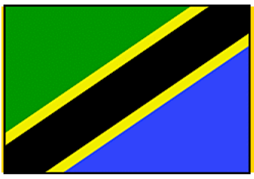
Climate Change Profile

Tanzania



Contents

General Climate[1]

Tanzania lies just south of the equator, at 1 to 11°S, and has a tropical climate that is predominantly highland, with exception of a narrow coastal strip. The greater part of Tanzania is a central plateau of around 900-1800m, punctuated with mountain ranges (which include Mount Kilimanjaro). The coastal regions of Tanzania are warm and humid, with temperatures 25 to 17°C through most of the year, dipping just below 25°C in the coolest months (June through to September, or 'JJAS'). The highland regions are more temperate, with temperatures around 20-23°C throughout the year, dropping by only a degree or so in JJAS.

Seasonal rainfall in Tanzania is driven mainly by the migration of the Inter-Tropical Convergence Zone (ITCZ). The ITCZ is the point of convergence of easterly trade winds from the northern hemisphere (north-east trades) and the southern hemisphere (south-east trades) in a zone of low pressure that brings rainfall (Godwin, 2005). The exact position of the ITCZ changes over the course of the year, migrating southwards through Tanzania in October to December ('OND'), reaching the south of the country in January and February ('JF'), and returning northwards in March, April and May ('MAM'). This causes the north and east of Tanzania to experience two distinct wet periods – the 'short' rains in OND and the 'long' rains in MAM,

[1] McSweeney, C. *et al.* (2008) unless otherwise stated

whilst the southern, western and central parts of the country experience one wet season that continues October through to April or May. Annual rainfall is greatest in lowland areas towards the coast and also around Lake Victoria, and lowest in central and northeastern regions.

The movements of the ITCZ are sensitive to variations in Indian Ocean sea-surface temperatures and vary from year to year; hence the onset, duration and intensity of these rainfalls vary considerably each year. One of the most well documented ocean influences on rainfall in this region is the El Niño Southern Oscillation (ENSO). ENSO is the collective term for the coupled ocean-atmosphere phenomenon of El Niño and the Southern Oscillation Index (SOI). Warm ENSO events ('El Niños') usually cause greater than average rainfalls in the short rainfall season (OND), whilst cold phases (La Niña) bring a drier than average season.

Key climate vulnerabilities: Drought; flooding; food security; infectious disease epidemics

Observed Climate Changes[2]

Temperature

- Mean annual temperature has increased by 1.0°C between 1960 and 2003; this increase in temperature has been most rapid in JF and slowest in JJAS.
- Daily temperature observations show a small increasing trend in the number of hot[3] days, and a larger increasing trend for hot nights. Hot nights, for example, have increased by 50 (equivalent to +14 percent) between 1960 and 2003. Increases in both hot days and nights have been greatest in DJF.
- The frequency of cold[4] days has not changed; however, the frequency of cold nights has decreased in all seasons, amounting to 34 fewer days per year (equivalent to -9 percent). The rate of decrease is most rapid in DJF.

Precipitation

- Rainfall over Tanzania show decreasing trends in annual rainfall, decreasing at an average rate of 2.8mm per month per decade (equivalent to -3 percent), particularly in southern areas.
- Observed decreases have also occurred in MAM and JJAS, decreasing by 4.0 and 0.8mm per month per decade, respectively (equivalent to -3 and -6 percent).
- There is no significant trend in the proportion of rainfall occurring in heavy events[5].

Current Climate Vulnerability

Table 1 lists the natural hazards that have affected Tanzania over the past 20 years. Tanzania suffers from both too much and too little rainfall, with both drought and flooding events occurring on a number of occasions over the past 20 years.

Droughts affect agricultural productivity and hence food security. The drought in 2005-2006 caused a 50-70 percent drop in food and cash crop yields, resulting in an 85 percent increase in cereal prices (WFP, 2006). The UN World Food Programme (WFP) estimated that 3.7 million people needed food assistance (ibid). Northern Tanzania was particularly affected by drought in 2009 and 2010, causing the loss of 660,000 livestock in the five districts of Arusha region; this was mostly cattle, but also goats, sheep and donkeys (Arusha Times, 2010). Droughts also have implications for crop production in subsequent years as many are forced to eat the seeds intended for planting, and sell off their livestock they can't feed (IRIN).

Droughts also affect hydropower generation; in 2006, for example, the government introduced daytime cuts in electricity as reservoir levels in the main hydroelectric source were only 2 feet above the level at which production would have to halt (BBC, 2006).

Flooding regularly devastate homes, crops and infrastructure; floods in northern Tanzania in late 2006 to early 2007, for example, killed 35 people and damaged or destroyed 5,000 homes (IFRC, 2008). Flood events are also often followed by outbreaks of diseases such as diarrhoea, and cholera as clean water and

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[2] McSweeney, C. *et al.* (2008) unless otherwise stated

[3] 'Hot' day or 'hot' night is defined by the temperature exceeded on 10% of days or nights in current climate of that region and season.

[4] 'Cold' days or 'cold' nights are defined as the temperature below which 10% of days or nights are recorded in current climate of that region or season.

[5] A 'Heavy' event is defined as a daily rainfall total which exceeds the threshold of the top 5% of rainy days in current the climate of that region and season.

sanitation in short supply, and also of diseases spread by mosquitoes, which breed in the flood water. The 2006-2007 flood events were followed by outbreaks of Rift Valley fever in 8 districts, resulting in deaths of humans and livestock (ibid).

Hazard	Number of Events	Deaths	Total of Population Affected
Drought	4	-	5,854,000
Average per event		-	1,488,500
Earthquake	4	5	8,491
Average per event		1	2,123
Epidemic (unspecified)	3	82	1,055
Average per event		27	352
Epidemic (bacterial)	14	4,900	82,835
Average per event		350	5,917
Epidemic (parasitic)	1	590	4,853
Average per event		590	4,853
Epidemic (viral)	4	126	978
Average per event		32	245
Flood (unspecified)	4	172	216,884
Average per event		43	54,221
Flood (flash)	3	66	4,800
Average per event		22	1,600
Flood (general)	13	156	120,471
Average per event		12	9,267
Landslide	1	13	150
Average per event		13	150
Storm	3	-	1,282
Average per event		-	427
Storm (tropical cyclone)	1	4	2,500
Average per event		4	2,500
Tsunami	1	10	-
Average per event		10	-

Table 1 – Natural Hazards in Tanzania (1991-2010) (CRED, 2010)

Climate Change Projections[6]

Temperature

- The mean annual temperature is projected to increase by 1.7 to 2.5°C by the 2060s, and 2.1 to 3.9°C by the 2090s. Increases are projected to be slightly larger in the west (Figure 1).
- Projected rates of warming are greatest in JJAS, increasing by 2.2 to 4.1°C by the 2090s, with the maximum projection of 4.8°C.
- All projections indicate increases in the frequency of days and nights that are considered 'hot' in current climate.
- Annually, projections indicate that 'hot' days will occur on up to 40 percent of days by the 2060s, and up to 65 percent of days by the 2090s.
- 'Hot' nights are projected to increase more quickly that hot days, occurring on up to 68 percent of nights by the 2060s and up to 91 percent of nights by the 2090s. The increase in DJF is the most rapid of the seasons, occurring on up to 99 percent of nights by the 2090s.
- All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate. These events are expected to become exceedingly rare, and do not occur at all by the 2090s in any projections under some climate change scenarios.

[6] McSweeney, C. *et al.* (2008) unless otherwise stated

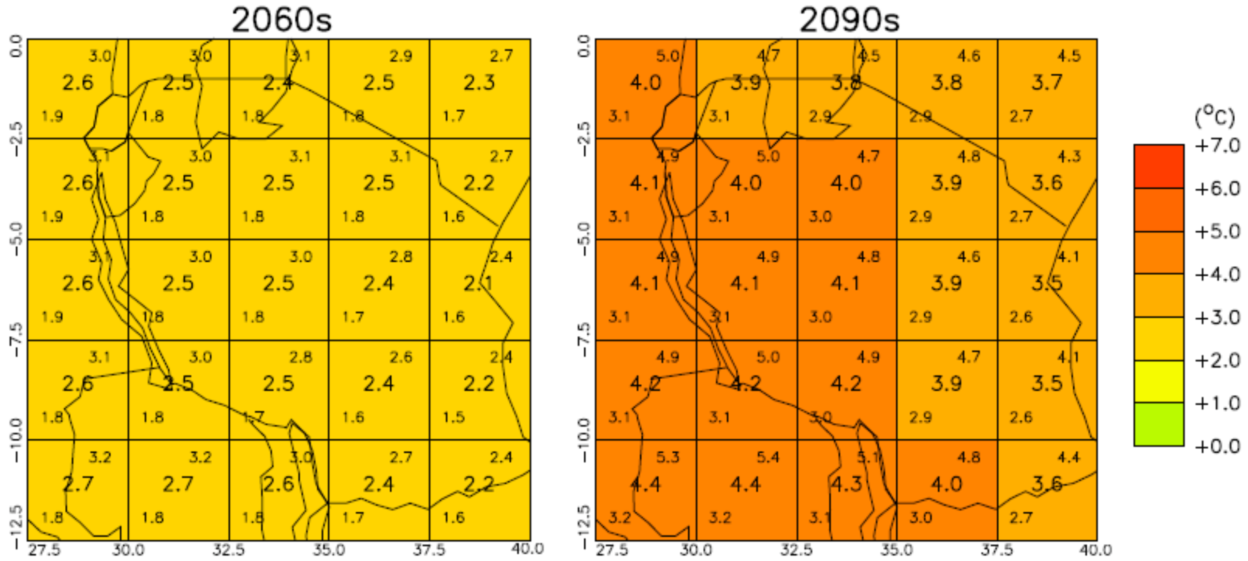

Figure1 – Projections of mean annual temperature for Tanzania for the 2060s and 2090s (the central value in each grid box gives the central estimate of the model projections, and the values in the upper and lower corners give the maximum and minimum) (McSweeney *et al.*, 2008). See 'A note on the projections' at the end of this document for more information on these maps.

Rainfall

- Projections of mean rainfall indicate increase in annual rainfall, with a similar increase across the country. Seasonal changes are more complex, with increases in JF rainfall projected for most of the country, but particularly the very south (see Figure 2), while increase in MAM rainfall are greatest in northern areas (see Figure 3). In JJAS, rainfall increase in the very north of the country, but decreases in central and southern areas, suggesting that rainfall generally increases in the wet seasons of each region.
- The largest increase in rainfall is projected for JF, with increases of 8 to 14mm per month (equivalent to 5 to 7 percent) and 13 to 23mm per month (7 to 11 percent) for the 2060s and 2090s respectively. The upper end of the projections show maximum increases of 50mm per month by the 2090s, equivalent to a 26 percent increase.
- The proportion of rainfall that falls in heavy events is projected to increase, from 5 to 10 percent in annual rainfall by the 2090s, to a maximum of 14 percent. Increases are projected for JF, MAM and OND season (see Figure 4 for MAM example).
- Maximum 1- and 5-day rainfall totals are projected to increase in all seasons. The largest increases are seen in MAM – by up to 24mm in 1-day events, and up to 36mm in 5-day events by the 2090s.

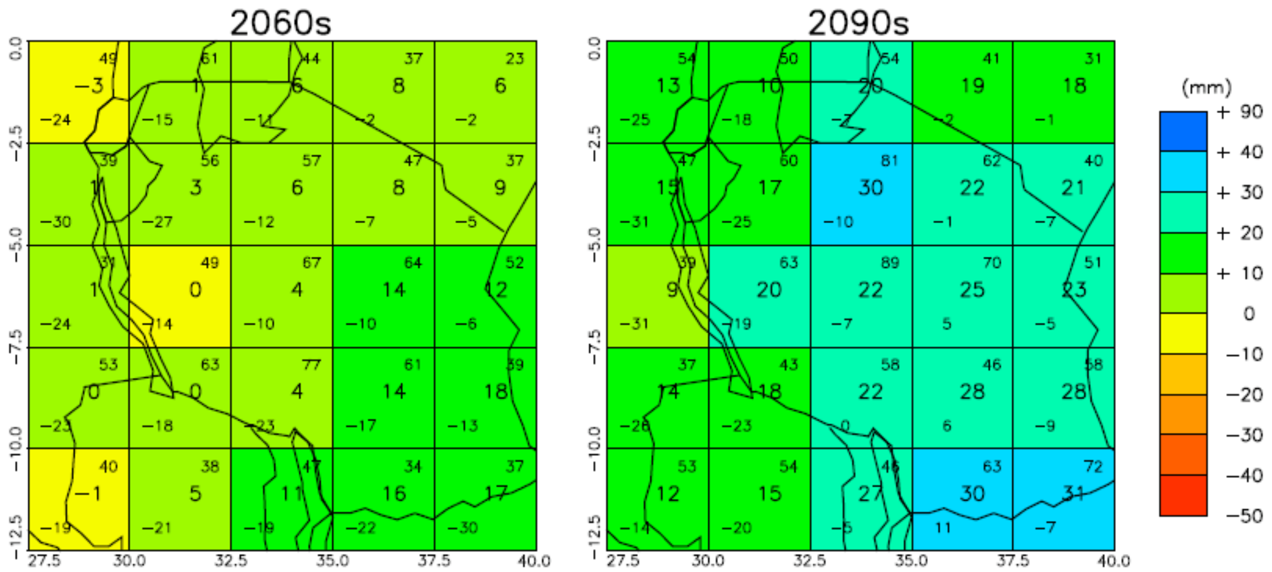

Figure 2 – Projections of changes in JF rainfall (in mm) for Tanzania for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

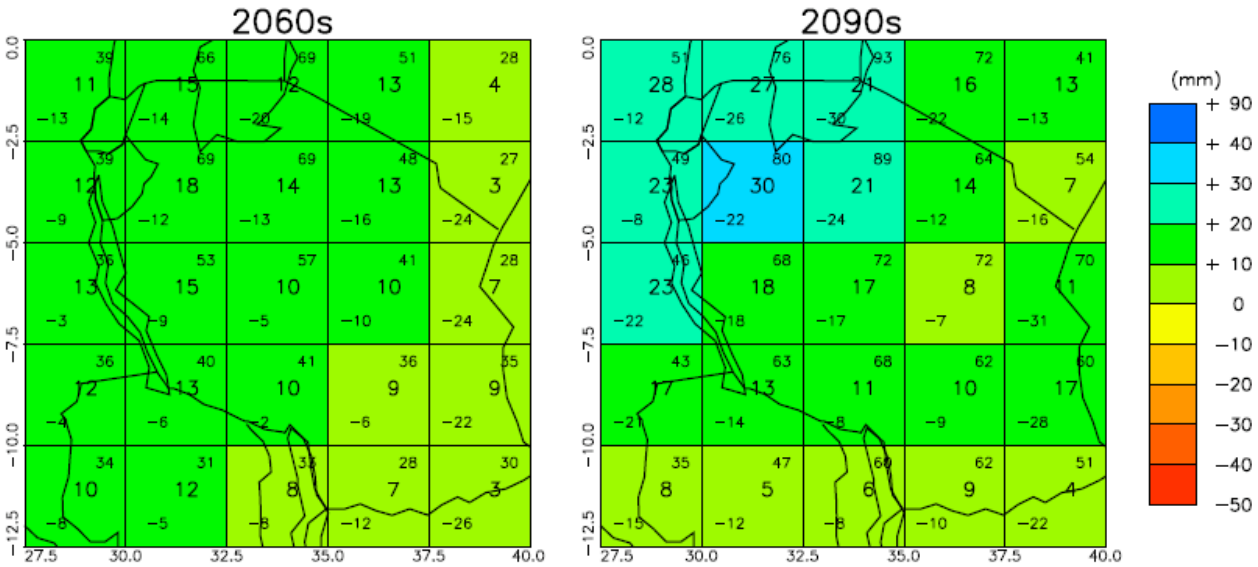

Figure 3 – Projections of changes in MAM rainfall (in mm) for Tanzania for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

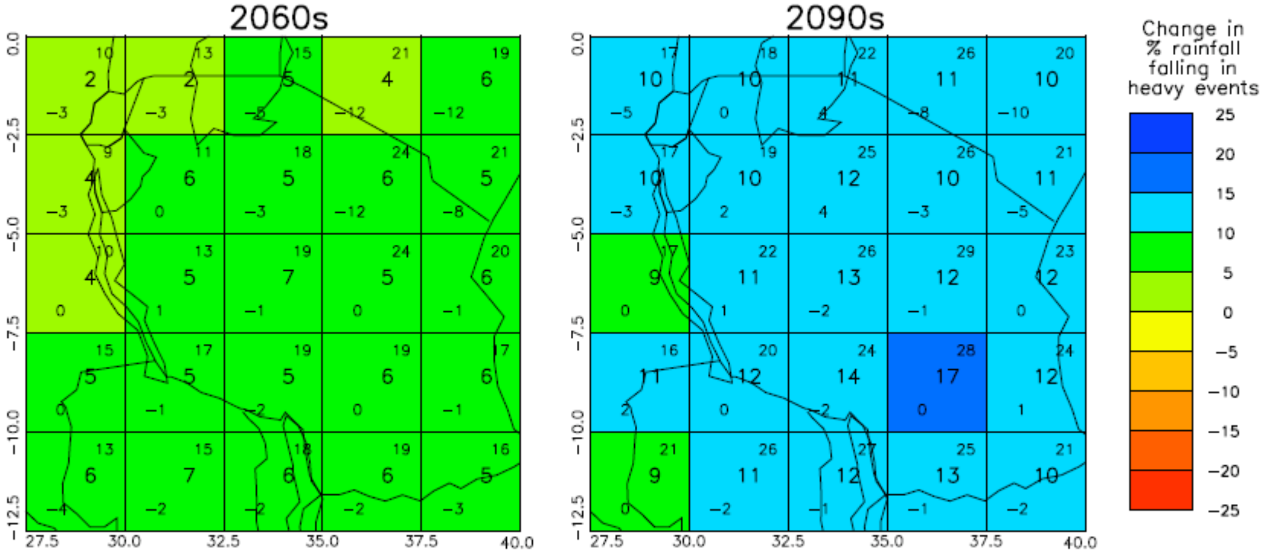

Figure 4 – Projections of percentage changes in the amount of rainfall falling in 'heavy' events during the MAM season for Tanzania for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

Sea Level Rise

Sea level rise projections are taken from the Intergovernmental Panel on Climate Change 4th Assessment Report (IPCC AR4)[7]; projections are given as a range (lower and upper bounds) for the 2090s:

- Low scenario: 0.23 to 0.43m
- Medium scenario: 0.26 to 0.53m
- High scenario: 0.28 to 0.56m

Climate Change Impacts

Flooding

With an increase in heavy rainfall predicted for Tanzania's rainy season(s), it is likely that the risk of flooding will increase as a result. With 1- and 5-day rainfall maximum totals projected to increase, runoff into rivers will be greater during storms, thus increasing the chance of rivers bursting their banks. The Rufiji

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[7] Taken from the IPCC Working Group I (The Physical Science Basis): Chapter 10 (Global Climate Projections) (Meehl *et al.*, 2007). Regional sea level projections are estimated by applying regional adjustments (Fig 10.32, p813) to projected global mean sea level rise from 14 climate models.

Basin in particular was highlighted in the Initial National Communication as likely o experience an increased risk of flooding during the MAM season (URoT, 2003).

Water Resources

With increasing temperatures across the whole country, but differing changes to rainfall patterns, the changes to water resources are not consistent for all of Tanzania. Projections under climate change vary across the country's main river basins of Rufiji, Pangani, Ruvu, Great Ruaha, Malagarasi, Kagera, Mara, Ruvuma, and Ugalla River. The Ruvu basin, for example, is important for supplying water to Dar es Salaam and is projected to experience a decrease in annual runoff of 10 percent (URoT, 2003). A similar reduction is also projected for the Pangani basin (6-9 percent), which could have knock-on effects for the Tanga, Kilimanjaro, and Arusha regions (Agrawala *et al*., 2003). In contrast, however, the Rufiji basin in the south is project to experience an increase in runoff of around 5 to 11 percent (URoT, 2003).

Demand for water is also likely to increase with rising temperatures, in addition to other factors such as rising population, hydropower development and agriculture. Climate change is therefore only one of many elements to the management of water resources.

Coastal Areas

Tanzania has a coastline of about 800 km and also has numerous islands along the coastal belt. The coastline supports a high human population and vigorous economic activities, including tourism, industry, subsistence agriculture, mining and fisheries. With 16 percent of the population living in coastal areas, sea-level rise is likely to have a considerable impact on Tanzania's coastal communities and the ecosystems they depend on for their livelihoods.

Sea level rise is threatening the availability of freshwater by causing salt water intrusion into Tanzania's aquifers and deltas. The Tanzanian Government identifies the regions likely to be hardest hit as: Dar es Salaam, the Coastal region, Mtwara and Lindi. Sea level rise will increase the risk of coastal flooding; Damages in Dar es Salaam alone are estimated to reach US$48-82 million (based on sea-level rise of 0.5 and 1m respectively).

Important infrastructure like beach hotels, training institutions, roads, offices and fish landing sites along the coast could be affected by sea-level rise.

Among Tanzania's important and productive coastal ecosystems, mangroves are the most vulnerable to inundation, followed by sand and mud flats. Sea-level rise would also cause salt water intrusion in Tanzania's aquifers and deltas, affecting fresh water availability, especially in coastal areas.

Agriculture & Food Security

Maize is the staple food crop for Tanzania, while coffee and cotton are important cash crops, tending to be produced in large and small plantations respectively (Agrawala *et al*., 2003).

Maize yields are predicted to decrease as a result of rising temperatures. Decreases are largest in central, semi-arid areas where there is a little or no increase in rainfall to compensate. The scale of reductions in maize yield varies between studies, with countrywide reductions projections from around 8 percent (Thornton *et al*., 2010) to 33 percent (URoT, 2003).

Yield increases are projected for coffee (up to 18 percent) and cotton (up to 17 percent) in the areas where rainfall increases – i.e. particularly in northern, north-eastern and south-eastern areas (URoT, 2003). Climate change may also boost productivity in barley, rice, wheat and some other grains (Chambwera & MacGregor, 2009).

Warmer, wetter conditions may also increase the risk to crops from pests and disease. Coffee, for example, is at risk from a small black beetle, *Hypothenemus hampei* (or 'Coffee Berry Borer'), which causes millions of dollars of damage to coffee producers worldwide – but particularly in East Africa. Rising global temperatures may increase the populations of the beetle, expanding its habitat and putting wider areas of coffee crops in danger (Bosire, 2009).

Rising temperatures may also reduce the coverage of suitable rangelands for livestock, whose carrying capacity is already over-subscribed (URoT, 2007).

Public Health

Malaria is endemic for much of Tanzania; however, with rising temperatures there is a risk that malaria will spread to central highland areas, such as Mbeya, Njombe, Iringa, and Arusha. Outbreaks of malaria tend to follow periods of heavy rain, which provides standing water in which mosquitoes breed. Increases in heavy rainfall events may also result in greater opportunities for mosquitoes to breed and hence increase disease incidence of malaria and for other mosquito-borne diseases such as Rift Valley fever.

Infectious diseases such as cholera, dysentery and typhoid are often present in the aftermath of droughts or flooding, with clean drinking water and appropriate sanitation in short supply. As the risk of flooding increases under climate change, it is likely that so too will the risk of diseases outbreaks.

Housing & Communities

With the projected increase in heavy rainfall events and maximum rainfall totals, homes, schools and community buildings and infrastructure will be at increasing risk from flooding.

Biodiversity & Conservation

Around 44 percent of Tanzania is covered by forest, which is important for biodiversity – 43 threatened mammal species and 33 threatened bird species depend on it for their habitat (Agrawala *et al*., 2003). Rising temperatures and declining available water across forested areas will result in a general shift to drier regimes; from subtropical dry forest, subtropical wet forest, and subtropical thorn woodland to tropical very dry forest, tropical dry forest, and small areas of tropical moist forest respectively (ibid). Forests are also used as an important for fuel and livelihoods – particularly charcoal production – and so are also at risk from human demands. The rate of deforestation in Tanzania was estimated by the UN Food and Agricultural Organisation (FAO) at 420,000 sq km per year, split between fuel needs (70 percent) and land clearing for agriculture (30 percent) (Liganga, 2010).

Agriculture and forest degradation is also causing soil erosion, the environmental cost of which has been estimated to be over one third of the national Gross Domestic Product (GDP), while the added costs of excessive sediment and nutrient loading in lakes and rivers may be higher (Beyadi, 2010). Climate change will exacerbate erosion through higher temperatures and more intense rainfall.

Livelihoods

Agriculture is the most important sector for Tanzania, accounting for around 60 percent of GDP, employing over 80 percent of the population, and contributing to 60 percent of the country's exports (Gathanju, 2010). A study by the International Institute for Environment and Development (IIED) found that the reduction in agricultural productivity caused by climate change could cause a drop in GDP of up to 68 percent by 2085 if adaptive action is not taken (Chambwera & MacGregor, 2009).

Important cash crops of coffee and cotton could experience improved yields under climate change, which could benefit livelihoods. However, this is dwarfed by the charcoal industry (e.g. coffee is worth $60 million a year compared to $650 million towards employment, rural livelihoods and the wider economy), which puts an increasing stress on the nation’s forests (Lyimo, 2009). Policies to protect Tanzania’s forests (possibly as part of a climate change response) may cause a reduction in the charcoal industry to encourage the use of other fuels such as kerosene.

Energy

Tanzania relies heavily on hydropower for production of electricity, and is therefore dependent on availability of water for power generation. The change in availability of water will vary across the country (as discussed above) and so hydropower potential may decrease in the Ruvu and Pangani basins (which supply major towns and industry), while increasing in the Ruifji basin, in which are the Mtera and Kidatu hydropower installations (URoT, 2003). Increases in heavy rainfall may also put hydropower at risk from flood damage.

Tanzania’s natural gas supplies may also be at risk from climate change with rising sea levels increasing the vulnerability of the Songo Songo and Mnazi Bay reserves (Agrawala *et al*., 2003).

Transport

With the projected increase in mean and heavy rainfall, there is an increase in the risk to Tanzania’s transport systems through flooding, particularly in coastal areas with the added vulnerability from rising sea levels. This has the secondary effect of restricting the distribution of aid during and after such events.

Government Response

The Government of Tanzania endorsed the United Nations Framework on Climate Change Convention in1996 and, as part of the international process, published its Initial National Communication to the UNFCCC in 2003. The document presented an inventory of national sources of greenhouse gas emissions, provided an assessment of vulnerability and adaptation to climate change impacts, and suggested policy options for mitigation and adaptation. The Ministry of Environment, under the Vice President’s Office, was responsible for compiling the report and remains the focal point for co-ordinating the government’s climate change response. They have further developed a National Adaptation Programme of Action (NAPA), which seeks to prioritise projects contributing to the national adaptation effort in order to qualify for funding from the Global Environment Facility through the United Nations Environment Programme.

Likely Adaptation Options

Potential adaptation options were assessed as part of the production of Tanzania's NAPA. Options were then ranked according to their sector (e.g. agriculture, water, energy, etc) and perceived need, resulting in the following prioritised list (URoT, 2007):

- Increase irrigation by using appropriate water efficient technologies (e.g. drip irrigation) to boost crop production in all areas.
- Alternative farming systems (such as crop rotation, zero grazing and growing of crops that need little water, such as millet and sorghum and drought-resistant varieties of maize) and relocation of water sources including wells along the low lying coastal areas.
- Develop water harvesting and storage programs for rural communities particularly those in dry lands.
- Community based catchments conservation and management programs.
- Explore and invest in alternative clean energy sources e.g. wind, solar, bio-diesel, etc.
- Promotion of application of cogeneration in the industry sector.
- A forestation programmes in degraded lands using more adaptive and fast growing tree species.
- Develop community forest fire prevention plans and programmes.
- Establishing and strengthening community awareness programmes on preventable major health hazards.
- Implement sustainable tourism activities.
- Enhance wildlife extension services and assistance to rural communities in managing wildlife resources.
- Water harvesting and recycling.
- Construction of artificial structures, e.g., sea walls, artificially placing sand on the beaches and coastal drain beach management system.
- Establish good land tenure system and facilitate sustainable human settlements

Useful Websites

- UNDP Climate Change Country Profiles: http://country-profiles.geog.ox.ac.uk/
- UNFCCC NAPAs from Non-Annex I Countries: http://unfccc.int/national_reports/napa/items/2719.php
- UNFCCC First Communications on Climate Change for Non-Annex I Countries: http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php
- Adaptation Learning Mechanism: http://www.adaptationlearning.net/
- IPCC Reports: http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm

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A note on the projections…

The climate change projections used in this profile were developed as part of a UNDP project, carried out by McSweeney *et al.* (2008), to produce a series of climate change projections for individual developing countries. The study uses a collection, or 'ensemble', of 15 General Circulation Model (GCM) runs to produce projections of climate change for three of the SRES emissions scenarios (see Nakićenović & Swart (2000) for more details on emission scenarios). The three emissions scenarios used in the study were 'A2', 'A1B' and 'B1', which can be broadly described as 'High', 'Medium' and 'Low' respectively (McSweeney *et al*., 2010).

The figures quoted here refer to the 'central estimates' (i.e. the median results) from the 15 GCMs across the 3 emissions scenarios. Where maximum figures are also quoted, they refer to the 'High' (A2) scenario model results. The maps shown are for just the 'High' scenario. Both figures and maps are described for two future 'timeslices' – i.e. decadal averages for the 2060s and 2090s.

For a more detailed description of the UNDP Climate Change Country Profiles, please see McSweeney *et al*. (2010). Complete projections (with maps, plots, supporting text and data files) for all 52 countries are available to download via the website at http://country-profiles.geog.ox.ac.uk/.

Note: This profile is designed to give a brief, non-technical overview of the current and future climatic conditions of Tanzania; this should not be considered as a country strategy. The key climate impacts are summarised by sector; however, this should not be taken as an exhaustive list, and the corresponding list of adaptation options are as a guide of likely or possible strategies.

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