NATIONAL REPORT OF THE UNITED REPUBLIC OF TANZANIA ON SEA LEVEL MEASUREMENTS

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1. INTRODUCTION

Tanzania is situated just south of the Equator, on the mid-eastern part of the continent of Africa and on the Southwest of the Indian Ocean (1^{o}-11^{o} 45'S; 29^{o} 21'-40^{o} 25'E). The country has an area of 945,200 km ^{2}, making it the largest in East Africa. Tanzania is a United Republic consisting of two sovereign states of ex-Tanganyika, now known as Tanzania Mainland (942,800 km^{2}) and the Islands of Zanzibar (2,400 km^{2}). The union creates a unique political situation, since Zanzibar under the Union Constitution retains a wide range of autonomy in most areas of government and its economy. Matters concerning Zanzibar as such are dealt with by the Revolutionary Government of Zanzibar, whereas those in respect of Tanzania Mainland are dealt with by the Union Government.

Facing the Indian Ocean on the east, Tanzania is bordered by Malawi and Mozambique in the south; Zaire, Zambia, Burundi and Rwanda in the west; and Uganda and Kenya in the north. Tanzania Mainland encompasses the major island of Mafia (518 km^{2}) while Zanzibar consists of two major islands of Unguja (1,666 km^{2}) and Pemba (795 km^{2}). A number of small offshore islands fringe the coasts of Tanzania Mainland and Zanzibar. Five administrative regions are situated along the Mainland's coast: Tanga, Coast, Dar es Salaam, Lindi and Mtwara. The islands of

Zanzibar consist of three regions in Unguja and two regions in Pemba. In 2006, the population of Tanzania was estimated at 37.9 million, with a GDP per capita of $723 (as of 2005). Hence, the country is classified as one of the World's poorest.

The country is characterised by a narrow coastal plain occupying the eastern seaboard of the Indian Ocean. The coastline of Tanzania Mainland is approximately 800 km long, extending from the Kenyan border in the north (4^{o} 7'S) to the Mozambican border in the south (10^{o} 5'S). The coastline is somewhat straight and is bounded by sandy, open beaches and some cliff out-croppings in the south and with extensive mangrove forests in the riverine estuaries and deltas.

Permanent rivers, seasonal rivers and numerous creeks traverse the coastal plains. The permanent rivers discharging into the Indian Ocean are the Pangani, Wami, Ruvu, Rufiji, Matandu, Mbemkuru, Lukuledi and Ruvuma. The continental shelf is characterised by seagrass, fringing coral reef and island habitats. The shelf is generally narrow, dropping sharply after the depth of 60 m. The 200 m depth is about 2 km from the coast at the narrowest point and 80 km at the widest point. The widest points are the Zanzibar and Mafia Channels and off the Rufiji Delta. With the exception of the narrow coastal belt, most of the country lies on the Great African Plateau with altitudes ranging between 1,000 and 2,000 m above mean sea level.

The dominant current prevailing along the Tanzanian coast is due to the East African Coastal Current (EACC), which flow northwards throughout the year. This current can possess velocity under wind acceleration of up to 2 m/s during the Southeast monsoon. Because of the steepness of the continental offshore margin, this current is generally close inshore. It is only impended, never reversed, by the Northeast monsoon along this section of the coast. It is at this time that it tends to be deflected out to sea and reduced to speeds of less than 0.25 m/s. There is thus a northward movement of coastal surface water along the coast all year through.

According to UNEP (1985), the sea surface temperature along the coastal waters of East Africa within the latitude band 0^o-10^o S varies from a minimum of 23^o C to a maximum of 28^o C [February (26.0 -28.0^o C); May (28.0^o C); August (24.0-26.0^o C) and November (27.0^o C)]. This latitude band covers most of the Tanzanian coastline (4^o 7'-10^o 5'S).

The Tanzanian coastal area is of significant social and economic importance. It contains various critical terrestrial and marine habitats, valuable natural resources such as fisheries, forestry, agriculture and mining produce as well as tourist attractions. The major ports (Dar es Salaam, Tanga, Mtwara and Zanzibar) handle not only Tanzania's cargo, but also transit goods to land-locked countries of Burundi, Democratic Republic of Congo, Malawi, Rwanda, Uganda and Zambia. Although the ports of Zanzibar and Mkoani (Pemba) were expanded in the early 1990's, their capacities are still small. The port of Dar es Salaam handles about thrice as much trade as the rest of the Tanzanian ports. And one of the results of the multiplier effect is that Dar es Salaam is by far the largest urban centre in Tanzania.

The Constitution governing the Union designates only 21 subject areas, including Management of the Exclusive Economic Zone. Authority over territorial waters and matters of natural resource management are within Zanzibar's exclusive jurisdiction. As such, the Zanzibar tide gauge which is under the Zanzibar Department of Surveys and Urban Planning, is within the jurisdiction of the government of Zanzibar.

In 1973, Tanzania extended its Territorial Sea from 12 to 50 nautical miles. It became signatory to the United Nations Convention on the Law of the Sea (UNCLOS) in 1982 and ratified it in 1985. In 1989, the proclamation of 50 nautical miles Territorial Sea was revoked in an act which established a 12 miles Territorial Sea and 200 miles Exclusive Economic Zone (EEZ). However, owing to lack of capital, enforcement capabilities and technological expertise, Tanzania has not been able to effectively manage such a large EEZ area of approximately 223,000 km^2, which encompasses a coastline length of about 1,500km.

This report presents a brief overview of the extent to which sea levels have been monitored in Tanzania by tide gauges as of 2006. In addition to local interests in sea level observations such as storm surge warning, marine engineering constructions and vessel movements in ports, there has also been a considerable interest from a global point of view of ocean circulation studies and climate change research. There is now a world belief that some form of global warming is underway, and one manifestation of this phenomenon is a corresponding rise in mean sea level.

Some attempts to assess the possible consequences of this tragedy on the coastal ecosystems of Tanzania have already been made (Wemba-Rashid, 1991; Fay, 1992; Mgaya, 1997; Mwandosya *et al.*, 1998). Rises of sea level by only a few tens of centimetres will have serious consequences for many coastal areas. The most evident would be coastal inundation and erosion, but many other potential impacts are imminent. Hence, to develop a response strategy in a timely manner, the reliable assessment of sea level changes is required.

In recognition of the regional and global efforts to monitor sea level, Tanzania is an active member of the Intergovernmental Oceanographic Commission (IOC). Member countries of this regional body have co-operated in the development of a Global Sea Level Observing System (GLOSS), which was established by IOC in 1985 to monitor global sea levels and also to help develop national capabilities to assess and anticipate changing risks.

The actual determination of changes in relative sea level is extremely complex, as it involves a consideration of many factors, and requires decades of high quality observations, data analysis and modelling. A tide gauge measuring system consists of a sensor that detects either real sea level (i.e. the level of the air-sea interface) or pressure beneath the water surface, and stores the measurements either locally or via telemetry at a processing centre.

The most common type of tide gauge used world-wide is the stilling well float gauge. However, other technologies such as bubbler pressure gauges are now used routinely in many countries. Acoustic techniques, which measure the travel time of pulses reflected from the air-sea interface with automatic compensation for various variations in sound velocity, also now have improved performance. In all types of systems the long-term stability in relating sea level measurements to a known local datum can be improved by the use of effective and regular datum control.

2. STATUS OF SEA LEVEL NETWORK

The Tanzanian sea level network consists of two operational stations of Zanzibar and Dar es Salaam. Zanzibar has a satellite transmitting station while Dar es Salaam has a mechanical float gauge. There are also four historical stations at Mtwara, Tanga, Latham Island and Mkoani in Pemba. In the 1990 GLOSS plan, Zanzibar and Mtwara were proposed as GLOSS stations among 17 stations in the Central and Western Indian Ocean. A regional workshop held in Mombassa in 1991 further recommended the establishment of Dar es Salaam and Tanga stations, out of 15 extra GLOSS stations that were proposed in the region. Of all the tide gauge stations in Tanzania, the Zanzibar station has been operating quite well since 1984. The station is linked to UHSLC and IOC/GLOSS, and is also considered as one of the prime Indian Ocean stations for monitoring long term changes in world sea level.

The tide gauge stations in Tanzania are operated by individual institutions. The Zanzibar Department of Surveys and Urban Planning is responsible for the Zanzibar Station. The old station at Mkoani in Pemba Island was also under the same Department. The Dar es Salaam tide gauge station is administered by Tanzania Ports Authority, but before installation of the new gauge in Dar es Salaam, the Station was under the Institute of Marine Sciences of the University of Dar es Salaam. Old tide gauge stations of Mtwara and Tanga were both under the Division of Surveys and Mapping of the Ministry of Lands, Housing and Urban Development.

3. INSTALLED AND OPERATIONAL STATIONS

3.1 Zanzibar Station

The tide gauge in Zanzibar is located on the seaward end of the main jetty in Zanzibar Harbour, off the coast of Zanzibar town (6^{o} 09.3′; 39^{o} 11.4′E). Unlike most harbours on the Tanzanian coast, the Zanzibar Harbour is not situated on an embayment. However, the harbour is protected by a number of offshore islands, reefs and sandbanks that also complicate the current patterns in the vicinity of the harbour area.

There are no rivers draining into the harbour, except for a sewer outfall that discharges domestic effluents and storm water in the south at Malindi. The effluents drain from the Stone town area. The winds prevailing in Zanzibar are the monsoon winds. The Northeast monsoons (December to February) are characterised by higher air temperatures, lower wind speeds and consequently calmer sea. Highest wind speeds are experienced from June to September (averaging 6 m/s in the afternoon). During the interchanging monsoons (March, November and December) the wind speeds are lowest (Averaging 6 m/s in the afternoon).

Air temperatures vary from less than 22 ^{o}C to more than 30 ^{o}C and humidity from 65% to 95%. The heavy (long) rains are experienced from March to May while the short (light) rains are received during November and December. The annual rainfall recorded from the nearby meteorological station (Chukwani) averages 1,381 mm, with the heaviest rainfall occurring in April, averaging 312 mm in total. According to the Admiralty Tide Tables (1992), Zanzibar Harbour experiences a mean spring tidal range of 3.9 m. The currents near this station have not been determined since no studies have been conducted except for short surveys of duration less than a day.

No information is available on when this station was established. A Munro IH40 instrument was in operation on an established site on the seaward end of the main jetty in Zanzibar Harbour until the mid 1950's. At some stage the stilling well broke up, due to corrosion and lack of support. Under the terms of the United Kingdom-Zanzibar Survey and Mapping Project, which came into effect in 1977, a total of three tide gauges were to be installed on the islands of Zanzibar and Pemba. Following field observations by the UK Hydrographic Office, it was decided that there was only one site currently available which did not dry out at low tide, namely the jetty at Zanzibar Harbour. A Munro IH109 with a digitization interval of one hour was then brought to Zanzibar from the UK in September 1983. The decking of the jetty where this instrument was installed was 6.9 m above seabed.

In 1983, a permanent Tide Gauge Bench Mark (TGBM) was established at a suitable site (521209E; 9319992N) within 30 m of the instrument and connected by secondary levelling to the Primary Bench Mark (BM1), some 300 m distant at the roundabout outside the dock gates. BM1 is the fundamental benchmark to which all other levelling in Zanzibar are related, and has a fixed value of 3.800 m above Land Survey Datum (LSD). TGBM was found to be 0.005 m below BM1 and thus had a height of 3.795 m above LSD. The UK Hydrographic Office had stated that Chart Datum (CD) was 2.08 m below LSD. Thus TGBM was 5.875 m above CD.

The Munro IH 109 instrument was later relocated to another site in 1990, closer to the Ferry Terminal to give way for harbour expansion. Within the same year, a satellite sea level transmitting station was installed at the same site and the two instruments worked simultaneously. This new position of the instruments necessitated another levelling to be conducted in 1991. Three other auxiliary benchmarks (TGBM1, TGBM2 and TGBM3) were then established and levelled relative to BM1. The old instrument worked until 1993 when the stilling well broke due to corrosion.

Zanzibar Station

A satellite sea level transmitting station (tide logger, float type) was installed in February 1993 at the same site and the two instruments worked simultaneously. After relocation, the old instrument worked for a few months when the stilling well broke due to corrosion. The new tide gauge was equipped with two channels: Handar Encoder 436A (ENC) and Handar Encoder 436B (ENB) with datalogger (ENO). The digitization intervals were 4 min (ENC) and 15 min (ENB, ENO), respectively. Satellite transmission interval was once per hour.

The station was recently upgraded (July 2006) to accommodate three channels of sea level data collected and transmitted every 15 minutes. The channels take records at 1, 3 and 15 minute intervals, respectively. The upgrade included new installations for solar panel, Satlink logger, GPS dome antenna, waterlog Yagi antenna and a Druck pressure sensor. A field engineer from UHSLC performed this work in co-operation with local surveyors from the Zanzibar Department of Surveys and Urban Planning, who also surveyed the station.

3.2 Dar es Salaam Station

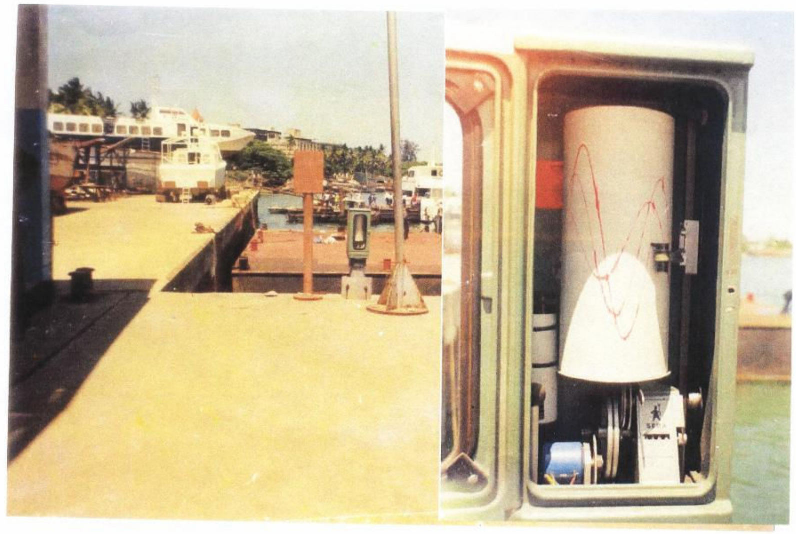
The tide gauge is located on the Ferry Terminal of the Dar es Salaam Harbour in front of the Marine Police offices (06^{o} 49.2'S; 039^{o} 17.3'E). The natural harbour of Dar es Salaam is a tidal basin formed by two coalescing creek systems with a narrow opening to the sea. It thus possesses the basic requirements of a sheltered port site. In general terms, the harbour is considered a product of deep sub-aerial erosion by vigorous streams of valleys which subsequently were drowned by eustatic changes of the sea level during the Quaternary Era.

The port has three main components: the entrance channel, connecting the ocean and the outer anchorage with the inner harbour; Kurasini Creek (Gerezani Creek) and the semi-circular part of the harbour facing the main part of the city; and the Southern Creek system in the form of an inverted Y.

The relative width of the entrance channel varies, so that the maximum width at a depth of 6.5 m is about 123 m. The overall length of the channel is about 4 km, and there is a current with a maximum speed of 1.8 m/s. The channel shelters the inner harbour from unfavourable conditions which sometimes prevail in the open sea outside the harbour. The ocean end of the channel is sheltered by the Inner and Outer Makatumbe islands. The port of Dar es Salaam has recently being expanded to enable ships to enter the port at all times of the day and night. Previously, transiting at the entrance channel was limited to day hours and flood periods only. The inner harbour is a completely sheltered land locked natural basin. The South creek is navigable for a distance of 2 km inland. It branches to become the valleys of Yombo, Mzinga and Mbagala rivers. The catchment area of the rivers is however, relatively small.

The wind speeds in Dar es Salaam are lowest during the rainy season when the maximum speed is 3-5 m/s. The speeds are greatest in the months of December/January and July/August during the first weeks of the monsoon, ranging from 5 to 8 m/s. The mean daily temperature is about 26^{o} C, the mean seasonal range is about 4^{o} C, and the mean daily range is about 8^{o}C. Generally, air temperatures vary from less than 22 ^{o}C to more than 30 ^{o}C and the mean humidity from 63% to 95%. The heavy (long) rains are experienced from March to May while the short (light) rains are received during November and December. The annual rainfall recorded from the nearby meteorological station at Kurasini averages 1,075 mm, with the heaviest rainfall occurring in April, averaging 289 mm in total. Tides are semidiurnal, with tidal ranges of up to 4 m. The mean spring tidal range is 3.2 m

The Dar es Salaam station has a mechanical SEBA float gauge that was installed in 1997 by the Tanzania Ports Authority. This tide gauge replaced a Leupold and Stevens float gauge (model A-71) whose stilling well was damaged by a boat. The Leupold and Stevens float gauge worked from 1986 to1990 under the University of Dar es Salaam. Recording of sea level data is by analogue charts at 10 min intervals. Processing of sea level data is carried out in by the UK Hydrographic Office and Proudman Oceanographic Laboratory (POL). TPA intends to digitize the analogue charts for processing with the view to improve the tidal regime for the port.



Dar es Salaam Station

4. HISTORICAL STATIONS

4.1 Mtwara Station

Mtwara Port was constructed in the early 1950's as a deepwater port of what was then known as Southern Tanganyika. The tide gauge was installed on 16th December 1955 by the East African Railways at the eastern end of Mtwara dock (10° 17'S; 040° 11'E). The depth alongside the quay was 9.3 m below Chart Datum. By the time of installation, the reference Bench Mark was not tied to the primary levelling. A value of 11.21ft above mean sea level was given to the B.M., and this was used for the Mtwara-Nachingwea trig net. The mean spring tidal range at Mtwara Harbour is 3.7 m. The tide gauge in Mtwara was a Munro IH 109 float type, which worked from 1959 to 1962. Previously, a Munro IH 40 was in operation from 1956 to 1957.

Mtwara probably experiences highest wind speeds along the Tanzanian coast. The speeds are greatest in May to August and lowest in March. The wind directions are unique on the Tanzanian coast as they predominantly blow northerly and easterly during the Northeast and Southeast monsoons, respectively. Unlike other tide gauge stations in Tanzania, Mtwara experiences a unimodal type of rainfall with a single annual maximum. Heaviest rainfall is received in January (213 mm), and the total annual rainfall is 1,164 mm. The rains fall from December to April, with a mean of 193 mm/month. The temperatures at Mtwara range from just less than 21.1 °C to just more than 30.2 ^{o}C.

Fig 1: Aerial photograph of Mtwara Port

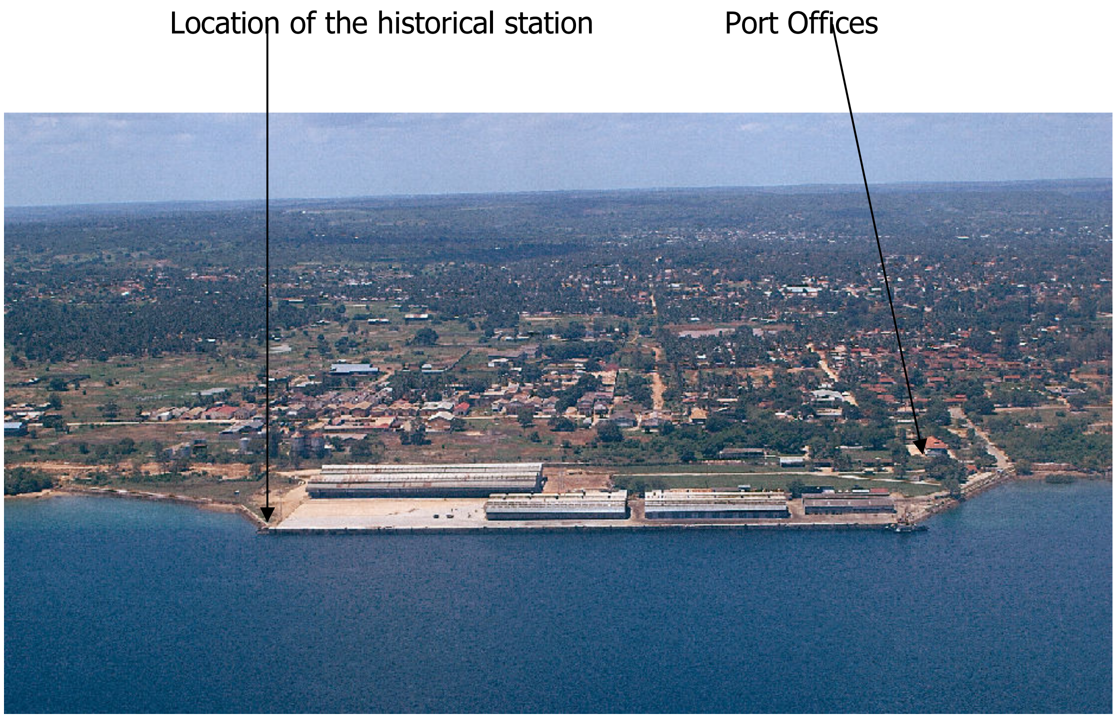
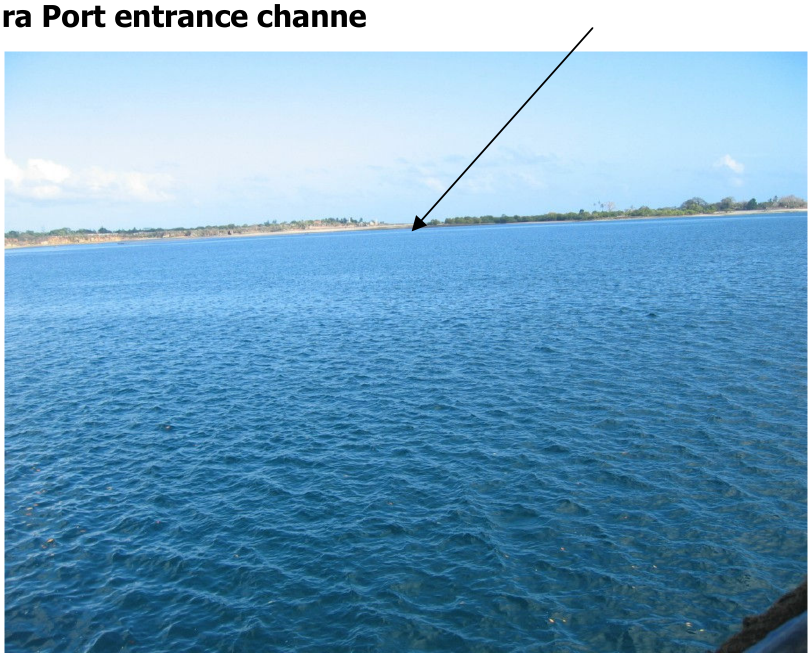


Fig 2: Previous location of the Tide Gauge

Fig 3: Previous location of the Mtwara Tide Gauge

Fig 4: Mtwara Port main quay

Fig 5: Mtwara Port entrance channe



4.1.1 Proposed Rehabilitation of Mtwara Station

The suitable location for installation of the new gauge may be on the same location or any other ideal place as may be determined by the installation experts, depending on the convenience of users and the type of the gauge. Tanzania Ports Authority is prepared to provide the following support:

- Site security (in terms of vandalism)
- Tide house
- Electricity at site
- Telephone at site
- Free and unrestricted access to data collected by the equipment
- Assistance to help facilitating the installation - (angle irons and pipes)
- Availability of local technicians to look after the equipment

The bench mark for the new tide gauge has to be re-established from the nearest bench mark outside the port, which is 2 km from the previous tide gauge location. The electric power and telephone lines are readily available in the port, the nearest electric pole being 40 m from the old tide gauge location, whilst the telephone line is situated 200 m away. Also the Port is fenced for security purposes and there are Security Guards within the port around the clock.

The responsibility for the new tide gauge will be under Tanzania Ports Authority. On the other hand, the Land Survey Department in the Ministry of Lands and Human Settlements Development will perform leveling of the instrument on a regular basis. The contact addresses of the relevant officials of the two institutions are as follows:

The Port Master
Tanzania Ports Authority
P.O. Box 530
Mtwara
Tanzania
Telephone:+255 23 2333125
Fax: +255 23 2333153
E-mail: pmmtwara@tanzaniaports.com

The Director of Survey
Ministry of Lands, Housing and
Human Settlements Development
P.O. Box 9132, Dar es Salaam
Tanzania
Telephone: +255 22 2121342-9
Fax: +255 22 2124576
E-mail: smd@raha.com

5. AVAILABILITY OF DATA FROM THE STATIONS

Table 1 below summarises the availability of data from both operational and non-operational stations.

TABLE 1: Availability of Data from operational and historical stations

Station	Span of Data	Data Sources
Zanzibar	1 March 1984 to-date	UHSLC, PSMSL, NODC, JASL, GLOSS
Dar es Salaam	6 July 1986 to 30 September 1990	UHSLC, PSMSL, JASL
	8 July 1997 to-date (Unprocessed)	TPA
Mtwara	1956-1957; 1959-1962	PSMSL, UKHO, GLOSS
Tanga	1962-1966	PSMSL

ABBREVIATIONS

UHSLC: University of Hawaii Sea Level Centre
Website: http://www. ilikai.soest.hawaii.edu

PSMSL: Permanent Service for Mean Sea Level
Website: http://www.pol.ac.uk/psmsl

NODC: National Oceanographic Data Centre (US)
Website: http://www.nodc.noaa.gov

JASL: Joint Archive for Sea Level

Website: http://www.uhslc.soest.hawaii.edu/uhslc/jasl.html

UKHO: UK hydrographic Office

Website: www.ukho.gov.uk; www.ukho.gov.uk/easytide

GLOSS: Global Sea Level Observing System

Website: http://www.pol.ac.uk/psmsl/programmes/gloss.info.html

TPA: Tanzania Ports Authority

Website: http://www.tanzaniaports.com

IOC: Intergovernmental Oceanographic Commission

WOCE: World Ocean circulation Experiment

6. INSTALLATION AND MAINTENANCE OF GAUGES

Tanzania has currently no human capacity for the installation of tide gauges. A limited capacity is available for operating the tide gauges, so training is required especially to operate the new tide gauges to be installed. Repair and maintenance of gauges requires the expertise of engineers from outside the country. The Zanzibar station for instance, relies on the services of a field engineer from the UHSLC. As for levelling, surveyors are readily available all over the country that may be able perform the work. Training of more personnel in tidal data analysis and tide gauge maintenance may create more interest in sea level data collection.

7. SEA LEVEL PRODUCTS

(a) Tide predictions for Zanzibar are produced by the UHSLC, UKHO and POL. Also the UKHO and POL produce tide predictions for Zanzibar as well for Dar es Salaam port. The predictions are in the form of heights and times of low and high water for each day of the year. Tidal information is of paramount importance in ports operation and other activities.

(b) The Tanzania Ports Authority produces Hydrographic Charts and navigation aids

(c) Some limited literature related to sea level is available

8. RECOMMENDATIONS

a) The tide gauge stations to be installed should be equipped with sensors for time series measurements of sea surface temperature. This variable is important in sea level data analysis and interpretation but no records are being taken at the moment. Other meteorological factors like wind, rainfall, air temperature and air pressure may be obtained from nearby meteorological stations.

b) The tide gauges should regularly be levelled at least once or twice a year so as to be able to filter out any variations that may be associated with land subsidence or uplift. Alternatively, the stations should be equipped with Global Positioning Systems (GPS).

c) To effectively cover the whole of Tanzanian coastline, additional stations should be established in the future. Hence, apart from Tanga and Mtwara, Chole Bay in Mafia Island (7° 57'S; 39° 45E), Kilwa Masoko (8° 54'S; 39° 30'E) and Lindi (10° 00'S; 39° 43'E) are proposed for consideration as additional sea level stations.

9. METEOROLOGICAL DATA

Data on rainfall, atmospheric pressure, winds and sea surface temperature for tide gauges are available at the nearby meteorological stations. Data for Dar es Salaam, Mtwara and Tanga may be obtained from:

Director General, Tanzania Meteorology Agency
P.O. Box 3056, Dar es Salaam, Tanzania.

Data for Zanzibar and Mkoani stations may be obtained from:

Director of Meteorology, Ministry of Communications and Transport
P.O. Box 266, Zanzibar, Tanzania

Annex 1: Monthly rainfall near the tide gauge stations (mm)

Met Station	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	Rainfall days
Tanga (Airport)	28	36	106	257	268	70	68	80	85	110	154	76	1338	109
Dar es Salaam (Airport)	74	83	143	273	152	34	32	28	26	60	122	108	1135	92
Dar es Salaam (Kurasini)	49	75	114	289	216	25	27	24	37	63	73	83	1075	88
Zanzibar (Chukwani)	58	64	144	312	285	52	27	31	40	67	166	135	1381	97
Mtwara (Airport)	213	195	171	195	45	13	16	10	42	21	53	192	1166	93
Pemba (Wete)	66	46	162	436	443	134	74	50	36	97	225	147	1916	140

Annex 2: Temperature ranges near the tide gauge stations (^oC)

Meteorological Station	Means			Extremes		Dry bulb		Dew point	
	Max	Min	Range	High	Low	6:00	12:00	6:00	12:00
Tanga (Airport)	30.3	22	8.2	36.5	15	26.1	29.1	22.4	22.2
Dar es Salaam (Airport)	30.5	21	9.5	35.2	13	25.7	29.2	22.3	21.2
Dar es Salaam (Kurasini)	29.7	22	7.8	35.3	15	25.3	28.5	22.5	22.2
Zanzibar (Chukwani)	30.3	24	6.8	38.8	19	26.2	29.1	23.4	23.3
Mtwara (Airport)	30.2	21	9.1	35.1	15	25.4	28.7	21.9	21.4
Pemba (Wete)	29.9	21	8.8	35	13	27		23	

Annex 3: Humidity, Cloud cover and Wind speed near the tide stations

Meteorological Station	Humidity (%)			Cloud Cover		Wind Speed	
	3:00	6:00	12:00	6:00	12:00	6:00	12:00
Tanga (Airport)	93	80	67	4.4	3.7	7	12
Dar es Salaam (Airport)	95	82	63	4.9	5	6	10
Dar es Salaam (Kurasini)	93	82	67	4.5	4.6	5	9
Zanzibar (Chukwani)	92	85	71	5.6	5.1	7	9
Mtwara (Airport)	94	81	66	5.2	5.6	9	11
Pemba (Wete)		78		4.7		3	

10. BIBLIOGRAPHY OF SEA LEVEL LITERATURE IN TANZANIA

Very little has been done on analysis on sea level data from tide gauge stations in Tanzania. Below is a list of related literature.

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Mgaya, Y.D., 1997: Global warming: A threat to human societies and natural ecosystems. *Tanzania Journal of Science*, 22: 65-74.

Mwandosya, M.J., Nyenzi, B.S. and M.L. Luhanga, 1998: *The Assessment of Vulnerability and Adaptation to Climate Change Impacts*. Centre for Energy, Environment, Science and Technology. Dar es Salaam, 235 p.

Wemba-Rashid, J.A.R., 1991: Effects of sea level changes on settlements: Examples from Tanzania (Summary). IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of sea Level Changes in the Western Indian Ocean and Islands. Mombassa, Kenya, 24-28 Nov. 1991, IOC Workshop Report No. 77.