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SEA LEVEL MONITORING IN PAKISTAN AS A COMPONENT OF INTEGRATED COASTAL ZONE MANAGEMENT

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INTRODUCTION AND BACKGROUND

There are calamitous reports about global warming and its possible effects on weather around the world. The latest estimates forecast a temperature increase of 1.4 -5.8° C with a corresponding rise in sea level by 0.09-0.88 m over a period of 1990-2100 (IPCC, 2001). Global mean sea level is a potentially sensitive indicator of climate change. A rise in the sea level caused by climate change would directly threaten low-lying coastal areas and small Island states (UNEP, 1990). A number of studies mostly using tide gauge data from the Permanent Service for Mean Sea Level (PSMSL), Bidston Observatory, England have obtained rates of global SLR during the last 100 years that range between 0.3 and 3.0 mm/year, with most values concentrated between 1 and 2 mm/year (Pirazzoli, 1993). Since most values are concentrated between 1-2 mm/year, this range may be treated as eustatic sea level rise (Hicks and Crosby, 1974).

Sea level changes are generally local in nature, being affected by a complex combination of local, regional and global processes, which operate on different time and space scales. SST is one of the most important climatic parameters affecting sea level variations. Among the major causes of global sea level changes, factors such as meteorological, hydrological, volcano-tectonic and anthropogenic factors usually prevent accurate estimates (Pirazzoli, 1993). Because of these local factors affecting the SLR, rise in sea level will be different in different places. Local land subsidence and uplift could substantially increase or decrease the apparent SLR. In areas like Bangladesh local factors are amplifying the effects of rise in sea level (Khan *et al.*, 2000). The rates of rise along Bangladesh coast show that the sea level is rising at a faster rate along Bangladesh coast as compared to the mean global rate, implying the dominance of local factors like subsidence over sea level changes.

Besides, the climatic impacts on sea level variations, sea level information has several practical applications including coastal engineering, in which sea level data are needed as instantaneous levels, as well as statistics of extreme levels over long periods. Short-term measurements are needed for ship movements in harbors and ports, for issuing storm surge and tsunami warnings, and for the operation of sluices and barrages. Over a longer period, data are needed for tidal analysis and prediction, for control of siltation and erosion, for inputs to models to estimate the paths of pollutants, and for the design of reclamation schemes and the construction of disposal sites.

Scientific and practical applications interact in many ways. For example, knowledge of long-term sea level rise will need to be input into the engineering design of coastal structures. The knowledge of sea level rise may also help in the understanding of complex coastal processes, such as sedimentation and erosion, which may result in high costs. A second example concerns sea level data assimilation into numerical models (e.g. storm surge, water quality).

PAKISTAN AND SEA LEVEL MONITORING

Pakistan coastline is about 990 km. long and coastal zone is divided into two distinct regions called Sindh coast (Indus deltaic region) and Balochistan Coast (Figure-1).

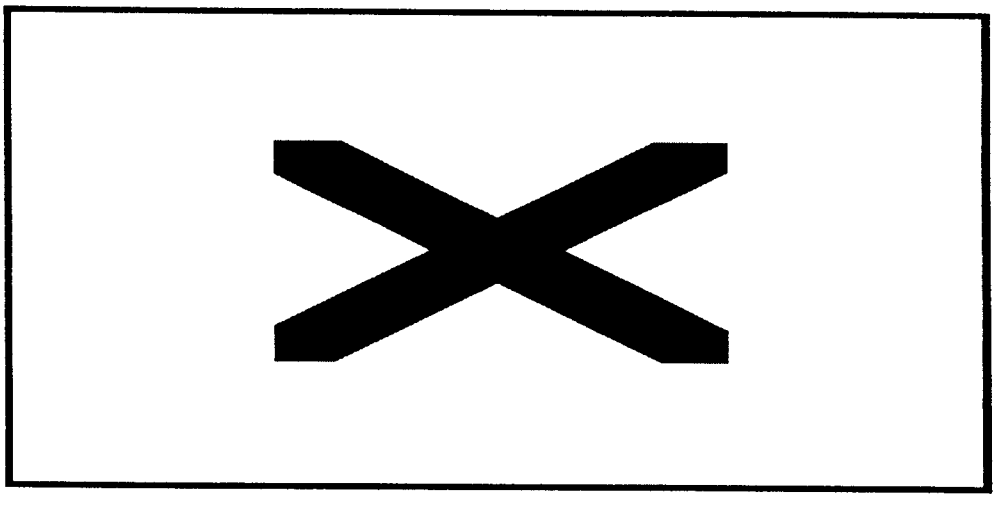

Figure-1. Pakistan Coastline.

There is a long history of sea level monitoring at Karachi Harbour (24° 48' N, 66° 58' E). However, the data were collected for the smooth port operation. Trend analysis shows that the sea level is rising along the Pakistan Coast with the rate of 1.1 mm/year (Figure-2).

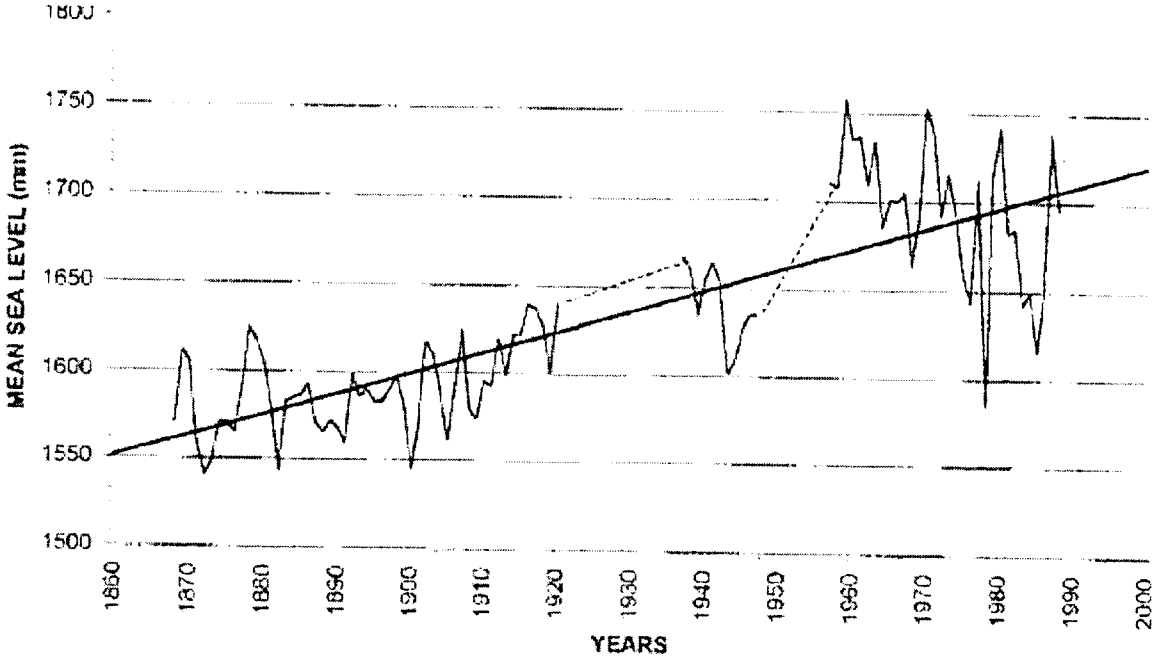

Figure-2. Historical Tidal trends along Karachi Coast (Source: Quraishee, 1988).

The frequent discontinuation of monitoring of tidal data at Karachi port was mainly due to siltation. However, 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° 07' N 62° 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 under different on going 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.

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.

A PROPOSAL FOR THE ESTABLISHMENT OF TIDE GAUGE STATIONS ALONG PAKISTAN COAST

Due to flat topography, the Indus Deltaic creek system (Sindh Coast) is vulnerable to sea level variations. This area is also prone to storms/cyclones, which cause a great deal of inundation in the low-lying areas and thus the area is more vulnerable to flooding. In 1999 a Cyclone named 2A, hit Indus delta that was a catastrophe for the people of the area. With that cyclone, the seawater accompanied by a huge storm surge intruded in land and inundated hectares of agriculture land with saline water. Now the top agricultural soil and land presents a view of ponds fill with saline water. The global SLR is also playing an important role in the recent abnormal coastal flooding. Most of the Balochistan coast lies in the subduction zone and also needs continuous monitoring of sea level variations along the coast.

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. Shah Samodo Creek

4. Gwadar
5. Jiwani — **Balochistan Coast**
6. Pasni

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. 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.

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

4. 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 harbour dredging.

5. To study the coastal flooding in combination of storm surges and changes in the cyclongenesis in the region.
6. To assess the vulnerability and impacts of sea level variations on marine environment, ecology, landuse and landcover pattern, resources and socio-economy

7. 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.

8. 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.

SETTING UP OF NETWORK

The proposed network needs due consideration of local as well as International community to materialize. IOC/UNESCO must allocate finds for the tidal stations to ensure the continuous recording of sea level data along the Pakistan coast and continuous flow of collected data to PSMSL/GLOSS data bank, international community for research and to meet local needs. Training on the latest equipment, its maintenance and data analysis/quality control capability are also recommended for its smooth functioning.

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 tide stations in the region through training will be very much required.

REFERENCES:

Hicks, S. D. and Crosby, J. E. 1974: *Trends and variability of mean sea level 1893-1972.* US NOAA, Technical Memoranda No. 13, 1-14.

IPCC, 2001. Summary for Policymakers. A Report of Working Group I of the Intergovernmental Panel on Climate Change, IPCC, WMO, Switzerland.

Khan, T. M. A., Singh, O. P. and Rahman, M. S., 2000. Recent Sea level and Sea Surface Temperature Trends along Bangladesh Coast in Relation to the Frequency of Intense Cyclones., Mar. Geodesy, 23, 2, 103-116.

Pirazzoli, P. A., 1993. Global sea level changes and their measurement. Global and planetary change, 8, 135-148.

Quraishee, G. S., 1988. Global Warming and Rise in Sea Level in the South Asian Seas Region, in The Implication of Climatic Changes and the Impact of Rise in Sea Level in the South Asian Seas Region, pp. 1-21,

UNEP, 1990. Fact Sheet No. 3, United Nations Environment Program, Nairobi, Kenya.