HYDROGRAPHIC ASPECTS OF CHOLE BAY, MAFIA ISLAND

A.M. Dubi
Institute of Marine Sciences
University of Dar es Salaam, P.O. Box 668, Zanzibar
E-mail: dubi@ims.udsm.ac.tz

Mafia has been a port on the monsoon trade routes from the Arabia to Sofala for almost 2000 years. The Island has not changed significantly since ancient times and retains a traditional culture of fishing and subsistence agriculture. By 1991, development of tourism on the Island seemed very slow. Factors limiting the number of visitors included the lack of adequate travel connections between the island and the mainland, and inadequate and poor hotel services. Currently, accessibility to Mafia Island has improved. Mafia Island can now be reached by air in addition to the traditional sea travel. However, the Island does not have proper harbour facilities for coastal shipping. There are two areas, which have been under consideration for harbour development, namely Kilindoni and Utende. Kilindoni has the advantage of being near to the administrative centre and storage facilities, but the deepwater anchorage is about 1 kilometre offshore, which makes transshipment of cargo or the building of a jetty necessary. The Utende site has the advantage of having deep water adjacent to the beach, but the construction of the harbour will involve blasting and dredging, operations which may destroy the environment and cause pollution. The site is considered hydrographically unsuitable, as there are strong currents at the entrance to Chole Bay as well as the anchorage in Chole channel. This study assessed shoreline dynamics and collected information on near-shore sediments, currents, waves and beach profiles off Utende Beach, which can be used by potential investors in harbour development and tourism. The Methodology included visual observation and field measurements. Results show that although tidal currents gush in and out of Chole Bay reaching ebbing speeds of 2.5 m/s and flooding speeds of 1.5 m/s during spring tides, they are nevertheless not a threat to harbour or jetty construction. Upon reaching the bay, the currents are diffracted and lose momentum such that near-shore waves and currents are not significant

Keywords: *Mafia Island, Chole bay, Kilindoni, Utende, Shoreline dynamics*

INTRODUCTION

Mafia Island is located in the Indian Ocean, approximately 120 kilometres southeast of Dar es Salaam and 21 kilometres off the eastern extent of the Rufiji River delta. The island extends between latitudes 7° 38′ S – 8° 5′ S and longitudes 39° 35′ E – 39° 55′ E (Figure 1). It takes approximately 30 minutes by air or seven hours by sea from Dar es Salaam. The Main Island is about 48 kilometres long and 17 kilometres wide at its widest point. A 33-kilometre long broken reef fringes the southeastern part of the island including the smaller islands of Jina, Juani and Jibondo. The patch reef constituting Tutia lies just beyond the southernmost extent of the fringing reef.

A detailed account of the geology of Mafia Island can be found in Kent *et al.* (1971). Generally, the Island is studded by rocks that range in age from Miocene to Recent (Kent *et al.*, 1971). The Island is part of ancient Miocene Rufiji river delta, that is currently above the water owing to eustatic movements and block faulting that occurred over the coastal and offshore deltaic zone of Tanzania (Mruma, 1996; Kent *et al.*, 1971). Beach sand and Pleistocene-Holocene beach ridges are found in the northern part of the site, and extend northward into the Mafia Island Lodge area. The sand is

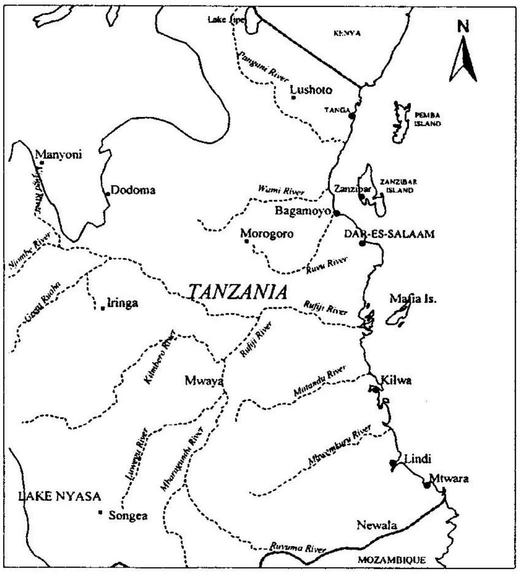

Figure 1:Location map of Mafia Island

mainly composed of carbonate sand mixed with quartz and feldspar.

The study area is Utende Beach and the adjacent Chole Bay, which lies between the southeastern part of Mafia, Jina, Juani and Chole Islands (Figure 2). The study was carried out at two sites at Utende Beach and one site each at the main entrances of Chole Bay, namely Chole Channel and Kinasi Pass. The aim of the study was to increase baseline data on shoreline dynamics, collect information on near-shore sediments, currents, waves and beach profiles, which can be used by potential investors in harbour development and tourism.

METHODOLOGY

Information on beach profiles and near-shore waves, currents and sediments was gathered during the southerly monsoon winds of September 2000. Surface currents at Chole Pass and Kinasi Pass and near-shore currents and waves were measured using an Aanderaa self-recording current meter model 9 (RCM9) and a pressure gauge. The current meter is a self-contained instrument that can be moored in the sea for long periods of time. It measures horizontal current speed and direction, temperature, salinity, turbidity as well as pressure from which the water depth above the instrument can be deduced. The wave gauge was deployed near the current meter on the tidal flat. It can measure up to 2.5 bar of absolute pressure. Waves were recorded at a sampling frequency of 1 Hz. Profiles were measured using a surveyor's level of type Leica NA828.

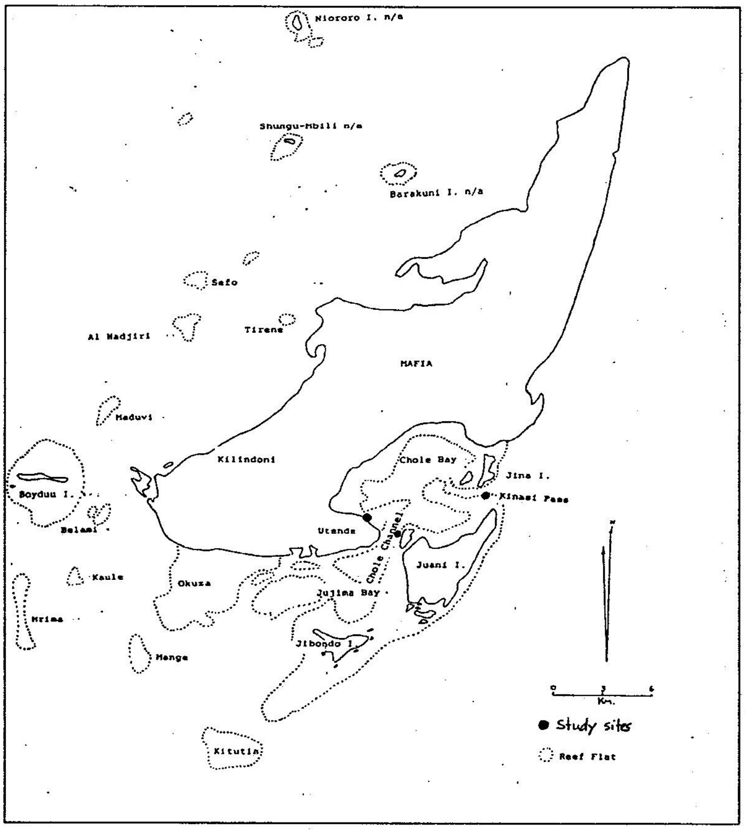

Figure 2: Study sites (Utende Beach and the main entrances to Chole Bay). Adopted from Horril et al. (1991)

RESULTS

Beach sediments, shoreline dynamics andprofiles

A survey of Mafia Island beaches show that shorelines are receding. The most affected areas are the Utende beach situated in the Chole Bay and Kitoni beach situated on the southwestern part of Mafia Island (Plate 1). The shore at Utende is vegetated by the same mangrove stands that were described by Dubi et al. (1997). Off Utende Beach there is a creek from where a boat-launching ramp is planned. The beach seems to change morphology with season, i.e. it accretes and erodes with season. The northern part of Utende beach consists of Pleistocene-Holocene beach ridges. The sand is mainly composed of carbonate sand mixed with quartz and feldspar (Dubi et al., 1997). Unconsolidated quaternary sediments that seem to be of fluviatile origin are well exposed at the cliff. They vary in character from a thin conglomeratic layer to dark coloured silt at the base of the cliff as depicted in. The cliff was previously a source of building material (soil) for the people of the Jibondo Island.

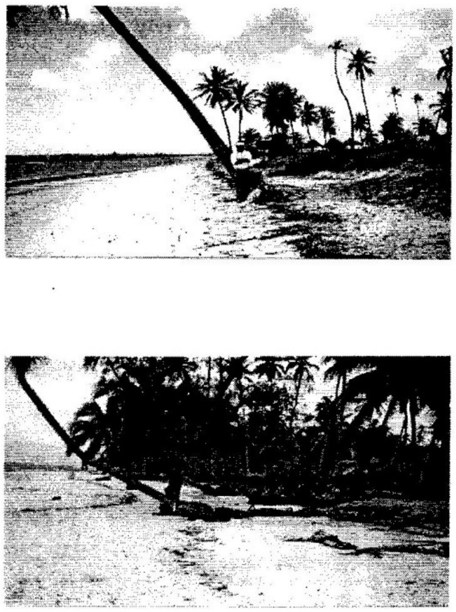

Plate 1: Signs of beach erosion at Utende (top picture) and Kitoni beach on the southwestern coast of Mafia Island. Note the falling coconut trees

The shore is vegetated by the same mangrove stands that were described by Dubi et al. (1997). Off the creek (off Mafia Island Marine Park's Headquarters), the beach seems to change morphology with season, i.e., it accretes and erodes with season. Beach profiles and sediments at the proposed site are different from those in the north off the Mafia Island Lodge adjacent to the dispensary. Off the creek, the average slope of the beach is 1:45. Hence, for the purpose of designing a jetty, the profile of the beach can be represented by a linear equation $y = -0.0229x + 97.282$, where x is the distance, in meters, from the observed highest water mark seaward. The shoreline is oriented 356°. The observed highest watermark near the dispensary is at elevation 98.273 m and the lowest water level is at elevation 93.773 m relative to the dispensary plinth level, which is assumed to at elevation 100 m. The slope of the beach is about 1:20 and hence the profile can be represented by a linear equation of the type $y = -0.0483x + 98.273$, where x is the distance, in meters, from the observed highest watermark. The shoreline is oriented 340°

Grain size distribution of the sediments is varied even within short distances. Off the MIMP Headquarters, the median grain size was found to have a Phi-value of 1.086, which is equivalent to 0.47 mm and the mean grain size is 1.14. A few hundred meters northward, at the dispensary, the median grain size (d_{50}) has a Phi-value of 1.61, which is equivalent to 0.32 mm and the mean grain size is of Phi-value equal to 1.66 at the dispensary. Figure 3 and Figure 4 show cumulative distribution and grain size distribution of beach sands at Utende beach.

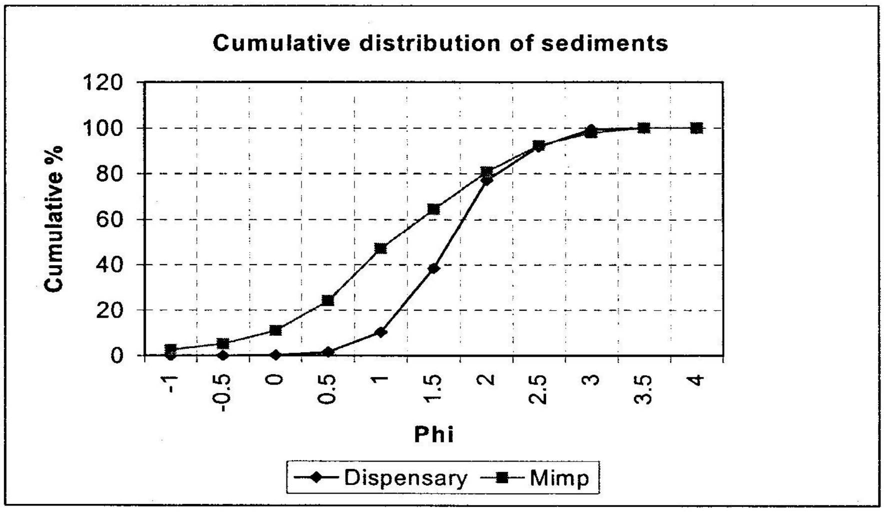

Figure 3.: Cumulative distribution of beach sands at Utende

Near-shore currents and waves on the tidal flat

Tides have semidiurnal characteristics with two unequal high waters and near-shore currents are of the order of 10 cm/s as shown in Figure 5. Figures 6 shows histogram of the direction of the near-shore flood tide. This figure shows that the flooding tide is predominantly northerly (60^{o}). The ebb tide is also predominantly northerly as shown in Figure 7. Figure 8 shows the time series of waves measured during high water on the tidal flat. Wave spectra, as shown in Figure 9, are broad banded and exhibit very low energy.

Entrances to Chole Bay (Kinasi Pass and Chole Channel)

Current measurements show that flood tide enters Chole Bay mainly through Kinasi Pass and the Chole Channel. Some water enters the bay also through Jina Pas, Juani Pass and Jibondo Pass. The water leaves the area through the same routes. There is a considerable water exchange between and Northern Jujima Bay via Chole Channel. Kinasi Pass is the most important with regard to tidal water transport in the Chole Bay with very little water entering or exiting through Jina Pass. At Kinasi Pass, flood tides are westerly and ebb tides are easterly during both neap and spring tides. During spring tides, ebb tidal currents reach a maximum speed of 1.6 m/s while flood tidal currents reach a maximum speed of 1.5 m/s. During neap tides, ebb currents reach a maximum speed of 1.5 m/s while flood currents reach a maximum speed of

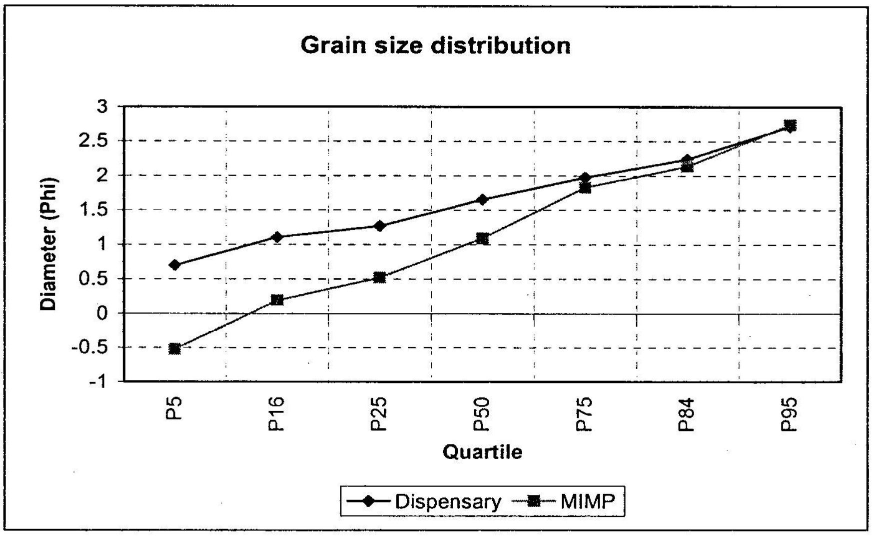

Figure 4.: Grain size distribution of beach sediments at Utende

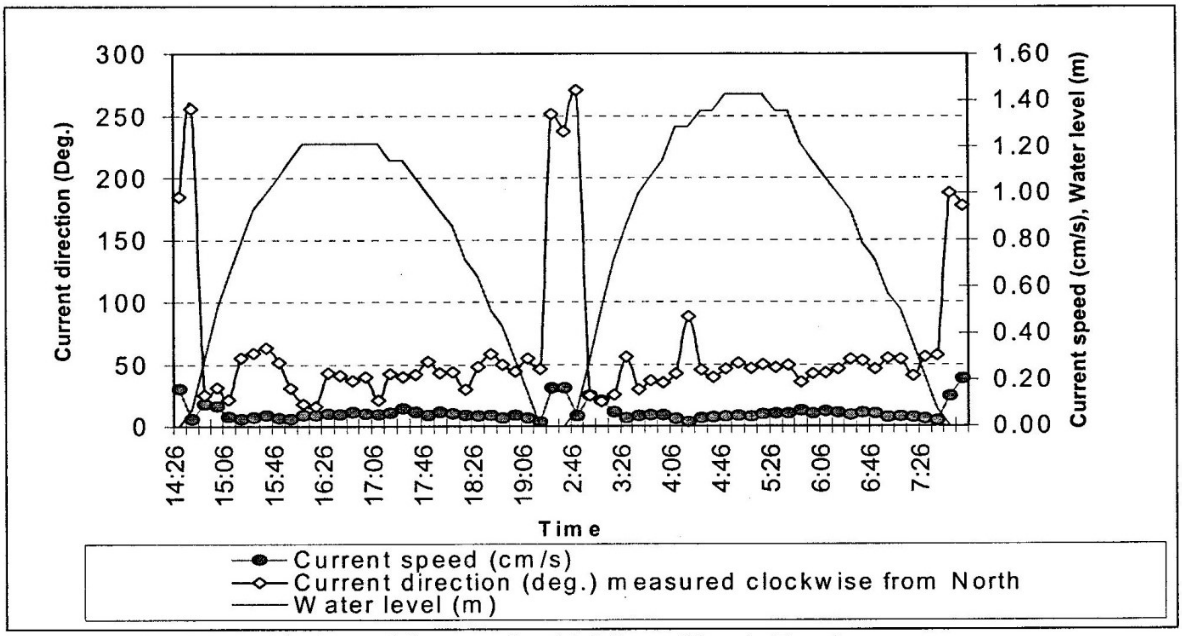

Figure 5.: Hydrographical conditions on the tidal flat at Utende Beach

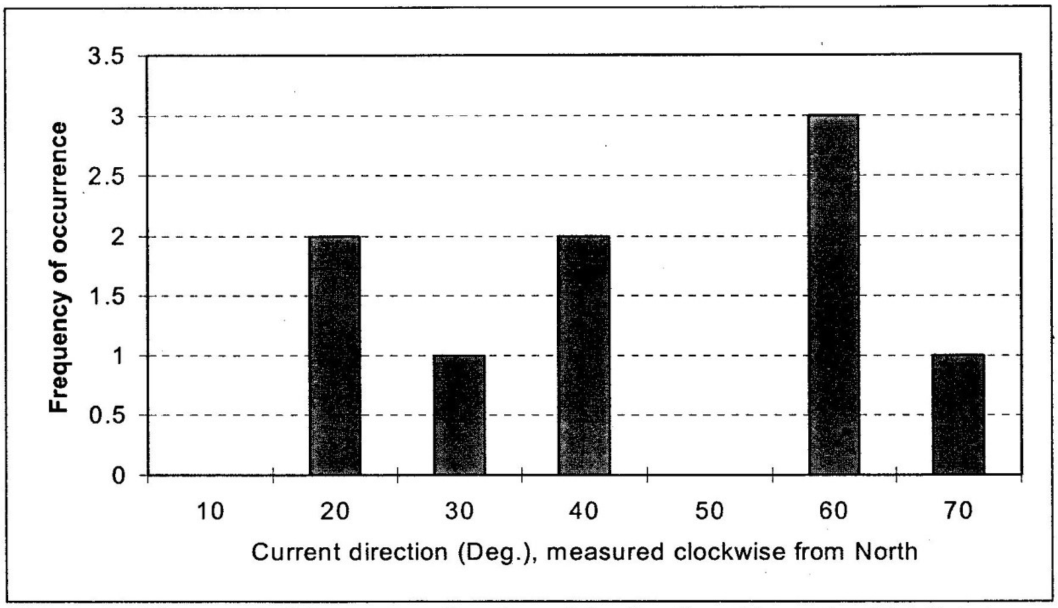

Figure 6.: Histogram of the current direction of the flooding tide on the tidal flat at Utende Beach

1.0 m/s. (Figure 10). It can be seen that there is hardly and slack water between flood and ebb tides. At the Chole Channel, flood currents are northerly and ebb currents are southerly (Figure 11). Flood currents reach a maximum speed of 1.7 m/s while ebb currents reach a maximum speed of 0.8 m/s. Figure 12 shows that flood currents are consistent in direction.

CONCLUSION

Strong currents to the order of between 1.5 m/s and 2.5 m/s are experienced where the water enters and leaves Chole Bay, i.e. at Kinasi Pass and Chole Channel.. During flood tides, the flood currents entering Chole bay converge resulting in downwelling in the middle of the

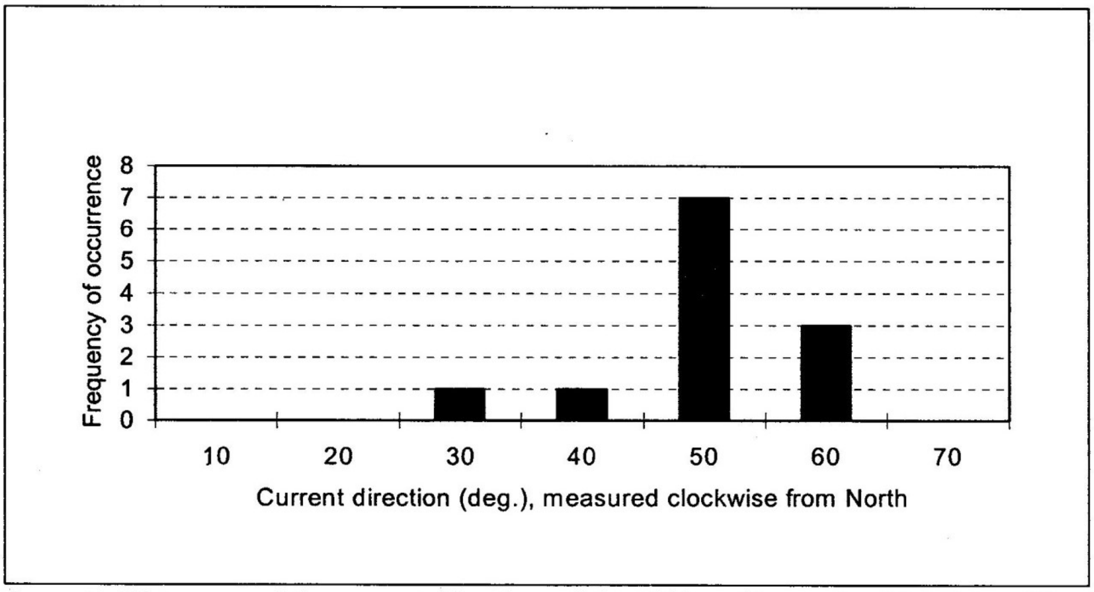

Figure 7: Histogram of the current direction of the ebbing tide on the tidal flat at Utende Beach

bay, while during the ebb tides the ebb currents flowing out of the bay diverge resulting in upwelling in the middle of the bay.

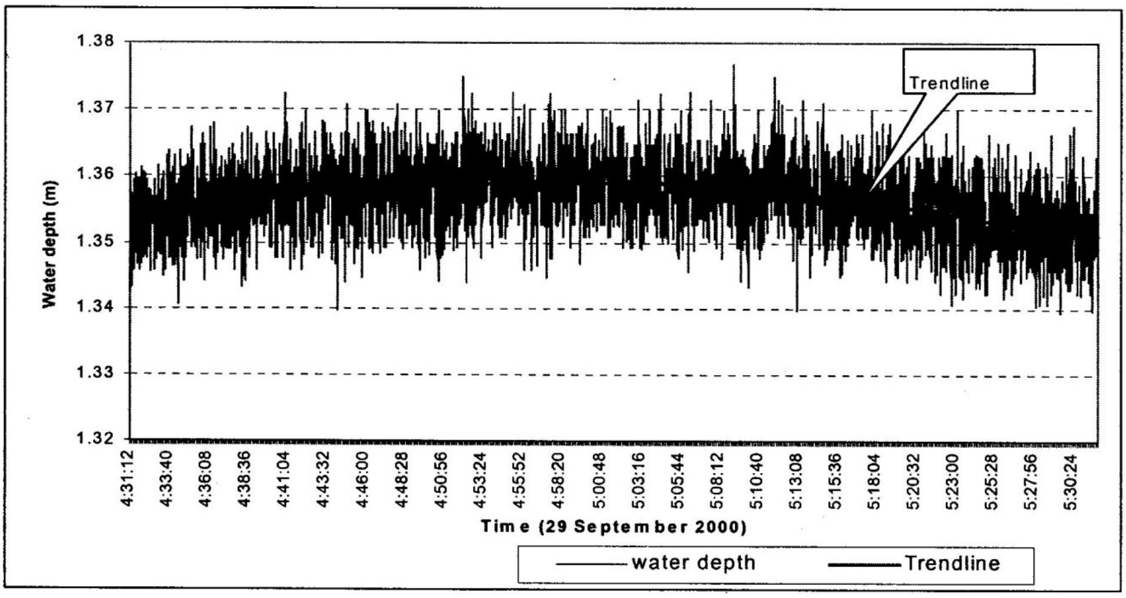

Figure 8. Time series of waves measured on the tidal flat

Despite the gushing flood and ebb currents at Kinasi Pass and Chole Channel, in the near-shore area, the currents are weakened to the order of 0.1 m/s by refraction and diffraction, a situation which favours harbour or jetty construction. The near-shore currents and waves in combination with other factors, however, are strong enough to cause erosion of the beach.

ACKNOWLEDGEMENT

The author acknowledges, with many thanks, financial support for the study from Sida-SAREC through the Director of the Institute of Marine Sciences.

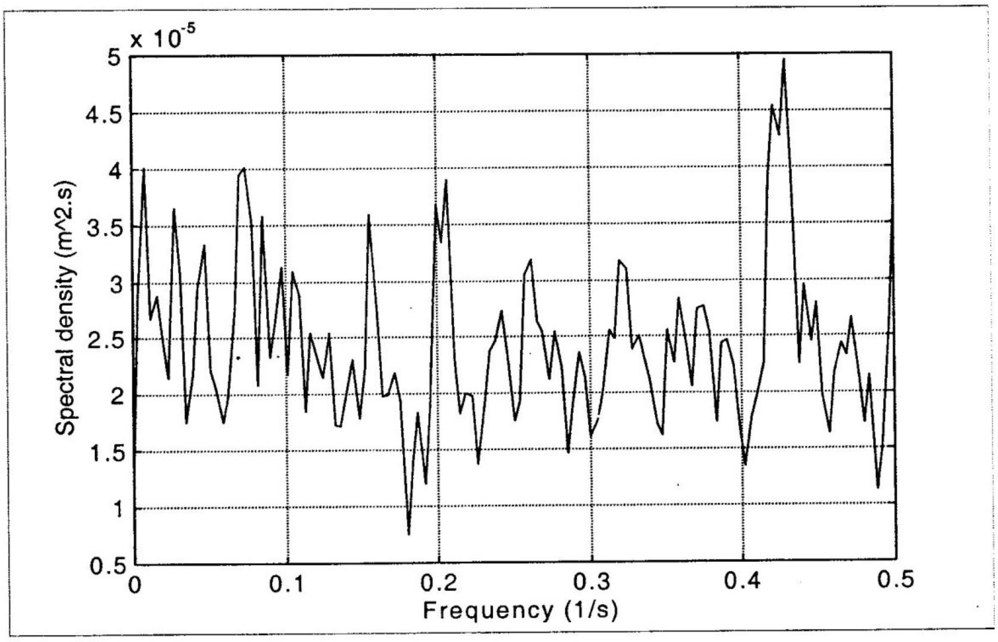

Figure 9: Wave spectra on the tidal flat at Utende Beach

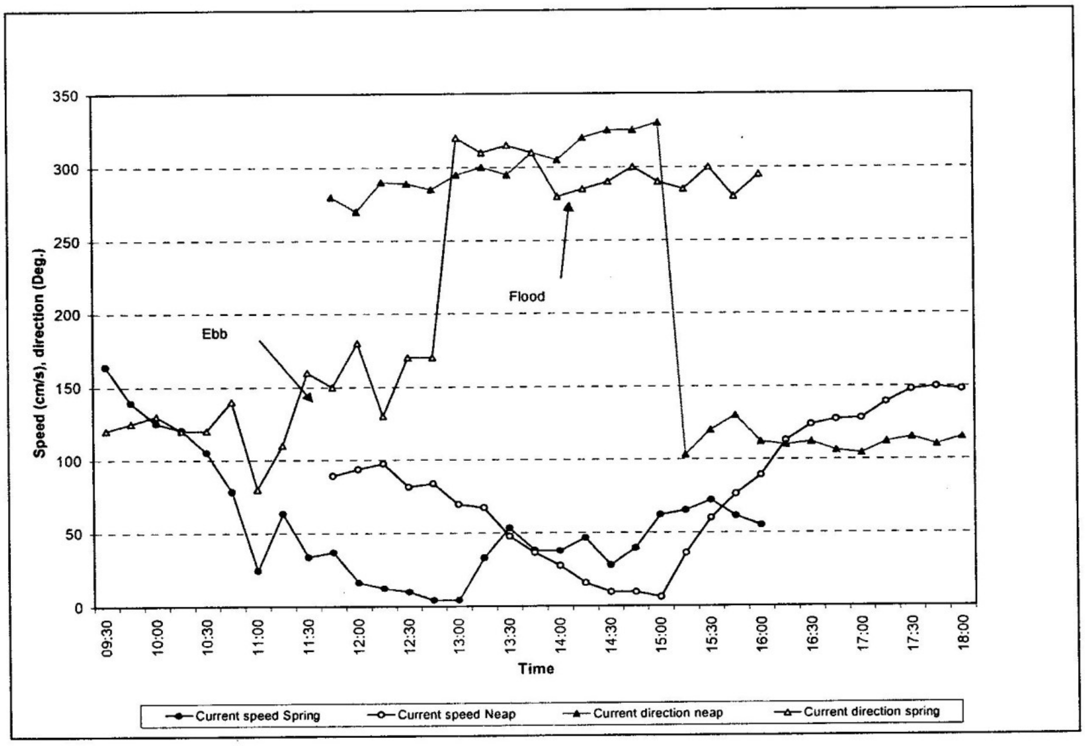

Figure 10: Current speed and direction during neap and spring tides at Kinasi Pass

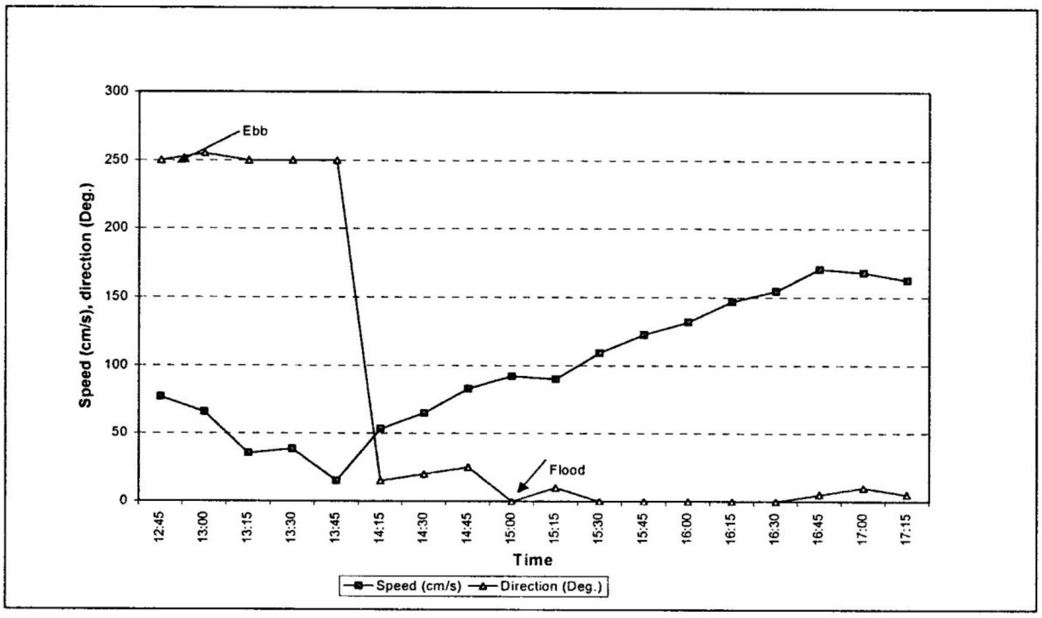

Figure 11: Current speed and direction during neap and spring tides at Kinasi Pass

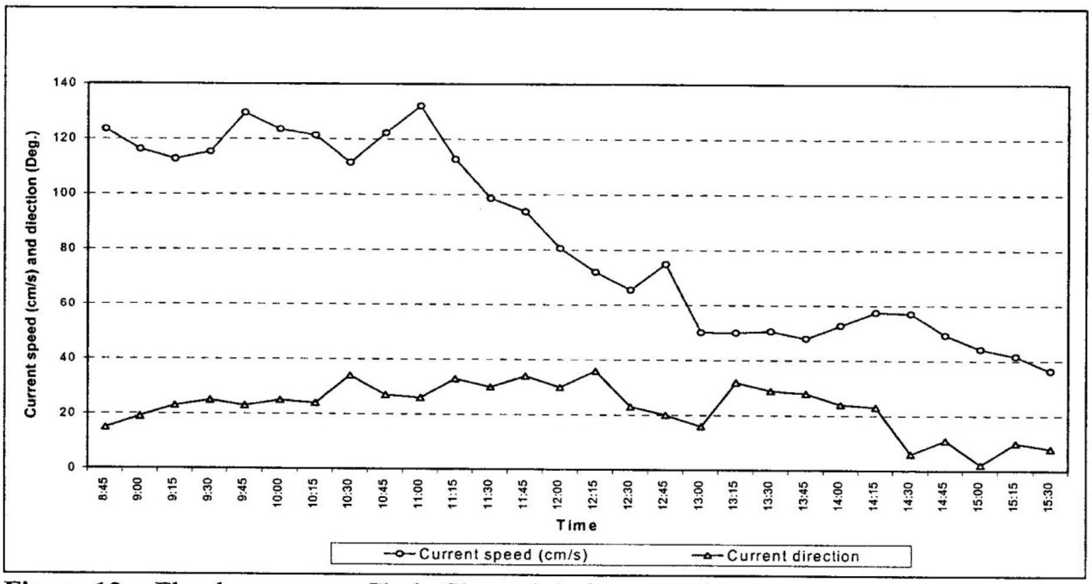

Figure 12.: Flood currents at Chole Channel during neap tide

REFERENCES

1. Dubi, A.M., Shunula, J.P. and Muzuka, A.N.N., Environmental Impact assessment for the proposed Mafia Island Marine park (MIMP) HQ. Institute of Marine Sciences Report No. IMS 1997/03. 1997

2. Horrill, J.C. and Ngoile, M.A.K.,. Results of the physical, biological and resource use surveys: Rationale for the development of a management strategy. A report for the Mafia Island Marine reserve Steering Committee. The Society for Environmental Exploration and the University of Dar es Salaam. 1991

3. Kent, P.E., Hunt, J.A. and D.W. Johnstone, The geology and geophysics of Coastal Tanzania. Geophysical paper No. 6, London. 101 pp., 1971

4. Mruma, A.H, Geology and tectonics of the coastal zone and major islands of Tanzania.

In Mohamed, S.K. and Betlem, J., (eds.). *Proceedings of the National Workshop on coastal erosion,* Zanzibar, 11-12 April 1996. Zanzibar Environmental Series No. 20. Commission for Lands and Environment – Zanzibar. 1996