INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

(of UNESCO)

SEA LEVEL MEASUREMENT AND ANALYSIS IN THE WESTERN INDIAN OCEAN

NATIONAL REPORTS

KENYA

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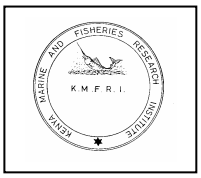

1.0 INTRODUCTION

Kenya lies along the Equator on the East coast of Africa between latitudes 50^{o} 40´ N and 4^{o} 4´ S and between longitudes 33^{o} 50´ E and 41^{o} 45´ E. It has a land surface area of 590,000 km^2 and a coastline of about 600 km long. Kenya has diverse landforms ranging from the coastal plains through the dry Nyika plateau to the savanna grasslands and the highlands on both sides of the Rift Valley. The Coastal plain rises from sea level datum (OD) to over 200m OD, the Foot Plateau extends from an elevation of 200m OD to 500m and the Nyika at above 500m OD. There are several rivers that drain into the Indian Ocean. The Kenyan coastline is characterised by mangrove forests, coral reefs and sandy beaches protected from the open ocean by the fringing reefs.

Most of Kenya's population is concentrated around the coast. Shipping transport is one of the main sources of foreign exchange. There are several ports along the coastline. Mombasa is the principal seaport of Kenya and is one of the most modern and busiest ports in Africa. The port is linked with the world's major ports with over 20 sailings per week. In addition, Mombasa is the main sea gateway for inland states in East and Central Africa region namely: Uganda, Congo, Rwanda, Burundi and Sudan. The other ports are located in the old town, Malindi and Lamu. These ports offer valuable services for both cargo and fishing vessels. They are situated in shallow lagoons. To facilitate safe navigation for marine vessels using the ports and those on transit, Kenya embarked on a programme of installing tide gauges at the ports as part of the national sea level network.

1.2 Description of the National Network and History of its Development

Time series records of sea level heights are crucial because they provide information on the highly variable nature of the boundary between land and sea. The analysis of long time series of data now available from several stations has revealed a worrying trend of rise in mean sea level. To address this concern, the Intergovernmental Oceanographic Commission (IOC) of UNESCO at it's 13^{th} Assembly in 1985 invited a group of experts to develop a Global Sea Level Observing System (GLOSS). The objective of GLOSS was to provide high quality standardized data from which valuable sea level products can be produced for international Oceanographic projects particularly the ongoing Tropical Ocean and Global Atmosphere (TOGA) and World Ocean Circulation Experiment

(WOCE) 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.

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 Headquaters 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 continuos 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 requested for a tide gauge through IOC-UNESCO from the University of Hawaii in June, 1986 to start its tide gauge network. Following KMFRI's request, the University of Hawaii donated a tide gauge which was installed at Liwatoni jetty in Kilindini harbour, Mombasa. There are critical gaps in data during the periods that this gauge was not operational. However, due to variation in sea level along the Kenyan coastline, this one gauge proved inadequate. We therefore requested for another gauge to be installed in Lamu. Kenya Ports Authority (KPA) installed another gauge on the Fisheries jetty in Lamu at the end of 1988. The gauge was operated jointly with KMFRI. However, marine growth (barnacles, algae, etc) covered the transducer, affecting the quality of data. Problems with electricity connections on the jetty led to a return to the classical sea level data collection methods; using a graduated string.

Further in December, 1987 at the second session of the Regional Committee for Cooperative Investigations of the North and Central Western Indian Ocean (IOCINCWIO), a proposal for a regional component of GLOSS was adopted to encourage rapid development of sea level data acquisition and use within the region. Kenya was nominated to coordinate the regional component of GLOSS.

The regional workshop on ‘‘Consequences of Sea Level Changes on the Western Indian Ocean Coasts and Islands’’ held in Mombasa in 1991 recommended the establishment of Kiunga, Lamu, Malindi and Shimoni in Kenya as part of national network among others in the IOCINCWIO region.

Within the framework of IOC –UNEP – WMO Pilot Activity on Sea Level Changes and Associated Coastal Impacts in the Indian Ocean, Cells for Monitoring and Analysis of Sea Level (CMAS) was formed for each country. Kenya is actively participating in the CMAS. The activities are:

(i) overseeing/assisting in data collection and data transmission in collaboration with appropriate national agencies.

(ii) Data storage and analysis to generate products aimed at understanding the data, and products useful for coastal zone management.

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 that we have continuos 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.

Fig 1 is a map of the Kenya coastline showing installed and planned stations.

2.0 STATUS OF SEA LEVEL NETWORK

2.1 Installed and operational stations

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. A Valeport BTH 700 gauge was installed in Lamu at the end

of 1988 but has not been 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). The TOGA Sea Level Centre agreed to assist in installing another gauge in Lamu in early 1994. Both gauges are float type installed on a stilling well.

Both Mombasa and Lamu gauges are located in shallow lagoons. They are installed on jetties and far from rivers to avoid the effect of freshwater on tides. The jetties provide ideal sites with water throughout the tidal cycle. Liwatoni jetty (Mombasa) and Lamu jetty were found most suitable because they provide a semi–enclosure for the tide gauge, protects it from strong wave effects and provides a strong and firm supporting structure, the water depth is enough (more than 2m below the lowest predicted astronomical tide) to allow successful operation of the stilling well. Both jetties are also very easily accessible.

The problems faced in operating the stations are:

- Rusting of tide gauge parts
- Rusting of the support connecting the tide well to the jetty
- Marine growth on transducer
- Corrosion of stilling well.
- Frequent damage of tide gauge house roof in Lamu by boats which are usually moored around the jetty. Due to this damage, a lot of water leaks from the roof and poses a great danger to the tide gauge computer.
- Non compatibility of tide gauge computer with the PCs used at KMFRI. This results in data not being recorded on diskettes formatted at KMFRI.
- Communication problem – lack of telephone and internet facilities at Lamu station makes it difficult for KMFRI and UHSLC to respond quickly in case of a breakdown of the tide gauge.

Kenya Marine and Fisheries Research Institute (KMFRI) is responsible for maintaining both the Mombasa and Lamu tide gauge stations. Two KMFRI Technicians are attached to each station.

Duties of tide station Technicians are:

- Take readings twice a day, one each in morning and afternoon.

- Ensuring that tide staff is clean
- Requesting for painting of gauge support every six months
- Reporting any faults or strange behavior of the gauge immediately. In addition, they record the same in the Tide Station Report Form.
- General maintenance of the tide gauges
- Cleaning the transducer after every six months
- Perform zero checks once a week
- Requesting for leveling of benchmark once a year.

The following persons are attached to the tide gauge stations.

Mombasa station:

Messers Shadrack Monari and Gideon Otieno Adina
Field Technicians
Kenya Marine and Fisheries Research Institute
P.O. Box 81651
Mombasa, **Kenya**.

Lamu Station:

Messers Dismus Kosieny and Maurice Okwaro
Field Technicians
Kenya Marine and Fisheries Research Institute
Lamu Tide Station
P.O. Box 335
Lamu, **Kenya**.

Tide gauge benchmark (TGBM) description:

Station : Mombasa	Latitude: 04^{o} 04´S
Country : Kenya	Longitude: 039^{o} 039’ E)
JASL # : 101A	Time Meridian: 045E (GMT + 3hr)
GLOSS # : 008	TOGA # : 1005
NODC # : 30034901	Tide gauge serial No.: 0164003076

For Mombasa, there are only three Benchmarks (1, 2A, 3A). @ is a bolt fixed at 3.8 m above tide staff zero.

DATE	BM @	BM 1	BM 2	BM 2A	BM 3	BM 3A	BM N-3
April 23, 1987	12.467	18.647	19.184		45.547		
June 6, 1989	12.467	18.645	19.193		Missing		20.427
July 2, 1995	12.467	18.623	destroyed	19.297	destroyed	18.115	not recovered
Nov. 22, 1998	12.467	18.609		19.302		18.093	

NOTE:

-1987 leveling was done by Ted Murphy of TOGA Sea Level Centre. 1989 leveling was performed by Survey of Kenya, P.O. Box 30046, Nairobi. Nikolai Turetsky and Jerard Jardin both of TOGA Sea Level Centre performed leveling of in 1995 and 1998 respectively.

TGZ = ACD – 37.355

TGZ = EARD – 36.165

TGZ = SOK – 110.638

Where ACD – Admiralty Chart Datum

EARD – East Africa Railway Datum

SOK – Survey of Kenya Datum

Heights are in feet above tide staff zero.

BENCHMARK DESCRIPTION:

BM	ESTABLISHED	SURVEYOR	TYPE OF MARK AND COMMENT
@	06/18/86	T. Murphy	rod stop of 3.8 m staff (fiberglass encased)
@	07/ /95	N. Turetsky	To restore staff, it was removed and replaced. Survey before and after indicate no change in Staff level.

BM1	04/23/87	T. Murphy	S.S. pin 1"x1" set in green epoxy located on side-walk next to fence (190 deg from staff on the NW corner of the Resident Customs Office about 50 feet NNE from the tide staff and About 5 feet E of the sloping sea wall. (See Fig 2).
BM2	04/23/87	T. Murphy	S.S. pin 1"x1" set in green epoxy with "BM2" incised in concrete walkway located 30 meters 205 deg from guardhouse gate at Ras Liwatoni
BM2A	07/ /95	N. Turetsky	S.S. 1" square set in epoxy, not stamped. Just left of the double metal blue door on W side of the Wanainchi Marine Products (K) Limited, Shipping, Bunkering and Operations Building. BM is just off the step, about 40 yards NE of BM1.(See Fig 2)
BM3	04/23/87	T. Murphy	S.S. pin 1"x1" set in green epoxy with "BM3''incised in concrete 70 degrees (52 yards) from Fisheries Office BLDG entrance, at base of flag pole, Fisheries Dept. Post Office.
BM3A	07/ /95	N. Turetsky	S.S. 1" square set in epoxy; not stamped. On the W side of the Wanainchi Marine Products (K) LTD Warehouse, just left of The large sliding blue metal door. BM is about 15 feet S of the guard house at the wharf entrance and about 60 yards NE of BM2A. (See Fig 2).

Benchmark Levelling Trend.

In Mombasa there appears to be some settling of BM 1. About 1/2" over 12.5 years which is believable considering BM1 is on the edge of the seawall that is made from a pile of rocks. This settling is possible because the warf in Mombasa was checked and found to be having signs of cracks in the cement. Unfortunately the other 3 BMs have too few data points to make any predictions of trend.

TIDAL BENCHMARK AND LEVELLING RECORD FOR LAMU.

Station : Lamu Latitude: 02° 17´ S

Country : Kenya Longitude: 040° 54’ E

JASL No. : 149A Time Meridian: 045E (GMT + 3hr)

GLOSS No.: TOGA No. : 149 NODC No.:

Serial No. : 16287190

In Lamu there are four Benchmarks (UH1, UH2, UH3, UH4) and they were all installed in 1995. @ is the top of the staff. SW1 and SW2 are float switches that are used as a back up check for the encorders. They are mounted to the tide staff support.

DATE	BM @	BM UH1	BM UH2	BM UH3	BM UH4	BM SW1	BM SW2
June 25, 1995	11.017	14.859	16.097	18.165	16.837	9.022	8.564
Nov. 16, 1998	11.017	14.838	16.070	18.140	16.804	9.047	8.587

NOTE:

- Elevations are in feet
- Benchmarks SW1 and SW2 are reference level switches which are used for month-to-month sea calibration. It is not a permanent benchmark and is not to be used for long-term vertical control point analysis.

BENCHMARK DESCRIPTION:

BM	ESTABLISHED	SURVEYOR	TYPE OF MARK AND COMMENT
@	06/25/95	N. Turetsky	rod stop of 5.0 m staff. Tide staff is from Shelly signs England, model D50. 5 meters long, solid plastic, 5 separate sections mounted to wooden piling which was pile driven into sea floor. It is located just outside of the tide house, onto the new Lamu terminal jetty across from the Lamu Museum.

UH1	06/ /95	N. Turetsky	S.S. square 1" set in epoxy; not stamped. On the lip of the sloping seawall, 1 foot SE of the jetty bridge about 10 meters W of the tide station, near the lamp post. (See Fig 3).
UH2	06/ /95	N. Turetsky	S.S. square 1" set in epoxy; not stamped. On the front terrace of the Lamu Museum, on the south side of the northern most column. (See Fig 3).
UH3	06/ /95	N. Turetsky	S.S. square 1" set in epoxy; not stamped. At the NW corner of the Lamu Museum, about 4 inches from the museum wall on the N side of the corner, about 3 feet E of the corner. (See Fig 3).
UH4	unknown	unknown	Brass bolt head 1" hexagonal; not stamped. At the NW corner of the Rohda Mosque, about 25 meters North of UH3. (See Fig 3) This BM was found during the establishment of the tide gauge BM system June, 1995. We were not able to determine its origin. but we suspect it was established by the Lamu Department of Water.
SW1	06/ /95	N. Turetsky	S.S. hex head bolt on top of ABS black housing. Mounted to the same piling as the tide staff, to the right and just above SW2. OPEN/CLOSE level below SW1: Date | Opens | Closes | Comments 06/95|-0.224' |-0.203' | ave : -0.214' made:11/94
SW2	06/ /95	N. Turetsky	S.S. hex head bolt on top of ABS black Housing. Mounted to the same piling as the tide staff, to the left and just below SW1. OPEN/CLOSE level below SW1: Date | Opens | Closes | Comments 06/95|-0.219' |-0.203' | ave : -0.211' made:11/94

Benchmark Levelling Trend.

Lamu has a short leveling data set. While the switch levels have increased by about 0.025 ft, the other benchmarks have decreased by about the same amount. The "@" (benchmark at the staff) is a bolt sticking out of the piling that the staff is mounted to. Some fishermen have tied their boats up to the bolt and it was bent upwards. This has the effect of the landbound benchmarks appearing to "sink" in relation to the "@" and the switches have the appearence of rising in relation to the land based BMs. At this point for us we are going to watch for trends over the next few levelings but can not make assumptions on 2 data sets.

There was another station at Lamu owned by KPA and was leveled using the Survey of Kenya Datum. When Nikolai established the new station in Lamu, he did tie the leveling to the Survey of Kenya Datum. The two points have therefore been leveled relative to each other.

Tide predictions for Mombasa have been performed by Mr. David Blackman of PSMSL, Bidston, U.K. After attending a training course on sea level data analysis, Mr. Charles Magori, a Research Scientist at KMFRI now produces tide predictions for both Mombasa and Lamu using a software provided by the TOGA Sea Level Centre. The predictions compare very well with those produced at Bidston. The predictions are in form of High-Low Listings and Hourly Values. They are distributed free of charge to all organisations dealing with Marine environment in Kenya to facilitate their navigational activities.

Both stations are dedicated to the following global projects

(a) Tropical Oceans Global Atmosphere (TOGA)
(b) Global Sea Level Observing System (GLOSS) and
(c) World Ocean Circulation Expedition (WOCE).

Sea level data from both Mombasa and Lamu is send to the following Data Centres

(a) University of Hawaii Sea Level Centre (UHSLC)
(b) Permanent Service to Mean Sea Level (PSMSL)

Both stations are equipped with modern data loggers, measuring sea level every minute and storing on diskette at 15 minutes interval. We make copies of the data on diskettes

and the computer hard disk before forwarding them to the TOGA Sea Level Centre in Hawaii where further quality control is performed. The diskette is posted to UHSLC by airmail on a monthly basis. In addition, the Lamu tide gauge is equipped with a satellite data transfer device to enable real time access to data.

The nearest meteorological station to the Mombasa tide gauge station is Moi International Airport. It is approximately 5km from the station. Lamu Airport is the nearest meteorological station to Lamu tide station.We are exploring the possibility of acquiring from the Kenya Meteorological department data which might be related to sea level changes (winds, rainfall, atmospheric pressure and temperatures) collected at stations close to the tide gauges over the last 10 years. Part of the these data are on paper, we are now entering them into the computer and we will be able to compare them with sea level data soon.

2.2 Installed but not Operational

None

2.3 Planned station

In addition to the two existing stations, we plan to install three more tide gauges. These will be at: Shimoni (4^o 39´ S, 39^o 23´E), Malindi (3^o 15´S, 40^o 08´E) and Kiunga (1^o 45´S, 41^o 29´E).(see Fig 1). Ultimately, there will be five stations to cover the Kenyan coast. The cost of installation for the three tide gauges is estimated at Ksh 1.5 million (equivalent to USD 25,000).

REASON FOR INSTALLION OF THE STATIONS.

The Kenyan coastline is about 600 km long. Using the existing data listing for Mombasa and Lamu, we intend to evaluate the trends of sea level fluctuations along the entire Kenyan coast. However, it is unfortunate that we are unable to include the southern, middle and extreme Northern parts of the Kenyan coast due to lack of data, as there are

no tide gauges in those regions. This is the reason why it is necessary to install tide gauges at the planned stations. Once the proposed stations are installed, we shall obtain high spacial 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. In addition, Kiunga gauge will be closest to the Equator and the only one within the Somali Current reversal zones and will thus cover an area of great interest to local scientists and the international scientific community as well.

The proposed gauges are 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. It is also useful for other institutions including: Fisheries department, Kenya Ports Authority, Kenya Navy and Survey of Kenya among others. In addition, the programme will also provide information for international oceanographic projects in which Kenya is participating, like TOGA and WOCE.

3. AVAILABILITY OF DATA FROM STATIONS.

The sea level data available at the KMFRI CMAS are in the JASL format. For the Kenyan stations, we have hourly, daily and monthly means.

For Mombasa station, available data is from 1975/6 and 1986-1998.

The data available from Lamu station is in digital form and analogue charts. The digital data is from 1989, and 1996–1998 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

4. CAPACITY AVAILABLE

4.1 Installation and maintenance of gauges

In Kenya, there is limited capacity for repair and maitenance of the two 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 the TOGA Sea Level Centre in Hawaii for installation and maintenance of the two tide gauges. Their names and address is given below.

Nikolai Turetsky and Jerard Jardin
Field Technicians
TOGA Sea Level Centre
University of Hawaii
1000 Pope Road, MSB 317
Honolulu HL 96822
Hawaii, U.S.A.

However, these Technicians visit our stations for servicing and maitenance of the gauges once in three years. Regular maintenance of both gauges is supervised by KMFRI's Principal Laboratory Technologist (Mr. Ben Ogega) and GLOSS Regional Coordinator/IOCINCWIO (Mr. Mika Odido).

Processing of Data:
Raw data from both stations is processed in KMFRI by Mr. Charles Magori on monthly basis. The data is subjected to quality control by comparing the observations with tide staff readings which are recorded on the tide staff report form. Monthly data is then converted to TOGA format for our own use (eg analysis and products preparation) using a program provided by TOGA Sea Level Centre. In addition, the raw data is forwarded on a monthly basis to the TOGA Sea Level Centre in Hawaii where further quality control is performed. The processing of raw sea level data in Kenya is supervised by Mr. Mika Odido.

- Information on the fate of those who have followed IOC sponsored sea level courses at PSMSL and elsewhere:

None of the Technicians on site has received training at PSMSL, TSLC, etc. However, a few of them have received local training and some additional hints when Nikolai Turetsky and Jerard Jardin visited Kenya in 1995 and 1998 respectively. This has contributed much in improving the accuracy of the data.

Training requirements

Since no Technicain attached to our tide gauge stations has received training at specialised sea level centres, there is need therefore to train our technicains at PSMSL, TSLC or within the region. The training should be in form of an attachment of about six months during which the following should be covered.

(a) Assisting in installation of new stations
(b) Repair of faulty tide gauges
(c) Maitenance checks
(d) Levelling of tide gauge benchmarks

There is also a need to provide refresher courses.

4.2 Analysis and Interpretation of data.

In Kenya, six scientists working for KMFRI have received postgraduate training on Physical Oceanography at the University of Gothenburg, Sweden. Their names, qualifications, insitutional affiliation, and address is given below:

	Name	**Qualifications**	**Institutional affiliation**
(1)	Mr. Mika Odido	Msc(Physical Oceanography) PhD candidate ’’	Principal Research Officer
(2)	Mr. Michael Nguli	Msc (Physical Oceanography) PhD candidate ’’	Principal Research Officer
(3)	Mr. Charles Magori	Msc (Physical Oceanography)	Research Officer
(4)	Mr. David Kirugara	Msc (Physical Oceanography)	Research Officer
(5)	Mr. Johnson Kitheka	Msc student (Physical Ocean.)	Senior Research Officer

(6) Mr. Clive Angwenyi Msc student (Physical Ocean.) Research Officer

Address: Kenya Marine and Fisheries Research Institute
P. O. Box 81651, Mombasa, Kenya.

Three of them have received additional 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 and Clive Angwenyi in Cape Town, South Africa in 1998.

TRAINING REQUIREMENTS.

There is need to train more scientists in the tide prediction and data analysis within the Physical Oceanography group. The training will enhance the idea to initiate sea-level related research activities. We anticipate that IOC will organise more training courses on sea-level research.

DATA ANALYSIS

The KMFRI CMAS has performed analysis of data in its possesion.

- time series analysis of various data sets
- harmonic and spectral analysis of hourly height data for Mombasa and Lamu
- tide predictions for Mombasa and Lamu.

5. SEA LEVEL PRODUCTS.

In Kenya, we now produce tide predictions for both Mombasa and Lamu. These predictions are in form of High-Low listings and hourly values. They are distributed to all organisations dealing with marine environment free of charge. Once the predictions prove to be accurate and reliable, we shall start distributing them at a fee.

-Sea level anomalies

Evidence of climate change in Kenya is scarce due to a paucity of historical information and monitoring efforts. Also, little attention has been given to the phenomenon of sea level rise. Long term continous recording of tidal elevations with a view to establishing

the mean sea level for a complete tidal epoch (19 years) only commenced in 1986. Initial survey department, albeit based on recorded data of shorter than desired length, indicate no discernible trend in sea level rise along the Mombasa tide station.

Areas along the Kenyan coastline which can be inudated with water for given sea level rise are shown in Fig 1.

Products not produced but would be useful are:

(a) monitoring of storm surges to provide essential statistics on return periods for extreme events.
(b) Design and construction of harbours and other coastal structures
(c) Monitoring circulation and heat transfer.
(d) Input into flood warning procedures

6. BIBLIOGRAPHY OF SEA LEVEL LITERATURE.

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7. RECOMMENDATIONS.

Kenya is trying to develop a sea level observing network. Two stations have been established and three other stations are planned to complete the national network. However, to achieve this, there is an urgent need to develop capacity not only for installation and maitenance of tide gauges, but also for analysis and quality control of data. This will enable KMFRI to produce quality sea level products useful to local scientists and produce continuos high quality data to international programmes and data centres.

A first step in this regard would be a period of attachment for local scientists and technicians to a specialised sea level centre (UHSLC, PSMSL, etc) for a period of one month to enable them acquire the necessary techniques for installation and maitenance of

our sea level data and products preparation. The following topics should be covered during the attachment period.

(a) review of sea level equipments: types, installation, levelling and maintenance.
(b) Processing and quality control of data.
(c) Analysis of data and products preparation.

Emphasis should be placed on strengtening the national network in order to utilise data at local and regional level. The existing stations should be operated through acquisition of bench mark and levelling information, maintenance of gauges, supply of spares and observer supervision, national coordination including technical support and supervision of national network.

There is need to review the status of sea level observing network in Kenya, the achievements of the programme, shortfalls and measures which should be taken not only to ensure that the stations continue to operate, but also to complete the proposed national network.

There is also a need to start collection of other parameters which affect sea-level like wind, rainfall, sea surface temperature, salinity and air pressure. KMFRI should make cooperation with other institutions which collect environmental data related to sea level such as the Kenya Meteorological Department.

Still more needs to be done to develop an adequate national network.There is a need to create a demand for sea level products in the country. This can be done by provision of training on analysis and use of data and also dissemination of documents and bronchures on importance and use of sea level data. Increased demand for data will lead to improved data flow and quality which will ultimately benefit international programs (eg GLOSS, TOGA, WOCE).

Follow up seminars for those already involved in sea level measurements should be organised so that they can exchange ideas with their colleagues in the region (and elsewhere) and share experiences they have had and increase their capabilities.

I further recommend that the Mombasa tide station be equipped with facilities for satellite transmission of data. This will provide a real-time data network. KMFRI being the organisation in charge of the tide gauges in Kenya should be encouraged to archive copies of the data. The Kenya National Oceanographic Data Centre (KeNODC) which was established recently should encourage exchange of sea level data and information in the country. One of the priorities of KeNODC should be to build a higher database of sea level and associated environmental data. Training on data analysis and prediction of sea level should be provided to interested scientists in the country to encourage usage the data. This will contribute towards improving quality of data collected.

Appropriate strategies should be developed to respond to the needs of the future. One response no doubt will be long-term monitoring of sea level at stations already installed and other sites with marked local influence on sea level variations.

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