ZAMBIA

AFRICAN DEVELOPMENT BANK

NATIONAL CLIMATE CHANGE PROFILE

PRODUCED IN COLLABORATION WITH:
African Climate & Development Initiative, University of Cape Town;
Climate Systems Analysis Group, University of Cape Town;
Energy Research Centre, University of Cape Town; Cirrus Group.

October 2018

ZAMBIA

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENT

This national climate change profile, one in a series of 25 national-level assessments, is the product of the African Development Bank-led project "Enhancing the capacity of African countries to use climate information to inform decision-making and implement NDCs", sponsored by the Africa Climate Change Fund (bit.ly/AfDB-ACCF). The profiles were developed by a diverse group of experts from the University of Cape Town including the African Climate & Development Initiative (www.acdi.uct.ac.za), the Climate System Analysis Group (www.csag.uct.ac.za) and the Energy Research Centre (www.erc.uct.ac.za)) and the Cirrus Group. In addition, these profiles have benefited from the suggestions and inputs of multiple reviewers over the course of project development, and we would like to recognize and appreciate their efforts.

1. BACKGROUND

1.1. Geographic and socio-economic context

The Republic of Zambia (henceforth 'Zambia', shown below in Figure 1-1) is a landlocked country in Southern Africa, bordered by Namibia, Zimbabwe and Mozambique to the south, Malawi and Tanzania to the east/north-east, Democratic Republic of Congo to the north, and Angola to the west. Zambia's economy is largely based on the country's diverse and rich natural resources, particularly the deposits of copper, nickel, and tin which supports the mining industry, as well as an increasingly diversified and modernised commercial agriculture sector. The country achieved rapid economic growth during the 'commodities boom' of ~2004-2014 and it was estimated that Zambia's total GDP was ~USD 19.6 billion in 2016 (17^{th} largest in Africa), resulting in the World Bank reclassifying the country from a 'Least Developed Country' to a 'Middle Income Country'. However, despite the recent economic and developmental gains, Zambia continues to be challenged by widespread poverty and disparities (particularly between rural and urban areas), aggravated by slowed economic growth, reduced demand for commodities and downgrades to the country's long-term credit rating by international ratings agencies. Consequently, at present an estimated ~64% of Zambians live below the international poverty line of USD 1.90 per day, the 9^{th} highest rate in Africa. Zambia is also a rapidly urbanising country, with the urban population of ~39% increasing at a rate of ~4.1% a year. The large majority of the rural population (~90% of rural households) are dependent on rainfed subsistence agriculture as a source of livelihood, and as a result the aforementioned households are particularly vulnerable to climate-related hazards. Zambia also has the highest proportion of undernourishment in Africa with almost half the population suffering from this.

As a geographically diverse country, Zambia has multiple agro-ecological zones with distinct climates and soil types, however the majority of the country is classified as humid-subtropical with smaller semi-arid zone in the south and southwest. The country is vulnerable to rainfall variability and drought which results in negative impacts on rainfed agriculture, livestock production and the generation of hydroelectricity from the country's surface waters (notably including Lake Kariba) – it is estimated that drought impacted on at least 1.2 million Zambians in the period 1996–2016. Zambia's population is also vulnerable to the negative impacts of flooding as a result of the country's diverse network of surface waters, intense rainfall events during the wet season, and the comparatively dense population of settlements and agriculture in flood-prone river basins – as a result, floods have impacted negatively on ~4.36 million people in Zambia in the period 1996–2016, the 3^{rd} highest number in Africa. Additional socio-economic and demographic indicators for Zambia are summarised in Table 1-1, below.

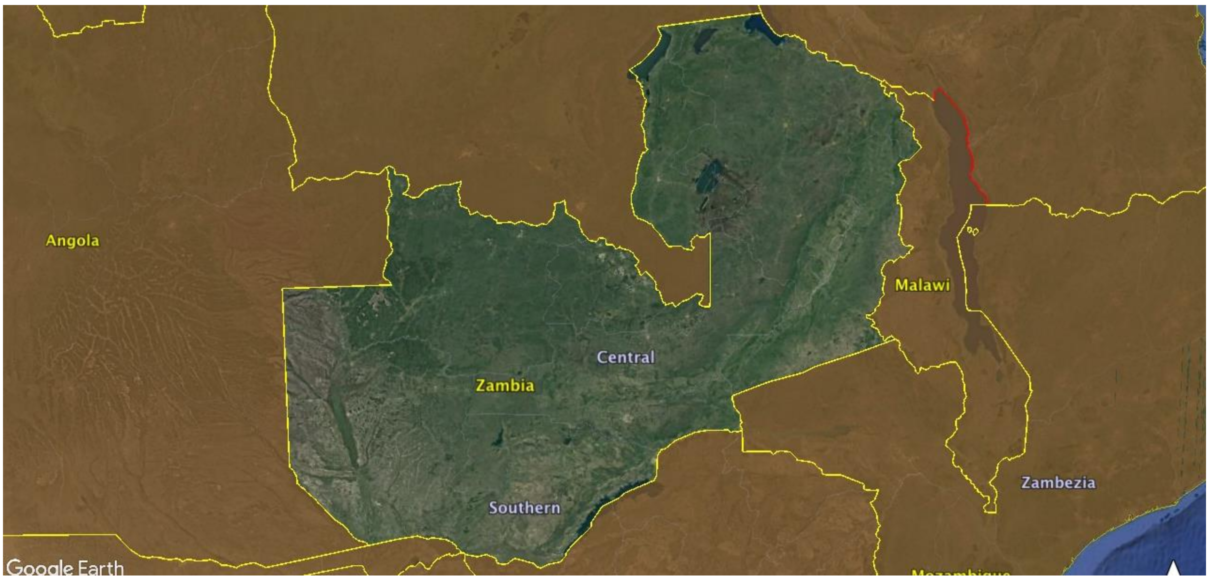


Figure 1-1: Map of Zambia

Table 1-1: Socio-Economic Context of Zambia (reference year ranges from 2014 - 2017)

<table>
<tr><th colspan="2">VARIABLE</th><th>SCORE/TOTAL</th><th>UNIT</th><th>RANK
(OUT OF 54)</th></tr>
<tr><td colspan="5">Geography, Socio-Economy and Demographics</td></tr>
<tr><td colspan="2">Population[1]</td><td>17,237,931</td><td>people</td><td>22</td></tr>
<tr><td colspan="2">Population growth rate[1]</td><td>3.1</td><td>% population. yr-1</td><td>9</td></tr>
<tr><td colspan="2">Population density[1]</td><td>23</td><td>People/km2</td><td>40</td></tr>
<tr><td colspan="2">Land area[1]</td><td>743,014</td><td>km2</td><td>17</td></tr>
<tr><td colspan="2">% Urban population[1]</td><td>38.5</td><td>% population</td><td>31</td></tr>
<tr><td colspan="2">% Urbanisation rate[2]</td><td>4.1</td><td>% population. yr-1</td><td>16</td></tr>
<tr><td colspan="2">Economy: total GDP[2]</td><td>19.6</td><td>USD billions. yr-1</td><td>17</td></tr>
<tr><td colspan="2">Economy: GDP by PPP[2]</td><td>65</td><td>billion international dollars. yr-1</td><td>16</td></tr>
<tr><td colspan="2">Economy: GDP/capita[2]</td><td>1,178</td><td>USD per capita/yr.</td><td>22</td></tr>
<tr><td colspan="2">Population below the poverty line[3]</td><td>64.4</td><td>% below USD 1.90 per day</td><td>9</td></tr>
<tr><td colspan="2">Gender Inequality Index[4]</td><td>58.7</td><td></td><td>18</td></tr>
<tr><td colspan="2">GINI co-efficient[3]</td><td>55.6</td><td></td><td>6</td></tr>
<tr><td colspan="2">HDI[5]</td><td>0.58</td><td></td><td>15</td></tr>
<tr><td colspan="2">Access to electricity[6]</td><td>27.9</td><td>% population</td><td>33</td></tr>
<tr><td colspan="5">Summary indicators of climate change vulnerability</td></tr>
<tr><td colspan="2">Workforce in agriculture[7]</td><td>55.8</td><td>% workforce</td><td>18</td></tr>
<tr><td colspan="2">Population undernourished[8]</td><td>47.8</td><td>% population</td><td>1</td></tr>
<tr><td colspan="2">Number of people affected by drought[9]</td><td>1,200,000</td><td>people</td><td>26</td></tr>
<tr><td colspan="2">Number of people affected by flood events[9]</td><td>4,349,008</td><td>people</td><td>3</td></tr>
<tr><td rowspan="3">ND-Gain Vulnerability Index[10]</td><td>Total</td><td>41.9</td><td></td><td>15</td></tr>
<tr><td>Readiness</td><td>0.38</td><td></td><td>12</td></tr>
<tr><td>Vulnerability</td><td>0.54</td><td></td><td>29</td></tr>
</table>

2. CLIMATE AND WEATHER

Zambia has a humid sub-tropical climate, largely due to its elevated plateau. Rainfall occurs primarily during austral summer (December to March) and there is a clear dry season from May to September. Rainfall is generally higher over the northern parts and decreases towards the south. The rainfall regions or river catchments extend beyond the county's borders primarily into Angola to the west and Zimbabwe to the south.

Variations in rainfall amounts within the full region are relatively large, therefore four sub-regions are distinguished here. The Zambia regions are illustrated in Figures 2-1 and 2-2, below, and summary descriptions can be found in Table 2-1 below.

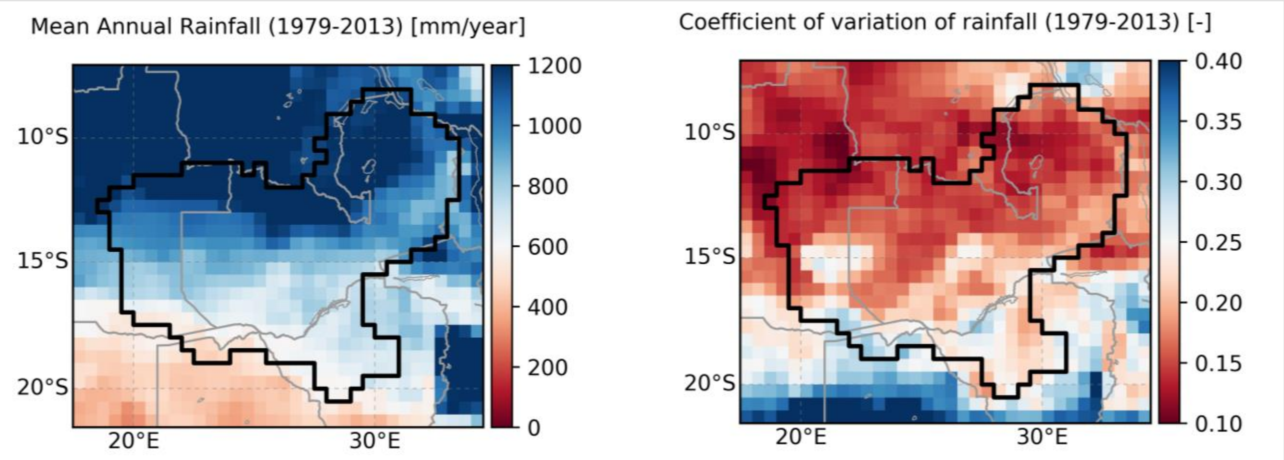
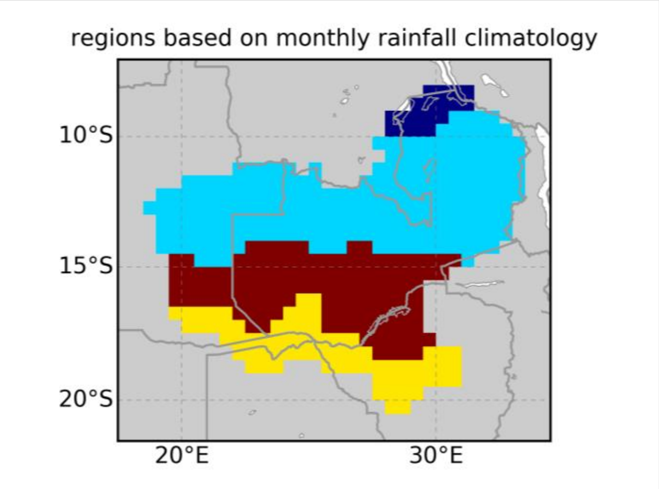


Figure 2-1: Main characteristics (magnitude and variability) of rainfall in Zambia and its region



Coloured regions on the map (above) correspond to the colours used in rainfall and temperature graphs (below)

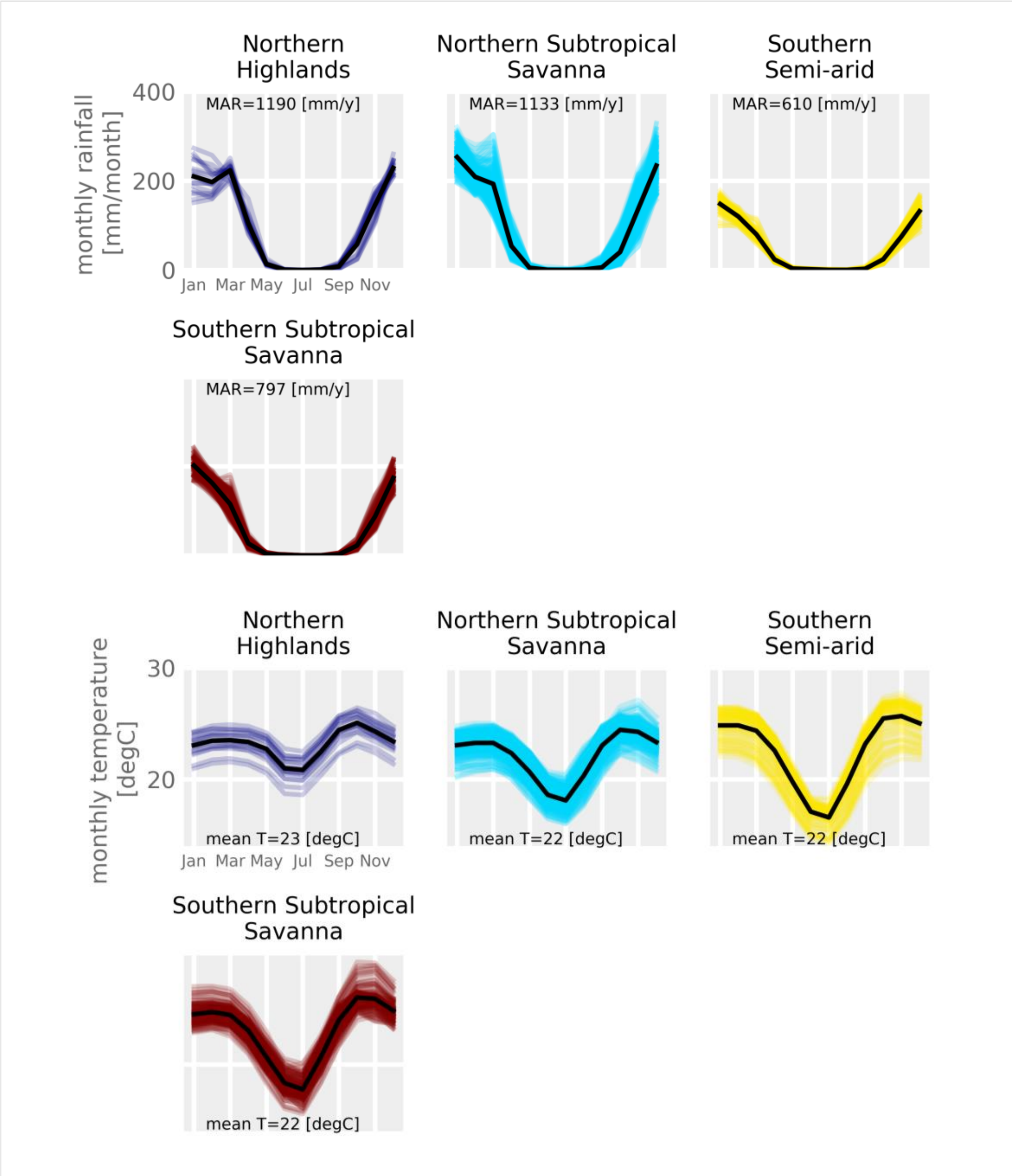


Figure 2-2: Rainfall regions of Zambia based on similarity of standardised rainfall climatology, and their rainfall and temperature climatologies

Table 2-1: Main characteristics of rainfall of Zambia region

NORTHERN HIGHLANDS	A relatively small high rainfall region with a mean annual total rainfall of 1190 mm/year. Low variability from year to year is found in this region. Rainfall occurs in a single rainy season during austral summer peaking over 200 mm/month in December-January and again in March. A clearly defined dry season occurs from May to September. Daily mean temperature averages 23° C with a seasonal cycle of just 4° C. Slightly cooler temperatures occur in June and July and the warmest temperatures occur in September-October (just before the rainy season starts).
NORTHERN SUBTROPICAL SAVANNA	A large high rainfall region with a mean annual total rainfall of 1130 mm/year. Clear spatial variation in rainfall is evident, with rainfall decreasing from north to south over the region. Low levels of year to year variability occur in this region. Rainfall occurs in a single rainy season during austral summer peaking at over 200 mm/month from December to March. A clearly defined dry season occurs from May to September. Daily mean temperature averages 22° C with a seasonal cycle of ~5° C. Coolest temperatures occur in June and July and the warmest temperatures occur in September-October (just before the rainy season starts).
SOUTHERN SUBTROPICAL SAVANNA	A moderate rainfall region with a mean annual total rainfall of around 800 mm/year. Spatial variability of rainfall is evident with values decreasing from north to south over the region and interannual variability is moderate. Rainfall occurs in a single rainy season during austral summer peaking at over 200 mm/month in January. A clearly defined dry season occurs from May to September. Daily mean temperature averages 22° C with a seasonal cycle of ~7° C. Coolest temperatures occur in June and July and the warmest temperatures occur from September – March, peaking in September – November (just before the rainy season starts).
SOUTHERN SEMI-ARID	A semi-arid region with a mean annual total rainfall of 610 mm/year. Spatial variability of rainfall is evident with values decreasing from north-east to south-west over the region and interannual variability is moderate to high. Rainfall occurs in a single rainy season during austral summer peaking at around 180 mm/month in January. A clearly defined dry season occurs from May to September. Daily mean temperature averages 22° C with a seasonal cycle of ~8° C. Coolest temperatures occur in June and July and the warmest temperatures occur from September – March, peaking in October-November (just before the rainy season starts).

2.1 Observed historical climate variations and climate change trends

The majority of Zambia experiences **relatively low rainfall variability** on an inter-annual basis, though it increases over the more southern parts. On **decadal time scales** Zambia also experiences **some variability** with some periods being relatively drier or wetter than others. This variability can be seen in the supporting evidence plots provided in the supplementary Appendix **(Figures A-1 to A-4).**

Long term trends across the region show **increasing temperatures** over the period 1979 – 2015 especially over the more southern regions, although that trend appears to be weaker in the second half of that period. Long term trends in total annual rainfall are strongly positive over all regions with the exception of the Northern Highlands and the trends statistically significant over the two southern regions. The frequency of rainfall events are also strong and significant over these southern regions, but not over the two northern regions. Trends in the frequency of extreme rainfall events are generally not evident. Long term trends and variability in the Zambia region are summarized in **Table 2-2** below and illustrated further in the supplementary Appendix **(Figures A-1 to A-4).**

Table 2-2: Summary of trends in rainfall and temperature attributes in Zambia (1979 - 2015)

REGION	MEAN T [DEG C/DECADE]	TOTAL RAINFALL [MM/DECADE]	EXTREME RAINY DAYS [DAYS/DECADE]	RAINY DAYS [DAYS/DECADE]
Northern Highlands	+0.18	not evident	not evident	not evident
Northern Subtropical Savanna	+0.15	+38.2	+1.8	slight upward
Southern Subtropical Savanna	+0.21	+45.4	not evident	+4.7
Southern Semi-arid	+0.24	+32.9	not evident	+5.1

2.2 Projected (future) climate change trends, including temperature, precipitation and seasonality

Projected changes in main attributes of climate for the Zambia region are summarized in Table 2-3, below, and described in Sections 2.2.1 and 2.2.1. Additional analysis and visualisation of projections can be found in **Figures A-5 to A-8** in the supplementary Appendix.

2.2.1 Projected changes in precipitation from present to 2100

Rainfall projections across the Zambia regions, with the exception of the Northern Highlands, show a pattern of **potential decreasing rainfall** emerging in the second half of the century. The pattern appears to be consistent for the majority of CMIP5 models within the ensemble. Relative magnitudes of potential decreasing rainfall equates to between 20% and 35% of the baseline normal. **The decrease in rainfall** seems to be strongly associated with **decreases in rainfall events rather than extreme events.** The Northern Highlands region shows a potential increase in rainfall and extreme rainfall frequency, but a decrease in general rainfall frequency. It must be noted that these results are derived from GCM projections which may not accurately represent changes in extreme rainfall dynamics.

2.2.2 Projected changes in temperature from present to 2100

Air temperature is projected to be between 1.5 and 3°C warmer in the Zambia regions by the 2050s. By 2100 the range of projected temperatures is greater with projected increases of 3.5°C to 7°C.

Table 2-3: Summary of projected climate changes across regions of Zambia for key climate variables by 2050

REGION	AVERAGE TEMPERATURE [°C]	TOTAL ANNUAL RAINFALL [MM/YEAR]	NUMBER OF HEAVY RAINFALL [DAYS/YEAR]	RAINY DAYS [DAYS/YEAR]
Northern Highlands	**Increasing** +2°C to +3°C by 2050s but changes evident in next decades	**Normal to increasing**, no change by 2015, but change ranging from no change to clear increase of up to15% could become evident after 2070s	**Normal to increasing**, ranging from no change to increasing by 2050, but generally increasing by up to 50% by 2100.	**Normal to decreasing**, ranging from no change to decreasing of up to 10% by 2100. Change may become evident from 2060s.
Northern Subtropical Savanna	**Increasing** +1.5°C to +3°C by 2050s but changes evident in next decades	**Normal to decreasing**, no change by 2015, but change ranging from no change to clear decrease of up to 20% could become evident after 2070s	**Normal to increasing**, ranging from no change to increasing by 2050, but generally increasing by up to 50% by 2100.	**Normal to decreasing**, ranging from no change to decreasing by 20150, and generally decreasing by up to 15% by 2100.
Southern Subtropical Savanna	**Increasing** +2°C to +3°C by 2050s but changes evident in next decades	**Normal to decreasing**, ranging from no change to a clear decrease of up to 35% by 2100. Change may become evident from 2040s.	No consistent signal in projections	**Normal to decreasing**, ranging from no change to decreasing by 20150, and generally decreasing by up to 35% by 2100.
Southern Semi-arid	**Increasing** +1.5°C to +3°C by 2050s but changes evident in next decades	**Normal to decreasing**, ranging from no change to a clear decrease of up to 35% by 2100. Change may become evident from 2020s.	No consistent signal in projections	**Normal to decreasing**, ranging from no change to decreasing by 20150, and generally decreasing by up to 35% by 2100.

2.3 Expected climate vulnerabilities

NOTE: Determining vulnerability of different sectors to climate variations or change is extremely challenging as there are many factors involved in vulnerability and different approaches can yield different results. The vulnerabilities presented here are based on UNFCCC reporting documents such as national communications or national adaptation plans of action where available, and other literature where UNFCCC documents are not available.

In landlocked, largely humid-subtropical Zambia projected temperature increases and indications of normal to decreasing annual rainfall trends for large parts of the country will increase pressure on water resources, with implications for households, industry and agriculture, as well as for hydropower production.

While Zambia's modernised commercial agriculture sector is likely to be impacted, rain-fed subsistence agriculture, practiced by 90% of the rural population, is particularly vulnerable to the increased pressure on water resources, as well as to the direct impacts of increasing temperatures and the projected increase in extreme rainfall. Half of the urban Zambian population lives in slums with lack of proper access to critical services such as health care, water supply and proper housing, deeming them particularly vulnerable to extreme temperatures and rainfall events, as well as the slower knock-on effects that climate change may have on the economy. Densely populated flood prone river basins are of further concern, given the projected increase in extreme rainfall events in parts of the country.

Table 2-4: Broad scale sectoral vulnerabilities and potential climate change impacts in Zambia

SECTOR	IMPACTS
Agriculture	- Crop loss and reduced yields owing to increased temperatures and changing rainfall patterns - Increased incidence of pests and diseases - Reduced crop yields owing to waterlogging, especially in the north - Reduced crop yields owing to increasing frequency of drought, especially in the south - Increased death and heatstroke in livestock owing to increased temperatures - Decreased fodder availability for livestock
Fisheries	- Decreased fish populations owing to increased sedimentation of rivers - Reduced aquatic biodiversity owing to increased water temperatures and decreased river flows
Water resources	- Increased flooding and siltation in rivers, especially in the north - Reduced availability of water resources during drought, especially in the south - Decreased water quality owing to contamination of water resources during flooding, especially in the north - Reduced water storage negatively affecting hydropower production, especially during the summer months
Built infrastructure and human settlements	- Increased potential for migration from rural to urban areas - Damage to or destruction of infrastructure owing to extreme events, especially flooding
Human health	- Changes in the prevalence of vector-borne diseases, such as malaria - Increased incidence of water-borne diseases, especially cholera and diarrhoea - Increased potential for malnutrition and stunting, especially during drought

3. CLIMATE CHANGE MITIGATION, GREENHOUSE GAS EMISSIONS AND ENERGY USE

The major carriers of Zambia's energy mix, and the energy demands of major economic sectors, are summarised in Section 3.1, below. The major sources of GHG emissions, described by fuel source and sector, are described in Section 3.2. The latter section also includes summarised statistics on Zambia's agriculture sector, historical land use change and vegetation cover Zambia's national energy consumption and resultant GHG emissions includes multiple sectors, of which the most important sources of Zambia's GHG emissions are related to secondary emissions resulting from diverse practices and activities in the industrial, waste management, agriculture and forestry sectors, totalling ~366 MT CO_2e (see 3.2.2, below).

3.1 National energy production and consumption

Zambia's energy sector, and the resultant distribution of GHG emissions is largely characterised by a split between three major users and fuel sources: i) the manufacturing, industrial and mining sector activities which demand electricity, coal and diesel to support extraction, processing and transport of commodities; ii) grid-connected electricity users, primarily comprising urban households and commercial enterprises, generated by hydropower; and iii) the use of biomass fuel by impoverished rural and urban households to meet domestic energy needs, including both firewood as well as charcoal (the latter particularly in urban areas). In terms of national energy production, the total annual demand of 9.1 MTOE is primarily supplied by biomass fuels (~7.8 MTOE or ~86% of total energy production). Hydroelectricity is the second-largest source of energy production, totalling 1.2 MTOE and supplying virtually the entire national electricity supply. With respect to national energy consumption, biofuels and hydroelectricity are supplemented by coal (imported as well as mined domestically) and oil, collectively contributing ~1 MTOE. The residential sector accounts for the majority (~4.8 MTOE, ~60% of total) of Zambia's energy consumption, which includes domestic consumption of biomass fuels, urban domestic consumption of electricity and potentially additional consumption of diesel to supply home generators. The next-largest consumer of Zambia's energy is the industrial sector (2.6 MTOE), in particular the mines and mineral processing facilities, which have considerable demands for electricity, coal and diesel. The transport sector is the third-largest consumer of energy in Zambia, demanding ~1 MTOE of energy, of which ~90% is for road transport and is supplied by oil products.

Unless stated otherwise, all energy figures are derived from UN Stats (2014) [10]; World Energy Council (2016); [11]; and the World Resources Institute (2013) [12]. Agriculture & forestry-related emissions are also reported from Food and Agriculture Organisation (2014-2017) [14] and Global Forest Watch. (2015-2017) [15].

3.2 National energy production, primary energy supply and national energy consumption

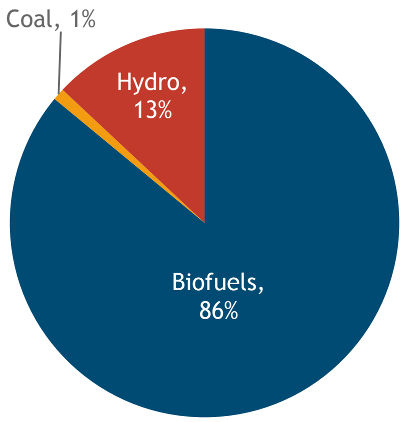


Figure 3-1: Distribution of Zambia's national energy production between major energy carriers (2014-2016)

Table 3-1: National energy and electricity production in Zambia (2014-2016)

NATIONAL ENERGY PRODUCTION		
Source	**Total (MTOE)[1]**	**% of total energy production**
Coal[11]	0.1	1.0
Hydro[11]	1.2	13.2
Biofuels[11]	7.8	85.7
Total national energy production	9.1	
Electricity[12]	Hydro	97.2
	Oil	2.8

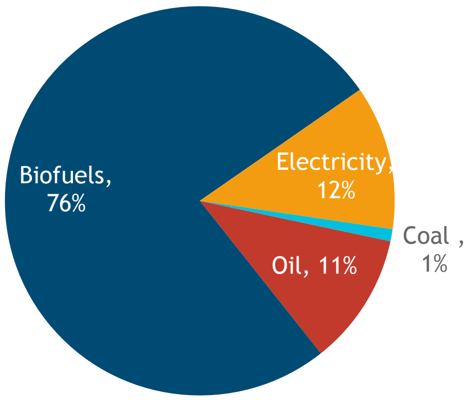


Figure 3-2: Distribution of Zambia's national energy consumption by major energy carriers

Table 3-2: Zambia's national energy consumption by energy source

CONSUMPTION BY ENERGY SOURCE[11]	
Source	**Total (MTOE)**
Coal	0.1
Oil	0.9
Biofuels	6.1
Electricity	0.9
Total national energy consumption by source	8.0

[1] *Energy is expressed in 'Megatonnes of Oil Equivalent', where 1 Tonne Oil Equivalent = 11,630 KiloWatt hours (KWh)*

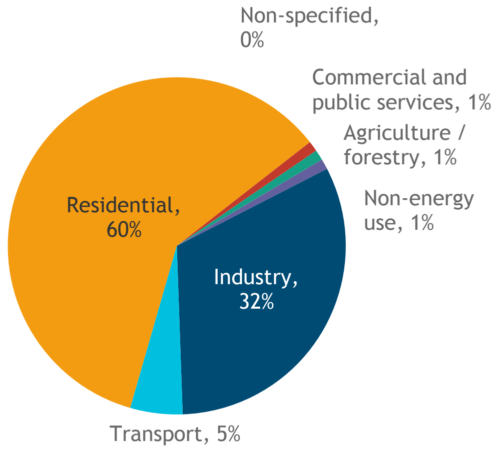


Figure 3-3: Distribution of Zambia's national energy consumption by sector (2014-2016)

Table 3-3: Zambia's national energy consumption by sector (2014-2016)

CONSUMPTION BY SECTOR[11]	
Source	**Total (MTOE)**
Industry	2.6
Transport	0.4
Residential	4.8
Commercial and public services	0.1
Agriculture / forestry	0.05
Non-specified	0.04
Non-energy use	0.1
Total national energy consumption by sector	8.0

Table 3-4: Zambia's national total primary energy supply (estimated for 2014-2016)

TOTAL PRIMARY ENERGY SUPPLY[11]		
Source		**Total (MTOE)**
Coal		0.1
Oil	Crude Oil	0.7
	Oil Products	0.3
Hydro		1.2
Biofuels		7.8
Electricity		-0.11
Total primary energy supply		10.1

3.3 National greenhouse gas emissions by source and sector

Section 3.2.1, below, describes GHG emissions from fuel combustion – these figures include direct combustion of fuels as a primary energy carrier as well as conversion to other forms of energy (e.g. as electricity). The latter figures are based on statistics from the International Energy Agency (IEA). Section 3.2.2, further below, describes GHG emissions from all sectors of national energy consumption, which therefore includes emissions from fuel combustion, industrial/manufacturing processes, household-level energy consumption and AFOLU (Agriculture, Forestry and Other Land Use). The latter figures are compiled by the World Resources Institute's Climate Access Indicator Tools (CAIT), which employs different methodologies and reporting standards to the IEA. Therefore, while there is some resultant duplication between the two datasets, each provides slightly different approaches to categorisation of major GHG emitting sectors and are both included for consideration. Section 3.2.3 provides additional details on Zambia's Land Use and Land Use Change sector, including detailed summaries of emissions from the agriculture sector and historical land use changes.

3.4 GHG emissions from fuel combustion, by source and sector

Oil is the largest contributor to Zambia's greenhouse gas (GHG) emissions from fuel combustion (~2.5 MT CO_2e), followed by coal (~0.9 MT CO_2e) (IEA, 2013). The sectors account for the largest proportion of national GHG emissions from fuel combustion include transport (1 MT CO_2e, of which 0.9 is accounted for by road transport), manufacturing and construction (~2 MT CO_2e), and other non-specified energy uses in the non-residential sector. At present the majority of Zambia's electricity is generated by hydroelectricity facilities with no resultant GHG emissions from electricity and heat production.

Table 3-5: Zambia's national greenhouse gas emissions from fuel combustion

NATIONAL GHG EMISSIONS FROM FUEL COMBUSTION BY FUEL SOURCE AND SECTOR [13]		
Source / Sector		**Total emissions (MT CO_2e)**
Coal		0.9
Oil		2.5
Total fuel source emissions		3.4
Electricity and heat production		0.03
Other energy industry own use*		0.04
Manufacturing industries and construction		2.0
Transport	Road	0.9
	Other	0.1
	Total	1.0
Other	Residential	0.02
	Non-residential	0.4
	Total	0.4
Total sector emissions		3.4

** Includes emissions from own use in petroleum refining, the manufacture of solid fuels, coal mining, oil and gas extraction and other energy-producing industries.*

3.5 GHG emissions from primary energy consumption, by source and sector

As described above in Section 3.2.1, sectors including transport, manufacturing and construction account for a considerable proportion of Zambia's GHG emissions from fuel combustion and primary energy consumption (at least ~2.4 MT CO2e). As detailed in Table 3-6, below, the emissions from primary energy consumption also include a substantial proportion of GHG emissions resulting from 'other fuel combustion' – the latter category, which may include multiple unspecified actions, is most likely to be related to energy-intensive activities in the mining and mineral processing sector, emitting ~21.8 out of a total of 24.2 MT CO2e emitted by primary consumption of energy.

However, despite the significant emissions of GHGs from the latter sources by direct consumption of primary energy, the largest sources of Zambia's GHG emissions are related to secondary emissions resulting from diverse practices and activities in the industrial, waste management, agriculture and forestry sectors, totalling ~352 – 366 MT CO2e (Tables 3-6 & 3-7). The two largest sources of emissions from these sectors, and the largest sources of Zambia's GHG emissions overall, are the sectors of agriculture (contributing ~23.1 MT CO2e or ~6% of total national emissions) and land use change/forestry (which contributes ~340 MT CO2e or ~87% of total national GHG emissions). Several activities which drive emissions from this sector include clearance of savanna and woodland to establish crop agriculture, burning of rangelands to encourage regrowth of grazing for livestock, and removal of wood for fuel (including firewood used by rural households as well as for production of charcoal to supply urban households). These activities are described and quantified further in Section 3.2.3, below.

Table 3-6: Zambia's national greenhouse gas emissions from primary energy consumption (estimated for 2014-2016)

NATIONAL GHG EMISSIONS FROM PRIMARY ENERGY CONSUMPTION BY SOURCE AND SECTOR [14]		
Source / Sector		**Total emissions (MT CO_2e)**
Energy	Electricity and heat	0.1
	Manufacturing and construction	1.4
	Transport	1.0
	Other fuel combustion	21.8
	Fugitive emissions	0.01
	Energy sub-total	24.2
Industrial processes		0.7
Agriculture		23.1
Waste		2.1
Land use change and forestry (LUCF)		340.1
Total emissions (including LUCF)		390.2

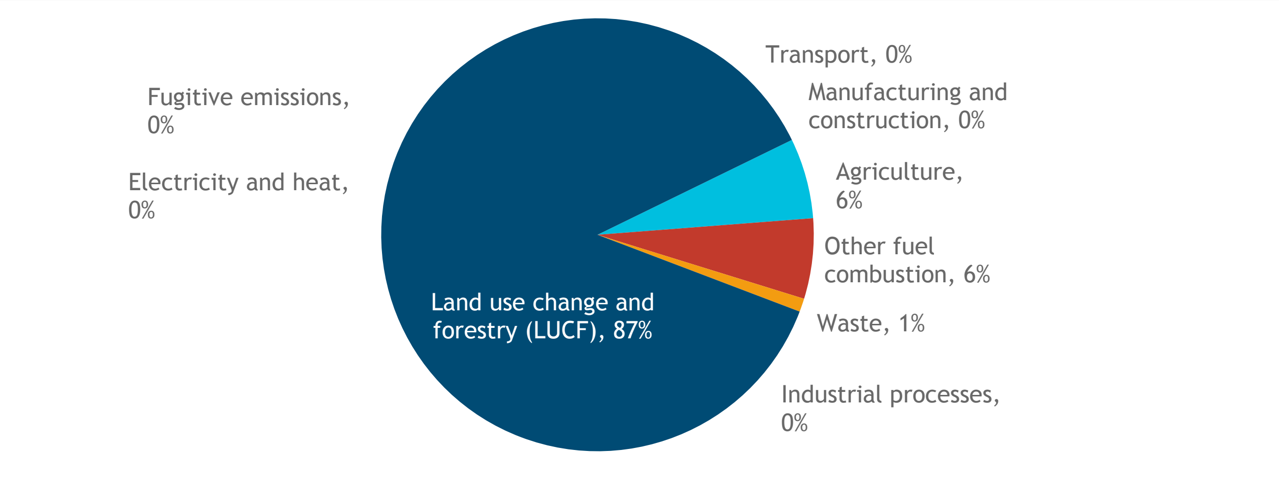


Figure 3-4: Distribution of Zambia's GHG emissions by major sectors

3.5.1 GHG emissions from agricultural practices

As described in Section 3.2.2, above, the agriculture, forestry and land use change sectors are the largest contributors to Zambia's total national GHG emissions, totalling ~352 – 366 MT CO2e (Tables 3-6 & 3-7). It is estimated that burning of biomass fuels, including firewood as well as charcoal for domestic energy uses, is the largest single source of national GHG emissions at ~320 MT CO2e per annum.

Following the burning of biomass fuels, the second-largest contributor to GHG emissions is burning of savanna grasslands, woodlands and forests as a result of land clearance, and accidental and deliberate fires (collectively totalling ~22.3 MT CO2e). Several GHG sources related to livestock production and manure management (inter alia enteric fermentation, manure left on pastures and soils) contribute a total of additional 5.9 MT CO2e. Agricultural practices such as cultivation of organic soils and addition of fertiliser contribute ~2.3 and ~1 MT CO2e, respectively.

Table 3-7: National annual greenhouse gas emissions from agricultural practices, forestry and other land use in Zambia (estimated for 2014-2017)

VARIABLE		ANNUAL EMISSIONS (MT CO_2E)
Annual GHG emission from agricultural practices [15]	Burning - crop residues	0.1
	Burning - savanna	13.5
	Crop residues	0.2
	Cultivation of organic soils	2.3
	Enteric fermentation	3.1
	Manure management	0.3
	Manure applied to soils	0.2
	Manure left on pasture	2.3
	Rice cultivation	0.05
	Synthetic fertilizers	1.0
	Sub-total (Agricultural practices)	23.0
Annual GHG emission from land use change[15]	Grassland	3.0
	Cropland	0.01
	Forest land	5.8
	Burning biomass	320.0
	Sub-total (Land use change)	328.7
Total emissions		351.6

Wooded vegetation areas, with tree cover ranging from ~10% up to ~100% tree cover, collectively account for ~59 million hectares or ~78.6% of Zambia's total land cover, including over ~36 million hectares of Miombo woodland in the '10-30% tree cover' category of forests (Table 3-8). These large woodland and forest areas provide a large and valuable 'sink' of biomass carbon, where Global Forest Watch estimates that the total aboveground biomass carbon content of Zambia's forests is ~2400 million tonnes of carbon. However, as a result of ongoing land use change and deforestation, the extent of Zambia's wooded areas is reduced annually at a rate of 0.1 – 0.4 % (Table 3-8).

Table 3-8: Vegetation cover and land use change in Zambia (estimated for 2015)

VARIABLE		TOTAL (HECTARES)	TOTAL (% OF LAND AREA)	UNIT
Total tree cover [16]	10-30% canopy cover	36,281,317	48.21	% of total land area
	30-50% canopy cover	14,237,205	18.9	
	50-100% canopy cover	8,605,341	11.4	
	Total	59,123,863	78.6	
Land use change and agricultural expansion	Historical annual rate of deforestation[17]	10-30% canopy cover	0.1	% of previous year
		30-50% canopy cover	0.3	
		50-100% canopy cover	0.4	
	Area of agricultural land[18]	23,722,267	31.5	% of total land area
	Historical annual area converted to agricultural land[18]	-308,570	-1.3	% of previous year

4. SUMMARISED NATIONAL PRIORITIES FOR CLIMATE CHANGE ADAPTATION AND MITIGATION

Zambia's main priority actions related to climate change are described in the country's submissions to the UNFCCC through the Intended Nationally Determined Contributions (NDC) document. This document includes detailed descriptions of Zambia's major commitments and priorities related to GHG mitigations (Table 4-2, below) as well as major priorities related to adaptation, derived from the Climate Response Strategy and draft National Adaptation Plan (NAP) (Table 4-3, further below).

Zambia's NDC includes both mitigation and adaptation components based on her national circumstances and is in line with decisions 1/CP.19 and 1/CP.20. The successful implementation of Zambia's NDC will result in an estimated total emission reduction of 38,000 GgCO2eq which translates to 47% (internationally supported efforts) against 2010 as a base year. This emission reduction is conditional and subject to the availability of international support in form of finance, technology and capacity building. The total budget for implementing both components is estimated at US$ 50 billion by the year 2030, out of this USD 35 billion is expected to come from external sources while $15 billion will be mobilized from domestic sources.

Table 4-1, below, gives details on Zambia's GHG reduction targets outlined in the country's NDC, with information on target gases and sectors, the use of international markets in achieving targets (e.g. the use of carbon credits), and accounting methods used to quantify GHG emissions (e.g. inclusion of land use and land use change).

Table 4-1: Summary of Zambia's NDC commitments for reduction of GHG emissions

GHG EMISSIONS REPORTED IN NDC (MT CO_2E/YR)	BASE LEVEL	REDUCTION TARGET	TARGET YEAR	SECTORS AND GASES	USE OF INTERNATIONAL MARKETS	LAND-USE INCLUSION / ACCOUNTING METHOD
119.81	BAU	25 to 47 percent (conditional)	2030	CO_2, CH_4, N_2O; Energy, agriculture, LULUCF, waste	Does not rule out the possibility of using market-based mechanisms	Revised 1996 IPCC Guidelines and 2000 Good Practice Guidance.

4.1 National priorities for climate change mitigation

Zambia's major priorities for actions and investments related to climate change mitigation are based on the implementation of three programs driven by the country's Climate Response Strategy and aligned with national development policies in relevant sectors including *inter alia* energy, forestry, agriculture, water, and transport. Further, these programs are aligned with various climate-related activities identified in Zambia's NDC including national REDD+ program, NAMAs and Technology Needs Assessment (TNA), among others. The three priority programmes through which Zambia's NDC actions are categorised are: i) Sustainable Forest Management; ii) Sustainable Agriculture; and iii) Renewable Energy and Energy Efficiency (summarised further below in Table 4-2).

Zambia's priority mitigation actions for the agriculture, forestry and land use change sectors are detailed and extensive, reflecting the large contribution of these sectors to total national GHG emissions. Priority actions identified include a strong focus on increasing the coverage of forest and woodland through participatory forest management, regeneration and reforestation of degraded areas, and integrated measures to control wildfires. Promotion of Conservation Agriculture is also prioritised by the Sustainable Agriculture programme of Zambia's NDC, aiming to reduce emissions through reduced fertiliser use, increased sequestration of soil carbon, and slowed rate of removal of native vegetation for agricultural expansion. In addition, promotion of small-scale biogas facilities, both for on-grid electrification as well as smaller household-level applications, is considered for areas where livestock husbandry is prominent.

National priorities for mitigation of GHG emissions in the energy sector include a strong focus on increasing the generation and accessibility of electricity through on-grid and off-grid renewable energies such as solar PV and wind. In addition, several actions identified in Zambia's NDC relate to fuel switches, including from coal to biomass energy for industrial applications. In addition, mitigation priorities related to energy use are closely linked to priorities in Sustainable Forest Management programme, reflecting the significant proportion of GHGs which are attributed to biomass fuel use and resultant land use change. Actions identified to reduce GHG emissions from biomass fuel use include promotion of efficient woodfuel stoves, efficient charcoal kilns, and alternative fuels such as ethanol and LPG for domestic applications. Zambia's NDC also identifies opportunities to reduce emissions from fuel use in the transport sector by promoting increased production of biofuels for blending with diesel.

Zambia's major priorities for actions and investments related to climate change mitigation are summarised in Table 4-2, below, and represent mitigation actions for the sectors of energy, transport and AFOLU. Proposed activities and investments within each sector are further categorised according to 'Technology Type', based on the categories of technologies listed by the Green Climate Fund's (GCF) impact indicators for mitigation projects (key for technology types provided below Table 4-2). The below-mentioned technology types and specific actions represent Zambia's immediate national priorities for investments in climate change mitigation and reflect recent and ongoing policy-level measures to reduce GHG emissions and increase energy efficiency.

Table 4-2: Mitigation priorities in Zambia's NDC

PRIORITY SECTOR	SECTOR-SPECIFIC ACTION	TECHNOLOGY TYPE* [2]
Energy	Fuel switch (coal to biomass)	1
	Switch from existing isolated diesel to mini-hydro	1
	Off grid RE to non-electrified rural – P.V and Wind	1, 6
	On grid expansion program to support economic growth and grid extension through inter-basin water transfer	1
	Grid extension to non-electrified rural areas	1
	Ensuring the best use of hydropower by careful management of the water resources	1, 5
Transport	Fuel switch (diesel/HFO to biodiesel)	2, 8
	Introduce and increase blending of bio-fuels with fossil fuels and where possible substitution with bio-fuels	2, 8
AFOLU	Conservation/ Smart agriculture	4, 9
	Rural biogas plants	4, 9
	Forest enhancement including natural regeneration and afforestation/reforestation	4, 9
	Sustainable charcoal production to include improved kilns	4, 9
	Improved cooking devices to include improved biomass stoves, use of ethanol and LPG stoves, and switch to electric stoves	4, 9
	Participatory forest management (CFM, JFM, PFM)	4, 9
	Forest fire management	4, 9

[2] **GCF Technology Type Key (derived from GCF's Results Framework for mitigation)*

1. Reduced emissions through increased lower emission energy access and power generation.

2. Reduced emissions through increased access to low-emission transport.

3. Reduced emissions from buildings, cities, industries and appliances.

4. Reduced emissions from land use, deforestation, forest degradation, and through sustainable management of forests and conservation and enhancement of forest carbon stocks.

5. Strengthened institutional and regulatory systems for low-emission planning and development.

6. Increased number of small, medium and large low-emission power suppliers.

7. Lower energy intensity of buildings, cities, industries, and appliances.

8. Increased use of low-carbon transport.

9. Improved management of land or forest areas contributing to emissions reductions.

4.2 National priorities for climate change adaptation

Zambia's NDC includes detailed and integrated measures for adaptation in sectors including AFOLU, water, and health, which emphasise a landscape-scale approach at the watershed level in order to maximise synergies between adaptation and mitigation. The adaptation measures identify six major watershed regions, namely Tanganyika; Luapula; Chambeshi; Luangwa; Kafue; and Zambezi. The adaptation measures identified are based on 11 priority actions within three major programmes: i) Adaptation of strategic productive systems (agriculture, wildlife, water); ii) Adaptation of strategic infrastructure and health systems; and iii) Enhanced capacity building, research, technology transfer and finance for adaptation. Specific themes which are identified for capacity-building, technical support and investments include Climate Smart Agriculture (CSA), Sustainable Forest Management (SFM), Sustainable Fisheries and Aquaculture (SFA), Renewable Energy Technologies (RET), and Early Warning Systems (EWS), change management and climate change planning.

The majority of Zambia's rural population are reliant on one or several forms of natural resource-based livelihoods, including agriculture, wildlife, forestry and fisheries. As a result, multiple adaptation priorities are identified for the latter sectors, which are based on sustainable and integrated management. With respect to management of climate change impacts on the water sector, Zambia's NDC notes adaptation priorities will focus on protection and conservation of water catchment areas and enhanced investment in water capture, storage and transfer (linked to agriculture, energy, ecological, industrial and domestic use purposes) in selected watersheds. Additional adaptation options identified for Zambia's water sector include water technologies for savings, recycling, irrigation and sustainable management for household, agriculture and industrial purposes. With respect to measures to directly reduce loss of life and health impacts resulting from climate change, Zambia's NDC notes the need to "enhance decentralized climate information services for early warning and long-term projections on the effects of climate change to support sustainable management of the production systems, infrastructure development and public health" and "Mainstream climate change in the National Health Policy, Environmental Health (EH) Policy, and Water and Sanitation Policy".

Zambia's proposed activities and investments related to adaptation are categorised according to 'Technology Type', based on the categories of technologies listed by the Green Climate Fund's (GCF) impact indicators for adaptation projects (key for technology types provided below Table 4-3).

Table 4-3: Adaptation priorities in Zambia's NDC

PRIORITY SECTOR	SECTOR-SPECIFIC ACTION	TECHNOLOGY TYPE[3]
AFOLU	Promotion of Climate Smart Agricultural (CSA) practices for crop, livestock and fisheries production including conservation of germplasm for land races and their wild relatives	1, 2
	Develop a National Wildlife Adaptation Strategy and ensure its implementation through supportive policies, local community, civil society and private sector participation	4, 5
	Institutionalize integrated land use planning compatible with sustainable management of natural resources and infrastructure development	3, 4, 5
	Capacity building in Climate Smart Agriculture (CSA), Sustainable Forest Management (SFM) Sustainable Fisheries and Aquaculture (SFA), Renewable Energy Technologies (RET), and Early Warning Systems (EWS), Change management and climate change planning	1, 4, 7
Water	Protection and conservation of water catchment areas and enhanced investment in water capture, storage and transfer (linked to agriculture, energy, ecological, industrial and domestic use purposes) in selected watersheds	2, 4
	Water technologies for savings, recycling, irrigation and sustainable management for household, agriculture and industrial purposes	2, 4
Health	Mainstream climate change in the National Health Policy, Environmental Health (EH) Policy, and Water and Sanitation Policy	2, 5
	Enhance decentralised climate information services for early warning and long-term projections on the effects of climate change to support sustainable management of the production systems, infrastructure development and public health	1, 6
Institutional	Mainstream climate change adaptation into country development plans and strategies	5

*[3] *GCF Technology Type Key (derived from GCF's Results Framework for adaptation)*

1. Increased resilience and enhanced livelihoods of the most vulnerable people, communities, and regions.

2. Increased resilience of health and wellbeing, and food and water security

3. Increased resilience of infrastructure and the built environment to climate change threats

4. Improved resilience of ecosystems and ecosystem services

5. Strengthened institutional and regulatory systems for climate responsive planning and development

6. Increased generation and use of climate information in decision making

7. Strengthened adaptive capacity and reduced exposure to climate risks

8. Strengthened awareness of climate threats and risk reduction processes

5. ASSUMPTIONS, GAPS IN INFORMATION AND DATA, DISCLAIMERS

The observed and projected climate trends described in Section 2 'Climate and Weather' are derived from a combination of publicly-available observational data and CMIP5 climate models. Detailed information is included in Section 6. Appendix 1, including '6.1.b. Historical Trends and Variability Analysis' and '6.1.c. Climate Projections Visualisations'.

Unless stated otherwise, all statistics reported in Section 1 ('Geographic and Socio-Economic Context' and Section 3 'Climate change mitigation, greenhouse gas emissions and energy use') are derived from databases of publicly available datasets managed by international or multilateral agencies including inter alia The World Bank Group, the United Nations, World Resources Institute and International Energy Agency.

Unless stated otherwise, all energy and greenhouse gas emission figures are derived from UN Stats (2014); World Energy Council (2016); the World Resources Institute (2013), and the International Energy Agency (2016). Agriculture & forestry-related emissions are also reported from Food and Agriculture Organisation (2014-2017) and Global Forest Watch. (2015-2017). Full references are provided as a supplementary appendix.

As a result of the use of standardised methodologies and data sources across the 25 countries included in this AfDB Climate Change Profile, statistics and estimates reported herein may differ from other publicly available datasets or national estimates. Readers are advised to always check for updated publications and newly released national datasets.

This AfDB Climate Change Profile series is intended to provide a brief touch-stone reference for climate change practitioners, project managers and researchers working in African countries. The figures and estimates provided herein are intended to inform the reader of the main climate-related challenges and priorities, however these should be used to inform a process of additional research and in-country consultations. The University of Cape Town, the African Development Bank and its Boards of Directors do not guarantee the accuracy of figures and statements included in this work and accept no responsibility for any consequences of its use.

6. APPENDIX 1

1.a Supporting evidence

The climate projections detailed in Chapter 2 (above) are supported by rigorous analysis of observed and model projections data. More details of this analysis and supporting figures can be found below.

1.b Historical trends and variability analysis

The analysis of historical trends and variability of key climate variables is presented below. This analysis uses the WATCH Climate Forcing dataset which has been selected as the most broadly representative of station observations across Zambia. Long term (1979 to 2013) trends as well as inter-annual variability (decade to decade) has been analysed for total annual rainfall, number of rainfall days, number of extreme rainfall days, and daily mean temperatures for each of the four climate regions across Zambia. The plots below detail **inter-annual variability** (dotted lines), **decadal variability** (smooth bold solid curves) and **long-term trends** (thin straight lines) for each region and statistic. This allows for comparison of different types of variability against the long-term trend. It can be seen that for rainfall statistics, inter-annual and decadal variability are typically fairly large compared to long term trends. For example, for total annual rainfall, the Northern Highlands region has very high inter-annual (900mm in some years to 1700mm in other years) and moderate decadal variability (1000mm in some decades to 1450mm in other decades). The long-term trend is not statistically significant and is only around -3mm over the 30-year period.

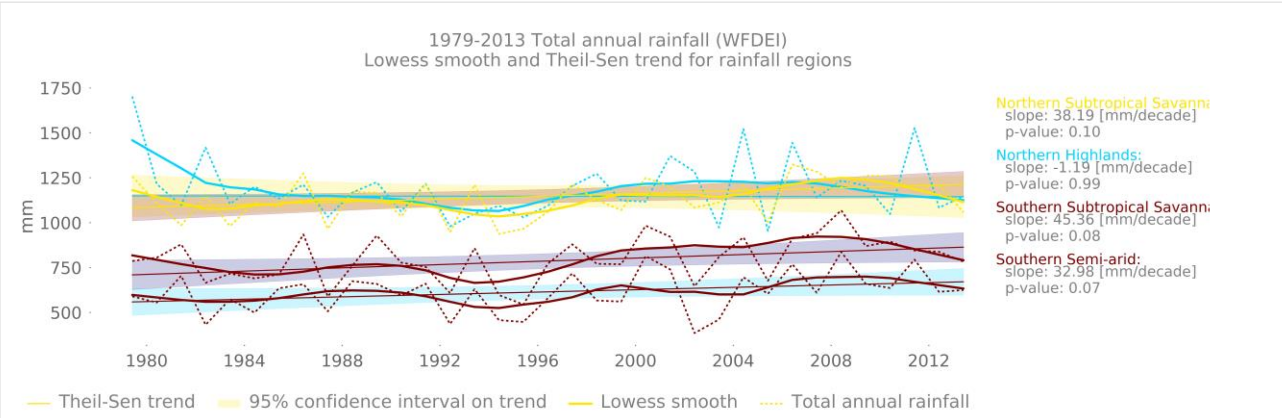


Figure A-1: Long term trends and variability in total annual rainfall for rainfall regions

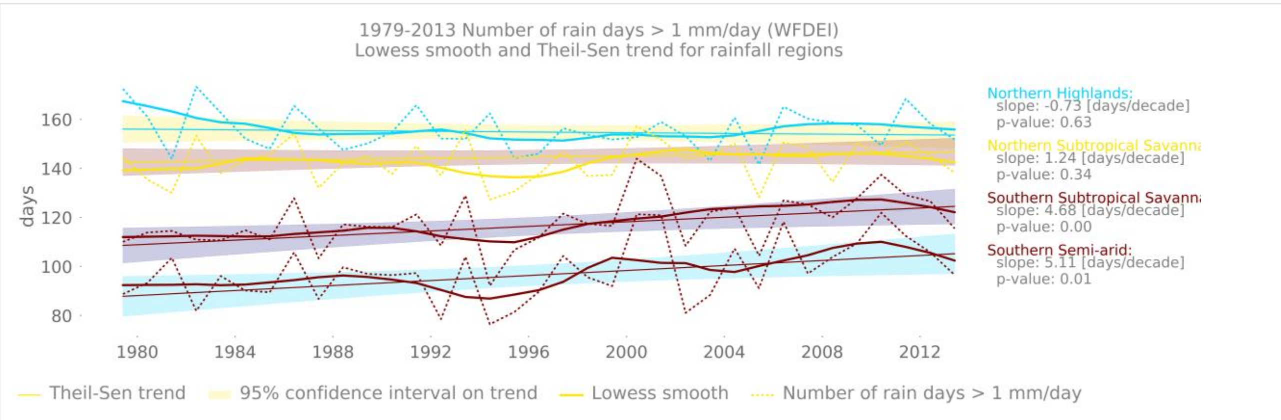


Figure A-2: Long term trends and variability in frequency of rainfall events for rainfall regions

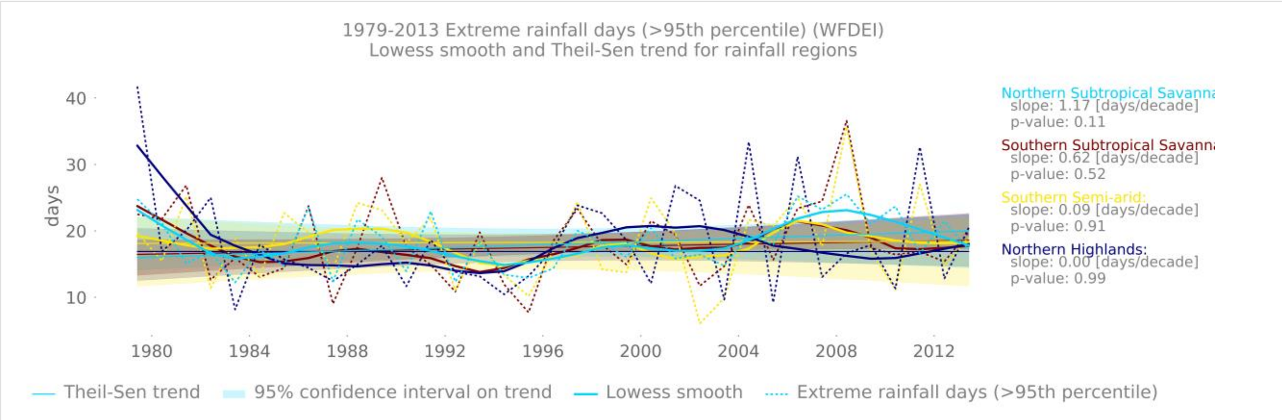


Figure A-3: Long term trends and variability in extreme rainfall events for rainfall regions

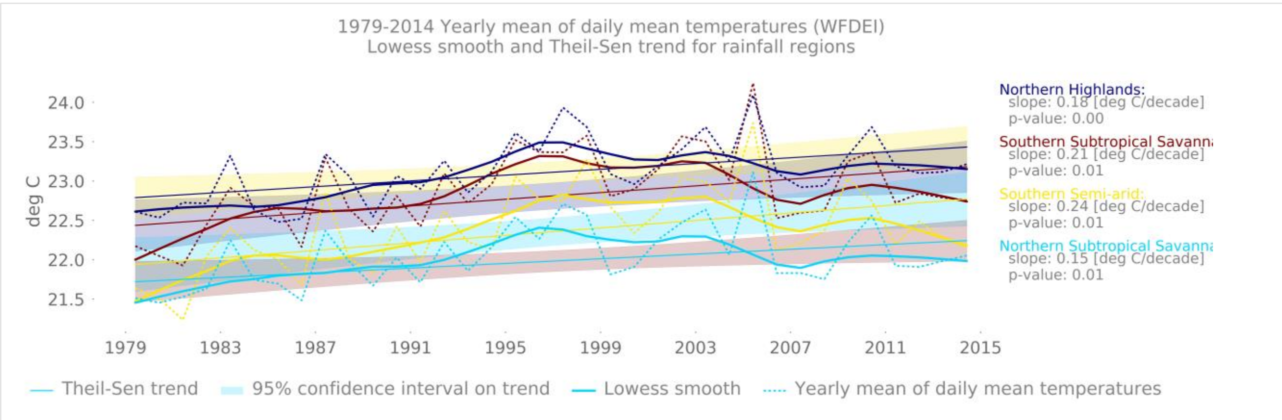


Figure A-4: Long term trends and variability in daily mean air temperatures for rainfall regions

1.c Climate projections visualizations

The plots below (Figures A-5 – A-8) are called plume plots and they are used to represent the different long-term projections across the multiple climate models in the CMIP5 model archive used to inform the IPCC AR5 report. The plots show projected variations in different variables averaged over the climate regions. The blue colours indicate variations that would be considered within the range of natural variability, so in other words, not necessarily the result of climate change. The orange colours indicate projection time series where the changes would be considered outside of the range of natural variability and so likely a response to climate change. It is important to note that these are global climate model projections and so likely do not capture local scale features such as topography and land ocean boundary dynamics. They also may not capture small scale features such as severe thunderstorms that can have important societal impacts. Finally, these projections are averages over relatively large spatial areas and it is possible that different messages would be obtained at small spatial scales and if various forms of downscaling are performed.

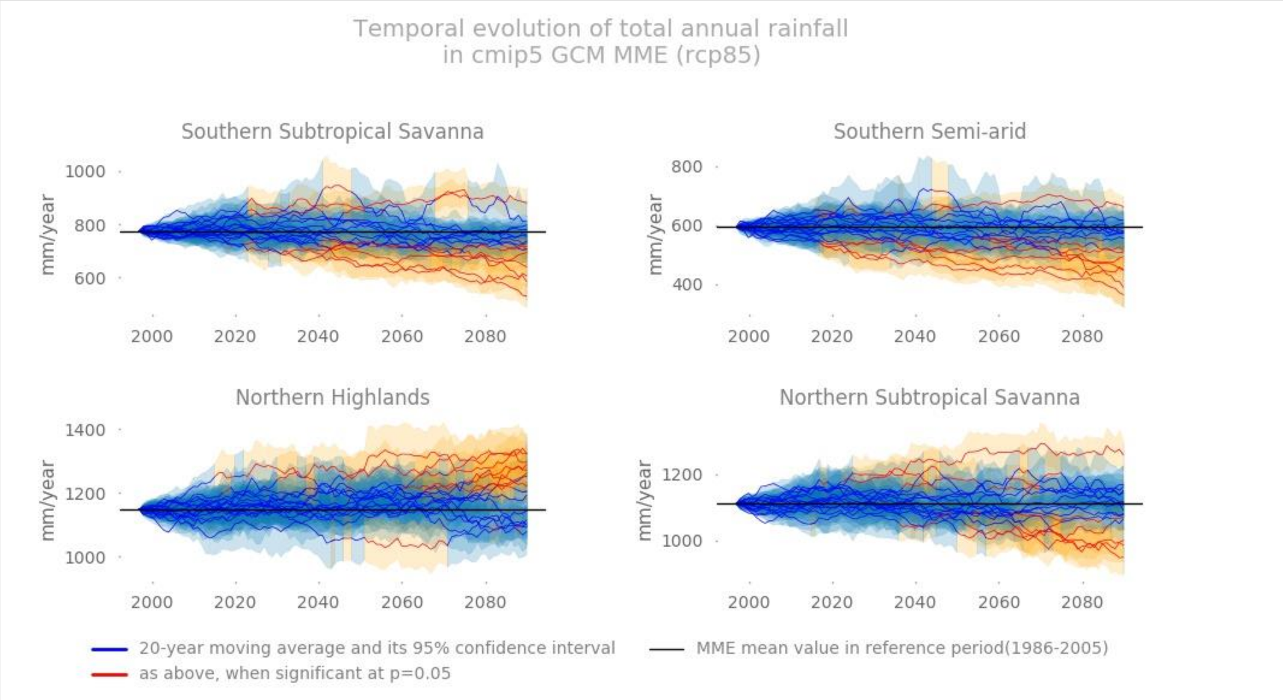


Figure A-5: Projected changes and emergence of changes in total annual rainfall

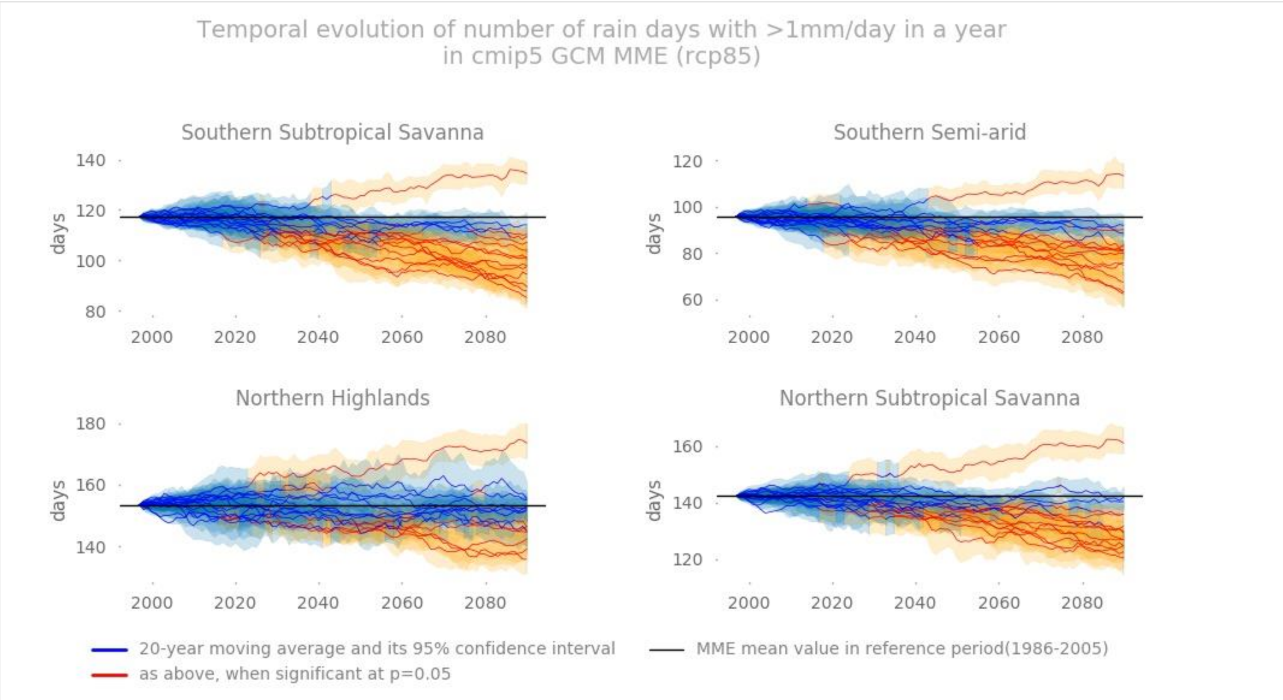


Figure A-6: Projected changes and emergence of changes in number of rain days per year

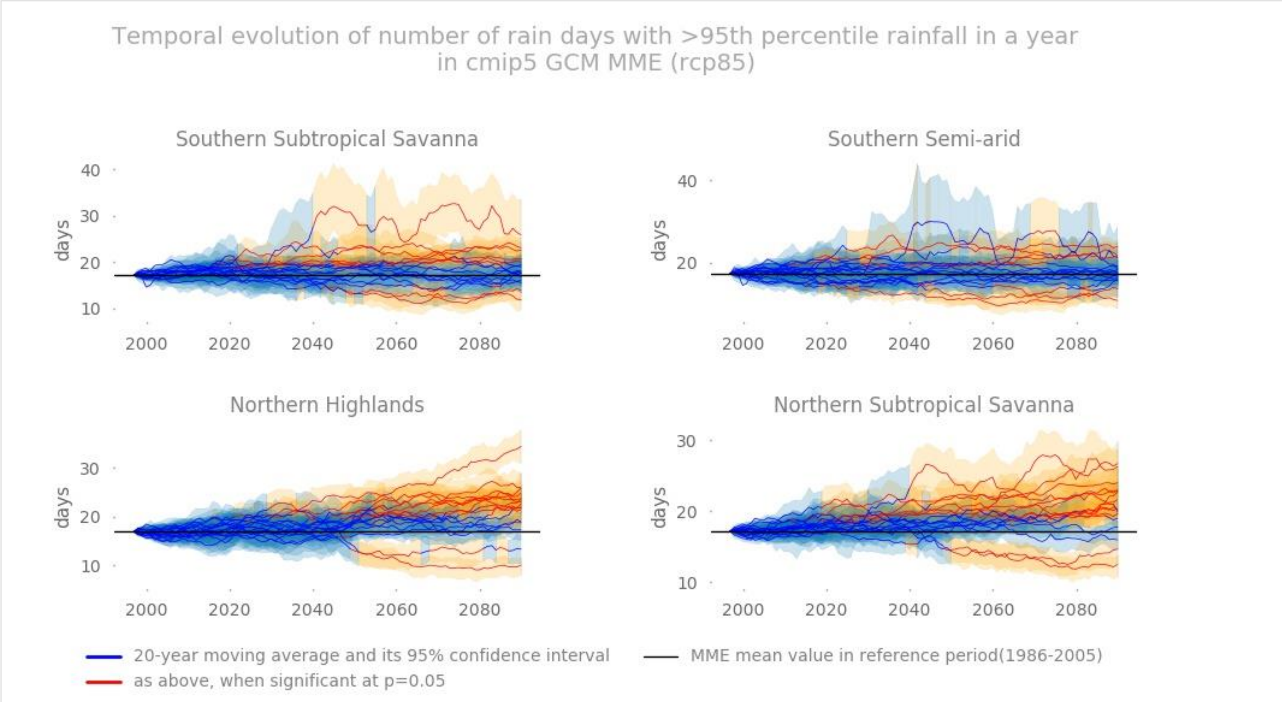


Figure A-7: Projected changes and emergence of changes in number of very heavy rainfall days (greater than 95th percentile) per year

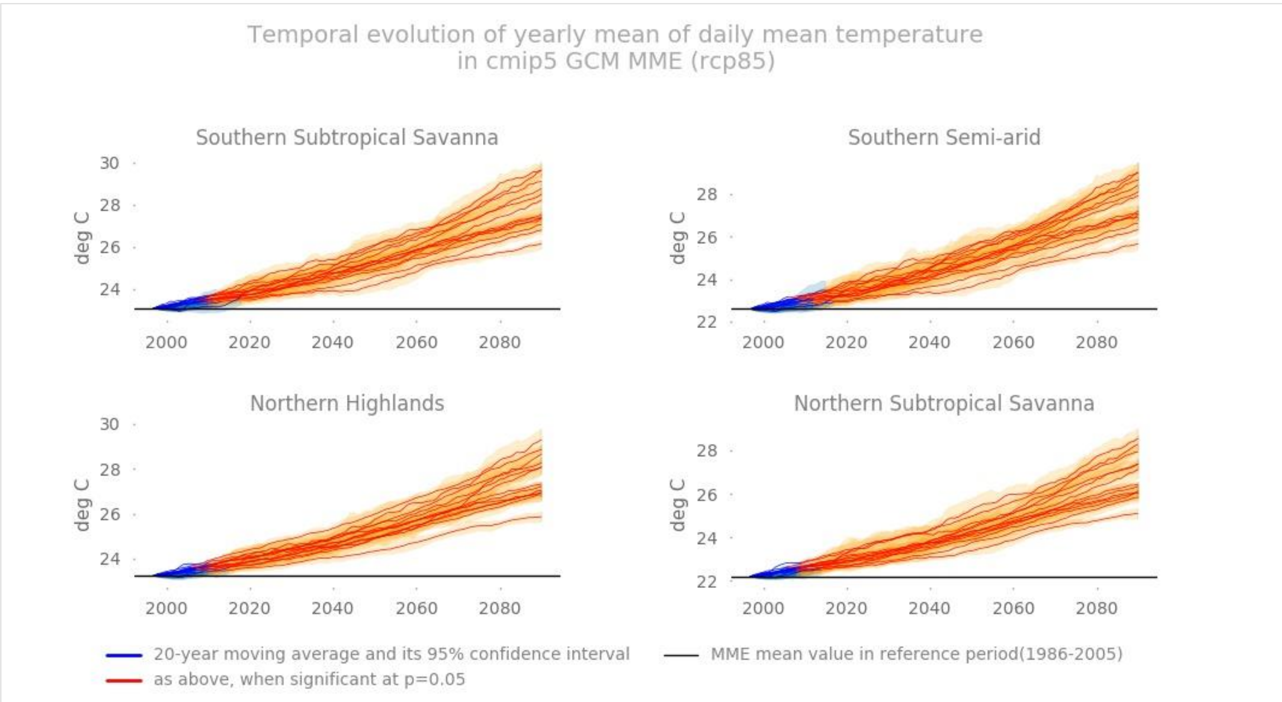


Figure A-8: Projected changes and emergence of changes in annual mean daily mean temperatures

7. REFERENCES

1. Worldometers. (2017). African countries by population. Retrieved from http://www.worldometers.info/population/countries-in-africa-by-population/
2. World Bank. (2016). Data Bank. Retrieved from http://databank.worldbank.org/data/home.aspx
3. African Economic Outlook. (2010). Statistics. Retrieved from http://www.africaneconomicoutlook.org/en/statistics
4. African Economic Outlook. (2014). Statistics. Retrieved from http://www.africaneconomicoutlook.org/en/statistics
5. UNDP. (2016). Human Development Report (Data for 2015). Retrieved from http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf
6. World Bank. (2014). Data Bank. Retrieved from http://databank.worldbank.org/data/home.aspx
7. World Bank. (2012). Data Bank. Retrieved from http://databank.worldbank.org/data/home.aspx
8. World Bank. (2015). Data Bank. Retrieved from http://databank.worldbank.org/data/home.aspx
9. Emergency Events Database. (2017). Disaster List (1996-2016). Retrieved from http://emdat.be/emdat_db/
10. ND GAIN. (2015). Country Rankings. Retrieved from http://index.gain.org/ranking
11. International Energy Agency. (2014). Energy balances. Retrieved from www.iea.org/statistics/statisticssearch/
12. World Bank. (2013). Data Bank. Retrieved from http://databank.worldbank.org/data/home.aspx
13. International Energy Agency. (2013). CO2 emissions. Retrieved from http://www.iea.org/statistics/topics/CO2emissions/
14. World Resources Institute. (2013). CAIT Climate Data Explorer. Retrieved from http://cait.wri.org/
15. Food and Agriculture Organisation. (2014). FAOSTAT Data. Retrieved from http://www.fao.org/faostat/en/#data
16. Derived from Global Forest Watch. (2017). Country Profiles. Retrieved from http://www.globalforestwatch.org/
17. Derived from Global Forest Watch. (2015). Mean 2001-2014. Retrieved from http://www.globalforestwatch.org/
18. Food and Agriculture Organisation. (2011). FAOSTAT Data. Retrieved from http://www.fao.org/faostat/en/#data