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Short-Term and Long-Term Geomorphological Dynamics of Mangalore Spits Using IRS-1A/1C Data

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ABSTRACT

The city of Mangalore is situated at the confluence of rivers Gurpur and Netravati. Two spits are formed in this area, i.e., northern spit of "Bengre" and the southern spit of "Ullal" as the rivers flow close and parallel to the seashore for some distance. The spits have been subjected to constant geomorphological changes in length, width, position, accretion and erosion patterns etc., for the past several decades. A seawall was constructed in 1984 around the tip of Bengre spit and another one along the shoreline of Ullal spit in 1987, by the Government of Karnataka in order to prevent the spits from being eroded. Two breakwaters were also constructed in 1992 near the estuarine mouth as part of the development of old Mangalore Port. The paper presents the results of a study undertaken to identify the geomorphologic changes that occurred in the area, using IRS-1A/1C data for the years of 1988, 1994, 1996. The study clearly demonstrated that the IRS data could be effectively utilized for monitoring the geodynamics of an area. It was observed that the spits were highly unstable earlier. However, the construction of seawalls was helpful in arresting the migration of the estuarine mouth and in stabilizing the spits against coastal erosion.

Introduction

Coast, the dynamic junction of ocean, atmosphere and land, undergoes continuous geomorphologic changes in response to natural forces and human activities [Komar (1976), Bruun (1985), Horikawa (1978)]. Natural processes such as continental drift, tides, waves, currents etc., are always at work, but they hardly induce major geodynamic changes in a short span of time. On the other hand, the anthropogenic activities cause immense geomorphologic changes at a rapid rate. For highly dynamic areas such as beaches, coastal inlets, lagoons, spits and river mouths, it is necessary to gather timely information on the dynamics of coastal geomorphology for the purpose of erosion control measures, planning of the Ports, Navigational facilities etc. (SPM 1984 Bruun and Garritsen 1960).

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About the Study Area

The historical city of Mangalore is located at the confluence of Gurpur and Netravati rivers (Figure 1). The two rivers, as they join the sea, give rise to two spits, the northern sand spit of 'Bengre' and the southern spit of 'Ullal'. Years back, the Gurpur river might have a straight entry into sea at the northern portion of the Bengre spit. Later this may have got choked and it had a new entrance at the Sultan's Battery area. But, subsequently this too got closed and the present entry to sea is at a further southern location, along the Netravati river. As an evidence, the portion of the spit at Sultan's Battery has the narrowest of its width. The northern sand spit is about 500 metres wide with an average height above chart datum of 3.3 metres. It runs longitudinally north-south for about 5 km and is separated by the sea on the west and the Gurpur river on the east. A road runs all along the length of the spit. The western side of the road is mainly utilized as fish drying yards. The spit side of the estuary is calm and helps in the berthing of boats.

The southern spit of 'Ullal' is shorter in length as compared to northern spit. The length is just over 1.5 km and has been formed by the deposition of sand. Throughout its length, there is no noticeable vegetation. The Ullal town situated on the main land has partly extended its growth into the spit too. On this sand spit fishing activities are carried out. The spit side of the estuary is also used for berthing of boats. The fishermen thickly populate both the spits. The estuarine mouths of Gurpur and Netravati Rivers have been reportedly migrating towards the north since long, forcing the two spits to change the shape, size and orientation.

Bannur *et al.* (1991) have studied the changes in the geomorphology of the Gurpur-Netravati, Pavanje-Mulki and Seetha-Swarna estuaries using the Landsat MSS (Multi Spectral Scanner) for the period from January 1973, March 1973, January 1982, IRS-1A FCC (False Color Composite) of December 1989 and SOI topographic map of 1:50000 scale published in 1912. They concluded that the Gurpur-Netravati estuarine mouth was migrating to the north, whereas Mulki-Pavanje estuarine mouth was migrating to south.

Gangadhar (1995) studied the shoreline changes in the Nethravathi-Gurpur estuary area using SOI Toposheets published in 1912, 1967 and satellite imageries of 1988-1991 and aerial photograph of 1979. They too concluded that the Nethravati-Gurpur estuarine mouth was migrating to the north and the Mulki-Pavanje estuarine mouth was migrating to south.

Manavalan *et al.* (1996) studied the area of Gurpur-Netravati as well as the Mulki-Pavanje estuarine mouth using the IRS-1 C PAN data of January 1996 and IRS-1A LISS-II data of December 1998. They found that the Bengre spit was more stabilized and widened, while the deposition on the Ullal spit was less. There were more shoals formed near to the estuarine mouth.

The spits are subjected to severe erosion and accretion. This endangered the lives of the people residing in the two spits. Hence, the Government of Karnataka built seawalls in the area. The paper presents the study of the geomorphologic history of the two spits, it's present status and their possible future in the light of the seawalls and breakwaters built in the area.

Parameters of Interest Studied in the Present Work

In the present work parameters like accretional, erosional pattern of the spits, effect of seawalls and breakwaters constructed at the Old Mangalore Port on the two spits were studied. In addition, spit dynamics such as change of width, length of the spits from 1912 to 1996 are also dealt with. Further, the effect of NMPT breakwaters on the adjacent shoreline is presented. The paper also highlights the possible future of the spits, in the light of the seawalls and breakwaters constructed in the area.

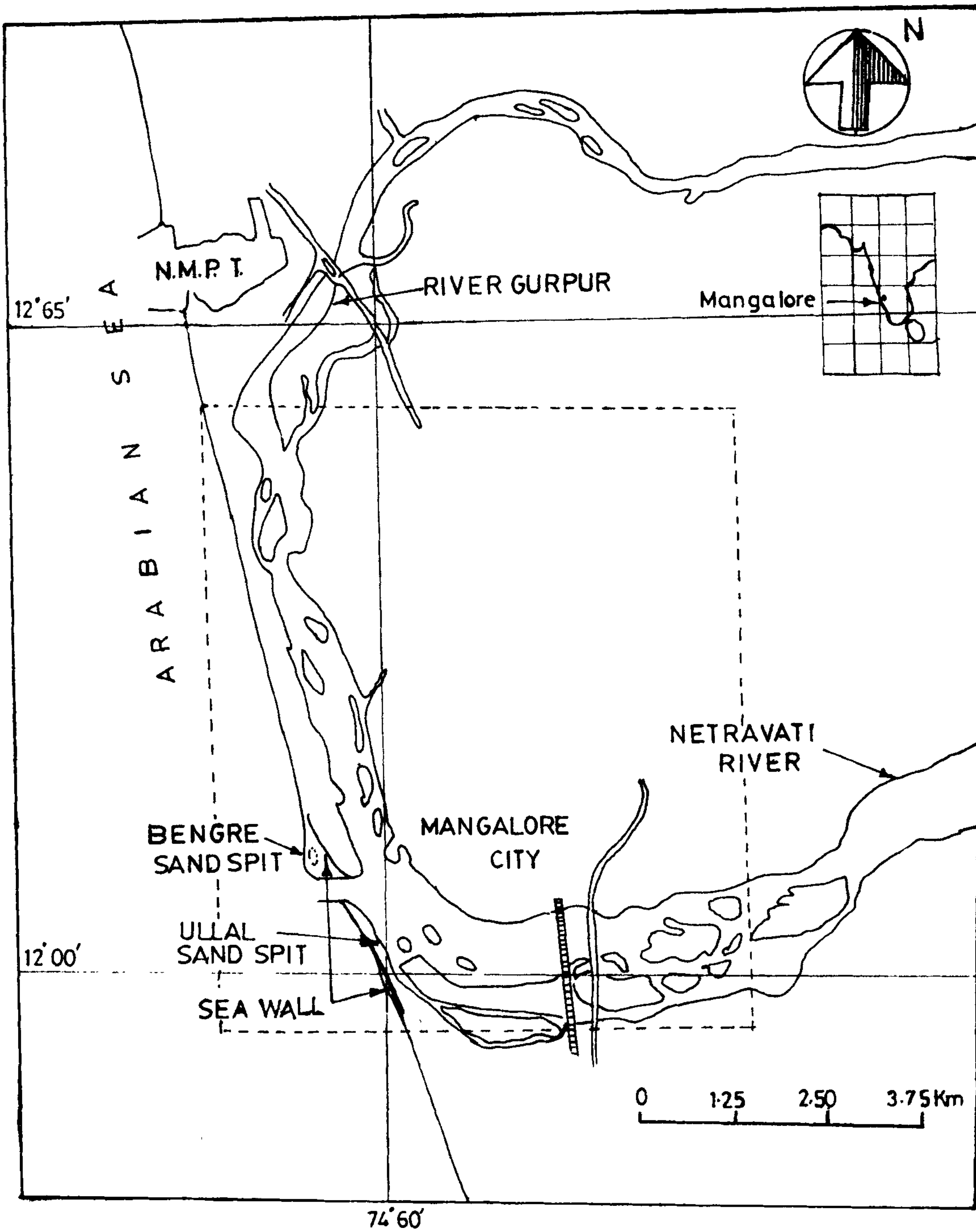

Fig. 1. Location of Study Area

Table 1: Data Products used in Present Study

Sl. No.	SOI Topographic Maps (No. 48 K/13)		Satellite Products Path and Row P 28-R59 (No. 48K/13)			Naval Hydrographic Chart (No. 48 K/13)	
	Year	Scale	Year	Satellite and Sensor	Scale and Date of Pass	Year	Scale
1	1912	1:63360	1988	IRS-1A/ LISS II	1:500000 12-11-98	1992	1:50000
2	1967	1:50000	1994	IRS-1A/ LISS II	1:500000 10-11-94	--	--
3	--	--	1996	IRS-1C/ LISS III	1:250000 29-1-96	--	--

Data Products used in the Study

The various data products used in the present study are presented in the Table 1.

Registration Methodology

The SOI topographic map of 1:50000 scale published in 1967 was used to prepare the base map. The SOI topographic map of 1912 of scale 1:63360 was enlarged accurately to 1:50000 scale with the help of the Optical Pantograph. The IRS-1A imageries of 1988, 1994 of 1:500000 scale and IRS-IC imagery of 1996 of 1:250000 were enlarged to 1:50000 scale, using the high magnification enlarger Procom 2, which enables the user to enlarge and scan one set of data, if desired to merge and register two sets of data at one common scale. The projected image was registered to the base map using a set of Ground Control Points (GCPs). In the present study, selected GCPs were the, bridges across Netravati and Gurpur rivers. The National Highway N.H. 17 and Sultan Batteri. The results of the study were quantified using the Digital Planimeter.

Results and Discussion

The estuarine mouth was found to be dynamic and did undergo morphological changes over the period due to several factors. The geomorphologic changes during the following periods were studied:

1. 1912-1967
2. 1967-1988
3. 1988-1992
4. 1992-1994
5. 1994-1996

The migration of the estuarine mouth was measured in the North-South direction with reference to the center of the confluence width. The change in length of the spits and confluence width too was measured in North-South direction. Erosion and accretion area were compared as the sum of all erosion and accretion pockets of the particular spit.

Period of 1912-1967

The Figure 2 shows the shorelines of Bengre and Ullal spits respectively for the years 1912 and 1967. Discharge in the Netravati River is very large compared to that in the Gurpur river and this could have induced the changes near the estuarine mouth. Further, the alignment of the shoals to the south shore, near the estuarine mouth in the Netravati River could have altered the flow towards the north. This in turn, might have resulted in the migration of the estuarine mouth and caused erosion near the tip of Bengre spit and accretion near the tip of Ullal sand spit. Heavy silt discharge carried by the two rivers might have been the reason for the net gain of land near the mouth, and increase in the shoal area in the estuarine system. The deposition of 76,549 sq. metres found at the shoreline of Tannirbavi is probably due to the positioning of a broken ship due to ship-breaking activity that was going on at the spot during this period.

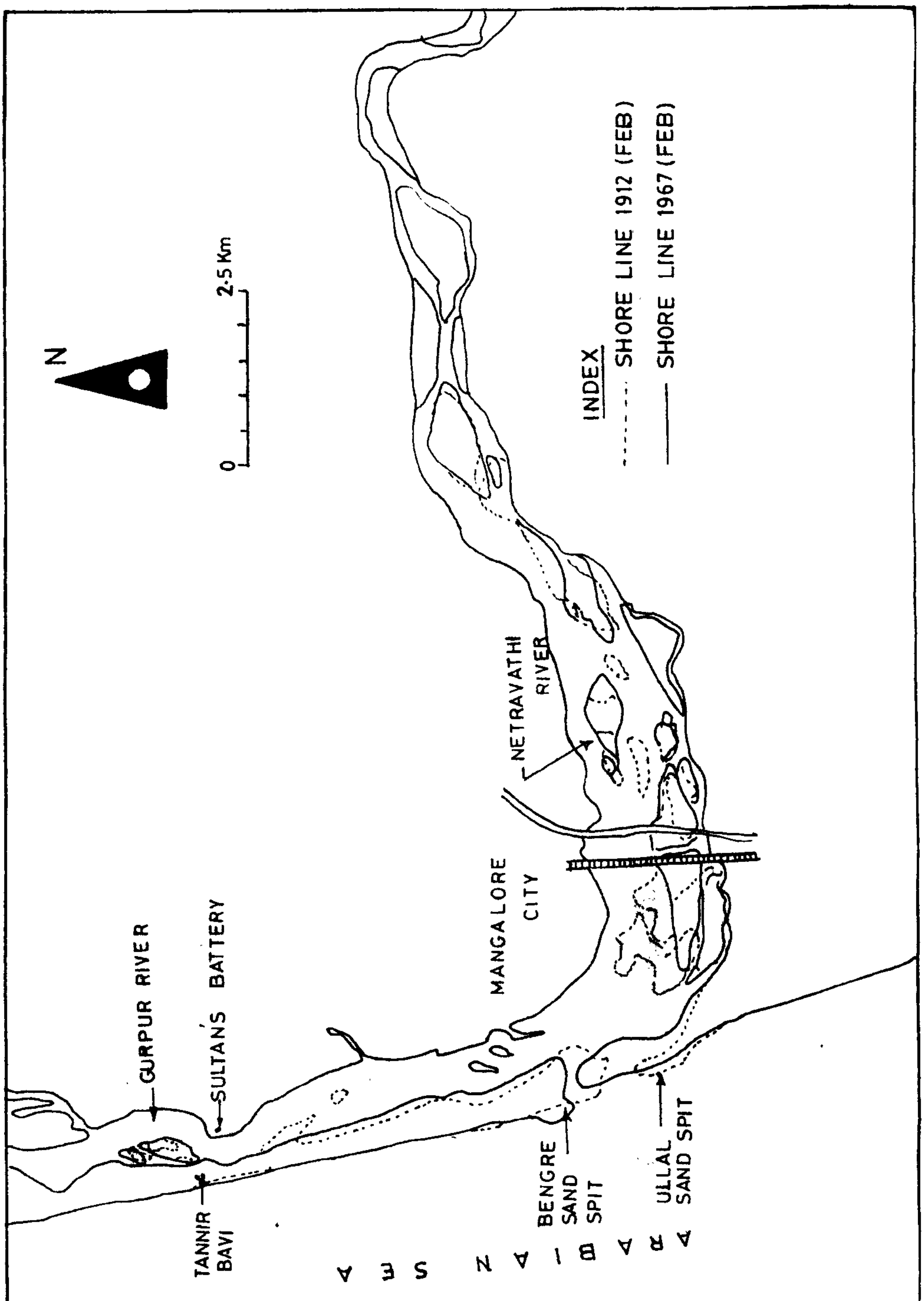

Fig. 2. Long term Geomorphological changes at Benge & Ullal Sand spits 1912-67

Period of 1967-1988

Due to the construction of sea wall in 1984 near the Bengre sand spit, the erosion near tip of the spit has ceased and on the contrary accretion has taken place (Fig. 3). At the same time, spurs were constructed on the riverside of Bengre spit to prevent erosion and hence some accretion has taken place there too. The shoreline near the Tannirbavi has eroded, probably due to winding up of the ship breaking activities in 1967, at this location. Hence, the shoreline in this location nearly attains its shoreline configuration of 1912. The zero vertical movement of Ullal sand spit indicates that, it has remained stable. Due to the construction of spurs near the Bengre sand spit, one shoal near the old Mangalore Port has eroded and other shifted its orientation.

Period of 1988-1992

Figure 4 shows the shorelines of 1988 and 1992. No migration of the estuarine mouth and no change in length of the spits, indicate that the spits have stabilized. In fact, the construction of seawalls has stopped the migration of the estuarine mouth. However, due to erosion of the sharp edges near the tip of the Ullal spit, the confluence width has increased. The erosion of the sharp edges might have been caused by the heavy flow from the two rivers during the monsoon. Increase in shoal area in the estuarine system, indicates that the two rivers carried heavy silt discharge in this period. The shoreline at the NMPT has attained an equilibrium position.

Period of 1992-1994

Figure 5 depicts the shorelines of the spits for the years 1992 and 1994. Due to the construction of seawalls, the migration of the estuarine mouth has completely stopped. The accretion near the tip of Bengre sand spit is due to construction of the north breakwaters. This accretion increases the average width as well as maximum width of the Bengre spit. The north breakwater not only stabilized the spit, but is even accreting it. Due to the construction of the breakwaters near the estuarine mouth the flow in the estuarine mouth is confined to a definite narrow passage along the centerline of the entrance channel. Due to this, the velocity in the estuarine mouth has increased further and has caused the sediments that got deposited in the estuarine mouth to be flushed out increasing the draft in the estuarine mouth. The shoreline around NMPT has stabilized in this period.

Period of 1994-1996

Due to the effect of breakwaters near the estuarine mouth some more accretion was observed in this period (Figure 6). This accretion was due to the sediments brought by the two rivers. But major contribution was from Netravati River. During a field visit, this accretion pattern was clearly observed and recorded. In 1995, in order to develop the Old Mangalore Port, dredging work was taken up in the entrance channel to increase the available draft. The material dredged was about 2.4 million tonnes. This material was dumped on the riverside of the Bengre sand spit and on the shoreline of the Ullal sand spit near the south breakwater. Due to this dumping, some land has been reclaimed at these two places.

In New Mangalore Port, the port authorities have dredged in the lagoon area for the construction of the coal berth (Refer Fig. 7). This dredged material was dumped near the southern side of the south breakwater. Hence, near the southern side of the south breakwater, some land reclamation has taken place. The amount of the land reclamation is found to be around 71315 sq. m. from the imageries. The total results obtained for the various time periods are presented in Table 2 for the purpose of comparison.

Figure 8 to 11 show the consolidated data from 1912 to 1996 regarding change in confluence width, change in length of Bengre spit, change in length of Ullal sand spit and

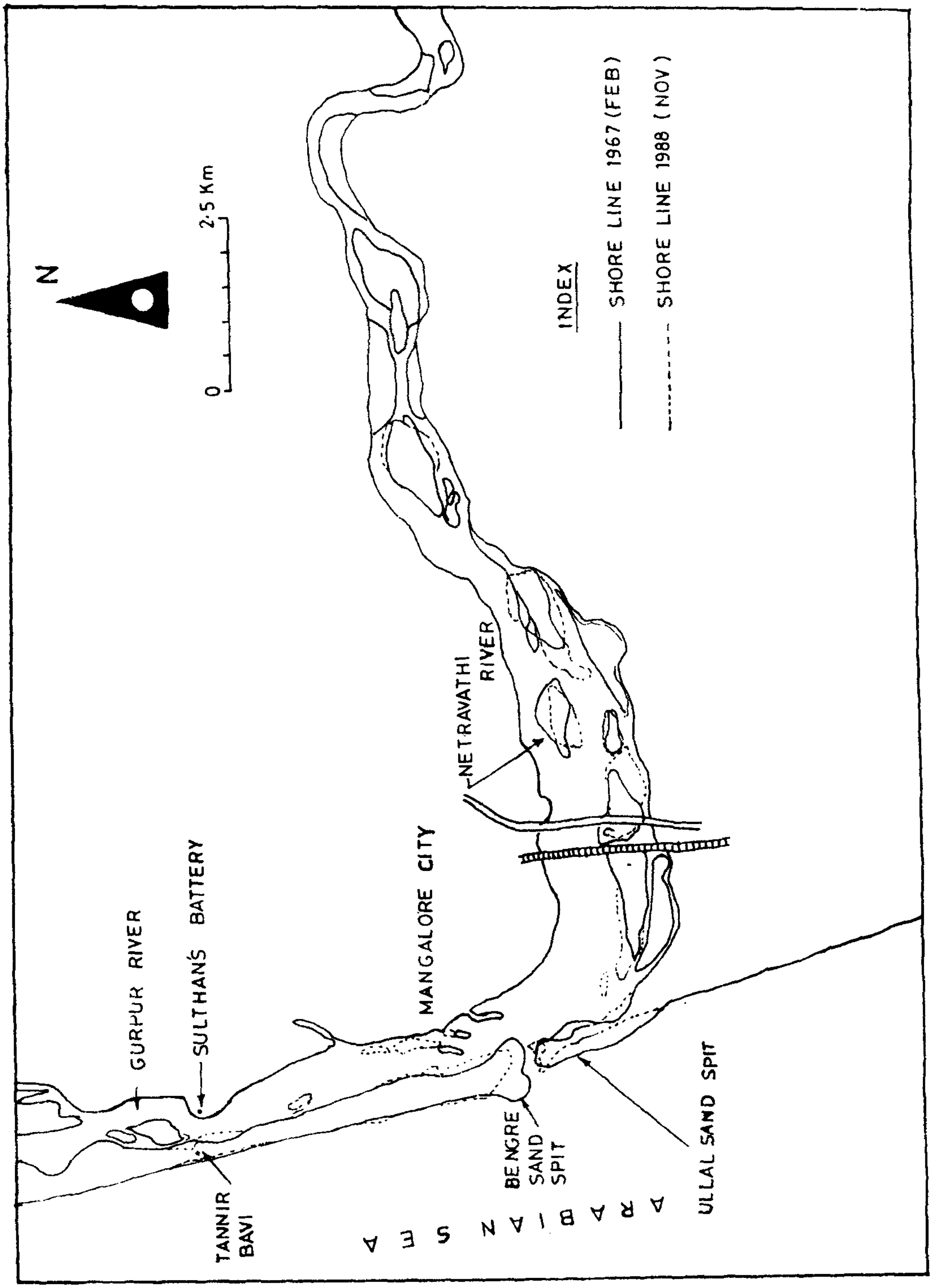

Fig. 3. Long term Geomorphological changes at Benge & Ullal Sand spits 1967-88

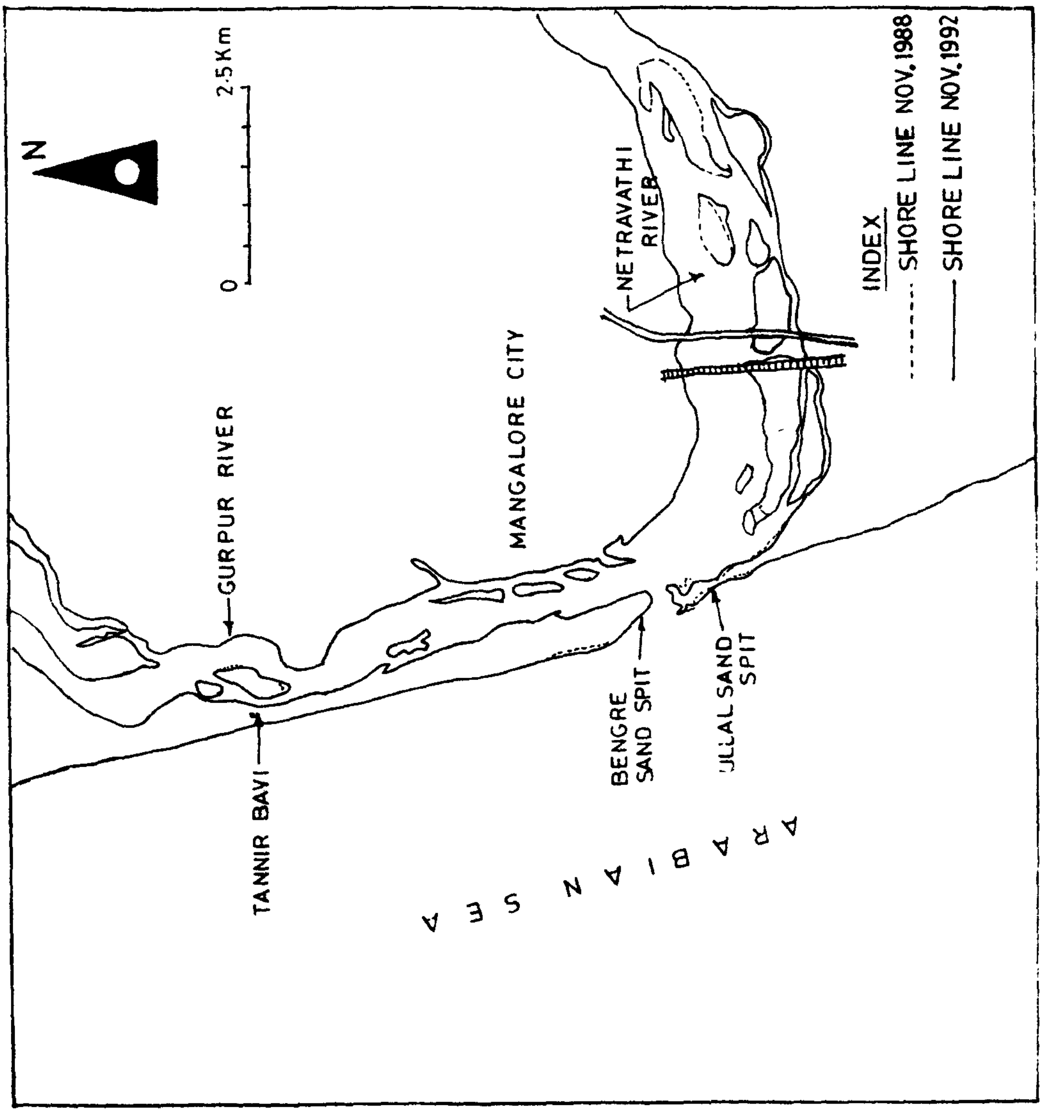

Fig. 4. Short term Geomorphological changes at Benge & Ullal Sand spits 1988-92

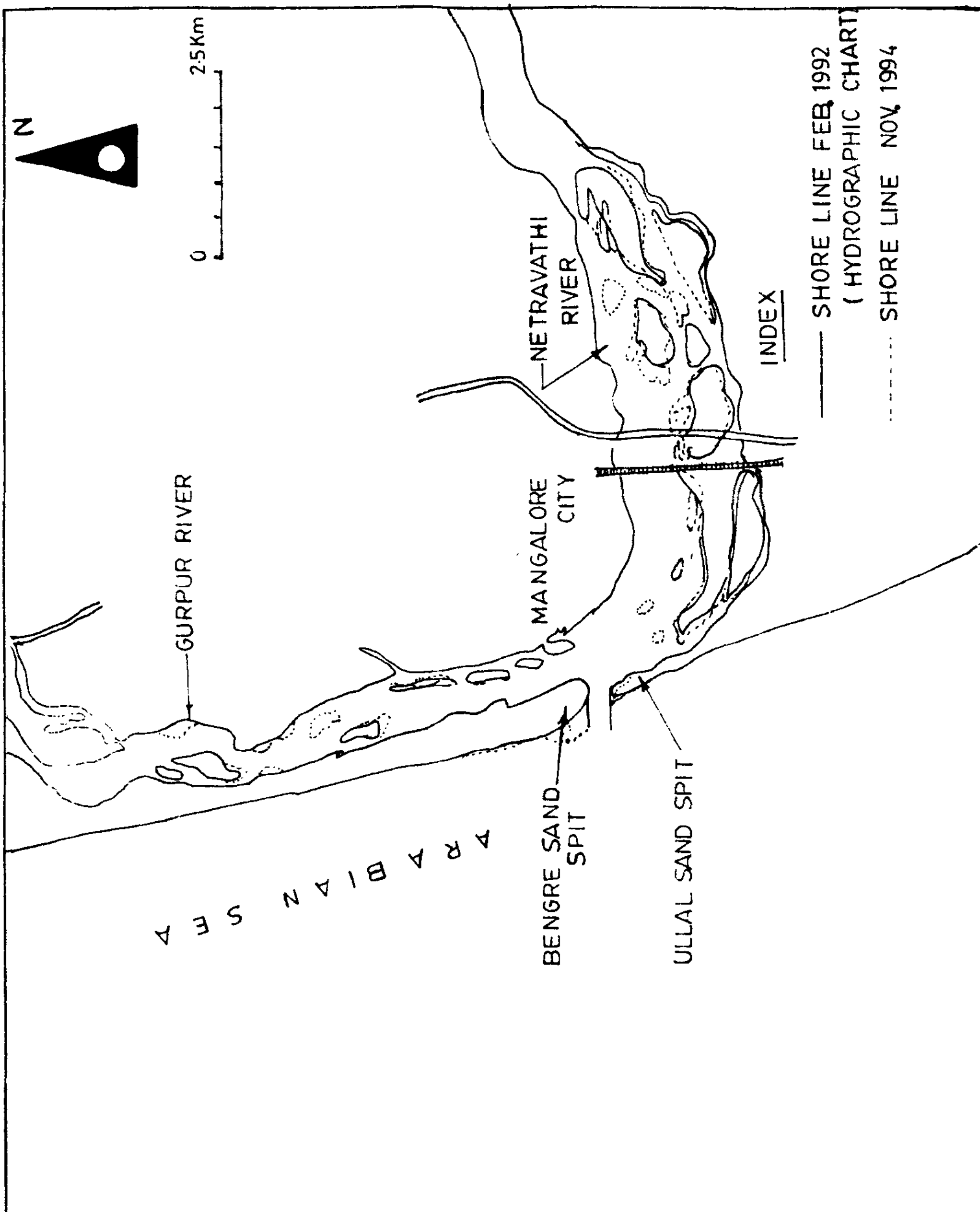

Fig. 5. Short term Geomorphological changes at Benge & Ullal Sand spits 1992-94

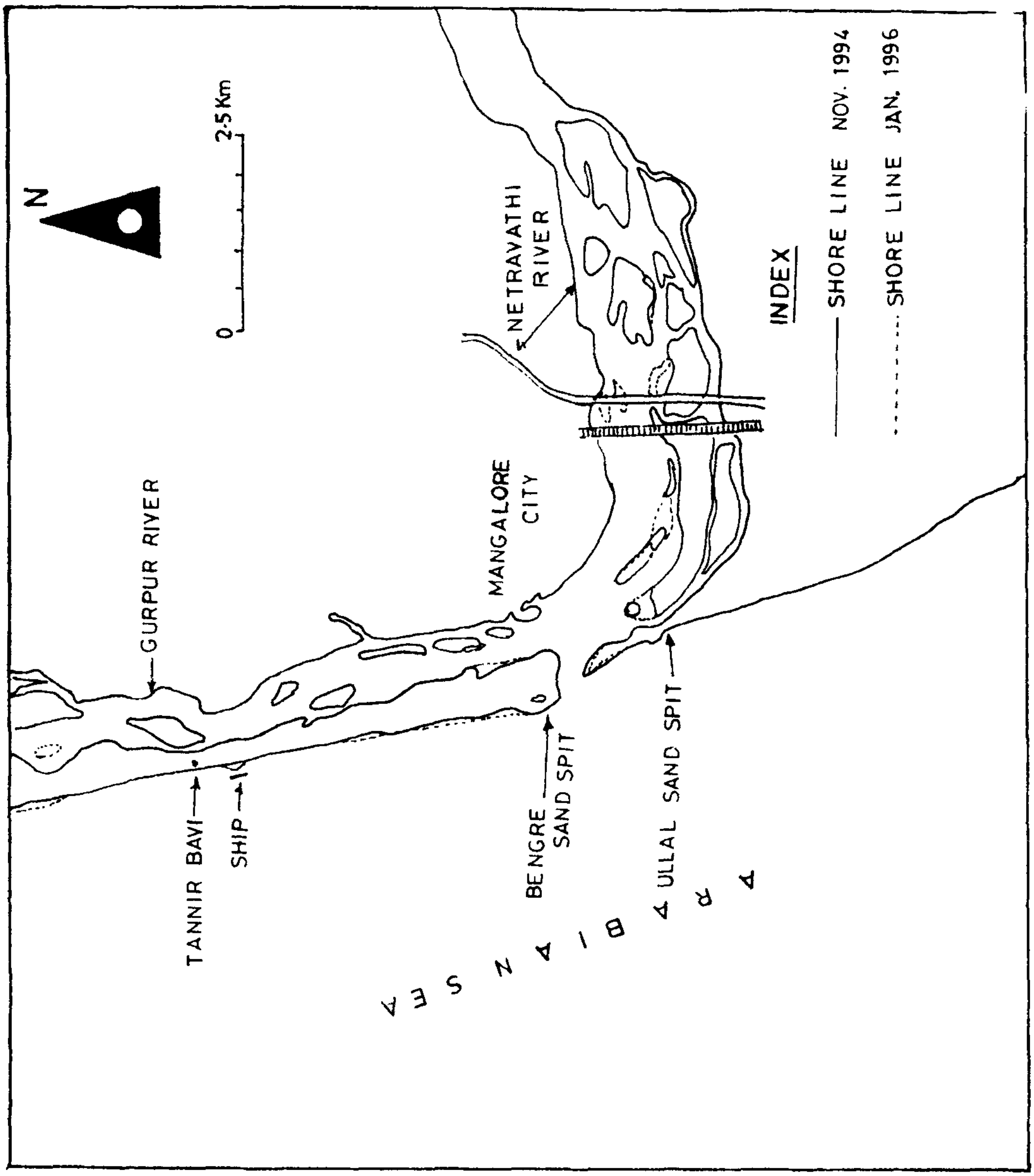

Fig. 6. Short term Geomorphological changes at Benge & Ullal Sand spits 1994-1996

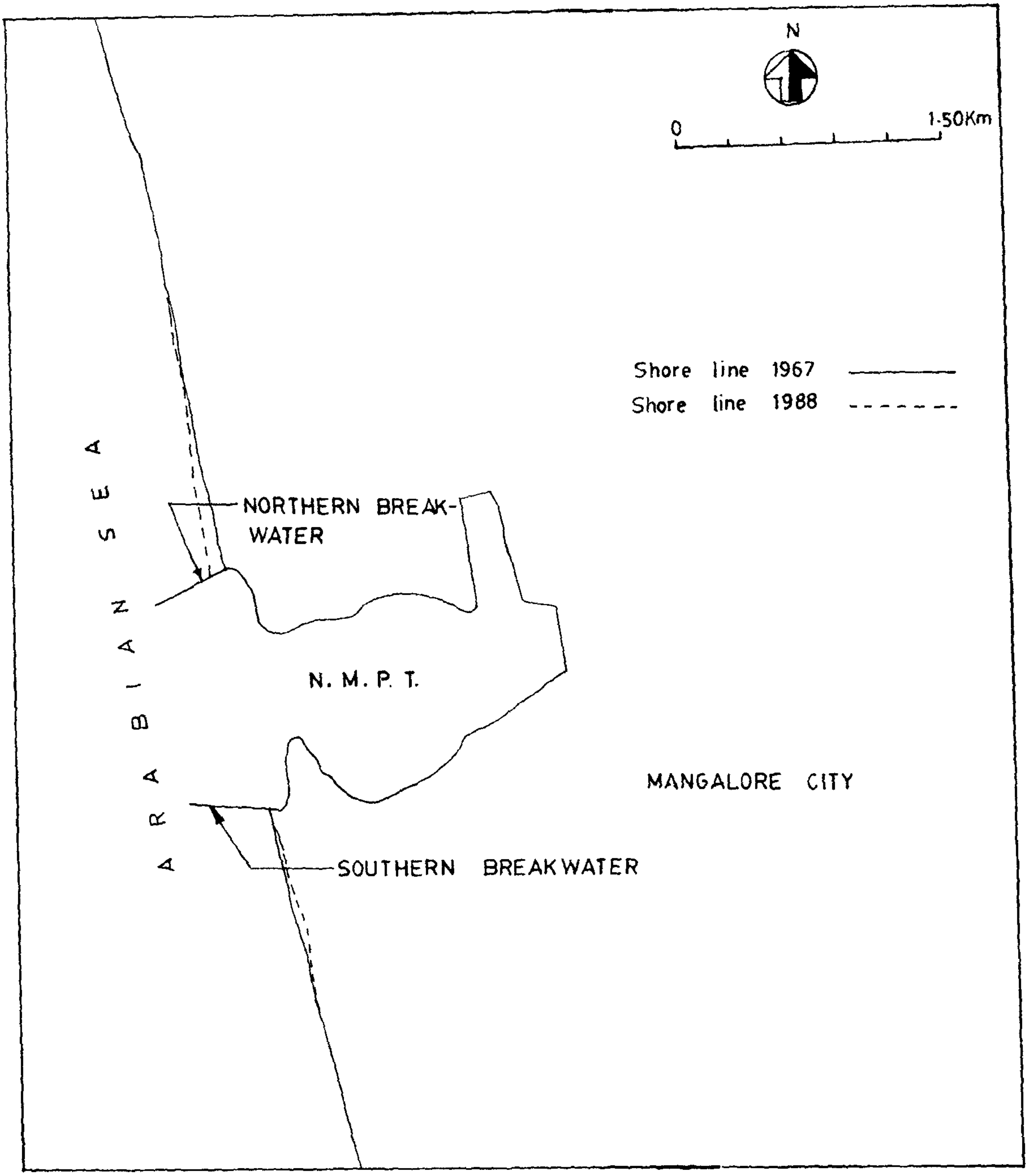

Fig. 7. Effect of N.M.P.T. Breakwater on Shore Line

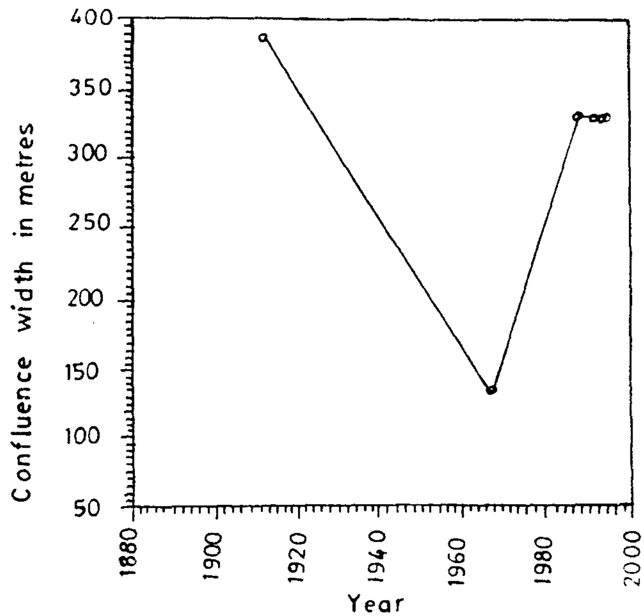

Fig. 8. Change in the Confluence Width

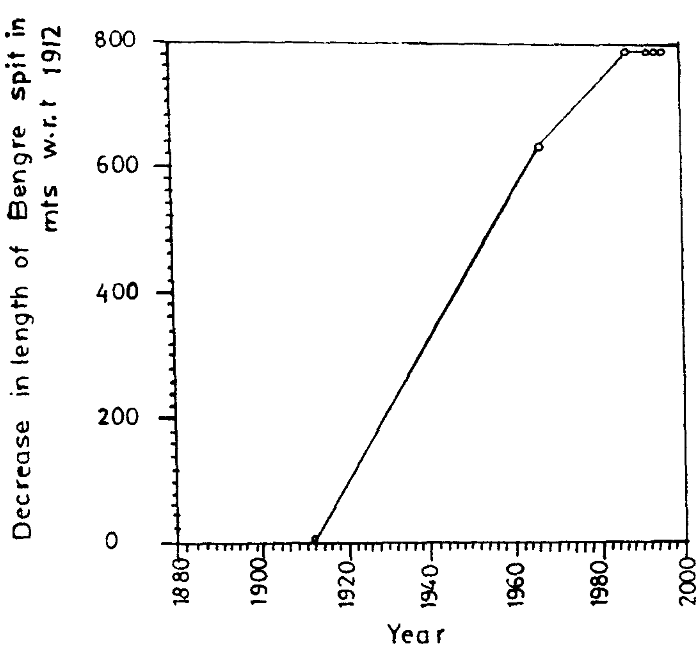

Fig. 9. Change in length of Bengre Sand Spit

migration of the estuarine mouth in a graphical form. From Figure 8, it may be clearly seen that 1984 onwards the confluence width has not changed at all. Similarly Figures 9 and 10 demonstrate that lengths of the Bengre and Ullal spits remained constant. Figure 11 proves that estuarine mouth had stabilized very well from 1984 onwards. All this may be attributed to the construction of seawalls around the two spits. Thus, it may be concluded that the spits have remained stable since 1984, i.e., stable for more than 12 years, as on 1996. Hence, as an extrapolation, it may be forecast that the 'Status Quo' would be maintained in the near future too. This however is subject to assumption of no further human interference with the geomorphology of these two spits. Any such interference in the future could cause aggravated and volatile changes in the geomorphology of the area.

Table 2. Results Obtained in the Present Study

Parameter		1912-1967	1967-1988	1988-1992	1992-1994	1994-1996
Migration of Estuarine Mouth in m		759 to North	76 to north	Nil	Nil	Nil
Change in Length of Spits in m	**Bengre**	Shorter by 632	Shorter by 152	Nil	Nil	Nil
	Ullal	Elongated by 886	No Change in length	Nil	Nil	Nil
Variation in Confluence Width in m.		Reduction of 254	Increase of 196	Nil	Nil	Nil
Erosional Area in m^2	**Bengre**	518393	359753	Nil	Nil	Nil
	Ullal	94152	392659	83742	27438	7868
Accretion Area in m^2	**Bengre**	520801	221442	50802	214461	207210
	Ullal	423009	74076	43716	7838	6528

Conclusions

Based on the data procured and subsequent discussions, following conclusions have been drawn:

⇒ The study clearly demonstrates that the multi-dated and multispectral IRS data could be effectively used for monitoring the geo-dynamics of an area.

⇒ The construction of seawall in 1984 at Bengre sand spit has resulted in the stabilization of the spit against migration, as well as it has helped in arresting erosion of the Bengre spit.

⇒ Seawall constructed in 1987, along the shoreline of Ullal sand spit prevented the erosion of the spit on the seaside shoreline. However, in the portions where there is no seawall built, erosion has been observed.

⇒ Due to the construction of breakwaters at the estuarine mouth, the Bengre spit accreted heavily on the north of northern breakwater. This might be probably due to the sediment that is brought by the two rivers in monsoon period, getting deposited due to the WSW and westerly waves.

⇒ Effect of New Mangalore Port breakwaters is to accrete slightly, on the north of northern breakwater, and erode on south side of southern breakwater. This indicates net north to south littoral drift of a small magnitude in the area. The shoreline on either side of the NMPT breakwaters has stabilized from 1988 onwards.

⇒ In 1995, the NMPT authorities dredged the lagoon area of the port to construct the coal berth. The dredged material was dumped on the south of the southern breakwater. This land reclamation of 71315 sq. m. is clearly seen in the IRS imagery.

⇒ The estuarine mouth was migrating towards

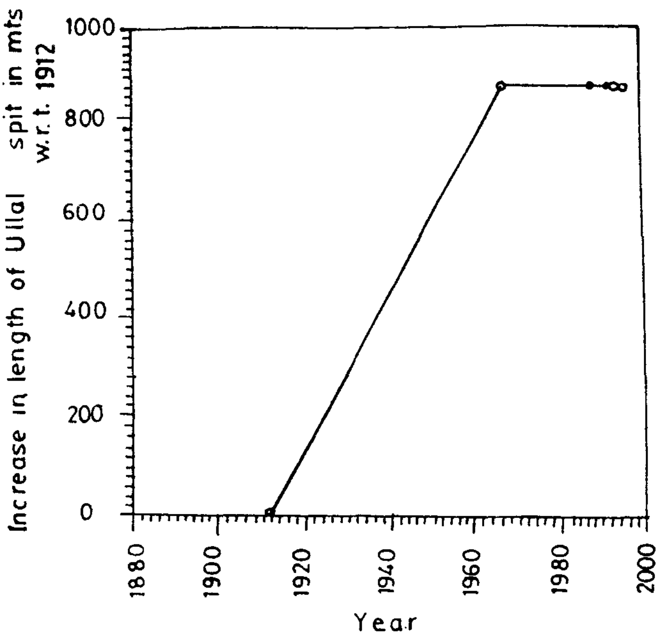

Fig. 10. Change in length of Ullal Sand Spit

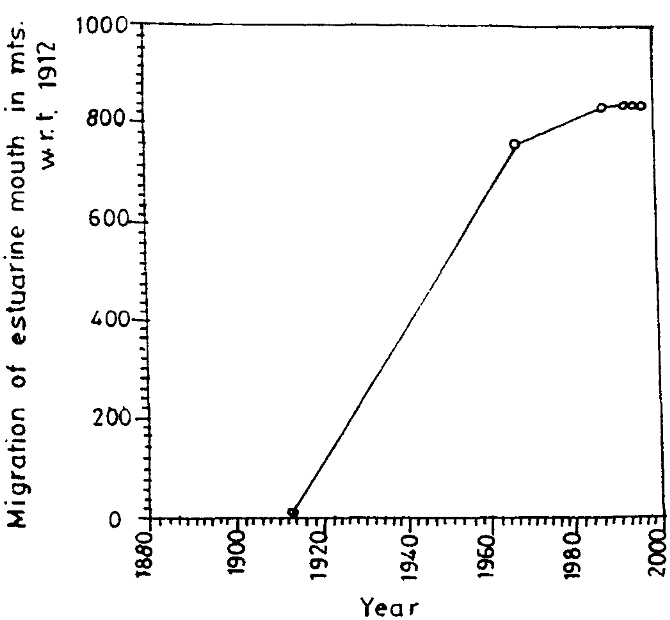

Fig. 11. Migration of the Estuarine Mouth

north before the construction of the seawalls, i.e., before 1984. After the construction of the seawalls the migration of estuarine mouth has ceased.

⇒ It may be reasonably forecast that the two spits are stabilized now and no more damage to property may be expected in near future, subject to the condition that no further human interference be thrust upon these two spits.

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