# SEA LEVEL MONITORING AND STUDY OF SEA LEVEL VARIATIONS ALONG PAKISTAN COAST: A COMPONENT OF INTEGRATED COASTAL ZONE MANAGEMENT

Tariq Masood Ali Khan and M. M. Rabbani
National Institute of Oceanography
St-47, Block-1, Clifton, Karachi, Pakistan.
Tel. #: 92-21-9251172-78, Fax. #: 92-21-9251179
E-mail: niopk@cubexs.net.pk, tariqmak@yahoo.com

## INTRODUCTION

Pakistan has a coastline of about 990 km and the Exclusive Economic Zone (EEZ) of about 240,000 km$^2$. It roughly divided into two main sections on the basis of its physiographical characteristics viz. the Sindh coast and the Balochistan coast. The Sindh coast is roughly 320 km long with continental shelf deep stretches into the ocean and located in the south-eastern part of the country between the Indian border along Sir Creek on the east, while the Balochistan coast is 670 km long with steep and narrow continental shelf at south-western part of the country and borders with Iran near Jiwani in the west (UNEP, 1996). The area Pakistan coastline is shown in Figure-1.

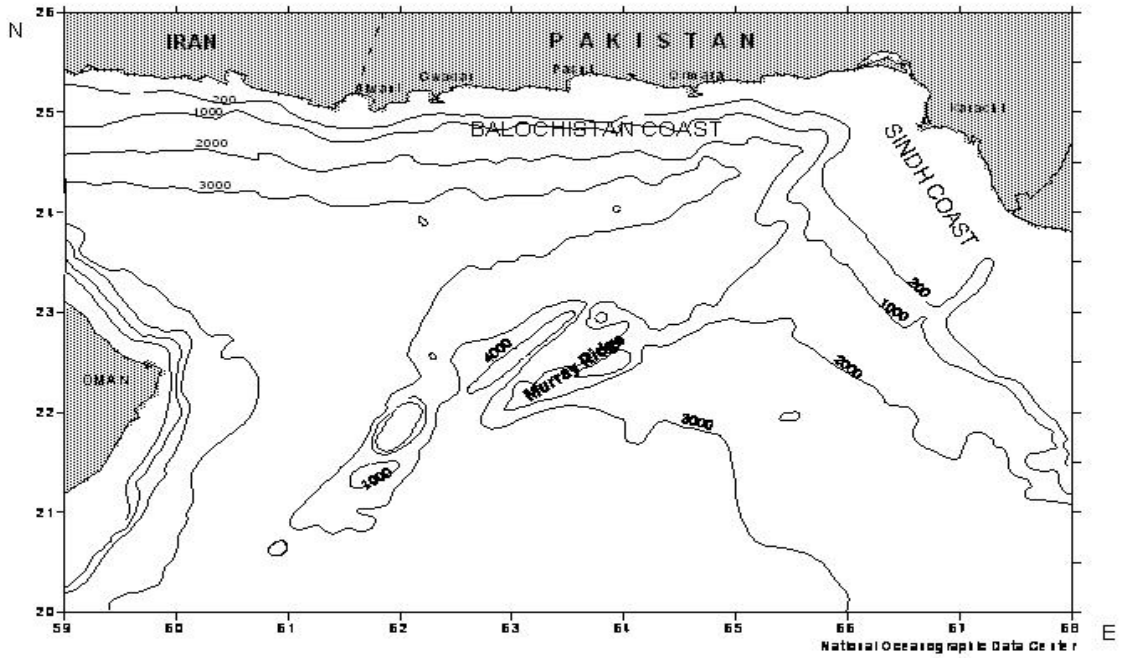


Figure-1. Map showing Pakistan coastline

The UNEP in its regional seas program in 1989 has included Pakistan in a group of countries, which are vulnerable to impact of rising sea level. If the present trend of sea level rise (SLR) at Karachi continues, in the next 50 years the sea level rise along the Pakistan Coast will be 50 mm (5 cm). Since the rising rates of sea level at Karachi within the global range of 1–2 mm/year, the trends may be treated as

eustatic sea level rise. Historical air temperature and sea surface temperature (SST) data of Karachi also show increasing pattern and has registered increasing trend of about 0.67 $^{o}$C in the air temperature over the last 35 years. Whereas the mean SST in the coastal waters of Karachi has also registered an increasing trend of about 0.3 $^{o}$C in a decade.

Sindh coastal zone is more vulnerable to sea level rise than Balochistan coast, as uplifting of coast by about 1-2 mm/year due to subduction of Indian Ocean plate is a characteristic of Balochistan coast. Within the Indus deltaic creek system, the area nearby Karachi is most vulnerable to coastal erosion and accretion than the other deltaic region mainly due to human activities together with the natural phenomenon such as wave action, strong tidal currents and rise in sea level.

The long-term trend of mean sea level for Karachi Harbor is taken from the study conducted by Quraishee in 1988 and the increasing pattern in sea level about 1.1 mm/year at Karachi Harbor has been taken as a base reference to study the impact of sea level rise along Pakistan coast. The graphical representation of tidal behavior with trend line is shown in Figure-2. As the rate of increment in sea level at Karachi is within the global range, the rate may be treated as eustatic sea level rise i.e. the rise is due to thermal expansion of sea water. However, the higher base provided by SLR for storm surges and tides would be particularly important for the Indus delta, where the beach slope is only about 0.1 degree (Wells and Coleman, 1984). A synoptic view of he Indus delta is shown in Figure-3.

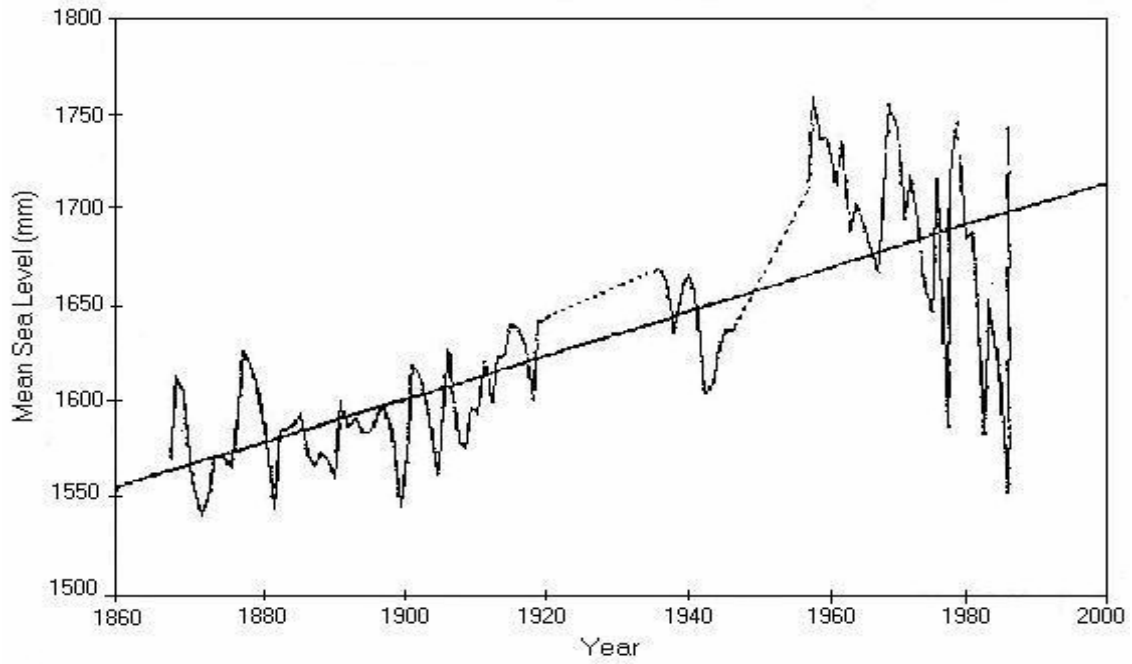


Figure2. Sea Level Trend along Karachi Coast, Pakistan.

Figure-3. Synoptic view of Indus Delta having flat topography.

## SEA LEVEL MONITORING IN PAKISTAN AND TYPE OF TIDE GAUGES

As discussed above, there is a long history of sea level monitoring at Karachi Harbor (24$^o$ 48' N, 66$^o$ 58' E). The data were collected for the smooth port operation. The frequent discontinuation of monitoring of tidal data at Karachi port was mainly due to siltation. Presently GLOSS designated station at Karachi is non-operational due to faulty gauge, lack of funding, maintenance and trained manpower. Efforts are being made to replace the same with new tidal observatory. Another GLOSS designated station in Pakistan is along Balochistan coast at Gwadar Port (25$^o$ 07' N 62$^o$ 20' E). The situation is almost similar to that of Karachi and has become non operational.

Besides, above-mentioned GLOSS designated stations along Pakistan coast; sea level variations are being observed at various locations of Pakistan different projects such as Left Bank Outfall Drain Programme (LBOD). However, the data is being collected according to the requirement of the projects, thus continuous recording of tidal data may not be available from these locations.

The floating type tide gauges were being used in Pakistan (Figure-4). However, in the proposed tidal observatories along Pakistan coast digital tide gauges are recommended.

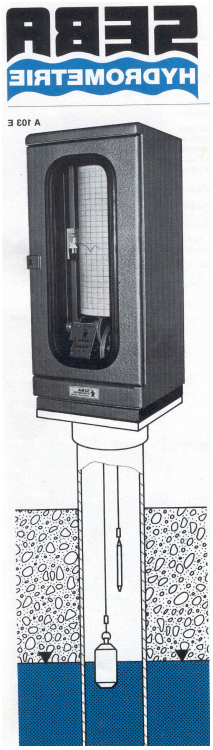


Figure-4. Floating type tide gauge, Gwadar, Pakistan.

## ASSESSMENT OF THE PRESENT GLOSS STATIONS IN PAKISTAN

1. Not all-existing gauges in the country are operational (such as Gwadar). Lack of spare parts and adequate funds to run the stations have led to this station being non-operational.

2. Stations are not multi-parameter gauge stations, therefore not equipped with additional sensors for measuring meteorological parameters.

3. Tide Gauges in Pakistan are not equipped with GPS. The GPS method of monitoring vertical land movements at the tide gauge site is a relatively new technique. Since gauges are relatively old and also lack of operational funds, they are yet to adapt this technique.

The above assessments demonstrate that much work remains to be done. Up-gradation/replacement existing tide gauges and establishment of additional stations are very much required in Pakistan since at present both GLOSS designated stations along Pakistan coast are not fully operational and do not collecting data properly.

## MAIN OBJECTIVES OF THE PROPOSED TIDE GAUGE NETWORK

1. Continuous monitoring of tidal levels at the selected tide gauge stations along the Pakistan coast.

2. Recent Tsunami destructions in South Asia compel Pakistan to monitor tidal continuous variations along Pakistan coast includes the Tsunami Warning Centre, a proposal suggested by NIO.

3. Study of sea level variations through historical tidal data and its relationship with changes in sea surface temperature, localized tectonic activities and global phenomenon such as ENSO events.

4. Study of seasonal variations in sea level and its relationship with meteorological and oceanographic parameters.

5. Focus on the changes in the extreme water levels (i.e. HHW's and LLW's) and try to relate these changes to climatic trends (seasonal, annual, decadal) including ENSO, as well as local tectonics (land subsidence or uplift) and to even more local effects such as harbor dredging.

6. The studies relating to vulnerability and the impacts of sea level rise on the coastal zone will help the other concerned departments to investigation on the appropriate adaptation options.

7. Based on the assessed vulnerability and available adaptation options of the study, the planner may undertake appropriate measures against the sufferings of the people and their economy.

## LOCATION OF PROPOSED TIDAL STATIONS

A network of at least 6 tidal stations including the upgradation of existing GLOSS stations along the Pakistan coast has been proposed to monitor the sea level variations. Stations will be equipped to record tidal data along with meteorological and oceanographic parameters and facility to use GPS techniques for vertical reference. The extent of vulnerability of the area as well as representation of both Sindh and Balochistan coast were the main considerations during selection of sites. The proposed sites are as follows:

1. Karachi
2. Keti Bandar — **Sindh Coast**

3. Gwadar
4. Pasni — **Balochistan Coast**
5. Ormara
6. Sonmiani

## BENEFITS TO INTERNATIONAL COMMUNITY

Installation of tide gauges along Pakistan coast will make possible to provide research quality tidal data continuously to PSMSL under GLOSS programme. The Global Sea Level Observing System (GLOSS) is an international programme coordinated by the Intergovernmental Oceanographic Commission (IOC) for the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research. The available data will also be provided to RNODC's for research purpose. Therefore IOC-UNESCO must allocate funds for the proposed tide gauge stations to ensure the continuous recoding of sea level variations along Pakistan coast and smooth flow of collected data to PSMSL/GLOSS data bank.

## TRAINING REQUIRED

Upgradation of existing tide stations (to measure both meteorological and other oceanographic parameters, replacement of damaged stations and installations of new tide gauges at the selected stations for developing a network, advance training in the latest equipment and improve maintenance and analysis capability for tidal stations in the region through training will be very much required.

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