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An overview of beach morphodynamic classification along the beaches between Ovari and Kanyakumari, Southern Tamilnadu coast, India

Beach morphology relates the mutual adjustment between topography and fluid dynamics. The morphological makeup of beach systems is not accidental because the arrangement and association of forms occur in an organized contextual space and time. Since the classification derived by Wright and Short (1983) obtained from the analysis of the evolution in a number of Southern Tamilnadu beach sites, beach systems are comprehended in terms of three-dimensional morphodynamic models that include quantitative parameters (wave breaking height, sediment fall velocity, wave period and beach slope) and boundary conditions for definable form-processes association (e.g. presence or absence of bars as well as its type). This has lead to the classification of beaches into three main categories relating the beach state observations with the physical forcing (Short, 1999) dissipative, intermediate (from the intermediate-dissipative domain to the intermediate-reflective domain) and reflective modes. Morphodynamic classification of beach types was based on the equations of Wright & Short (1984) (*Dimensionless fall velocity – Dean Parameter*).

Keywords: beach, equations of Wright & Short, waves, morphodynamic, India.

1. INTRODUCTION

Beach type will occur under certain ranges of waves and grain size parameters assuming that the beach will fully respond to governing parameters which may take days (e.g. associated with storm periods) or to about a year (e.g. modifications of sediment size and type by nourishment projects) (Benedet et al., 2004). In this way limitations in applying the Wright and Short approach are recognized particularity for intermediate phases prediction. Wright et al. (1987) found only a 36% of agreement between observed and predicted beach states. This classification is quantified by means of a dimensionless fall velocity parameter, which is defined as

$$\Omega = H_b/TW_s,$$

where H_b is the wave breaking height, T is the wave period and W_s is the sediment fall velocity.

Here we describe and discuss the morphodynamics of the beaches, based on the results obtained by cross shore beach profile surveys and *in situ* observations of the beaches in the last two years. The main goal of this paper is to elucidate a beach morphodynamic sequence and classification of beaches in Southern Tamilnadu coast.

2. STUDY AREA

The study area extends from Ovari to Kanyakumari (N 78°02', E 08°54' and N 78°16', E 08°79') along the southern coastal tract of Tamilnadu State, India cov-

ering about 110 km. It falls under the districts of Tirunelveli and Kanyakumari. It is bounded in the north eastern side by foot-shaped Rameswaram Island; in the East by the Bay of Bengal; in the west by Western Ghat and in the south by Kanyakumari coast which is characterised by the confluence of Indian Ocean, Arabian Sea and the Bay of Bengal (Fig. 1). Morphometric analysis of the drainage network reveals the prevalence of dentritic to sub-dentritic drainages. Nambiyar River drains some parts of Tirunelveli district. It originates in Mayamparambur area located at the foothills of Mahendragiri and receives water from Thamarai Aru and Kombai Aru and joins at Kuttankuli. In the study region, prominent changes are observed in the bathymetry between Kanyakumari and Ovari. The wave length of the sand waves is less and in the range around 250 m and wave height is greater in the deeper part which is of the order of 2000 m in wave length. Loveson (1994) has identified the existence of different blocks on the basis of different major lineaments and the nature of variation in geomorphic landforms along this study area: (i) Thiruchendur – Navaladi, (ii) Navaladi – Kanyakumari are one of those things. Srinivasan, R. and Srinivasan, V. (1990) have divided the entire stretch of Tamilnadu coast into eight different blocks. Waves and longshore currents have also played an important role in shaping the shoreline. The coastline configuration of the study region displays a varying trend in NE – SW and NNE – SSW directions (Fig. 2).
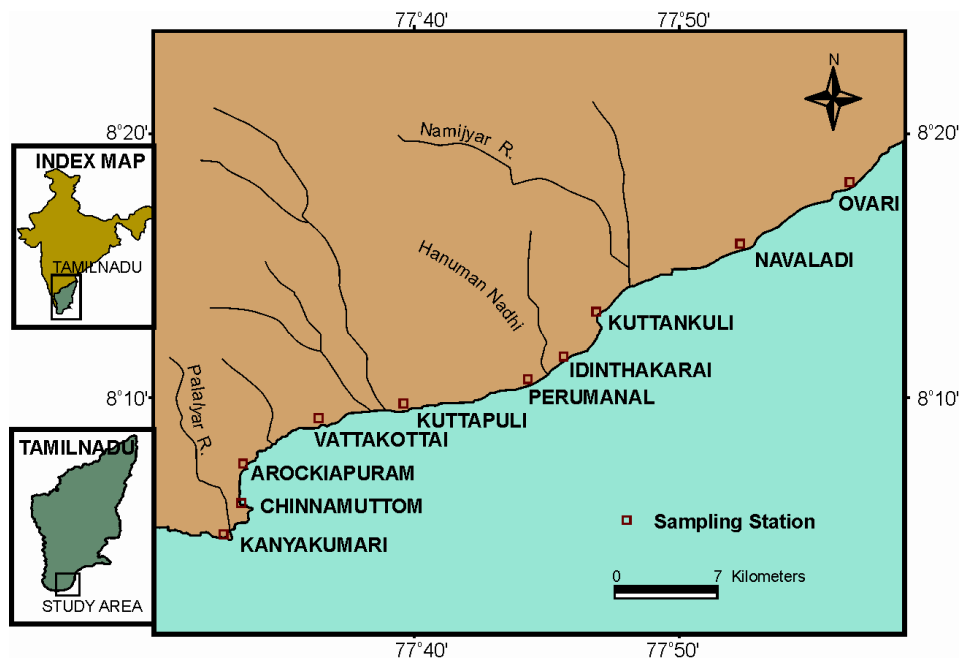

F i g. 1. Location map of the study area

Sheik Mujabar et al. (2007) reported that the tsunami induced large amount of beach erosion along the study area. Saravanan et al. (2009) reported the post-tsunami assessment 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. 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.
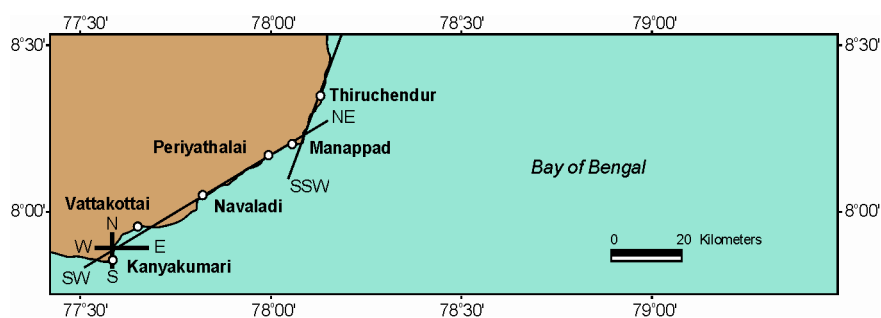

F i g. 2. Coastline configuration along the coast

3. DATA AND METHODS

3.1. Sediment characterization

A total of 122 sand samples were collected at 10 sandy beaches. Samples were taken at several cross-shore elevations in transects perpendicular to the shore at locations with different morphological features (e.g. beach face, surf domain, troughs or bars). Samples were rinsed with fresh water, dried 24 hours in the oven at 90°C and divided into sub-samples for sieving and settling analysis. Dry sieve analysis was performed using a series of sieves ranging in mesh size from 0.063 mm to 4.76 mm. Grain size distributions were determined using the GRADISTAT package.

For each fraction a textural analysis was performed. We have found a good agreement with the sediment velocity values predicted by Gibbs equation although using D_{50} sieve size and empirical sand density rather than quartz.

3.2. Classification of beaches

Beaches can be divided into various types on the basis of (i) their composition, (ii) their gradient and (iii) their configuration. Along the study area, beaches are both sandy and rocky in nature. Some are of mixed type. On the strength of the nature of rocks exposed along the beaches, the rocky beaches can be further grouped into beaches made up of (i) coralline rocks, (ii) crystalline rocks, (iii) hard calcareous sandstone and (iv) calcrete. Discontinuous exposure of crystalline rocks of khondalitic-charnockitic nature is abutting the beach segment of Ovari – Kanyakumari. This crystalline shoreline is protected by sandy permeable beaches of varying width between 30 to 100 m. The monsoonal wave climate sometimes strips off the sandy beaches, exposing the cliff face to wave attack and erosion. As a result, erosive features like kettle holes, sea caves and wave cut platforms are well developed in this crystalline shoreline. The extension of these rock exposures into offshore is also observed in certain beaches.

4. MORPHODYNAMIC STATE

Morphodynamic states of reflective, dissipative and intermediate beaches of the study area are assessed on the basis of energy regimes, gradient of the beaches, beach width, backshore width, wave type, coast exposure and morphological features in the nearshore zone.

4.1. Beach morphodynamic condition

The morphodynamic state of the beaches along the Southern Tamilnadu coast is shown in Fig. 3. A highly complex interaction between natural beach conditions such as the forcing waves, currents and winds; and the effect of man activities modify the beach morphology. Improved comprehension of the processes producing erosion and accretion has been the goal of many oceanographers and marine geoscientists. However, the relation between cause and effect is often ambiguous. Beach profile analysis assist us to understand and quantify the discrepancy in sediment level that are undergoing continuous changes in response to the environmental process variables such as wind, waves, tides etc. Major changes in sand volume on the beach tend to be systematic and can be related to the character of wave motion, tidal cycles and currents (Sastry et al., 1979). The beach profile survey also facilitates us to decipher the longshore and cross-shore sediment movement.
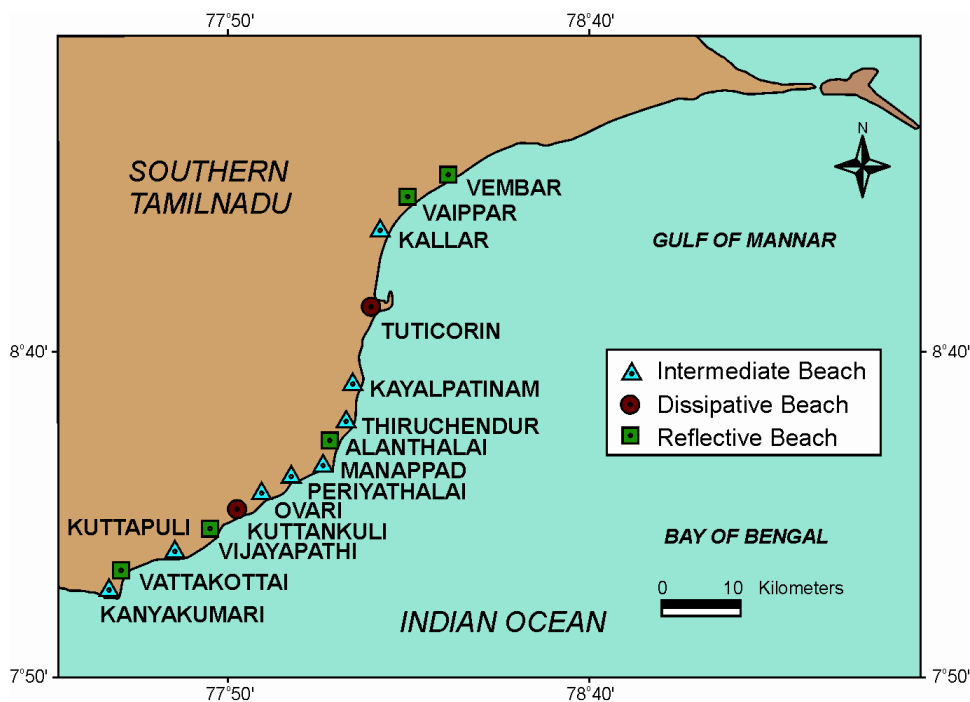

F i g. 3. Morphodynamic state of the beaches along the Southern Tamilnadu coast

4.2. Morphodynamic classification

Morphodynamic classification of beach types was based on the equations of Wright & Short, 1984 *(Dimensionless fall velocity – Dean Parameter)*. For equation $W_s = 0.06$ was considered for a medium grain size of 0.45 mm in Table 1.

T a b l e 1

Standard limit values for morphodynamic beach types and breaker type

Breaker type (Battjes, 1974)	Spilling ξb < 0.4	Plunging 0.4 < ξb < 2.0	Surging ξb > 2
Beach type (Wright & Short, 1984)	Reflective $\Omega < 1$	Intermediate $1 < \Omega < 6$	Dissipative $\Omega > 6$

4.3. Beach profile

Beach profile survey has 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. Beach morphology was monitored monthly for 24 months and seasonally from April 2005 to March 2007 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).
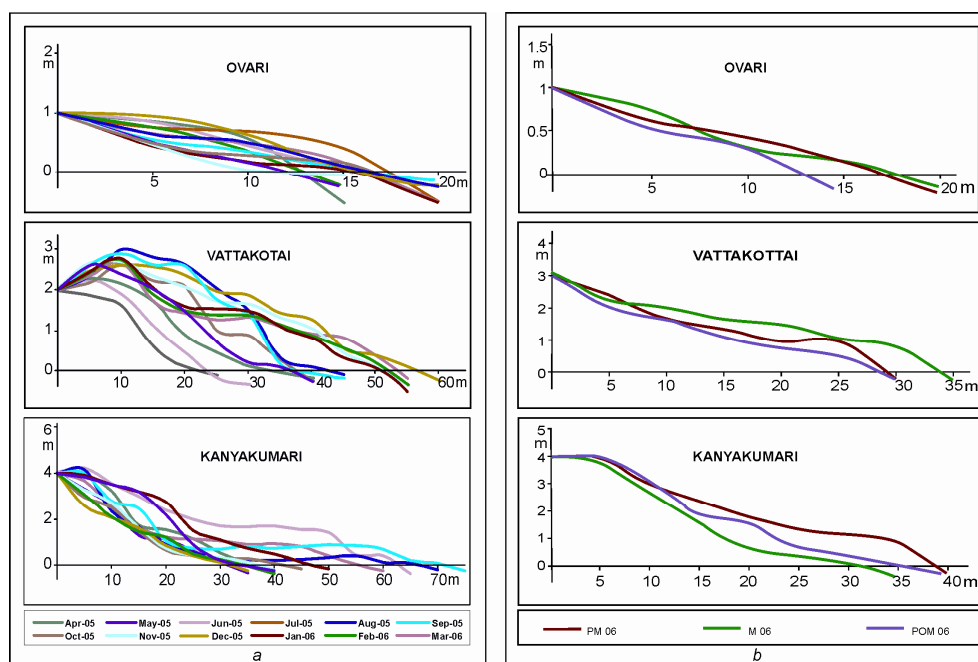

F i g. 4. Monthly (*a*) and seasonal (*b*) variations in beach profile (some selected areas; X-axis – distance from the reference point (in m), Y-axis – elevation point (in m); PM – Pre Monsoon, M – Monsoon, POM – Post Monsoon)

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 (Fig. 4, *a, b*). From these data, changes in the volume of sediments are calculated using a computer package to scrutinize the temporal variation. The study area is characterized by short term features such as transverse bars as well as long term features such as protuberances due to the presence of those offshore Islands and submerged sand shoals.

5. WAVE REFRACTION

A study of wave refraction along the beaches between Ovari and Kanyakumari has been made to investigate the changes that occur in the wave characteristics near the coast as deep-water waves of different periods approach the coast from various directions (Fig. 5, *a – e*). In the present area of investigation, the wave climate is characterized by the southwest monsoon (June – September), northeast monsoon (October – January) and non-monsoon periods (February – May). The predominant wave directions prevailing in the study region are referred in the wave atlas (Chandramohan et al., 1990) as SE during SW monsoon and NW during the NE monsoon. As the study area shows a trend of EW – NS orientation, the waves are approaching the coast predominantly from SE 45° during SW monsoon, NW 20° during northeast monsoon. Since the orientation of the shoreline along the study area is in general NS – EW direction, the waves approaching the coast between N 110° and N 135° are of greatest significance in conjunction with littoral processes.
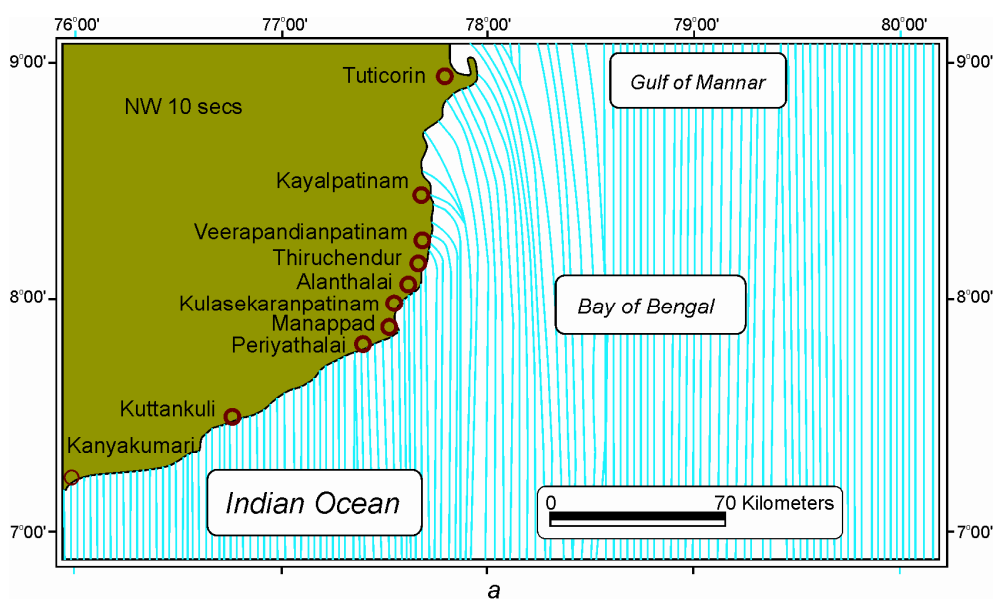

a

F i g. 5. Wave refraction diagram of the study area (see also p. 63 and 64)

b

c
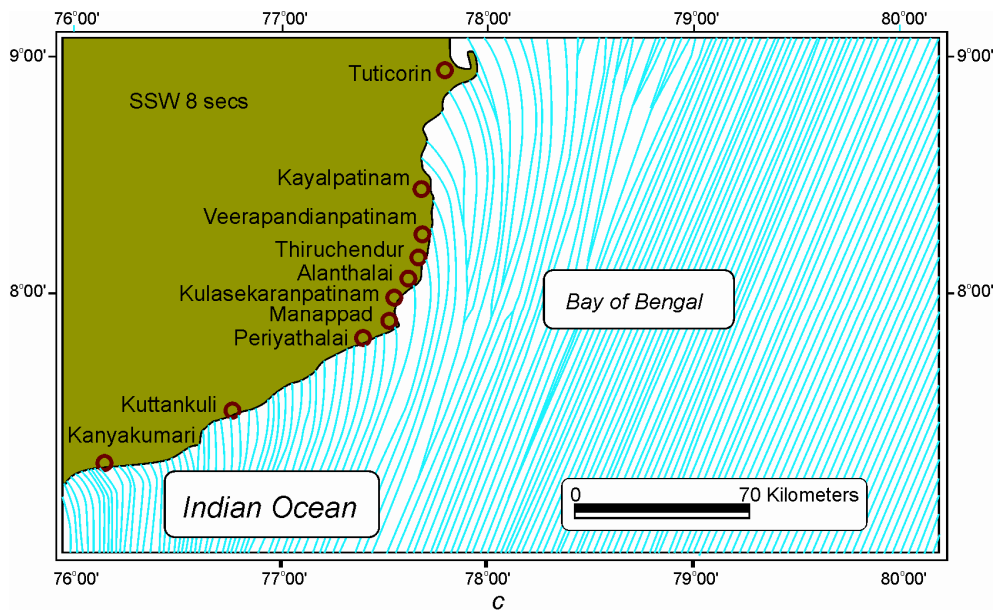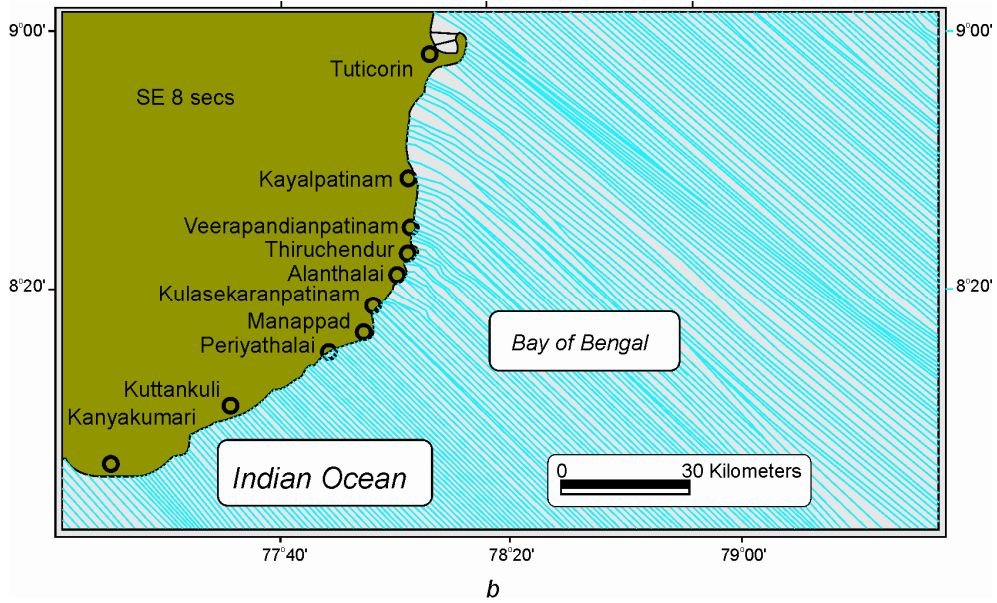
F i g. 5. Continuation
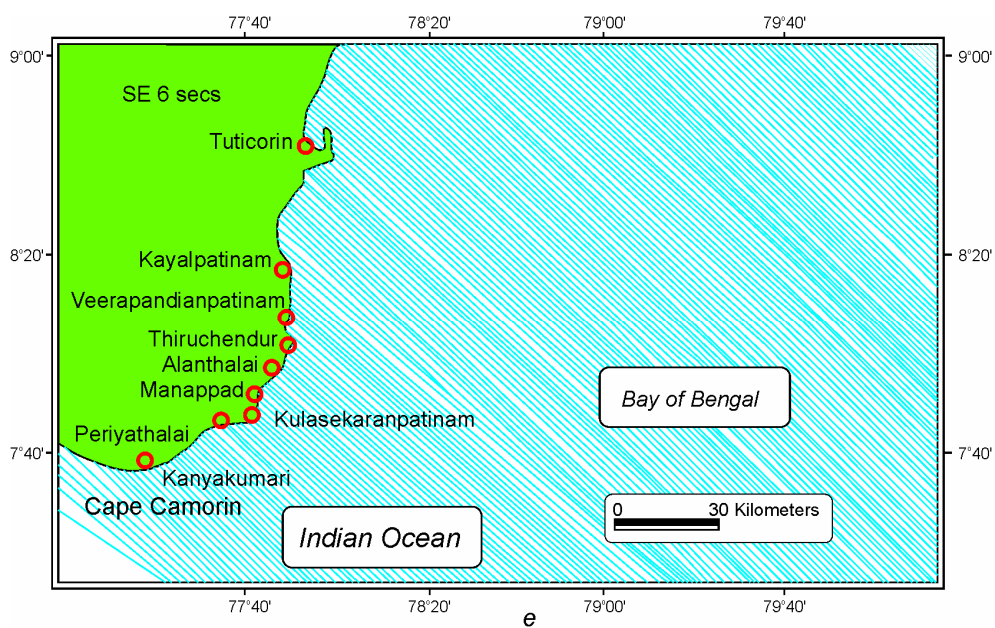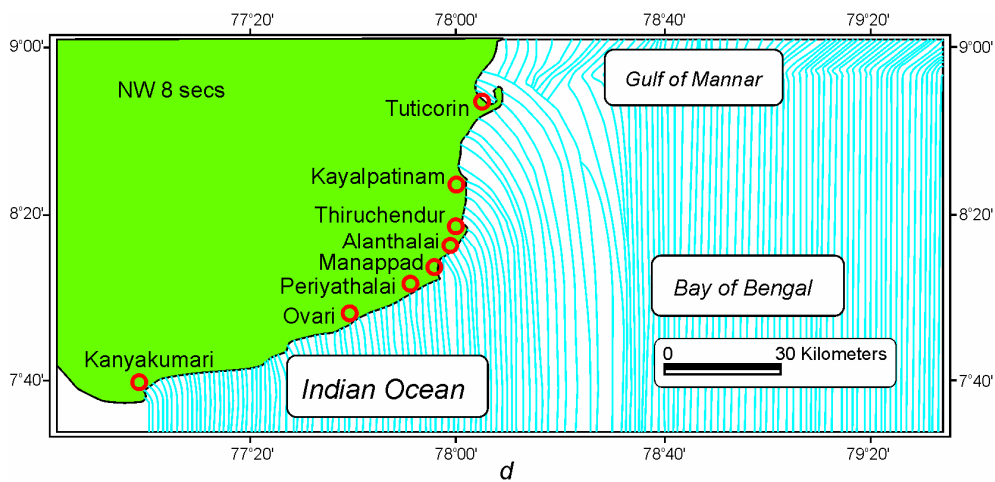
F i g. 5. Ending

Refraction diagrams have therefore been prepared for wave periods of 8 and 10 seconds approaching from N 110° and N 135° by following the Tarangam Programme. This programme was developed in the National Institute of Oceanography, Goa, on the basis of finite amplitude wave theory for computing the wave transformation factors (Chandramohan, 1988). The naval hydrographic chart (1973) was used to assess the water depth at a point for drawing bathymetric contours.

The wave refraction pattern for SE for the periods of 6, 8 and 10 sec are shown

in Fig. 5, *a – e*. The wave energy condition prevailing along the study area in different wave direction for different periods is given in Table 2. In the pattern of 10 sec the wave convergence is noticed at Thiruchendur, Manappad, Periyathalai and Vattakottai. An overview of refraction patterns of three wave periods reveals that wave energy is more pronounced and concentrated in wave period of 10 sec than the other two periods. It is also inferred that wave period of 10 sec plays a predominant role in the shaping of various landforms of depositional and erosional nature and in the redistribution of sediments.

T a b l e 2

Wave energy conditions prevailing along the study area

Station	SE			NW		SSW
	6S	8S	10S	8S	10S	8S
OVR	I	C	C	I	I	I
NAV	I	I	I	I	I	I
KUT	I	C	C	I	I	I
IDI	I	D	D	D	D	D
PERU	I	I	I	I	I	I
KUP	I	I	C	I	I	I
VAT	I	I	I	I	I	I
ARO	D	C	C	I	I	D
CHI	I	C	C	C	D	D
KAN	I	I	I	I	I	I

I – Inept Condition, D – Divergence, C – Convergence

N o t e. Here and in Tables 3 – 5: OVR – Ovari, NAV – Navaladi, KUT – Kuttankuli, IDI – Identhakarai, PERU – Perumanal, KUP – Kuttapuli, VAT – Vattakottai, ARO – Arokiapuram, CHI – Chinnamuttom, KAN – Kanyakumari.

Rajamanickam et al. (1986), Veerayya and Pankajashan et al. (1988) and Gujar (1996) have indicated from their studies along west coast of India that the predominant direction of waves in the area are from SW, WSW, W and WNW with periods ranging from 6 to 10 sec. Anbarasu (1994), Chandrasekar (1992), Angusamy et al. (1998), Chandrasekar et al. (2001) have discussed about the wave refraction pattern and its role in the redistribution of sediments along the east coast of India.

The overall pattern of wave refraction of the study area of SE direction displays strong convergence in number of beaches and the same may be ascribed to the prevalence of high energy conditions unlike the other two directions. It leads to the inference that sediment transportation and their degree of sorting are likely to be more intensive in south west monsoon period. The change of wave energy from convergence to divergence in a particular beach in different period has been attributed to the change in the quantum of sediment movement from one period to the other (Hanamgond, 1993).

The nature of cliffed coastline from Kuttankuli to Vattakottai with high order of erosion indicates a zone of high energy environment. This inference is also supported by strong convergent zones.

6. LITTORAL SEDIMENT TRANSPORT

The movement of material in this zone depends mainly on three factors: the nature of material available for transport (size and density), orientation and other features of the coast and the angle of wave approach (Swift, 1976; King, 1972). Littoral transport plays a major role in the development of certain shoreline features like spits and bars, and is causing considerable coastal erosion and accretion (King, 1974). The monthly longshore sediment transport rates estimated based on the monthly observations on breaking wave height, surf zone width and the longshore currents are presented in the Table 3 – 5. The monthly volume of longshore sediment transport rates and directions are estimated for the coast at Kuttankuli, Vattakottai, Thiruchendur, Alanthalai, Manappad, Periyathalai, Ovari and Kanyakumari.

T a b l e 3

Monthly data of long shore current (V) along the study area (m/s)

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	0.48	0.01	-0.16	-0.01	-0.18	-0.06	-0.36	-0.39	-0.43	-0.09	0.14	0.29
NAV	0.44	0.13	-0.20	-0.32	-0.22	-0.22	-0.30	-0.22	-0.32	-0.16	0.11	0.20
KUT	0.40	0.14	-0.21	-0.33	-0.24	-0.24	-0.30	-0.33	-0.33	-0.10	0.12	0.18
IDI	0.31	-0.10	-0.09	-0.07	-0.21	-0.08	-0.07	-0.01	0.03	-0.11	0.04	0.04
PERU	0.42	0.04	-0.20	-0.13	-0.26	-0.10	-0.29	-0.14	-0.34	-0.06	0.12	0.18
KUP	0.38	0.02	-0.23	-0.20	-0.23	-0.31	-0.26	-0.16	-0.32	-0.04	0.16	0.16
VAT	0.50	0.03	-0.05	-0.10	-0.01	-0.21	-0.31	-0.16	-0.30	-0.08	0.10	0.16
ARO	0.30	0.12	-0.10	-0.06	-0.28	-0.09	-0.07	-0.04	0.06	-0.13	0.06	0.08
CHI	0.39	0.02	-0.07	-0.04	-0.1	-0.07	-0.3	-0.4	0.05	-0.07	0.01	0.16
KAN	0.34	0.14	-0.04	-0.20	-0.07	-0.20	-0.30	-0.15	-0.30	-0.17	0.10	0.16

(-) Northerly direction, (+) Southerly direction

T a b l e 4

Monthly data of breaking wave height (HH) along the study area (m)

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	0.50	0.20	0.20	0.50	0.30	0.45	0.70	0.45	0.60	0.45	0.50	0.50
NAV	0.40	0.45	0.30	0.15	0.40	0.30	0.55	0.40	0.35	0.45	0.445	0.60
KUT	0.50	0.50	0.25	0.20	0.20	0.15	0.50	0.20	0.25	0.40	0.55	0.55
IDI	0.40	0.45	0.40	0.25	0.30	0.70	0.30	0.60	0.80	0.30	0.45	0.30
PERU	0.50	0.35	0.15	0.20	0.30	0.20	0.45	0.20	0.55	0.45	0.35	0.45
KUP	0.30	0.40	0.20	0.15	0.25	0.10	0.60	0.30	0.45	0.25	0.40	0.40
VAT	0.25	0.15	0.05	0.25	0.10	0.25	0.20	0.20	0.20	0.05	0.15	0.20
ARO	0.30	0.40	0.25	0.25	0.35	0.60	0.20	0.45	0.60	0.25	0.35	0.20
CHI	0.40	0.20	0.25	0.20	0.25	0.35	0.85	0.50	0.55	0.35	0.55	0.50
KAN	0.20	0.20	0.25	0.20	0.15	0.30	0.35	0.35	0.15	0.25	0.20	0.20

T a b l e 5

Monthly data of surf zone width (W) along the study area (m)

Station	A	M	J	J	A	S	O	N	D	J	F	M
OVR	18	20	20	22	15	19	18	17	20	18	20	20
NAV	19	20	16	18	17	20	16	16	20	20	20	20
KUT	18	16	15	15	20	18	17	15	17	15	20	20
IDI	13	12	12	11	12	14	13	12	14	12	12	14
PERU	17	20	15	15	20	18	17	15	17	15	20	20
KUP	20	18	15	16	17	20	18	17	16	18	19	20
VAT	16	14	18	14	14	17	15	14	17	18	16	16
ARO	20	22	20	17	19	20	17	16	18	19	22	22
CHI	17	17	16	18	17	19	20	17	20	18	20	20
KAN	16	14	13	16	15	12	14	15	14	17	18	16

In general, the sediment transport is northerly during March to October and southerly during November to February. The longshore sediment transport is higher in the northerly direction as compared to southerly direction at all locations except Kanyakumari. This occurs because the rocky outcrops shelter the Kanyakumari beach and manmade features such as harbour across the surf zone would act as a barrier and sand would be deposited on the updrift side of such barrier.

7. RESULTS AND DISCUSSION

The wave refraction analysis has delineated the different wave energy conditions prevailing in the study area. There are areas of erosion and accretion observed along the coastal stretch which depends primarily the direction of wave approach, wave period and wave refraction pattern. In the nearshore zone of present study area, the movement of sand alongshore is due to the action of waves and currents.

A complete study of wave dynamics is imperative at this instant which includes the measurement across the swash and surf zones of local sediment transport, wave height, wave energy conditions, longshore current etc., to comprehend and describe the swash processes precisely. Also the time scale of each study should be commensurate with that of the duration of the directional wave event that drives the transport. Further, emphasis has to be placed on formulating computer models to conjecture the performance of sediment movement for the development and management of coastal zone.

The direction of littoral drift is from south to north during the period of March to October when the waves are between S and SE and from north to south during the period November to February when the wave directions are between E and ENE. The seasonal changes in the direction of littoral drift with the SW and NE monsoons cause cyclic variations of the beach morphology along the coast under investigation. The rocky outcrops scattered across the littoral zone cause reversal of beach cycles at different stations along the coast. For example at Kanyakumari (October) during SW monsoon, the southerly movement of sediment is observed. The net littoral drift at all stations is generally from south to north with the exception of Kanyakumari station, where the net drift is southwards. The net erosive nature of the study area (except Kanyakumari) from March to October is due to the prevalence of high waves from S and SE directions.

Morphodynamic states of reflective, dissipative and intermediate beaches of the study area (Table 6) are assessed on the basis of energy regimes, gradient of the

beaches, beach width, backshore width, wave type, coast exposure and morphological features in the nearshore zone.

T a b l e   6

Beach morphodynamic classification along the beaches between Ovari and Kanyakumari

I. Breaker type (Battjes, 1974)	Spilling $\xi b < 0.4$	Plunging $0.4 < \xi b < 2.0$	Surging $\xi b > 2$
Locations	Kuttapuli, Vijayapathi, Arokiapuram and Vattakottai	Kuttankuli, Chinnamuttom and Kanyakumari	Ovari and Perumanal
II. Beach type (Wright & Short, 1984)	Reflective $\Omega < 1$	Intermediate $1 < \Omega < 6$	Dissipative $\Omega > 6$
Locations	Kuttapuli, Vijayapathi, Arokiapuram and Vattakottai	Kuttankuli, Chinnamuttom and Kanyakumari	Ovari and Perumanal

Dissipative beaches. The high wave energy condition with low gradient beach slope has surf scaling parameter. They have higher rate of dune and backshore recession. Dissipative beaches in the study area are composed of fine to medium sand and hence the mobility of the beaches is greatly enhanced than the higher energy conditions of the reflective beaches. Due to the repeated oscillations of high wave energy condition in the dissipative beaches, scarping of the beach profiles occur. Beaches falling under this category are Ovari and Perumanal.

Reflective beaches. Low modal wave heights and steep gradients of the beach have resulted in low surf scaling parameter. However, if the wave height increases seasonally, the beaches in these environments would be severely affected by the erosional processes. The same is attested by the present study during the northeast monsoon and the erosion sensitive concave beach profiles dominate over convex profiles. The mobility of the beaches is hindered by the coarseness of the sediments, low energy condition and steep beach gradients. Beaches like Kuttapuli, Vijayapathi, Arokiapuram and Vattakottai fall under this category.

Intermediate beaches. Intermediate domains exhibit the characters of both reflective and dissipative beaches. Moderate gradient and abundant supply of sediments are seen more with dominant alongshore movement than with onshore-offshore movement. Broad backshore width is noticed in the intermediate state of beaches in Perumanal and Vijayapathi coast. Flat and moderate beach gradient with strong rip current and well developed cusps that disappear as the reflective shoreline conditions dominate over the intermediate state are perceptible in the zeta form bay between Kuttapuli and Arokiapuram. The gradients of the beaches which are gentle with low energy conditions are seen in Ovari coast. Along with other modes of beach cuttings, rip currents developed in this coast caused the continual erosion. Along the study area such as Kuttankuli, Chinnamuttom and Kanyakumari belong to this category.

8. CONCLUSION

The morphodynamic behaviour of the beaches has been identified in the beaches between Ovari and Kanyakumari area. The different morphologies of ap-

pearance on the beaches show that the morphodynamic behaviour also has a direct influence on the wave refraction, with the mechanical processes of wave. The morphodynamic behaviour of the beaches is presented as a determinant factor which should be incorporated into the coastal recovery, in order to estimate the time of recovery of the sandy beaches and the effectiveness of the clearing methods in the most precise way. However, within the proposed model, and from the existing data, it is not possible to determine the time scale of these processes, nor the influence that the possible contributions of wave from the continental shelf would have on this natural process of sediment regeneration.

Clearly, regardless of the wave-climate strength, the nearshore zone of the coast is constantly modified, which requires the use of observation and interpretation tools with high acquisition frequencies. The complementary data provided will enable the precise determination of the energy and temporal scales to which the coastal dynamics are sensitive (for instance, the wave-action duration involving morphological changes in the intertidal domain). Also, they will allow more precise calculations of the sand-transport rate due to littoral drift. Finally, with the aim of simulating coastline morphodynamics, it will be necessary to better define the wave-height threshold beyond which the ridge morphology is modified. To conclude this paper, we must note that cross-shore morphodynamics need to be studied in order to complete the analysis of the morphodynamics of coast. In addition, the interaction between the systems must be intensively investigated.

ACKNOWLEDGEMENT

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АННОТАЦИЯ Морфология берега отражает взаимное влияние топографии и динамики жидкости. При этом морфологическое строение береговых систем не является случайным, а определяется распределением и пространственно-временным взаимодействием береговых форм. Начиная с классификации, предложенной Райтом и Шортом (1983), основанной на анализе эволюции нескольких участков пляжа Южного берега Тамилнаду, пляжные системы рассматриваются в рамках трехмерных морфодинамических моделей, включающих количественные характеристики (высоту обрушения волн, скорость образования осадков, волновой период и уклон пляжа) и граничные условия для определенных взаимосвязей береговой динамики (т. е. наличие или отсутствие баров и их тип). Это привело к подразделению пляжей на три основные категории в соответствии с их поведением по отношению к внешним силам (Шорт, 1999) – рассеивающие, промежуточные (от промежуточно-рассеивающих до промежуточно-отражающих вариантов) и отражающие. Морфодинамическая классификация типов пляжей основана на уравнениях Райта и Шорта, 1984 *(безразмерная скорость осадкообразования – параметр Дина)*.

Ключевые слова: пляж, уравнения Райта и Шорта, волны, морфодинамика, Индия.

АНОТАЦІЯ Морфологія берега відображає взаємний вплив топографії та динаміки рідини. При цьому морфологічна будова берегових систем не є випадковою, а визначається розподілом і просторово-часовою взаємодією берегових форм. Починаючи з класифікації, запропонованої Райтом та Шортом (1983), заснованої на аналізі еволюції декількох ділянок пляжу Південного берега Тамілнаду, пляжні системи розглядаються в рамках тривимірних морфодинамічних моделей, які включають кількісні характеристики (висоту обвалення хвиль, швидкість утворення опадів, хвильовий період та ухил пляжу) та граничні умови для певних взаємозв'язків берегової динаміки (тобто наявність або відсутність барів і їх тип). Це призвело до підрозділу пляжів на три основні категорії відповідно до їхньої поведінки відносно фізичних сил (Шорт, 1999) – розсіюючі, проміжні (від проміжно-розсіюючих до проміжно-відбиваючих варіантів) і відбиваючі. Морфодинамічна класифікація типів пляжів заснована на рівнянні Райта та Шорта, 1984 *(безрозмірна швидкість осадоутворювання – параметр Діна)*.

Ключові слова: пляж, рівняння Райта та Шорта, хвилі, морфодинаміка, Індія.