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National Report on Tide Gauges in Kenya

Introduction

The Intergovernmental Oceanographic Commission (IOC) of UNESCO developed a Global Sea Level Observing System (GLOSS) program in 1985 to address the growing concern about the rise in mean sea level around the globe. The objective of GLOSS was to provide high quality standardized data from which valuable sea level products can be produced for international oceanographic such as World Ocean Circulation Experiment (WOCE), Tropical Oceans Global Atmosphere (TOGA) and regional research programmes as well as for practical application on a national level. Kenya is one of the countries participating in GLOSS and has already received support and assistance in terms of training of our specialists and provision of equipment through IOC.

Kenya's Participation in Sea Level Monitoring Program

In Kenya, the first gauge was installed in 1933 in Kilindini harbour, Mombasa by the former East Africa Railways and Harbours Corporation and was in operation until 1956. Another gauge (Munro gauge) was installed in the 1960's at the Kipevu pilot jetty at the present Kenya Ports Authority Headquarters and operated intermittently upto 1976. However, little data is available from this gauge. In 1975/6, a team from the Permanent Service for Mean Sea Level (PSMSL) collected one-year continuous data.

In the late 1980's, the University of Hawaii in collaboration with the TOGA Sea Level Centre established a network of sea-level stations, which continue to provide useful information. Realising the importance of sea level data for navigation and harbour planning, beach protection and development and overall marine research, Kenya Marine & Fisheries Research Institute (KMFRI) requested for a tide gauge through IOC-UNESCO from the University of Hawaii (UH) in June, 1986 to start its tide gauge network. Following that request, the University of Hawaii donated a tide gauge, which was installed at Liwatoni jetty in Kilindini harbour, Mombasa. A second tide gauge was installed by UH in Lamu in 1996. KMFRI is responsible for maintaining both the Mombasa and Lamu tide gauge stations. Two KMFRI Technicians are attached to each station.

The TOGA Sea Level Centre (TSLC) in collaboration with the University of Hawaii agreed to assist in upgrading Kenya's stations so as to ensure continuous availability of good quality data. Modern tide loggers, measuring sea level every 15 minutes interval were installed. The Lamu gauge was in addition equipped with a satellite data transfer device to enable real-time access to data. This ensures better control on the timeliness and reliability of data. Both Mombasa and Lamu are principal stations on the Global Sea Level Observing System (GLOSS). Both stations continue to operate well and data is available. Kenya is also coordinating the regional component of GLOSS.

Status of GLOSS Stations in Kenya

Mombasa Tide Gauge (Latitude: 04° 04'S Longitude: 039° 039'E)

A Leopold Stevens gauge was installed in Mombasa in 1986. This was later changed to a Fisher and Porter float gauge in 1991. The station continues to operate well and data is available. Some of the benchmarks were removed during construction work at the harbour where the gauge is located. The Mombasa gauge is float type installed on a stilling well. The station is equipped with modern data logger, measuring sea level every minute and storing on diskette at 15 minutes interval.

In August 2006, a major upgrading of the Mombasa tide gauge was carried out with the assistance of field technicians from UHSLC. This involved a thorough overhaul of the existing equipment, installation of additional sensors (pressure and radar sensor). The station was also equipped with satellite data transmission facilities to enable near real-time data access.

A photo of the upgraded Mombasa station is shown below.



Photograph of Upgraded Mombasa Tide gauge

Lamu Tide Gauge (Latitude: 02° 17' S; Longitude: 040° 54' E)

The Lamu gauge is a float type installed on a stilling well. It was installed in 1996 by the University of Hawaii Sea Level Centre (UHSLC). The station is equipped with modern data loggers, measuring sea level every minute and storing on diskette at 15 minutes interval. In addition, the Lamu tide gauge is equipped with a satellite data transfer device to enable real time access to data. Earlier, there was a Valeport BTH 700 gauge was installed at the end of 1988 but was not operational since 1992. This was due to a problem with electrical connection on the jetty where it was installed. During the time the gauge was out of operation, data was collected manually at half hour interval during day time (0900 to 1600 HRS).

In August 2006, the Lamu tide gauge station also underwent a major overhaul of equipment. The station was also fitted with additional sensor (pressure and radar sensor).



Lamu tide gauge house

Additional Stations

The Kenya Meteorological Department (KMD) is now in the process of installing three additional stations along the Kenyan coastline. These will be at: Shimoni ($4^{\circ} 39' S$, $39^{\circ} 23' E$), Malindi ($3^{\circ} 15' S$, $40^{\circ} 08' E$) and Lamu ($02^{\circ} 17' S$, $040^{\circ} 54' E$). Ultimately, there shall be five stations to cover the Kenyan coast.

KMD is the designated National Tsunami Focal Institution for Kenya. The additional stations are therefore being installed within the framework of Indian Ocean Tsunami Early Warning System (IOTEWS). In addition to measuring sea levels, the new stations are equipped with both oceanographic and meteorological sensors to monitor parameters such as SST, salinity, wind, humidity, solar radiation, precipitation, etc.

The objectives of having additional stations is also to enable us obtain high spatial resolution of sea level observations, hence generate better needed time series of sea level data for scientific, management and for local use as well as international use.

The new gauges will also be part of the National sea level programme. The aim of the programme is to provide sea level data and products to all categories of users in Kenya. This information is particularly important at the moment due to the increasing concern about global warming and related sea level rise. The data generated by the tide gauges is a crucial input into the proposed IOTEWS.

More information about the additional tide gauges can be obtained by contacting the director of KMD (director@meteo.go.ke).

Data From Mombasa And Lamu Stations

The sea level data (hourly, daily and monthly means) for the Kenyan stations are available at KMFRI in JASL format. Sea level data from both Mombasa and Lamu is sent to University of Hawaii Sea Level Centre (UHSLC). Monthly means are available at the Permanent Service to Mean Sea Level (PSMSL).

For Mombasa station, available data is from 1975/6 and 1986-2006.

The data available from Lamu station is in digital form and analogue charts. The digital data is from 1989, and 1996–2005 and the analogue chart is from 1990 to 1992. All the digital data from both stations are available in International data centres namely PSMSL and UHSLC.

The data can also be obtained from the following web sites.

- <http://www.soest.hawaii.edu/UHSLC>
- <http://www.pol.ac.uk/psmsl/gloss.info.html>

It should be noted that the available data has some unprecedented data gaps resulting from occasional breakdown of equipment.

Capacity Available

There is still limited capacity for repair and maintenance of the our tide gauges. Lack of spare parts and tools has been a major hindrance to carrying out minor repairs jobs and levelling. We rely on services of technicians from UH Sea Level Centre for installation and maintenance of the two tide gauges. Regular maintenance of both gauges is supervised by KMFRI's Principal Laboratory Technologist (Mr. Jimmy Onyango) and the National Sea Level contact (Dr. Charles Magori).

None of the Technicians on site has received training at PSMSL, UHLC, etc. However, a few of them have received in-service training and some additional hints during the visits to Kenya by field technicians from UHSLC. This has contributed fairly well in improving the accuracy and quality of the data.

Four Kenya scientists have received training sponsored by IOC. The training is on Sea Level Data Analysis and Interpretation. They are Mika Odido at PSMSL, UK in 1992, Charles Magori at Dehra Dun, India in 1995, Clive Angwenyi in Cape Town, South Africa in 1998 and Antony Kibue in Oostende, Belgium in 2006.

Concluding Remarks

The national network will now comprise of 5 tide gauge stations. 2 gauges are operated by KMFRI while KMD will run 3 gauges. In order to have a national network that is fully operational, there is an urgent need to develop capacity for installation and maintenance of tide gauges and also for analysis and quality control of data. This will enable the country to produce high quality sea level products for local scientists and international programmes data centres and also IOTEWS.

GLOSS and ODINAFRICA III project should consider organising more regional training workshop for local scientists and technicians. The topics to be covered during the workshop should include:

- Review of sea level equipments: types, installation, levelling and maintenance.
- Processing and quality control of data.
- Analysis of data and products preparation.

The national network will be greatly strengthened through regular maintenance and levelling of benchmarks, maintenance of gauges, supply of spares and observer supervision. The national network of tide gauges will also contribute to enhancing the regional sea-level monitoring network. This is crucial considering that the region is an important component in the formation of the proposed Indian Ocean Tsunami Early Warning System.

It is important to note in the national network for Kenya, there are now 2 tide gauge stations installed in Lamu (one operated by KMFRI and one by KMD). This is quite in order and will assist in checking for redundancy in the system.

Kenyan personel (Dr. Charles Magori and Sam Ngete both of KMFRI) are currently in the process of upgrading of the GLOSS-Africa website. The page was recently moved from IOC website (where it was initially hosted) to the IODE website in Oostende. The site is now being restructured and thereafter shall be fed with new information regarding GLOSS and related activities in Africa.