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A LONGSHORE SEDIMENT TRANSPORT ESTIMATION FOR THE INDIAN COAST

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ABSTRACT

An empirical sediment transport model has been developed based on longshore energy flux equation. Study indicates that annual gross sediment transport rate is high (1.5×10^6 m^3 to 2.0×10^6 m^3) along the coasts of south Orissa, north Tamilnadu, south Kerala, north Karnataka and south Gujarat, whereas it is comparativcly less (0.5×10^6 m^3 to 1.0×10^6 m^3) along the south Tamilnadu coast. Coast between Pondicherry and Point Calimere in Tamilnadu, and the Maharashtra coast experience negligible annual net transport. The direction of annual net transport along the east coast is towards north and along the west coast towards south except at south Gujarat coast.

INTRODUCTION

The morphology of the Indian coast is quite complex, with long sandy beaches and high dunes along the low-lying east coast, and with many pocket beaches and headlands along the west coast. For the coastal developments in general, port and harbour development and control of beach erosion in particular, a thorough understanding of the littoral environment is essential. The entire stretch of the Indian coast, from New Moore Island in the east to Jakhau in the west, has been considered in the present study for estimating the longshore sediment transport rate.

METHODS

India Meteorological Department publishes weather data transmitted by the ships plying in the Indian waters in the form of Indian Daily Weather Reports. The swell data reported for the period 1968 to 1986 are considered for the present study. Indian coastal region is divided into 8 grids each of $5^\circ \times 5^\circ$ size and the swell data pertaining to each grid are compiled (Fig. 1). Based on the Shore Protection Manual (1975), the deep water version of the longshore transport equation is related to the longshore component of the wave energy flux as,

$$Q = 1288 \left[(\rho g^2) / (64\pi) \right] T (Ho.Kr)^2 \sin 2\alpha_b \qquad (1)$$

where Q = volume rate of longshore transport in m^3/yr, p = density of sea water in kg/m^3, g = acceleration due to gravity in m/s^2, T = wave period in s, α_b = breaker angle, and Ho = deep water wave height and Kr = refraction coefficient (Chandramohan et al., 1988).

As the data compiled for the present study correspond to deep water condition, eqn (1) is used for estimating the longshore sediment transport rate.

RESULTS AND DISCUSSION

The segments of the coastline bounded by each grids are: Grid 1 - from New Moore Island to Paradeep, Grid 2 - from Chandrabhaha to Ganjam, Grid 3 - from Gopalpur to Ramaypatnam, Grid 4 - from Allur to Athirampatnam, Grid 5 - Manamelkudi to Cochin, Grid 6 - from Ponnani to Karwar, Grid 7 - from Goa to Tarapur and Grid 8 - from Umbergaon to Jakhau.

The annual gross and net transport rates were estimated for every 10^{o} variation of coastline in each grid, and the results are presented as rose diagrams in Fig. 2. The transport rates at selected locations along the Indian coast are presented in Table 1.

In Grid 1, the direction of transport is towards northeast from February to November and southwest in December and January. Shorelines oriented about 80^{o} with north are subjected to maximum transport, with a gross volume of 2.10×10^{6} m^{3} and a net volume of $1.4 \times 10^{6} m^{3}$ per year. The direction of annual net sediment transport is towards northeast.

In Grid 2, the transport is northeasterly from March to October and southwesterly from November to February. Coasts with inclination of 80^{o} to north undergo transport of sediment with a gross volume of $1.87 \times 10^{6} m^{3}$ and net volume of $1.56 \times 10^{6} m^{3}$ per year. The average orientation of this coastline is 40^{o} with annual gross and net longshore transport of $1.26 \times 10^{6} m^{3}$ and $0.74 \times 10^{6} m^{3}$ respectively. The direction of annual net transport is northeasterly.

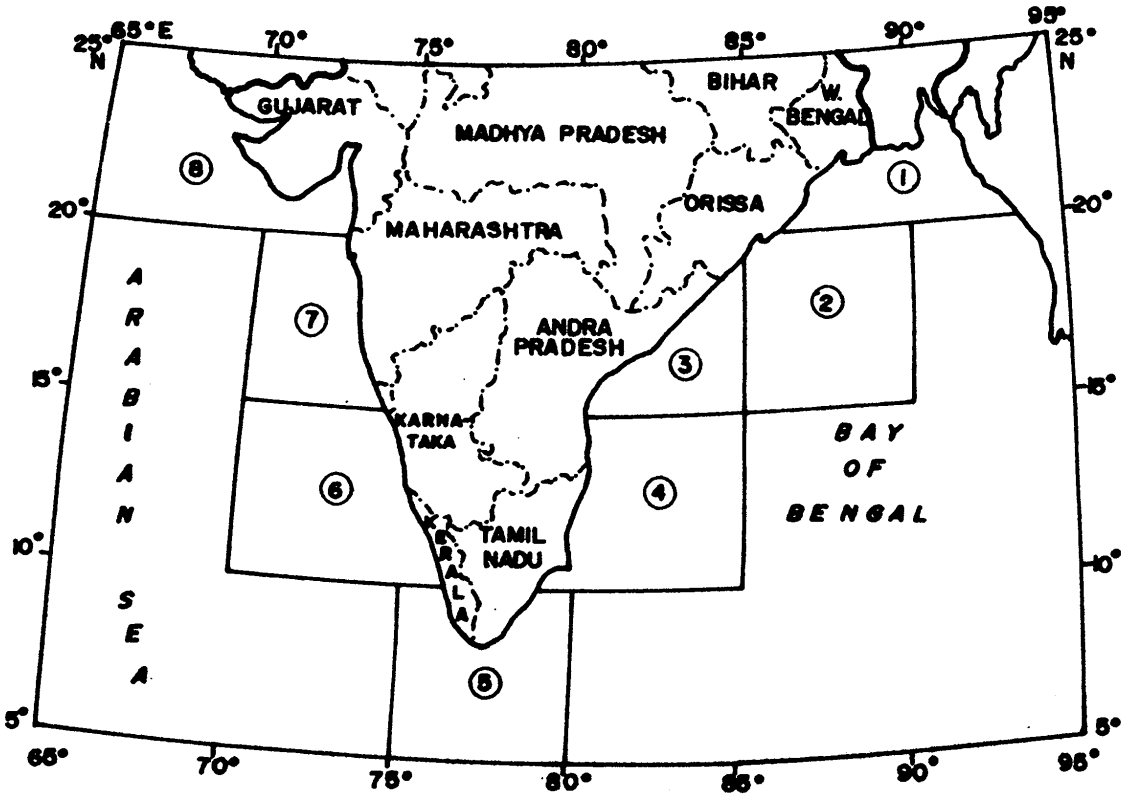

Fig. 1. Map showing the grid.

Table 1. Estimated longshore transport rate at important places

LOCATIONS	Rate in $10^6 m^3/yr$	
EAST COAST:	**Southerly**	**Northerly**
Dariapur	0.273	1.528
Paradeep	0.284	1.625
Gopalpur	0.260	0.962
Visakhapatnam	0.318	0.845
Kakinada	0.262	0.960
Machilipatnam	0.502	0.440
Krishnapatnam	0.698	0.895
Madras	0.683	1.027
Pondicherry	0.692	0.939
Cuddalore	0.698	0.895
Karaikal	0.660	0.656
Manamelkudi	0.490	1.432
Tuticorin	0.330	0.330
Kanyakumari (east)	0.312	0.398
Kanyakumari (tip)	0.336	1.080
WEST COAST:		
Trivandrum	1.630	0.615
Quilon	1.573	0.623
Alleppey	1.062	0.677
Cochin	0.977	0.693
Calicut	1.089	0.349
Mangalore	1.069	0.362
Coondapur	0.873	0.508
Karwar	1.511	0.199
Goa	0.820	0.530
Malwan	0.734	0.686
Ratnagiri	0.625	0.925
Tarapur	0.720	0.712
Valsad	0.594	0.980
Veraval	1.651	0.163
Dwaraka	1.018	0.391

In Grid 3, the transport is northeasterly from March to October and south westerly during the rest of the year. Coasts oriented at 80° to north are subjected to highest transport with a gross volume of 1.53 x $10^6 m^3$ and a net volume of 1.09 x $10^6 m^3$ per year. Average orientation of the coastline in this grid is around 50° and the annual gross and net longshore transport rates are 1.23 x $10^6 m^3$ and 0.70 x $10^6 m^3$ respectively. The direction of annual net transport is northeasterly.

In Grid 4, the transport is northerly from April to October and southerly from November and March. Coasts having inclination of 40° to north undergo maximum transport with a gross volume of 1.94 x $10^6 m^3$ and a net volume of 0.91 x $10^6 m^3$ and 0.44 x $10^6 m^3$ respectively and south of Pondicherry till Point Calimere, 1.25 x $10^6 m^3$ and 0.06 x $10^6 m^3$ respectively. The annual net transport is northerly between Pondicherry and Allur and southerly from Point Calimere to Chidambaram.

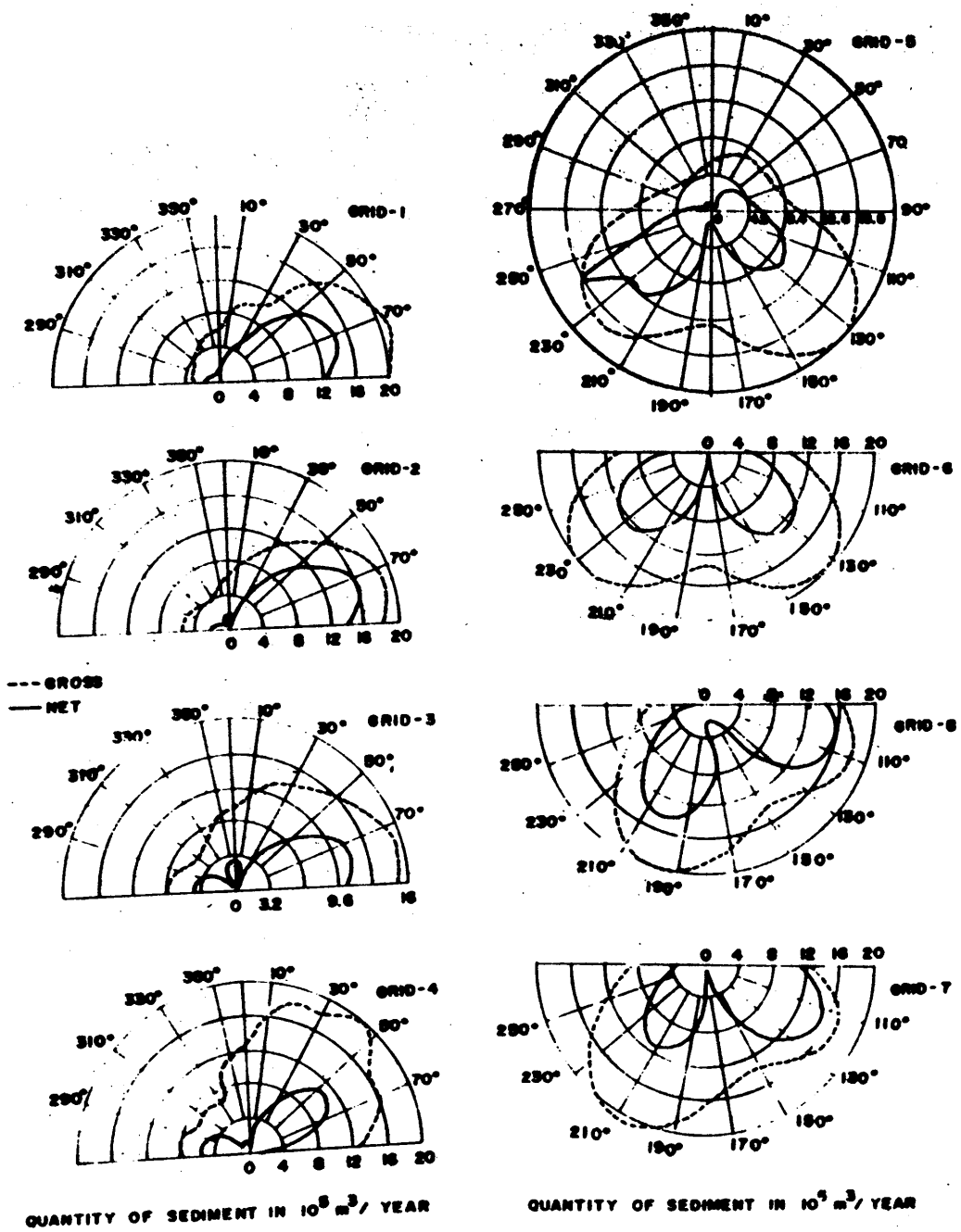

Fig. 2. Rose diagrams for annual sediment transport rate.

The coastal segment in Grid 5, is exposed to high wave energy environment compared to the other part of the Indian coast due to its better exposure to the Indian Ocean. Between Manalmelgudi and Kanyakumari, the direction of transport is northerly from March to December and southerly in January and February. Coasts

having the inclination of 90° to north undergo maximum transport with a gross volume of 1.11 x $10^6 m^3$ and a net volume of 0.59 x $10^6 m^3$ per year.

The transport between Kanyakumari and Trivandrum is southerly from May to December and northerly from January to April. Between Trivandrum and Cochin, the transport is southerly from January to March and June to September, and northerly in April, May and from October to December. Coasts having an orientation of 130° to north undergo maximum transport of sediment in a year with a gross transport of 2.27 x $10^6 m^3$ whereas, orientation of 160° experience less transport with a gross volume of 1.86 x $10^6 m^3$ and a net volume of 0.55 x $10^6 m^3$ per year.

In Grid 6, the transport is southerly from February to September and is nearly equal on either directions from October to January. Coasts having inclination of 130° to north undergo maximum annual sediment transport with a gross volume of 1.94 x $10^6 m^3$ and a net volume of 1.28 x $10^6 m^3$. The average orientation of the coastline is about 150° and the annual gross and net transport rates are 1.6 x $10^6 m^3$ and 1.1 x $10^6 m^3$ respectively. The annual net transport is southerly.

In Grid 7, the direction of longshore transport during southwest monsoon is northerly, and southerly during the rest of the year. Coasts having inclination 130° to north undergo maximum transport rate with a gross volume of 1.69 x $10^6 m^3$ per year and a net volume of 1.34 x $10^6 m^3$ per year. The average orientation of this coastline is around 170° and the annual gross and net transport rates are 1.46 x $10^6 m^3$ and 0.72 x $10^6 m^3$ respectively.

In Grid 8, the sediment transport between Umbergaon and Surat is southerly from November to April, and northerly during the rest of the year. Coasts having the inclination of 200° to north are subjected to maximum transport with a gross volume of 1.69 x $10^6 m^3$ and a net volume of 1.38 x $10^6 m^3$ per year. The average orientation of this coastal stretch is around 180° and the annual gross and net transport are 1.84 x $10^6 m^3$ and 1.01 x $10^6 m^3$ respectively. In between Mahuva and Jakhau, transport is easterly throughout the year except in November. Large transport of about 2.3 x $10^5 m^3$ per month occurs during the southwest monsoon. The average orientation of the coast along this stretch is around 130° and the annual gross and net longshore transport rates are estimated to be 1.55 x $10^6 m^3$ and 1.10 x $10^6 m^3$ per year respectively.

CONCLUSIONS

The results are reasonably applicable for the east coast and it has inherent limitation for the west coast, where numerous headlands and estuaries are intersecting the littoral zone. Study shows that annual gross sediment transport rate is high (1.5 x $10^6 m^3$ to 2.0 x $10^6 m^3$) along the coasts of south Orissa, north Tamilnadu, south Kerala, north Karnataka and south Gujarat whereas it is comparatively less (0.5 x $10^6 m^3$) along the south Tamilnadu coast. Coast between Pondicherry and Point Calimere in Tamilnadu and Maharashtra coast experience negligible quantity of annual net transport. The annual net transport at the southern most tip of Indian Peninsula (Kanyakumari East Cape) is negligible. The annual net transport along

the east coast is northerly and along the west coast it is southerly except on the south Gujarat coast.

ACKNOWLEDGEMENTS

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