The Economics of Climate Change in Zanzibar

1. Current Weather Data for Zanzibar and the Effects of Climate Variability and Extremes

May 2012
Executive Summary

A large proportion of Zanzibar’s GDP is associated with climate sensitivity activities, either directly such as with agriculture or tourism, or indirectly for example from the use of natural resources. The economy of the islands, and the livelihoods of the people, is therefore very dependent on weather and the climate. The islands are also affected by the regional patterns of extreme weather, which lead to major events such as floods, droughts and storms.

The starting point for the study has been to assess the current climate of Zanzibar, and to look at the observational data to see how the climate has been changing over recent decades. The analysis has then assessed the impacts and economic costs of the extreme events (droughts, floods, storms, etc.) which periodically affect the islands, and the current adaptation deficit on the islands, identifying early no regret options that would address these immediate effects.

The findings are summarised below. A full write-up of the data and findings is included in a technical report, available on the project web-site at http://www.economics-of-cc-in-zanzibar.org/.

The current climate

- Zanzibar currently has a tropical climate, with fairly constant average temperatures across the year. It has relatively high levels of average precipitation, and experiences strong rains in March to May, with shorter rains in November and December. The dry season lasts from June to October. However, there is variability across and between the two islands (Unguja and Pemba), and considerably variability across years.

- Zanzibar is also periodically affected by major East African climate extremes, associated with El Niño and La Niña years. These regional events lead to large climate variability, with heavy precipitation (floods) and dry spells (droughts). These extreme events have major economic costs on the islands, which are significant at the macro-economic level, as well as affecting livelihoods.

The climate of Zanzibar is changing

There is strong observational data to suggest that the climate of Zanzibar is changing. There is also strong evidence that extreme events are intensifying. Meteorological data from the islands show the following changing trends.

- Temperatures have been rising over the last thirty years on both islands, with a strong increase in average and maximum temperatures. The increases are highest in the months December to May (see box below) and the highest ever temperature recorded on the island was in 2007 (at over 39 degrees).

- The changes in rainfall are complex, and there does not appear to be a simple precipitation trend across the islands. However, there are indications of changes in rainfall variability, and there have been higher rainfall intensity events recorded in recent years.

- There are observational trends of increasing wind speeds on the islands over the last 20 years (see box below), with an increasing tendency of extreme wind events.

- There is some evidence that extreme events are intensifying. The most extreme cases of temperature, heavy rainfall and wind speeds on record on the islands have all occurred over the last ten years.
Temperature Trends

There are observational changes of increasing temperatures on both islands, with the strongest increases in the period December – May. The changes between recent decades are shown below (note the time series is shorter for Pemba). While some care must be taken in interpreting these trends, because of decadal variations and the relatively short time periods involved, they do show strong rising trends.

Average Monthly Maximum Temperatures (Degree Centigrade)

Source of data. TMA.

Zanzibar’s economy is also strongly dependent on the marine and coastal environment. Again, observational data shows changes are occurring, with the following trends.

- Data of sea surface temperature shows a rising trend over the past twenty years. These increases are likely to be one of the major causes of the decline in shallow water seaweed harvesting on Zanzibar. There has also been more extreme warming associated with some recent ENSO years, which have led to coral bleaching.

- Tide gauge data for Zanzibar shows some large inter-decadal trends, with variations (both decreases and increases) over time. However, alongside increasing wind speeds on the islands, there have been increases in wave (sea surface) heights and high water levels (see below). This would suggest that the wave climate regime may be changing, and increasing wave activity could be a factor in enhanced coastal erosion, especially in shores which lack natural protection.

There are recent recorded examples of coastal erosion and saltwater intrusion on the islands, which are possibly linked to some of the trends above. However, these effects are also likely to be associated with socio-economic drivers (loss of mangroves, over abstraction of water) and care must be taken in attributing all or even most of these recent trends only to climate change.
Wind speed and High Water Level Trends

Data are shown below on the changes in annual monthly mean speeds and monthly high water levels over the past twenty or so years. This shows strong increases, reflecting changes that are highly relevant to coastal impacts.

Annual monthly mean wind speeds for Zanzibar

Key. The dotted blue lines and the dotted yellow lines in (b) indicates the ten years monthly mean averages for the evenings and mornings wind speeds, respectively.

Source of data: Tanzania Meteorological Agency, Zanzibar Station; Shaghude and Dubi (2008).


Source: Shaghude and Dubi (2008).
Extreme events – changing signals and economic costs

The increased intensity of extreme events is leading to impacts with high economic costs.

- The highest ever recorded precipitation event on the island was recorded in 2005, with a flood that seriously damaged at least 1,000 homes and displaced 10,000 people. The immediate relief and disaster response costs associated with this individual event were $100,000, but from an analysis of the event, we conclude the full economic cost was probably at least $1 million, equivalent to 0.2% of Zanzibar’s GDP, with a high estimate (including the full direct and indirect costs of the event) that could be as high as 1% of GDP. Heavy rainfall events in 2011 also led to major impacts, including the damage of road infrastructure on Pemba.

- Low and erratic rainfall in 2006/7 on the islands led to a major crop failure. The contribution of agricultural crops to GDP on the islands was significantly lower in 2007, and was a strong factor in reducing GDP (by several %). The crop failures in 2007 also led to a large-scale hunger crisis in 2008, which affected over 20% of the population (300,000 people). The health costs of this failure (using prevention costs as a proxy) have been estimated at $5 – 7 million, equal to 1% of Zanzibar GDP.

- There is evidence of strengthening wind speeds on the islands associated with the monsoons. This has led to increased impacts from storms (and storm surges). Major wind storm events occurred in 2009 (leading to widespread building damage) and in 2011, leading to injuries (and a fatality).

These changes in extremes are economically important, and affect the livelihoods of many people on the islands.

The study has also considered the existing policy environment and the areas to address the trends of increasing extremes.

Existing Disaster Risk Management

In recognition of the events above, progress has been made on disaster risk management on the islands. There is a newly established Disaster Management Policy for Zanzibar, a Disaster Management Commission/Department, and an Emergency Preparedness and Response Plan. Nonetheless, further strengthening and implementation would be beneficial to enable these policies and disaster risk reduction plans to work more effectively, and there is an issue whether the current strategy is taking account of the changing patterns of trends and extremes.

Zanzibar’s adaptation deficit

The impacts of current climate variability (discussed above) provides strong evidence that that Zanzibar has an existing adaptation deficit associated with current climate extremes, particularly due to the recent increases in the intensification of these events.

Addressing this deficit is a priority for early adaptation, because it leads to immediate benefits by reducing current economic losses (from current variability) as well as providing greater resilience to future climate change. Such measures are often termed no-regret measure (i.e. due to their net positive present value). However, taking advantage of many of such measures requires better capacity and institutional strengthening.

A number of possible early priorities have been identified that could help address the issues of current climate variability and the adaptation deficit, particularly in relation to current disasters.

- There is an urgent need to enhance the capability and resources of the Zanzibar meteorological agency, the marine institute, and other related institutes looking at meteorological data (both terrestrial and marine), and a key priority is to improve data collection and interpretation. This is
likely to require additional meteorological stations, tide gauges and sea temperature loggers, as well as institutional capacity, support and training. These systems need to be put in place now, to allow sufficient baseline data collection, and to provide a time series of observational changes of climate change over coming years. This evidence base is critical to allow effective responses in future years.

- There is the potential for advances in Disaster Risk Management and Reduction. While the existing policy sets out the architecture and responsibilities, further strengthening would be beneficial (in capacity, governance, infrastructure, etc.) to enable the systems to be fully effective. There is still an inadequate warning system in Zanzibar (particularly in Pemba) and not all stakeholders are effectively involved in disaster management activities. Warning systems could also be further developed and tested to make them more effective.

- One of the critical areas is the potential for improving the effectiveness of early warning information. This could be advanced by strengthening the TMA and extending the current system to ensure the communication and dissemination of information is effective and reliable, so that early warning information reaches (and is understood by) the range of potential users (fishermen, communities at risk, farmers, etc.), many of which do not currently receive or act on this information. The potential for community based early warning systems is also highlighted.

- There would be benefits from gathering disaster and risk data in a more systematic way, to improve the system of reporting. This is important as it will provide baseline information to allow analysis of the current likelihood and probabilities of different type of hazards.

- There is also the potential to strengthen the existing institutional and legal framework (though progress in this area is being taken forward), with capacity building within Ministries and Departments across Government in the areas of agriculture, health, and emergency services. There is also the potential to improve the collection, analyse and dissemination of DRR information (using risk maps for example), and for capacity building and training for responses, for local and district level.

- There are a number of areas where sectoral plans and policy could factor in these current and emerging risks. A particularly important area is for land-use, spatial planning and major/critical infrastructure siting, where risk mapping would allow the reduction of current and future exposure to extreme events (e.g. from flooding).

- Finally, the current disaster and emergency response plans do not yet plan for the effects of climate change (because of the lack of evidence to date). There is a need to start planning for the potential increases in extreme events that may arise, i.e. the changes in likelihood and magnitude of events, and to mainstream climate change into DRM.
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This report was prepared for the Study Advisory Committee in Zanzibar.

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The views expressed in this report are entirely those of the authors and do not necessarily represent the Revolution Government of Zanzibar, DFID’s own views or policies, or those of DEW Point.

Note: in this inception report, the use of the Zanzibar is a shorthand for the Zanzibar Archipelago and thus includes Unguja, Pemba and other islands.
Introduction

Zanzibar consists of two main islands, Unguja and Pemba, and several other smaller islands some of which are uninhabited. It is located in the Indian Ocean, about 30 kilometres from the mainland coast, between latitudes 5 and 7 degrees south of the Equator.

The climate of Zanzibar is warm and humid (tropical), experiencing warm daily temperatures and a mean of over 1000 mm/year of rainfall.

The main rainy season is during the months of March to May (Masika) and October to November (Vuli). The cold (drier) season (Kipupwe) is during the months of June to August, while the hot season (Kaskazi) is experienced from December to February. Note that even in the cold season, most locations receive some showers (off-season rains). Data from the temperature and precipitation monitoring data from Zanzibar are presented in the next section.

Zanzibar has a fairly small seasonal temperature variation of around 3°C to 4°C which is not uncommon in tropical areas. Much higher variability exists for rainfall, with high variability in monthly rainfall totals, especially in the rainy seasons with differences as high as 250mm/month between the 10th percentile and 90th percentile values.

The tropical location means that the seasonality is tied to the movement of the Inter-tropical Convergence Zone (ITCZ) which moves north and south during the year. The ITCZ results in a double rain season, with long rains during March to May and short rains during the months of October to December. This occurs as the ITCZ moves southwards at the beginning of summer and then northwards at the end of summer. Rainfall is associated with the shift in the ITCZ, hence an early summer and a late summer rainfall season.

However, all regions of the Tanzania– including Zanzibar - are influenced by the wider regional East African climate. This is heavily influenced by the El Niño – Southern Oscillation (ENSO) events and also sea surface temperatures in the Indian (Indian Ocean Dipole). Although differences exist between the exact effects of El Niño the broad pattern is increased rainfall during El Niño years and decreased rainfall during La Niña years, frequently leading to floods and droughts. Flooding is particularly severe when an El Niño year occurs in combination with the positive phase of the Indian Ocean Dipole (as in 1997 and 2006).

Meteorological Station Data for Zanzibar (Temperature and Precipitation)

The starting point for this analysis is to look at the recent observed data to build up a picture of the current climate, and investigate any recent decadal changes.

There are two main meteorological stations, one on each island (Zanzibar Airport on Zanzibar and Karume Airport on Pemba) but also a number of other rain gauges which provide additional information.
**Temperature**

Data on the island has been sourced from the Zanzibar office of the TMA. The temperature records extend back to the early 1970s.

The monthly data on maximum and minimum temperatures are first shown for Zanzibar below. This shows the warm (tropical) climate.

**Zanzibar Airport Monthly Mean Maximum Temperature Degree Centigrade**

Source: TMA

**Zanzibar Airport Monthly Mean Minimum Temperature Degree Centigrade**

Source: TMA

The data shows a fairly constant average temperature (monthly) across the year, though with lower temperature in the dry season. The same pattern is observed for Pemba.
Data from the Climate Systems Analysis Group

Data on current observations have also been taken from the Climate Systems Analysis Group (CSAG), University of Cape Town, Climate Information Portal (CIP). There has one climate station, Zanzibar/Kisauni¹, shown on the figure below².

¹ Station ID: 63870. Coordinates: 6.22° S, 39.22° E. Altitude: 15 (meters)
² There is a meteorological station on Pemba, but this is not in the CSAG system
These are important because these have been used to downscale the data for the future climate projections.

There is also data from the CCAP Climate Module (using data provided by the Climate Systems Analysis Group (CSAG), University of Cape Town, SA) which includes information for the Pemba/Karume Station, situated at 25 metres.

The observed maximum and minimum temperature from the CSAG data for Zanzibar is shown below. The data is the average of the period 1979 – 2000. The blue envelope shows the range across years. The data shows a fairly constant average temperature (monthly) across the year, though with lower temperature in May to October.
Observed monthly mean daily maximum (top) and minimum (bottom) temperature, Zanzibar

Observed monthly mean daily maximum temperature Pemba

Source of data: GCAP Climate Module, with data from the Climate Systems Analysis Group (CSAG), University of Cape Town, SA.
Temperature Trend information

Data at the global and African level reports significant increases in temperatures over the last fifty years (IPCC, AR4, 2007). Average global temperatures have risen by almost 0.8ºC over the last century, and slightly higher than this in Africa, with a particularly sharp rise over last 50 years rise (IPCC, 2007). These changes can only be explained by anthropogenic emissions (IPCC, 2007).

![Observed temperature in Africa](image)

Source: IPCC, WG1-AR4³ The black line shows the observed (actual) changes in surface temperature in Africa over the past century.

There have also been rises in sea level, and changes in the pattern of rainfall, extreme rainfall (floods) and droughts. These trends are very real and are accelerating.

There have been other broad assessments of observational data for Africa also showing changing information. An analysis of 6 meteorological stations in Tanzania carried out by New et al (2006) as part of a larger assessment for Africa showed clear evidence of decreasing numbers of cold days and nights and an increase in the number of heat-waves, and in the frequency of hot nights.

For the Tanzania and Zanzibar, the United Republic of Tanzania National Adaptation Programme of Action (NAPA) (URT, 2007) reported that monthly minimum and maximum temperatures for the United Republic of Tanzania over the last 30 years (between 1974 and 2004) have shown an upward trend at many meteorological stations, including Zanzibar. The NAPA reports the increasing trend is mostly associated with the months of January, July and December.

This upward trend can be seen in the monthly data below.

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Trend line for Average Monthly Maximum Temperatures (Degree Centigrade), Zanzibar

There has also been an upward trend in the maximum daily temperature. The highest recorded temperature on the island was recorded in February 2007, at 39.4 degrees.

A comparison of decadal trends is shown below.

This shows strong increase in the months of December to May for Unguja, from the 1970s to the 2000s. There seems to be even stronger trend for Pemba – even though the data series is not as long – with a strong increase since the 1980s.

While some care must be taken in interpreting these trends, because of decadal variations, there does appear to be a strong trend of rising temperatures over much of the year over recent decades.
**Average Monthly Maximum Temperatures (Degree Centigrade).**

**Average of 1971-2000 and 2001 – 2011 Unguja.**

Source: TMA

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**Average Monthly Maximum Temperatures (Degree Centigrade).**


Source: TMA
Rainfall

The annual rainfall levels for both islands are plotted below.

Source: TMA

The monthly values are shown below. Data are plotted over the last decade to illustrate the seasonal patterns. The data shows the strongest rains in March to May, but with a bi-modal distribution that includes shorter rains in November and December. The dry season generally lasts from June to October.

Source: TMA
Some care must also be taken, because there is significant rainfall variability across the islands. Mustelin et al (2009) report that rainfall does vary over the individual islands, with generally higher rainfall on Unguja in the west.

Data from rain gauge data across the islands is shown below, showing the variability.
RGZ (2007) has GIS maps of rainfall that show the breakdown across the islands, which suggest relatively low differences across regions, though with a slight equal North-South divide in annual mean rainfall regime for Unguja, (northern part has higher mean annual rainfall ranging from 1600 mm to 1800 mm whereas the southern part ranges from 1200 mm to 1400 mm) and an east-west divide for Pemba (the western part, with relief of 30-90 metres above sea level, generally receives higher rainfall than the eastern lower side with relief of -18-30 metres above seas level).
Data from the Climate Systems Analysis Group

The observed monthly precipitation data from the CSAG data set for Zanzibar is shown below. The data shows the overall signals highlighted above, but also shows there is a wide range across years. This dataset is important, because it is used for the baseline for the future climate projections.

**Observed monthly rainfall Zanzibar (Unguja)**

Source of data: Climate Systems Analysis Group (CSAG), University of Cape Town, SA

Further rainfall data is shown below, for the observed monthly rain days and the intensity, and for observed dry spells.

**Observed monthly rain days Zanzibar (Unguja)**

**Observed monthly rain days (>10 mm/day) Zanzibar (Unguja)**
Observed monthly dry spell duration (Unguja)

Source of data: Climate Systems Analysis Group (CSAG), University of Cape Town, SA

Data are also available on the monthly rainfall for Pemba, shown below. While the overall pattern is similar, there are differences in the observable trends to Unguja, noticeable with higher variability of rainfall levels and differences in rainfall levels between the two rainy seasons.

Observed monthly rainfall Pemba

Source of data: Climate Systems Analysis Group (CSAG), University of Cape Town, SA

Rainfall Trend information

The Tanzanian NAPA (URT, 2007) reports a decreasing rainfall trend for Zanzibar (Pemba station) over last 20 years, shown below.
Rainfall Pattern at Pemba Meteorological station

Source: NAPA (URT, 2007)

However, there appears to be no such trend on Zanzibar.

Rainfall Pattern at Unguja Meteorological station

The URT NAPA also reports that recently, rainfall pattern has become much more unpredictable with some areas/zones receiving extremely minimum and maximum rainfall per year.

Similarly, New et al (2006) report an increase in the average intensity of rainfall, a small increase in the maximum number of consecutive wet days and a small increase in the maximum number of consecutive dry days.

The highest rainfall intensity was recorded during the April 2005 event (see below).
Onset of the Rains

There are many anecdotal reports of changes in rainfall patterns, in terms of greater variability and in particular, the onset of the rainy season. Several reports highlight that farmers used to know the likely onset of the March to May season (Masika), almost down to the date in late March when the rains would arrive. However, particularly care must be taken in reporting such trends. To investigate this, the study has looked at daily rainfall for the month of March at the Zanzibar station, to investigate if the data backs this up.

As an initial analysis, the daily rainfall for Unguja station has been compared for the decades of the 1970s and 2000s, as an illustration below (note a full statistical analysis of the data would be worthwhile). This initial look highlights a number of issues.

First, there has always been variability in the rainfall levels and onset dates, as evidenced by the patterns for the 1970s. The regularity of the rains has varied significantly on an annual (and probably decadal) basis. There therefore appears to be some bias in the historical recall of farmers, i.e. in over-attributing how exact rainfall patterns have been historically.

Nonetheless, there is perhaps indication that variability has changed, in relation to the timing of onset (as represented by the greater variation in the graph for the later time period) and certainly in the intensity of events, with more examples of very heavy rainfall periods in the 2000s.
Rainfall data (daily) in March at Unguja, 1970 – 1979. Note set to scale of maximum of 50 mm/day.
Rainfall data (daily) in March at Unguja, 2000 – 2009. 
note set to scale of maximum of 50 mm/day.
**Wind Speed data**

**Wind Speeds**

Wind records indicate an increase in wind speeds over the past 20 years on Zanzibar. This has been accompanied by an increase in wave height (see below).

![Graph](image)

20 years (1988-2007) monthly means of the wind speed (a) and the annual monthly means of wind speeds (b) for Zanzibar.

Key. The dotted blue lines and the dotted yellow lines in (b) indicates the ten years monthly mean averages for the evenings and mornings wind speeds, respectively.

Source of data: Tanzania Meteorological Agency, Zanzibar Station; Shaghude and Dubi (2008).
Analyses of the 20 years (1988 – 2007) wind data from the Zanzibar meteorological station (Zanzibar International Airport) shows that, strongest winds are experienced in January, February and August, with the monthly mean wind speeds generally exceeding 10 knots during these months (Shaghude and Dubi, 2008). The data shows significant inter-annual variations of the wind speeds with stronger wind speeds during the last decade (1998-2007) than during the decade before. Furthermore, the evenings winds are generally stronger compared to the morning winds.

Shaghude and Dubi (2008) further report that the analyses of the 20 years monthly averages of the surface wind speed shows that the frequency of the number of months where the morning/evening monthly averages had exceeded 10 knots was higher during the 1998 – 2007 decade than during the previous decade, suggestive of the increasing tendency of extreme winds events. This would also suggest that the wave climate regime has also changed over the last 2-3 decades, with the tendency of increasing wave activity and associated coastal erosion, especially in those shores which lack natural protections.

![Number of monthly frequencies with the monthly averages for the morning/evening surface wind speeds exceeding 10 knots.](image)

Source of data: Tanzania Meteorological Agency, Zanzibar Station; Shaghude and Dubi (2008).

**Data Gaps, Early Priorities for Strengthening of Met Services**

While there is meteorological measurement data for the islands, this is clearly an area that would benefit from early strengthening (equipment, training, and institutional strengthening). As examples, there are some issues with some of the Pemba data set, and for this reason it is not reported in the CSAG database. Similarly, there is a network of wider rain gauges on the islands, but there have not been the resources to maintain continuous data recording, which reduces the effectiveness of these measurements.

A key point here is that in order to build up the data to allow interpretation of trends, data is needed for significant time periods, i.e. it is necessary to start these activities now, to allow the data to be used effectively in the near future.
A critical priority is therefore to build the capacity of the Zanzibar office of the Tanzanian Meteorological Agency. Following discussion with the local Zanzibar office, urgent early steps are to provide the resource to allow the rain gauge network to be maintained, to enhance office equipment (including computers) to allow local data collection and analysis, and to train staff to ensure there is greater capacity on the islands. There is also a need to expand the two stations, especially given that both sites are currently sited on the airports (not necessarily the most important sites for climate change). As examples, wind speed data would be more useful in relation to the north of the islands. Ideally, 3 meteorological monitoring stations would be sited on each island (i.e. six across Unguja and Pemba), to allow the differences in rainfall, etc. to be adequately captured. One option for these might be to consider automated stations (these cost around $30 – 40,000 each), which allow a more efficient network.

**Key early steps**

A key priority is to enhance the capability and resources of the Zanzibar meteorological agency, providing the resources to ensure data collection and data interpretation. This is critical to allow analysis of observational changes of climate change over coming years.

**Sea Levels, Sea Temperature and Marine Data**

**Sea level data and sea surface height**

One of the key observations of climate change is that sea levels are rising. There are global trends in rising sea levels recorded over the last century, attributed to Meehl et al., (2007):

- Thermal expansion (the increase in water volume (in mm) due to rising temperatures).
- Changes in surface air temperature (to calculate the contribution of land based ice).

While sea levels have been changing naturally for thousands of years, recent rises have been attributed to anthropogenic activity.

From 1900-2009, global sea levels rose by 1.7 ±0.3 mm/year (Church and White, 2006). Between 1993 and 2009, the estimated rate of sea-level rise was 2.8 ±0.8 mm/year from in-situ measurements such as tide gauges (Church and White, 2011). The Intergovernmental Panel on Climate Change (IPCC, 2007) reported that human influences are very likely to have contributed to this rise over the 21st century. More specifically, Jevrejeva et al. (2009) calculated that 75% of the 20th century rise was attributable to human induced climate change.

However, a changing climate is not the only driver of sea-level change. Geological changes (e.g. subsidence or tectonic movements) also affect relative sea level rise. There is no information available on the land movements for Zanzibar, though there is some regional level information. Additional non-climatic factors may also be important, such as human-induced subsidence (due to groundwater extraction).

**Zanzibar Monitoring Data**

Sea-level data is need for the physical monitoring of coastal processes. The Tanzanian sea level network consists of two operational stations of Zanzibar and Dar es Salaam, and three historic non-operational tide gauges at Mtwara, Tanga and Pemba (Mahongo, 2001; Mahongo and Khamis, 2006; Nhnyete and Mahongo, 2007). Details are provided in the box, from Mahongo and Khamis (2006).

In terms of annual variability, Zanzibar generally experiences two high peaks of monthly sea level (Mustelin et al, 2009), during the transition months (March/April and October/November) due to currents and wind regimes (and the East African Coastal Current). The monthly tide gauge data is shown below.

The network of sea level stations in Tanzania consists of only two operational stations, Zanzibar (GLOSS Station No. 297) and Dar es Salaam. Zanzibar has a satellite transmitting station while Dar es Salaam has a mechanical float gauge. Four tide gauges were also installed in the past at Mtwara (GLOSS Station No. 9), Tanga, Latham Island and Mkoani in Pemba, but they are now not operational (historical stations). Periodic levelling is carried out in the operational stations. The Zanzibar tide gauge station is managed by the Zanzibar Department of Surveys and Urban Planning. The old tide gauge station at Mkoani in Pemba Island was also managed by the same department.

The tide gauge in Zanzibar is located on the seaward end of the main jetty in Zanzibar Harbour, off the coast of Zanzibar town (6o 09.3'; 39o 11.4'E). No information is available on when this station was first established. A satellite sea level transmitting station (tide logger, float type) was installed in February 1993.

The tide gauge was located on the Mkoani Harbour (5o 21’S; 39o 38’E). A Munro IH 109 float type tide gauge was incorrectly installed at Mkoani in July 1991 and so it never worked.

Data at the Zanzibar station is available in hourly, monthly and annual mean sea levels in digital form, by a number of international agencies (UHSLC: University of Hawaii Sea Level Centre. PSMSL: Permanent Service for Mean Sea Level. NODC: National Oceanographic Data Centre (US). JASL: Joint Archive for Sea Level. GLOSS: Global Sea Level Observing System.

The figure below shows the annual sea-level measurements at the Zanzibar station during the period

A number of the global sets has been considered (see list in box). The University of Hawaii data site shows a decreases in the period from 1990 – 2000: but increases since this time through to 2011.

Similar trends are reported from the Permanent Services for Mean Sea Level (PSMSL), source: PSMSL [http://www.psmsl.org/data/obtaining/stations/1600.php](http://www.psmsl.org/data/obtaining/stations/1600.php), though this data set only reports to 2004. Data is reported used different mm values, though this maybe due to different datum (e.g. a local datum, rather than an international one).

However, it is important to note that estimates of trends of sea-level change obtained from tide gauge records of short durations (< 50 years) can have a significant bias due to inter-annual-to-decadal water level variability (Douglas, 2001), and hence it is difficult to interpret Zanzibar’s sea-level change records. Furthermore, sea-level rise at any particular location generally differs from the global mean value, because of the interplay between ocean circulation and subsurface density changes (Brown et al, 2011). These differences create a pattern of sea-level rise.

The more recent data goes some way to explaining anecdotal evidence of rising high tides. This is also backed up by the observational data.

Preliminary analysis of satellite data indicates that sea surface height (SSH) have been increasing faster in the Western Indian Ocean than in the Eastern Indian Ocean over the last 25 years. Analyses of satellite derived data, particularly the satellite altimetry at the local level would be important to provide a better understanding on the extent at which this generalized model for the Western Indian Ocean is applicable to the Tanzanian coast.

The Monthly Mean High Water (MHW) for the period 1984 – 2004 is reported to have been fluctuating between 3.7 m and 3.95 m (Shaghude and Dubi, 2008) with an overall increasing trend, which could be associated with the meteorological and oceanographic parameters such as winds and waves.

![MONTHLY MEAN HIGH WATER LEVELS](image)

Other regional stations give rising trends. For instance, in Mombasa (located within the same region and with measurements approximately over same duration, 1986-2002), a 1.1mm/year rising sea level trend is measured (Magori, 2005; Kibue, 2006).

This illustrates that careful consideration should be made in interpreting short-duration sea-level measurements; also highlighting that measurements should be continued, and as their duration increases, they will become more useful, both scientifically and for future risk assessment and coastal management purposes.

Further work is ongoing. There is the Regional Ocean Modeling System (ROMS) model of the Zanzibar Channel\(^4\). The model is forced at the boundaries by the annual cycle of HYCOM at 1/12° resolution. It is forced at the surface with the annual cycle of winds stress and surface heat fluxes derived from the meteorological station in Zanzibar. The initial condition was derived from HYCOM and after one year of adjustment it reached a steady state describing the annual cycle.

Note this means that particular care must be taken in interpreting observations of impacts. The NAPA (URT, 2007) reported ‘The intrusion of sea water into water wells along the coast of Bagamoyo town and the inundation of Maziwe Island in Pangani District, off the Indian Ocean shores, are yet another evidence of the threats of climate change.’ Unfortunately there is not sufficient data to make this statement robustly, especially given the tide data above.

There is also some anecdotal evidence of higher tidal variability (wave heights)\(^5\). Again, while there do appear to have been some high tide measurements recorded, the observational data sets do not indicate any particular trends over the past 25 years.

Mahongo (2001) made some recommendations that still have relevance

<table>
<thead>
<tr>
<th>Mahongo (2001) recommended.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The older stations should be rehabilitated and equipped with data loggers so as to obtain reliable digital data which is easy to process. A priority here is for Pemba.</td>
</tr>
<tr>
<td>• Rehabilitation of the non-operational stations should be accompanied by training of personnel for maintenance.</td>
</tr>
<tr>
<td>• A single (URT) agency should be commissioned to act as a link to the tide gauge stations so as to harmonise the activities of the stations such as levelling, analysis of data and mobilization and training of technical personnel.</td>
</tr>
<tr>
<td>• The tide gauge stations should also be equipped with sensors for time series measurement of sea surface temperature. This variable is important in sea level data analysis and interpretation but no records are being taken at the moment.</td>
</tr>
<tr>
<td>• The available sea level records should be analysed so as to monitor the trend of sea level, to identify any anomalies and to provide scientific information that may be of practical importance for the conservation of the coastal zone. The analyses may also be of regional and global importance if they can provide relevant information on aspects such as those that relate to global warming and sea level rise.</td>
</tr>
<tr>
<td>• 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 rise or fall of ground level.</td>
</tr>
</tbody>
</table>

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\(^4\) developed by Gabriela Mayorga-Adame in 2007 was further developed by Shigalla Mahongo of the Tanzania Fisheries Research Institute (TAFIRI), Tanzania, during his one-month ROMS training provided by Dr. Javier Zavala-Garay at Rutgers University, USA, in July and August 2008. Mr. Mahongo’s visit was supported by a POGO-SCOR Fellowship (Grants and Contributions).

http://www.theissresearch.org/scientists/theiss/zanzibar/research.php

\(^5\) http://news.bbc.co.uk/1/hi/world/africa/7100107.stm
Sea Temperature, Currents and Salinity

There is some regional (West Indian Ocean) data that reports rising sea temperatures, particularly for shallow waters. Preliminary analysis of satellite data indicates that sea surface temperature (SST) and sea surface height (SSH) have been increasing faster in the Western Indian Ocean than in the Eastern Indian Ocean over the last 25 years. Based on evidence from other countries, the SST increase on the continental shelf, and particularly in shallow areas is faster than the global SST average. A study of satellite and in situ SST would be of value for establishing to what extent this also applies to Zanzibar and whether Zanzibar may see a faster increase in SST than areas with deeper water such as Pemba.

The Institute for Marine Sciences has a sea temperature logger and SST has been logged continuously at Chumbe since 1998. The data – and the potential effects- are discussed below.

The oldest and longest record of in-situ measurements of Sea Surface temperatures along the coast of Tanzania have been recorded at Chumbe reefs, Zanzibar, where a SST data logger had been installed since 1998. The time series data of SST from this temperature logger indicated interannual variability but with no significant SST anomaly suggestive of coral reef bleaching event apart from the SST anomaly observed during the ENSO event of 1998 (Muhando, 2009). The results were consistent with the SST data derived from NOAA coral reef watch for the Zanzibar coral reef bleaching data product (Muhando, 2009).


The assessment of sea surface temperature trends in the Western Indian Ocean region, spanning from the coastal waters of the Mainland countries of Somalia in the north to Mozambique in the south and the Oceanic Islands of Seychelles, Comoros and Madagascar using low resolution satellite data and a limited number of in situ measurements show that the mean and maximum SSTs in East African coastal waters have been increasing at a rate of 0.018C/yr over the last 50 years (Mcclanahan, et al., 2007). The results further indicated significant spatial variability, with the patterns of maximum SSTs increasing from inshore to offshore locations and the minimum SSTs increasing from south to north. The rate of temperature rise was generally higher during the ENSO years than during the non-ENSO years. The three ENSO events of 1982–1983, 1987–1988, and 1997–1998 had the highest recorded mean SSTs in the Western Indian Ocean. Evidence for significant bleaching and mortality in the western Indian Ocean during some of the ENSO events (e.g. the 1982-1983) but may be due to a lack of investigation. The 1997–1998 event had both ENSO and IOD components (Saji et al. 1999) and was associated with massive coral bleaching in the entire Western Indian Ocean Region.
Coral bleaching and mortality

Coral bleaching is the whitening of corals, due to stress-induced expulsion or death of their symbiotic protozoa, zooxanthellae. The corals that form the structure of the great reef ecosystems of tropical seas depend upon a symbiotic relationship with unicellular flagellate protozoa, called zooxanthellae, that are photosynthetic and live within their tissues. Under stress, corals may expel their zooxanthellae, which lead to a lighter or completely white appearance; bleaching and eventually coral mortality (when the bleaching is prolonged). Although coral bleaching could be associated with a wide range of environmental stresses, massive coral bleaching events have often been associated with rising sea surface temperatures. In the Indian Ocean, most of the massive coral bleaching events are believed to be driven by the ENSO and Indian Ocean Dipole variability’s.

As highlighted above – and presented in the impacts chapter - the 1997–1998 event was associated with coral bleaching in the entire Western Indian Ocean Region including on Zanzinar.

Effects of climate change on sea weed (farming)

The seaweed farming industry started in Zanzibar during the late 1980s and is viewed as a potential economic opportunity, an alternative livelihood option, an alternative supplement option and an alternative option for reducing pressure on marine resources such as coral reefs, fish and mangroves (Msuya, 1998).

Seaweed farming in Zanzibar has empowered the women from their long time dependent on their husbands in controlling the family’s socio-economic needs (Msuya, et al., 1994; Msuya et al., 1996). Anecdotal survey from the seaweed farmers show that seaweed farming had been going on very successful during the early 1990s, but serious seaweed die-offs started to be experienced during the late 1990s and 2000s. Although the sea-weed die-offs along the entire coast of Tanzania was associated with a number of environmental parameters such as increasing sea surface temperature, changing rainfall climate regime, change of wave and climate regime, amongst others, the study of Mmochi et al (2005) conducted at four seaweed farming villages in Tanga revealed that elevation of sea surface temperatures above the tolerance limit of the seaweeds on the intertidal waters was the mostly likely environmental parameter which could be associated with the major die-offs of the seaweeds in many seaweed farming sites. Later studies by Msuya et al (2007) in Bagamoyo, Tanzania mainland where seaweed farms were established in relatively deeper waters using floating lines approach demonstrated that elevated temperatures on the intertidal waters during low tides have been the major limiting environmental factor for the seaweed farming.

There is also some anecdotal evidence of higher sea temperatures leading to increased jellyfish blooms but there are no data records on the islands.

Other issues

There are some reports of changing sediment patterns and even of tidal currents (an issue highlighted at the workshop), though these need to be seen in the context of natural processes and variations. There has been some work as part of the Zanzibar Port Study, though this was not yet available for reporting in the study.

Sediment and tidal current monitoring is also a potential area, though these are less important than tide gauge and temperature data in the context of climate change.
**Data Gaps, Early Priorities for Strengthening of Coastal/Marine Data**

The discussion above highlights that while there are data available, there is a strong case for strengthening this. This section discusses key priorities.

**Equipment**

With new technologies (e.g. SAR altimetry) wave measurements from satellites will become available at higher resolution and closer to the coast over the next few years. The availability of coastal wind and wave measurements in one or more stations would improve the reliability of the satellite data, and make it easier to relate the offshore wave climate (including extremes) to wave climate at the coast.

The lack of tide gauge and sea temperature data is highlighted as a critical gap for Zanzibar. While future satellite data provides the opportunity to get additional information in these areas, these are reliant on local in-situ measurements, to validate. With even a few more local observational sites, provided these were sited appropriate, there is the opportunity to benefit from a combination of satellite information and modelling to provide information across the islands.

One temperature logger already exists in the Zanzibar Channel the additional temperature logger should be installed in the Pemba Channel. A second SST logger at Pemba would provide valuable data for a comparison between these two very different sites. In combination with satellite SST the two loggers will provide information about variability and change in sea temperature that would be of value for planning climate change adaptation measures in these different environments.

Given that Zanzibar contains many other extensive reef sites, the data logger at Chumbe provides only part of information about the SST trends along the Zanzibar Islands, and the changing environment of important reef systems. Analyses of SST data derived from high resolution satellite sensors such as MODIS coupled with additional in situ measurements from temperature data loggers would provide a better and more reliable information about the overall SST trends in Zanzibar waters.

The existing temperature logger is currently under the management of the IMS. The cost of an additional temperature logger is relatively trivial. However, unless this can transmit data back, it may be less useful, as the cost of travelling to Pemba to retrieve data on a regular basis would not be possible given existing IMS budgets.

It is stressed that these monitoring systems need to be put in place now, to allow sufficient data collection periods. These systems have a critical role in allowing analysis of observational changes of climate change over coming years, i.e. to be able to project what will happen next, and to allow effective adaptation responses.

Apart from the temperature logger, equally important is the tide gauge for monitoring of the trends in sea level. The existing tide gauge at Zanzibar harbour ideally needs to be supplemented with another one, which should be installed in the Pemba Channel\(^6\). Having two tide gauges would provide a more reliable information on the future trends of sea level changes on the islands (as well as the country). Such information is vital for the formulation of the measures for the climate change adaptation strategy. A tide gauge with satellite transmission costs about £15 000 (around $22 000)\(^7\).

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\(^6\) From the perspective of the Global Sea Level Observing System (GLOSS) an additional tide gauge at Pemba is not strictly necessary, and would not contribute to determining trends in global or regional mean sea level. However, from a national perspective, operational TGs, transmitting data in real-time from Pemba (and also Tanga on the mainland) is a good idea; it would provide valuable information on sea level variability and tidal cycles, and be of value for comparison with the existing Zanzibar TG. Combined with sea surface height data from satellite altimetry, which will be available at higher resolution and closer to the coast, data from the two TG stations may also be used to characterise sea level variability more generally along the coast of Tanzania (personal communication from Val Byfield, Phil Woodworth and Simon Holgate (University of Southampton/Liverpool).

\(^7\) The water temperature is monitored by the pressure sensors, so an additional temperature logger might not be needed. Where measured, the temperature data is usually sent back via satellite and put on the GTS where it can be pulled off in real time by met agencies. For GLOSS stations, BODC archive the temperature along with any other variables (pressure etc) and
Last but not least there is also an urgent need for documenting the existing anthropogenic pressures on the marine and coastal resources and strengthen the institutional capacity of the Zanzibar Government on how to mitigate the anthropogenic pressure on these resources. The climate change adaptation strategy needs to be formulated after gathering adequate information of not only the existing environmental pressure on the marine and coastal resources but also the human pressure on the resources.

**Training**

To support installation of new equipment it would be advisable to provide local training, to increase the number of people able to maintain the equipment and analyse the data. Such a course could be held at IMS, drawing on local and UK expertise in relevant areas (analyses of sea level data, analyses of satellite derived data and modelling).

**Key early steps**

A key priority is to enhance the capability and resources of the tide gauge and sea surface temperature monitoring, for both islands, providing the resources to ensure data collection and data interpretation, and the training of staff and institutional strengthening to support this. This is critical to allow analysis of observational changes of sea level rise over coming years.

Another important issue is to understand underlying land movement (uplift or subsidence) on the two islands – to assess the relative sea level rise - noting there could be differences because of the differing geology of Unguja and Pemba.

These marine data needs should be considered in tandem with the other meteorological areas, to ensure they can link together.
Extreme Events: Droughts, Floods, Heat and Storms

East Africa, Tanzania and Zanzibar are all affected by current climatic variability and periodic extremes with serious floods and prolonged drought, associated primarily with El Niño – Southern Oscillation (ENSO) events.

These extreme events have dramatic impacts on infrastructure, the built environment and the economy, cutting across key sectors including agriculture, industrial processing, manufacturing, tourism, infrastructure, and health. These have large impacts and high economic costs. There is some information on the historical impacts and economic costs of extreme events—floods and droughts in Tanzania and East Africa more generally. Details on the country level events are presented in the box, summarised from Watkiss et al 2011. These imply costs of extreme ENSO years are equivalent to 1 to 5% of GDP.

These events are particularly important because the local economy of East Africa is very dependent on the climate, because a large proportion of activities are associated with climate sensitive activities.

As Zanzibar is also affected by these events, and is similarly reliant on climate sensitive activities, a critical question is how much do the current effects of climate extremes affect the islands currently, i.e. what is the current cost of climate variability and extremes on the islands.

Note that as well as the direct effects to Zanzibar of these regional events, there are also the indirect effects from impacts on mainland affecting the islands, e.g. in terms of electricity connections and power crisis, food availability and shortages, etc. Thus, in considering these effects it may also be necessary to consider whether there are additional multiplier effects from events at the URT level.

This section looks at the evidence on recent climate extremes on the islands.

Major Extreme Events in Tanzania

There were major droughts in Tanzania in 1996-97, 1999-2000, and a very severe drought in 2005/2006.

- The (La-Niña) event of 1996/97 was responsible for the severe drought that occurred in most parts of Tanzania leading to insufficient rainfall for hydroelectric power generation and urban water supplies. Crop failure was widespread and rangelands could not support livestock resulting in large production shortfalls. In 1997, growth dropped to 3.3% from the previous year’s 4.2%, attributed mainly to electricity shortages and load shedding arising from reduced hydro-electricity (World Bank, 2004).

- The drought of 2005/2006 affected most parts of the country, triggering food shortages and a power crisis, and reducing economic growth (relative to projections). In 2005 the agricultural sector grew by only 5.2% compared to 5.8% growth in 2004. This was attributed to the severe drought that affected most parts of the country, triggering food shortage and power crisis (URT, 2005). Another estimate reports that this major drought was estimated to have cut GDP growth by 1% in 2006 (ECA, 2009).

There were severe floods in 1997/1998, as well as major episodes in 2000/01 and recent flooding in 2009.

- The 1997/98 El Niño, for example, resulted in cereal deficit of almost 1 million tonnes in Tanzania, leading to a national food crisis. The livestock sector also underwent severe losses due to increased disease infection, drowning, damaged water facilities (dams, boreholes, water troughs), and disruptions in market infrastructure and road systems (Kandji et. al., 2006), though in some marginal agriculturally areas, the additional rainfall led to higher production.

- The EMDAT database (EMDAT, 2008) reports that the floods in early 2007 in Tanzania were widespread (Kigoma, Tabora, Rukwa, Shinyanga. Nzega, Kishapu, Shinyanga Rural, Mwanza and Tanga. Hanang and Babati Districts) leading to major damage and displacement.

- The restoration costs of infrastructural losses from the (2009) flooding in Kilosa have been estimated at 200 billion Tanzanian shillings, around 0.02% of the 2009 GDP for Tanzania (Munishi et al 2010)).

- There are also additional costs from these events in terms of disaster response, for example, information from the International Federation of the red cross & red crescent societies (IFRC, 2010) indicates large IFRC and donor funding to address the events of 2006 drought and 2010 flood.
The estimates above show that current climate variability has macro-economic impacts in Tanzania, i.e. which are measurable in terms of GDP. The reasons for this are explained by the economic structure of the country, which remains heavily dependent on rain fed agriculture - the sector contributing around 27% to GDP, around 30% of exports, as well as 65% of raw materials for domestic industry. A key issue is the high importance of food crops (65% of agricultural GDP). These agricultural activities are very climate-sensitive activities. Historically the country was also heavily dependent on hydro-generation for electricity (almost entirely so before 2003) which led to major supply issues in drought years.

The impacts of droughts shock on GDP has been highlighted as a particular issue for Sub-Saharan Africa (see Benson and Clay, 1998) and for neighbouring Kenya (Mogaka et al 2006) and the EAC (GTZ, 2009), indicating individual major drought years have economic costs that can be very significant (e.g. 5% of GDP) and that combined effects of floods and droughts over the long term have been estimated to cost the Kenyan economy annually 2.4 percent of GDP. The estimates above for Tanzania, which indicate major drought years reduce GDP by 1% or so, are therefore considered a possible underestimate.

These annual events impact negatively on growth and output, as well as affecting millions of livelihoods. The continued burden of these events over time leads to large economic costs and reduces long-term growth. Moreover, the full economic costs (including non-market sectors) are likely to be even higher than reported. As well as affecting sectoral output, these events have macro-economic consequences through price changes, diversion of resources for rebuilding, etc. These long-term effects maybe even greater than the immediate effects of events, and may lead to wider issues, for example comparative investment relative to other countries.

For individuals, these events can be catastrophic, from the effects of individual events (on homes, assets and livelihoods), or from the cumulative effects over time, and consequential effects on assets, investment, health and education (especially for children), etc. These effects therefore will have major impacts on the achievement of the Vision 2025 objectives, and the growth trajectories for the country.

**Extreme Rainfall and Floods**

Zanzibar has a history of floods, but the most notable event was the extreme rainfall and flood in April 2005 which led to estimated 10,000 people losing their homes or being displaced (DREF, 2007). This was considered to have been the worst downpour in 40 years, lasting 36 hours and measured 149+ millimetres. Detailed are provided in the box below. According to a government assessment report (cited in DREF, 2007) 10,000 households lost their homes and one person was killed as a result of the subsequent flooding, though other reports cite the number of houses actually affected as being lower, i.e. at closer to 1000, with 10,000 people affected (i.e. made homeless).

The Tanzania Red Cross Society participated in the initial government assessment as well as the regional disaster response team (RDRT) assessment coordinated by the Federation’s regional delegation in Nairobi. The assessments sought to determine the requirements for a possible health, water and sanitation, and relief operation.

An initial CHF 80,000 (reported as USD 67,500 OR EUR 52,000) was allocated from the federation’s disaster relief emergency fund (DREF) through the Tanzania Red Cross Society to respond to this operation. With a further 30 000 CHF subsequently, taking the total to just under $100 000. However, the costs presented only relate to the immediate disaster relief costs: it does not include the full costs of this event.

Information from the Dartmouth floods Observatory, Global Active Archive of Large Flood Events, has a record of the 2005 event, summarised below, though this does not have details of the damage.

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9 [http://www.dartmouth.edu/~floods/Archives/index.html](http://www.dartmouth.edu/~floods/Archives/index.html)
The 2005 flood on Zanzibar source DREF (2007b) http://www.ifrc.org/docs/appeals/05/05ME025.pdf

'A two-day uninterrupted downpour, on 17 April, lead to severe flooding in the low lying areas of the island. The Urban West region in the locations (wards) of Mwanakelewke, Jang’ombe, Sebuleni, Kwahani, Mombasa and Miembeni were particularly by floods. The situation was made worse by the failure of the drainage system to accommodate the flood waters. Most of the drains were blocked by uncollected solid waste and the presence of buildings along the storm water channels.

One person died in the disaster which saw some 800 houses being submerged by waters. A total of 1,758 families or 10,548 people were directly affected. Many of them are homeless or displaced. Most of the flood victims have been accommodated by relatives and their neighbours. Some 148 individuals are sheltered in two local primary schools buildings (108 in one and 40 in the other). Those living on the school grounds benefit from direct assistance, whereas the majority of those accommodated by neighbours and relatives have not received any form of support.

Few families ventured to move back in their damaged houses and their safety remains a concern because the structural stability of the houses has not been verified and appropriate vector control measures have not been conducted to minimise the likelihood of contracting diseases due to the waste water contamination and solid waste management.

The floods also caused a significant loss to the infrastructure, badly damaging a bridge in the southern locations. The road system was also affected and some parts remained impassable until the flood water subsided. The water supply services were disrupted by the flooding. The supply system which is reliant on five boreholes suffered damages to the pumping system as well as overhead pollution arising from heavily polluted water.

Two cases of cholera have been reported but no disease outbreaks have been reported by the Health authorities. The health of the population is still at great risk from the heavily polluted waters in residential areas.'

The response plan was to provide non-food relief items to in flood-affected communities and contribute to reducing morbidity linked to poor sanitation and lack of access to clear water.

- To provide bed nets, cooking utensils, blankets to 1,000 families (approximately 6,000 beneficiaries).
- To prevent morbidity and reduce vulnerability from water-related diseases and poor environmental sanitation.

<table>
<thead>
<tr>
<th>Detailed Locations</th>
<th>Zanzibar - Mtoni, Kariakoo, Jangombe, Magomeni, Darajabovu, and in the Zanzibar town centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Began</td>
<td>16-Apr-05</td>
</tr>
<tr>
<td>Ended</td>
<td>18-Apr-05</td>
</tr>
<tr>
<td>Duration in Days</td>
<td>3</td>
</tr>
<tr>
<td>Dead</td>
<td>1</td>
</tr>
<tr>
<td>Displaced</td>
<td>300</td>
</tr>
<tr>
<td>Damage (USD)</td>
<td></td>
</tr>
<tr>
<td>Main cause</td>
<td>Heavy rain</td>
</tr>
<tr>
<td>Severity *</td>
<td>1.0</td>
</tr>
<tr>
<td>Affected sq km</td>
<td>510</td>
</tr>
<tr>
<td>Magnitude (M)**</td>
<td>3.2</td>
</tr>
<tr>
<td>Date Began</td>
<td>16-Apr-05</td>
</tr>
<tr>
<td>Notes</td>
<td>Heaviest rains in 40 years - one dead, hundreds homeless.</td>
</tr>
<tr>
<td>Source</td>
<td>Dartmouth floods Observatory, Global Active Archive of Large Flood Events</td>
</tr>
</tbody>
</table>

To examine the full potential costs, the current study has scoped out some of the potential additional effects and looked to quantification and valuation of these. First, there are the damage costs of flooding on property. As a proxy, rebuilding costs can be used to scope out the size of the damages. Some region-specific data on house construction costs were obtained from an UNHCR report into construction efforts in post-conflict Rwanda which estimated that the average cost of reconstructing a
house was $794 in 1998. This has been adjusted to the year of the weather event using relevant inflation indices.

It is difficult to verify exactly how many homes were destroyed versus how many households were affected. Discussion with the Government of Zanzibar (Disaster Management Department (in the Second Vice President’s Office)) has revealed no data is available on this event, because it occurred before the Department was set up. We have therefore assumed the number of houses directly damaged at 800 homes (noting some reports estimate 10,000 households lost their homes, which would increase the damages by an order of magnitude). Multiplying by the repair cost estimates above (as a proxy for damage costs), this implies the real cost of the flood was at least an order of magnitude larger than the relief effort, e.g. just below $1 million (assuming 800 homes were destroyed).

There are additional intermediate resettlement costs that need to be added to these figures, that go beyond the immediate disaster risk reduction costs for the 10 000 people affected and made homeless. There are also additional costs from lost household earnings, etc. and from wider effects such as education disruption such as loss of school materials and time at school. There are also likely to have been damages to localised food sources (e.g. kitchen or community gardens), though there are no reports that larger scale agriculture was affected. Given the large number of people affected, it seems likely that these wider effects were at least as large as the direct damage to property. There was also wider infrastructure damage from the floods, with damage to the road system and a bridge. This included major disruption to the main road to the East coast (through Mwanakererewe). These would lead to additional impacts through lost time and indirect effects on the economy. There are also some reports of water supply disruption, including to borehole pumping systems. It is also stressed that critical transport routes that are in major flood zones are a priority for adaptation, because of the wider multiplier effects when they are disrupted.

For mortality impacts, in the absence of values for mortality risk changes in East Africa, it is possible to use benefit transfer methods to apply a Value of a Prevented Fatality used for road accidents in the UK by the DfT. The value applied by the DfT is £1.25 million per fatality. This can be adjusted by PPP GDP per capita with a subsequent weighted average value for East Africa – yielding for 2007 a value of just under £40,000 for each death directly caused by flooding. The wider health effects of the event are not known, but potentially include indirect effects from water contamination and pollution, and associated health impacts (a number of cholera cases were recorded after the event, but there was not a widespread outbreak).

UNDP reports current (2010) Zanzibar GDP at $661 million. Therefore, this one flood event had a full cost that is likely to be equivalent to at least 0.2% of GDP, but probably closer to 1%10.

There were also heavy rains in 2011 (along with heavy floods in Dar during this period), with reports of roads washed away in Pemba, and with significant Government funds allocated to flood victims.

From discussion on the islands, a large proportion of the road maintenance budget (perhaps 35%) is spent on repairing roads after the rainy season.

There are also many areas of Zanzibar city that are subject to frequent flooding (see impacts section), though these are now being addressed through a major storm drain projects.

As an island state, Zanzibar is also at risk from coastal flood, from high tides and storm surges. The Zanzibar Disaster Management Policy (2011) reports that on 21st March 2008 Zanzibar experienced the highest rise in sea level, which caused flooding of the old town (though no more information is available on the extent of the flooding or the damage.

10 Note that these events do not necessarily lead to direct and equivalent reductions in GDP, because the costs may not be fully borne, because they involve wider welfare costs (rather than just financial costs) and because some of the consequences of these events can sometimes have perverse effects on GDP, for example, increasing GDP through construction associated with rebuilding.
Extreme winds and storms

Sallema and Mtui (2008) identified that recent cyclones have affected Zanzibar, highlighting the 1994 tropical storm that killed 5 people on Zanzibar. They also highlight that the small pelagic fisheries industry in Zanzibar was affected by the 1997/8 El-Nino, with a dramatic reduction in fish catch. Several studies also highlight the effects of the 1998 event on corals (Obura, 2002).

The Zanzibar Disaster Management Policy (2011) reports on two more recent events.

Exceptionally strong winds occurred in the Amani and Kwamtipura areas in December 2009. This led to the damage of many homes, mostly in relation to roof damage (or loss). The event triggered a local emergency response, and a fund was set up to provide rebuilding funds.

There were also major wind extremes in 2011, affecting Mkonzi District (Pemba) and Urban, West and Central Districts of Unguja in February 2011. These also led to property loss and destruction of infrastructure (roads).

Low rainfall, drought and food security

There are also reports that the agriculture sector - which is a highly climate sensitive sector – has experienced poor performance sector in recent years (see GOZ, 2010) due to recurrent droughts, which have recently increased both in frequency and severity.

There was also a vulnerability assessment of the 2005/6 agricultural season (MALE, 2006). This reports that the short rains performed poorly in 2005, rainfall intensity in the off-season was below normal. This led to impacts, partly because the dry spell affected crops, but also because farmers put off planting because of the conditions. The long dry spell caused either germination failure or crop withering on about 54% (12,057 acres) of the total planted area. The dry spell caused shortage of pasture and water, increased livestock susceptibility to diseases, and reduced livestock productivity. This also led to farmers encroaching on other areas, leading to environmental degradation and also causes serious effects on water resources and ecosystem.

The dry spell also led to the use of poor and unsafe water quality from the alternative sources such as ponds, and the MALE review reports incidences of diseases such as diarrhea and bilharzias have occurred.

In 2006 – and especially 2007 – had low and erratic rainfall led to widespread crop failures. The agricultural statistics do show lower value in 2007, as shown below, and appear to have contributed to a relative reduction in GDP in that year - while crops usually represent around 21% of GDP, in 2007, this dropped to around 17%. In very simplistic terms, this suggests that the 2007 event could have reduced national level GDP by several %, but it is stressed a more in depth econometric analysis is needed to pick out the exact effects on sector and national GDP. As a result, the Task Force has recommended short and mid-term/long term mitigation measures, including provision of 40 tonnes of various seeds (12 tons cowpeas, 2 tons (millet), 7.8 tons (maize), and 18 tons (sorghum).) and 7,659 bundles of cassava planting material to households, though it does not report how much this would cost..
The Zanzibar Emergency Preparedness and Response Plan (ZEPRP) (2011) reports that in March 2008 Zanzibar experienced a hunger crisis resulting from 2006/07 poor crop performance, which was attributed to inadequate and erratic rainfall in that period. This drought, together with rising food prices caused by crop failures of the previous harvest season led to problems of food insecurity, with malnutrition widely reported.

The Zanzibar Disaster Management Policy (2011) also reports on the 2008 event, citing the WHO WHO Humanitarian Appeal 2009 Country Profile (WHO, 2009). The WHO appeal reports:

With the recent food crisis and food insecurity, levels of acute malnutrition have significantly raised in the past few months across the country with 22.5% (300,000 people) now requiring food mainly children under the age of five and pregnant and lactating women who are malnourished. The
population at risk for food insecurity is about 700,000. Surveys conducted between March and April 2008 in 8 districts indicated nutritional levels of between 20 and 29.8 percent (global acute malnutrition (GAM) whilst severe acute malnutrition (SAM) was between 2.5% to 7.5%. Moreover, long rains in all areas were below normal and similar patterns are expected for the short rains season soon.

It is possible to look at the potential health costs of this event. The total welfare costs are difficult to derive given the information available. However, it is possible to derive a cost, based on the costs of prevention for additional cases of disease, and approach used in recent WHO analysis (Ebo, 2008). For malnutrition, Ebi derived costs from the unit cost of preventing and treating additional cases of the disease (which includes breastfeeding promotion, child survival programmes, nutritional programmes, growth monitoring) and used treatment costs from the Disease Control Priorities in Developing Countries Project (DCCP2) for the cost-effective methods of treatment.

Ebi cites that the average costs of nutritional interventions per child for addressing underweight range from $17.4 to $23.1, and include breastfeeding promotion, child survival programs (with a nutritional component), nutritional programs, and growth monitoring and counselling, though she also notes that these costs are very conservative, citing Edejer et al. (2005) which has estimates ten times higher.

If the lower costs are applied, then the proxy costs of the 2008 malnutrition would be $5 to 7 million, effectively 1% of Zanzibar GDP. This just represents the health cost of the event: it does not include the economic costs in terms of production, exports, etc.

Strictly speaking these programmes are really implemented to prevent chronic long-term effects, and they also have long term benefits, but they do at least give an initial estimate of the potential importance of the event.

These documents also report that that child malnutrition is strongly present in Zanzibar with 23% of under-fives being stunted, 6% wasted and 19% underweight.

Since this event there has been progress with the Zanzibar food security and nutrition programme (RGS, 2008) and the MKUZA puts an emphasis on tackling food security and nutrition from a cross-sectoral perspective.

**Extreme heat**

Temperatures have been rising over the last thirty years on the islands, with a strong increase in maximum temperatures: the highest ever temperature recorded on the island was in 2007, when temperatures reached over 39°C.

There are no reports of the impacts that this had on the island, but such high extreme temperatures are usually associated with a number of impacts. There is strong empirical data that shows that mortality rates increase with such temperature extremes, as well as many other health outcomes. These temperatures also lead to infrastructure damage, such as road surfaces, and some building components. They also have other economic costs through increased energy costs for air conditioning.

**Disease Outbreaks**

There is also the data from the EM-DAT database\(^{11}\) which includes some specific events for the islands. These include the cholera epidemic in 2006 (which EM-DAT records killed 50 people and affected 106 people) and the viral epidemic of 2000 (which killed 8 people and affected 200). The database also lists flood, drought and storm events but these do not report any events for Zanzibar.

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\(^{11}\) EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium); http://www.emdat.be/
Many of the disease outbreaks are associated with heavy rainfall and floods, when water supplies are contaminated, compiling other existing issues.

The Zanzibar Emergency Preparedness and Response Plan (ZEPRP) (2011) reports that epidemics especially cholera outbreaks and malaria in Zanzibar arise mainly due to the poor living environment. SMOLE (2005) reports that more than 70% of the population in urban areas in Zanzibar live in unplanned settlements, and these are characterized by lack/inadequate provision of infrastructural services such as water supply and liquid and solid waste collection, treatment and disposal.

The Zanzibar Disaster Management Policy (2011) reports that there have been frequent outbreaks of water-borne diseases including cholera and dysentery, particularly during high rainfall seasons, due to contamination of the drinking water. It reports that the most severe cholera outbreak in Zanzibar occurred in 1979 whereby 40% of cholera positive patients died, while in 1983 14% of the positive cholera patients were reported dead.

Changing Trends in Extremes and Socio-economic Drivers

There is some indication that there has been an intensification of these extreme events over recent decades and these may reflect a changing climate already. This is reported in the URT NAPA (URT, 2007) and by New et al (2006), as well as the Zanzibar NAPA.

It is stressed that the most extreme cases of temperature, rainfall and wind speed recorded on the islands (back to the 1970s) have been over the last decade.

However, the potential trends in the costs of such events are determined by socio-economic trends, as much as climate. Indeed a significant part of the recent historic trends in the increasing damages that have been seen over recent decades can be attributed to the increase in population, including urbanisation, and increased value of assets in flood-prone areas, to changes in the terrestrial system, such as deforestation and loss of natural floodplain storage, as well as to changes in climate.

What is clear is that a better system of recording and tracking these events is needed, and for enhanced capabilities to predict extremes, and communicate these meteorological forecasts.

This has been the subject of a recent needs assessment of the Tanzanian Meteorological Agency (undertaken by the UK met office). This will be published next month, but highlights that a key area of institutional strengthening is on the communication of extreme events and warnings. The findings of this review will be added to the next version of this report.

Key early steps

A key priority is to enhance the capability and resources to measure and predict extremes, for both islands, providing the resources to ensure data collection and data interpretation. This is critical to allow analysis of observational changes and early warning coming years.

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12 Land Registration in the Informal Settlement o Zanzibar SMOLE. Study Series, Zanzibar, 2005
Disaster Risk Reduction

The Zanzibar Vision 2020 set out a policy on disaster prevention, preparedness and post disaster rehabilitation capability is to put into place the most efficient and effective disaster preparedness systems and capabilities for post-disaster response in all relevant places and also involve entities such as insurance, social security institutions, non-governmental organizations, community based organizations, and scientific communities in disaster prevention and response activities.

The Vision’s policy objectives on disaster prevention, preparedness and post disaster rehabilitation capability included:

- Enhancing prevention, preparedness and response capacities against natural and human made disasters at all appropriate levels, including central and local governments, in co-operation with such entities as insurance, non-governmental organizations, community based organizations, and scientific communities.
- Promote and encourage all parts of society to participate in disaster preparedness planning in such areas as water, food storage, fuel and first aid, and in disaster prevention through activities that build the culture of safety and cleanliness.
- Encourage continued mobilization of domestic and international resources for disaster reduction activities.
- Ensure the participation in disaster planning and management of all stakeholders, including women, children, the elderly and people with disabilities.
- Establish a comprehensive information system that identifies and assess the risk involved in disaster-prone areas and establish reliable communication channels and response decision-making capabilities among the actors in pre-event disaster management and preparedness activities.
- Recognize, support and facilitate the role of all internationally recognized institutions and their member national societies in disaster prevention, preparedness and response at domestic and regional levels.

Zanzibar Disaster Risk Management

In June 2006, Government of Zanzibar decided to establish a department to be the overall coordination body for all disaster related matters in the Islands. The Disaster Management Act, No.2 of 2003 was the basis for the establishment of this Department. At a similar time, the results of capacity and needs assessment on disaster management which was carried out in Zanzibar in 200713 This has led, with the help of UNDP, to the strengthening of the structural, legal and institutional DRR framework.

The newly established Disaster Management Policy for Zanzibar, published in August 2011 set a clear mechanism of establishment of Disaster Management Commission in the Islands. This also identified many of the climate extremes assessed above.

The existing legal frameworks on disaster management in Zanzibar now includes Disaster Management Policy (2011), the Emergency Preparedness and Response Plan (2011) and Disaster Communication Strategy (2011). There are also plans to revise the 2003 Act.


13 http://www.preventionweb.net/files/globalplatform/TanzaniaStatement1.doc
The documents – particularly the Disaster Management Policy, set out the actions needed to improve the overall level of disaster risk reduction in the Islands. These include

- Set operational frameworks and establishing National Disaster Management Commission for Zanzibar so as to effective implementing the Disaster Management Policy of 2011 and the international strategies of disaster risk reduction. This Commission has already been formed and met during the 2011 ferry disaster.
- Review Disaster Management Act of 2003 so as to fully implement the Disaster Management Policy Frameworks.
- Harmonize other sectoral policies, plans and acts to conform with existing disaster management policy by having regular forums so as to enhance the linkages and interaction between the DMD and other stakeholders
- Develop emergency preparedness and response plans at district levels in all 10 districts of Zanzibar Islands. This initiative has started with the assistance from UNICEF
- Establish comprehensive and participatory mechanisms for public awareness on disaster preparedness and response at different levels of the community
- Strengthen DMD’s internal technical expertise and capacity in terms of skills, knowledge, and working tools towards coordinating DRR issues at both national and local levels.

It outlines that the responsibility sits with the Disaster Management Department and the Disaster Management Commission, Committees, agencies and other stakeholders. Disaster Management Committees shall also be at national, district and shehia levels.

The situational analysis in the Disaster Management Policy for Zanzibar recognizes that sector development plans do not exhaustively factor in prevention and mitigation to disasters and that the linkages among sectors are not well incorporated. It highlights that activities under disaster response include warning system, rapid damage and needs assessment, resource mobilisation, search and rescue, evacuation, relief distribution and construction of temporary shelters. However, auxiliary national structures and other obligatory needs are not well established and/or inadequate for effective response (though the process has started for developing National Operational Guidelines and Monitoring and Evaluation Framework for the policy).

It also recognises that the legislation is short of motivation in its implementation and other stakeholders are not effectively involved in disaster management activities. It also highlights that effective disaster risk reduction depends on the level of development of warning systems. Warning systems need to be developed, and tested continuously for the purpose of making them effective. It highlights that the efficiency of Tanzania Meteorological Agency, Zanzibar Zone so far is not efficient as it lacks equipment and funds. Similarly traditional prediction mechanisms have not been well utilised to provide reliable information, and that there is inadequate warning system in Zanzibar.

This area does seem to be a major gap, and has been identified also by the TMA needs assessment (see earlier). The issue of the effective dissemination and use of the early warning information is critical, particularly to the range of potential users (fishermen, communities at risk, farmers, etc.) who do not currently receive this information. This requires a community based early warning system.

This is a particular issue for Pemba (especially for fishing communities). There is also an issue with the collection and sharing of information, and the analysis, as evidenced by the difficulty in trying to get data on the extreme events above (which had to collated from other sources).

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14 The Disaster Management Commission will be the principal functional body for disaster management in Zanzibar and responsible for overall coordination for Disaster Management Policy, programmes, plans and strategies at all levels. It will also coordinate and collaborate with national, regional and international disaster risk reduction bodies. The Commission shall be headed by the Executive Director under the Ministry responsible for matters regarding the coordination of disaster management. The National Disaster Management Committee shall be composed of all the Principal Secretaries under the Revolutionary Government of Zanzibar and be headed by the Chief Secretary and the Secretary shall be the Principal Secretary of the Ministry responsible for disaster management.
Some of this is recognised in the document, which highlights the role for Early Warning Agencies: The function of early warning agencies comprises of timely forecasts and disseminations of information on potential hazards to appropriate government officials and the population at risk. Tanzania Meteorological Agency (TMA) and Ministries responsible for agriculture and health bear the responsibility of early warnings. TMA serves a final early warning and the monitoring system against hazardous weather. The Ministry responsible for agriculture monitors trends in food production, pest and food products diseases forecast future trends and impending for shortages in specific locations, while the Ministry responsible for health is responsible for providing early warning on epidemics.

and their responsibilities
Tanzania Meteorological Authority (Zanzibar Zone) shall have the following responsibilities: Forecast, monitor and disseminate information on potential hazardous weather to other institutions and population at risk; collect, analyse, interpret and process all weather related data.

The document also notes some other existing policies that relevant for climate related issues. One of the most important of these is the Zanzibar Food Security and Nutrition Policy (2008)\textsuperscript{15}.

The recent draft Zanzibar Emergency Preparedness and Response Plan (ZEPRP) is a Multi-Hazard plan that sets actions to be taken in response to an emergency or major disaster. It aims to facilitate the coordination for the delivery of resources and services necessary to deal with the consequences of an emergency or major disaster. The ZEPRP describes the disaster situation and planning assumptions, concept of operations, response and recovery actions, organizational and specific assignments of responsibilities to the departments and government agencies tasked with local response efforts. This document assesses recent events (including the climate related events outlined above), identifying that drought, floods, and strong winds are major types of hazards in Zanzibar.

**Summary of potential hazards in Zanzibar**

<table>
<thead>
<tr>
<th>I: NATURAL HAZARDS</th>
<th>II: MAN-MADE/TECHNOLOGICAL HAZARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flood</td>
<td>1. Epidemics(Cholera, Rift Valley Fever, Bird Flu,</td>
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<tr>
<td>2. Drought</td>
<td>Swine Flu, etc.)</td>
</tr>
<tr>
<td>3. Cyclones</td>
<td>2. Fire Outbreak</td>
</tr>
<tr>
<td>4. Earthquake</td>
<td>3. Road Accidents</td>
</tr>
<tr>
<td>5. Lightning</td>
<td>4. Pest Infestation</td>
</tr>
<tr>
<td>7. Tsunami</td>
<td>6. Power Failure</td>
</tr>
<tr>
<td>8. Strong Winds</td>
<td>7. Proliferation of Unplanned Settlements</td>
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<tr>
<td>9. Beach erosion</td>
<td>8. Environmental Degradation and Pollution</td>
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<tr>
<td></td>
<td>9. Marine Accidents</td>
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<tr>
<td></td>
<td>10. Oil Spill</td>
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<td></td>
<td>11. Civil Disorder</td>
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<td></td>
<td>12. Aircraft Accidents</td>
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<tr>
<td></td>
<td>13. Hazardous Material</td>
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<tr>
<td></td>
<td>14. Industrial Disasters</td>
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<tr>
<td></td>
<td>15. Terrorism</td>
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<tr>
<td></td>
<td>16. Food Poisoning</td>
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<tr>
<td></td>
<td>17. Subsidence</td>
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<tr>
<td></td>
<td>18. HIV/AIDS</td>
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<tr>
<td></td>
<td>19. Animal Disease outbreak</td>
</tr>
</tbody>
</table>

Source: ZEPRP.

\textsuperscript{15} The Zanzibar Food Security and Nutrition policy was formulated so as to promote sustainable and permanent availability, equitable accessibility and utilization of safe and nutritious food for all through integrated and well-coordinated multi-sectoral measures at all levels. The policy creates a conducive environment that enables all Zanzibar to have equitable access at all times to safe, nutritious and culturally accepted food in sufficient quantities for an active and health life. The policy further is aimed at providing special protection of vulnerable population groups from the emergency situation on their food security and nutrition situation.
Of the climate relevant hazards, the document attributes the highest likelihood to cyclones (highly likely) followed by floods and droughts (both likely).

Likelihood of occurrence of potential hazards in Zanzibar

<table>
<thead>
<tr>
<th>S/N</th>
<th>Hazard Type</th>
<th>Likelihood of Occurrence</th>
<th>Estimated Impact on Public Health and Safety</th>
<th>Estimated Impact on Property</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unlikely</td>
<td>Likely</td>
<td>Highly Likely</td>
</tr>
<tr>
<td>1</td>
<td>Earthquake</td>
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<tr>
<td>2</td>
<td>Flood</td>
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<tr>
<td>3</td>
<td>Tsunami</td>
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</tr>
<tr>
<td>4</td>
<td>Cyclones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Drought</td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td>Landslides</td>
<td></td>
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<tr>
<td>7</td>
<td>Lightning</td>
<td></td>
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<tr>
<td>8</td>
<td>Marine Accidents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Epidemics (Cholera, Rift valley fever, bird flu, etc)</td>
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<tr>
<td>10</td>
<td>Fire Outbreak</td>
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<tr>
<td>11</td>
<td>Collapse of old and dilapidated buildings</td>
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<tr>
<td>12</td>
<td>Proliferation of unplanned settlements</td>
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<tr>
<td>13</td>
<td>Environmental degradation and pollution</td>
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<td>Power Failure</td>
<td></td>
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<tr>
<td>16</td>
<td>Hazardous Materials</td>
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<td>Industrial Disasters</td>
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<tr>
<td>18</td>
<td>Oil Spill</td>
<td></td>
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<tr>
<td>19</td>
<td>Terrorism</td>
<td></td>
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<tr>
<td>20</td>
<td>Road Accidents</td>
<td></td>
<td></td>
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<tr>
<td>21</td>
<td>Aircraft Accidents</td>
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<tr>
<td>22</td>
<td>Subsidence</td>
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<tr>
<td>23</td>
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<td>24</td>
<td>Strong Winds</td>
<td></td>
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<tr>
<td>25</td>
<td>HIV/AIDS</td>
<td></td>
<td></td>
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<tr>
<td>26</td>
<td>Animal Diseases (Anthrax, Break quarter, etc)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Beach erosion</td>
<td></td>
<td></td>
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<tr>
<td>28</td>
<td>Food Poisoning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ZEPRP.

It is stressed that these lists and tables of the hazards are based on the information obtained during the consultative meetings, i.e. they are not based on statistics about frequencies, impact indicators or costs.

The document does have some discussion of climate change, as below:

*Climate Change has now been confirmed beyond reasonable doubt to be a global reality. Although currently there is little or no research that has been done on climate change in Zanzibar, several extreme weather incidents have been observed during the past years. For example, on 21st March 2008 Zanzibar experienced the highest rise in sea level, which caused flooding of the old town. Changes in sea level have led to beach erosion in many places throughout Zanzibar such as Jambiani, Kiwengwa and Nungwi.*

Though this does not yet address the implications of climate change on the disaster risk plans, though this is because of the lack of evidence to date. However, it is important to understand the level of increase in activity this may entail, the potential risks (and changes in likelihood) and what needs to happen to mainstream climate change into DRM. Such an assessment would be an extremely useful first step.

While there is much to do to translate these efforts through to fully addressing the current adaptation deficit on the islands, and to prepare for the potential increase in these events due to climate change, there is a policy environment and existing DRR framework. There is also a sub-national disaster risk
reduction platform which was established with the help of UNDP\textsuperscript{16}, following the recommendation of the UNISDR/ Hyogo framework of action. An initial meeting was organized in May 2011. A launch will take place in the future bringing together all the stakeholders including the CSOs, academia and private sector.

UNDP is also developing National Operational guidelines with DMD for the Disaster Management Policy, and there are additional UNICEF financed projects on-going at DMD at the district and community level (Pemba).

Discussion with UNDP has highlighted that UNICEF has focused on water and sanitation, WHO and UNICEF have done some work on addressing epidemics (cholera) and FAO and WFP have worked together with Ministry for Livestock and Fisheries and Ministry of Agriculture and Natural Resources within the agricultural field with a special focus on food security\textsuperscript{17}.

Early warning and seasonal forecasting

The Tanzanian meteorological agency (TMA) does provide early warning advance and seasonal forecasts\textsuperscript{18}, as part of its wider responsibility to provide weather, climate services and warnings for the safety of life and property to the general public and to various users, including agriculture. However, these are only effective if communicated through to those who respond, whether these are for disaster risk management or for farmers. As highlighted earlier, this issue is the subject of a current needs assessment and review, and the findings from this will be added to the next version of this report.

Data Gaps, Early Priorities for Strengthening DRM

There are clearly a large number of areas to strengthen climate related disaster risk management. Discussion with UN Emergency Working Group focal point (Emilia Holkeri\textsuperscript{19}) and DMD have highlighted the following possible options.

To strengthen the existing institutional and legal framework (DMD, committees, sub-national platform, some coordination functions). Note that this is current being advanced through the UN partnering agencies (UNDP, UNICEF and to lesser extent WFP and UNFPA) DMD under the UN Development Assistance Plan (UNDAP) 2011- 2015: The UNDP led project supports the implementation of the disaster management policies and the strengthening of institutional and coordination capacity of the Mainland and Zanzibar Disaster Management Departments. The project further aims to ensure that disaster risk management becomes a multi-sector and multi-stakeholder concern which engages

\textsuperscript{16} A multi-stakeholder platform which strengthens the institutional capacity and memory, offers advice to the government/DMD (which functions as the secretariat), promote sand advocates DRR, functions as knowledge sharing platform, offers technical assistance to the government, etc.

\textsuperscript{17} In the context of Delivering as One and the wider support to the UN Development Assistance Plan 2011-2015 (UNDAP) Emergencies Programme Working Group, UNDP’s has a unique role and a comparative advantage to further strengthen the institutional coordination framework and adoption of disaster management policies and plans. UNDP’s long-term engagement in disaster management ensures sustainable institutional capacity and coordination at the central level which compliments the work of other UN agencies of the Emergencies Programme Working Group. Through UNDAP, UNICEF is committed to strengthening emergency preparedness and response at the regional and district levels through development of Emergency Preparedness and Response Plans for select regions, Emergency WASH and local level disaster management communication. WFP will offer support in establishing food security Early Warning systems, capacity needs assessment, training in nutrition food security, a review of the existing nutrition surveillance system and will work with UNDP and UNFPA to integrate a food security component in the National Operational Guidelines for Mainland and Zanzibar. FAO will support relevant ministries in Mainland and Zanzibar with the establishment of livestock and food crop diseases Early Warning Systems. UNFPA will assist the Tanzania Red Cross in procurement of contraceptives, delivery kits and dignity kits and will work closely with UNDP and WFP to incorporate reproductive health and gender in the National Operational Guidelines for Mainland and Zanzibar. WHO will support the Ministry of Health and Social Welfare in developing an All Hazard Emergency Preparedness and Response plan, guidelines for medical emergency requirement and will support emergency WASH coordination meetings. Drawing on the experience and commitment of the UN system in Tanzania, the overarching objective of the UNDAP Emergencies Programme Working Group is to ensure that Tanzania is significantly better equipped to prepare for and respond to disasters. Source: Personal communication Emilia Holkeri, UNDP.

\textsuperscript{18} http://www.meteo.go.tz/wfo/seasonal.php

\textsuperscript{19} We are very grateful to Emilia Holken for commenting on an earlier draft of this report and providing some context and suggestions. However, it is stressed that the discussion here – and any errors – are the responsibility of the authors.
relevant Ministries, Departments and Agencies and local government as well as non-state actors such as civil society, the private sector and local communities. The ultimate expected result of the project is that the Disaster Management Departments in Zanzibar are equipped to prepare for and respond to disasters in a timely and effective manner and other parts of government are aware of disaster management/preparedness and incorporate such in appropriate planning. Building on its experience in Disaster Risk Reduction and established record of disaster management support in the country, UNDP will contribute to enhancing emergency preparation and response capacities of the Government of Tanzania and the Revolutionary Government of Zanzibar. Emphasis will be on strengthening the institutional capacity of PMO-DMD and 2nd VPO-DMD by ensuring the operational framework and dialogue structure for the Disaster Risk Reduction policies, regulations and guidelines are in place and through targeted capacity development in Disaster Risk Reduction in line with the Hyogo Framework for Action 2005-2015 standards.

There is further opportunity for other ministries to develop capacity. Under the previous joint programmes between the government and UN partnering agencies the capacity of the Ministry of Agriculture and Natural Resources, Ministry of Livestock and Fisheries and the Ministry of Health has been enhanced. The current UNDAP also addresses aspects of food security and nutrition and health and aims at strengthening the related coordination mechanisms within the sectors. Yet there is potential to strengthen these areas further, as well as the overall emergency response (rescue services, fire brigade and police).

There are also potential opportunities to:

- There is a need to improve the collection, analysis and dissemination of DRR information e.g. through developing, updating periodically and widely disseminating risk maps and related information to decision-makers, the general public and communities at risk in an appropriate format and recording, analysing, summarizing and disseminating statistical information on disaster occurrence, impacts and losses, on a regular bases through international, regional, national and local mechanisms.

- Identify, assess and monitor disaster risks and enhance early warning. There is a need to move to more robust EWS (including structures and systems).

- There remains a gap on regional and Tanzanian cooperation in systematically exchanging this type of information and warnings. An early warning system could benefit if information or data would also be obtained from the mainland, and from regional centres.

- The effectiveness of responses could be improved with local training and education.

- There is a need for further research about hazards and their possible effects and DRR in general. This should however be focused on the most likely hazards such as floods, droughts or heavy rains and storms.

- The technical capacity and knowledge as well as human and material resources at the district and shehia level in the disaster management committees could be significantly enhanced. Therefore more efforts will need to be put in strengthening the local and regional capacity (UNICEF supports DMD currently in addressing some of the short-coming in terms of enhancing the technical capacity and knowledge base at the district level.).

In terms of cross-sectoral links.

- Land use and planning should include risk and vulnerability assessments.
- Contingency planning throughout the sectors could be introduced.
- Access to safe drinking water and improvement of sanitation would improve resilience to natural disasters.
- Identification of the most flood risk areas should be identified and responses addressed. This is occurring in the Zanzibar city plan – but there is a need for a broader assessment.
• There is a need to identify critical infrastructure in the island and assess the risks and move to introduce adequate responses and measures.

Key early steps

There is a need to gather data in a more systematic way, and to improve the system for reporting. This is important to provide the baseline information to allow analysis of the current likelihood and probabilities for different type of hazards.

There is an inadequate warning system in Zanzibar (and particularly in Pemba). There is still a gap on ensuring all stakeholders are effectively involved in disaster management activities, and warning systems need to be further developed, and tested to make them effective. This involves strengthening of the TMA, but also to provide the additional step of communicating and disseminating information effectively and reliably. The issue of the effective dissemination and use of the early warning information is critical, particularly to the range of potential users (fishermen, communities at risk, farmers, etc.) who do not currently receive this information. This probably requires a community based early warning system.

There is a need to strengthen the existing institutional and legal framework (though progress in this area is being taken forward), and capacity building within Ministries and Departments across Government in areas of agriculture, health, and emergency services. There is also a need to improve the collection, analyse and dissemination of DRR information (using risk maps for example), and for capacity building and training for responses, and for local and district level.

There are a number of areas where other sectoral plans and policy need to factor in these risks. This includes land use and planning. There is a also a need to identify the most at risk areas (e.g. for flooding) and also to identify critical infrastructure at risk, and to move to adequate responses and risk reduction measures.

The current disaster and emergency response plans do not adequately assess the risks of climate change, though this is because of the lack of evidence to date. However, it is important to understand the level of increase in activity this may entail, the potential risks (and changes in likelihood) and what needs to happen to mainstream climate change into DRM. Such an assessment would be an extremely useful first step.
References


