SENEGAL

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.

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ACKNOWLEDGEMENT

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1. BACKGROUND

1.1 Geographic and socio-economic context

Senegal is a coastal country at the western-most point of Africa, situated at the transition between Africa's humid tropics in the south and the semi-arid/arid Sahel region to the north. Senegal is bordered by the Atlantic Ocean at the west coast, Mauritania at the northern border of the Senegal River, Mali at the eastern interior, and by Guinea and Guinea-Bissau at the south of the so-called Casamance area. The centre of Senegal is also bisected by the small state of Gambia, penetrating ~320 km inland along the length of the Gambia River. The population of Senegal is estimated to be ~16.1 million people, of which ~42% are estimated to live in urban areas. On average, the national population density is moderately dense (~83 people/km^2, ranked as 19th most dense in Africa) but varies widely between the densely-populated provinces of Dakar, Thies and Diourbel, the moderately dense high-rainfall provinces in the south, and the arid and remote provinces in the north (Louga, St. Louis) and the eastern interior (Tambacounda). Senegal's economy is largely based on natural resources including fish, groundnuts, livestock, and minerals such as iron and phosphates. In addition, the economy is increasingly diversified to include tourism and services. Senegal is one of the larger and more prosperous economies in the ECOWAS (Economic Community of West African States) region and is increasingly serving as a regional hub for logistics, services, transport and trade, with an estimated GDP of USD ~14.8 billion (20th largest in Africa); however, poverty and income inequality remain widespread with an average GDP/capita of ~USD 958 / year and over 38% of the population living below the poverty line. Both the GINI coefficient and gender inequality index are high for Senegal further reflecting these disparities. Senegal's ND-GAIN index is 42.5. This index summarizes the country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience and for Senegal indicates that the country has both a great need for investment and innovations to improve readiness and a great urgency for action. As a result of the climatic diversity across the country's regions, ranging from the humid tropical Casamance region in the south towards the aridity of the north and north-west interior, Senegal is vulnerable to climate-related hazards such as drought and rainfall variability, as well as floods. It is estimated that droughts resulted in negative impacts on at least 1.7 million Senegalese, while floods impacted on an additional 1.16 million people, during the period 1996-present. The country's vulnerability to climate-related hazards such as flooding as well as coastal erosion and coastal surges is increased by the relatively large population in the coastal zone, where ~10 million people are estimated to live within 100km of the coast. Key socio-economic and demographic indicators for Senegal are further presented and summarised in Table 1-1, below.

Figure 1-1: Map of Senegal

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

VARIABLE		SCORE/TOTAL	UNIT	RANK (OUT OF 54)
Geography, Socio-Economy and Demographics				
Population[1]		16,054,275	people	24
Population growth rate[1]		3.0	% population. yr-1	12
Population density[1]		83	People/km2	19
Land area[1]		192,497	km2	35
% Urban population[1]		42.2	% population	24
% Urbanisation rate[2]		3.6	% population. yr-1	29
Economy: total GDP[2]		14.8	USD billions. yr-1	20
Economy: GDP by PPP[2]		40	billion international dollars. yr-1	18
Economy: GDP/capita[2]		958	USD per capita/yr.	27
Population below the poverty line[3]		38.0	% below USD 1.90 per day	24
Gender Inequality Index[4]		52.8		28
GINI co-efficient[3]		40.3		34
HDI[5]		0.49		30
Access to electricity[6]		61.0	% population	17
Summary indicators of climate change vulnerability				
Workforce in agriculture[7]		46.1	% workforce	22
Population undernourished[8]		10.0	% population	27
Number of people affected by drought[9]		1,773,702	people	24
Number of people affected by flood events[9]		1,168,357	people	12
Population living within 100 km of coast[10]		10,054,565	people	9
Population living in informal settlements [6]		39.4	% urban population	36
Incidence of malaria[8]		98	cases per 1000 population at risk	32
ND-Gain Vulnerability Index[11]	Total	42.5		14
	Readiness	0.37		13
	Vulnerability	0.52		35

2. CLIMATE AND WEATHER

Senegal's climate varies from desert in the north to more tropical in the far south. Rainfall occurs in a single season roughly from June to September while the rest of the year remains dry.

The rainfall region or river catchments of Senegal extend far beyond the border of the country to the east into Mauritania and Mali. Climate variations within this larger region occur primarily from north to south and therefore the region is separated into three latitudinal sub-regions. These Senegal regions are illustrated in **Figures 2-1** and **2-2**, below, and summary descriptions can be found in **Table 2-1** below.

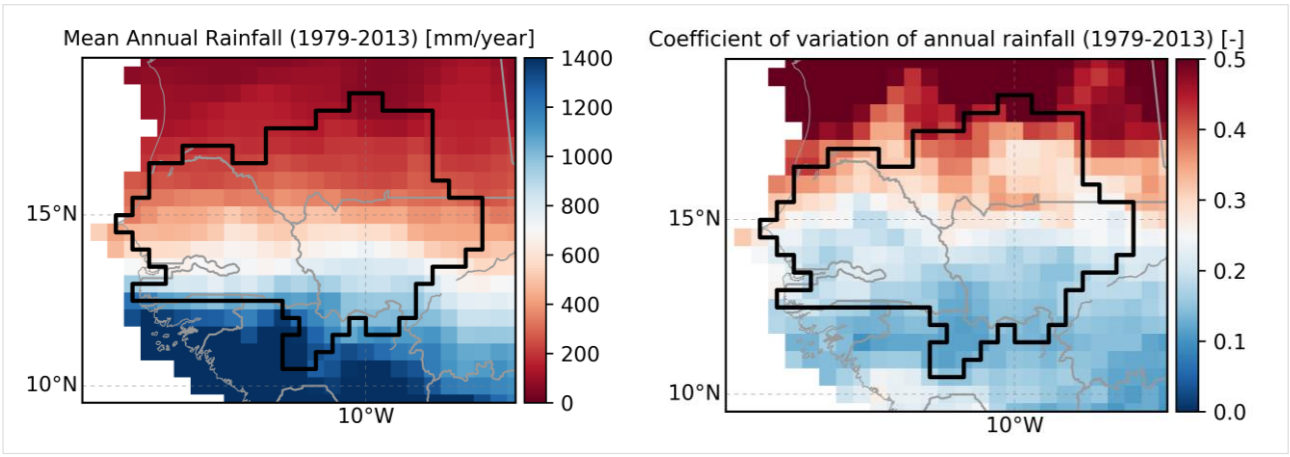
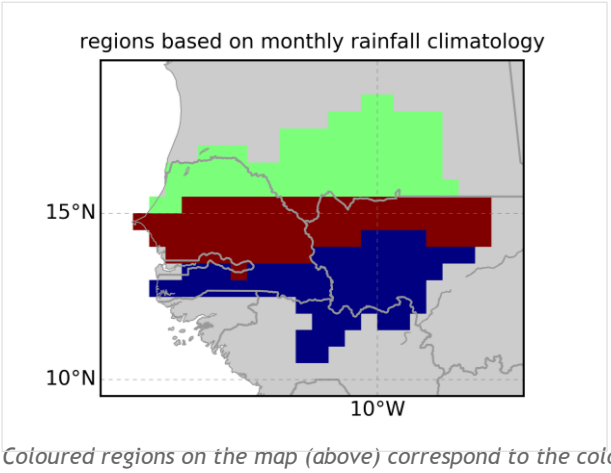


Figure 2-1: Main characteristics (magnitude and variability) of rainfall in Senegal and its region



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

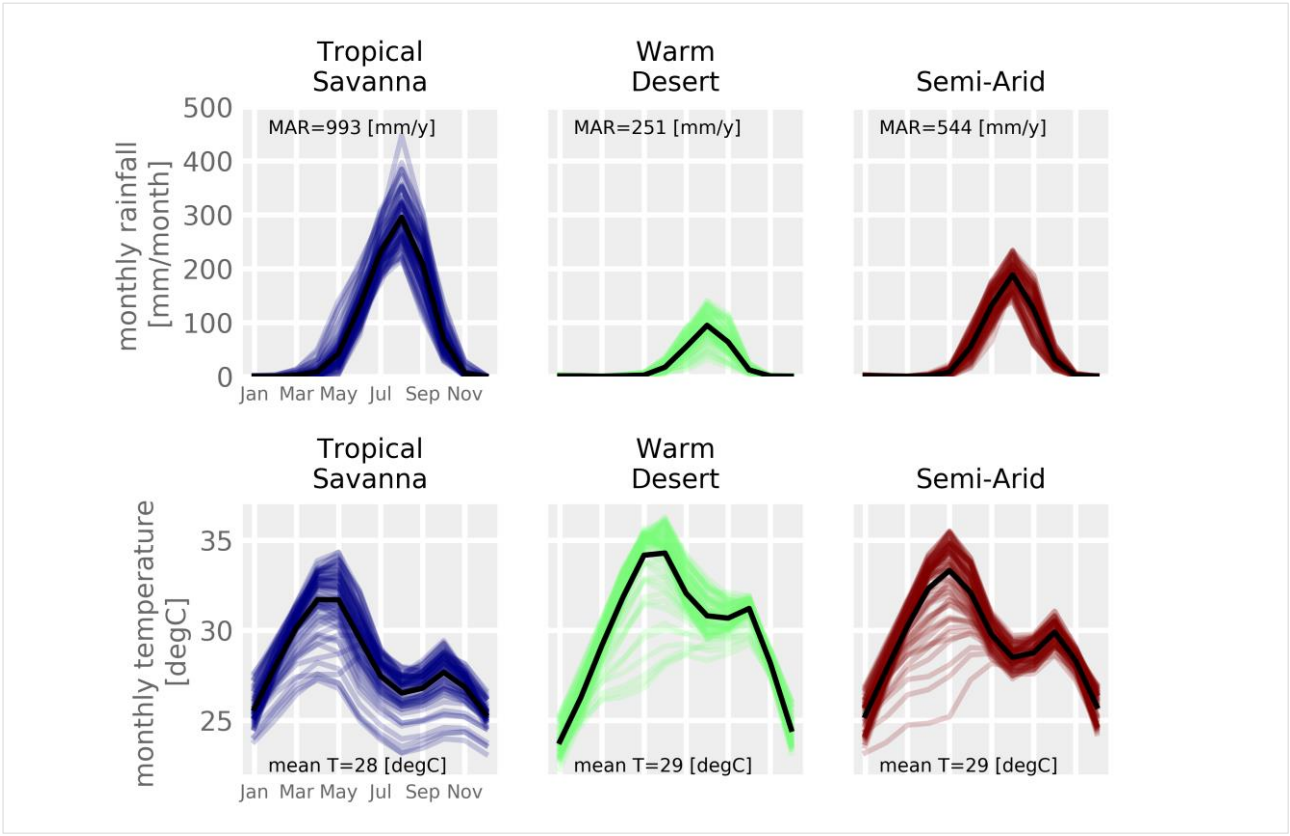


Figure 2-2: Rainfall regions of Senegal based on similarity of standardised rainfall climatology, and their rainfall and temperature climatologies

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

WARM DESERT (SAHEL)	A Sahelian desert region with a daily mean temperature of 29° C and mean annual total rainfall of only 250 mm/year with drier conditions over the north shifting to slightly wetter conditions to the south. Variability of rainfall from year to year is moderate to high. The region has a short rainy season from June to September peaking at around 100 mm/month during August. No rainfall occurs during the rest of the year. The region experiences a strong seasonal cycle of daily mean temperature (~11° C) with warmest temperatures during boreal summer and coolest temperatures during winter.
SEMI-ARID	A semi-arid region with daily mean temperature of 29° C and mean annual total rainfall of just over 540 mm/year with drier conditions over the north and slightly wetter conditions to the south. The variability of rainfall from year to year is generally moderate. The region has a rainy season from June to October peaking at around 200 mm/month during August. No rainfall occurs from November to April. The region experiences a strong seasonal cycle of daily mean temperature (~8° C) with warmest temperatures during boreal summer, though peaking in May – June at the start of the rainy season, and coolest temperatures during winter.
TROPICAL SAVANNA	A more tropical region with daily mean temperature of 28° C and mean annual total rainfall of 990 mm/year and rainfall increasing from north to south over the region. The variability of rainfall from year to year is generally moderate to low. The region has a pronounced rainy season from May to September peaking with 300 mm/month in August. A dry season with very little rainfall occurs from November to March. The region experiences a strong seasonal cycle of daily mean temperature (~7° C) with warmest temperatures during boreal summer, though peaking in May – June at the start of the rainy season, and coolest temperatures during winter.

2.1 Observed historical climate variations and climate change trends

The northern parts of Senegal experience **relatively high rainfall variability** on an inter-annual basis, but this decreases further south as the climate gets wetter. On **decadal time scales** Senegal 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 are statistically significant across the regions and show **increasing temperatures** over the period 1979 – 2015, although that trend appears to be weaker in the second half of that period. Long term trend in total annual rainfall are all strong and statistically significant over all three regions. There are also statistically significant positive trends in the frequency of rainfall events and extreme rainfall events over the 35-year period. Long term trends and variability in the Senegal regions 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 Senegal (1979 - 2015)

REGION	MEAN T [DEG C/DECADE]	TOTAL RAINFALL [MM/DECADE]	EXTREME RAINY DAYS [DAYS/DECADE]	RAINY DAYS [DAYS/DECADE]
Warm Desert (Sahel)	+0.19	+32.6	+2.0	+3.5
Semi-arid	+0.17	+38.7	+2.1	+4.4
Tropical Savanna	+0.19	+36.3	+2.1	+2.8

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

Projected changes in main attributes of climate for the Senegal 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 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 Senegal regions show no consistent signal in annual total rainfall or the frequency of rainfall events or extreme rainfall events by 2050 or 2100.

2.2.2 Projected changes in temperature from present to 2100

Air temperature is projected to be about 1 to 3°C warmer in the Senegal 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 Senegal 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]
Warm Desert (Sahel)	**Increasing** +1.5°C to +3°C by 2050s but changes evident in next decades	No consistent signal in projections	No consistent signal in projections	No consistent signal in projections
Semi-arid	**Increasing** +1.5°C to +3°C by 2050s but changes evident in next decades			
Tropical Savanna	**Increasing** +1°C to +3.5°C by 2050s but changes evident in next decades			

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.

Senegal is a climatically diverse country, with both humid tropical and more arid regions, where an increasing temperature trend is likely to increase the pressure on water resources. This will likely to be more of a concern in the arid north and north-western areas, where severity will to some extent depend on the trajectory of future rainfall for which there is currently no clear direction of change projected. Increasing temperatures and potential changes to rainfall patterns is of further concern for both the economy and for food security, given the important role of agriculture, a highly climate sensitive sector which engages around half of Senegal's work force. However, the economy is diversifying, with increasing emphasis on services and tourism, the latter of which could further be prone to impacts of increasing temperatures and, in coastal areas, sea-level rise and associated stresses. The third of the population living at the coast, and particularly low lying human settlements and associated developments, are further directly vulnerable to sea-level rise and associated stressors.

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

SECTOR	IMPACTS
Agriculture	- Crop loss and reduced yields owing to increased temperatures, changing rainfall patterns and salinization of coastal aquifers - Increased incidence of pests and diseases - **Crop loss owing to shifting rainfall patterns, including delayed onset of rainy season and increased length of dry spells** - Increased migration from rural, inland to urban, coastal areas - Increased potential for conflict between farmers and pastoralists - Desertification and loss of agricultural and grazing land, especially in the more arid inland areas
Fisheries	- Loss of habitat and breeding grounds, especially mangroves - Changed fish migratory patterns owing to changes upwelling and ocean circulation patterns - Increased human migration to the coast, increasing pressure on marine fisheries - Loss of life and property - Increased salinization of Saloum Estuary
Water resources	- Increased variability in run-off leading to decreased surface water availability, especially away from the main river courses - Increased demand for irrigation water, especially for rice near the Senegal river - Reduced water storage, negatively affecting hydropower production - Increased potential for conflict between farmers, fisherfolks and pastoralists over limited water resources - Increased salinization of coastal aquifers
Built infrastructure and human settlements	- Damage to or destruction of coastal infrastructure due to sea level rise and increased storm intensity - Increased migration from rural, inland to coastal, urban areas - **Damage to or destruction of inland infrastructure due to extreme events, especially flooding**
Human health	- Increased prevalence of vector-borne diseases such as malaria - **Increased potential for malnutrition and stunting, especially during drought** - **Increased potential for water-borne diseases, especially during floods** - Increased prevalence of respiratory diseases due to increased Harmattan winds in the more arid inland areas

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

The major carriers of Senegal'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 Senegal's agriculture sector, historical land use change and vegetation cover.

3.1 National energy production and consumption

The energy sector of Senegal is characterised by a split between the domestic collection and use of biofuels, primarily to supply domestic energy as well as for various commercial and industrial purposes, and the importation of fossil fuels (oil and gas) to generate electricity and meet the demands of the transport, industrial and manufacturing sectors. The country has no exploitable reserves of fossil fuels and as a result is particularly vulnerable to fluctuations in fuel price, availability and exchange rates.

In terms of total national production of energy, biofuels (largely in the form of woody biomass such as firewood and charcoal but also including livestock dung in some areas) contribute ~96% (1.8 MTOE out of a national total of 1.9 MTOE energy produced). Electricity is mainly generated by oil (~84%) and gas (4%), in addition to which some hydroelectricity facilities contribute an additional ~8.6%. At present, non-hydro renewable energy contributes a relatively small share of ~1.8% to electricity, however it is anticipated that this share will increase through the development of solar, wind, and additional hydroelectricity facilities (Table 3-1).

With respect to total national consumption of energy, biofuels and oil contribute ~1.1 MTOE each, out of a total national consumption of 2.7 MTOE per annum. Consumption of electricity (largely generated by oil and gas) accounts for an additional 0.3 MTOE, followed by coal (0.2 MTOE) (Table 3-2). Figures reported by IEA do not include estimates of total national consumption of gas, however, it is likely that LPG fuels contribute more towards domestic energy use than these figures suggest. Senegal previously implemented a program to subsidise the costs of LPG and therefore reduce the urban demand for charcoal which drives environmental degradation and desertification. However, the removal of the LPG subsidy in ~2009 resulted in significant increases in charcoal demand, as the majority of urban Senegalese could not afford the unsubsidised LPG and have limited access to electricity.

Table 3-3 summarises the sectors that account for the majority of national energy consumption. The residential sector is estimated to consume ~1.3 MTOE out of a total of 2.7 MTOE, which is largely consumed as biomass as well as some electricity and LPG. The second-largest consumer of energy is the transport sector, accounting for 0.8 MTOE, which is largely consumed as oil by road transport. Finally, the industrial sector consumes ~0.4 MTOE, which is likely to be consumed as oil (e.g. for powering generators and machinery) as well as biomass (both for powering biomass-fuelled boilers as well as for direct heating, such as in food processing). Commercial and public services, agriculture and fishers, and other non-specified energy uses account for the small remaining share of energy consumption (the latter activities cumulatively accounting for ~0.2 MTOE).

With respect to national energy consumption of 7.7 MTOE, biofuels contribute 5.3 MTOE, electricity contributes 0.5 MTOE and direct consumption of gas contributes 0.3 MTOE (used for domestic as well as industrial applications). National consumption of oil is estimated to be ~1.7 MTOE, including domestic as well as imported resources (Table 3-2). Despite the large contribution of oil and gas exports to GDP, oil products contribute only ~26% to total national energy consumption while the remaining majority of national energy consumption is provided by biofuels in the domestic sector (residential sector consumes ~5.1 MTOE out of a national consumption total of 7.7 MTOE). Commercial and industrial sectors, transport and public services are the next-largest consumers of energy, accounting for ~2.5 MTOE (of which ~1 MTOE is consumed by transport). The sectors of agriculture, forestry and non-energy uses collectively consume a further ~0.2 MTOE of energy (Table 3-3). The total annual GHGs emitted by the abovementioned sectors and fuel carriers are described further in Section 3.2.

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].

The tables and figures below describe Senegal's energy sector, including total national energy production, primary energy supply and national energy consumption by fuel carrier and sector.

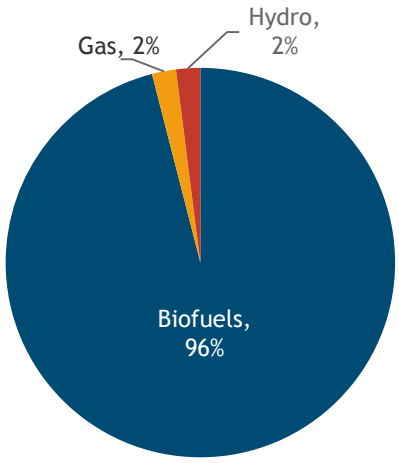


Figure 3-1: Distribution of Senegal's national energy production between major energy carriers (2014-2016)

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

NATIONAL ENERGY PRODUCTION		
Source	**Total (MTOE)** [1]	**% of total energy production**
Gas[12]	0.04	2.1
Hydro[12]	0.03	1.50
Biofuels[12]	1.79	95.51
Total national energy production	1.87	
Electricity[6]2	Hydro	8.8
	Non-Hydro renewable	1.8
	Oil	85.1
	Gas	4.3

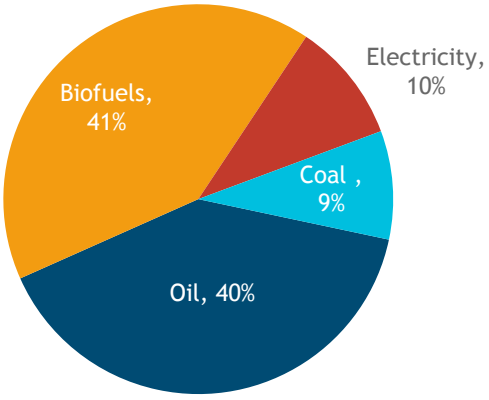


Figure 3-2: Distribution of Senegal's national energy consumption by major energy carriers

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

CONSUMPTION BY ENERGY SOURCE[12]	
Source	**Total (MTOE)**
Coal	0.2
Oil	1.1
Biofuels	1.1
Electricity	0.3
Total national energy consumption by source	2.7

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

[2] *As a result of inconsistencies and gaps in the underlying data, figures for electricity generation derived from the World Bank Data Bank have been adjusted to account for data gaps and are considered to be indicative estimates.*

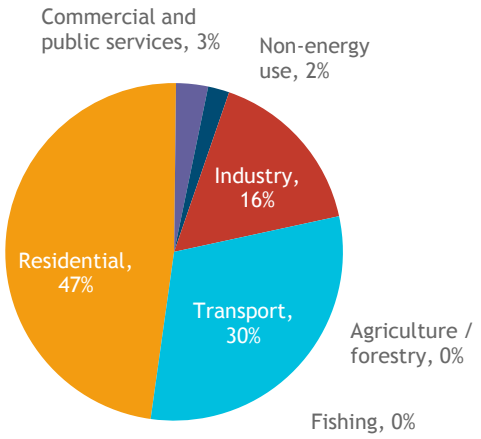


Figure 3-3: Distribution of Senegal's national energy consumption by sector (2014-2016)

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

CONSUMPTION BY SECTOR[12]	
Source	**Total (MTOE)**
Industry	0.4
Transport	0.8
Residential	1.3
Commercial and public services	0.1
Agriculture / forestry	0.0
Non-specified	0.0
Non-energy use	0.1
Total national energy consumption by sector	2.7

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

TOTAL PRIMARY ENERGY SUPPLY[10]		
Source		**Total (MTOE)**
Coal		0.2
Oil	Crude Oil	0.9
	Oil Products	0.9
Gas		0.0
Hydro		0.0
Biofuels		1.8
Electricity		0.00
Total primary energy supply		4.0

3.2 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). These 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.

3.2.1 GHG emissions from fuel combustion, by source and sector

Oil is the largest single contributor to Senegal's GHG emissions from fuel combustion, contributing 5.1 out of a total of 6 MT CO_2e (IEA, 2013), followed by GHG emissions from coal (0.9 MT CO_2e) and gas (0.1 MT

CO_2e). As described in Section 3.1, Senegal is dependent on oil imports to power electricity generation, the transport sector and off-grid applications in the manufacturing and construction industries. The latter sectors collectively account for 5.5 MT CO2e out of a total of 6-8.8 MT CO2e emitted by fuel combustion (including emissions of ~2.2 MT CO2e from generation of electricity and heat, ~2.3 MT CO2e emitted by the transport sector and 1.1 MT CO2e from manufacturing industries and construction (Table 3-5).

As described in Table 3-6, below, additional emissions of up to ~3.3 MT CO2e are attributed to other fuel combustion activities. The latter emissions could potentially be attributed to a diverse array of activities, including private generators and off-grid uses by businesses, households, and farmers. Furthermore, as noted in Table 3-6, Senegal's emissions of ~6-8.8 MT CO2e from fuel combustion and primary energy use is a relatively small contribution to the total national emissions from all sources and activities, estimated to be ~30.8 MT CO2e including secondary emissions from sectors including industry, agriculture, forestry and waste management. The largest contributors to Senegal's GHG emissions are the sectors of agriculture (~11 MT CO2e) and land use change and forestry (~5.3 MT CO2e), accounting for over half of total national GHG emissions. The activities which drive emissions from the latter sectors are likely to include inter alia emissions related to household energy needs, particularly collection of firewood and production of charcoal. In addition, emissions from Senegal's agriculture sector are driven by clearance of vegetation for expansion of agriculture, degradation and loss of land cover as a result of overgrazing, and emissions related to enteric fermentation and manure management in the livestock sector (described further in Table 3-7, Section 3.2.3).

Table 3-5: Senegal'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		5.1
Gas		0.1
Total fuel source emissions		**6.0**
Electricity and heat production		2.2
Other energy industry own use*		0.0
Manufacturing industries and construction		1.1
Transport	Road	2.2
	Other	0.1
	Total	2.3
Other	Residential	0.3
	Non-residential	0.0
	Total	0.3
Total sector emissions		6.0

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

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

Table 3-6: Senegal'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	2.2
	Manufacturing and construction	1.1
	Transport	2.3
	Other fuel combustion	3.1
	Fugitive emissions	0.0
	Energy sub-total	8.8
Industrial processes		2.7
Agriculture		11.0
Waste		3.0
Land use change and forestry (LUCF)		5.3
Total emissions (including LUCF)		30.8

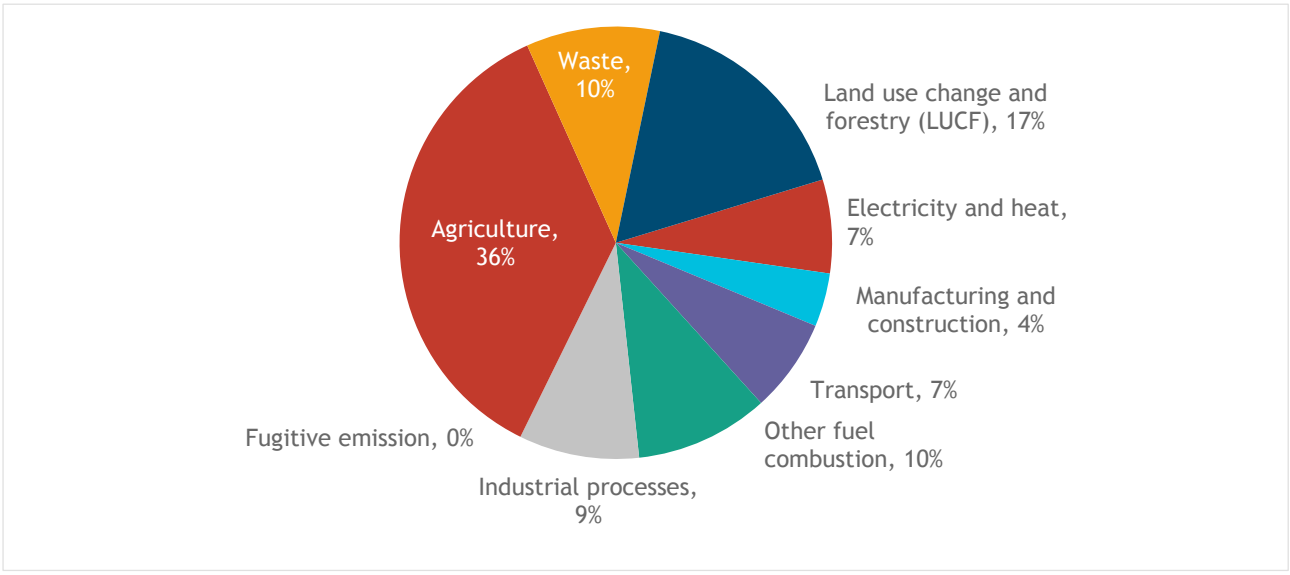


Figure 3-4: Distribution of Senegal's GHG emissions by major sectors

3.2.3 GHG emissions from agricultural practices

Senegal's total annual GHG emissions from the sectors of agriculture, forestry and land use change contribute ~15.7–22 MT CO_2e (Tables 3-6, 3-7). Table 3-7, below, estimates the activity-level emissions within these sectors. The agriculture sector, which contributes emissions of ~10.6–11 MT CO_2e includes emissions of ~7.5 MT CO_2e from activities related to enteric fermentation and manure management in the livestock sector. Crop production generates emissions of ~3 MT CO_2e of which 2.6 is contributed by burning of savanna, 0.2 MT CO_2e from rice cultivation, and 0.1 MT CO_2e each from crop residues and synthetic fertilisers.

Senegal's emissions from land use change, totalling ~5.1–5.3 MT CO_2e, include 4.4 MT CO_2e from forest land and an additional 0.7 MT CO_2e from burning of biomass – activities in these areas include clearance for expansion of new farmlands, harvesting of woody biomass as domestic fuel and removal of timber for forestry. Table 3-8, below, provides further detail on emissions from the land use change and forestry sector in Senegal.

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

VARIABLE		ANNUAL EMISSIONS (MT CO_2E)
Annual GHG emission from agricultural practices [15]	Burning - crop residues	0.0
	Burning - savanna	2.6
	Crop residues	0.1
	Enteric fermentation	4.0
	Manure management	0.3
	Manure applied to soils	0.1
	Manure left on pasture	3.1
	Rice cultivation	0.2
	Synthetic fertilizers	0.1
	Sub-total (Agricultural practices)	10.6
Annual GHG emission from land use change [15]	Forest land	4.4
	Burning biomass	0.7
	Sub-total (Land use change)	5.1
Total		15.7

Senegal's diverse environment includes several different classes of wooded vegetation, occurring in mixed mosaics of savanna and sub-tropical woodlands and decreasing in density and canopy cover from the humid sub-tropics of the southern border towards the Gambian border and the arid central midlands. The largest extent of wooded vegetation occurs as Sahelian Acacia savanna, with a canopy cover of ~10-30% and covering an area of ~4.6 million hectares (~23% of total land area). The higher rainfall of the southern Casamance region supports small remaining remnants of dense subtropical forest, occurring as Guinean Forest-Savanna mosaic and containing valuable rosewood, teak and other valuable commercial forestry species. The latter forest areas are mainly confined to forest reserves and are threatened by ongoing illegal logging and timber smuggling into neighbouring Gambia and Guinea-Bissau. Consequently, it is estimated that Senegal's remaining forested areas with canopy cover greater than 30% are limited to approximately ~37,000 hectares (~0.2% of total land area) and are subject to an annual deforestation rate of ~1.3%. Global Forest Watch estimates that the remaining forest and woodland areas of Senegal contain a biomass carbon stock of ~335 million tonnes.

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

VARIABLE		TOTAL (HECTARES)	TOTAL (% OF LAND AREA)	UNIT
Total tree cover [16]	10-30% canopy cover	4,622,504	23.50	% of total land area
	30-50% canopy cover	35,715	0.2	
	50-100% canopy cover	1,621	0.0	
	Total	4,659,841	23.7	
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	1.3	
	Area of agricultural land[18]	9,712,066	49.4	% of total land area

4. SUMMARISED NATIONAL PRIORITIES FOR CLIMATE CHANGE ADAPTATION AND MITIGATION

Senegal'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. The document includes detailed descriptions of the country's major commitments and priorities related to GHG mitigations (Table 4-2, below) as well as major priorities related to adaptation, derived from the draft National Adaptation Plan (NAP) (Table 4-3, further below).

Senegal's NDC indicates that under the unconditional scenario, emission reductions relative to baseline projections will be 3%, 4% and 5% in 2020, 2025 and 2030 respectively and under the conditional scenario, expected emission reductions will be 7%, 15% and 21% for the same years. Senegal's NDC identifies the needs for investment in mitigation actions, which are estimated to require investments of ~USD 6.8 billion, of which USD 5 billion is dependent on identifying conditional sources of financial support. With respect to investment needs for adaptation, Senegal estimates that the total costs for proposed national adaptation actions will be at least ~USD 14.56 billion, including USD 12.725 billion from conditional sources of support as well as a national contribution of ~USD1.832 billion. Senegal's NDC includes detailed estimates of conditional and unconditional adaptation investments within different sectors inter alia agriculture, fisheries, livestock production, water resources, health etc.

Table 4-1, below, gives details on Senegal'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 Senegal's NDC commitments for reduction of GHG emissions

GHG EMISSIONS REPORTED IN NDC (MT CO2E/YR)	BASE LEVEL	REDUCTION TARGET	TARGET YEAR	SECTORS AND GASES	USE OF INTERNATIONAL MARKETS	LAND-USE INCLUSION / ACCOUNTING METHOD
28.12	BAU	(unconditional; conditional)		CO_2, CH_4, N_20; Energy, industrial processes and product use, agriculture, waste	Not mentioned	Land-use and forestry excluded
		3 percent; 7 percent;	2020;			
		4 percent; 15 percent	2025;			
		5 percent; 21 percent	2030			

4.1 National priorities for climate change mitigation

As described in Section 1 and Section 3 (above), Senegal's economy is relatively diverse and urbanised, acting as a regional service and transport hub with well-developed agricultural and fishery sectors. Consequently, the country's NDC identifies detailed mitigation priorities and actions in thematic areas including the energy, industry, transport, waste management and AFOLU (Agriculture, Forestry and Other Land Use) sectors. Within each sector, Senegal's NDC identifies detailed, costed actions for unconditional (i.e. voluntary, nationally budgeted) and conditional (i.e. conditional on external support) actions. Proposed activities and investments within each sector are also 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)

With respect to Senegal's proposed activities to mitigate against climate change through the energy sector, Senegal's proposed NDC mitigation actions include diverse and detailed measures to reduce emissions through generation and distribution of electricity (which at present is primarily generated by fossil fuels). Priorities identified include a strong focus on increased efficiency of generation, transmission and use of electricity. In addition, proposed measures to increase efficient energy use include manufacture and promotion of efficient insulation materials for construction, distribution of efficient LED lighting, implementing compulsory audits of energy footprints of commercial companies and public buildings, and initiating energy demand studies for new construction projects. Senegal's NDC intends to expand renewable energy facilities for off- and on-grid generation of electricity, including multiple unconditional and conditional investments in solar PV, wind turbines, hydroelectricity, and small-scale biogas digesters. In addition, measures are proposed to reduce emissions from charcoal production and use, including distribution of efficient stoves and kilns as well as measures to introduce sustainable harvesting and community management of woodlots for charcoal production.

Mitigation priorities for Senegal's AFOLU sector include conditional and unconditional actions within themes including crop production, livestock management, forest management and use of woodfuel for domestic energy. Proposed activities to reduce deforestation and forest degradation include replication and upscaling of measures to introduce participatory/community management of forest reserves, improved monitoring of forest areas for logging and fires, and regeneration and reforestation of degraded woodlands, forests and mangrove areas. Mitigation actions identified for Senegal's crop production sector include techniques for reducing emissions from flooded rice cultivation, promotion of organic and/or conservation agriculture to increase soil sequestration of carbon, and promotion of integrated farming systems based on mixed agro-forestry, crop and livestock production. The opportunity to utilise livestock production as a feedstock for biogas digesters is noted in priorities for both the agriculture and energy sectors of Senegal's NDC.

Mitigation priorities identified for Senegal's transport sector are based on reducing emissions from vehicles by introduction of integrated public transport systems such as a Rapid Bus Transit system for Dakar. With respect to mitigation options for Senegal's industrial and manufacturing sectors, which contributes annual GHG emissions of ~2.7 MT CO2e, options noted include reduced emissions through adoption of efficient cement production. In the waste management sector (which contributes GHG emissions of ~3 MT CO2e), Senegal aims to construct at least three integrated waste management centres, which will include facilities for recycling as well as capture of methane gas.

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

PRIORITY SECTOR	SECTOR-SPECIFIC ACTION	TECHNOLOGY TYPE[3]
Energy	Enhance distribution of electricity and household fuel	1, 3
	Improve energy efficiency	
	Production of typha-based thermal insulation materials and adoption of the Nubian Vault technique in rural housing and community infrastructure	
	Pilot phase to promote refrigeration equipment	3, 5, 7
	Compulsory audits for large companies	5
	Energy supply studies for new facilities (75 studies / year)	
	Pilot environmental upgrade program	5
	Waste recycling in agro-industry (biogas)	1
Transport	Enhanced public transport: Bus Rapid Transit (BRT) pilot (red line: Dakar/Guédiawaye)	2, 8
Industry	Improve industrial processes: substitution of CO2 with Clinker in the manufacture of cement	3, 5
Waste	Construction of 3 integrated waste recovery centres (CIVDs) in Tivaoune, Touba and Kaolack	1
	Reinforcement of the purification capacity of the STEP de Camberène, Rufisque and installation of new STEPs in the towns of Ziguinchor, Fatick, Kaolack, Kolda, Matam, Joal, Nioro and Bakel	
AFOLU	Program of Recovery and Acceleration of the Cadence of the Senegalese Agriculture (Programme de Relance et d'Accélération de la Cadence de l'Agriculture Sénégalaise: PRACAS)	4, 8
	Reduction of emissions from firewood and charcoal consumption: Participatory management of forests (more than 30 forests with PROGEDE)	

[3] *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.

PRIORITY SECTOR	SECTOR-SPECIFIC ACTION	TECHNOLOGY TYPE[4]
AFOLU (cont)	Reduction of Emissions from Deforestation and Forest Degradation: Strengthening monitoring and participatory management of forests by increasing the number of Forest Service Officers, reforestation, green walls (Grande muraille verte: GMV), eco-villages, annual reforestation and restoration of mangroves by the State and other actors, etc.	4, 8
	Reduction of emissions from bush and pasture fires (BAU: 907,656.2 ha burned on average from 2006 to 2010)	
	Sequestrations due to reforestation of classified forests	

4.2 National priorities for climate change adaptation

Senegal's NDC identifies detailed adaptation priorities for multiple vulnerable sectors, including biodiversity, coastal zones, agriculture, forestry, fisheries, livestock, water and human health. Proposed activities and investments related to adaptation are further 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). The actions identified include a strong focus on safeguarding the livelihoods of vulnerable communities from the impacts of climate change, such as integrated management of natural resources and establishment/strengthening of protected areas to ensure sustained supply of ecosystem services in the water, livestock, agriculture, and fishery sectors. In addition, measures to promote increased adoption of financial services and insurance in productive sectors are identified (such as for fishermen, farmers and pastoral livestock herders). Other institutional-level measures identified for the latter sectors include increased capacity to monitor, report and issue early warnings on disaster- and climate-related risks for the fisheries sector and coastal zone. As a result of the risks of floods and resultant impacts on sanitation and human health, Senegal's NDC prioritises actions including inter alia improvements to urban sanitation and drainage infrastructure, improved planning of urban infrastructure to integrate watersheds and wetlands, and improved surveillance of human health and epidemiology.

Additional adaptation measures proposed for the livestock production sector, which is an important source of livelihood and contributor to Senegal's GDP, include measures to increase access to veterinary services and monitoring of animal health, and on development of improved livestock genetics to increase resilience to climate change. Similarly, adaptation actions proposed for the agriculture sector include promotion of climate-resilient crops and cultivars, promotion of sustainable land management approaches, and integration of farming with on-farm trees and other forms of agroforestry.

[4] *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.

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

PRIORITY SECTOR	SECTOR-SPECIFIC ACTION	TECHNOLOGY TYPE[5]
Biodiversity	Implementation of instruments such as: the "Stratégie et le Plan National d'Action sur la Biodiversité" (SPNAB), the "Politique Nationale de Gestion des Zones Humides (PNZH), the framework bill on biodiversity and protected areas	4, 5
Coastal	Establishment and support of a coastal observatory	5
	Protection of vulnerable areas and / or displacement of vulnerable populations	1
	Scientific and technical studies on restoration of threatened coastal ecosystems	5, 6
Water	Resource management	2
	Integrated water resource management	2, 4
Fishing	Promotion of fisheries insurance	5, 7
	Disaster risk management and prevention	5, 7, 8
	Improved management effectiveness and expansion of marine protected areas and marine parks	2, 4
	Development of sustainable aquaculture and sustainable management of fisheries resources	
Agriculture	Promotion of sustainable land management technologies	4
	Improvement and adaptation of plant and forest production	4
	Promotion of agricultural insurance	1, 5, 7
	Promotion of climate information	6, 7
	Scale up collaborative management of natural resources	4
Livestock	Development of pastoral units	1
	Promotion of pastoral insurance	1, 5, 7
	Genetic improvement of species	1
	Improvement and adaptation of production and animal health;	
Flooding	Strengthening sanitation infrastructure and storm drainage systems in cities	3
	Planning of urban ecosystems integrating watersheds	3, 4
Health	Strengthening and implementation of the epidemiological surveillance system	6, 7

[5] **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 Senegal. 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 (1979-2014) for each of the three climate regions across Senegal. 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 Semi-Arid region has very high inter-annual (400mm in some years to 700mm in other years) and moderate decadal variability (450mm in some decades to 600mm in other decades). The long-term trends is statistically significant and could be around 120mm over the 30-year period.

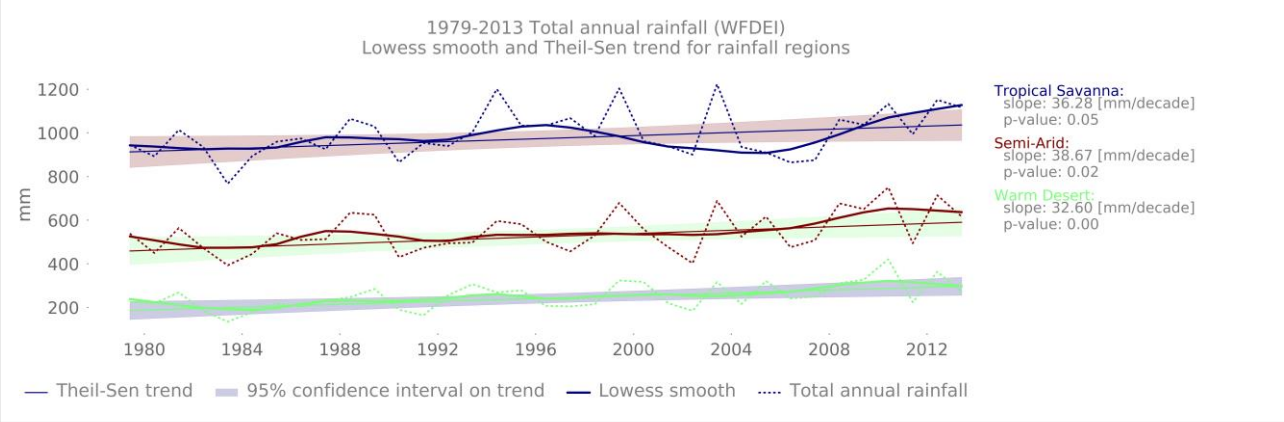


Figure A-1: Long term trends and variability in total annual rainfall for rainfall regions

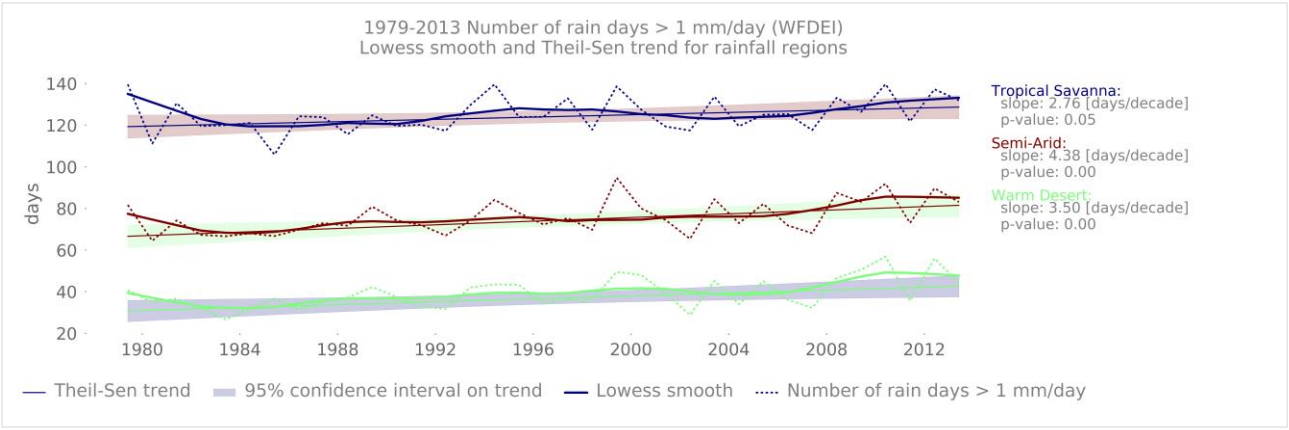


Figure A-2: Long term trends and variability in frequency of rainfall events for rainfall regions

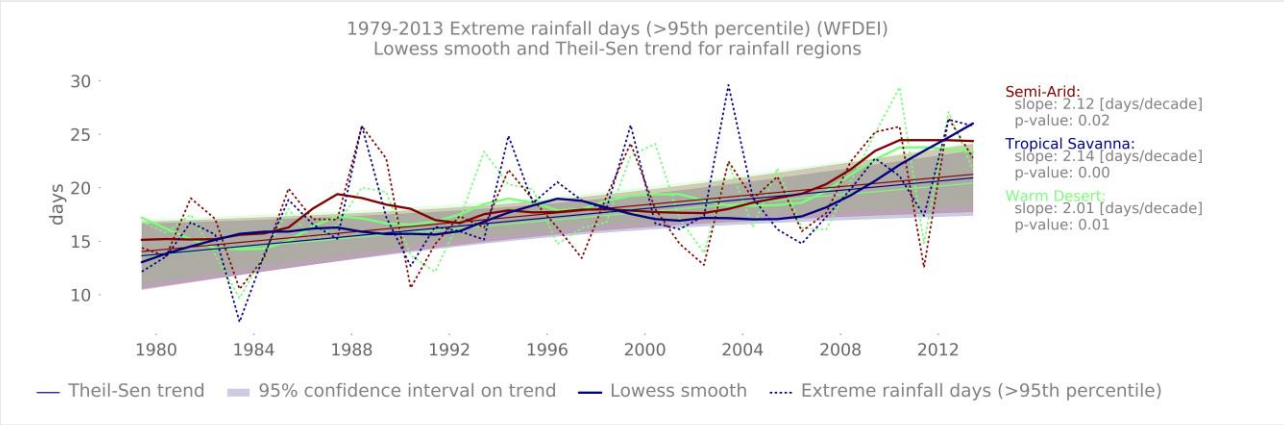


Figure A-3: Long term trends and variability in extreme rainfall events for rainfall regions

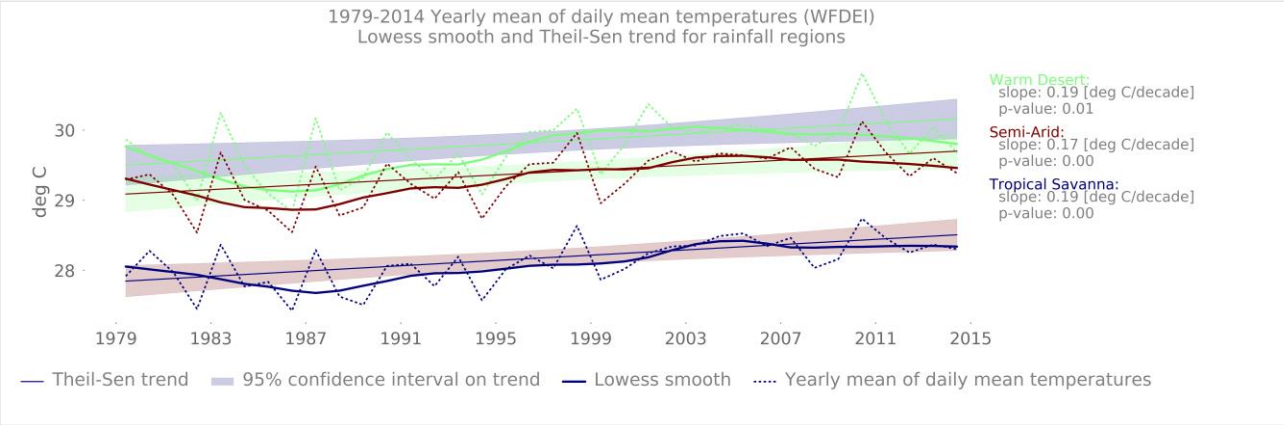


Figure A-4: Long term trends and variability in daily mean air temperatures for rainfall regions

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.

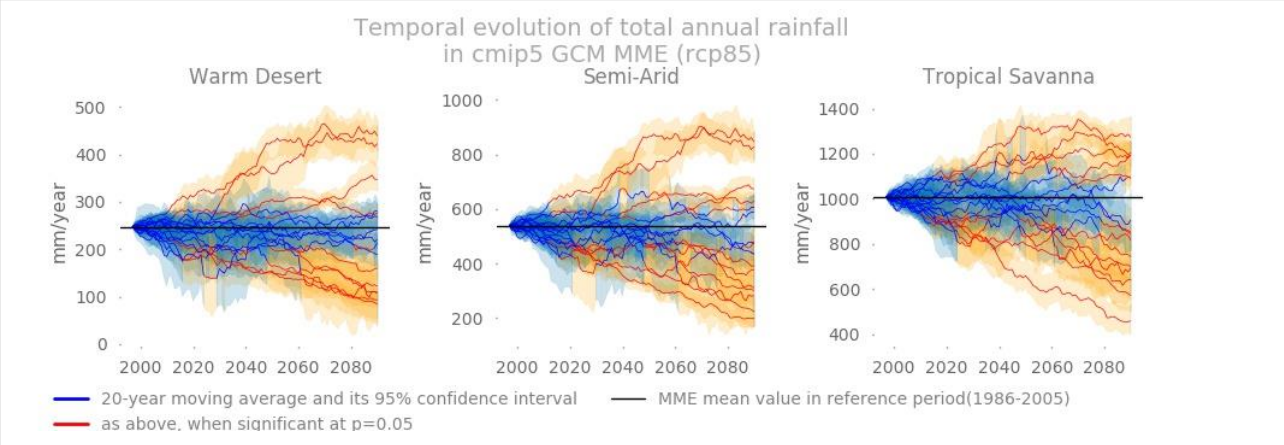


Figure A-5: Projected changes and emergence of changes in total annual rainfall

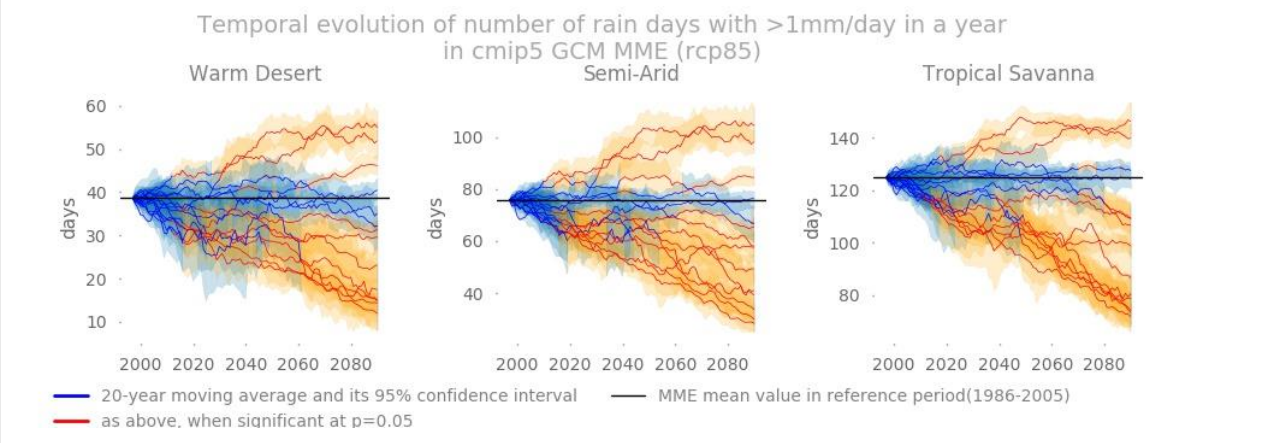


Figure A-6: Projected changes and emergence of changes in number of rain days per year

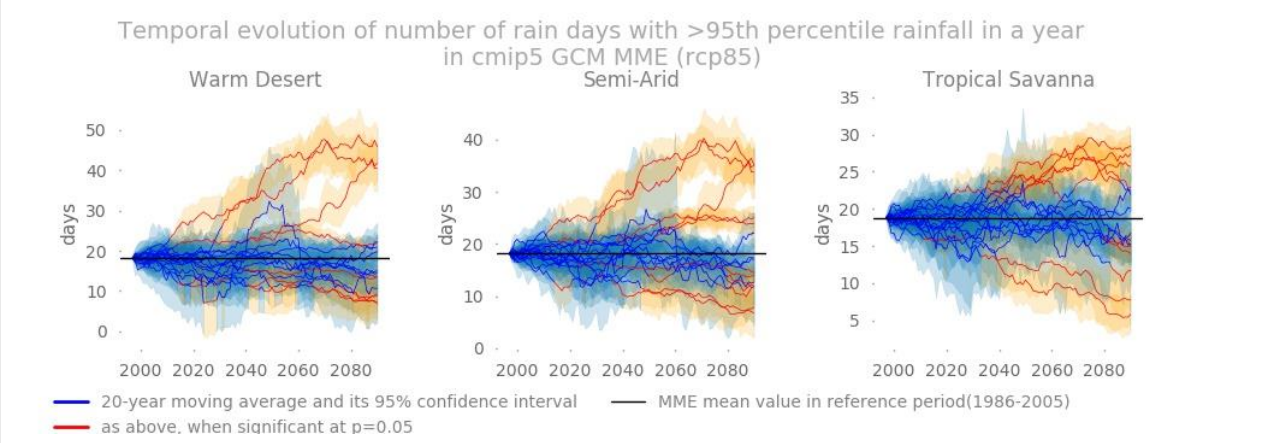


Figure A-7: Projected changes and emergence of changes in number of very heavy rainfall days (greater than 95th percentile) per year

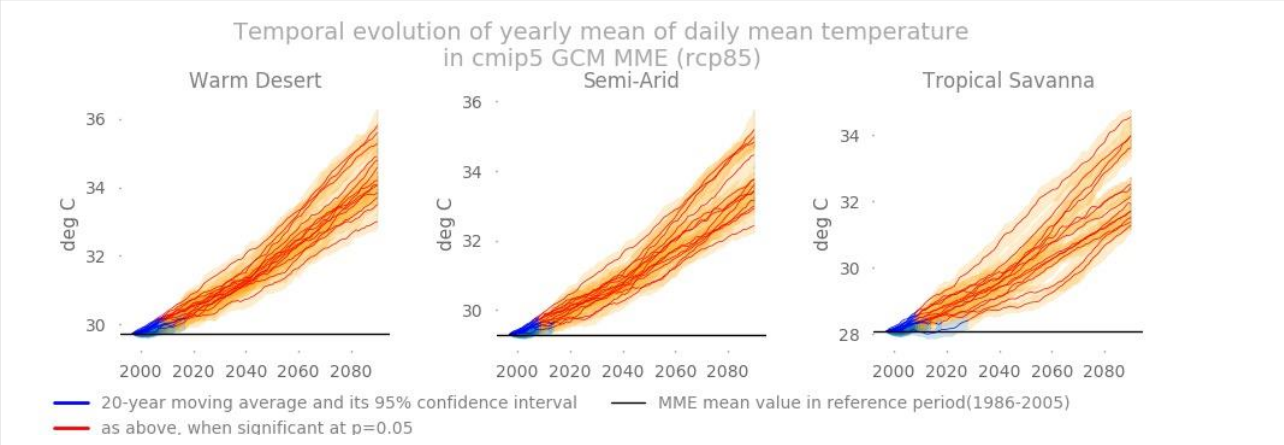


Figure A-8: Projected changes and emergence of changes in annual mean daily mean temperatures

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