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Short Communication

Evaluation of the Nethravathi spit complex, west coast of India: Integrated change detection study using topographic and remotely sensed data

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The Nethravathi spit complex of Karnataka coast consists of Mangalore spit to the north and Ullal spit to the south of Nethravathi-Gurupur river mouth. The integration of topographic sheets and satellite imageries of this area has enabled the evaluation of the migration of spits over a period of 83 years. Morphologically, Mangalore spit has shrunk by 750 m in length and 749780 m^2 in area. On the other hand the Ullal spit exhibits an increase in length of 800 m and an area of 111620 m^2. The spits show no prominent lateral migration. Shrinkage of the Mangalore spit and the growth of the Ullal spit indicates net northward migration of the estuarine mouth.

Quantification of temporal and spatial variations involving shoreline changes and associated coastal geomorphic features has been attempted for various regional settings[1-3]. Of all the coastal geomorphic expressions, spits and barrier islands have attracted special attention of many workers [4-8]. Hequette & Ruz[4] have worked on migration of the spits and barrier islands of southeastern Canadian Beufort Sea using aerial photographs of different years. McBride *et al.*[7] have used the historical maps, toposheets and aerial photographs to derive the geomorphic response types of a barrier coastline. In the Indian scenario, particularly concerned to southern and central west coast, studies on the growth and migration of the spits are sparse[9-11]. The objective of this investigation is to appreciate the morphological changes of the spits over a period of 83 years with respect to length, width, and area, in order to delineate the migration of the spits.

The Nethravathi spit complex is a part of the Karnataka coast (central west coast of India) and is associated with Nethravathi-Gurupur river system (Fig.1). The primary data used for the study is derived from Survey of India Toposheets surveyed during the years AD 1910, and AD 1967, published by the Surveyor General of India and geocoded satellite imagery (FCC) of IRS 1B satellite, acquired during March 1993 by NRSA, Hyderabad (path 28, row 59). Using uniform geographical coordinate grid system these maps were brought to the same scale[2]. As suggested by other workers[2, 5] the high water line is used to demarcate the boundary of the spits. The high water line on the toposheets is clearly visible while that on the satellite imagery is identified by difference in colour and tone from that of the adjacent features. Four permanent geographical features in the study area (road intersections, highway intersections, historical sites etc.), were used as the primary control points for the proper alignment of these maps[2]. Using a digital planimeter (Ushikata, Japan Model X Plan 360 D) the area of the spits were measured. Length of the longest possible line on the spits is taken as the length of the spit. Average length of east-west transects drawn normal to the shoreline, across the spits represent the width. Migration of the spits landward or seaward was determined by averaging the displacement of the spits at their seaward and landward ends along the latitude.

It was observed that, over a period of 83 years the Ullal spit has grown northwards, parallel to the shore, by 800 m in length and 111620 m^2 in area (Fig 1, Table 1). Contrastingly, the Mangalore Spit has shrunk from its distal end by 750 m in length and 749780 m^2 in area. The rate of accretion of the Ullal spit is 1344 m^2/y whereas rate of erosion of the Mangalore spit is 9033 m^2/y. Since a spit grows in the direction of net shore drift irrespective of seasonal drift[5,6], the northward growth of the Ullal spit

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indicates that the effective shore drift in the study area during the years AD 1910 –1993 was towards north.

Supply of sediment for the growth of these spits is from longshore drift and river discharge[10]. Since the Nethravathi-Gurupur river basin is tropical in nature, the discharge mainly depends on the monsoonal rainfall. The amount of rainfall is maximum during SW monsoon. Hence, during this season river discharge and consequent supply of the sediment to the shore drift are more[12]. The Ullal spit consists of coarse to medium sand while the Mangalore spit consists of coarse to fine sand[13]. The skewness values of the Ullal spit sediments vary from – 0.1382 to + 0.5425 and that of the Mangalore spit[13] vary from – 0. 4097 to + 0.8351. The sediments of the Ullal spit are poorly sorted while that of Mangalore spit are well to moderately sorted[13]. From the nature of sorting and heavy mineral constituents present in the sediments of Ullal and Mangalore spits, it can be inferred that the Nethravathi-Gurupur river system has contributed a major amount of sediment for the growth of these spits[13]. As the Ullal spit grows towards north it enforces the shift of river mouth towards north enforcing the erosion of Mangalore spit from its distal end.

Kunte & Wagle[10] opined that shore drift and river drift of equal strength have helped in growth of the longer Mangalore spit. They have also inferred that if river drift dominates over shore drift the distal end of the spit deflects seaward and vice versa. Thus in 1910 the river drift along Nethravathi channel was dominant over longshore drift and hence distal end of Ullal spit was deflected towards seaward. On the contrary in 1993 longshore drift was dominating over river drift which has resulted in landward deflection of Mangalore and Ullal spits. Along shore shrinkage and development of the broad distal end of Mangalore spit by AD 1967 (Fig. 1), is probably due to intermittent dominance of one of the drifts over the other.

It was observed that between AD 1967 and 1993 the Ullal spit has drastically eroded (Table 1). This is mainly due to the construction of a shore normal breakwater on the Mangalore spit. The construction of this breakwater was started during 1991 and completed in 1996 (personal communication, A.E. E., Port and Fisheries Sub Division, Udupi). The length of this breakwater is 375 m. Its width on the landward end and seaward end are 25 m and 45 m respectively. It has been well established that the shore normal construction which extends beyond the nearshore environment, impedes the normal longshore drift and causes the deposition at the updrift side[5, 6], which might have caused the widening of the Mangalore spit. Such a trend has also been suggested (personal communication, Mr. Dinesh, Geologist, GSI, Mangalore) for the imagery of March 2000 of IRS 1C L III, which shows that the northern side of the breakwater is almost filled (much more than 1993) whereas Ullal spit has reduced in size. The breakwater on the Mangalore spit disturbs the normal southerly component of shore drift prevailing during SW monsoon, and enforces a sediment starvation scenario

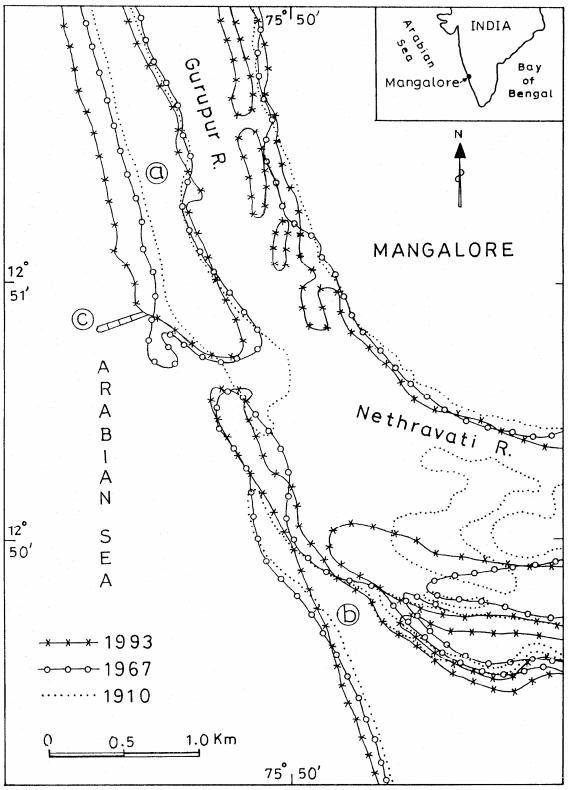

Fig. 1—Morphological changes in the Mangalore and Ullal Spits over 83 years. The narrow and pointed distal end of Mangalore spit in 1910 has become wide in 1967 and once again has become narrow in 1993; (a — Mangalore spit, b — Ullal spit, c — Shore normal breakwater)

Table 1 — Morphometric quantification of Mangalore and Ullal Spits

Name of the spit	Year	Length (m)	Width (m)	Area (m^2)
Mangalore spit	1910	8500	276	4097980
	1967	8000	353	3925400
	1993	7750	431	3348200
	1910	350	224	66880
Ullal spit	1967	1000	259	345300
	1993	1150	184	178500

around the Ullal spit, triggering drastic depletion of Ullal spit. Continuous erosion and accretion scenario, as an effect of the construction of the breakwater, was observed too in Elmer beach, United Kingdom[14].

The lateral migration (in the East-West direction) of the spits is not of considerable extent over the 83 years time span. Between AD 1910 and 1967, the width of the Mangalore spit has increased by 77 m (Table 1) which has enforced seaward migration by about 130 m. Seaward migration of the distal part of Mangalore spit by about 250 m has been observed between 1967 and 1993 (Fig. 1). This is mainly effected by the increase in width of the spit by 78 m consequent to the construction of a shore normal breakwater. In the case of Mangalore spit the lateral migration has been confined to the distal and middle parts, near to the breakwater. The linear variation (Table 1) depicted by the shrinkage of the Mangalore spit and the elongation of the Ullal spit suggests a northward migration of the estuarine mouth over the entire time span of 83 years.

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