variations, particularly for the upper part of the profiles; this indicates that this part is more sensitive to equilibrium adjustment than the lower part. The first temporally related eigenfunction fluctuates significantly, but recovers rapidly i.e. the response time is short. The second mode would be representative of the formation and erosion of a bar at the offshore end of the studied profile. The third mode is apparently related to the direction of wave incidence, suggesting a transport of sediments alongshore. This does not necessarily indicate that the main volume of transported sediment is being moved in a direction normal to the shore, since a longshore transport of sediments of stationary characteristics in time, might exist.

At certain locations of the study area the beaches experience erosion during the southwest and northeast monsoon seasons. The period of maximum erosion almost coincides with the onset of southwest monsoonal wave climate. The intravariability observed along the different zones of the study area clearly depicts the fact that these changes are probably the result of differential wave activity in the dynamic zone and associated flows, longshore currents, physical settings of the beach and anthropogenic activity that helps in transporting the sediments. The EOF analysis has identified most stable point (pivot point) along the beach profile about which the seasonal movement of sand in the onshore offshore direction takes place. The present study reveals that the curve of 3rd spatial eigen function in the beach profile is dependent of grain size variation along the study area.

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1	**OVARI**												
DRP*	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	1	1	1	1	1	1	1	1	1	1	1	1	1
5	0.68	0.7	0.5	0.25	0.29	0.8	0.42	0.47	0.37	0.2	0.5	1.1	0.45
10	0.26	0.28	0.3	-0.5	0.08	0.5	0.32	0.35	0.25	0.1	0.05	0.5	0.18
15	-0.8	-0.1	-0.25	-0.38	-0.24	0.1	0.1	0.25	0.1	-0.15	-0.25	0.2	0.05
20						-0.1	-0.38	-0.1	-0.15	-0.3		-0.2	-0.5
Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
1	1	1	1	1	1	1	1	1	1	1	1.00	1	**1.00**
0.75	0.65	0.85	0.3	0.85	0.85	0.65	0.55	0.45	0.45	0.95	0.62	0.75	0.54
0.35	0.5	0.55	0.16	0.45	0.7	0.5	0.35	0.3	0.05	0.65	0.43	0.3	0.31
-0.25	0.18	-0.5	-0.25	0.05	0.4	0.1	0.05	0.15	-0.035	0.05	0.14	0.15	-0.22
	-0.5			-0.15	-0.5	-0.25	-0.15	-0.5		-0.25	-0.22	-0.15	

(RP-Reference Point**)** (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

2	**KUTTANKULI**												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2.06	1.99	1.9	1.98	1.98	1.99	1.96	2.04	2.02	1.92	1.62	1.64	2.06
10	1.76	1.62	1.58	1.71	1.69	1.56	1.51	1.72	1.8	1.32	1.07	1.12	1.76
15	1.46	1.39	1.24	1.37	1.42	1.21	1.16	1.39	1.42	1.2	0.86	0.89	1.46
20	0.91	0.79	0.78	0.7	0.8	0.64	0.59	0.8	0.9	0.84	0.58	0.52	0.91
25	0.64	0.56	0.61	0.57	0.55	0.43	0.33	0.59	0.62	0.64	0.51	0.33	0.64
30	0.29	0.31	0.33	0.24	0.22	0.16	0.05	0.28	0.32	0.34	0.34	0.06	0.29
35	0.16	0.23	0.26	0.18	0.16	0.09	0.04	0.2	0.25	0.36	0.36	0.09	0.16
40	-0.1	-0.1	-0.12	-0.1	-0.08	-0.03	-0.05	-0.12	-0.14	-0.15	-0.15	-0.11	-0.1
Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
2	2	2	2	2	2	2	2	2	2	2	2	2	2
1.99	1.9	1.96	1.98	1.99	1.96	2.04	2.02	1.92	1.62	1.64	2.04	1.92	1.98
1.62	1.58	1.62	1.69	1.56	1.51	1.72	1.8	1.32	1.07	1.12	1.72	1.32	1.71
1.39	1.24	1.26	1.42	1.21	1.16	1.39	1.42	1.2	0.86	0.89	1.39	1.2	1.37
1.1	0.99	0.96	1.04	0.92	0.78	1.05	1.12	0.92	0.66	0.7	1.05	0.92	1.03
0.56	0.61	0.6	0.55	0.43	0.33	0.59	0.62	0.64	0.41	0.33	0.59	0.64	0.57
0.31	0.33	0.31	0.22	0.16	0.05	0.28	0.32	0.34	0.28	0.06	0.28	0.34	0.24
0.23	0.26	0.24	0.16	0.09	0.04	0.2	0.25	0.36	0.21	0.09	0.2	0.36	0.18
-0.1	-0.12	-0.13	-0.08	-0.03	-0.05	-0.12	-0.14	-0.15	-0.13	-0.11	-0.12	-0.15	-0.1

(RP-Reference Point**)** (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

3	VIJAYAPATHI												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	1.75	2.15	1.85	1.8	1.4	1.13	1.3	1.65	1.5	1.75	2	2.26	2.15
10	1.7	2.2	1.3	1.6	0.95	0.8	1.25	1.3	1.55	1.7	1.95	2.3	2.1
15	1.55	2.1	0.9	1.15	0.65	0.75	1.3	0.85	1.5	1.65	2	2.29	2
20	1.35	1.75	0.65	0.95	0.35	0.8	1.25	0.81	1.35	1.3	1.65	2.08	1.75
25	1.05	1.25	0.3	0.45	-0.2	0.45	0.85	0.3	0.75	0.75	1.15	1.8	1.35
30	0.45	0.75	-0.2	-0.6		0.05	0.45	0.25	0.35	0.25	0.55	1.25	0.85
35	-0.35	-0.5				-0.25	0.35	0.1	0.2	-0.2	-0.05	0.75	0.5
40							0.05	-0.35	-0.05			-0.05	0.3
45							-0.35						-0.2
50													

Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
2	2	2	2	2	2	2	2	2	2	2	2.00	2.00	2.00
2.31	2.4	1.85	1.65	1.44	1.55	1.9	2.25	2.1	2.36	2.15	1.44	2.70	1.96
2.29	2.35	1.25	1.35	1.2	1.6	1.85	2.15	2.15	2.35	2.2	1.37	2.65	1.69
2.16	2.25	1.1	0.75	0.63	1.35	1.6	1.85	1.85	1.95	1.9	1.19	2.60	1.41
1.95	2.04	0.65	0.25	0.23	1.4	1.15	1.4	1.7	1.5	1.6	1.03	2.30	1.08
1.85	1.75	0.5	-0.05	0.15	1.15	0.65	0.9	1.5	1.45	1.5	0.65	2.00	0.73
1.3	0.8	-0.15		-0.05	1.05	0.6	0.95	0.45	0.6	0.55	0.46	1.10	-0.10
0.4	0.4			-0.25	0.85	0.65	0.75	0.1	0.15	0.15	0.30	0.70	
-0.1	-0.25				0.35	0.1	0.35	-0.15	-0.05	-0.2	0.08	-0.20	
					-0.05	-0.2	-0.2				-0.15		
					-0.3								

(RP-Reference Point**)** (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

4	PERUMANAL												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-05**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2.16	2.09	1.7	1.45	1.3	0.6	1.42	1.7	1.75	1.95	2	1.9	2.17
10	2.18	2.06	1.1	1.15	0.9	0.5	1.4	1.67	1.7	1.9	1.9	1.88	2.11
15	2.08	1.96	0.85	0.7	0.5	0.35	1.39	1.6	1.65	1.8	1.75	1.7	2.08
20	2	1.84	0.72	0.51	0.25	0.15	1.34	1.2	1.25	1.35	1.25	1.2	2.12
25	1.86	1.69	0.25	0.1	-0.1	0.2	1.12	0.77	0.82	1.4	1.35	1.3	1.55
30	1.22	1.17	-0.1	-0.25		0.1	0.78	0.8	0.85	0.35	0.3	0.2	1
35	0.29	0.26	-0.3			-0.2	0.6	0.53	0.6	0.1	-0.05	-0.15	0.55
40	-0.08	-0.15					0.32	0.15	0.2	-0.2	-0.25	-0.4	0.3
45							-0.1	-0.2	-0.15				-0.25
50							-0.3						
												continued…	

Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	PM-06	M-06	POM-06
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
2	2	2	2	2	2	2	2	2	2	2	2	2	2
2.19	2.24	1.65	1.45	0.6	1.6	2.05	2.15	2	2.08	2.3	1.49	2.55	1.88
2.2	2.2	1.05	1.15	0.5	1.65	2	2.05	2.05	2.12	2.35	1.45	2.5	1.59
2.16	2.08	0.9	0.55	0.35	1.5	1.75	1.75	1.85	1.85	2.05	1.32	2.45	1.32
1.85	2.02	0.45	0.05	0.15	1.55	1.3	1.3	1.7	1.35	1.75	1.08	2.2	1.03
1.8	1.8	0.3	-0.25	0.2	1.3	0.75	0.85	1.5	1.25	1.65	0.77	1.9	0.71
1.15	0.85	-0.35		0.1	1.2	0.7	0.9	0.45	0.4	0.6	0.66	1	0.41
0.25	0.45			-0.2	1	0.75	0.7	0.1	0.05	0.2	0.47	0.6	0.17
-0.25	-0.2				0.4	0.1	0.3	-0.15	-0.2	-0.15	0.25	-0.2	-0.23
					0.1	-0.1	-0.25				-0.12		

(**RP-**Reference Point) (**PM-**Pre Monsoon, **M-**Monsoon and **POM-**Post Monsoon)

5	**KUTTAPULI**												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	1.95	2.12	1.85	2.03	1.97	2.28	1.69	1.8	1.9	1.9	1.8	1.95	2.45
10	1.6	2.08	1.5	2	1.94	2.07	1.37	1.65	1.8	1.8	1.9	1.85	2.32
15	1.47	1.62	1.4	1.58	1.5	2	1.15	1.73	1.97	1.9	2.05	1.95	2.16
20	1.43	1.66	1.43	1.6	1.55	2.1	1	1.77	1.95	1.9	1.9	1.85	1.85
25	1.15	1.35	1.15	1.35	1.25	1.75	0.13	1.77	1.9	1.8	1.65	1.5	1.25
30	1.13	1.33	1.08	1.28	1.23	0.97	-0.3	1.38	1.3	1	0.85	0.8	1.15
35	0.55	0.72	0.5	0.69	0.6	0.55		0.65	0.55	0.3	0.15	0.1	0.25
40	-0.24	-0.06	-0.2	-0.1	-0.2	-0.15		-0.13	-0.2	-0.15	-0.2	-0.3	-0.15
Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
2	2	2	2	2	2	2	2	2	2	2	2.00	2.4	2.00
1.64	2.12	2.2	1.85	2	1.87	2.27	2.34	2.22	2.47	2.32	1.90	3.15	2.02
1.35	1.62	2.05	1.8	1.75	1.62	2.19	2.25	2.3	2.38	2.12	2.03	3	1.79
1	1.22	1.65	1.32	1.6	1	1.95	1.9	2	2.25	2.08	1.70	2.2	1.41
0.95	0.95	1.5	1.25	1.65	0.93	1.85	1.75	1.77	1.75	1.75	1.66	1.4	1.36
0.9	0.8	1.25	1.1	1.35	0.35	1.55	1.45	1.6	1.5	1.15	1.30	0.8	1.14
0.85	0.8	1.1	1.15	0.55	-0.15	1.35	1.25	1.33	1.05	0.6	0.79	0.6	1.10
0.5	0.4	0.77	0.75	0.15		0.25	0.5	0.74	0.35	0.3	0.44	-0.01	0.62
-0.35	0.1	-0.05	-0.05	-0.15		-0.25	-0.2	-0.22	-0.05	-0.15	-0.18		-0.11
	-0.4												

(**RP-**Reference Point) (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

6	**VATTAKOTTAI**												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2.17	2.08	2.4	2.3	2.35	2.36	1.95	2.43	2.43	2.42	2.28	2.21	2.42
10	1.94	1.05	2	1.85	1.9	1.63	1.16	2.65	2.5	2.58	2.36	2.34	2.51
15	1.59	0.69	1.95	1.7	1.75	1.05	0.64	2.65	2.55	2.6	2.45	2.3	2
20	1.52	0.65	1.2	0.85	1	0.58	-0.18	2.47	2.32	2.35	2.25	2.1	1.6
25	1.65	0.75	0.7	0.4	0.55	-0.2		1.77	1.6	1.65	1.85	1.75	1.52
30	1.49	0.64	0.1	-0.25	-0.1			1.22	1.05	1.1	1.9	1.8	1.48
35	1.11	0.36	-0.1					-0.03	-0.15	-0.05	1.7	1.6	1.08
40	0.54	-0.25						-0.15	-0.25		1.25	1.1	0.8
45	-0.19										0.5	0.4	0.3
											-0.05	-0.15	0.1
												-0.35	-0.5
Feb-05	Mar-05	Apr-05	May-05	Jun-05	Jul-05	Aug-05	Sep-05	Oct-05	Nov-05	Dec-05	PM-06	M-06	POM-06
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
2	2	2	2	2	2	2	2	2	2	2	2.14	2.00	2.00
2.38	2.35	2.25	2.42	2.25	2.1	2.33	2.28	2.4	2.39	2.51	3.00	2.96	3.00
2.57	2.36	1.75	2.15	1.65	1.43	2.52	2.48	2.45	2.26	2.4	2.38	3.10	2.01
1.85	1.7	1.7	2	1.1	0.99	2.44	2.39	2.2	2.3	2.55	1.65	2.25	1.67
1.5	1.4	0.85	1.45	0.45	0.23	2.26	2.24	2.05	2.05	2.35	1.37	2.03	1.11
1.38	1.25	0.45	0.7	-0.2	-0.1	2	1.75	1	1.7	1.95	0.96	1.63	0.77
1.39	1.3	0.1	0.2	-0.35		1.5	1.35	0.85	1.65	1.85	0.98	1.52	0.56
1.09	1.1	-0.05	0.1			0.3	0.15	0.25	1.3	1.4	-0.14	1.05	-0.21
0.85	0.9	-0.2	-0.25			0.1	-0.05	-0.25	1.05	1.25		0.84	
0.55	0.8					-0.1	-0.2		0.45	0.55		-0.25	
0.2	0.4								0.1	0.4			
-0.35	-0.2								-0.35	0.1			

(**RP-**Reference Point) (**PM-**Pre Monsoon, **M-**Monsoon and **POM-**Post Monsoon)

7	**AROKIAPURAM**												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
0	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2.77	2.7	2.3	2.45	2.1	2.9	3.18	3	3.05	2.35	2.6	2.55	2.75
10	2.56	2.49	1.6	1.65	1.3	2.27	2.88	2.7	2.75	2.2	2.4	2.35	2.45
15	1.59	1.49	0.55	0.63	0.38	1.65	2.35	2.2	2.25	1.6	1.45	1.4	1.75
20	0.67	0.59	0.1	0.05	-0.3	0.82	1.83	1.71	1.75	0.5	0.5	0.5	0.55
25	0.29	0.22	-0.25	-0.2		-0.1	1	0.85	0.9	0.15	0.2	0.15	0.25
30	-0.08	-0.17					-0.1	-0.23	-0.17	-0.25	-0.25	-0.25	-0.15
Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3
2.9	2.05	3.27	2.7	2.15	2.5	3.35	3.55	2.7	2.25	2.9	2.96	2.75	2.55875
2.6	1.35	1.75	1.85	1.55	2.25	2.5	3.15	2.45	2.1	2.45	2.50625	2.45	1.82375
1.75	0.75	1.4	0.5	1.3	1.6	2.05	2.65	1.75	1.65	1.7	2.00625	1.75	0.93125
0.85	0.15	-0.1	-0.2	0.25	1.1	1.75	2.25	1.15	1	0.55	1.4325	0.55	0.1425
0.35	-0.15	-0.3		-0.3	0.75	0.85	1.35	0.4	0.4	0.05	0.6625	0.25	-0.055
-0.05					-0.35	-0.25	-0.1	-0.1	-0.05	-0.1	-0.2	-0.15	

(RP-Reference Point**)** (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

8	**KANYAKUMARI**												
DRP	**Jan-04**	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**Jun-04**	**Jul-04**	**Aug-04**	**Sep-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Jan-05**
	RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
0	4	4	4	4	4	4	4	4	4	4	4	4	4
5	4.3	3.55	3.99	3.6	3.8	3.85	4	3.8	4.07	2.7	2.85	2.35	4.16
10	4.18	2.8	3.85	3.45	2.2	3.4	3.1	2.2	3.75	2.4	2.2	1.85	3.88
15	3.7	1.2	3.42	2.1	0.95	3.2	2.22	2	3.2	1.7	1.8	1.4	3.55
20	3.23	0.85	2.7	1.85	0.8	2.7	1.72	1.8	2.4	1.2	1.4	1.1	2.9
25	2.1	0.6	0.5	1	0.75	2.1	1.4	1.25	1.6	0.9	0.9	0.55	1.5
30	1.8	0.45	0.3	0.8	0.5	1.51	1.22	1.1	1.3	0.55	0.45	0.35	1.1
35	-0.07	0.1	0.15	-0.15	-0.16	-0.11	-0.24	-0.24	-0.26	0.4	0.2	-0.15	-0.27
40			-0.56										
Feb-05	**Mar-05**	**Apr-05**	**May-05**	**Jun-05**	**Jul-05**	**Aug-05**	**Sep-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
RP	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**	**RP**
4	4	4	4	4	4	4	4	4	4	4	4	**4**	4
3.05	4.03	3.95	3.3	3.71	3.52	4.15	3.84	2.95	3.25	2.6	3.96	3.75	3.93
2.1	3.74	3	2.6	3.55	2.55	2.35	2.8	2.5	2.7	2.05	2.96	2.6	3.10
1.45	3.2	1.75	1.3	3	1.65	1.65	2.1	1.45	1.6	1.6	2.38	1.6	1.94
1.2	2.2	1.55	1.15	2.4	1.2	0.9	1.05	0.65	0.75	0.85	1.77	0.65	1.54
0.5	0.9	1.15	0.6	2	1.15	0.55	0.75	0.4	0.4	0.4	1.35	0.35	0.75
0.25	0.2	0.55	0.15	1.7	1.05	0.3	0.7	0.25	0.35	0.15	1.15	0.15	0.40
-0.05	-0.19	-0.19	-0.3	-0.14	-0.27	-0.22	-0.27	-0.17	-0.27	-0.25	0.85	-0.36	0.07
											-0.25		-0.23

(RP-Reference Point**)** (**PM**-Pre Monsoon, **M**-Monsoon and **POM**-Post Monsoon)

Table.1:-Monthly and Seasonal beach profile data along the study area

	Monthly Sand Volume Change along the Study Area (cubic metre/metre) with reference to January 2005												
	Jan-04	**Feb-04**	**Mar-04**	**Apr-04**	**May-04**	**June-04**	**July-04**	**Aug-04**	**Sept-04**	**Oct-04**	**Nov-04**	**Dec-04**	**Feb-05**
OVA	4.68	3.4	0.32	1.48	1.33	5.57	5.63	4.54	4.51	3.93	9.94	9.8	3.82
KUT	-23.8	-3.6	-8.7	-2.5	-4.7	-11.2	-17.3	-3.5	-1.6	-14.7	-29.6	-17.5	-2.6
VJP	-14.39	-4.49	-26.43	-25.16	-34.92	-29.46	-5.83	-17.54	-10.56	-17.22	-10.25	9.47	11.26
PER	12.47	1.01	-30.39	-37.25	-44.78	-38.04	-13.23	-15.9	-18.15	-12.01	-3.55	-7.94	5.08
KUP	-13.54	-12.02	-15.32	-24.9	-27.21	-12.31	-34.27	1.28	-1.17	8.58	7.87	-4.24	-16.78
VKT	-26.26	-41.04	-29.66	-42.88	-49.34	-51.69	-60.34	0.77	-5.46	-16.31	1.16	34.75	-0.32
ARO	-4.04	0.06	-14.82	-5.92	-19.79	-10.64	12.93	12.54	16.68	-3.19	1.21	-3.9	2.1
KAN	62.62	2.96	46.44	30.09	23.64	103.8	56.61	44.63	7.07	11.12	20.23	62.62	2.96

Mar-05	**Apr-05**	**May-05**	**June-05**	**July-05**	**Aug-05**	**Sept-05**	**Oct-05**	**Nov-05**	**Dec-05**	**PM-06**	**M-06**	**POM-06**
3.71	4.89	-0.16	7.34	12.51	7.83	3.34	6.29	1.07	12.21	6.40	4.50	2.34
-5	-3	-3.3	-9.5	-15.3	-2.8	-0.7	-10.2	-24.3	-4.4	-18.50	-26.70	-15.10
13.09	-25.16	-38	-43.97	-11.1	-6.05	2.24	-6.46	-4.45	-6.63	-15.28	8.89	-16.23
8.03	-25	-35.25	-49.63	-0.78	-12.45	-5.62	-0.92	6.06	-8.18	-19.23	-3.84	-19.82
-10.79	-9.89	-4.12	-6.64	-30.91	-0.56	0.04	31.7	9.58	6.41	-10.57	-7.37	-15.13
-5.38	-29.65	-30.27	-38.96	-57.01	10.91	11.33	-15.83	9.31	22.56	-23.81	1.84	-28.57
-15.71	1.63	-13.12	-11.12	3.4	14.55	-6.11	-0.07	-3.45	6.19	4.03	0.56	-8.20
55.26	49.81	12.03	107.47	85.81	81.58	41.31	34.78	38.85	23.74	66.04	14.21	27.90

OVA-Ovari , KUT- Kuttankuli, VJP- Vijayapathi, PER- Perumanal, KUP- Kuttapuli,
VKT- Vattakottai ARO-Arokiapuram, KAN- Kanyakumari

Table.2:-The monthly beach sand volume along the study area (w.r.f to Jan 05)

S. No	**Profile Station**	**Eigen values (λ)**			**Percentage of Information**		
		λ1	**λ2**	**λ3**	**λ1 (%)**	**λ2 (%)**	**λ3 (%)**
1	Ovari	0.3121	0.0193	0.008	90.235	5.5677	2.3142
2	Kuttankuli	1.4302	0.0052	0.003	99.3229	0.3608	0.2101
3	Vijayapathi	2.3508	0.0763	0.0099	96.0796	3.1195	0.4043
4	Perumanal	2.0246	0.0822	0.0173	94.7827	3.8462	0.8083
5	Kuttapuli	2.2774	0.0349	0.0128	97.4687	1.4949	0.5479
6	Vattakottai	2.5697	0.166	0.037	92.1365	5.9511	1.3283
7	Arokiapuram	3.4598	0.1353	0.0116	95.5352	3.7349	0.3201
8	Kanyakumari	5.8207	0.1248	0.0267	96.9299	2.0785	0.4454

Table.3:-First three eigen values (First three Principal components) derived from EOF analysis from eight profile station

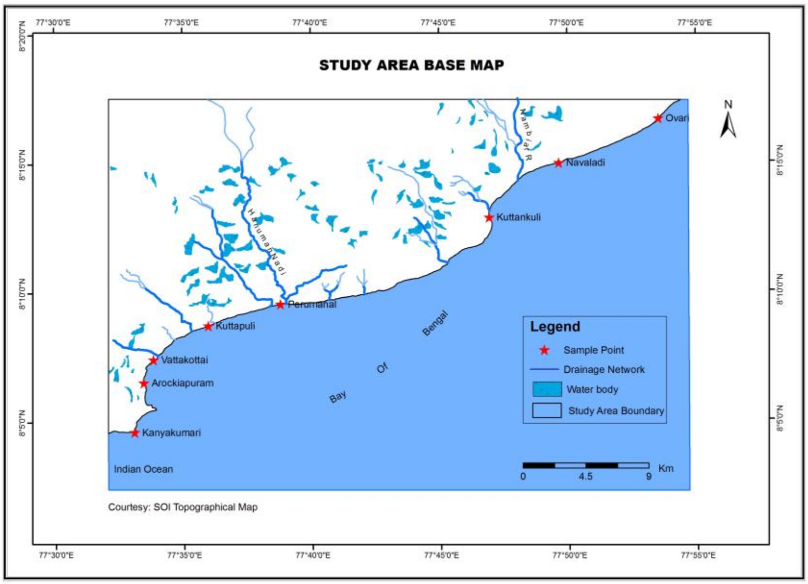

Figure.1:-Location and profile station along the study area

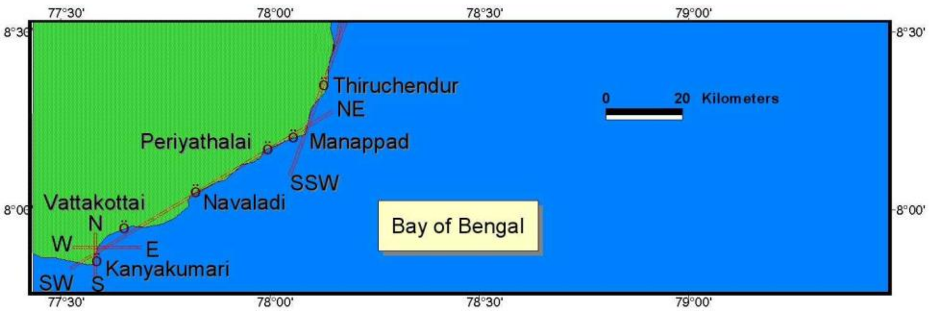

Figure.2:- Shoreline configuration along the study area

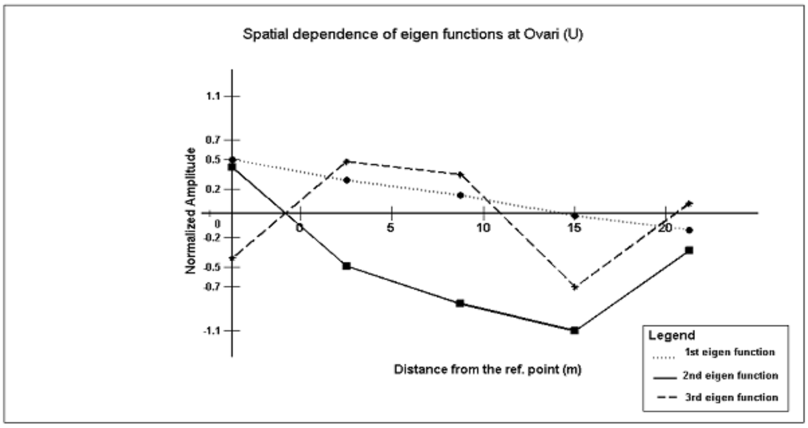

Figure 3(a)

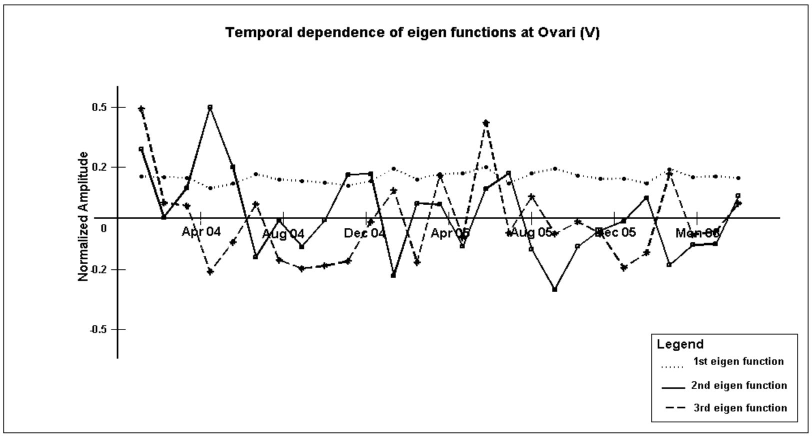

Figure3(b)

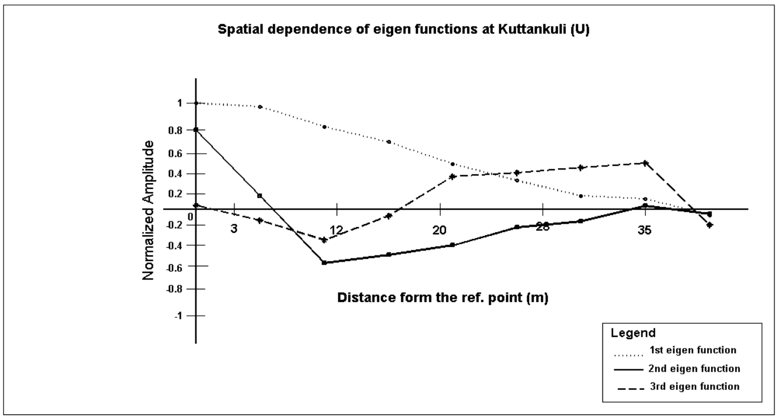

Figure 4(a)

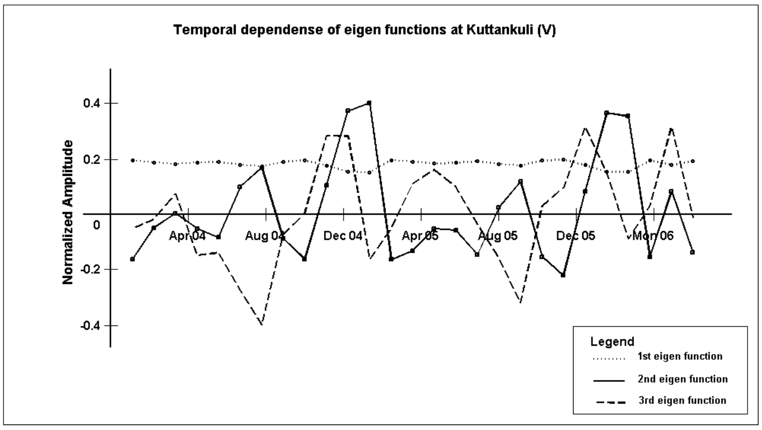

Figure 4(b)

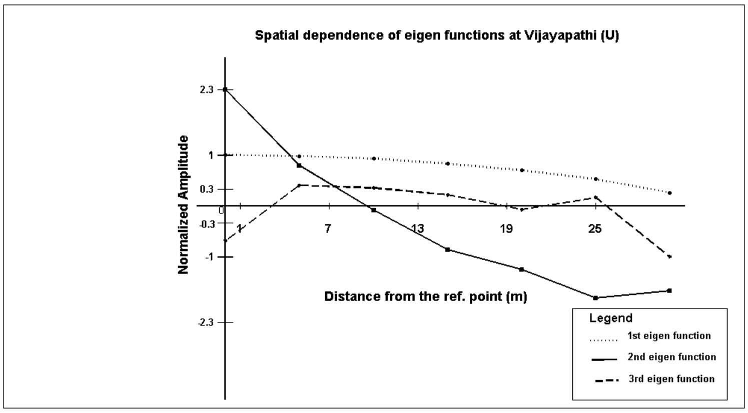

Figure 5(a)

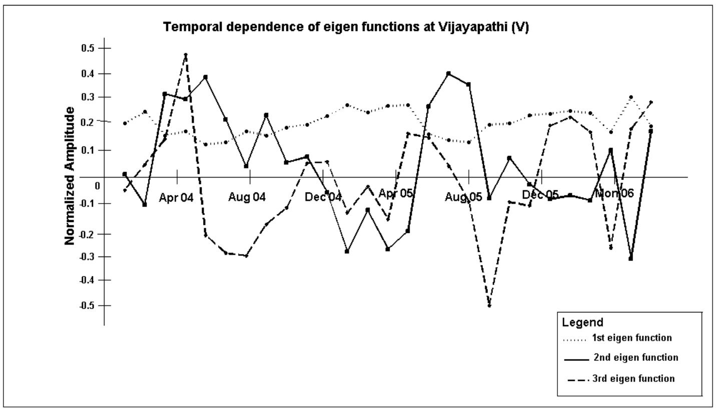

Figure 5(b)

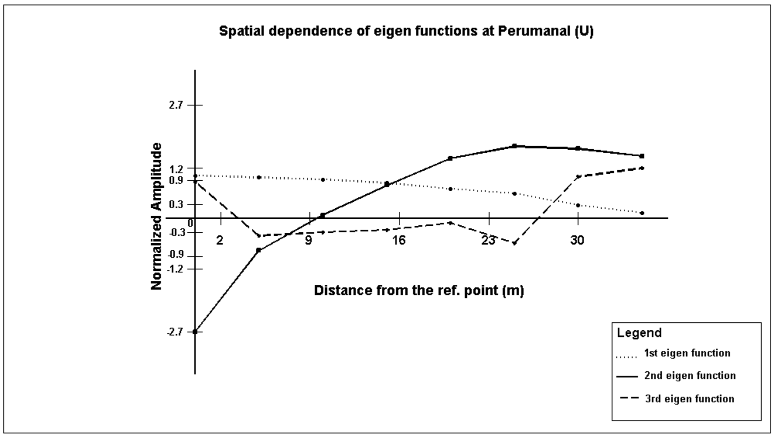

Figure 6(a)

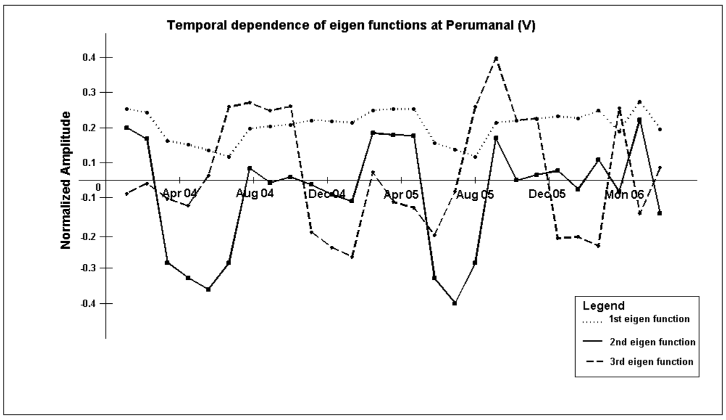

Figure 6(b)

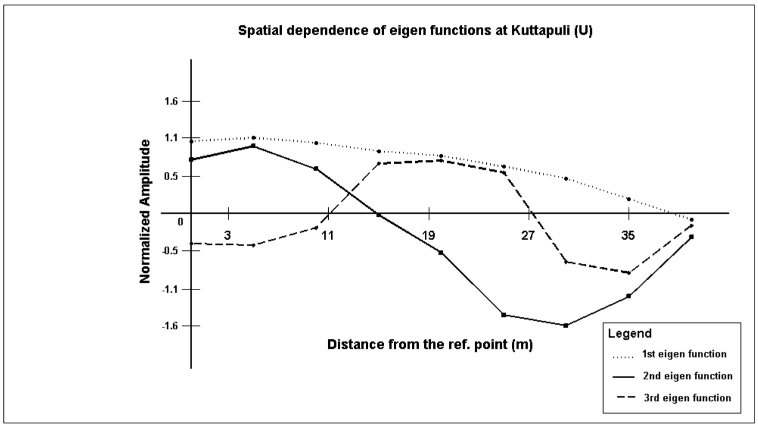

Figure 7(b)

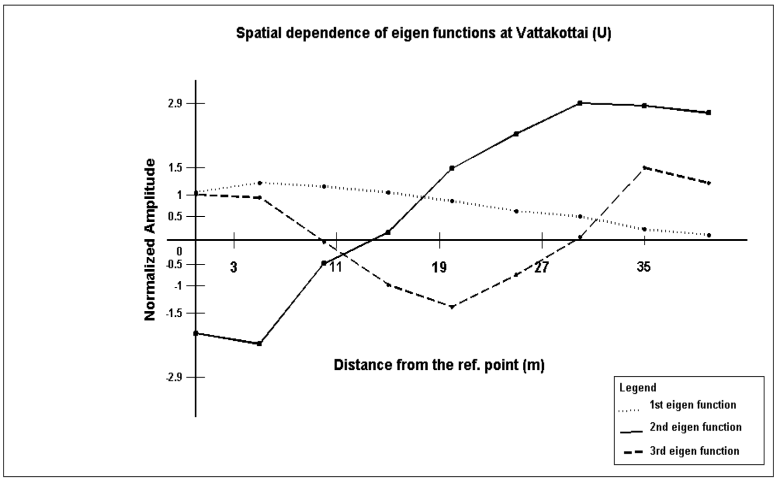

Figure 8(a)

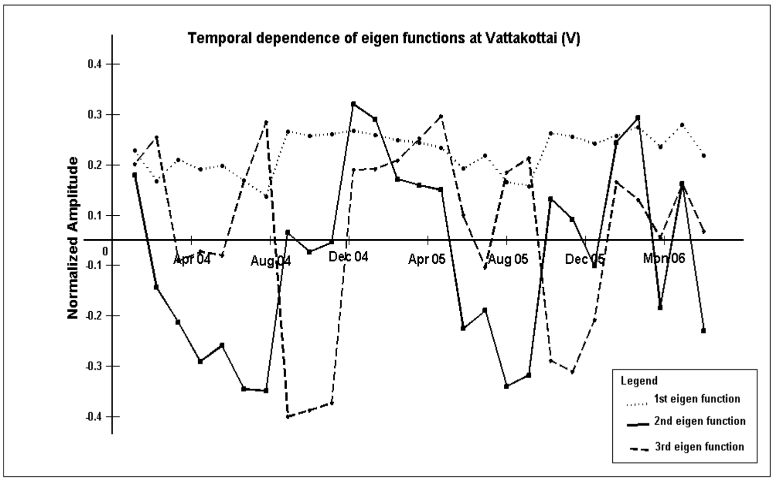

Figure 8(b)

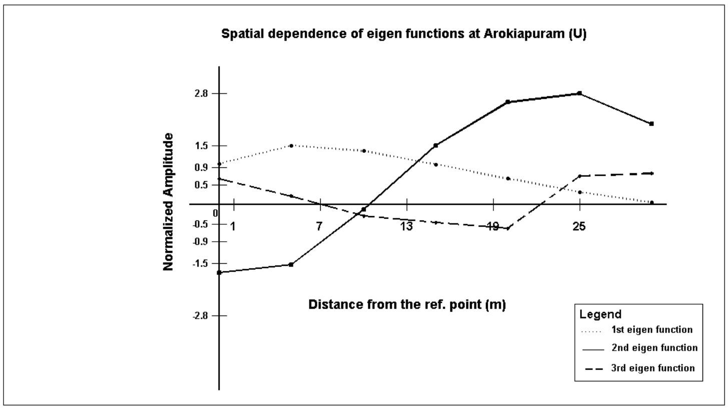

Figure 9(a)

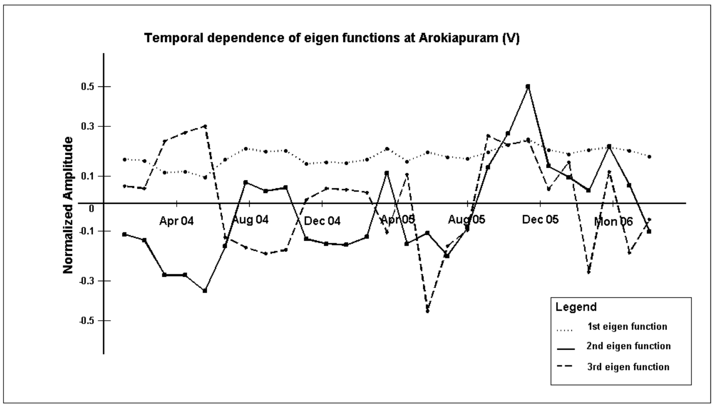

Figure 9(b)

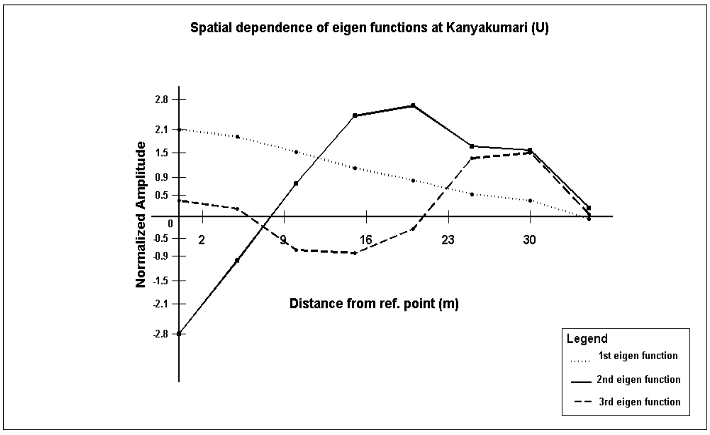

Figure 10(a)

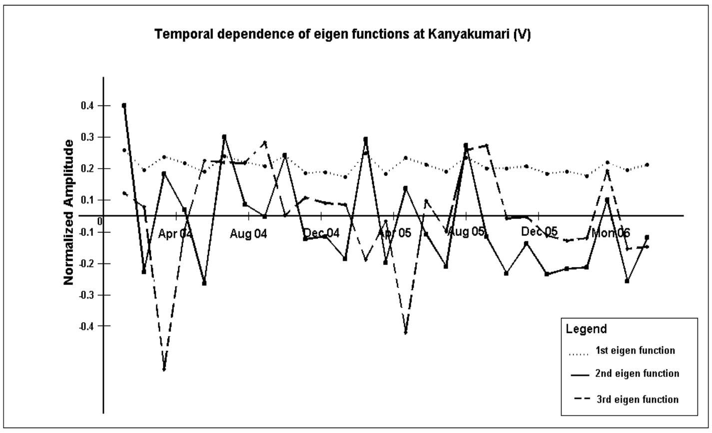

Figure 10(b)

Figure.3 a to 10b EOF results for Spatial and Temporal variations

Photo.1 After Beach Placer mining at Navaladi coast

Photo.2 Beach Profile survey along the study area