



**Securing Permanent Forests to Combat Climate Change
and Enhance Sustainable National and Local Economies in
Cameroon**

ANNEX 22C

**REPORT ON CLIMATE ANALYSIS AND
PROJECT CLIMATE RATIONALE**

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ABBREVIATIONS AND ACRONYMS

ACCF	Africa Climate Change Fund
AEZ	Agro-Ecological Zones
AR6	Sixth Assessment Report
GCF	Green Climate Fund
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
LaRC	Langley Research Center
	National Aeronautics and Space
NASA	Administration
NDC	Nationally Determined Contributions
SMHI	Swedish Meteorological and Hydrological
	United Nations Framework Convention of
UNFCCC	Climate Change
WCRP	World Climate Research Programme
WMO	World Meteorological Organization

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1. INTRODUCTION

The increase in the concentration of greenhouse gases (GHGs) in the atmosphere has culminated in the global climate warming, with anthropogenic activities constituting the main cause. Climate change represents one of the most pressing global environmental issues today, therefore the international community has taken necessary actions to address the problem. In light of this, Cameroon and other signatories to the United Nations Framework Convention of Climate Change (UNFCCC) have taken steps to fight climate change. This includes the elaboration and submission of its Nationally Determined Contributions (NDCs) to the UNFCCC Secretariat in 2015 and a revised version in 2021. Cameroon's current NDCs include plans for curbing GHG emissions and for enhancing the resilience of the national population to the impacts of climate change. However, there is a need for financial resources to implement these plans. To do so, domestic and international climate finance both play a key role.

Within the UNFCCC, the Green Climate Fund (GCF) was established in 2010 to support developing countries in their transition towards a climate-resilient and low-carbon development pathway. Cameroon elaborated its GCF Country Programme which was validated by national stakeholders in 2019 and represents the nation's strategic framework for engagement with the GCF. As part of the GCF process, the International Union for the Conservation of Nature (IUCN), a GCF accredited entity, is supporting the government of Cameroon in the preparation of a full GCF funding proposal titled "Securing permanent forests to combat climate change and enhance sustainable national and local economies in Cameroon". The goal of the project is to reduce emissions from deforestation and forest degradation in permanent forest areas in the country while enhancing resilience as well as social, and economic development at the local and national levels. A strong climate rationale is a prerequisite for approval of a GCF project by the Board. It is within this premise that this climate rationale document is presented as part of the elaboration process of the GCF full proposal. Objectives of this climate rationale analysis are as follows:

- ✓ To depict the climate change profile and trends for the project sites, including evidence for climate change; and
- ✓ To provide a justification for climate change adaptation in the proposed sites for project implementation.

2. METHODOLOGY

The climate rationale analysis was completed through the review of existing literature and the analysis of past and future climatic trends for the different proposed sites (impact areas and intervention areas). For the analysis of past climatic data, it is ideal to obtain data from existing meteorological stations in the different project sites or from locations of close proximity to the proposed project sites. However, access to ground data was challenging due to the inexistence of meteorological services in the proposed sites for the implementation of project activities. In this light, past climatic data for the impact and intervention areas was obtained from the NASA Langley Research Center (LaRC) POWER Project funded by the NASA Earth Science/Applied Science Program and analysed using Microsoft Excel. The future climatic projections for the project sites

were obtained through the use of the climate information tool¹. This web-based tool provides climate change information for any part of the globe and was developed by the Swedish Meteorological and Hydrological Institute (SMHI) on behalf of the GCF, the World Meteorological Organization (WMO) and World Climate Research Programme (WCRP). The tool was developed to support developing countries' access to climatic data so as to enable them to strengthen the climate rationale of their elaborated climate change projects.

3. BASELINE AND CURRENT IMPACTS

3.1. CLIMATE CHANGE IN AFRICA AND CENTRAL AFRICA

The United Nations Intergovernmental Panel on Climate Change (IPCC) observed in its Sixth Assessment Report (AR6) that all land regions in Africa experienced hot extremes and mean temperatures above natural variability relative to the period of 1850-1900. The African continent has witnessed a rapid surface temperature increase compared to the global average, with human-induced climatic changes emerging as a dominant driver. Similarly, over the last three decades, Africa has recorded a higher rate of relative sea level increase than global mean sea level rise. Moreover, there is a projected increase in the frequency and intensity of heavy precipitation events almost everywhere in Africa from additional global warming.

The Central Africa region has recorded changes in climatic parameters. The region has observed a decrease in mean precipitation, decrease in standardized precipitation index, increase in river flooding and an increase in ecological and agricultural droughts³. The Central Africa region is projected to experience an increase in heavy precipitation and pluvial flooding.

3.2. CLIMATE CHANGE AND IMPACTS IN CAMEROON

Over the past two decades, Cameroon has experienced seasonal and frequent extreme climatic events, such as floods and recurrent droughts. These, coupled with the instability of the duration of the rainy seasons, has made climate change emerge as a significant problem for the Cameroonian society⁴.

The northern part of the country has been affected by climate change. The region has suffered recurrent droughts which triggers the prevalence of diseases that expose over three million individuals. This situation is exacerbated in the Far North region of the country with a cereal deficit of 30,000 tonnes culminating in a food insecurity rate of 33.6%. Furthermore, the presence of refugees (57,000) and displaced persons (223,642) further exert pressure on natural resources, including pastures and water points⁵.

¹See: <https://climateinformation.org/>

² IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

³ IPCC (2021)

⁴ NDC (2021)

⁵ SNADDT, Diagnosis 2018

climate change is exerting increasing pressure on Cameroon's main sectors feeding the national budget, which leads to increasing social vulnerabilities and contributing to the degradation of the infrastructure necessary for economic activity. The national agriculture sector is considered as one of the most vulnerable sectors⁶. Climate variation in the country is already causing an alteration of the frequencies, types and intensities of crops and livestock diseases and pests, the availability and timing of water supplies for irrigation as well as the severity of soil erosion⁷. The increasing temperature and declining precipitation trend observed in the country has a negative impact on the agriculture sector through the shortening of the production period, and the loss of agricultural and grazing land (Saha, 2021). This is evident as the agriculture sector of Cameroon is predominantly rainfed and employs a critical mass, an estimated 60% (Republic of Cameroon, 2015), of the nation's population.

3.3. PROJECTED CLIMATE CHANGE IN CAMEROON

Due to its exposure, sensitivity and low adaptive capacity, Cameroon remains very vulnerable to climate change. Climate projection scenarios reveal an increase in temperatures in all five agro-ecological zones (AEZ) of the country (Republic of Cameroon, 2015). The northern Sudano-Sahelian AEZ is projected to experience an increase in temperature of +0.7°C by 2025, +1.2°C by 2035, +2.5°C by 2055, +3.6°C by 2075, and +4.8°C by 2100. In the four remaining AEZs, temperature increase will rise from +0.6°C in 2025 to +3.6°C in 2100⁸. Pertaining to rainfall, the scenarios forecast an overall drier and less rainy climate in the Sudano-Sahelian AEZ, with an increase of 0 to +2% and a higher concentration of rainfall in space and time. There will be a decrease in rainfall in the order of -1 to -5% in the High Savannah (Adamawa) and High Plateau (highlands) AEZs. The Coastal or Littoral AEZ is projected to experience a precipitation increase from 0 to +2% in between 2021 and 2040, while the bimodal forest AEZ will experience an increase in precipitation from -2 to 0%. Overall, a high variability of future rainfall is expected over the whole of Cameroon with values ranging from -12 to +20 mm of rain per month (from -8 to +17%) in the 2100s.

Extreme weather and climate events such as droughts and floods are expected to be more frequent in Cameroon, leading to negative impacts on human health and life with the Sudano-Sahelian AEZ (exposed to drought, desertification and extreme floods) and the coastal zone (severely affected by floods and sea level rise) being the most vulnerable. It is projected that an average of five droughts per decade should be expected in the Sudano-Sahelian AEZ, with a death toll of at least 500 per event. On the other hand, at least five to ten floods per year are projected for the country depending on rainfall intensity⁹.

⁶ Republic of Cameroon. (2015). Plan National d'Adaptation aux Changements Climatiques du Cameroun

⁷ Molua, E. L. (2003). Global Climate Change and Cameroon's Agriculture: Evaluating the Economic Impacts

⁸ Cameroon's revised NDC 2021

⁹ MINEPDED, 2015a, Tchindjang, 2013, Vulnerability study, 2021

4. PROJECT CONTEXT

4.1. PAST AND FUTURE CLIMATE VARIABILITY

4.1.1. SUDANO-SAHELIAN (IMPACT AND INTERVENTION AREAS)

According to a study from Kummu et al. (2021), the Sudano-Sahelian zone is the most vulnerable to climate change as the associated risks have pushed food crops and livestock production outside the safe climatic space, therefore threatening food security in the region. This ecological zone is generally characterized by 8 months of drought and 4 months of rain. The temperatures are relatively low throughout December and February, though they are especially high during March through April. The climatic conditions that occur in this ecological zone are rather harsh, with an agronomic season of between 2 and 3 months, an average annual temperature that exceed 28°C, low average annual precipitation levels of 800mm, and a relative humidity that barely exceeds 60% and that remains low until the rain arrives (ONACC, 2018a).

Past trends:

August is the wettest month in this region, with an average rainfall of 240mm a year, spread over an average of 18 days of rain. The dry season lasts for 7-8 months (October-April), with no visible rainfall between the months of November and February. The evolutionary trends from 1950-2015 of the rainfall parameters are presented in Figure 1. According to these two rainfall parameters, the climate near Maroua, Cameroon is experiencing a progressive decrease in rainfall amounts and a decrease in the number of rainy days per year.

On a seasonal scale, the rain has progressively started earlier around the first half of May and ended earlier around the end of September and the beginning of October. In addition, the recorded rainfall amounts have gradually decreased during the rainy season, while they have increased during the dry season (ONACC, 2018a).

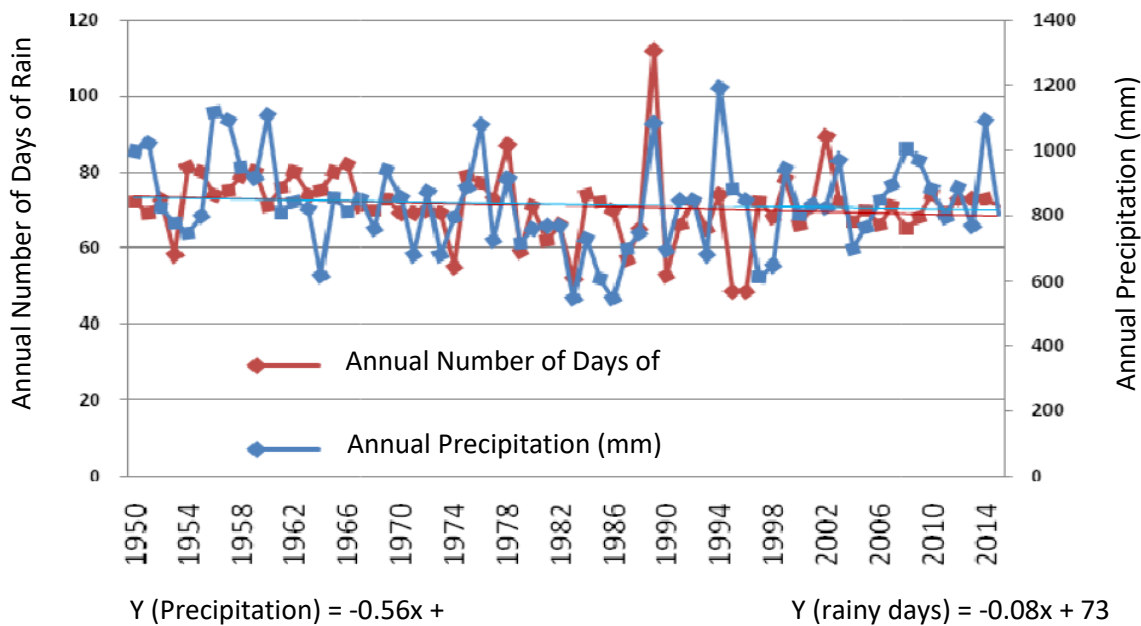


Figure 1: Annual evolution of precipitation and number of rainy days in Maroua from 1950-2015 (ONACC, 2018a)

When looking at temperature data from Maroua, it is typically characterized by a relative decrease in average temperatures starting from the month of March. The temperature starts at 33.3°C, and slowly decreases until the month of November, when the lowest average temperature is observed (28.4°C). The average temperature then suddenly increases back up until March (Figure 2).

Jan

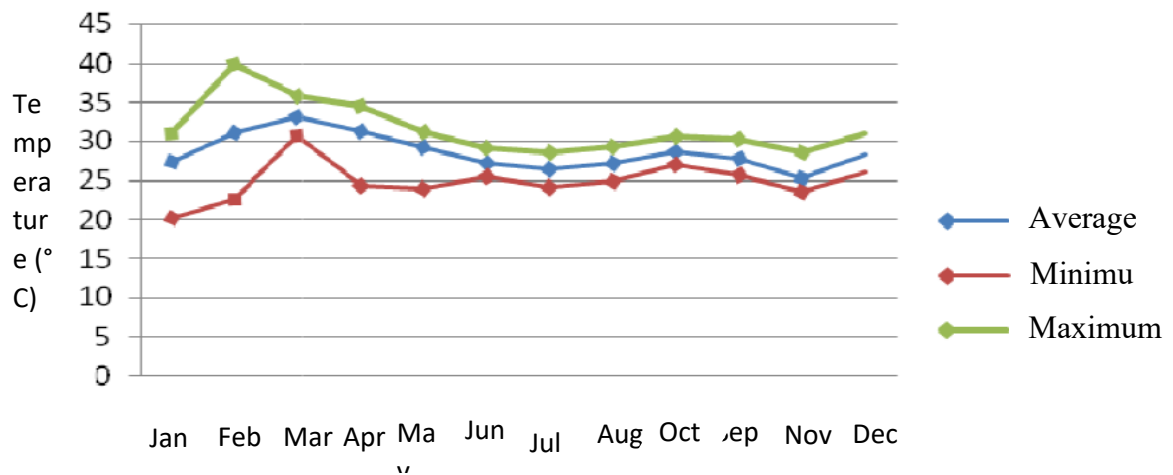
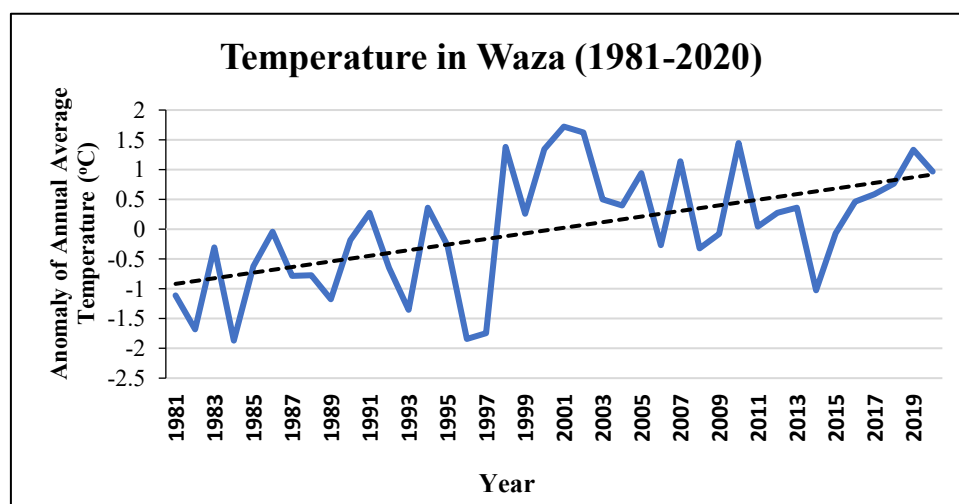


Figure 2: Average monthly temperatures in Maroua from 1950-2015 (ONACC, 2018a).

When looking at the seasonality scale, the trends of the minimal and average temperatures are progressively increasing during the dry and rainy seasons. These temperatures vary considerably from month to month, but when averaging out the 12 months of the year, the average annual temperature has gradually increased from 1950 to 2015. While the maximum temperatures have been greatly fluctuating during the past 40 years, they have been showing a slight decreasing trend. However, the minimal temperatures have been increasing at a significantly higher rate when compared to the average and maximum temperatures (Figure 3), causing an overall small increase in average annual temperatures in the ecoregion.

Figure 3 shows the analysis of past climatic parameters within the project intervention area (Waza) for the Sudano-Sahelian AEZ. The analysis revealed a fluctuation in temperature and precipitation over time. Overall, an increasing temperature trend and a decreasing precipitation trend for Waza is observed over the period of 1981-2020.



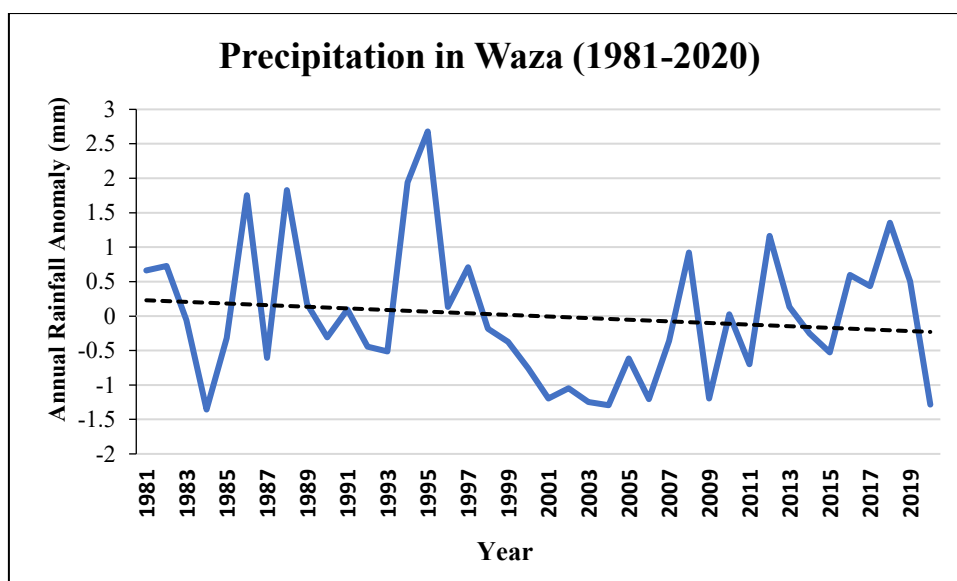


Figure 3: Analysis of past temperature and precipitation data of Waza (1981-2020).

Future trends:

Model projections of the average annual precipitation were carried out by the UNDP (2008), the CSC (2013) and the CSC & WUR (2013). These models indicate significant changes in the distribution of rainfall amounts within the Sudano-Sahelian AEZ. Forecasts show an increase in precipitation towards the end of 2035, followed by a decrease in precipitation between 2075 and 2100. The arid northernmost areas will receive less rainfall in the future, while the southernmost areas of the ecological zone will receive more. Overall, this AEZ is expected to decrease in average annual precipitation from 1-3mm by 2060, and 0-2mm by 2090. By 2030, rainfall will decrease by 12-14mm from March to May. By the year 2060, rainfall will decrease by 14-26mm between the months of June and August, and by 2090, rainfall will decrease 26-54mm between the months of July and November (ONACC, 2018b).

In terms of temperatures, all the modelled scenarios show a warmer climate regardless of the area of the country. However, the Sudano-sahelian AEZ in particular is projected to experience an increase of 0.7°C in average annual temperature by

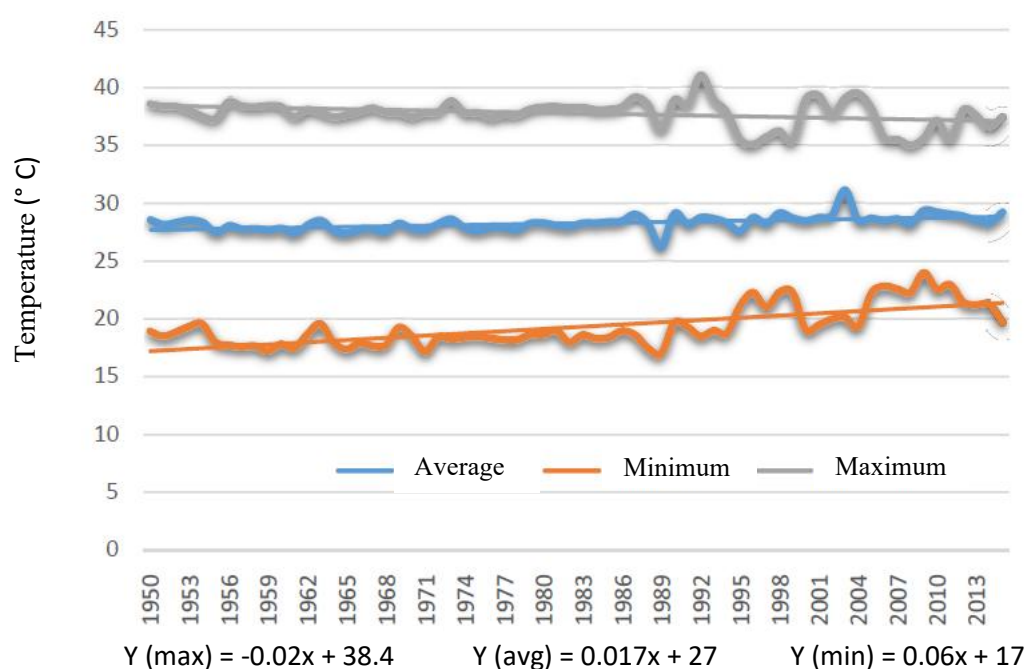


Figure 4: Average, minimum and maximum annual temperatures in Maroua from 1950-2015 (ONACC, 2018a).

2025, 1.2°C in 2035, 2.5°C in 2055, 3.6°C in 2075 and 4.8°C in 2100 (UNDP, 2008; CSC, 2013; CSC & WUR, 2013). The results are not surprising since past trends point to a gradual increase in minimum and average temperatures from 1950 to 2015 that is likely to continue in the decades to come. These substantial projected increases in temperatures are probable in the context where the temperature of the region is strongly influenced by the harmattan and the dry air in the Sahara Desert. Various climate projections indicate that the Sahara will become increasingly hot, which will directly contribute to increasing temperatures. This situation will also be accompanied by an increase in the frequency of hot days and nights in the Sudano-Sahelian zone of Cameroon by 2090 (ONACC, 2018b).

The outcome of the climate projections for the proposed project impact and intervention areas for the Sudano-Sahelian AEZ are explained in the following sections.

a) Climate projections for the impact area

Bénoué

Temperatures for Bénoué are projected to increase across the three time periods of the RCP (2011-2040, 2041-2070, and 2071-2100) compared to the baseline (1981-2010). The precipitation under RCP 8.5 is projected to increase for the period of 2022-2040 under RCP 4.5 while a decrease in precipitation is projected for the other two periods, 2041-2070 and 2071-2100,. The soil moisture is projected to decrease for the periods of 2041-2070 and 2071-2100 under RCP 4.5. Contrarily, an increase is projected for the other periods under both RCPs, with the exception of the period of

2071-2100 under RCP 8.5, which projected no change from the baseline (Table 1). Overall, with the exception of the temperature changes for the periods of 2041-2070 and 2071-2100 under RCP 8.5 which are large, all the other changes in precipitation, temperature and soil moisture are small.

Table 1: Projected climate parameters for Bénoué

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	4
Precipitation (%)	4	-1	-3	1	3	8
Soil moisture (%)	4	-1	-4	1	2	0

Bouba Ndjida

Temperatures and precipitation for this site are projected to increase across the three periods (2011-2040, 2041-2070, and 2071-2100) compared to the baseline (1981-2010). The soil moisture content is projected to increase (RCP 4.5 – 2011-2040; and 2011-2040 – RCP 8.5) and decrease for the other time periods for both RCPs (Table 2). However, with the exception of the projected changes in temperature for RCP 8.5 (2041-2070; and 2071-2100) which are large, the projected changes in precipitation and soil moisture are considered small.

Table 2: Projected climate parameters for Bouba Ndjida

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	4
Precipitation (%)	3	3	4	6	5	7
Soil moisture (%)	1	-2	-4	4	-1	-5

Faro

The precipitation and temperatures for Faro are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). The soil moisture content is projected to increase (RCP 4.5 – 2011-2040; RCP 8.5 - 2011-2040 and 2041-2070) and decrease for the other time periods of both RCPs (Table 3). However, with the exception of the projected changes in temperature for RCP 8.5 (2071-2100) which are large, the projected changes in precipitation and soil moisture are small.

Table 3: Projected climate parameters for Faro

RCP 4.5	RCP 8.5
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Climatic parameter	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	4
Precipitation (%)	3	3	5	7	7	8
Soil moisture (%)	1	-1	-2	4	1	-2

Kalamaloué

Compared to the baseline (1981-2010), this site is projected to increase in temperature under RCP 4.5 and 8.5 for the three periods. An increase is also projected for precipitation under RCP 8.5. Precipitation under RCP 4.5 for all the periods is projected to decrease compared to the baseline, while soil moisture is projected to remain unchanged from the baseline for both RCPs (Table 4). With the exception of the projected changes in temperature for RCP 8.5 (2041-2070 and 2071-2100) which are large, the projected changes in precipitation are small.

Table 4: Projected climate parameters for Kalamaloué

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	5
Precipitation (%)	-1	-1	-7	3	6	15
Soil moisture (%)	0	0	0	0	0	0

Mozogo Gokoro

The precipitation (except for the period 2071-2100 – RCP 4.5) and temperatures for the location are projected to increase under both RCPs compared to the baseline (1981-2010). The soil moisture content is projected to remain unchanged under RCP 4.5 for 2011-2040, increase under RCP 8.5 for 2011-2040 and 2041-2070, and decrease for the other time periods for both RCPs (Table 5). However, with the exception of the projected changes in temperature under RCP 8.5 for 2041-2070 and 2071-2100 which is large, the projected changes in precipitation and soil moisture are small.

Table 5: Projected climate parameters for Mozogo Gokoro

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	3	1	3	5

Precipitation (%)	2	2	-3	4	8	5
Soil moisture (%)	0	-6	-13	5	1	-12

Vallée du Mbéré

The precipitation and temperatures for Vallée du Mbéré are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). The soil moisture content is projected to remain unchanged under RCP 4.5 for 2011-2040, a decrease under RCP 4.5 for 2071-2100, and an increase for the other time periods across both RCPs (Table 6). The projected change in temperature for the period 2071-2100 under RCP 8.5 is large while the other projected changes are small.

Table 6: Projected climate parameters for Vallée du Mbéré

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	4
Precipitation (%)	5	6	9	4	10	18
Soil moisture (%)	0	1	-1	2	3	2

Tchabal Mbabo

The temperature, precipitation and soil moisture, except for the period of 2071-2100 under RCP 8.5, are all projected to increase under both RCPs compared to the baseline (Table 7). However, only the projected changes in temperature under RCP 8.5 for the periods 2041-2070 and 2071-2100 are large while the other projected changes are small.

Table 7: Projected climate parameters for Tchabal Mbabo compared to the baseline (1981-2010)

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	5
Precipitation (%)	6	5	6	7	7	8
Soil moisture (%)	3	1	1	3	1	-1

Ma Mbed Mbed

Temperatures are projected to increase across the three periods (2011-2040; 2041-2070; and 2071-2100) compared to the baseline, with the largest temperature increase recorded for the period of 2071-2100 under RCP 8.5. Pertaining to precipitation, a projected increase is recorded for the different periods under both RCPs, although considered small. Soil moisture at this location is projected to fluctuate across all time periods under both RCPs, although the changes are considered small (Table 8).

Table 8: Projected climate parameters for Ma Mbed Mbed

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	3	1	3	5
Precipitation (%)	4	3	1	5	5	6
Soil moisture (%)	5	-4	-3	9	4	-5

Kalfou

Kalfou's precipitation and temperatures are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). The soil moisture content is projected to increase during the time period of 2011-2040 under both RCPs and a decrease for the other time periods for both RCPs (Table 9). The projected changes in temperature for the periods 2071-2100 and 2041-2070 under RCP 8.5 are large while the other projected changes are small.

Table 9: Projected climate parameters for Kalfou

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	5
Precipitation (%)	3	4	1	5	6	6
Soil moisture (%)	2	-3	-6	1	-2	-10

b). Intervention areas

Waza

Compared to the baseline period of 1981-2010, the temperature for Waza is projected to increase under both RCP 4.5 and 8.5 across the three periods, with the changes for 2041-2070 and 2071-2100 under RCP 8.5 being large. Precipitation is projected to decrease under RCP 4.5, and increase under RCP 8.5. Pertaining to soil moisture, an increase is projected for 2011-2040 under RCP 8.5, while with the exception for the period 2041-2070 (RCP 8.5), the other time periods are projected to witness a reduction compared to the baseline (Table 10).

Table 10: Projected climate parameters for Waza

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	5
Precipitation (%)	-0.27	-0.095	-3	2	6	7
Soil moisture (%)	-3	-5	-12	1	0	-4

4.1.2. SOUTH-EAST HUMID FOREST (IMPACT AND INTERVENTION AREAS)

Overall, the southern regions of Cameroon are generally humid and equatorial, while the climate becomes semi-arid toward the northern regions. Throughout the year there is typically a long dry season from December to May, a lighter rainy season from May to June, a brief dry season from July to October, and the wettest months are during the rainy season from October to November. The ecological zone has a humid tropical climatic condition, with an average annual temperature of 24°C, and an average annual precipitation level of around 1500mm (ONACC, 2018b).

Past trends:

In terms of past annual trends for the period of 1950-2015, the amounts of precipitation received and the number of rainy days in the most northerly area of the ecological zone has gradually decreased. On a seasonal scale, past precipitation data reveal an overall decrease in the amount of precipitation and the number of rainy days throughout the year. The brief dry season is an exception in which past trends indicate increasing precipitation levels. Throughout the rest of the ecological zone, rainfall amounts tend to increase during the brief dry season and the lighter rainy season, while the long dry and rainy seasons are decreasing in overall precipitation (ONACC, 2018b).

With regard to temperatures, past data from ONACC (2018b) between the years 1950-2015 reveal an increase in average maximum and minimum temperatures on an annual scale. On a seasonal scale, temperatures show an overall tendency to increase, both for the average maximum and minimum temperatures. On a monthly basis, similar data reveal an overall increase in maximum, minimum and average temperatures, except for an overall decrease in maximum temperatures during the month of November, and in minimum temperatures during the month of January.

The analysis of past temperature and for the project's intervention area (Ngoyla) for the South-East humid forest AEZ is presented in Figure 5, which reveals a fluctuation in temperature and precipitation over time. Generally, an increasing temperature trend and a decreasing precipitation trend for Ngoyla is observed over the period of 1981-2020.

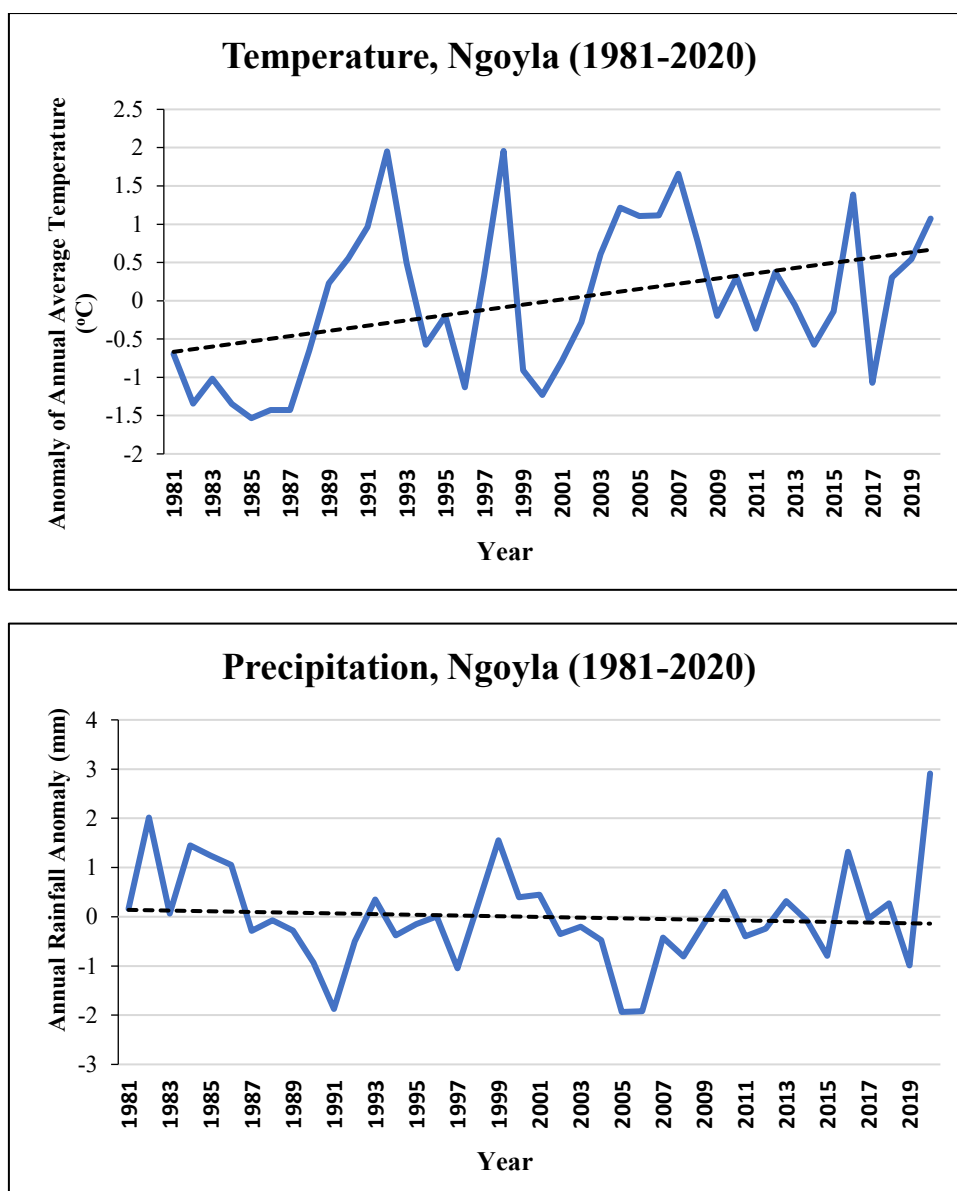


Figure 5: Analysis of past temperature and precipitation for Ngoyla (1981-2020)

Future trends:

Trends from past climate data indicate changes in rainfall and temperature patterns. These changes, in conjunction with more erratic rainfall patterns, and stronger winds and population growth, make the forested area of eastern Cameroon increasingly vulnerable to the effects of climate change (ONACC, 2018b).

Regarding the 2030, 2060 and 2090 projections of climatic parameters, it appears that an increasingly hot climate is expected throughout the Eastern Region until 2090, while precipitation will vary considerably from one location to another. Generally, the average annual precipitation is expected to decrease by 2-9mm by 2030, 4-9mm by 2060 and 8-14mm by 2090. Average annual temperatures are expected to increase by 0.8-1.°C by 2030, 1.8-2.8°C by 2060, and 2.8-4.8°C by 2090 (ONACC, 2018b).

The outcome of the climate projections for the proposed project impact and intervention areas for the South-East humid forest zone are explained in the following section.

a) Climate projection for impact area

Lobéké

The temperature for Lobéké is projected to increase under both RCP 4.5 and 8.5 compared to the baseline (1981-2010). In terms of precipitation, an increase is projected for 2041-2070 and 2071-2100 for RCP 8.5. Other periods are projected to witness a decrease compared to the baseline, with the exception of 2011-2040 under RCP 4.5 where no change was projected. Regarding soil moisture, a decrease is projected for both RCPs compared to the baseline (Table 11). Aside for the temperature change for 2071-2100 under RCP 8.5 which is large, all projected changes are considered small

Table 11: Projected climate parameters Lobéké

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	1	1	2	3
Precipitation (%)	0	-2	-1	-2	2	4
Soil moisture (%)	-2	-3	-3	-3	-2	-2

Mefou

The temperature and precipitation for the site are projected to increase for both RCPs compared to the baseline, with the exception of 2011-2040 under RCP 8.5. Additionally, aside from the period of 2011-2040 under RCP 4.5, soil moisture is projected to reduce under both RCPs compared to the baseline (Table 12).

Table 12: Projected climate parameters Mefou

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	3
Precipitation (%)	1	4	3	0	4	9
Soil moisture (%)	0	-1	-2	-2	-3	-3

Dja

Compared to the baseline, temperature and precipitation are projected to increase for both RCPs, with the exception of 2011-2040 under RCP 8.5. Aside from the period of 2041-2070 under RCP 4.5 with no projected change from the baseline, the soil moisture for the location is projected to reduce under both RCPs compared to the baseline (Table 13).

Table 13:. Projected climate parameters Dja

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	2	1	2	3
Precipitation (%)	1	3	4	-1	4	8
Soil moisture (%)	-1	0	-2	-1	-2	-3

Mengame

Precipitation and temperatures in Mengame are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). Soil moisture content is projected to remain unchanged under RCP 4.5 for the years 2041-2070 and 2071-2100, increase under RCP 8.5 for the years 2071-2100 and decrease for the other time periods across both RCPs (Table 14). The projected changes in temperature for the periods of 2071-2100 and 2041-2070 under RCP 8.5 are large while the other projected changes are small.

Table 14:Projected climate parameters Mengame

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	2	1	2	3
Precipitation (%)	3	6	10	1	8	20
Soil moisture (%)	-1	0	0	-2	-1	6

b) Intervention areas

Nki

The temperature of the Nki area is projected to increase under both RCPs across the three periods compared to the baseline (1981-2010). With the exception of the period 2011-2040 under RCP 4.5 where no change is projected from the baseline, and 2011-2040 under RCP 8.5 with a projected decrease, all other projections showed an increase in precipitation. Pertaining to soil moisture, a decrease is projected under both RCPs (Table 15).

Table 15: Projected climate parameters for Nki

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	2	1	2	3
Precipitation (%)	0	2	1	-1	1	7
Soil moisture (%)	-1	-4	-3	-2	-4	-2

Boumba Bek

Compared to the baseline, the temperature is projected to increase for both RCPs. With the exception of the period of 2041-2070 and 2071-2100 under RCP 8.5 which show a projected increase in precipitation, all other periods under both RCPs project a decrease in precipitation. Regarding soil moisture, a decrease is projected under both RCPs (Table 16).

Table 16: Projected climate parameters for Boumba-Bek

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	1	1	2	3
Precipitation (%)	-0.47	-1	-0.11	-3	1	5
Soil moisture (%)	-3	-4	-5	-4	-4	-5

Ngoyla

While the temperature for Ngoyla is projected to increase from the baseline for both RCPs, the soil moisture is projected to decrease from the baseline. Compared to the baseline, the projections for precipitation revealed that it will remain unchanged under RCP 4.5 for the years 2041-2070 and 2071-2100; increase under RCP 8.5 for the years 2041-2070 and 2071-2100; and decrease for the period 2011-2040 under RCP 4.5 and 8.5 period (Table 17). Of the projected changes, only the temperature change for 2071-2100 under RCP 8.5 is large while the others are small.

Table 17: Projected climate parameters for Ngoyla

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	2	1	2	3
Precipitation (%)	-0.28	0	0	-1	2	8

Soil moisture (%)	-1	-4	-3	-2	-2	-1
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4.1.3. WESTERN HIGHLANDS (IMPACT AND INTERVENTION AREAS)

This ecozone experiences a warm and temperate equatorial climate with one long wet season lasting 9 months (March to November), and a short dry season that last the remaining 3 months. During the wet season, humid monsoon winds blow moist air in from the Atlantic Ocean, and as the winds eventually reach the mountainous highlands, they release their moisture as rain (UNDP, 2008). Due to the mountainous environment, the ecozone typically has a cooler climate than the rest of Cameroon, with an average annual temperature of 20°C in some areas.

Past trends for the Western Highlands:

Throughout this ecozone, the amount of annual precipitation and number of annual rainy days has varied tremendously from 1950–2015. However, the overall annual trend shows that the total average rainfall and number of rainy days have progressively decreased over the past 70 years. For instance, the evolution of annual precipitation and number of rainy days from 1950-2015 have both significantly decreased for Mamfe city. Its annual precipitation levels have been reduced by over 700mm and have lost on average 10 days of rain a year (Figure 6).

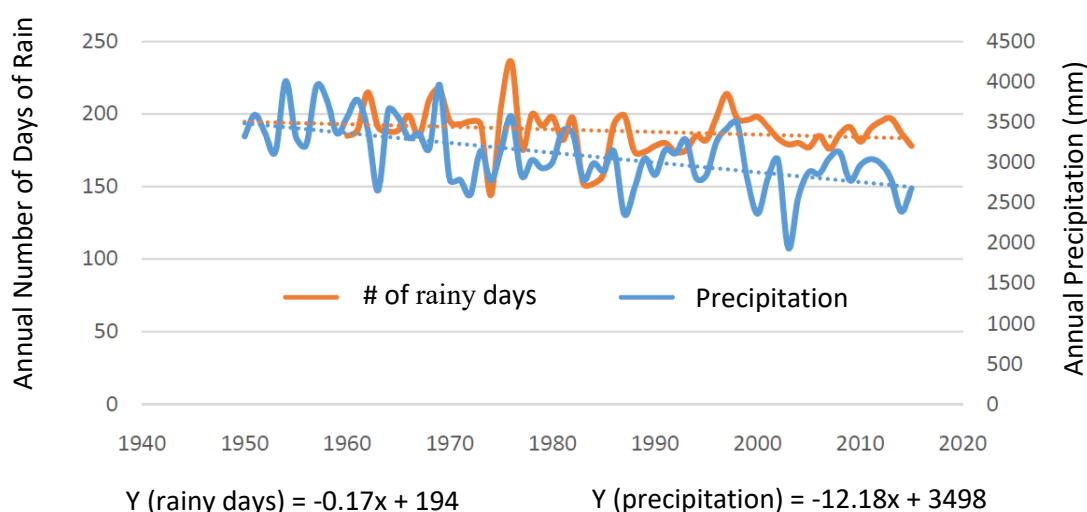
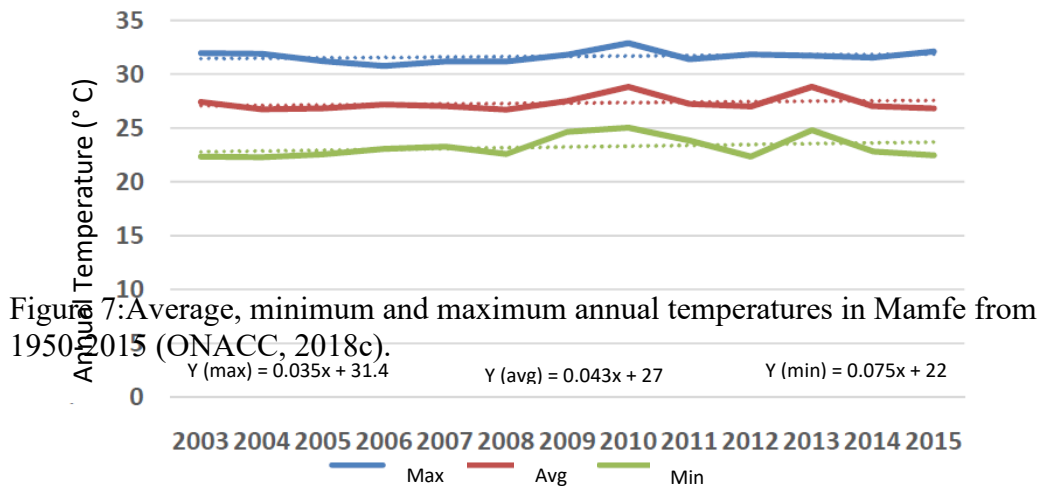


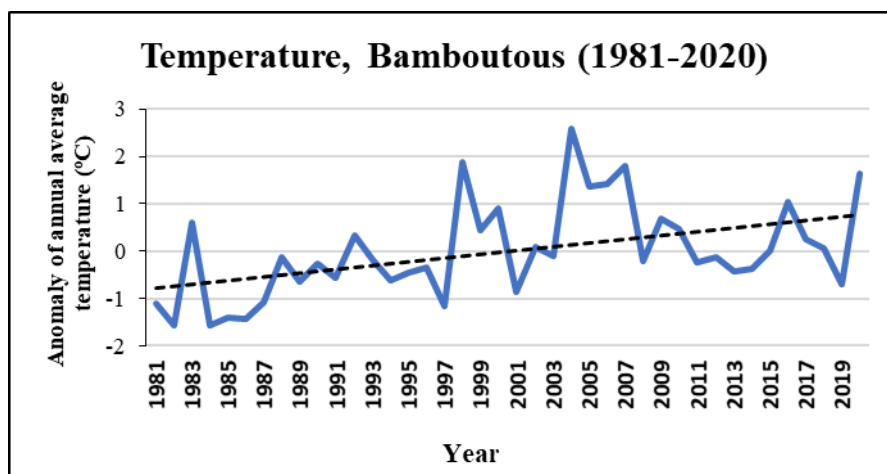
Figure 6: Annual evolution of precipitation and number of rainy days in Mamfe from 1950-2015 (ONACC, 2018c).

Temperature data taken during 2003-2015 from the same city reveals a small gradual increase in average, maximum, and minimum temperatures on an annual scale (Figure 6). On a seasonal scale, temperatures show an overall tendency to increase, during both wet and dry seasons. This increase in average temperatures is mainly due to the increase in the average maximum temperatures. On a monthly annual basis, data from ONACC (2018c) reveals that average temperatures have risen for the months of January, July, August, September, October, November, and December, but



have fallen during the months of February, March, April, May, and June.

The analysis of past climatic parameters within the intervention area (Bamboutous) for the Western Highland AEZ is presented in Figure 8. There exist evidence confirming that the climate of Bamboutous has been changing over the past decades. The location has been experiencing a steady increase in temperature for the period of 1981-2020 (Figure 8). Overall, precipitation at this site has been experiencing a slight increasing trend for the period of 1981-2020 as demonstrated in Figure 8.



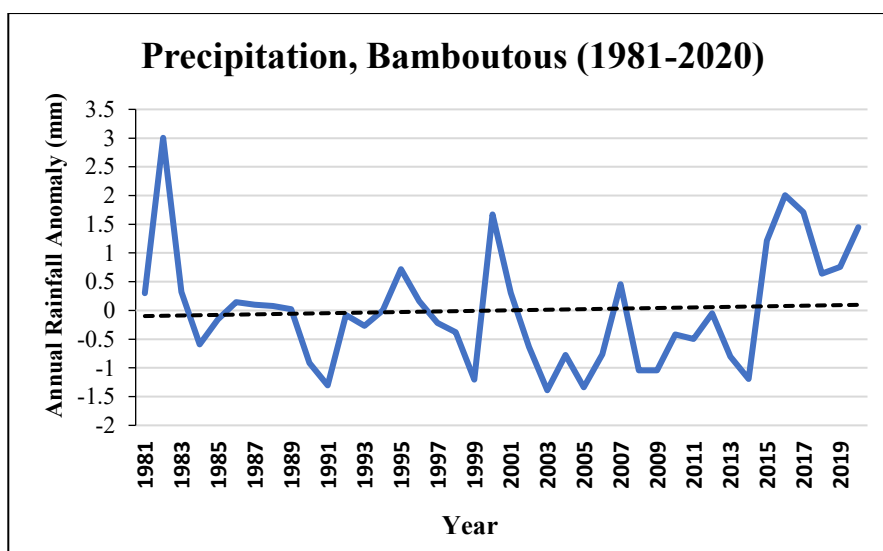


Figure 8: Analysis of past temperature and precipitation for Bamboutous (1981-2020)

Future trends for the Western Highlands:

The projections of the models of the average annual precipitation carried out by UNDP (2008), CSC (2013), and CSC & WUR (2013) indicate significant changes in the distribution of rainfall amounts within the Western Highlands. Forecasts show that during the months of the long-wet season (March to November), the A will experience progressively reduced rainfall of 12-14 mm between the months of March and May in 2030, 14-26mm between the months of June and August in 2060, and 26-54mm between the months of July and November in 2090. On an annual scale, the projections indicate a decrease in rainfall of 8mm by 2030, 20mm by 2060, and reach an annual reduction of 25mm by 2090 (UNDP, 2008).

In terms of temperatures, a significant increase is projected in the Western Highlands regardless of any emission scenario, with very strong increases in temperature for high emission scenarios. In addition, an increase in temperature extremes is expected, and the number of cold days and nights is expected to decrease, while the number of hot days and nights is expected to increase by 2030, 2060 and 2090. Overall, the average annual temperature of this ecozone is projected to increase by 1.1-1.4°C by 2030, 1.8-2.5°C by 2060, and 2.2-4.2°C by 2090 (UNDP, 2008).

The outcome of the climate projections for the proposed project impact and intervention areas for the Western Highland zone is explained in the following section.

a) Impact area

Takamanda

The precipitation and temperatures in Takamanda are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). Conversely, the soil moisture content of the location is projected to decrease from the baseline for both RCPs (Table 18). With the exception of the temperature change under RCP 8.5 for 2071-2100 which is large, the other projected changes for temperature, precipitation and soil moisture are small.

Table 18: Projected climate parameters for Takamanda

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	4
Precipitation (%)	1	2	1	3	3	1
Soil moisture (%)	-1	-1	-2	-1	-3	-6

Korup

The precipitation and temperatures of the Korup area are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). Conversely, the soil moisture content of the location is projected to decrease from the baseline for both RCPs (Table 19). With the exception of the temperature change under RCP 8.5 for 2071-2100 which is large, the other projected changes for temperature, precipitation and soil moisture are small.

Table 19: Projected climate parameters for Korup

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	1	2	1	2	3
Precipitation (%)	1	5	3	2	3	2
Soil moisture (%)	-1	-2	-3	-1	-4	-6

Kimbi-Fungom

The precipitation and temperatures at this location are projected to increase across the three periods under both RCPs compared to the baseline (1981-2010). Conversely, the soil moisture content of the location is projected to decrease from the baseline for both RCPs except for the period of 2011-2040 under RCP 4.5, with no projected change from the baseline (Table 20). With the exception of the temperature change under RCP 8.5 for 2071-2100 which is large, the other projected changes for temperature, precipitation and soil moisture are small.

Table 20: Projected climate parameters for Kimbi-Fungom

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	2

Precipitation (%)	4	2	6	2	5	5
Soil moisture (%)	0	-2	-2	-1	-2	-2

The trends revealed by the projections for Kimbi Fungom is the same for the following locations: Rumpi Hills (Table 21); Kilum Ijim (Table 22); Kagwene (Table 23); Tofala Hills (Table 24); and Bayang-Mbo (Table 25).

Table 21:Projected climate parameters for Rumpi Hills

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (° C)	1	2	2	1	2	4
Precipitation (%)	3	4	7	3	3	9
Soil moisture (%)	-2	-2	-2	-1	-2	-4

Table 22:Projected climate parameters for Kilum Ijim

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (° C)	1	2	2	1	2	4
Precipitation (%)	4	4	3	2	6	6
Soil moisture (%)	-1	-2	-4	-1	-5	-7

Table 23:Projected climate parameters for Kagwene

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (° C)	1	2	2	1	2	4
Precipitation (%)	4	3	1	3	6	6
Soil moisture (%)	-1	-1	-2	-1	-3	-6

Table 24:Projected climate parameters for Tofala Hills

RCP 4.5	RCP 8.5
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Climatic parameter	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	3	4
Precipitation (%)	3	2	2	1	4	2
Soil moisture (%)	-1	-2	-3	-1	-3	-6

Table 25: Projected climate parameters for Bayang-Mbo

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	4
Precipitation (%)	4	7	7	3	10	17
Soil moisture (%)	-1	-1	-2	-1	-2	-4

Santchou

Temperatures and precipitation in Santchou are projected to increase across the three periods compared to the baseline. The soil moisture for the site is projected to reduce compared to the baseline but for the period of 2011-2040 under RCP 4.5. While the temperature change under RCP 8.5 for 2071-2100 is large, the changes in precipitation, temperature and soil moisture are small (Table 26).

Table 26: Projected climate parameters for Santchou

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2	1	2	4
Precipitation (%)	4%	7%	7%	3%	10%	17
Soil moisture (%)	-0.03%	1%	-3%	-0.013%	-2%	-3%

b). Intervention area

Bamboutous

Temperatures and precipitation for this location are projected to increase across three periods (2011-2040; 2041-2070; and 2071-2100) compared to the baseline (1981-2010). The soil moisture for the site is projected to reduce compared to the baseline. However, the changes in precipitation, temperature (except under RCP 8.5 for 2071-2100) and soil moisture are small (Table 27).

Table 27: Projected climate parameters for Bamboutous

Climatic parameter	RCP 4.5			RCP 8.5		
	2011-2040	2041-2070	2071-2100	2011-2040	2041-2070	2071-2100
Temperature (°C)	1	2	2.1	1	2	4
Precipitation (%)	2%	4%	2%	2%	2%	8%
Soil moisture (%)	-2%	-2%	-5%	-2%	-5%	-7%

CONCLUSION

All the proposed project sites across the three agro-ecological zones experienced an increasing temperature trend for the period of 1981-2020. Similarly, projections conducted for RCP 4.5 and 8.5 across three different periods (2011-2040; 2041-2070; and 2071-2100) all revealed an increase in temperature for all proposed project sites compared to the baseline (1981-2010). Regarding precipitation, with the exception of Bamboutous which portrayed a very slight increasing precipitation trend for the period of 1981-2020, all the other project sites demonstrated a noticeable declining precipitation trend for the same period. Projections for soil moisture and precipitation for the proposed project sites under RCP 4.5 and 8.5 generated mixed results, showing increases and decreases in soil moisture and precipitation for some sites under different periods. However, the projected changes in precipitation and soil moisture for all the proposed project locations were small. Overall, the trends show a past and projected increasing trend in temperatures, a past decreasing trend in precipitation and a projected increasing/decreasing trend in precipitation. This means that the proposed project presents benefits for climate change adaptation, especially since livelihood activities such as agriculture in the project sites currently rely solely on climatic parameters. These findings show that in the absence of appropriate adaptation measures, livelihood activities could be negatively impacted.

REFERENCES:

- Climates to Travel (n.d.). *Climate - Cameroon*. Cameroon climate: average weather, temperature, precipitation, when to go. Retrieved December 16, 2021, from <https://www.climatestotravel.com/climate/cameroon>
- Climate-Data (n.d.). *CLIMATE BAMENDA (CAMEROON)*. Climate. Retrieved December 16, 2021, from <https://en.climate-data.org/africa/cameroon/northwest/bamenda-2905/>
- CSC (2013). Scénarios de changement climatique pour le bassin du Congo [Haensler A., Jacob D., Kabat P., Ludwig F. (eds.)]. Climate Service Centre Rapport No. 11, Hamburg, Germany, ISSN: 2192-4058.
- CSC & WUR (2013). Fiches d'information des pays. Scénarios des changements climatiques dans le Bassin du Congo. Fiche d'information - Hydrologie et Energie - République du Cameroun - Zone 2. Rapport final 67p
- Kummu, M., Heino, M., Taka, M., Varis, O., & Viviroli, D. (2021). Climate change risks pushing one-third of global food production outside the Safe Climatic Space. *One Earth*, 4(5), 720–729. <https://doi.org/10.1016/j.oneear.2021.04.017>
- ONACC (2018). Pluviométrie et température dans la Région de l'extrême-Nord Cameroun. Analyse de l'évolution de 1950 à 2015 et projections jusqu'à l'horizon 2090.
- ONACC (2018). Pluviométrie et températures dans la Région de l'Est Cameroun: Analyse de l'évolution de 1950 à 2015 et projection jusqu'à l'horizon 2090.
- ONACC (2018). Pluviométrie et température dans la Région du Sud-Ouest: Analyse de l'évaluation de 1950 à 2015 et projection jusqu'à l'horizon 2090.
- UNDP (2008). UNDP Climate Change Country Profiles. Cameroun. Mc Sweeney, New & Lizcano. <http://www.helio-international.org/uploads/VARCameroon.Fr.pdf>