COASTAL EROSION: INVESTIGATIONS IN THE SOUTHWEST COAST OF SRI LANKA

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Abstract:

Sri Lanka is an island with a coastline of length approximately 1600 km. Coastal erosion has been identified as a major hazard in many coastal areas, particularly along the densely populated southwest coastline of the country. Numerical studies were conducted to assess the sediment transport rates in selected areas along the southwest coast. Field investigations were carried out at several locations to assess the behaviour of the coastline. In this on-going study, seasonal trends of sediment transport rates are to be assessed and compared with measured shoreline behaviour.

Keywords: Coastal Erosion, Sediment Transport, Southwest Coast

1 Introduction

Sri Lanka is an island with a coastline of length approximately 1600 km. Coastal erosion has been identified as a major hazard in many coastal areas, particularly along the densely populated southwest coastline of the country. In this region, the nearshore wave climate varies with the four climatic seasons caused mainly by the monsoonal winds. These seasons are the first inter-monsoon (March-April), southwest monsoon (May-September), second inter-monsoon (October-November), northeast monsoon (December-February). In this study, investigations were carried out to assess the sediment transport rates and behaviour of shoreline at selected locations along the southwest coastline.

2 Methodology

Numerical studies were conducted to assess the sediment transport rates in selected areas along the southwest coast. Field investigations were carried out at several locations to assess the behaviour of the coastline.

The studies conducted to assess the sediment transport rates were based on an investigation conducted earlier, namely CCD-GTZ Coast Conservation Project (Fittschen et al, 1992) in which the coastline in the western to southern region has been considered in terms of a number of coastal cells as indicated in **Fig.1**. In this study, eleven coastal cells (S5 to S16) betweeen Galle and Colombo were selected (**Fig. 1**).

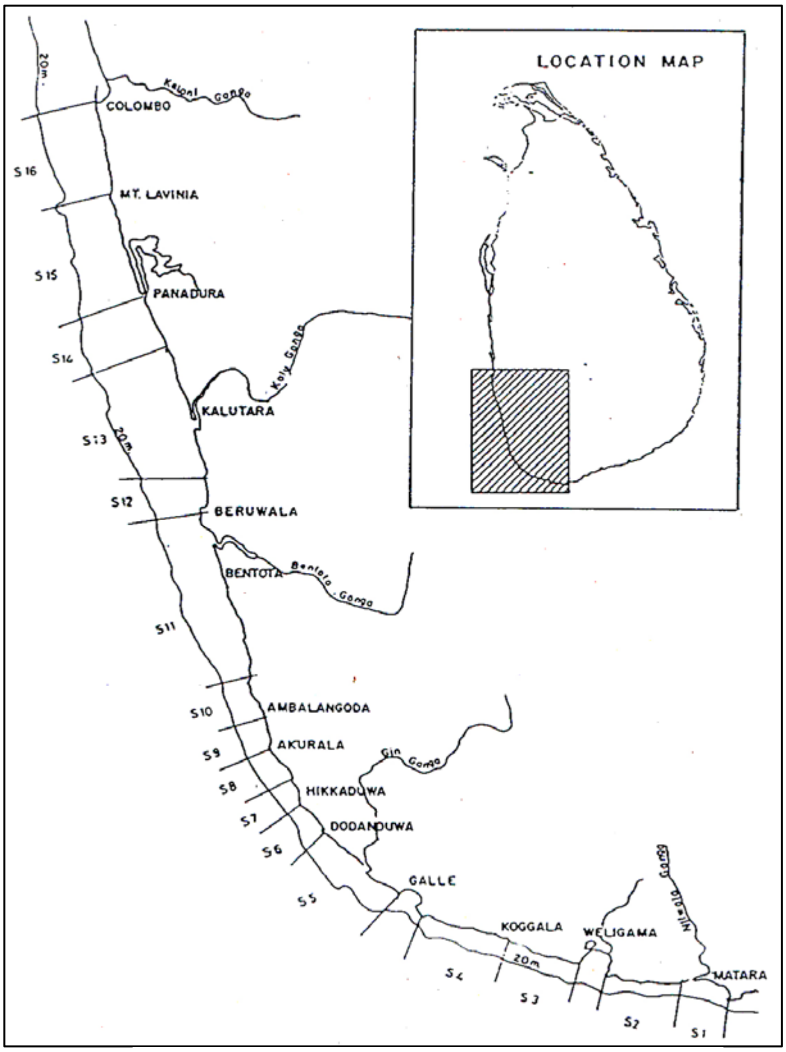

Fig. 1 Location of coastal sections S1 – S16

3 Investigations on Sediment Transport

In the absence of nearshore wave data required to assess the sediment transport, numerical modelling techniques were used to transform offshore wave measurements to selected coastal locations. Offshore wave data at -70 m depth at Galle has been collected by the Coast Conservation Department, Sri Lanka over a four year period (mid 1989-1995) was used in this study. The predominant direction of swell waves is southwest whereas sea waves have wide directional spreading. **Fig.2** illustrates the annual wave rose pattern of both swell and sea waves at Galle offshore. Admiralty charts were used to prepare digitized bathymetric data along the southwest coastline which is required to transform offshore wave conditions to nearshore regions using numerical models. MIKE 21 NSW (Nearshore Spectral Waves) model was used for the transformation. The NSW model takes into account of wave refraction, shoaling, bottom dissipation, wave breaking, wave-current interaction and wind-wave generation. At breaking depth, wave parameters which were required for the sediment transport calculations were extracted.

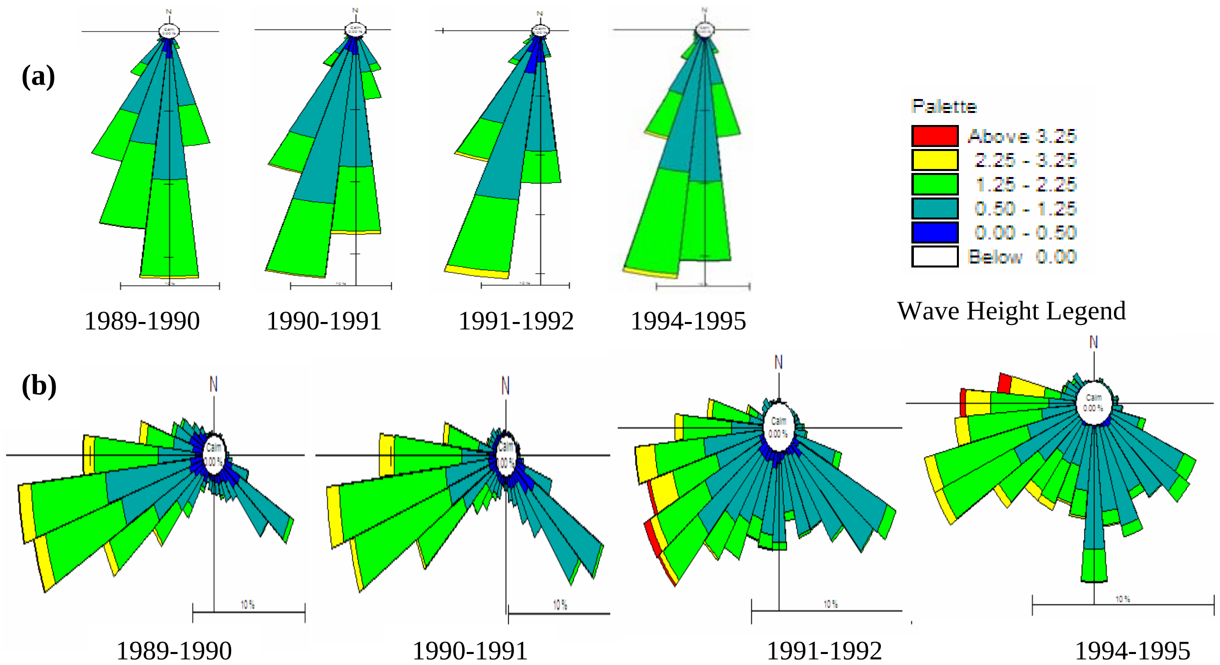

Fig. 2 Galle offshore wave Climate (a) Swell waves (b) Sea Waves

Nearshore wave climate established was used to assess alongshore sediment transport rates using empirical expression. There are many empirical formulae (CERC (1984), Bailard (1984) and Bijker (1971)) reported in literature that for the estimation of sediment transport rate Kamphuis (2002) formula is found to be more consistent and applicable to both field and model data (Smith et al, 2004) and it was used in this study. It is expressed in equation 1-a & 1-b as,

$$Q_{lst,m} = 2.27 H_{sb}^{2}\ T_{p}^{1.5}\ m_{b}^{0.75}\ d_{50}^{-0.25}\ \sin^{0.6}(2\theta_b) \qquad \text{1-a}$$

$$Q_{lst,m} = (\rho_s - \rho)(1-a)Q_{lst} \qquad \text{1-b}$$

in which $Q_{lst,m}$ is the transport rate of underwater mass in kg/s, Q_{lst} is the transport rate in m^3/s, H_{sb} is the significant wave height in m, T_p is the peak wave period in s, m_b is the beach slope from the breaker line to the shoreline, d_{50} is the median grain size in m, θ_b is the wave breaking angle, ρ_s and ρ are the density of sediment and sea water respectively and a is the porosity of the sediment.

The 1-D morphology equation (Kamphuis, 2000), expresses conservation of sand and calculates the change in the shoreline with regard to the distance along the shore. It was used to calculate corresponding shoreline variations with estimated sediment transport rates. To calculate the closure depth which was required in 1-D morphology equation, Hallermier's (1978) expression was used.

4 Investigations on Shoreline Behaviour

A series of field measurements were carried out in order to assess the behavior of the shoreline at selected coastal cells. The positions of the important features of the shore were measured with respect to a local reference line (**Fig. 3**). Monthly measurements were conducted to assess the seasonal variation of shoreline by measuring the movements of shoreline points and berm line points.

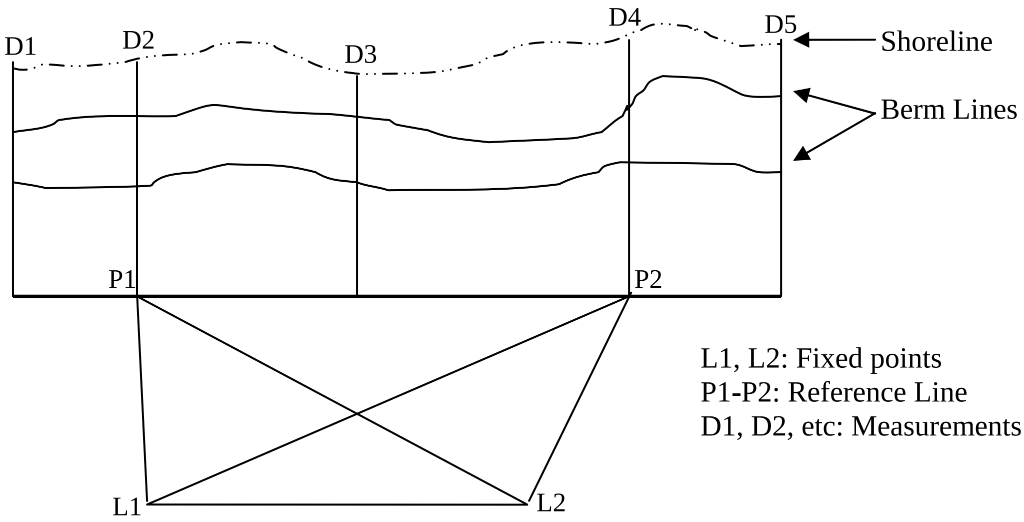

Fig. 3 Shoreline Measurements

5 Results and Analysis

The alongshore sediment transport rates estimated from wave conditions for different seasons have been tabulated in **Table 1**. The transport rates induced by swell are significant and directed northwards throughout the year, whereas sea wave has low transport capability and moves monthly net sediment either in northward or southward direction. The order of magnitude of the monthly sediment transport rate in the southwest coastline was found to be 10^5 m^3 in the southwest and northeast monsoon seasons. **Table 2** shows the possible seasonal (monthly) shoreline variation from one line model calculations in the selected locations. It can be identified whether the shoreline will erode or accrete in a particular season and the amount of possible shoreline variation.

Shoreline measurements revealed monthly variation of shoreline. When season changes from inter monsoon-2 to southwest monsoon, the field measurements have shown distinct changes of pattern in shoreline variation as shown in **Fig. 4**.

In this on-going study, seasonal trends of sediment transport rates are to be assessed and compared with measured shoreline behaviour.

Table 1: Alongshore Sediment Transport Rate

LOCATION		SW[a]	IM 1[b]	NE[c]	IM 2[d]
		x10^5 m^3/month			
Colombo	Swell	1.74	0.90	0.31	0.52
	Sea	0.24	0.07	0.00	0.16
	Total	1.98	0.97	0.31	0.68
Mount Laviniya	Swell	1.77	1.06	0.29	0.57
	Sea	0.09	0.05	-0.01	0.17
	Total	1.86	1.11	0.28	0.74
Wadduwa-Panadura	Swell	1.88	1.03	0.34	0.59
	Sea	0.15	0.05	-0.03	0.15
	Total	2.03	1.08	0.31	0.74
Kalutara	Swell	1.07	0.52	0.25	0.34
	Sea	0.00	0.02	-0.04	0.08
	Total	1.07	0.54	0.21	0.42
Maggona-Paiyaga	Swell	2.76	1.69	0.73	1.07
	Sea	0.39	0.10	0.03	0.02
	Total	3.15	1.79	0.76	1.09
Bentota- Beruwala	Swell	1.90	0.97	0.37	0.58
	Sea	0.48	0.09	0.04	0.10
	Total	2.38	1.06	0.41	0.68
Ahungalle-Kosgoda	Swell	2.16	1.07	0.41	0.64
	Sea	0.12	0.05	-0.02	0.13
	Total	2.28	1.12	0.40	0.77
Balapitiya	Swell	5.22	3.57	1.15	1.75
	Sea	0.28	0.12	0.03	0.03
	Total	5.50	3.69	1.18	1.78
Akurala-Ambalangoda	Swell	2.85	1.68	0.58	0.99
	Sea	0.16	0.07	0.00	0.20
	Total	3.01	1.75	0.58	1.19
Dodanthuwa-Hikkaduwa	Swell	1.25	0.70	0.23	0.35
	Sea	-0.03	0.03	0.01	0.20
	Total	1.22	0.73	0.24	0.55
Gintota-Dodanthuwa	Swell	1.28	0.83	0.23	0.37
	Sea	-0.44	-0.03	-0.04	0.20
	Total	0.84	0.80	0.19	0.57

[a]Southwest Monsoon, [b]First Inter Monsoon, [c]Northeast Monsoon, [d]Second Inter Monsoon

Table 2: Shoreline Variation

Location	Shoreline Variation (m)			
	SW	IM 1	NE	IM 2
Mount Laviniya	-0.83333	0.972222	-0.20833	0.416667
Wadduwa-Panadura	1.349206	-0.2381	0.238095	0
Kalutara	-6.71329	-3.78322	-0.71329	-2.23776
Maggona-Paiyaga	22.24599	13.37968	5.903743	7.176471
Bentota- Beruwala	-6.41667	-6.08333	-2.91667	-3.425
Ahungalle-Kosgoda	-1.02041	0.612245	-0.15306	0.918367
Balapitiya	31.56863	25.19608	7.696078	9.941176
Akurala-Ambalangoda	-31.9231	-24.8718	-7.69231	-7.61538
Dodanthuwa-Hikkaduwa	-26.3235	-14.9559	-5.05882	-9.41176
Gintota-Dodanthuwa	-7.67677	1.353535	-0.92929	0.40404

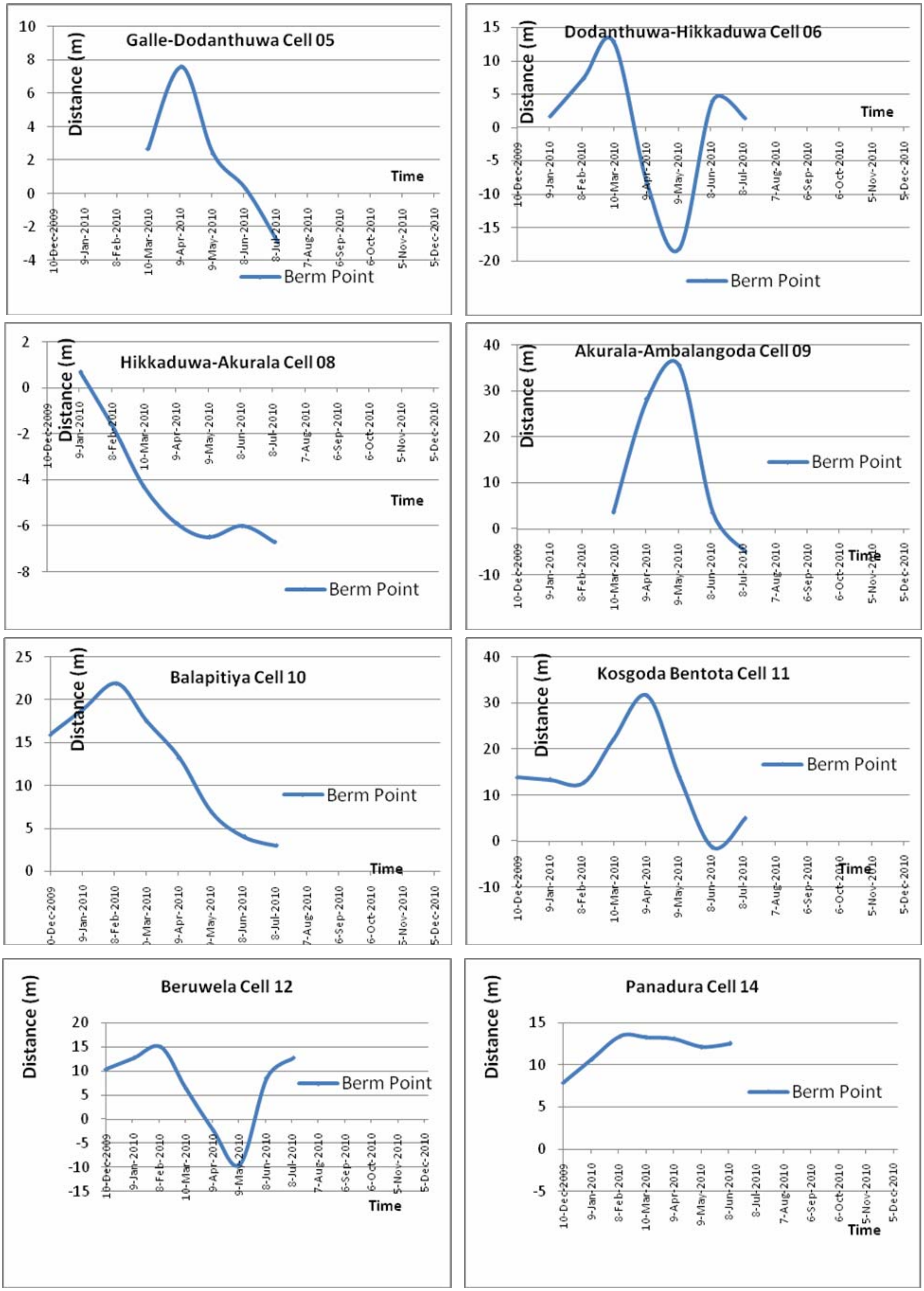

Fig. 4 Field measurements of shoreline variation

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References

Bailard, J. A., “A simplified model for longshore sediment transport.”, *Proceedings of the 19th International Conference on Coastal Engineering*, ASCE,1984; 1454-1470.

Ernest R. Smith, Bruce A. Ebersole, and Ping Wang, “Dependence of Total Longshore Sediment Transport Rates on Incident Wave Parameters and Breaker Type”, US Army corps, 2004.

Fittschen, T., Perera, J.A.S.C., Scheffer, H.J., “Sediment Transport Study For The Southwest Coast of Sri Lanka”, *CCD – GTZ Coast Conservation Project*, 1992; 9-14.

Kamphuis, J.W., “Introduction to Coastal Engineering and Management”, *Advanced Series on Ocean Engineering*, 2000; 16: 290-294,331-334.

Kamphuis, J. W., “Alongshore transport of sand.” *Proceedings of the 28th International Conference on Coastal Engineering*, ASCE, 2002; 2478-2490.

Shore Protection Manual, *Coastal Engineering Research Centre (CERC), U.S. Government Printing Office*, Washington, DC, 1984.

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