



## Angola



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### General Climate<sup>1</sup>

Angola is located in western southern Africa at 6-18° south of the equator and although the country has a tropical climate, temperatures remain relatively cool (20-25°C) throughout the year as a result of the high altitudes of the East African Plateau. Seasonal variations in temperature are small, dropping just below 20°C in the winter (June-July-August, or 'JJA') and barely exceeding 25°C in the summer (December-January-February, or 'DJF').

The hot winter months are very dry, receiving almost no rainfall between June and August. The wet season rainfall is controlled by the movement of the tropical rain belt (also known as 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 (Godwin, 2005). The ITCZ oscillates between the northern and southern tropics over the course of a year, bringing rain between October and April of 100-250mm per month. The wettest region is the northeast, and rainfall decreases southwards and towards the western coast.

**Key climate vulnerabilities:** Flooding; infectious disease; drought; food security

<sup>1</sup> McSweeney, C. *et al.* (2008) unless otherwise stated

## Observed Climate Changes<sup>2</sup>

### Temperature

- Mean annual temperature has increased by 1.5°C since 1960, an average rate of 0.33°C per decade. This is more rapid than the global average rate of warming. The rate of increase is most rapid in the winter and slowest in summer.
- The rate of warming is more rapid in the interior regions of the country in the east of Angola than the more coastal regions of the west.
- Daily temperature observations show that days per year that are classed as 'hot'<sup>3</sup> have increased by 49 between 1960 and 2003; this increase is greatest in September-October-November ('SON').
- The average number of 'hot' nights per year has increased by 44; this increase is also greatest in SON.
- The frequency of cold days<sup>4</sup> decreased significantly since 1960, annually and in all seasons except SON. Cold days have decreased by 23 days annually, with the largest seasonal decrease seen in March-April-Mar ('MAM').
- Cold nights have decreased in frequency by 10 nights per year per decade. This rate of decrease is most rapid in MAM and least rapid in SON.

### Precipitation

- Mean annual rainfall over Angola has decreased by around 2mm per month (2.4 percent) per decade since 1960. This annual decrease is largely due to decreases in MAM rainfall, which has decreased by 5mm per month (5.4 percent) per decade.
- There is not sufficient daily precipitation data available to determine trends in the contribution of heavy<sup>5</sup> rainfall events to total rainfall. Available 5-day maximum rainfall data indicate no discernable or significant trends.

## Current Climate Vulnerability

Table 1 below shows the natural hazards that have occurred in Angola in the past 20 years. Angola's key climate vulnerabilities relate to water. Angola suffers from both water shortages and from flooding, which have knock-on effects for housing, infrastructure and the spread of infectious diseases. Flooding in the wet season is a regular occurrence and can devastate communities; flooding during the wet season ending in early 2010, for example, claimed 54 lives and left 65,000 people homeless (Redvers, 2010). Flooding is not confined to rural areas, heavy rain in Luanda overwhelmed drains and resulted in roads, homes and schools being flooded or washed away (ibid). Drought is also a major problem; the drought and associated famine in 2002 left over 1.5 million people suffering from acute malnutrition, the World Food Programme estimated that a 221,000 tonnes of food aid would be required to meet the country's needs (BBC, 2002).

Hazard	Number of Events	Deaths	Total of Population Affected
Drought	3	58	130,000
<i>Average per event</i>		19	43,333
Epidemic (unspecified)	1	-	468
<i>Average per event</i>		-	468
Epidemic (bacterial)	12	3,628	95,935
<i>Average per event</i>		302	7,995
Epidemic (viral)	2	370	665
<i>Average per event</i>		185	333

<sup>2</sup> McSweeney, C. *et al.* (2008) unless otherwise stated

<sup>3</sup> '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.

<sup>4</sup> '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.

<sup>5</sup> A 'Heavy' event is defined as a daily rainfall total which exceeds the threshold that is exceeded on 5% of rainy days in current the climate of that region and season.

Hazard	Number of Events	Deaths	Total of Population Affected
Flood (unspecified)	4	24	9,016
<i>Average per event</i>		6	2,254
Flood (general)	18	311	893,659
<i>Average per event</i>		17	49,648
Landslide	1	13	-
<i>Average per event</i>		13	-

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

## Climate Change Projections<sup>6</sup>

### Temperature

- Central estimates of mean annual temperature show increases of between 1.9 and 2.7°C by the 2060s, and of 2.3 to 4.5°C by the 2090s. Maximum increases in mean temperature are projected to be 3.2°C and 5.1°C for the 2060s and 2090s respectively.
- The projected warming is higher in the southern and eastern regions of Angola, compared to western, more coastal areas (see Figure 1).
- All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate.
- Annually, projections indicate that 'hot' days are projected to occur on up to 40 percent of days by the 2060s, and up to 65 percent of days by the 2090s. Days considered 'hot' by current climate standards for their season are projected to increase most rapidly in SON and DJF (see Figure 2 for DJF projections).
- Nights that are considered 'hot' are projected to increase more quickly than hot days, projected to occur on up to 59 percent of nights by the 2060s and up to 91 percent of nights by the 2090s. Increases are also projected to be largest in DJF.
- 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, occurring on maximum of 1 to 4 percent of days in the year, and potentially not at all by the 2090s in many of the projections. Cold nights decrease in frequency more rapidly than cold days.

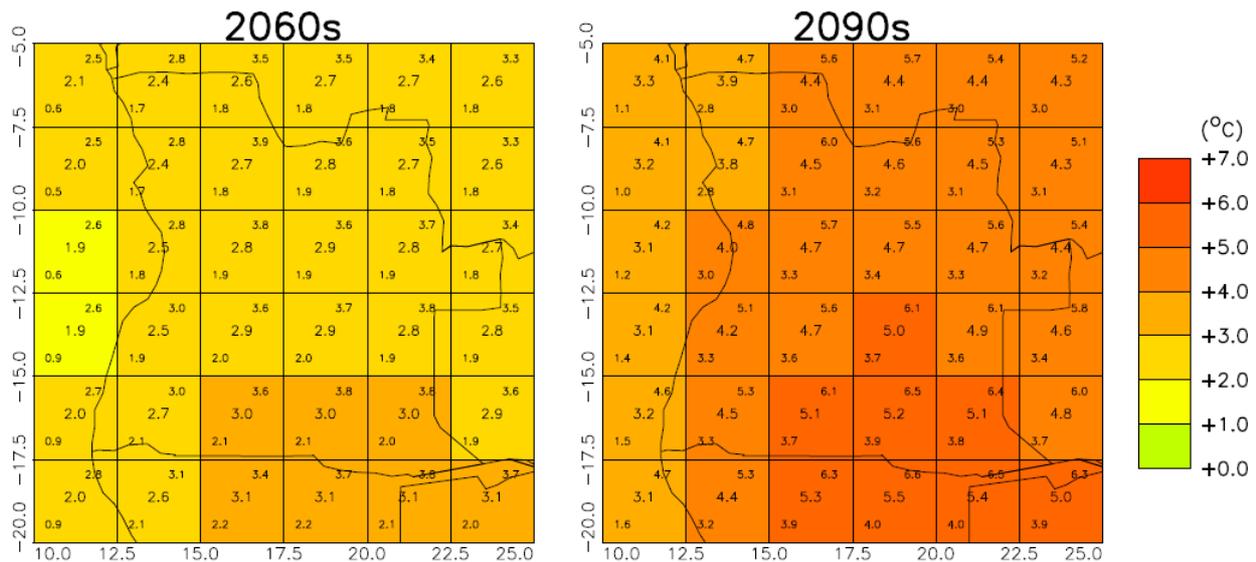


Figure 1 – Projections of mean annual temperature for Angola for the 2060s and 2090s (the central value in each grid box gives the central estimate of the model projections, and the values in the upper and lower corners give the maximum and minimum) (McSweeney *et al.*, 2008). See 'A note on the projections' at the end of this document for more information on these maps.

<sup>6</sup> McSweeney, C. *et al.* (2008) unless otherwise stated

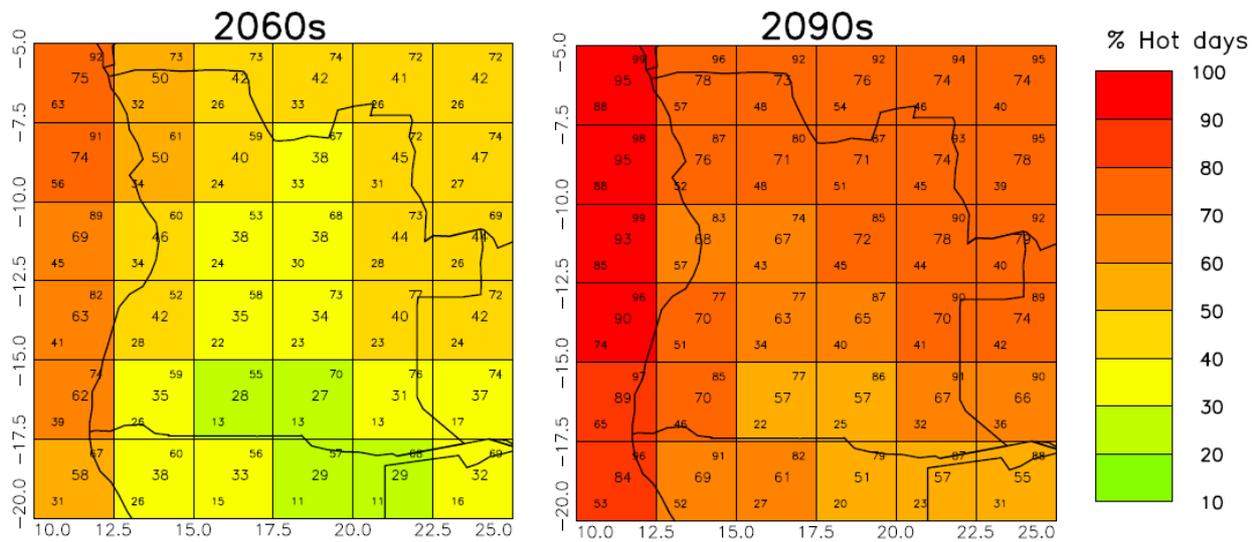


Figure 2 – Projections of percentage changes in frequency of ‘hot’ days in the DJF season for Angola for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

### Precipitation

- Projections of mean rainfall over Angola indicate a small decreasing trend for annual totals, with central estimates showing decreases of 1 to 6 percent by the 2090s for Angola as a whole, but the upper end of the projections show this decrease could be as much as 27 percent (see Figure 3), equivalent to an average reduction of 29mm per month.
- Seasonal totals show decreases projected for all seasons except DJF. The largest reductions are projected for SON, with central estimates showing decreases of 7 to 16 percent by the 2090s (Figure 4), equivalent to 5 to 16mm per month of SON.
- The projected increases in DJF rainfall are small, with central estimates giving an increase of only 0-1 percent (around 2mm per month) by the 2090s; however, the range in the projections is large (-48 to +33 percent) is large, suggesting substantial variability in the projections from different climate models.
- The proportion of total rainfall that falls in heavy events is projected to increase in all seasons except for JJA, when decreases are indicated. Projected changes are largest in the DJF season, with increases of up to 10 percent by the 2090s, and most notable in the northern parts of the country (Figure 5).
- Projections indicate that maximum 1- and 5-day rainfalls may increase in magnitude in DJF and MAM.

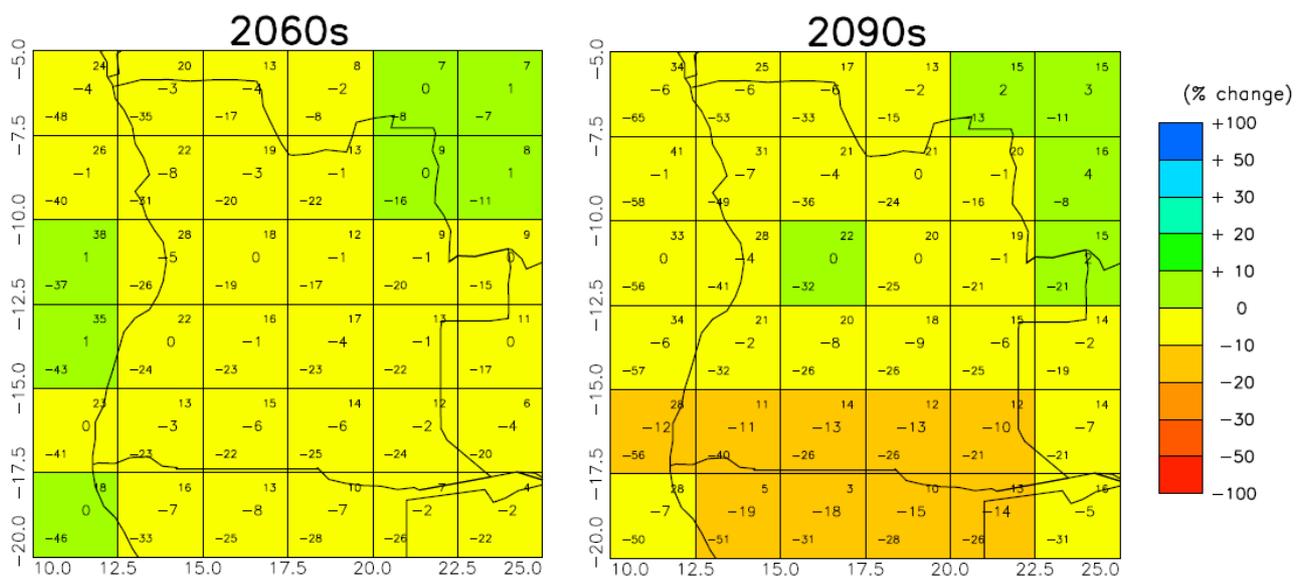


Figure 3 – Projections of percentage changes in annual rainfall for Angola for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

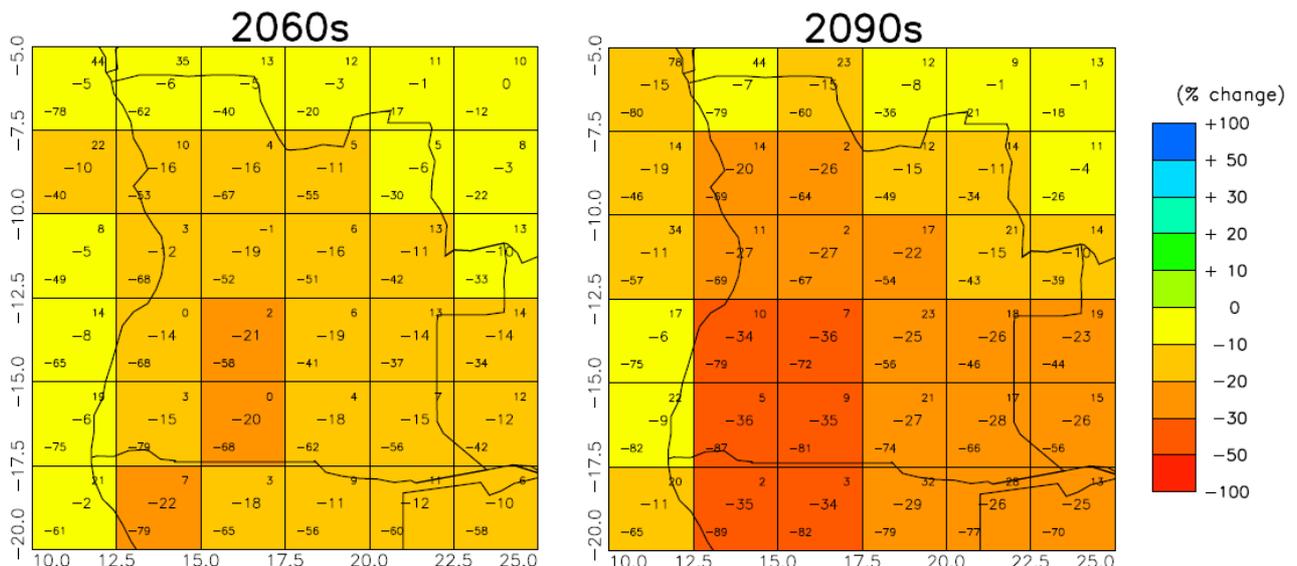


Figure 4 – Projections of percentage changes in SON rainfall for Angola for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

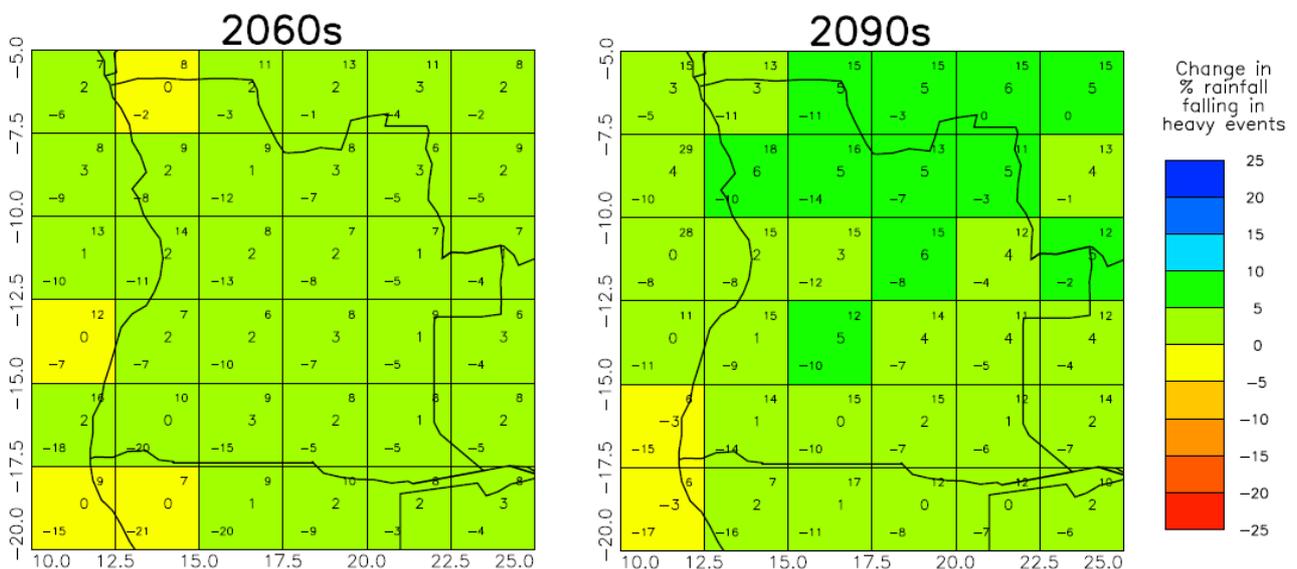


Figure 5 – Projections of percentage changes in the amount of rainfall falling in 'heavy' events during the DJF season for Angola for the 2060s and 2090s (see Figure 1 for details) (McSweeney *et al.*, 2008).

## Sea Level Rise

Sea level rise projections are taken from the Intergovernmental Panel on Climate Change 4<sup>th</sup> Assessment Report (IPCC AR4)<sup>7</sup>; 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

<sup>7</sup> 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.

## Climate Change Impacts

### Flooding

Angola suffers heavily for flooding events, and the damage they cause. The projections for climate change show that although mean precipitation is likely to be slightly reduced, there will be an increase in the amount of rain falling in heavy events. The risk of flooding events and landslides is therefore likely to increase. The projected increases are largest in northern parts of the country.

### Water Resources

An overall decrease in rainfall is projected for Angola, and the rain that does fall is likely to fall more inconsistently in heavy events. This is likely to cause an increase in pressure on water resources and an increasing need for storage to capture rain when it does fall. Angola has the second largest proportion of Africa's population using unimproved water sources, so the impact of decreasing water supply has serious implications for health and food security, particularly in rural areas (Mutangadura *et al.*, 2005).

### Coastal Areas

Rising sea-levels bring an increased risk of coastal erosion and – in combination with stronger storms – an increased risk of flooding from storm surges. With a large and increasing population in coastal areas, this impact will have increasing significance through the 21<sup>st</sup> century. Such areas include the capital city, Luanda, which itself has a population of around 5 million people.

### Agriculture & Food Security

While subsistence farming is the source of food for the majority of Angola, the nation still imports around 50 percent of its total food budget (CIA, 2008). Principal crops are a variety of roots and tubers – such as cassava – as well as cereals; good harvests in 2007 have helped to improve food security (USAID, 2007). The semi-arid areas of coastal and southern Angola are projected to experience a more than 20 percent reduction in growing season by 2050 for rain-fed agriculture (Thornton *et al.*, 2006). Conversely, Angolan agriculture is also at risk from flood events, which regularly sweep away both crops and livestock (Redvers, 2009). Flooding in southern Angola in 2010, for example, destroyed 180 farms in the district of Cunene, and devastated over 1,000ha of cultivated land in Huila (Angola Press, 2010a; 2010b and 2010c);

Crops will also be at risk from disease and pests; cassava, for example, has been affected by a virulent form of Cassava Mosaic Disease (CMD) (Rweyemamu *et al.*, 2006), which reduced crop yield by around 20 percent in 2007 (USAID, 2007). CMD is spread by whiteflies, which are encouraged by drought conditions that will be more likely in Angola under climate change (Epstein, 2002).

### Public Health

Angola has high malaria intensity and year round transmission. Projected increases in heavy rainfall events in three of four seasons will cause an increase in standing water and habitat for mosquitoes to breed, while increases in temperature may extend endemic area into the highlands, putting a greater number of the population at risk.

Diseases outbreaks in Angola often follow flooding events and the associated difficulties in providing clean water and sanitation facilities, the risks of such outbreaks is likely to increase with the risk of flooding. Flooding can also worsen existing public health problems; a cholera outbreak in slum areas of Luanda in 2006, for example, was compounded by flooding and resulted in over 1,200 deaths in just three months – the worst outbreak on record in the country (BBC, 2006).

### Housing & Communities

The greatest risk to housing is flooding, which can devastate entire communities. A single flood event in the district of Cuanza-Sul in early 2010, for example, left over 15,000 families homeless in just 48 hours (Angola Press, 2010d). Such flooding events have impacts on other aspects of the community by damaging or washing away school buildings and businesses. With a heavy rainfall events predicted to increase in all seasons except winter, Angola is an increasing risk from flooding and housing damage as a result of climate change.

### Livelihoods

Angola's national economy is driven predominantly by its oil and gas sector; oil production and associated activities accounts for around 85 percent of Angola's GDP (CIA, 2008). Since the end of the civil war in 2002, Angola has undergone substantial growth – more than 15 percent annually from 2004 to 2007 – that

has been supported by increased oil production (ibid). Angola – with funding from China, Brazil, Portugal, Germany, Spain, and the EU – has a substantial infrastructure investment programme (ibid). Climate change will threaten this infrastructure, particularly offshore drilling rigs and platforms where rising sea-levels and storm surges may threaten oil and gas production.

## Energy

Nationally, Angola has recently become Africa's largest exporter of crude oil, exporting almost all of the 2.1 million barrels a day it produces. Angola also has significant natural gas reserves, and plans are underway for converting gas into liquefied natural gas (LNG) for export and domestic use; currently, the majority of it is flared (EIA, 2010). The majority of its fossil fuel reserves are held offshore, and they are therefore at risk from changes in sea level and storminess. Less than 20 percent of the population have access to electricity (domestic heating and cooking needs are generally met through biomass in the form of fuel wood and charcoal), of which two-thirds is generated through hydropower and the remaining third is generated by diesel generators (reeep, 2009). The main hydropower sites are the Matala dam on the Cunene River, the Cambambe dam on the Kwanza River, the Mabubas dam on the Dande River (ibid). Decreased rainfall may reduce the water available for hydropower generation.

## Transport

Increased risk of flooding under climate change also increases the risk of damage to Angola's roads. Damage to the transport infrastructure during flood events also has knock-on effects for food security and public health as aid struggles to reach rural areas.

## Government Response

Angola is currently preparing a National Adaptation Plan of Action (NAPA) through the United Nations Framework Convention on Climate Change (UNFCCC) (Angola Press, 2008).

The government recently approved a new bill to development of production of biofuels in an attempt to improve domestic fuel supply, diversify the economy, promote migration towards rural areas, and provide a renewable source of energy for the future (Angola Press, 2010e). To avoid a conflict with food production, the Minister of Agriculture, Fisheries and Rural Development stated that biofuels will only be explored on 'marginal lands' (ibid).

The government has responded to the ongoing threat of rainy season cholera outbreaks; in partnership with the Red Cross, the Ministry of Health's programme of improved sanitation and community education resulted in a drop in WHO-recorded cholera cases from 2008 to 2009 (The Citizen, 2009). Cases and fatalities were reduced from 7,740 and 198 in 2008 to 681 and 3 in 2009 (ibid).

## Likely Adaptation Options

The following are a selection of possible adaptation options for Angola:

- Rainwater harvesting: collection of rainwater for both household and agricultural use will help offset the increasing unpredictable nature of rainfall.
- Concrete housing: promote the use of concrete for housing where possible; by subsidising the cost of concrete, this could provide more structurally sound buildings that can withstand flood events.
- Early-warning systems: implementation and improvement of such systems can help with preparedness for drought and flood events.
- Community preparation: incorporated with early-warning systems, actions plans for what to do before, during and after flooding events – such as provision of escape routes and development of emergency evacuation plans.
- Reforestation/afforestation projects: increase in plant cover to encourage interception of rainfall during heavy events and reduce risk of flooding. Added benefit of improving soil stability to reduce risk of landslides.
- Flood defences: Possible need to protect areas at risk from flooding (coastal and inland) with purpose-built defences, e.g. bunds, dams/reservoirs.
- Adaptation plans for coastal communities: assess risk to buildings now and in the future; consider relocation of most vulnerable homes. Consider possibility of purpose-built defences.

## 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](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](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](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 Angola. 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.*



Written by Robert McSweeney  
Edited by Mike Wiggins and Liu Liu  
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[www.tearfund.org](http://www.tearfund.org)

100 Church Road, Teddington, Middlesex TW11 8QE  
0845 355 8355 (ROI: 00 44 845 355 8355) [enquiry@tearfund.org](mailto:enquiry@tearfund.org)

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