Investing in rural people

**The Africa Integrated Climate Risk Management Programme : Building The Resilience of Smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW)"**

*(Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia)*

**Feasibility Study**

**October 2020**

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## Chapter 1 Overview

### 1.1 Introduction

1. Desertification and increased climate variability in the Sahel region in Africa have greatly contributed to the general degradation of natural resources for several decades. Combined, land pressure, water scarcity and the destruction of the plant cover due to unsustainable farming practices exacerbate the frequency and severity of droughts and lack of food access, especially for vulnerable and resource-poor communities. This leads to low agricultural productivities in the region, weak or under-developed agricultural markets, lack of access to capital and inadequate extension services. This disrupts the social cohesion of the region with displacements of populations from their homelands due to persistent violence, conflicts or insurgency.

2. To respond effectively to longer-term climate change and improve the ability of the region to manage the risks associated with increased climate variability, **The Africa Integrated Climate Risk Management Programme: Building The Resilience of Smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall (GGW)"** aims to promote a climate risk management continuum linking adaptation measures with risks preparedness, risks reduction and risk transfer schemes. This project proposes therefore implementing integrated climate change management approach all along the agricultural value chains while adopting risk management and risk transfer instruments such as insurance, which is increasingly recognized as a tool to help build farmer resilience and improve farmer well-being. The proposed program is contributing to the priority areas of intervention included in the GGWI Action Plan which is one of the earliest large-scale land restoration initiatives with the ambition to transform the region's degraded landscapes across 11 African countries from Senegal in the west to Djibouti in the east ( (Burkina Faso, Chad, Eritrea, Djibouti, Ethiopia, Mauritania, Mali, Niger, Nigeria, Senegal, and Sudan).The initial aim of the GGW was to create a 15 km wide and 8,000 km long plant barrier between the isohyet 100 and 400 mm of average rainfall along the Sahel to stop desertification. However, in recent years this vision has evolved into an integrated ecosystem management approach, striving for a mosaic of different land use and vegetation systems, including sustainable dryland management, the regeneration of natural vegetation as well as water retention and conservation measures. GGW projects and initiatives are implemented in all 11 countries, within their GGW intervention zones and beyond (regional activities). Climate change will amplify existing stress on water availability in the Sahel and will interact with non-climate drivers and stressors (political, social-economic- new pandemic such as coronavirus) to exacerbate the vulnerability of agricultural systems, particularly in semi-arid areas (IPCC, 2014). This will increase the vulnerability of smallholder farmers to climate risks and climate change impacts, and fuel the vicious cycle of poverty and vulnerability, food insecurity, migration and conflict in the region particularly in a context of COVID-19 and post COVID-19. It will further contribute to reducing greenhouse gas emissions from energy use within agricultural value chains through water mobilization, processing, packaging etc and lead to higher yield and animal husbandry. Alternative renewable energy technologies (RETs) would allow farmers to reduce deforestation, desertification and smoke from the use of fuelwood and improving health, education and other off farm activities beyond daylights. Combined with sustainable forest management and land use. To address the risks and vulnerability posed by climate change in smallholder farming in a more comprehensive and integrated way, IFAD in partnership with the African Development Bank and the World Food Programme proposes "The Africa Integrated Climate Risk Management : Building The Resilience of Smallholder farmers to climate change impact in 7 Sahelian Countries of the Green Great Wall (GGW)".

3. The regional programme is organized into three main mutually reinforcing components. Designed and Implemented effectively, the program will support the countries of the Sahel region in their efforts to transition towards low emission and climate resilient agricultural development pathways as expressed in their Intended Nationally Determined Contributions (INDCs) with the following unconditional reduction in emissions targets by 2030: Burkina 7,808.3 GgCO2e; Chad 23,449.07 GgCO2e; Mali 33,628,772 KT-eq. CO2; Mauritania GgCO2e; Niger 3.5% and Senegal 5% below business as usual levels; The Gambia 1750,4 GgCO2e conditional reduction in emissions.

4. The programme explores the feasibility of implementing an integrated climate risk management which brings together risk preparedness, risk adaptation, risk transfer in seven countries that are part of the GGWI: Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia. To support this, the feasibility study analyzes the way each country are : (1) strengthening the capacity of government stakeholders to support communities and smallholder farmers in preparing for climate change adaptation effectively (risk analysis and preparedness); (2) processes and systems to assist smallholder farmers and communities in adapting to climate change by adopting climate resilient activities and value chains (risk reduction); and (3) opportunities promote the creation of integrated risk transfer schemes where micro and macro insurance policies are interlinked.

5. As a result, the Feasibility Study in each of the seven countries sheds light at the design process of this programme, which aims at building and scaling up the resilience and adaptive capacity of smallholder farmers and rural communities of seven Sahelian Least Developed Countries (LDCs)[1] to climate change using Integrated Climate Risk Management Approach To achieve this goal, this programme seeks to upgrade, strengthen, scale up and replicate current existing and fragmented climate risk management practices by introducing a combination of climate risk preparedness, with climate risk reduction ( adaptation and mitigation) and climate risk transfer through micro insurance and macro insurance. The main targeted crops are key staple crops (millet, maize, sorghum, groundnuts) and livestock.

[1] The seven selected countries in the programme: Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia

## 1.2 Regional context

6. The seven covered countries (i.e. Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia) are seeking GCF grant to support smallholder farming communities in geographic areas that are extremely vulnerable to climate change and climate variability. These areas are marked by the highest levels of poverty and livelihood insecurity in their respective countries. Important investments from IFAD in the form of loans and grants for rain-fed, subsistence agriculture are under threat due to rising temperatures and unpredictable rainfall patterns. The GCF-funded interventions will be complementary to IFAD baseline investments (more focused on development outcomes), as they will specifically address climate change risks and impacts for which adequate support has not yet been fully lent. Despite the participant countries' efforts to address climate change through their National Adaptation Plans and various other investments, their fragmented approaches to climate risk, current climate financing gaps and a high debt ratio all limit their ability to scale up domestic investments in adaptation strategies and to overcome barriers that hamper effective climate change adaptation.

7. The seven selected countries are IFAD partner countries and all of them are Sahelian countries exposed to desertification, recurrent droughts and declining rainfall. They are all included within the GGWI which aims By 2030, to restore 100 million hectares of currently degraded land, sequester 250 million tons of carbon and create 10 million green jobs. The latest data collected/ from the 11 countries, the PAA, various stakeholders and NGOs as well as international partners on the GGW achievements up to 2019, shows that great efforts were made at regional and country levels, slowly paving the way to restoring the fertility of Sahelian lands and achieving the GGW targets. So far, the total rehabilitated area in 11 countries within the GGW intervention zone amounts to more than 3.6 million hectares. By 2030, the ambition of the initiative is to restore 100 million hectares of currently degraded land, sequester 250 million tons of carbon and create 10 million green jobs. The latest data collected/ from the 11 countries, various stakeholders and NGOs as well as international partners on the GGW achievements up to 2019, shows that great efforts were made at regional and country levels, slowly paving the way to restoring the fertility of Sahelian lands and achieving the GGW targets. So far, the total rehabilitated area in 11 countries within the GGW intervention zone amounts to more than 3.6 million hectares. For instance, the Sahel and the Chad Basin are currently facing their fourth major drought-related emergency in less than ten years. The current crisis is the result of late and erratic rainfall, which has decreased harvests by an average of 25 percent in Burkina Faso, Chad, Mali, Mauritania, Niger and Senegal. This has led the prices of staple crops to increase by up to 50 percent compared to the same period a year ago and long-term climate resilient development solutions are needed, especially in rural areas.

8. The agricultural sector in the Sahelian countries is still marked by low productivity and high vulnerability. Besides the structural issues associated to subsistence farming, the performance of the agricultural sector is also highly subject to a number of risks, such as : (i) high dependence on rainwater, which is the sole water source for a large majority of small farms and falls during only a few months of the year in many countries; (ii) recurrence of natural disasters and extreme weather events, locust outbreaks, animal and vegetable diseases, which reduce productivity levels; (iii) changes and variations in climate conditions from one year to another; (iv) fluctuations in the agricultural market for both inputs and outputs; (v) limited disaster management policies in support to agriculture, and (vi) the failure to adopt a land reform law, which has impacts on investment security.

| Type of risk | Factors | Effects |
|---|---|---|
| Climate | Rainfall and temperature variability, drought, floods | Lower yields, loss of productive assets or income |
| Biological | Pest, disease, infestation | Lower yields, loss of income |
| Market-related | Low prices, market volatility, variation of supply and demand | Lower yields, loss of income |
| Labour/ health | Illness, death, injury especially youth, women and elders | Loss of productivity, increased costs |

| | | |
|---|---|---|
| Policy and political | Regulatory changes, political instability, disruption of markets | Change in cost, taxes and market access |

**Table 1.2. Key risks faced by smallholder farmers in the Sahel**

9. The situation of people living in the conflict-affected regions of Chad, Mali, Niger and the Lake Chad Basin is particularity critical and as the conflicts are mainly over resources, they risk being exacerbated by climate change and climate variability. The impacts of climate change and recurrent natural disasters are leading to mass migration of people within the region causing grave security issues. The settlement of refugees in areas with scarce natural resources has resulted in increased degradation of the land and river basins and deforestation, which is, in turn, fueling the conflicts. This is particularly notable in the highlands and rangelands.

10. As indicated in the table below, most of these countries have received grants from IFAD and AfDB. All the selected countries are least developed countries (LDCs) and are also targeted by the GGWI. As a matter of fact, this programme will reinforce the initiative and contribute to the expected effects and impacts defined in the 2009 action plan for the GGWI:
    - Slowing soil erosion: the presence of vegetal cover slows wind speed and favors rainwater infiltration;
    - Degraded soil restructuring: an increase in organic matter of vegetal and animal origin entails soil restructuring;
    - Higher reforestation rate in countries crossed by GGWI: to restore eco-climatic balances and biodiversity;
    - Revival, development, and diversification of agriculture and stockbreeding, both in terms of vegetal and animal production volumes and size of the active population employed in these subsectors
    - Vegetal and animal biodiversity restoration, conservation, and development: deferred grazing and other privately owned wooded areas contribute to natural vegetation regeneration and return of wildlife (birds, small game, snakes, and the like);
    - Increasing coverage of local needs in forest products: especially firewood, lumber, and also ligneous and non ligneous products (gum, resins, roots, leaves, barks, fruits, pharmacopeia, and the like);
    - Improved living standard and health: due to noticeable improvement in nutrition, living environment, and more easily available household needs (water, energy, social infrastructures, and so forth);
    - Control of water resources: through water retention pond, artificial lakes, and hydraulic schemes that will contribute to enhanced production systems.

11. Besides the above effects and impacts, the program will also contribute to reducing emissions of carbon and other GHGs and enhancing sequestration for climate change mitigation. In all the selected countries, domestic financing is insufficient to address the adaptation gap costs. All selected countries are net overseas development aid (ODA) recipients that cover their annual budgets with limited debt relief grants. Under the new IFAD business model, 90 percent of the core resources under IFAD11 will be allocated to low income countries (LICs) and lower middle-income countries and cutting across all levels; 50 percent of core resources will go to Africa and between 25 to 30 percent of the core resources are projected to address the most fragile situations including environmental and climate fragility. However their allocation both from IFAD and AfDB are not sufficient to address climate change and additional climate financing is needed. This situation has been exacerbated by COVID -19 which puts more pressure on countries limited fiscal space.

### 1.3 Continental and regional context

12. Regardless of the level of GDP of a country in sub-Saharan Africa, more than eight out of ten rural households depend on agriculture and agriculture continues to be the distinctive feature of rural livelihoods. Most households earn at least 55 percent of their income from agricultural sources,

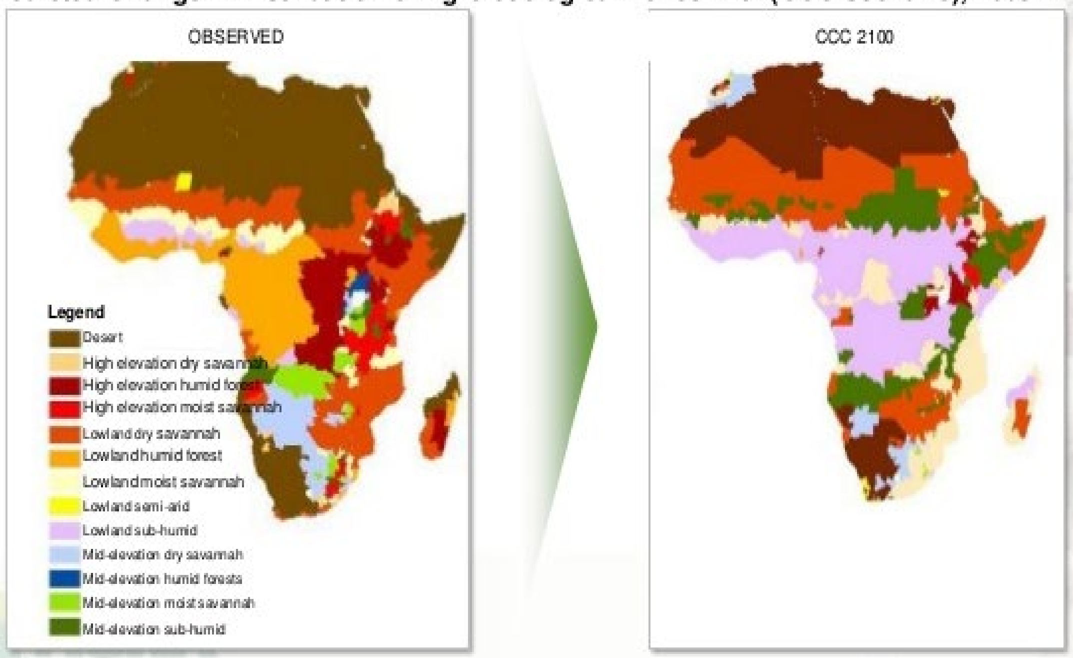
reaching approximately 80 percent in several countries (Nigeria in 2004) (Davis et al., 2017)[2]. Thus, smallholder farmers are largely at risk and highly vulnerable to weather related events, especially in view of the low share of non-farm wage income (eight percent), compared to countries in other regions with similar levels of GDP (33 percent) (Davis et al., 2017).This forced youth to migrate to cities, fuelled food insecurity and malnutrition and kept millions of people in poverty. Furthermore, climate events, especially disasters, have a ripple effect in the form of higher food and fodder prices, civil unrest and less social services as governments redeploy budgets to emergency situations. In the seven selected countries[3], smallholder farming is the main source of food, employment and income for most of the population. Countries have put agriculture back on the top of the development agenda and their growing revenue base has allowed them to increase the proportion of their national budgets going to this vital sector to create jobs. Private companies have invested heavily in Africa's agriculture value chains in recent years, thereby stimulating a renaissance in Africa's agri-food systems that multiplies the options available to small farmers in terms of the seeds they plant, the fertilizers they use, the markets they can now tap into and the information services that are now available to help them manage the risks of their farming activities. Agricultural growth in Africa has also expanded livelihood opportunities for millions of people now engaged in the expansion of off-farm activities that are part of the agri-food system.

13. This project is aligned with Decision 15/5: the African strategy on climate change agreed on by the Executive Council of the African Union. In the negotiations on the African common position on climate change, the African Union Commission was asked to elaborate, in collaboration with partners, a comprehensive African strategy on climate change to deal with short-, medium- and long-term climate change issues in Africa. The project at the national level will be anchored in each country's national adaptation plans and commitments. The table below summarizes, for each of the selected countries, the priority projects/activities identified in their NAPA or National Climate Change Policy and the links to this project's components. The project will promote an integrated way of reducing climate risks for farmers and countries in the region by transferring the weight to other stakeholders. In general, these NAPAs and NAPs contribute to Component 1 on climate risk assessments and preparedness and Component 2 on climate risk reduction measures and options.

14. To date, climate risks are still left to be borne primarily by farmers and governments in Africa, which have very limited opportunities to transfer them. Governments and communities continue to resort to employing emergency responses to climate risks, including 'self-insurance' by farmers (when farmers use their own savings and communal support), post-event compensation, relocation of victims, recovery and risk reduction. In light of the recent weather events (drought, floods and cyclones) and the fact that climate projections show increasing impacts of climate change on sub-Saharan African countries, which lack of planning tools and strategies to prepare for and address the impacts of related shocks, various countries are now working with partners to develop integrated climate risks management tools and options. More recent climate models predicts (see map below) an increase from 1 to 2°C between 2021 and 2050 with the following impacts in the Sahel including a shift on agro ecological zones: Recurrence of natural disasters, extreme weather events, droughts, floods, short rainy seasons, high evapotranspiration, humidity, heatwaves, pests and diseases

[2] Davis, B., Di Giuseppe, S., & Zezza, A. (2017). Are African households (not) leaving agriculture? Patterns of households' income sources in rural Sub-Saharan Africa. *Food policy*, 67, 153-174. doi: 10.1016/j.foodpol.2016.09.018.
3 Burkina Faso, Chad, Gambia (The), Mali, Mauritania, Niger and Senegal.

**Predicted Change in Distribution of Agro-ecological Zones with (CCC Scenario), 2003 – 2100e**




Source: "How Will Climate Change Shift Agro-Ecological Zones and Impact African Agriculture?" , P.Kurukulasuriya & R. Mendelsohn

15. African countries see the need to adopt integrated climate risk transfer mechanisms that build on existing or future baseline investments in smallholder agriculture with the latest state-of-the-art proven adaptation activities on both preparedness and adaptation but also risk transfer. These integrated approaches will contribute to improved resilience in the drylands by freeing up public resources that would otherwise have to be used for emergency responses. These resources can be redirected to programmes designed to strengthen the resilience of vulnerable segments of the population. They can be thought of as the "fiscal dividend" produced by resilience-enhancing interventions in the targeted countries.

16. Based on these considerations, the Governments of Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia are moving from an ex-post system of coping with agricultural emergencies to an ex-ante integrated risk management system. This shift reflects the need to design an integrated climate risk management approach that focuses on: (i) improving agriculture risk information systems and coverage for decision-making; (ii) enabling farmers to adopt better risk management technologies and instruments (including off-farm works and infrastructure); (iii) implementing the right adaptation options for the best value for money; and iv) introducing climate risk transfer mechanisms (index-based weather risk insurance) in the form of insurance to protect farmers from potential losses. The proposed project will strengthen smallholder farmers' resilience to climate change by building their capacity for integrated climate risk management, as well as those of public and private institutions that work in the smallholder farming sector. It will also contribute to the vital role that agriculture plays in adapting to and mitigating climate change, as well as to achieving the selected countries' commitments to national greenhouse gas emission reductions under their Intended Nationally Determined Contributions (I NDC) as expressed in the table below. With a population which is expected at least to double by 2040, the countries of the Sahel region are committed to the Paris Climate Agreement as expressed in their INDCs (conditional and unconditional) through mitigation and adaptation in the agricultural sector. unconditional reduction in emissions

**Table 1:** Countries INDCs in the agricultural sector, land use and forestry and energy by 2030.

| Sectors | Emissions per sector from the INDCs | Burkina (GgCO2e) | Chad (GgCO2e) | Mali (KT-eq. CO2) | Mauritania (GgCO2e) | Niger | Senegal | The Gambia (GgCO2e) |
|---|---|---|---|---|---|---|---|---|
| Agriculture/ livestock | Unconditional: | 7,236.3 | 38,215.70 | - | | - | 0.19% | |
| | Conditional: | 10,560 | 30,398.83 | 29% | -20,431.5 | - | 0.63% | 707.0 |
| Land use and forestry | Unconditional: | - | -17,387.48 | - | | - | - | - |
| | Conditional: | - | - 24,342.48 | 21% | | - | - | - |
| Energy | Unconditional: | 572.0 | 2,165.00 | - | | - | 6% | - |
| | Conditional: | 3,130.00 | 1,840.25 | 31% | -12,711.1 | - | 31% | 629.6 |
| Waste | Unconditional: | - | 455.85 | - | | - | 13% | - |
| | Conditional: | 76.30 | 402.85 | - | -386.1 | - | 31% | 413.7 |
| Subtotal unconditional | | 7,808.3 (6.6%) | 23,449.07 (18.2%) | -33,628,772 | 12%88% below business as usual level by 2030 | 3.5%88% below business as usual level by 2030 | 5%88% below business as usual level by 2030 | |
| Subtotal conditional | | 13,766.30 (11.6%) | 8,229.45 (71%) | -84,937,087 | 88% below business as usual level by 2030 | 34.6%88% below business as usual level by 2030 | 21%88% below business as usual level by 2030 | |

(Source, UNFCC,2020)

17. As the first program of the future GCF umbrella program the GGW, the proposed programme is to build and scale up the resilience and adaptive capacity of smallholder farmers and rural communities of the seven Sahelian Least Developed Countries (LDCs) targeted by this program.

**Climate drivers for vulnerability (weather and climate variability) in the Sahel**

18. Recent assessments indicate a long history of confronting serious crises in the targeted Sahelian countries, key climate drivers include extreme weather events (major floods, storms, dust and droughts resulting in loss of assets and disability for communities); weather related risks; crop losses (disruption of production due to adverse weather); and food price shocks. These climate drivers are also the main cause of low agricultural productivity, food insecurity and famine, desertification, locust's invasion, health issue, conflict and migration.

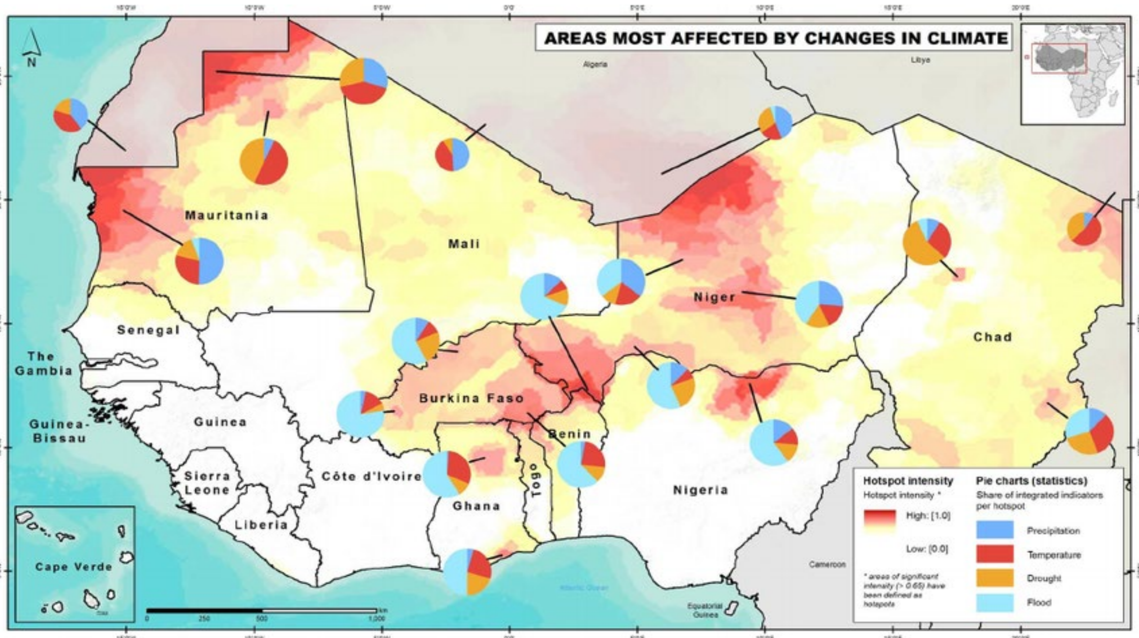



**Figure 1:** Most affected areas by climate change in the Sahel

**Temperature trends in the Sahel**

19. **Historical observations:** Over West Africa and the Sahel, 2018 was the 7th warmest year on record. The rate of increase in temp was 2.27ºC (1950-2018) and 3.88 ºC (1990-2018) per century (ACMAD, 2020). As may be expected, the largest trend (0.023ºC/year) occurs in the Inner Delta-Middle Niger Sub-Basin. This rate translates to a change in the average temperature of 0.85ºC between 1970 and 2006 or, using the trend since 1901, an increase of 1.91ºC and led to a 4-percent increase in global total runoff. Overlain on this has been a gradual warming of the region since the 1980s of between 0.3-1.0ºC (Padgham et al. 2013), with an increase of 0.2-0.5ºC per decade in some countries (Sylla et al., 2016) such as Ghana, la Cote d'Ivoire, Guinea and Senegal. However, some parts of the northern Sahel (e.g., southern Mauritania, Mali and Niger and northern Burkina Faso) show little warming over this period. The overall warming has been accompanied by an increase in hot extremes, making the region a hotspot region for climate change (Turco et al., 2015). This warming may be contributing to some of the changes in precipitation extremes as well as high evapotranspiration of Surface Water supply of the main transboundary river basins

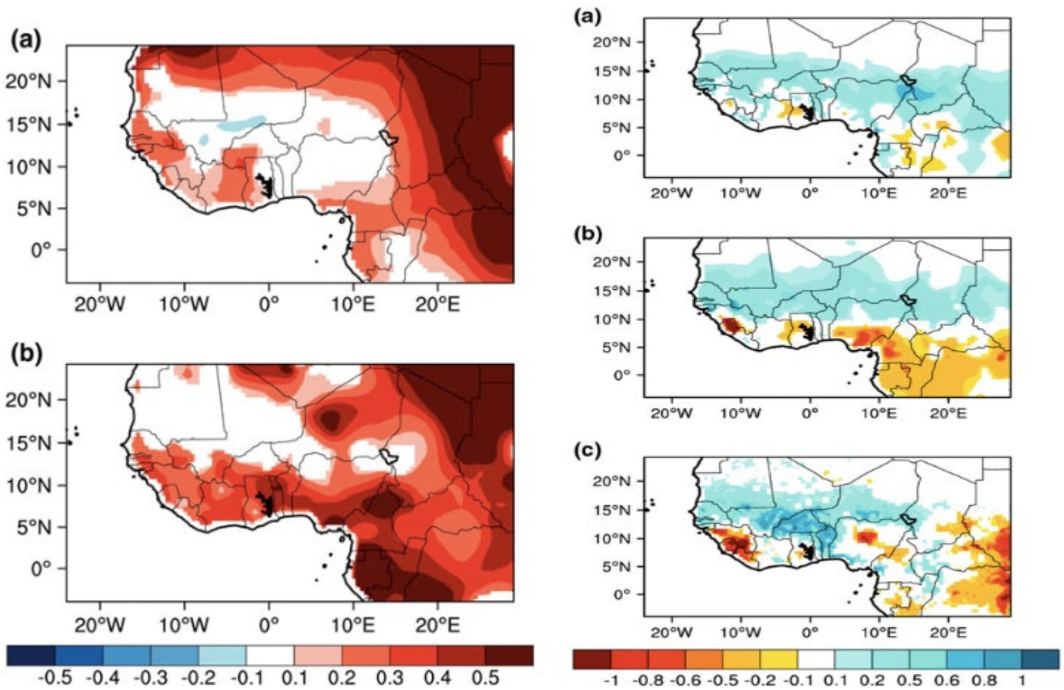



**Figure 2**. Linear trends in (left) temperature (degC per decade) and (right) precipitation (mm/day per decade) during the rainy season (May – September) over West Africa from 1980-2010 based on the multimodel CORDEX simulations. Temperature trends are calculated from two global datasets, and precipitation trend are calculated from three global datasets, to reflect the uncertainties. (From Sylla et al., 2016a)

20. **Temperature projections:** Projections for temperature suggest that an increase, especially for summer, is likely to largely exceed the global mean. Surface Water Supply Climate projections for the region suggest also that temperature increases in the Sahel are likely to be higher than the global average (IPCC, 2007). In fact, the IPCC anticipates that West Africa's temperature will rise between 2 °C and 4 °C by the end of the century. It should be mentioned that half of the models used for the IPCC AR4 projections agree on an increase of 0.5 °C from the median values for the entire region (Christensen, Hewitson, Busuioc, Chen, & Gao, et al. 2007). Disaggregated spatially, the greatest warming estimates (~4 °C) are likely to occur over land and in particular in the western Sahel, while the southern coastal areas should experience a temperature increase of 3 °C. Warming trends, therefore, are expected to be highest for the Senegal, Gambia, western Niger, and Upper Volta River Basins. Temporal projections indicate stronger warming occurring during the summer months (Oguntunde & Abiodun, 2013).

**Precipitation Trends in the Sahel**

21. In West Africa, the effect of climate variability on rainfall is critical for key development sector such as rainfed agriculture. Warming of the Sahara and of the nearby oceans changes the structure and position of the regional shallow circulation and allows more of the intense convective systems that determine seasonal rain accumulation , variability in seasonal rainfall totals and distribution the course of the 20th century. Seasonal rainfall variability in the Sahel can be explained as the response to anomalies in the atmospheric circulation that are planetary or regional in scale and that are mostly driven from afar—by changes in the surface temperature of the global oceans, by direct effect of increasing anthropogenic emissions of pollutants, or by a combination of both (Michela Biasutti,2018) Sahel rainfall is dynamically linked to the global Hadley cell and to the regional monsoon circulation. July-August-September Sahel

precipitation shifts northward and is correlated with both Pacific El Niño/La Niña sea surface temperature (SST) anomalies and the Atlantic dipole (Bette L. Otto-Bliesner). The maps below show ENSO impacts on rainfall anomaly approach in the Sahel and compares the averages 3 monthly rainfall during El Niño and La Niña seasons with the rainfall during neutral seasons. The social and economic consequence of reduced crop production or crop failure due to high rainfall variability or extreme rainfall, has led to a number of studies aiming to explore processes that control precipitation within the region (Tarhule et al, 2003). Rainfall pattern in West Africa is link to the dynamic of West African Monsoon, (WAM), which the inter-annual variability can be explained by the remote influence of El Niño-Southern Oscillation (ENSO) (Nigam et al, 2016). The analyze of observed data showed that the WAM is influenced either during the developing phase of ENSO, or during a long-lasting decline of La Niña events. Therefore, the teleconnection process strongly depends on the timing of ENSO (Joly et al,2009). For instance, a cause and effect relationship have been found between the droughts of 1983 and 1982/83 El Niño (Okonkwo, 2014)

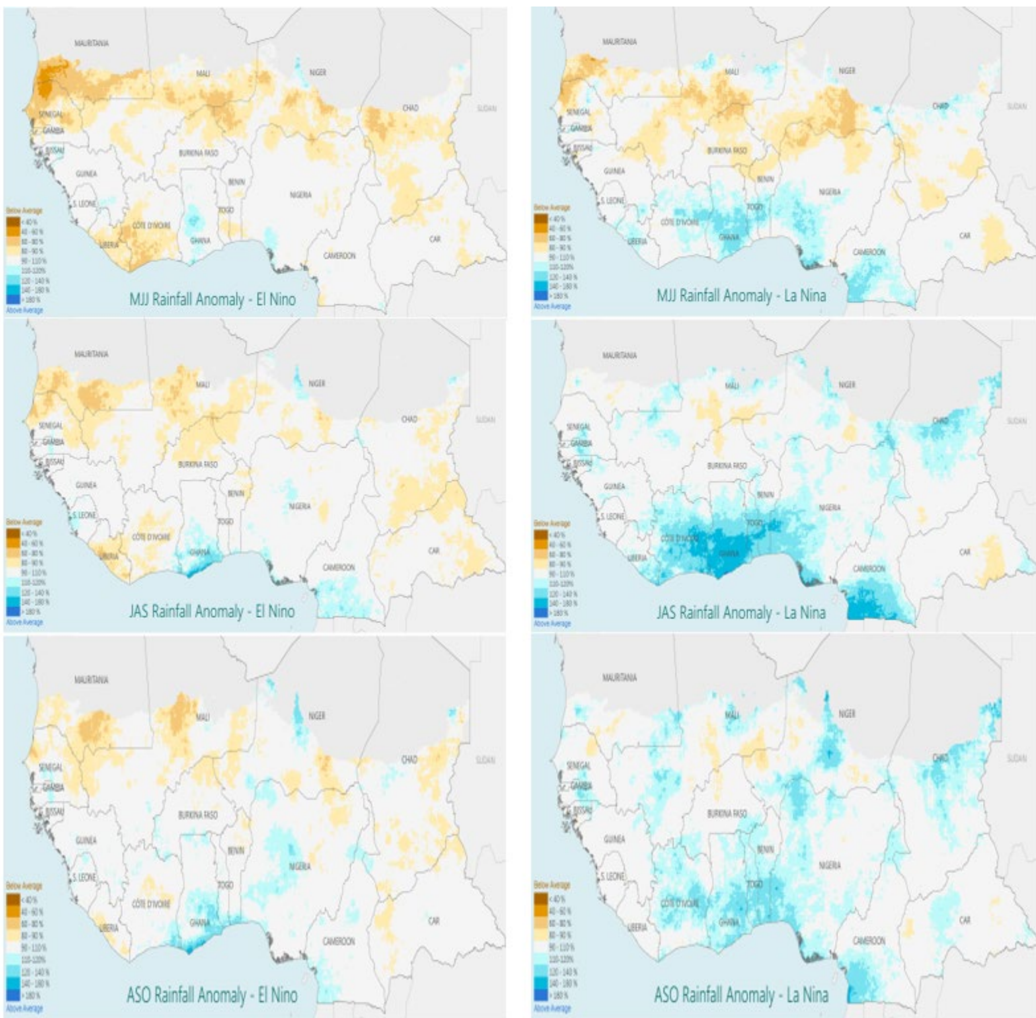



**Figure 3:** El Nino/Nina impact on rainfall. All calculations have been done on 3 monthly periods: MJJ = May to July (start of season); ASO = August to October (second part of the season); JAS = July to September - main rainfall months (core of the season). A negative (positive) anomaly for the El Niño (or La Niña) mean that the parameters take on average lower (higher) values in El Niño (or La Niña) affected seasons than in neutral seasons.

22. **Past Precipitations:** The first part of the 20th century shows a predominance of anomalously wet years and decades, followed by a decline in seasonal rainfall totals during the later half of the record, with overall low rainfall decades punctuated by devastating short-term droughts such as those of 1972 and 1983–1984 (Figure4). The Sahelian climate over the past decades has been dominated by the prolonged drought conditions during the mid-1960s to the mid-1980s (Hulme, 1992; L'Hote et al., 2002; Tarhule and Lamb, 2003), which reached peak extent in 1972 and 1984 with a 30% decrease in rainfall. Since the 1980s rainfall has not returned to pre-1960s levels. Precipitation has still not recovered completely since then, and drought continues to occur recurrently. For example, the droughts of 2011-12 hit many countries across the region (Masih et al., 2016) . Despite this partial recovery, there is evidence of changes in the characteristics of the seasonal cycle of rainfall (Biasutti, 2019). There has been an increased number of rain days with wetting concentrated in the late rainy season but also more intense and intermittent, higher inter-annual variability, and a delayed onset and an early retreat of the monsoon season (Biasutti and Sobel 2009; Diallo et al. 2013; Seth et al. 2013; Hartmann et al. 2013; Ibrahim et al., 2014; Sanogo et al., 2015; Panthou et al., 2014) leading to earlier dry seasons and shorter rainy seasons. These have likely had impacts on agriculture and livelihoods in terms of changes relative to traditional crop calendars, and potentially increased flooding and short-term drought (Biasutti, 2019).

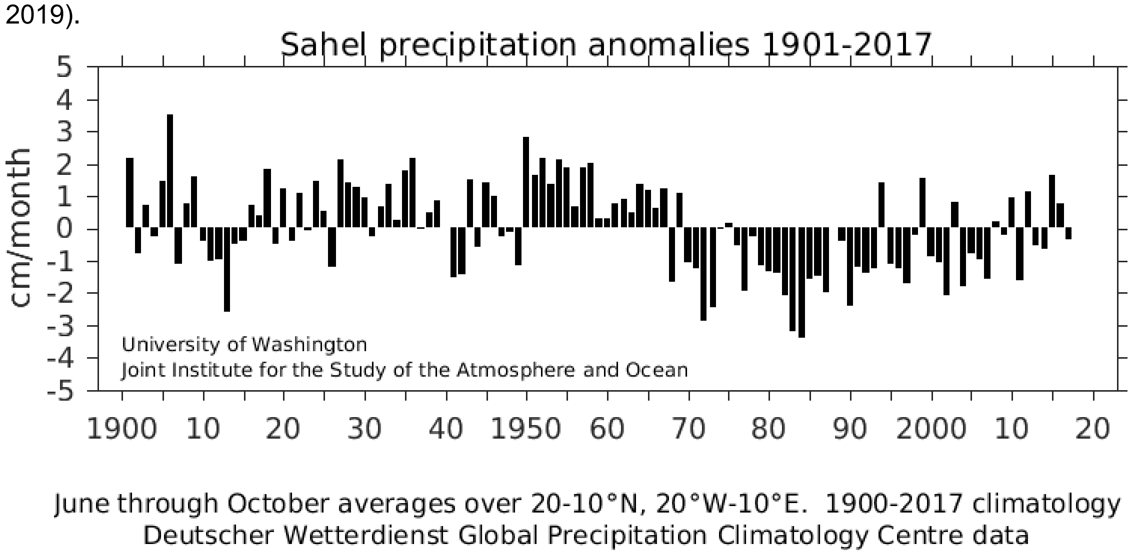
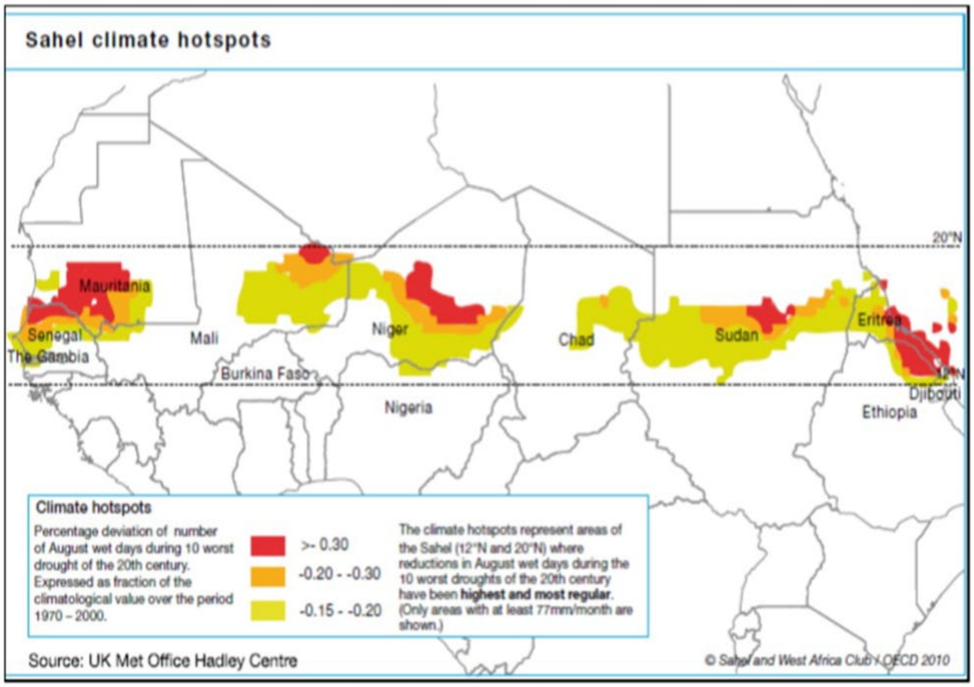


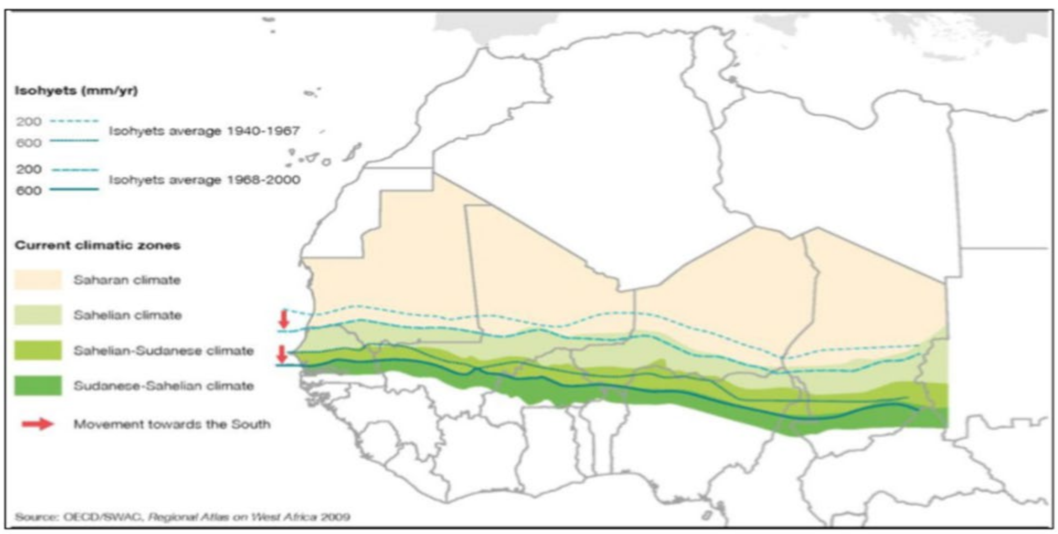

**Figure 4:** Sahel Precipitations anomalies 1901-217.

23. An analysis of historical observations for the average precipitation for the month of August over the period 1990 -2000 in the Sahel, suggests the presence of at least three climate hotspots in the Sahel of which two are in the West Sahel: one lies along the most western part of the region (Senegal and Mauritania) with the second stretching between Mali and Niger. These climate hotspots experienced rainfall declines by up to 100% during the 10 most severe droughts of the 20th century (West Sahel countries report, to the UNFCCC, 2015). The report include observations of erratic rainfall, the shift of isohyets to the south (see Map 3) 24, increased occurrences of dry spells, and severe multi-year droughts, such as the droughts in 1972-1990 and the more recent droughts over the last 10 years.




*Source: P. Heinrigs (2010) Security Implications of Climate Change in the Sahel Region: Policy considerations. OECD Sahel and West Africa Club Secretariat. Available at* https://www.oecd.org/swac/publications/47234320.pdf

**Figure 5:** Sahel climate hotspots




*Source: OECD/SWAC (2014) An Atlas of the Sahara-Sahel: Geography, Economics and Security. West African Studies. OECD Publishing. Available at* https://read.oecd-ilibrary.org/agriculture-and-food/an-atlas-of-the-sahara-sahel_9789264222359-en#page36

**Figure 6:** Shift of climate zones to the south

**Future precipitations**

24. While the COVID -19 has contributed to cut global CO2 emissions in 2020 in a short period, model-based predictions of future greenhouse gas induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate so that the continent on average could be between 2 and 6°C warmer by end of this century. Temperature projections over the Sahel

for the end of the 21st century from both the CMIP3 GCMs (SRES A2 and A1B emission scenarios) and CMIP5 GCMs (RCP4.5 and RCP8.5 scenarios) range between 3°C and 6°C above the late 20th century baseline (Meehl et al., 2007; Fontaine et al., 2011; Diallo et al., 2012; Monerie et al., 2012). Precipitation projections for the Sahel in the CMIP3 and CMIP5 archives show inter-model variation in both the amplitude and direction of change that is partially attributed to the inability of GCMs to resolve convective rainfall (WGI AR5 Section 14.8.7; Biasutti et al., 2008;Druyan, 2011; Fontaine et al., 2011; Roehrig et al., 2013). However, many CMIP5 models indicate a wetter core rainfall season with a small delay to rainy season by the end of the 21st century (Biasutti, 2013).

25. Projections from regional climate models (RMC,Jones et al., 2011), which downscale global climate model projections and can provide more refined regional information especially for extremes, indicate a similar overall range of projected change (Patricola and Cook, 2010, 2011; Mariotti et al., 2011; Vizy et al., 2013).The CORDEX RCM projections, show that most of West Africa is expected to see little change in precipitation, but a decrease of 5-40% in the West Sahel emerges over the 21$^{st}$ century and extends eastwards with time, covering Senegal, southern Mauritania and Mali and northern Guinea (Sylla et al., 2016a). Perhaps more importantly, models project a slight lengthening of the maximum dry spell length within the rainy season by mid-century, and a significant lengthening by the end of the 21$^{st}$ century across much of the region (Figure 3). This is accompanied by an increase in intensity of the most extreme precipitation events across the region, with increases of 5-10% by mid-century and more than 40% by end of century in many countries (Figure 4). The length of the wet season is also expected to change further, with further shortening across the region (Sarr, 2012; Ibrahim et al., 2014). Overall, Diffenbaugh and Giorgi (2012) identify the Sahel and tropical West Africa as hotspots of climate change for both RCP4.5 and RCP8.5 emission pathways, and unprecedented climates are projected to occur earliest (late 2030s to early 2040s) in these regions (Mora et al., 2013).

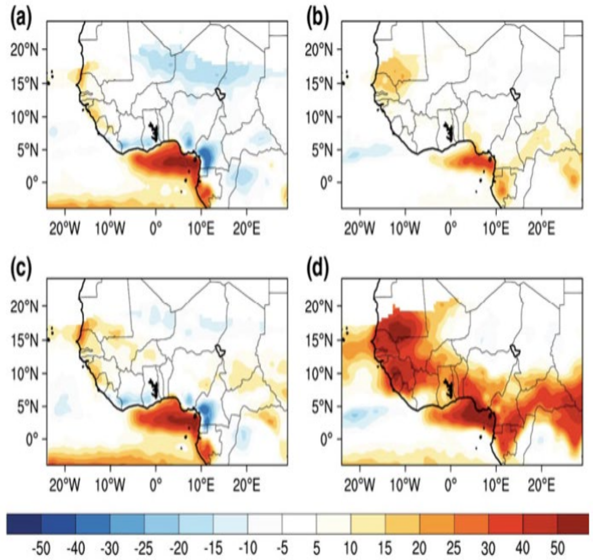
26. Four countries (Cote d'Ivoire, Gambia, Mali and Niger) which are located in West Africa

Tableau: Range of changes of three climate variables (ET, PCP and T) for all sites. The period 1986-2005 has been used as reference period to compute the relative changes of the annual mean for the climate variables. In this summary, all sites and RCMs have been used to capture the range of variability.

| CLIMATES SCENARIOS | | | | | |
|---|---|---|---|---|---|
| | | RCP45 | | RCP85 | |
| | | Horizon 2030 | Horizon 2050 | Horizon 2030 | Horizon 2050 |
| CLIMATE | PCP (%) | -5% to 5% | -10% to 10% | -8% to 8% | -16% to 16% |
| | T (°C) | 0.9 to 1.5 | 1.3 to 2.3 | 1.0 to 1.7 | 1.7 to 3 |
| | ET (%) | 2% to 4.5% | 3% to 6.5% | 2.5% to 5.5% | 4.5% to 8% |

FAO. 2019. Climate change impacts and responses in small-scale irrigation systems in West Africa: Case studies in Côte d'Ivoire, the Gambia, Mali and the Niger. Rome. http://www.fao.org/in-action/aicca/en/

**Figure 7**. Changes in seasonal (May–September) mean maximum Dry Spell Length (DSL) based on multimodel ensemble of CORDEX simulations for: a) RCP4.5 (2036/2065). b) RCP8.5 (2036/2065). c) RCP4.5 (2071/2100). d) RCP8.5 (2071/2100). (From Sylla et al., 2016a)



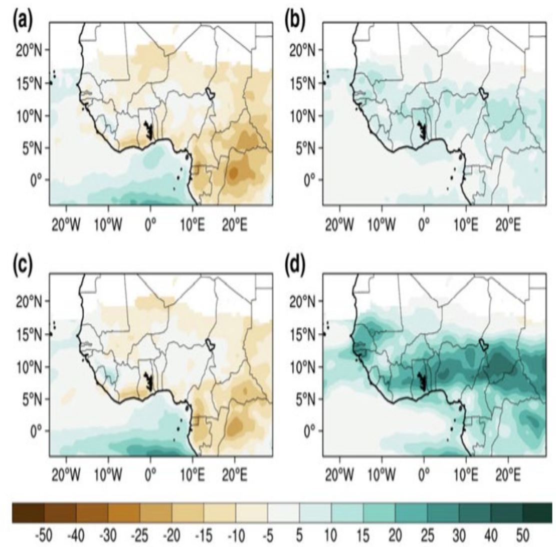




**Figure 8**. Changes in seasonal (May–September) mean intensity of precipitation events above the 95th Percentile (95Ptot) based on multimodal ensemble of CORDEX simulations for: a) RCP4.5 (2036/2065). b) RCP8.5 (2036/2065). c) RCP4.5 (2071/2100). d) RCP8.5 (2071/2100). (From Sylla et al., 2016a)

**Climate-related sectoral challenges and impacts in the major basins in the Sahel.**

27. **Social and economic impacts:** Climate vulnerability is the result of the complex interplay between the short and longer-term trends of climate change (e.g. heat, drought, erratic rainfall, sea level rise, heatwaves) and the socio-economic and political factors that enable effective adaptation. The West African Sahel is a region of rapidly growing populations, poverty, food insecurity, gender inequality, illiteracy, conflict, and political instability. Of the West Africa Sahel countries three (Burkina Faso, Chad, and Niger) rank in the bottom five countries of the global Human Development Index (HDI), one (Mali) in the bottom 10% and two (Mauritania) in the bottom 20%. Within Africa four of the West Sahelian countries (Chad, Mali, Mauritania, and Niger) are in bottom 10 (of 52) African countries in the Africa Gender Equality Index (AGEI) with only Burkina Faso and Nigeria ranking in the top 50%. The nutrition situation is very critical, with about 3.4 million children under the age of five expected to be affected by acute malnutrition. Poor households are particularly vulnerable given their dependence on natural resources for their livelihood (food security, nutrition and income). The resilience of the poor has been significantly compromised by both the food crisis and by conflict, including the effects on those communities that are hosting refugees (IOM, 2018). Within this, women and youth are disproportionally affected, which is a large scale problem, given the region is also one of the most youthful of the world, with 64,5% of young people aged less than 25 years (UNFP,2018).The instability of the West Sahel is reflected in the fragile state index ranking of its countries. Rural communities depend mainly on rainfed production, livestock and fishery along the key main river basins. Increasing temperatures and changes in precipitation are very likely to reduce cereal crop productivity, potential loss of species or a shift in composition in capture fisheries and impacts on seed availability for aquaculture, thereby threatening livelihoods, and loss of livestock. Stability of supply will be impacted by changes in seasonality,

increased variance in ecosystem productivity and increased supply variability and risks.Climate change threatens livestock production by affecting forage and fodder production, water availability, and livestock productivity (e.g. decreased milk production fertility, fitness, and longevity, and reduced calving rates). As drought and reduced rainfall diminish and alter traditional grazing areas and water resources, pastoral communities are increasingly under threat of losing their livelihoods and coming into conflict with settled agrarian communities as land degradation and competition over water and land resources increase. This will have strong adverse effects on food security. New evidence is also emerging that high-value perennial crops could also be adversely affected by temperature rise. Pest, weed, and disease pressure on crops and livestock are expected to increase as a result of climate change combined with other factors. Moreover, new challenges to food security are emerging as a result of strong urbanization trends with high demographics in the region. Climate change acts as a threat multiplier amplifying pre-existing vulnerabilities such as food insecurity and political instability.

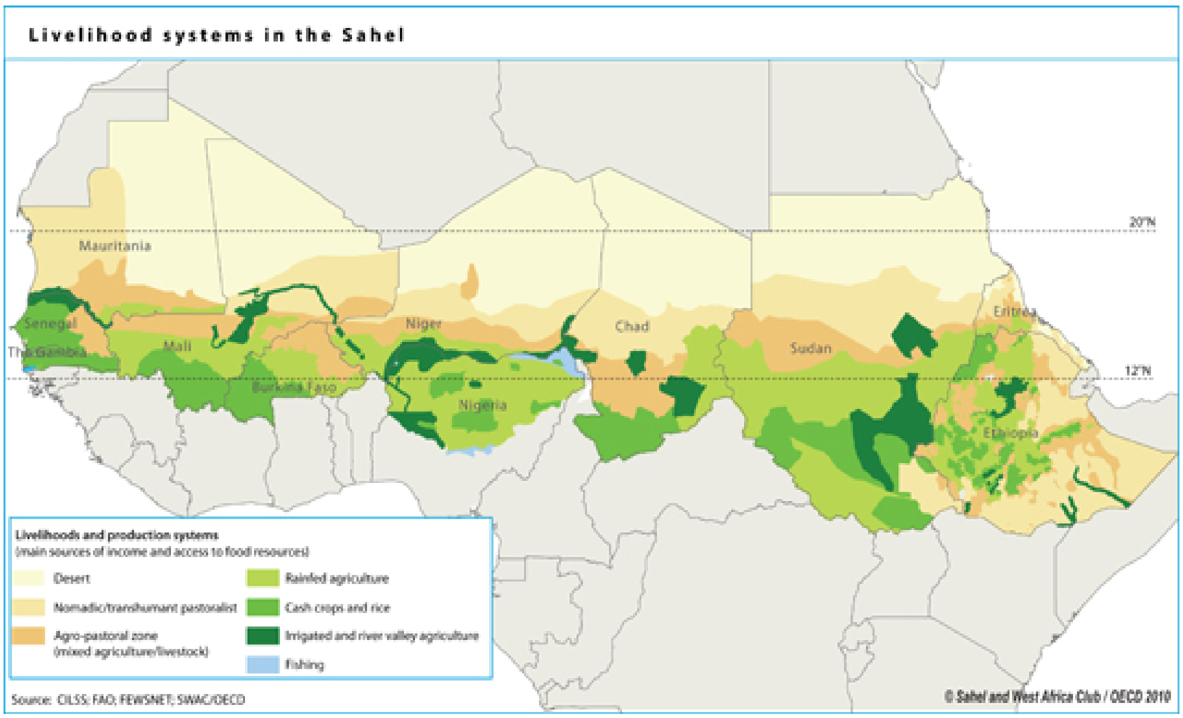



**Figure 9: Livelihood and production systems in the Sahel**

28. **Climate change and land degradation:** The Sahel is one of the most severely affected regions from land degradation and desertification in the world (UNEP, 1992-2018). The region has experienced severe drought and increasing deterioration of soil quality and vegetation cover (Geist and Lambin, 200). Land degradation is the reduction in the physical, chemical or biological status of land which may affect its productive capacity (Eswaran et al., 2001). Land degradation has resulted in the loss of the soil's productive capacity which is a great concern to the local people (Bielders et al., 2001) who are mainly subsistence farmers. Climate drivers such as drought, erratic rainfall, wind and temperature variability combined with human factors such as slash and burn farming, forest fires, deforestation, and mining concessions within selected watersheds, desertification unsustainable land use practices and watershed degradation, contribute to severe degradation adversely impacting their ecological functions, and compromising their integrity. Land degradation has adverse impacts on agricultural productivity, the environment and food security (Eswaran et al., 2001). The main human factors are pressure from population growth, agricultural intensification and to some extent migration. Though climatic and human factors may act independently, they can also have effects on each other. Over the

last years, changes in climate have  cause changes in land use practices (Mazzucato and Niemeijer, 2000) which have contributed to land degradation processes in the region including around the main water basins( Senegal river, Niger , Gambia, River, Lake Chad, Volta).  Interventions proposed in the programme such as land restoration, local proven techniques zai, ARN, agroforestry, CSA will contribute to protect soils against agents of erosion, increase agricultural productivity per unit land area and diversify farmers' sources of income, resulting in benefits for agricultural production and addressing land degradation.

29. **Climate change impact on water resources and river basins.** In the Sahel several studies found a decrease in surface and groundwater flow from the 1970s, resulting from the decreases in rainfall, and an increase in flow from the 1990s. A study the impacts of climate change on surface water resources in the Gambia Basin has shown a break in 1994 and an upward trend in the flow in the basin, unlike in the 1970s and 1980s, where discharges in the basin declined significantly[4]. In addition, prolonged conditions of rainfall and hydrometric deficits since the 1970s have been highlighted over the whole of the Gambia watershed. A long trend increase in temperature will considerably affect the hydrological cycle, thus changing rainfall pattern and the magnitude and timing of runoff[5].  Regarding Senegal River basin, finding from 36 rain gauge stations and 3 hydrometric stations, reveals two main shifts on annual rainfall in 1969 and 1994[6]. The first shift (1969) marks the starting point of the drought. After the second shift (1994), there is an increase of annual rainfall, compared to the previous period (1969–1994), which indicated a partial rainfall recovery not significant at a basin level. Overall, these findings demonstrate that there is a recovery of annual rainfall in the Senegal River basin, which is leading to the improvement of surface water availability.  A research aiming at assessing the climate change impact on the climate and the hydrology of the Senegal River Basin has shown that climate change is likely to impact considerably the basin's climate (with substantial changes of precipitation and temperature) and also the availability of water resources (with higher decrease of soil moisture, actual evapotranspiration and runoff) in the future[7]. This research is based on one regional climate simulation in the present day climate and two scenarios (RCP4.5 and RCP8.5) simulations in the future. Consequently, by the end of the 21$^{st}$ century (2071-2100) under the (RCPs) 4.5 and 8.5, a general decrease of river discharge, runoff, actual evapotranspiration, soil moisture is projected even though there are some localized increases in some parts of the basin (particularly in Guinean highlands) with the uncorrected simulations. This decrease is mainly related to the decline of precipitation. The most extremes changes of soil moisture, ET, and runoff are likely to occur in the northern basin, which is the driest and hottest part of the USB. Additionally, the available water resources exhibit substantial decrease (from -100% to -25%) in the majority of the basin for all data, except the Guinean highlands where an increase (50%) is found under RCP4.5 in the uncorrected data. Additionally, runoff is highly variable when compared to rainfall, soil moisture and evapotranspiration particularly in the drier northern basin. The small runoff coefficients of the basin have shown that a lower portion of the rainfall becomes runoff and also the sensitiveness to precipitation fluctuations.

**Figure 10:** Groundwater and renewable water resources

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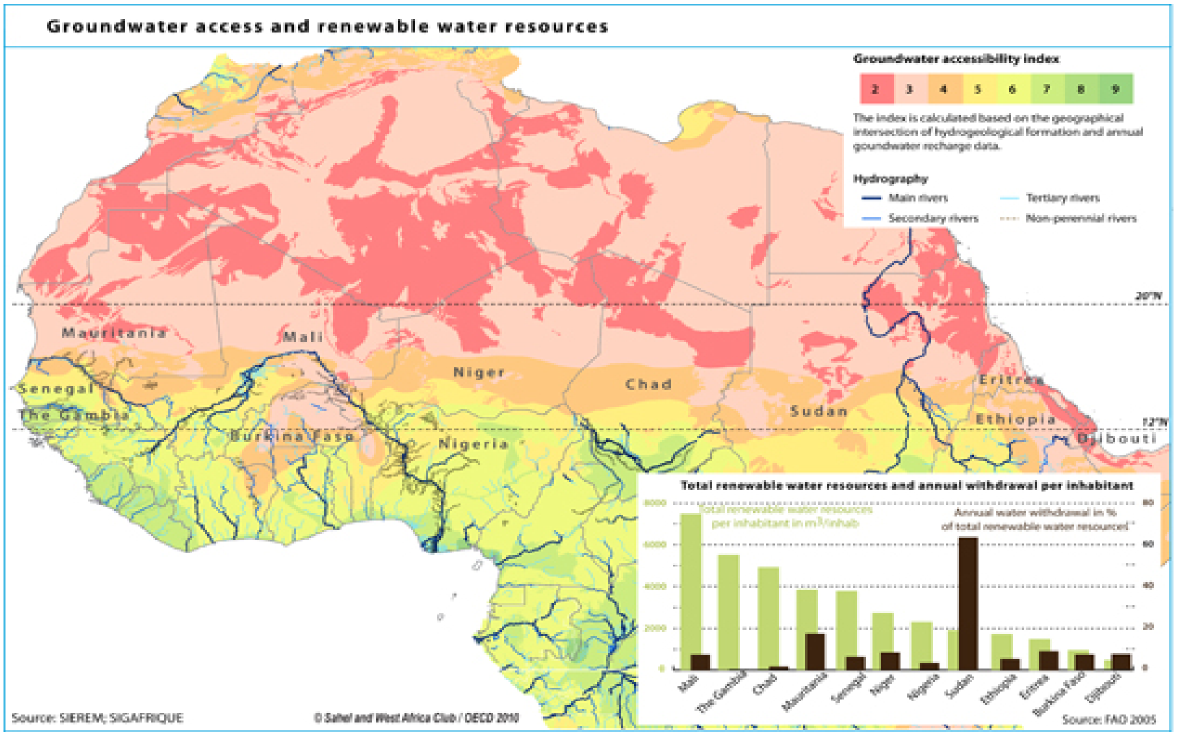
[4] Faye, C. 2019. Positive effects of climate change on water resources enhancement in Africa: Case of Gambia River Basin (Senegal). Hydrology - The Science of Water, Muhammad Salik Javaid, IntechOpen

[5] Azari, M.; Moradi, H.R.; Saghafian, B.; Faramarzi, M. 2016. Climate change impacts on streamflow and sediment yield in the North of Iran. Hydrol. Sci. J., 61, 123–133.

[6] Bodian, A., Diop, L., Panthou, G., Dacosta, H., Deme, A., Dezette, A., Ndiaye, P.M., Diouf, I. and, Vischel, T. 2020. Recent Trend in Hydroclimatic Conditions in the Senegal River Basin. Water 2020, 12, 436, doi:10.3390/w12020436. www.mdpi.com/journal/water

[7] Mbaye, M. L. 2015. Assessment of Climate Change impact on water resources in the Senegal River Basin at Bakel. PhD Thesis, Graduate Research Program on Climate Change and Water Resources Faculty of Sciences and Technology University of Abomey – Calavi




30. Where water is available, sustainable irrigation can make a critical difference. It reduces dependence on the weather, as multiple harvests are possible during the year, and may reduce under-employment and land pressure. The demand for modern energy access is significant especially in rural areas, Solar pumps for irrigation could increase agricultural productivity of key food crops and livestock. Solar water pumping (SWP) is poised to grow tremendously over the next decade due to declining costs, high reliability, and increased commercial availability in rural areas of less developed countries. Shifting from diesel to solar water pumping will help the selected countries save 31% on investment annually. SWP systems are reliable and have become much more affordable due to decreases in costs of PV modules—system costs have dropped by 80 percent since 2009 and many systems installed 20 or more years ago are still operational.

31. **Regarding the Niger River Basin.** Water remains the most critical constraint on agricultural production. Irrigated land is more productive and profitable than rainfed land particularly in Dosso, Tahoua Maradi and Zinder (targeted areas). Nevertheless, only 0.2% of agricultural land is under some form of water management. Of Niger's 270,000 hectares of irrigable land, 140,000 ha are concentrated in the Niger River valley. The rest of the country's irrigation potential comes primarily from the Komadougou River (part of the Lake Chad basin), several small seasonal rivers, dry riverbeds with easily accessible groundwater (dallols), the small oasis basins of Manga and Aïr and in some areas groundwater that is accessible with a pump. It therefore appears that Niger's irrigation potential is under-exploited: less than 100,000 ha, about 37% of estimated potential, are under irrigation. In addition to water harvesting, several types of irrigation techniques are being implemented and constitute ways to better adapt to climate change and climate variability. Nearly all aménagements hydro-agricoles (AHA) and medium-to-large irrigation systems are in the Niger River Valley where rice is the main crop. However, in some areas, high value vegetable crops are grown in the dry season, as land use has evolved over the past years.

32. **Lake Chad.** The shrinking of Lake Chad and its far-reaching consequences is an often-cited example of how a combination of weak institutions, poor resource management, population growth and pressure,

climate change and violent extremism can result in a disastrous social, economic and political situation (see Maps 8 and 9). Lake Chad Basin is currently one of the most unstable areas in the world. The water level is largely the result of the inflow from the Chari River from the south and, seasonally the Komodugu-Yobe river from the northwest. Rainfall also reaches the lake from smaller tributaries and groundwater discharge110. Inflow fluctuates with the shifting patterns of rainfall associated with the West African Monsoon, making it very sensitive to drought with years of little rain having a direct relationship with the water supply. Since 1963 when Lake Chad spanned an estimated 25,000 km2, it has contracted by over 90 percent, down to 1,350 km2. In addition to a decline in rainfall for much of the period, resource misuse and overuse as well as the increased demand for water associated with population growth contributed to this massive contraction. Between 1983 and 1994, the volumes of water used for irrigation were four times larger than during the previous 25 years. The population in the region increased from 13 million in 1960 to more than 35 million in 2007 and is expected to continue to grow by another 75 percent by 2025114. The reduction in the size of the lake has severely threatened the resources and livelihoods of the population. . The drying-up of the Northern half116 of the Lake caused migration to the remaining Southern shores, intensifying pressure on resources for agriculture, fishing, and livestock breeding in the rest of the lake area and related conflicts with spill over migration to Europe117. As the receding waters exposed new islands, land ownership issues created tensions between Cameroon, Chad, Niger and Nigeria118. The lack of capacity of existing political institutions to resolve these competing claims increased the likelihood of violent conflicts over resources. Disputes focusing on land and on fish catches and on access to and use of water, are occurring regularly. Numerous conflicts have broken out among pastoralists and farmers, and between different ethnic groups in Niger, because of the loss of the lake and its resources.

33. **Water quality degradation.** Precipitation and associated river discharge are major drivers of water pollution in the form of excess nutrients and sediment, transport into the main West frican Sahel Rivers. Changing climate conditions will affect water and wastewater treatment and disposal in several ways. Elevated stream temperatures, combined with lower flows, may require wastewater facilities to increase treatment to meet stream water quality standards. When drought frequencies increase, water quality in rivers may suffer because of reduced dilution of pollutant concentration, with potential health impacts. More intense precipitation and floods, combined with urbanization and associated increasing impermeable surfaces on the other hand, may amplify the likelihood of contaminated overland flow or combined sewer over flows contributing to declines in water quality in those areas. If flood frequencies increase, human health may be impacted by sewage contamination during flood events.

34. **Navigation constraints.** Navigation on the Senegal, Gambia, Niger River, Lake Chad will become increasingly vulnerable to more varied precipitation patterns. The impacts from extreme weather events, higher temperatures and heat waves, precipitation changes, and low flows and other climatic conditions are affecting the reliability and capacity of navigation in the Middle and Lower Niger. Drought often lowers vessel drafts on navigable sections. Continued low water flows have limited the duration of the navigation period and these rivers carries a heavy sediment load, making navigation difficult, during low flows. In the Inland Delta the drought that dried these channels has not allowed the annual "rinsing" of the seasonal barriers created by deposits of windblown sand and dunes. Climate change has also increase salinity.

**Climate change impact on the agricultural sector**

35. The agricultural sector across Sahelian countries continues to be marked by low productivity due to structural issues such as low soil fertility, lack of technology and capacity, and failure to adopt land reform ( *Zougmoré et al., 2016*), but also because of high vulnerability to climate and climate related risks ( see IFAD PARM risks management). These risks include: (i) high dependence on rainwater, which is the sole water source for a large majority of smallholder farms and is limited to a short wet season in many countries; (ii) high inter-annual climate variability that drives large year to year changes

in rainfall and temperature; (iii) recurrence of natural disasters and extreme weather events, including floods and droughts, locust outbreaks, livestock and crop diseases and pests, which all reduce productivity levels; (iv) fluctuations in the agricultural market for both inputs and outputs; and (v) limited disaster management policies in support of agriculture. Combined, these risks result in lower yields, loss of productive assets, loss of income, loss of productivity, increased costs, and changes in taxes and market access (IFAD, 2018). These can affect a farmer's ability to repay financial obligations and lead to a loan default. These financial shocks, combined with an inability to easily access external financing over time limits farmers' abilities to expand, diversify, and modernize their agriculture activities, and therefore increase their climate resilience and business opportunities. When natural disasters occur, governments tend to alleviate the effects of crop failures or other disasters by providing post disaster direct compensation as a relief measure, which does not address the underlying problem, and may even exacerbate it *(e.g. increase dependency;* FAO,2018). The weakness or absence of the agricultural insurance industry constrains farmer's resilience to climate risks.

### 1.4 Climate risks in the seven countries

36. The global impact of climate change and natural disasters has been worsening in the last few decades, especially in Africa. In the seven countries in this programme alone, according to the Emergency Events Database (EM-DAT), more than 800 natural disasters occurred between 1998 and 2017, claiming 360,000 lives. In addition, an average of about 358,000 people were affected by natural disasters per annum during this period. These disasters cost about USD 4.7 billion in total[8].

37. The risks of drought and flooding in the seven countries has been increasing over time. Figure 1 below presents the total incidence of drought and flood in the seven countries since the early 1900s, as reported by EM-DAT. There has been a shift in the total number of droughts and floods since the late 1990s: in 2004, there was only one occurrence of this kind of event, whereas prior to that year, single events were recorded in many years.

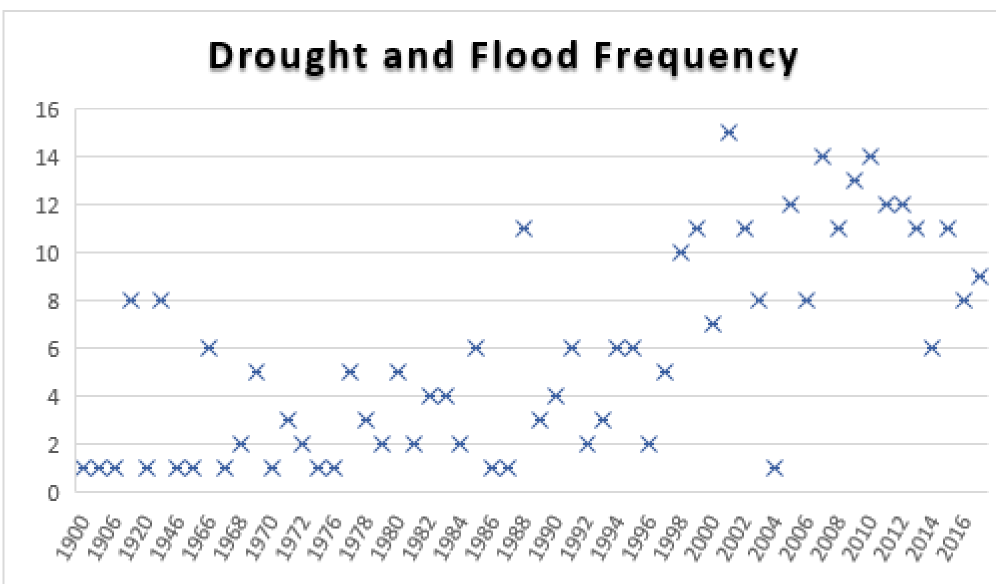



**Figure 1.4: Total drought and flood frequency in 10 African countries[9]**

[8] https://www.emdat.be/

[9] Emergency Events Database (EM-DAT), Université Catholique de Louvain (UCL), CRED, D. Guha-Sapir, www.emdat.be, Brussels, Belgium.

38. Climate projections based both on models and observations indicate that one of the most profound consequences of global warming is the likelihood of greater frequency and intensity of extreme weather events (IPCC, 2013[10]; Coumou and Rahmstorf, 2012[11]; Groisman et al., 2004[12]). This will have devastating consequences for human well-being and the livelihoods of rural people in poor countries (Nelson et al., 2014[13]; Wheeler and von Braun, 2014[14]), particularly in Africa. With one in four people in sub-Saharan Africa living in extreme poverty and most of the workforce engaged in small-scale agricultural production, most of the population does not have the same safety nets that are available in wealthier nations. Reducing the size of drought-vulnerable populations should therefore be a global priority over the next decade.

39. Marked by widespread chronic hunger, Africa is the most vulnerable region in the world to weather-driven food shortages and humanitarian crisis, as shown in the vulnerability map below. Climate disasters such as droughts, floods and tropical cyclones trigger destabilizing events and cause death and extensive loss of livelihoods and property in many African countries. Historical data indicates that drought was the cause of most deaths, especially in countries dependent on rain fed agriculture, as well as the highest economic losses. Floods and storms also contributed significantly. The impacts of climate change increase vulnerability by altering people's livelihoods, affecting health, forcing migration and causing conflicts. Generally, women, children and the elderly are particularly vulnerable and the least able to cope with environmental and climate change shocks.

40. In the seven selected countries, agriculture is localised in drylands, which are defined by the Aridity Index as arid, semi-arid and dry sub humid zones and account for three quarters of the seven countries' cropland, two-thirds of cereal production and four-fifths of livestock holdings. Today, frequent and severe shocks, especially droughts, limit the livelihood opportunities available to millions of rural households and undermine efforts to lift the poorest out of poverty. By 2030, the number of people living in the drylands in West Africa is expected to increase by 65 to 80 percent (depending on the fertility scenario). Over the same period, climate change could result in an expansion of the area classified as drylands, by as much as 20 percent under some scenarios, for the region as a whole, with much larger increases in some countries. This would bring more people into an ever more challenging environment and vulnerability to climate change (Cervigni and Morris, 2016[15]).

41. Governments in Africa recognize the need to reduce the barriers to climate change adaptation and agricultural productivity. The program will address these challenges by improving land productivity, ecosystem function, and climate adaptation. The program will support the implementation of the GGWI, which was established to strengthen the implementation of existing continental frameworks and addresses land degradation from Senegal on the Atlantic coast to Djibouti on the Red Sea. Originally the concept of the GGWI was limited to a tree planting initiative, but it then evolved to the promotion of SLM as a more ecologically appropriate, socioeconomically sustainable, and holistic approach at the landscape level to directly benefit local land and water users (farmers, agropastoralists, and mobile pastoralists). The GGWI plans to conduct a set of interrelated interventions in well-delineated regions of Sahelian countries with the aim of achieving: (i) Natural resource conservation, development, and management; (ii) strengthening infrastructure; and (iii) improving the populations living conditions. IFAD's baseline investments to support development plans in these countries has been focused on helping smallholder farmers adapt to the impacts of climate change and reduce the barriers to

[10] https://www.ipcc.ch/report/ar5/wg1/
[11] https://www.nature.com/articles/nclimate1452
[12] https://www.geos.ed.ac.uk/homes/ghegerl/Groisman_et_al_...s_intensity.pdf
[13] https://doi.org/10.1073/pnas.1222465110
[14] https://www.ncbi.nlm.nih.gov/pubmed/23908229
[15] http://hdl.handle.net/10986/23576

agricultural development in the countries. A summary of one IFAD baseline investment in the seven countries follows are described below:

| Country | Project name | Main adaptation activities | Synergies with programme's interventions |
|---|---|---|---|
| **Burkina Faso** | PAPFA - Agricultural Value Chain Promotion Project (2017-2024)<br><br>*Total project cost: USD71.70* million | • Capacity-building on sustainable land management (SLM)<br>• Promotion and dissemination of sustainable land and natural resource management techniques based on local knowledge and other innovative practices<br>• Improvements to ecological integrity, economic productivity and land services in watersheds and rangelands<br>• Promotion of income-generating activities<br>• Support for the National Agricultural Development Programme<br>• Promotion of good environmental and agricultural practices<br>• Promotion of soil and water conservation practices (zaï planting pits, micro-catchments, stone barriers, cover crops)<br>• Promotion of agroforestry (NTFP)<br>• Support for plot farming using assisted natural regeneration techniques at the sub-watershed level<br>• Composting techniques | *Sub-component 1.1. Improved marketing of rice, vegetables and mango:*<br><br>• **Rehabilitation and maintenance of approximately 300 km of agricultural feeder roads** and their connection to major highways to facilitate the evacuation of products to grouping centers, mini-rice mills, factories of mango and the markets.<br><br>*Sub-component 1.2. Improvement of post-harvest operations and processing of agricultural products:*<br><br>• **Construction of climate resilient infrastructures and equipment of about 13 packing and grouping centers and group selling of market garden products** that take into account solar or bioenergetic energy options to preserve the quality of market garden products;<br>• **Processing facilities to withstand changes in extreme climate events through:** i) Pilot projects for the installation of a cold chain powered by anaerobic digestion of mango waste and solar energy to preserve market garden products (tomatoes, okra, eggplant) according to quality standards and notebooks expenses of commercial contracts; ii) Modern drying of mango by forced convection and thermal recirculation with air recirculation to reduce the energy charges of gas consumption and to increase the quality of the finished product and; iii) By-products and waste recovery from mini-rice mills, grouping centers and mango packaging and processing units.<br>• **Sustain climate-proofed investments and support farmer-based organizations through** |

| | | | |
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| | | | **access to adapted financial services.**<br><br>*Sub-component 2.1. Improvement of productivity and quality of agricultural production:*<br><br>• **Water efficiency and management through hydro-agricultural developments** to improve / secure access to water and promote irrigated crops (3,300 ha of rice farming and 100 hectares of market gardening sites).<br>• **Advisory support and dissemination of climate-smart agriculture practices** such as: (i) the introduction of suitable varieties of rice and vegetables; (ii) integrated management of soil fertility; (iii) rotations and the association of cultures; (iv) the rational use of phytosanitary products; (v) efficient water management, including through intensive rice growing systems (IRS); (vi) "drip" irrigation systems; and (vii) integrated management of fruit flies and other mango parasites.<br><br>*Sub-component 2.1: Bottom-up structuring of Professional Farmers Organizations (FOs)*<br><br>• **Support for farmer-based organizations through:** (i) better structuring and empowerment of FOs; (ii) integrated promotion of essential nutrition actions, and (iii) promotion of gender balance and social inclusion. |
| **Chad** | Re-PER - Strengthening Productivity and Resilience of Agropastoral family Farms Project (2018 - 2024)<br><br>*Total project Cost:* | • Improvement of agricultural water catchment and management<br>• Increased mobilization of surface water<br>• Protection of cropland from water erosion<br>• Training for farmers on improved technical procedures<br>• Greater access to resilient seeds and veterinarian inputs<br>• Support for stockpiling | *Component 1: Productive investments for resilient agropastoral family farms.*<br><br>• **Development of approximately 25,000 hectares to ensure the availability and effective management of water**.<br>• Opening up of isolated production areas through the **rehabilitation of 150 km of rural feeder roads.** |

| | | | |
|---|---|---|---|
| | *USD94.90 million* | • Support for household income generating activities<br>• Promotion of environmental education and awareness<br>• Adoption of information and climate monitoring measures | • Distribution and use of improved seeds and climate-rational techniques.<br>• Improvement of short-cycle livestock production (small ruminants and local chickens) to withstand pests by **vaccinating small ruminants against plague and Newcastle disease, to the benefit of 208,500 households**.<br>• **Support of postharvest storage and processing activities in emerging agropastoral value chains.**<br><br>*Component 2: Strengthening of human capital and professionalization of farmers' organizations*<br><br>• Improved nutrition, **access to water** and functional literacy;<br>• **Support FO through the creation of farmers' organizations and support for development activity planning and technical services.**<br>**Sustain climate-proofed investments and support farmer-based organizations through access to adapted financial services.** |
| **Mali** | MERIT-Multi-Energy for Resilience and Integrated Territorial Manageme nt (2019 – 2024)<br><br>*Total project cost: USD $50.76 million* | • Support for the creation of a multi stakeholder platform bringing together private and public stakeholders to promote an inclusive policy dialogue on renewable energies and biogas<br>• Capacities building of national agencies in charge of the renewable energy sector to help them fulfil their mandate<br>• Support for technical, scientific and financial aspects to the policy process, leading to the formulation of a national programme to promote biodigesters<br>• Support for institutional reforms to enable better coordination between key stakeholders<br>• Diffusion of renewable energy technologies tested and validated under ASAP/PAPAM at large-scale<br>• Strengthening of the supply chain, distribution networks, | *Subcomponent 1.1: Strengthening the institutional framework for renewable energy promotion*<br><br>• **Sustain climate-proofed investments and support local authorities through**: (i) an inclusive policy dialogue on renewable energies and biogas in particular, by supporting the creation of a multi stakeholder platform bringing together private and public stakeholders; (ii) capacity building of national agencies in charge of the renewable energy sector to help them fulfil their mandate; (iii) technical, scientific and financial support to the policy process, leading to the formulation of a national programme to promote biodigesters. |

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| | | commercialization, financing schemes and customer services promoting all the renewable energy activities<br>• Training of local artisans and development of certification mechanisms to ensure the quality of works and customer service<br>• Diffusion of improved stoves and solar lamps relying on the creation of a revolving fund<br>• Creation of 150 Adaptation Community Plans (PCA) is planned according to a participatory and bottom up approach, from village level to communal level<br>• Implementation of a "terroir based" climate adaptation approach for the PCA priority activities<br>Promotion of bioenergy sources and integration of crop and livestock production for a sustainable intensification of production systems | *Subcomponent 1.2: Diffusion of the low GHG-emission nexus at household level.*<br><br>• **Support farmer-based organizations through**: i) information, awareness raising and promotion of renewable energies; ii) diffusion of 5,000 biodigesters, 3,000 photovoltaic kits, and 50,000 improved stoves and solar lamps each; iii) capacity building at local level and; iv) research and development to pilot new technologies.<br><br>*Subcomponent 2.1: Integrated terroir management.*<br><br>• **Watershed rehabilitation and water efficiency and management** through: i) access to ground water for market gardening (boreholes and solar pumping); ii) sustainable land and water management through the adoption of water and soil conservation techniques on 2,500 ha (to be defined according to the specificities of each area) and agroforestry techniques (restoration of 3,720 ha of agroforestry parks).<br>• **Support local public authorities and farmer-based organizations in defining rules for the management of natural resources through the establishment of local agreements** involving all stakeholders, and the implementation will rely whenever possible on the local workforce and competencies (High Labour Intensity Works in synergy with the World Food Programme).<br>• **Sustain climate-proofed investments by supporting initiatives for better access to land** and to reduce conflicts related to natural resources through the creation or strengthening of 600 village land commissions. |

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| | | | *Subcomponent 2.1: Bioenergy sources and the integration of crop and livestock production for a sustainable intensification of production systems.*<br><br>• **Construction of 250 improved cowsheds to increase animal holding periods and conditions in order to withstand changes in extreme climate events and pests.**<br>• **Dissemination of climate-smart agriculture practices such as the installation of demonstration plots on bioslurry and compost use** (92 testing plots with the support of research institutes, and 420 demonstration plots) and the implementation of 150 in-situ agroforestry trials.<br>• **Support FO's training, through the creation of mixed farmer field schools** (agroecology and fodder production) in each of the 1,250 targeted villages; and the support of integrated market gardens relying on bioslurry and other forms of organic compost in each of the 150 new sites (subcomponent 2.1) and in 250 pre-existing sites in need of support. |
| **The Gambia** | ROOTS - Resilient Organizations for Transformative Smallholder Agriculture Project (2019 – 2022)<br><br>*Total project cost: USD 80 million* | • Strengthening of community-based natural resource assessment and watershed/landscape management planning<br>• Promotion of sustainable watershed management<br>• Establishment of a water resources recovery system<br>• Installation of water-efficient irrigation systems for market gardening and rice<br>• Restoration of forest resources (agroforestry, mangrove conservation and reforestation)<br>• Support for policy dialogue and national climate policy framework | *Component 1. Agricultural productivity and adaptation to climate change.*<br><br>*Under sub-component 1.1:*<br>• Consolidation of 1,300ha of existing poorly performing tidal irrigation and **development of 2,800ha of new efficient tidal irrigation on existing agricultural lands**(average size per community land between 25 and 75ha)<br>• Development of **200ha new wet-season valley water control cascaded dykes**<br>• Development of **800ha new microcatchments runoff control dykes**<br>• **Support FOs through the establishment of and strengthen Water User Management Units** |

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| | | • Institutional capacity-building for community-based watershed<br>• Validation and demonstration of conservation agriculture tools and techniques for sustainable upland farming | • **Upgrade water allocation system of 20km of causeways** to access 800ha rice-growing swampy areas.<br>• **Dissemination of climate-smart agriculture practices such as ecosystem preservation activities** through the rehabilitation of 1,300ha of mangroves and 1,400ha of community forests.<br><br>*Under sub-component 1.2*:<br>• **Sustain climate-proofed investments through access to various agricultural services** (extension, input provision, financial education) with the focus on the promotion of Farmers' Field Schools for rice and vegetables<br>• **Support FOs through the emergence of 240 youth-led businesses** mainly focused on the provision of services to the value chains and **the capacity development of grassroots farmers' organisations** so that they develop services for their members, particularly women-led farmers organisations.<br><br>*Component 2. Access to markets*<br><br>*Under sub-component 2.1*<br>• **Sustain climate-proofed investments over a longer period of time and support local public authorities and FOs** through: (i) agricultural value-chain interaction platforms (AVIPs)-- one rice AVIP and one vegetable AVIP in each region with key value-chain stakeholders (producers, processors, traders, transporters) and the voice-based market information system introduced by NEMA will be scaled-up; (ii) capacity development of the National Coordinating Organization for Farmer Association in The Gambia (NACOFAG) as well as the national commodity organizations of food processors, rice and vegetable growers.<br>• **Construction of markets and feeder roads.** |

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| | | | *Under sub-component 2.2*: **Sustain climate-proofed investments and support local public authorities and FOs** by ensuring that: (i) FOs and SMEs prepare high-quality business plans with a particular focus on women-led FOs and SMEs; (ii) efficiently mobilized and utilized matching grant resources and (iii) a pilot project on post-investment business support to sustain the 4Ps, through linking the SMEs to specialized business development services, including certification and food safety standard. |
| **Mauritania** | PROGRES - Sustainable Management of Natural Resources, Communal Equipment, and the Organization of Rural Producers Project (2019 – 2022)<br><br>*Total project cost: USD 50 million* | • Integration of SLM into national and regional strategies<br>• Strengthening of the monitoring of water resources<br>• Development of climate resilient NTFPs, market gardening, poultry and the dairy value chain<br>• Sensitization and capacity-building on SLM<br>• Investment in the protection and rehabilitation of threaten ecosystems.<br>• Installation of efficient irrigation systems | *Component 1: preservation of natural resources used as agro-pastoral productive capital.*<br><br>• Rehabilitation of 9 500 ha of farmland (development in Ces/Drs, **dam rehabilitation and development of ponds, development of pastoral corridors**) which will be managed in climate resilient manner. These rehabilitated areas will be exploited using production techniques adapted to ecosystems.<br>• **Support FOs through agricultural capacity building using the farmer field schools (FFS) approach and the establishment of Management Committees** for each site. These management committees and the local farmers' organizations will benefit from capacity building in natural resource management to increase their resilience to climate change<br><br>*Component 2 improved access to basic social services and local facilities for the rural communities.*<br>**Sustain climate-proofed investments and support local public authorities and FOs** by strengthening the planning and management capacities of nearly 700 local structures and facilitate access to basic socio-economic services by financing 260 infrastructures of Community interest (drinking water, vaccination parks, slaughterhouses, shops, etc.). |

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| **Niger** | ProDAF – PRECI[16] Family Farming Development Programme in the Maradi, Tahoua and Zinder Regions *(*2015 – 2023*)*<br><br>*Total project cost:*<br>*USD 205.37 million* | • Execution of soil and water conservation/Soil protection and restoration works<br>• Development of pastoral spaces<br>• Introduction of GIS mapping<br>• Construction of infrastructure for water resource mobilization (weirs, mini-dams and ponds)<br>• Installation of small-scale irrigation systems (catchment kit, water pumping and distribution)<br>• Recovery/development of degraded lands upstream of the watershed<br>• Execution of hydro-agricultural works downstream from mini-dams<br>• Strengthening of farmers' technical capacities (rain-fed crops, irrigated crops, small-scale livestock farming)<br>• Strengthening of local expertise on agricultural climate risks | *Subcomponent 1.1: Structured, productive farms resilient to climate risks.*<br><br>• Recovering 16,000 ha of degraded land<br>• **Stabilizing dunes around watersheds in a 2,000 ha area**<br>• Creating 2,500 ha of sylvopastoral space<br>• Planting hedgerows on 400 ha of land.<br>• **To make better use of the available water resources**, the programme will: (i) build/rehabilitate 139 dams in series to recover approximately 700 ha of land for irrigation; (ii) build seven multipurpose mini-dams; and (iii) create four ponds. **The programme will furnish equipment for 6,800 ha of small-scale irrigation and get it up and running. Thus, the programme will generate a total of 7,500 ha of irrigated land.**<br><br>*Subcomponent 1.2: Capacity building for rural dwellers.*<br><br>• **Strengthen the institutions and organizations that provide assistance to family farms**: rural civil society organizations (farmers' organizations, CRA/RECA), decentralized technical services and the territorial authorities (communes, regional boards).<br>• To improve small-animal husbandry and poultry farming, the programme will include: (i) the creation of six new private veterinary services in the vicinity; (ii) advisory assistance in poultry farming and small-animal husbandry, with the introduction of 210 innovations in small-animal husbandry, benefitting 15,750 |

[16] Project to Strengthen Resilience of Rural Communities to Food and Nutrition Insecurity will cover more than the ProDAF intervention area (i.e. 186 municipalities in the Dosso, Tahoua, Maradi and Zinder regions, which have 46 municipalities and 6,606 villages); Total project cost: USD 195.6 million; Duration: 2019 – 2022.
The project's overall goal is to sustainably improve the food and nutrition security of rural households and strengthen their resilience to climate and environmental shocks. Its development objective is to increase the income of rural households, improve their livelihoods and ensure the socioeconomic integration of young people (both women and men) in promising rural professions.

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| | | | households; and (iii) the distribution of animals to reconstitute the livestock capital of 13,500 non-resilient two-person households (women and young people).<br><br>*Subcomponent 1.3: Women's leadership and the improvement of nutrition security.*<br><br>• **Support FOs through the creation of 1,350 women's groups under the Mata Masu Dubara Programme.** This programme will set up 90 new women-operated granaries for food security and 4,500 home gardens for nutritional support and provide 5,500 households with farming tool kits.<br><br>*Subcomponent 2.1: Structures for access to marketing platforms*.<br><br>• **Support FOs he construction of a semi-wholesale market** in nine new economic development poles, and 18 identified supplementary satellite hubs.<br>• **Rehabilitation/building of 850 km of rural roads**. Routine and periodic maintenance of these roads will be performed by independent road maintenance teams in cooperation with the management of the semi-wholesale market, the Community Advisory Assistance Directorate, the Ministry of Equipment and the Autonomous Road Maintenance Financing Fund.<br><br>*Subcomponent 2.2: Modes of infrastructure management and the financing of economic operators.*<br><br>• **Sustain climate-proofed investments though the creation of management structures for all commercial rural infrastructure created or rehabilitated and provide the requisite assistance.**<br>• **Provide assistance to the promoters of farming activities** |

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| | | | **or collaborate with agricultural activities** leading to profitable sales-oriented ventures through the creation of a cost-sharing financial mechanism.<br><br>*Subcomponent 2.3: Regional trade integration*<br><br>**Sustain climate-proofed investments and support local authorities and FOs through cross-border trade, increase knowledge about cross-border trade constraints and propose and test solutions with economic operators.** |
| **Senegal** | AGRI-JEUNES Tekki Ndawñi - Rural Youth Agripreneur Support Project *(*2019 - 2026*)*<br><br>*Total project cost: USD $93.28 million* | • Development of early warning systems and GIS<br>• Dissemination of best practices and local knowledge on adaptation to climate change<br>• Construction and rehabilitation of water storage units<br>• Training on anti-erosion techniques<br>• Installation of irrigation schemes for rice and pools for salt production<br>• Promotion of efficient water use for irrigation<br>• Promotion of alternative livelihoods through the development of apiculture and aquaculture<br>• Education of users on efficient water use Support to multi-stakeholder platforms to ensure a coherent approach to resilience and sustainability<br>• Promotion of consultation mechanisms for the scaling up of best practices in sustainable land management<br>• Construction of containment dykes, ponds and boreholes<br>• Promotion of soil conservation techniques<br>• Promotion of agroforestry and livestock<br>• Promotion of agricultural diversification<br>• Introduction of solar pumping<br>• Promotion of the use of biogas digesters | *Component 1: Development of profitable economic activities.*<br><br>• **Support FOs through the market inclusion of rural youth and their access to means of production** by providing start-up capital to youth in training or a productive credit to those who wish to develop an existing activity. These young people will receive support that will aid them in developing partnerships with farmers' organizations, umbrella organizations, interprofessional associations and other private sector operators.<br><br>*Component 2: Capacity-building and facilitation of inclusion*.<br><br>**Sustain climate-proofed investments of local youth** by studying their mobilization organizations, identifying interested rural youth through a rural vocational project and assisting them in the preparation and implementation of microprojects and business plans. It will also improve the quality and diversity of training, contributing to the development of a sustainable training supply. |

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| | | • Reduction of post-harvest losses<br>• Capacity-building<br>• Integration of climate change into sectoral policies on the management of agriculture and water resources<br>• Development of weather index insurance | |

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| **IFAD G 5+1 Sahel** | Emergency and Rural Development in Sahel: a Joint RBA-G5Sahel+1 Response to the 3C Challenges<br><br>Senegal, Burkina Faso, Chad, Niger,Mali,Mauritania | Component 1. Increase agro-sylvo-pastoral production and productivity through climate-smart agriculture practices<br><br>Component 2. Regional economic integration | Target Areas : Cross border areas where conflicts, crisis and heavy environmental challenges exist. Lake Chad (Niger, Chad), Liptako-Gourma (Niger, Burkina Faso, Mali) and the Senegal River Valley (Mali, Senegal, Mauritania) . | The overall program's goal is to strengthen in a sustainable way the resilience of the most vulnerable rural people in the Sahel region in order to mitigate the impacts of the COVID-19 crisis, Conflicts and Climate Change. The development objective is to improve rural producers' economic opportunities and livelihoods, with a focus on the most vulnerable groups (women and youth, landless, transhumant pastoralists), through the adoption of sustainable production practices and social cohesion approaches. |

### 1.5 Future climate projections and potential impacts on the selected countries

42. This section presents the potential impacts of climate change on regional climate and extreme climate variables, with a focus on the countries targeted by this proposal, which need to develop an Integrated Climate Risk Management Approach. Twenty regional climate simulations from CORDEX (http://www.cordex.org/) were analysed for this section. To put the results of the study in the context of the Paris Agreement, we present the impacts at four global warming levels – 1.5°C, 2.0°C, 2.5°C and 3.0°C, hereafter referred to as GWL1.5, GWL2.0, GWL2.5 and GWL3.0 – using the RCP8.5 climate forcing scenario. The impacts of global warming were projected for various climate events that influence agricultural activities. In this section, the hazards that have the biggest impacts on crop yields and production are analysed as well as the influence on climate change on their patterns. The climate conditions studied were:
    - Length of the rainy season, which determines the period for rain-fed agriculture
    - Precipitation intensity, which characterizes the potential risks to which cultivars could be exposed as the consequence of extreme rain events and flooding
    - Frequency of agricultural droughts (which combines precipitation and evapotranspiration)

- Frequency of heatwaves, which can intensify the negative consequences of low precipitation.

43. Regional climate models project shorter rainy seasons over all seven selected countries (Figure 1.5a). The change is mostly characterized by a delay in the onset of the season. However, the magnitude and the direction of the changes vary across the nations. The highest and most robust decrease (up to between five and 20 days) is projected for five countries, including Senegal and The Gambia. The smallest and the least robust decrease (< 2 days) is projected for Burkina Faso. Nevertheless, the robustness of the projections increases with the level of global warming.

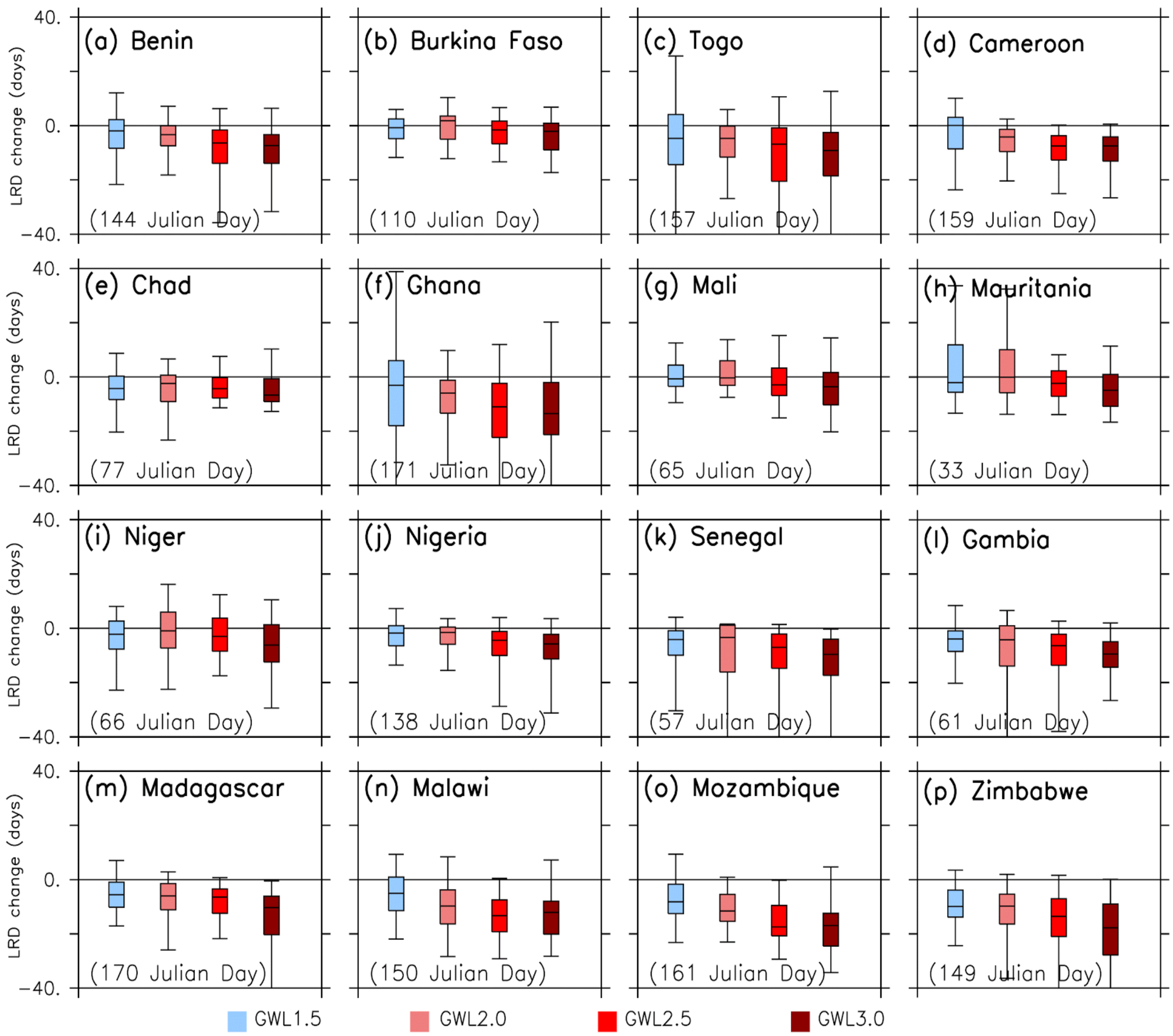


**Figure 1.5a: Projected changes in the length of the rainy season (LRD, in days) for 16 African countries**

**Note: The projections were carried out for global warming levels 1.5, 2.0, 2.5 and 3.0 (GWL1.5, GWL2.0, GWL2.5 and GWL3.0, respectively), as obtained from CORDEX RCMs simulation ensemble (20 members). The boxplot indicates the minimum, first quarter, median, third quarter and maximum values from the ensemble. All the changes are calculated in relation to the reference climate period (1971-2000) and the mean value is indicated in the lower left corner of each panel.**

44. A robust increase in the intensity of the simple precipitation index (SDII) is projected over all the countries and the magnitude of the increase becomes bigger as the global warming level increases (Figure 1.5b). This implies that the future climate of all the countries may be characterized by fewer days of rainfall, but their intensity may be greater than present day events. Moreover, the impact of this on the annual rainfall differs from one country to the next. In some, such as Chad and Niger, the surplus water from more intense precipitation may sufficiently offset the water deficit from the fewer rainfall days, thereby producing no change in (or increasing) annual precipitation levels. However, in other countries such as Mauritania and Senegal, the surplus from more intense precipitation may be less than the rainfall deficit, leading to a decrease in annual rainfall.

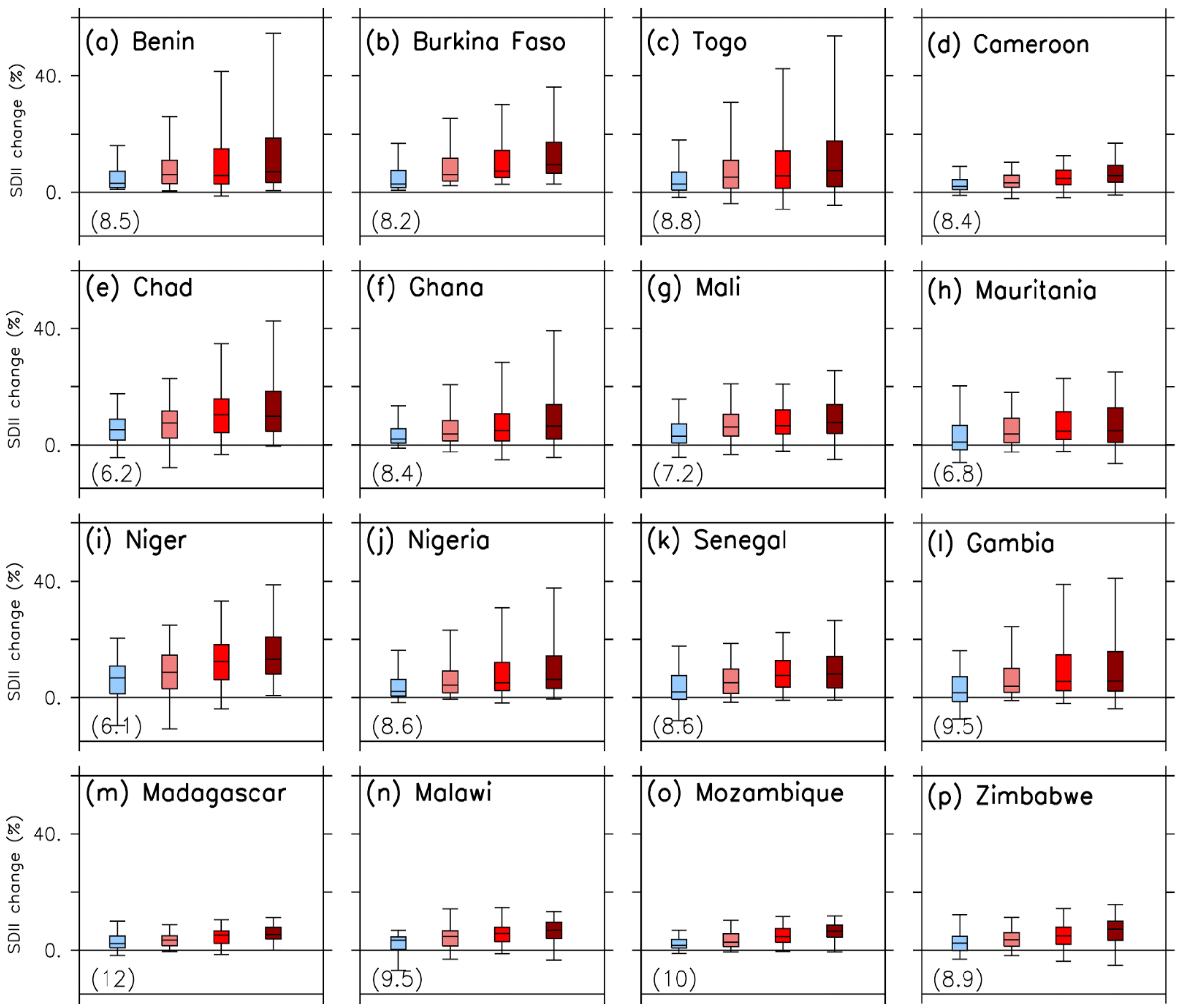


**Figure 1.5b: Projected changes in simple precipitation intensity (SDII, %) over 16 African countries**

**Note: The projections were carried out for global warming levels 1.5, 2.0, 2.5 and 3.0 (GWL1.5, GWL2.0, GWL2.5 and GWL3.0, respectively), as obtained from CORDEX RCMs simulation ensemble (20 members). The boxplot indicates the minimum, first quarter, median, third quarter and maximum values from the ensemble. All the changes are calculated in relation to the reference climate period (1971-2000) and the mean value is indicated in the lower left corner of each panel.**

45. The intensity and frequency of drought are projected to increase in some countries (Figure 1.5c). This increase is most pronounced over Chad, Mali, Mauritania and Niger and Nigeria, where the severity of the droughts grows as global warming levels rise. However, the projected changes in the Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI) for droughts differ: in most cases, they show opposing trends. For example, using the SPI, a decrease in drought frequency is projected for Chad, whereas projections using the SPEI indicate an increase in drought intensity. The discrepancy between the SPEI and SPI projections is due to the fact that SPI assessments do not take the influence of potential evaporation on drought projections into account. However, several studies have reported an increase in future potential evapotranspiration levels due to the global warming. Hence, using SPI (or precipitation) only for drought projections may result in the severity of the future droughts being underestimated. In addition, SPI drought projections are less robust than those of SPEI. For example, for Chad and Niger, all the simulations agree on SPEI projection over Chad, but they do not agree on that of SPI. However, no significant changes are projected for both SPEI and SPI droughts over Benin, Ghana and Togo.

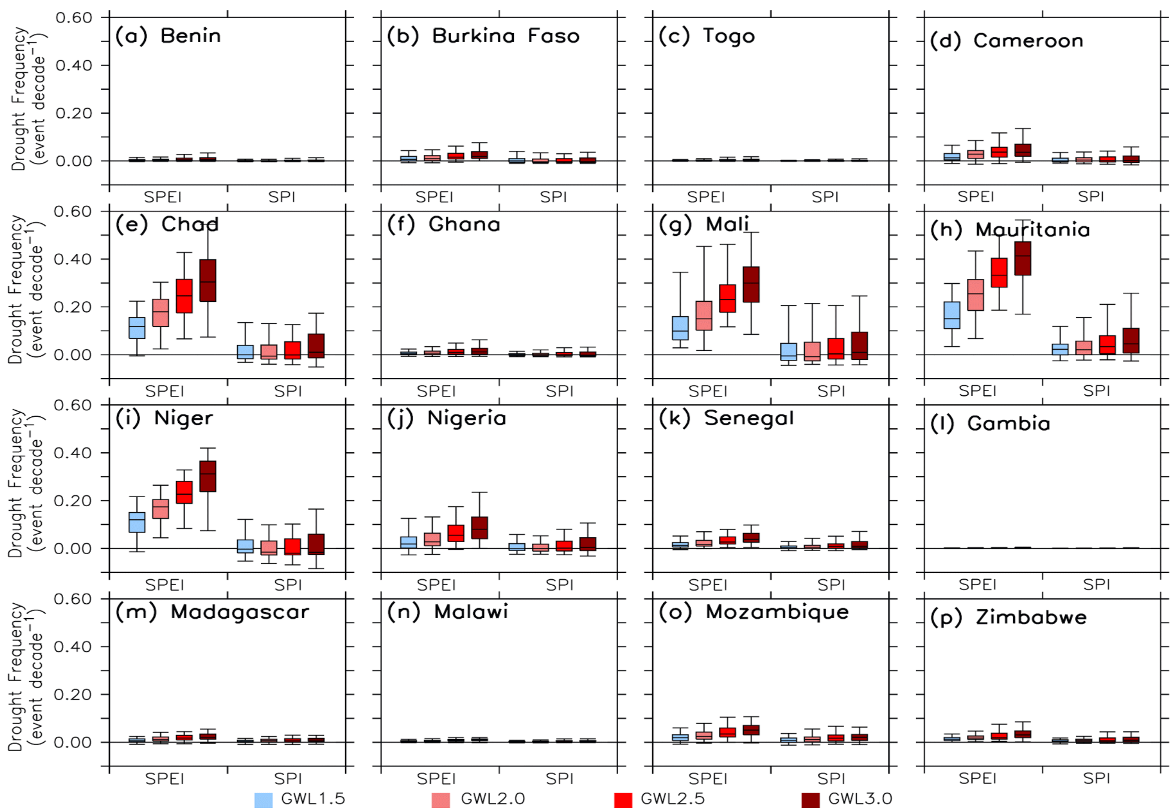


**Figure 1.5c: Projected changes in frequency of droughts using two different drought indices for selected African countries**

**Note: Projected changes in frequency of droughts were calculated using two different drought indices (SPEI and SPI: SPEI < -1.5; SPI < -1.5) for selected African countries under GWL1.5, GWL2.0, GWL2.5 and GWL3.0, respectively, obtained from CORDEX RCMs simulation ensemble (20 members). The boxplot, which shows the simulation spread (as a measure of robustness of the project), indicate the minimum, first quarter, median, third quarter and maximum values from the ensemble. SPI is calculated based on precipitation only, while SPEI is calculated based on the climatic water balance (precipitation minus potential evapotranspiration). All changes were calculated in relation to the reference climate period (1971- 2000).**

46. Finally, the impacts of climate change on the frequency of heat waves were projected over the countries. A heat wave is defined as a period of three or more consecutive days with maximum temperatures above the daily threshold (90th of daily maximum temperature for the reference period 1971-2000). The heat wave frequency is calculated based on the methodology used by Russo et al. (2014)[17]. All CORDEX simulations project an increase in heatwave frequency over all the countries (see figure 1.5d).

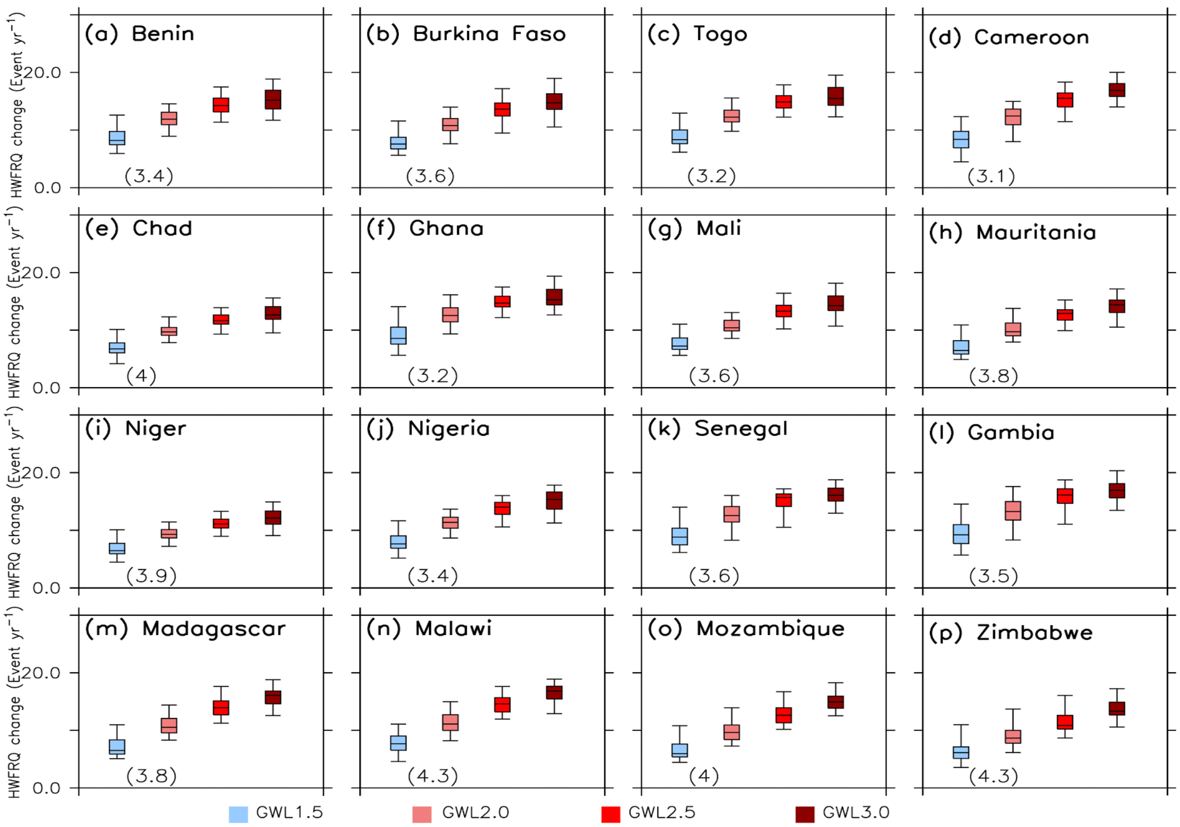


**Figure 1.5d: Projected changes in heatwave frequency (HWFRQ; event year$^{-1}$) over 16 African countries**

**Note: Projected changes in heatwave frequency (HWFRQ; event year-1) were calculated for the selected 16 African countries under GWL1.5, GWL2.0, GWL2.5 and GWL3.0, respectively, as obtained from the CORDEX RCMs simulation ensemble (20 members). The boxplot indicates the minimum, first quarter, median, third quarter and maximum values from the ensemble. All the changes are calculated in relation to the mean of the reference climate period (1971-2000) and the mean value is indicated in the lower left corner of each panel.**

47. CORDEX RCM simulations have been analyzed to show the potential changes on some climate and climate extreme variables over a group of 16 African countries. This analysis will support the design and implementation of the present GCF proposal in each country to focus on the most important climate extreme events.

48. There are two major projections that cut across all the countries. These include a decrease in the length of the rainy season and an increase in heatwave frequency, intensity and duration. While the decrease in the length of the rainy season is due to a delay in rainfall onset over some countries, in others, it is

[17] https://doi.org/10.1002/2014JD022098

due to both the delay in rainfall onset dates and early rainfall cessation dates. However, as the decrease in the length of the rainy season reduces the number of days of rainfall, it may reduce the length of growing season and pose risks to crop production and food security in these countries in the future. Hence, part of the adaptation strategy for all countries may be to train meteorological staff on how to calculate the onset days correctly and warn the farmers not to adhere to traditional sowing dates as they might change in the future. The projected increase in heatwaves, which is directly related to global warming, may affect both livestock and human health in the future. Changes in extreme rainfall events and droughts are country specific. Based on these changes, the countries can be classified into the following groups:

49. **Group A: Burkina Faso, Chad, Mali and Niger**
An increase in the intensity and frequency of extreme rainfall and droughts are projected for the countries in this group. While the projected increase in intensity and frequency of extreme rainfall may lead to destruction of farmland, properties, livestock and human lives due to floods, the projected increase in severity and frequency of droughts may lead to water scarcity, outbreak of diseases and reduced soil moisture and river flows. The projected increase in annual precipitation over these countries suggest that the annual water surplus from the rise in extreme rainfall will be more than the annual water deficit resulting from the decreased number of rainy days. Nevertheless, the increase in the SPEI for droughts indicated that the annual water surplus may not be enough to offset the annual water deficit caused by global warming induced potential evapotranspiration.

50. **Group B: The Gambia, Mauritania and Senegal**
A decreased intensity and frequency of extreme rainfall (and annual rainfall) and increased drought intensity and frequency are projected for these countries. This implies that while the current level of destruction from extreme rainfall events may be reduced, devastation from droughts should be expected. Hence, attention should be focused more on drought-related risks than on extreme rainfall events.

### 1.6 Seasonal agricultural calendars in the countries

51. Agriculture accounts for over 51 percent of employment and main source of livelihood. Various tradable commodities are grown in the region such as maize, soybean, dairy, livestock, rice, tree crops (cashew), horticulture and fish farming in other regions, including in the Lake Chad and Niger basin. However, the CORDEX RCM's projections of a regional decrease in the length of the rainy season and an increase in heatwave frequency, intensity and duration highlights the aim of determining the right period during which major agricultural activities, specifically to drought prone crops, must be available for successful agricultural production in the most important agro-ecological zones of each country. In its Operations Plans (OP)[18], the African Risk Capacity (ARC) has compiled drought profile for the seven countries[19] in order to prepare a set of country calendars of the major agricultural crops. Complementary information such as type of planting material, livestock migration, growing and harvesting periods, common cropping practices and any other relevant information regarding major agricultural crops are also included when available. Agricultural calendars can eventually be used in planning and management of activities related to agricultural practices, in particular in the rehabilitation of farming systems after disasters. Access to this information is valuable to the Ministries of Agriculture of the seven countries for use by agricultural planners, farmers, international organizations, agricultural NGOs and other related institutions. The figures below describe seasonal agricultural calendars in the latest version of the ARC's OPs in Burkina Faso, Mali, Mauritania, Niger, Senegal and The Gambia.

[18] An Operation Plan is a contingency plan aimed at providing rapid and efficient interventions to vulnerable populations in the event of drought and at obtaining payout from ARC. Read more on section on ARC.
[19] Chad has not prepared an OP as of date however the cropping calendar is similar to Niger.

The major agricultural crops in these countries seem to be staple crops (millet, maize, sorghum, groundnuts) and livestock (cash-asset), hence why the programme targets the latter.

### 1.6.1 Burkina Faso[20]

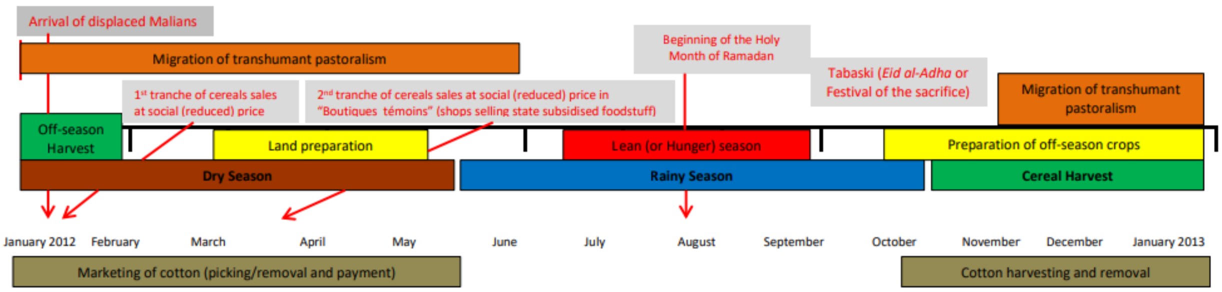


**Figure 1.6.1a. Seasonal Calendar in Burkina Faso**

| Foodstuff sources / -generating activity | Oct.09 | Nov.09 | Dec.09 | Jan.10 | Feb.10 | March.10 | April.10 | May.10 | Jun.10 | Jul.10 | Aug. 10 | Sept. 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainy Season | | | | | | | | | | | | |
| **Agriculture** | | | | | | | | | | | | |
| Millet | Harvest | | | | | | Land preparation (LP) | | Sowing | | Growing | |
| Sorghum | Harvest | | | | | | Land preparation | | Sowing | | Growing | |
| Cowpea | Harvest | Sale | | | | | Land preparation | | Sowing | Growing | Growing | Harvest |
| Groundnut | Harvest | | Sale | | | | | | LP | Sowing | Growing | |
| Maize | Harvest | | | | | | Land preparation | | Sowing | | Growing | Harvest |
| Rainfed rice | Growing | | Harvest | | | | Land preparation | | Sowing | | Growing | |
| Off-season rice | | | | | LP | Sowing | Growing | | Harvest | | | |
| Market gardening | | | Harvest | | | | | | | | | |
| **Stock (or Livestock) Farming** | | | | | | | | | | | | |
| Cattle – Milk production | | | | | | | | | | | | |
| Sheep/goats – Milk production | | | | | | | | | | | | |
| Migration of animals (specify) | | | | | | Departure | | | | | | Return |
| Cattle feed/inputs purchase | | | | | | | | | | | | |
| Cattle purchase/sale (specify) | | | Sale | | | | | | Purchase | | | |
| Livestock diseases | | | | | | | | | | Cattle diseases | | |
| **Forest exploitation** | | | | | | | | | | | | |
| Gathering | | | | | | | | | Leaves, fruit and wood | | | |
| **Other** | | | | | | | | | | | | |
| Local daily work - agricultural | | | | | | | | | | | | |
| Local daily work - other | | | | | | | | | | | | |
| Handicraft (manufacture, sale...) | | | | | | | | | | | | |
| Human exodus/migration | | | | | | | | | | | | |
| Lean (or Hunger) month | | | | | | | | | | | | |
| Debt/loans and repayments | | Repayment | | | | | | | | Loans | | |
| Malaria and other human diseases | | | Other diseases | | | | | | | | Malaria | |
| Food purchasing | | | | | | | | | Peak | | | |
| Festivals, social events, etc. | | | | | | | | | | | | |

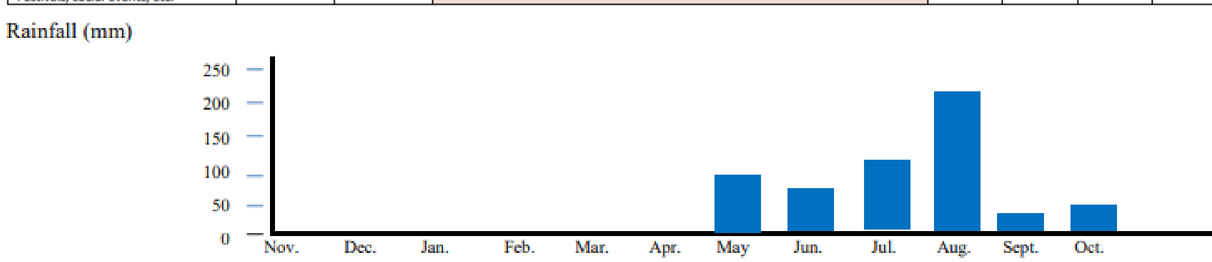


**Figure 1.6.1b. Seasonal calendar of an area in the North of the country with related rainfall**

[20] Burkina Faso 2016 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/07/BURKINA-FASO-_Operations-Plans_2017_EN_vo2CL.pdf

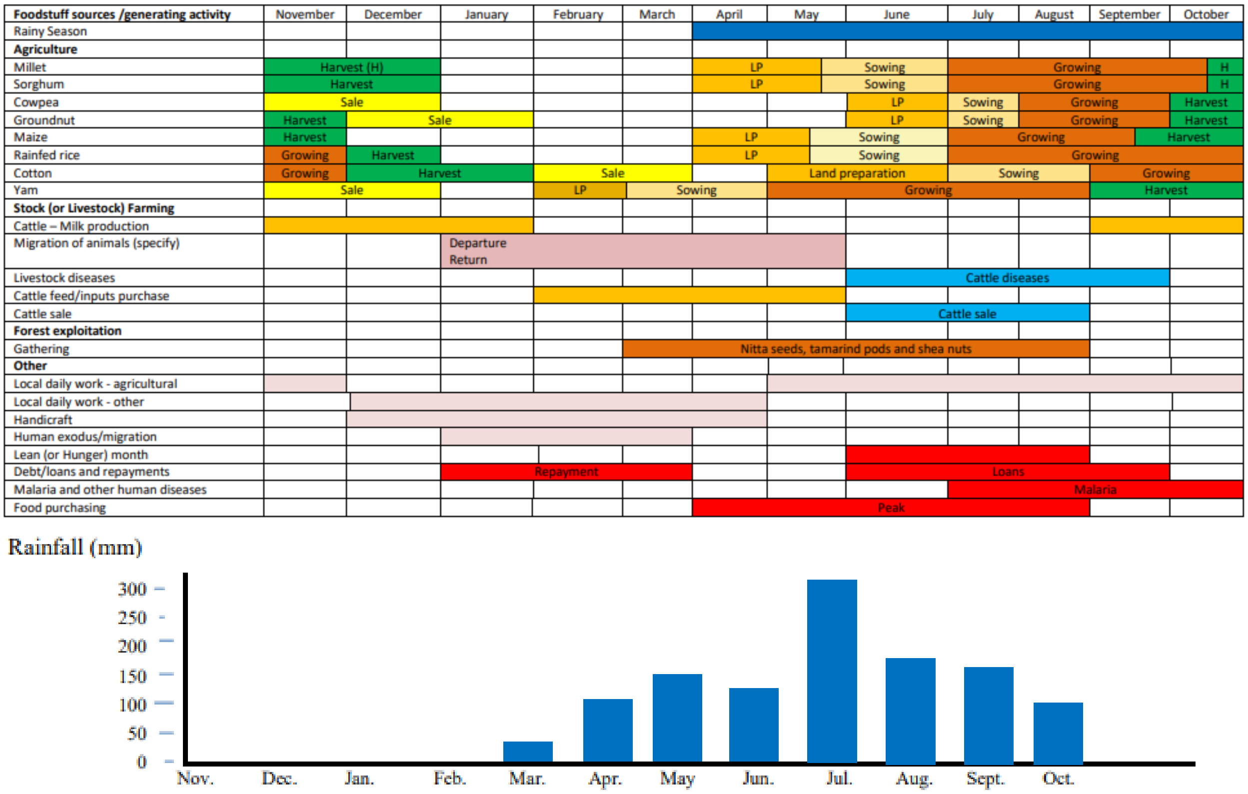


**Figure 1.6.1c. Seasonal calendar of an area in the South of the country with related rainfall**

### 1.6.2 Chad

52. Since Chad has not prepared an OP with ARC as of date describing its seasonal agricultural calendar, IFAD Climate Adaptation in Rural Development – Assessment Tool (CARD)[21] provided data for Chad to explore the effects of climate change on the yield of major crops (see figure below). This can support the quantitative integration of climate-related risks in agricultural development.

[21] https://www.ifad.org/en/web/knowledge/publication/asset/41085709

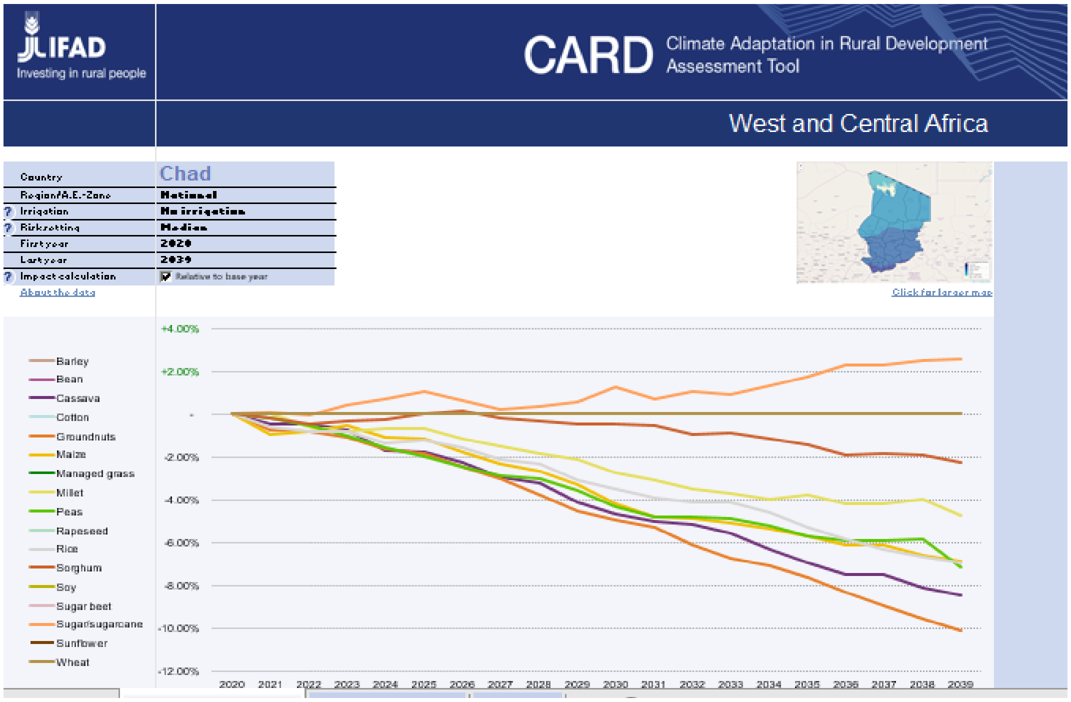


**Figure 5.2.3.1: CARD for Chad**

### 1.6.3 Mali[22]

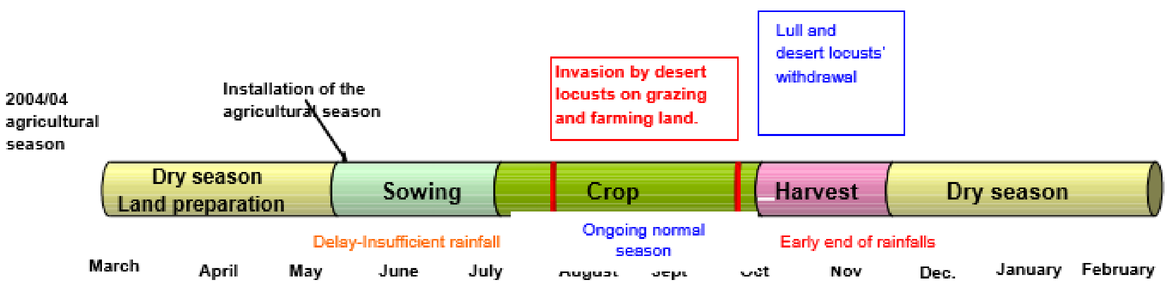


**Figure 1.6.2a. Seasonal calendar in Mali**

[22] Mali 2015 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Mali-Operational-Plan.pdf

| Crop | Land preparation | Sowing/transplanting | Weed control/weeding | Singling | Harvest | Threshing |
|---|---|---|---|---|---|---|
| Rice | May /June | 15 May to 30 July | June/July | _* | Oct. /Dec. | Nov./January |
| Millet | May /June | 15 May to 30 July | July/August | July/August | Nov./Dec. | Dec./January |
| Sorghum | May /June | 15 June to 30 July | July/August | July/August | Nov./Dec. | Dec./January |
| Maize | 1 May/20 June | 15 May to 30 July | June/July | _* | August/October | Sept./Oct. |
| Fonio | June/July | 15 June to 30 July | July/August | _* | Oct./Nov. | Nov./Dec. |
| Groundnut | May /June | 15 June to 30 July | July/August | _* | Oct./Nov. | Nov./Dec. |
| Cowpea | June/July | 15 June to 30 July | June/July | _* | Oct./Dec. | Nov./Dec. |
| Market gardening | September/Oct. | 15 Oct. to 15 Dec. | Nov. – Dec. - January | _* | From December | _ |

*Source*: DNA

** Crops not suitable for singling*

**Table 1.6.2b. Agricultural calendar of main crops**

### 1.6.4 Mauritania[23]

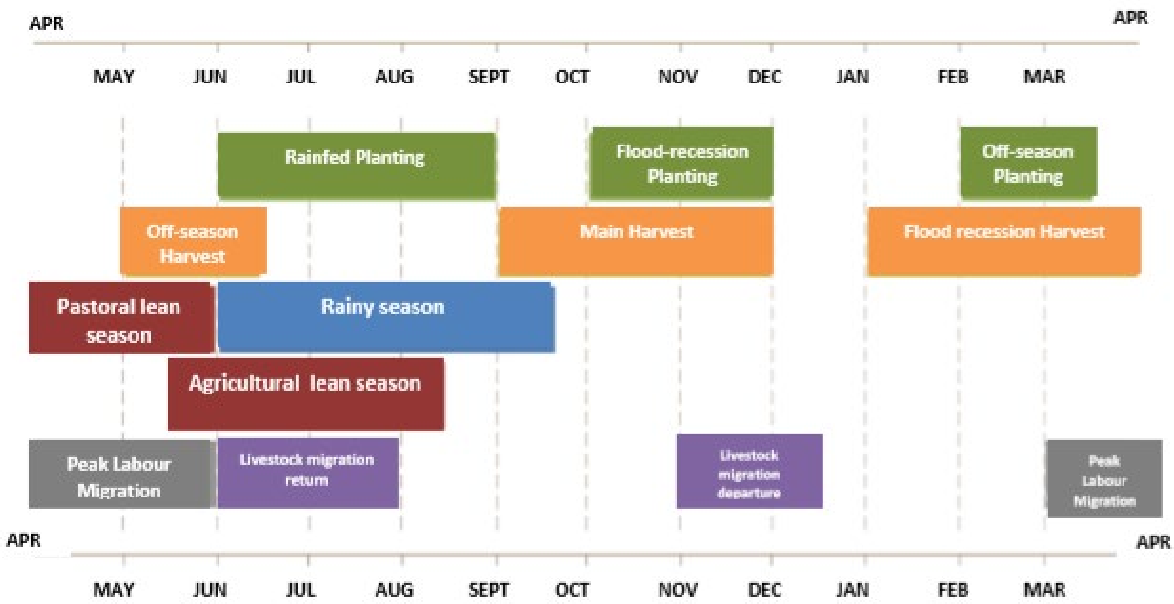


**Figure 1.6.3. Seasonal Calendar in Mauritania**

23 Mauritania 2016-2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Mauritania-Operational-Plan_EN.pdf

### 1.6.5 Niger/Chad[24]

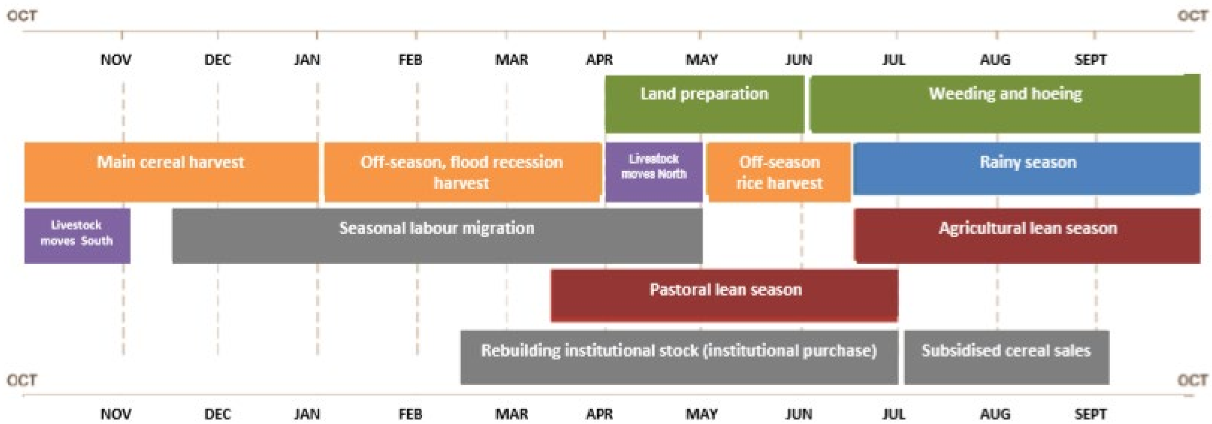


**Figure 1.6.4. Seasonal calendar for a typical year in Niger/Chad**

### 1.6.6 Senegal[25]

53. Farming in Senegal depends largely on the rainy season, which generally starts in May and ends in October. The harvest period of crops such as millet, sorghum, maize and groundnuts is October and November.

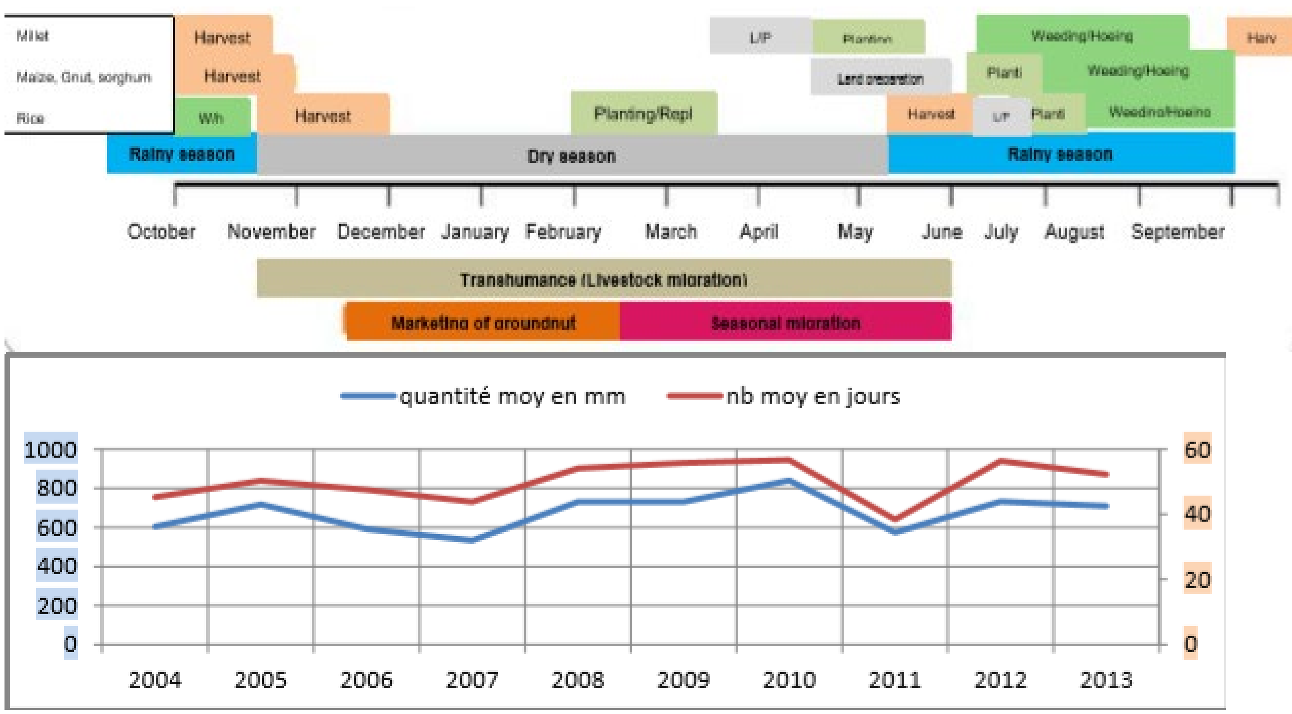


**Figure 1.6.4. Seasonal calendar in Senegal**

24 Niger 2016-2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Niger-Operational-Plan_EN.pdf

25 Senegal 2016 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Senegal-Operational-Plan_EN-1.pdf

### 1.6.7 The Gambia [26]

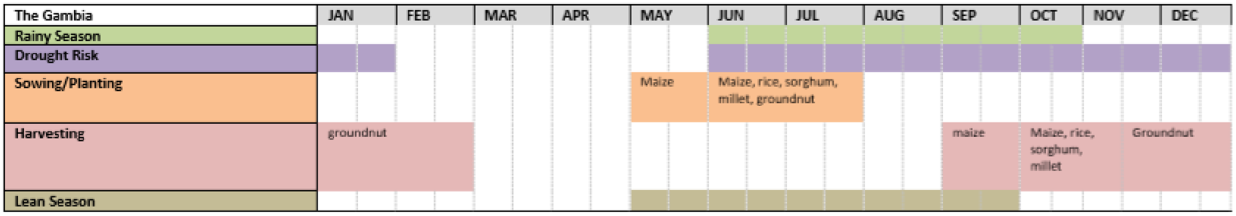


**Figure 1.6.6a. Seasonal calendar in The Gambia**

### 1.7 Coupling seasonal agricultural calendar and hydrological resources in the region

54. Water resources in the Sahel zone are characterized by very large hydrologic systems, often shared between several countries (Figure 1.7). These systems are represented by transboundary water basins, large aquifers, lakes and wetlands (UNEP, 2010). Transboundary water basins form an important water network covering all countries in the region. The most important are the Niger, Senegal and Volta rivers and Lake Chad network, which irrigate the Sahel. These basins have a considerable role to play socioeconomically, especially for maintaining food security throughout the Sahel belt. In addition to these rivers, many not insignificant rivers (Comoé, Mono, Pendjar, Ouémé, Zio, Bandama, Casamance) supply the southern and central area of the region (UA-BIRA., 2012). The area also has a wide variety of wetlands that represent a large water source for the population.

55. Water resources in the region are made up of freshwater reservoirs (inland Niger delta), natural lakes such as Lake Chad (the largest African endorheic basin shared by 8 countries) and Lake Tana in Ethiopia, the main reservoir of the Blue Nile (UNEP, 2010). These resources play an undeniably important role in maintening socio-economic life and ecosystem services in the Sahel region. This important river system is supplemented by large transboundary aquifer systems containing an abundance of renewable and non-renewable groundwater resources. Studies have shown proven interactions between aquifer systems and rivers that cross the same region, this is the case for the largest sedimentary aquifer systems in the Sahara (Iullemeden TaoudéniTanezrouft complex, Lake Chad Basin) and the Niger River (OSS, 2012). We can also mention the Senegal-Mauritania coastal aquifer systems (David Houdeingar, 2013), Nubian sandstone aquifers (Chad and Sudan), Upper Nile Basin (Sudan and Ethiopia), Ogaden-Juba in the Rift Valley and Awash in Ethiopia (UNEP, 2010). Because of the depth of the layers and the rigidity of some geological layers, these resources are difficult to mobilize, or even inaccessible in certain areas of the Sahel without the deployment of significant resources.

[26] The Gambia 2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/12/OP_Pool4_Gambia_OperationalPlan_2017.pdf


**Figure 1.7a. Major river basins in Africa (FAO, 2008)**

56. In the seven Sahelian countries, water must be therefore carefully managed for the benefit of the population and the environment to ensure food security today and in the future. With the global food crises and the growing population continent-wide, more food must be grown for the 212 million malnourished people across Africa and the one billion more people expected by 2050. (FAO, 2008) However, climate change is likely to result in water availability problems. Changes in precipitation would make extreme weather events more common, leading to more severe and frequent flooding and to lower dry-season water flows in rivers. Changes in the African climate have been assessed at major river basins (Figure 1.7). Model results derived from three Global Circulation Models (GCMs) (namely, CSIRO2, HADCM3 and PCM) and considering the two extreme cases named A2 and B2 provide the anticipated deviation of rainfall from average (in percent) for the periods 2030, 2050 and 2080. The results shown in the tables below indicate that while precipitation is expected to decrease by 33 percent in some regions and increase by 22 percent in others, the global mean surface temperature is expected to increase between 1.3 C and 1.7 C by 2050. (FAO, 2008)

57. Further warming is consequently expected to reduce crop productivity adversely. The main effect of climate change on semi-arid or tropical agro-ecological systems is a significant reduction in crop yield. This will place more pressure and higher demand for conversion of lands, extraction of water supply for irrigation, introduction of invasive species, more intensive use of chemical inputs and hence pollution and environmental damage, erosion, etc. which may seriously accelerate biodiversity loss and extinction. (FAO, 2008)

Table 1 and Table 2 report the future change in precipitation at different river basins in Africa for climate scenarios A2 and B2.

Table 1: Anticipated rainfall deviation from average (%) in major river basins in Africa using 3 GCMs for the A2 climate scenario

| | | CSIRO2-B2 | | | HADCM3-B2 | | | PCM-B2 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HIST. | 2030 | 2050 | 2080 | 2030 | 2050 | 2080 | 2030 | 2050 | 2080 |
| Central African | 0 | 0 | 1 | 1 | -4 | -6 | -10 | 4 | 7 | 13 |
| Congo | 0 | 1 | 2 | 3 | 2 | 3 | 6 | 2 | 3 | 6 |
| East African Coast | 0 | 7 | 11 | 21 | 3 | 6 | 10 | 2 | 4 | 7 |
| Horn of Africa | 0 | -4 | -6 | -11 | -11 | -17 | -29 | 7 | 11 | 22 |
| Kalahari | 0 | -4 | -6 | -11 | -11 | -17 | -29 | 7 | 11 | 22 |
| Lake Chad | 0 | -1 | -2 | -3 | 7 | 12 | 22 | 4 | 6 | 12 |
| Limpopo | 0 | -7 | -11 | -21 | -3 | -5 | -10 | -1 | -2 | -3 |
| Madagascar | 0 | 2 | 3 | 6 | 0 | 0 | 0 | 1 | 1 | 2 |
| Niger | 0 | -1 | -2 | -4 | 3 | 5 | 10 | 4 | 6 | 12 |
| Nile | 0 | 1 | 1 | 2 | 6 | 10 | 18 | 6 | 11 | 20 |

Table 2: Anticipated rainfall deviation from average (percent) in major river basins in Africa using 3 GCMs for the B2 climate scenario

| | | CSIRO2-B2 | | | HADCM3-B2 | | | PCM-B2 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HIST. | 2030 | 2050 | 2080 | 2030 | 2050 | 2080 | 2030 | 2050 | 2080 |
| Central African | 0 | 1 | 1 | 2 | -4 | -6 | -8 | 5 | 7 | 11 |
| Congo | 0 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 5 | 7 |
| East African Coast | 0 | 5 | 7 | 10 | 3 | 5 | 7 | 5 | 7 | 9 |
| Horn of Africa | 0 | 0 | 0 | 1 | -17 | -23 | -33 | 8 | 11 | 16 |
| Kalahari | 0 | 0 | 0 | 1 | -17 | -23 | -33 | 8 | 11 | 16 |
| Lake Chad | 0 | -2 | -3 | -4 | 8 | 12 | 18 | 8 | 11 | 16 |
| Limpopo | 0 | -3 | -5 | -7 | -6 | -9 | -12 | -3 | -4 | -6 |
| Madagascar | 0 | 2 | 3 | 4 | 1 | 1 | 2 | 2 | 3 | 4 |
| Niger | 0 | -1 | -2 | -3 | 7 | 10 | 14 | 5 | 7 | 10 |
| Nile | 0 | 0 | -1 | -1 | 6 | 9 | 13 | 13 | 19 | 27 |

58. Opportunities for facing the challenges faced by water resources are addressed in the proposed programme through the selection and access to specific climate-adapted varieties (e.g. heat-tolerant, submergence- drought and salinity tolerant, pest resistant) with short growing cycles from seeds to yields. The programme aims to provide adaptation and mitigation measures to help restore surface and groundwater tables by establishing a climate-smart irrigation system (bore holes irrigation schemes, drip…) powered with renewable energy to cope with the consequences of drought and heat extreme events, rehabilitated bore holes with deployed irrigation schemes. The increasing needs for irrigation induced by future climate change will be integrated in the design of the irrigation schemes. The programme also proposes water harvesting, efficient irrigation infrastructure, check dams, communal ponds, and groundwater recharge water allocation system, flood management and drainage as sustainable water management in the seven Sahelian countries.

59. Shared understanding of the water problems and consequences, solutions, and the interconnections and tradeoffs are crucial if actions are to achieve common objectives. Thus, the programme aims to strengthen understanding of climate risks to better inform decision-making, prepare for and manage climate shocks in the seven countries. This will include an impact-based multi-hazard early warning systems and an impact-based forecasting in the different countries. Farmers and decision makers engaging in climate risk preparedness will be able to better understand climate risks and tailored agro-climatic information services that will include advisories on how to further transfer disaster risk, increase productivity and capacity to cope with climate change and variability. By increasing their understanding and ability to prepare and manage risk, farmers will also be able to access unlocked weather index

insurance and receive compensation in case of drought/dry spells from public and private insurance companies . In order to ensure that increased productivity translates into increased food security and incomes, farmers will also benefit from increased access markets by decreasing post-harvest losses, enhancing quality of product to marketable level, climate resilient storage and roads, and further investing in climate-resilient practices, technologies and inputs along the selected agricultural value chains.

60. To achieve the objective of this programme aiming at building and scaling up the resilience and adaptive capacity of smallholder farmers and rural communities of seven Sahelian Least Developed Countries (LDCs) to climate change, water storage and harvesting techniques will be implemented. This will enhance productivity in rain fed agriculture, shifting the focus of irrigation development, making irrigated agriculture more productive, reforming irrigation and drainage institutions, developing information systems and knowledge networks, improving water education, building capacity and increasing research.

### 1.8 Barriers and opportunities with the GCF

61. The key barriers to strengthening smallholder farmers' resilience to potential risk elevation due to climate change in the seven GGWI countries are a combination of technical, financial, policy and regulatory barriers, both for the public and private sector participation, in order to integrate climate risk management. High premiums and limited products are also key barriers for risk transfer markets. To allow risk preparedness, risk reduction and risk transfer to be viable, key barriers summarized in the table below must be addressed by the programme.

| Key barriers | Baseline | Alternative with the GCF |
|---|---|---|
| Inadequate climate risk information services, limited knowledge and understanding of climate change impact impacts to better plan and develop integrated adaptive approach and solutions | • Poor spatial distribution of Hydro Met Equipment in each country and in the targeted area with no very few automatic weather station.<br>• Existing network of hydromet stations is sparse and deteriorating,<br>• Climate data, information, interpretation and knowledge are often inaccurate<br>• Because of limited data, there is a lack of awareness and understanding of the various forms of understanding climate risks for decision making including investments to support adaptation/ mitigations solutions and the development of the agricultural industry<br>• Limited knowledge sharing and transfer within and between communities and countries<br>• Weak Monitoring, Reporting, Verification | • Expand and upgrade existing early warning systems and hydro met observation networks to enhance data collection, interpretation, and understanding to inform and improve micro and macro insurance infrastructure development, climate models, products and adaptation measures.<br>• Increase access to agro-climatic information services (i.e. capacity building of meteorological services, forecasting, the use of ARC's Africa RiskView (ARV) etc.) to inform adaptation and risk transfer measures<br>• Raise awareness on the adoption best adaptations and mitigation measures in agriculture and livestock as well as risk transfer micro and macro insurance using reliable climate data and information<br>    • Multi-hazard Early Warning Systems enhanced by strengthening the capacity of the meteorological services to provide impact-based forecasting (i.e. enhancing climate equipment available in the countries and providing |

| | | |
|---|---|---|
| | | trainings to climate and meteorologists experts in countries on impact-based forecasting methodologies).<br>• Understanding of climate risks strengthened to better inform decision-making, prepare for and manage climate shocks through the elaboration of contingency plans that will lay out interventions and measures needed to adequately respond to climate shocks.<br>• Monitoring, Reporting, Verification (MRV) standards |
| Policy, institutional coordination mechanisms and capacity on integrated climate risk management | Weak capacity of farmers, local and national governments, private sector to foster integrated climate risks management and planning<br><br>• Insufficient skills and capacity by farmers to anticipate , address and deal with climate impacts<br>• Limited ability by local and national governments to issue critical warnings, guide farmers on the best adaptation/mitigation measures<br>• Limited capacity of farmers and farmers groups to seize opportunities given by risk transfers<br>• Limited capacity of met agencies to manage climate information's and maintain the climate infrastructure network, and provide useful information's to farmers | • Capacity building of countries and district levels strengthened to undertake climate risk assessments and elaborate climate risk profiles (i.e. climate risk modelling on the different countries and districts) and planning.<br>• The technical, organizational and marketing capacities of communities supported with diversified livelihood through the promotion of income generating activities (i.e. this contributes to building the resilience of farms and household to climate change, while contributing to a sustainable food production systems and national protein intake).<br>• Agricultural extension services strengthened to provide close assistance to small holder farmers in dealing with climate variability.<br>• Organizational and technical capacities of communities and farmers strengthened with the implementation of the adaptation and mitigation measures to foster the resilience of rice, millet, maize and sorghum production and post-harvest (i.e. selection and access to specific climate-adapted varieties).<br>• Capacity-building programs designed targeting government authorities, regulatory bodies, the insurance industry, distribution channels and smallholder farmers for adequate coordination, follow-up and capitalization of index-based agricultural insurance interventions. |

| | | |
|---|---|---|
| Policy, institutional coordination mechanisms and capacity on integrated climate risk management | Limited enabling Policy, institutional and regulatory and fiscal framework and weak coordination mechanisms on integrated climate risk management<br><br>• Lack of an adequate regulatory and fiscal framework on integrated climate risk management<br>• Lack of coordination, inconsistencies, to follow-up and capitalization of index-based agricultural insurance interventions.<br>• Lack of an enabling policy regulatory environment conducive to the development of agricultural insurance and adapted financial products<br>• Limited awareness among policy-makers and development practitioners, private sector about the risks posed by climate change, and how these relate to development priorities<br>• Limited coordination with Ministries of Finance for fiscal planning | • Support countries in reviewing and developing contingency plans, fiscal and regulatory frameworks to support integrated climate risks.<br>• Support institutional and legal framework for effective integrated climate risks management , Support to countries to sustain premiums payments from their own national budget to ARC<br>• Support countries governance on climate risk management and use of the pay outs to reach the end users , fostering alignment/ linkages with micro insurance and coordination , strengthening responsiveness capacity of countries to climate hazard (providing contingency funding for high frequency/low severity events for which risk transfer may not be suitable); developing comprehensive risk layering approach to climate risks financing, developing tools and instruments to support policy makers on integrated climate risks management...<br>• Develop tools, instruments and strategies to enable communities, insurances and the public sector and private sector to respond to climate change and variability<br>• Support high level policy dialogue to close the financing gap both on risk preparedness adaptation and mitigation, risks transfers<br>• Support cross-sector coordination mechanisms with all stakeholders (public, private, local communities and organization) on integrated climate risks management coordination , strengthening responsiveness capacity of countries to climate shocks |
| Limited adoption of best adaptation and mitigation measures associated with risk transfer and risk preparedness to build climate resilience | • Risk transfer is not viable without adoption of appropriate adaptations and mitigation measures associated with risks measures<br>• Various projects but fragmented and single and independent climate | • Promote the creation of integrated risk transfer schemes where micro, and macro insurance policies complement each other where possible<br>• Pilot and scale up adaptation with risk transfer mechanisms |

| | | |
|---|---|---|
| | risk preparedness, climate risk adaption or climate risk transfers schemes | • Promote public and private partnership to diversify business as a mean to adapt to climate change<br>• Access to micro level index insurance combined with agricultural inputs and other risk reduction and adaptation measures |
| Limited access to agricultural insurance as private insurers are reluctant to develop this market; farmers and in turn countries/ farmers are reluctant to pay premiums ; and high interest rate with financial institutions which limit investments | • High cost of insurance premiums due to relative high risk perception, absence or limited adapted insurance products available in the market and not interlinked with macro insurance schemes or other adaptation measures<br>• Low level of involvement and/or commitment of insurers and ministries of agriculture to the development of weather or parametric insurance in countries.<br>• Overall limited distribution and delivery modalities infrastructure for insurance to reach scale and sustainability<br>• Famers and countries not motivated to pay premiums. Low awareness and financial capacity<br>• Limited access to credit in general and to financial products tailored to smallholder farmers' needs in particular, such as insurance policies bundled with options from the other input packages (seeds, fertilizers or pesticides).<br>• Limited availability, access to and use of agro-climate information services<br>• Limited productive investments in low emission and climate resilient agriculture, forest management and energy for agriculture. | • Access to micro level index insurance combined with agricultural inputs, adaptation measures (Insurance for Work approach) or agricultural financial products tailored to each of the selected countries' context.<br>• Support to cover the insurance costs through a digressive approach in which the percentage of the insurance premiums assumed by the project decreases gradually over a four-year period (i.e. the project will cover 90 percent of the premium in the first year, 70 percent in the second, 50 percent in the third, and 0 percent in the fourth and final year).<br>• Technical support to reinforce and build distribution infrastructure, including use of digital tools (mobile platforms).<br>• The provision of premium for sovereign risk transfer (macro-insurance) supported and promoted in the recipient countries to support each Government cushions themselves from the impacts of climate hazards.<br>• The elaboration of disaster risk financing strategies supported in formulating comprehensive national disaster risk financing (DRF) strategies, building an understanding on the whole array of financing instruments available for disaster response, with an emphasis on sovereign risk insurance.<br>• Improved fiscal, institutional, legal framework to support agricultural insurance and access to financial products. |

**Chapter 2 Description of IFAD Baseline investments in each country.**

## 2.1 Burkina Faso

62. In Burkina Faso, IFAD loans help build inclusive and sustainable institutions underpinned by pro-poor investments and policies and appropriate innovation and education. Through the 2019-2024 country strategic opportunities programme (COSOP), IFAD aims to sustainably increase income and employment opportunities and the resilience of rural populations, especially women and youth, to food and nutrition insecurity and climate change. The COSOP revolves around two strategic objectives:

- Strengthen the resilience of vulnerable rural populations to food and nutrition insecurity and climate change.
- Improve the performance of key agricultural value chains that create employment and wealth for rural populations and respect the principles of sustainable natural resource management.

63. To achieve these objectives, key activities include:

- Enhancing and diversifying the livelihoods of rural poor and marginalized groups, especially women, in a sustainable way through inclusive local private-sector development; and
- Enhancing decentralized governance of, and equitable access to, public goods, services and natural resources.

64. The COSOP describes IFAD work with the Government to tackle challenges and develop operational strategies and policies based on best practices, feeding knowledge and ideas into policy development. By working at various levels, a total of fifteen IFAD projects including planned, ongoing and closed projects[27] help the Government create an environment, which facilitates efforts by local people, to reduce rural poverty and support climate risk adaptation and preparedness. These IFAD Projects represent US$ 659.63 million of total projects' cost, US$ 327.79 million of the total IFAD financing and have impacted 603,200 households up to date. The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Agricultural Value Chains Support Project in the Southwest, Hauts-Bassins, Cascades and Boucle du Mouhoun Regions | Signed | $123.93 |
| Agricultural Value Chains Promotion Project | Ongoing | $71.70 |
| Participatory Natural Resource Management and Rural Development Project in the North, Centre-North and East Regions | Ongoing | $117.45 |

## 2.2 Chad

65. In Chad, IFAD loans help provide poor rural women and men with the resources to increase their incomes and improve their food security. In nine IFAD-funded operations in the country, including planned, ongoing and closed projects [28], poor rural people have to overcome poor infrastructure, low rainfall and climatic variations. Plagues of pests combine with problems of soil erosion and desertification, threaten harvests and livestock. These IFAD projects improve Chad's risk adaptation and preparedness to climate while developing alternative income opportunities and improving productivity. The total projects' cost for the country's profile is US$ 244.68 million, with a total IFAD

[27] IFAD country profile: Burkina Faso available at https://www.ifad.org/en/web/operations/country/id/burkina_faso#anchor-1

[28] IFAD country profile: Chad available at: https://www.ifad.org/en/web/operations/country/id/chad#anchor-2

financing of US$ 176.47 million. These IFAD projects have impacted 294,350 households. The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Strengthening Productivity and Resilience of Agro-pastoral family Farms Project | Ongoing | $94.90 |
| Project to Improve the Resilience of Agricultural Systems in Chad | Ongoing | $36.20 |

## 2.3 Mali

66. IFAD has been funding a total of fifteen projects in Mali, including planned, ongoing and closed projects[29] that have impacted 558,303 households, in particular regions stretching across the Sahara and Sahel, for 30 years. With a total projects' cost of US$ 696.69 million and US$ 302.11 million total IFAD financing, activities target poor rural households, and prioritize the needs of women and young people. These include:

- Increasing and diversifying agricultural production;
- Ensuring access to basic social services; and
- Capacity-building and support for producers' organizations.

67. The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Multi-energy for Resilience and Integrated Territorial Management Project | Approved | $50.76 |
| Inclusive Finance in Agricultural Value Chain Project | Ongoing | $105.55 |
| Rural Youth Vocational Training, Employment and Entrepreneurship Support Project | Ongoing | $43.67 |

IFAD-funded operations aim to effectively adapt and prepare Mali to climate change due to its shrinking areas used for crops, fishing and pasturage, which exacerbate land conflicts, and push people to migrate further south, or abroad.

## 2.4 Mauritania

68. In Mauritania IFAD loans aim to improve food security and nutrition, increase the incomes of poor rural households, create jobs and reduce the country's dependence on food imports while supporting climate risk adaptation and preparedness. Activities target poor rural and have impacted 230,470 households with a special focus on women and young people.

69. The 2018-2024 IFAD's country strategy overarching goal in Mauritania is to improve living conditions and food and nutrition security for rural populations, especially women and young people. The specific development objective is to empower the rural poor and their organizations with regard to: (i) sustainable access to natural resources and communal equipment; and (ii) inclusive value chains.

70. There is a total of fifteen IFAD projects in Mauritania, including planned, ongoing and closed projects [30], whose main activities include:

- Strengthening organizations and institutions capacities and supporting communal and local development;

[29] IFAD country profile: Mali available at: https://www.ifad.org/en/web/operations/country/id/mali#anchor-2

[30] IFAD country profile: Mauritania available at: https://www.ifad.org/en/web/operations/country/id/mauritania#anchor-2

- Promoting linkages between supply and demand through better performing and more inclusive value chains;
- Advising farmers, including women and youth, to improve their production models and adapt them to climate change, restoring soil and making better use of surface and ground water.

71. The total projects' cost is US$ 380.38 million, with US$ 163.41 million of total IFAD financing. The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Sustainable Management of Natural Resources, Communal Equipment, and the Organization of Rural Producers Project[31] | Planned | $50.00 |
| Inclusive Value Chain Development Project | Ongoing | $45.21 |

## 2.5 Niger

72. IFAD has built its strategy in Niger on helping family farmers adapt to structural risks and potential external shocks. This model can improve food and nutrition security and fostering lower poverty, economic growth, sustainable rural development and resilience to climate change.

73. In Niger, IFAD has fourteen projects in total, including planned, ongoing and closed projects[32] that have impacted 1,252,922 small-scale rural producers' households, especially the most marginalized socio-economic groups, and help them cope with changes through climate risk adaptation and preparedness. By helping family farms and other rural households intensify and diversify production, post-production and marketing, IFAD make their livelihoods more resilient and sustainable. To achieve this goal, key objectives include:
- Sustainably increasing output of small farmers, foresters and pastoralists;
- Improving smallholders' post-production and marketing activities; and
- Strengthening social networks and collaboration among poor rural people, making local institutions and commercial activities more sustainable.

74. The total projects' cost is US$ 350.77 million and the total IFAD financing in Niger is US$ 739.4 million. The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Project to Strengthen Resilience of Rural Communities to Food and Nutrition Insecurity | Approved | $195.86 |
| Family Farming Development Programme in the Diffa Region | Ongoing | $18.72 |
| Family Farming Development Programme in Maradi, Tahoua and Zinder Regions | Ongoing | $205.37 |

## 2.6 Senegal

75. In Senegal, IFAD loans help sustainably increase food security and smallholder incomes and create permanent employment for rural people, particularly women and young people. A total of nineteen

[31] This project is a continuation of the Inclusive Value Chain Development Project
[32] IFAD country profile: Niger available at: https://www.ifad.org/en/web/operations/country/id/niger#anchor-2

IFAD-funded projects, including planned, ongoing and closed projects,[33] help smallholders' and their organizations gain better access to farm inputs and services, appropriate technologies and markets. These projects have impacted 544,643 households for a total cost of US$ 865.48 million and a total IFAD financing of US$ 313.66 million.

76. IFAD's overall goal for the 2019-2024 COSOP in Senegal is to contribute to the elimination of poverty (Sustainable Development Goal 1) through a sustainable increase in incomes of poor family farmers and young "agripreneurs". This goal will be achieved through three strategic objectives:
- Production, productivity and profitability of family farms are sustainably increased within modernized value chains;
- The professional capacity of value chain stakeholders, including farmers' organizations and rural small and microenterprises, is strengthened; and
- In-country and sub-regional partnerships for scaling up good practices and implementing pro-poor policy in rural areas are strengthened.

77. Activities focus on the development of sustainable value chains and the integration of women and youth into economic activities. IFAD also helps rural people learn how to set up and run businesses as well as how to reduce their vulnerability and mitigate risk in the future through disaster insurance (risk transfer through micro insurance). The following table describes the current IFAD projects/programmes as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Groundnut Competitiveness and Agriculture Diversification Project in Senegal | Planned | $255.00 |
| Rural Youth Agripreneur Support Project (Agrijeunes Tekki Ndawñi) | Signed | $93.28 |
| Support to Agricultural Development and Rural Entrepreneurship Programme - Phase II | Ongoing | $72.44 |
| Agricultural Value Chains Support Project-Extension | Ongoing | $53.98 |

### 2.7 The Gambia

78. The IFAD strategy in The Gambia is to contribute to the reduction of poverty, food insecurity, vulnerability and youth unemployment in rural communities. Particular attention is paid to gender, nutrition, and climate change through adaptation and preparedness. Activities focus on agricultural and rural development and aim to open up on- and off-farm employment opportunities for young people, women and men. IFAD work with traditional kafos (collectively run village groups) to enable a total of eleven IFAD-supported projects[34], which have already impacted 195,069 most vulnerable households. Total projects' cost is US$ 287.54 million, with a total of US$ 113.53 million IFAD financing.

79. The IFAD programme during the 2019-2024 COSOP in the country two strategic objectives:
- Enhance the productivity and resilience of family farms through sustainable management of natural resources and adaptation to climate change, with a focus on youth and gender impacts;

[33] IFAD country profile: Senegal available at https://www.ifad.org/en/web/operations/country/id/senegal#anchor-2

[34] IFAD country profile: The Gambia available at: https://www.ifad.org/en/web/operations/country/id/gambia#anchor-2

- Improve the management capacity and inclusiveness of professional farmers' organizations/cooperatives, and enhance farmers' access to communal assets, markets, and profitable agricultural value chains.

80. To achieve these objectives, key activities include:
    - Supporting rice and vegetable value chain development, including strengthening the capacity of farmers, community organizations and their members;
    - Strengthening access to markets for agricultural products; and
    - Adding value to rice and vegetable production by strengthening value chain participants, business development, and through a Capital Investment Stimulation Fund.

81. IFAD also participates in development initiatives designed to make land and water supplies more resilient to climate change, notably for producing rice and vegetables. The following table describes the current IFAD programme as of date:

| Name | Status | Costs (in million) |
|---|---|---|
| Resilience of Organizations for Transformative Smallholder Agriculture Programme[35] | Signed | $80.00 |

### 2.8 IFAD's Adaptation for Smallholder Agriculture Programme (ASAP) I[36]

82. ASAP was launched by IFAD in 2012 to make climate and environmental finance work for smallholder farmers. A multi-year and multi-donor financing window, ASAP provides a new source of co-financing to scale up and integrate climate change adaptation across IFAD's approximately USD 1 billion per year of new investments. The programme is joined up with IFAD's regular investment processes and benefits from rigorous quality control and supervision systems. ASAP is driving a major scaling up of successful 'multiple-benefit' approaches to smallholder agriculture, which improve production while reducing and diversifying climate-related risks. In doing so, ASAP is blending tried-and tested approaches to rural development with relevant adaptation know-how and technologies. This will increase the capacity of at least 8 million smallholder farmers in 43 countries to expand their livelihood options in an uncertain and rapidly changing environment.

83. The ASAP fund allows IFAD country programmes to design projects as of date from a climate-informed perspective and leverage resources for technical assistance to achieve outcomes described in the table 2.8b. Thanks to the joint efforts and generous support of 10 donors, ASAP has received US$300 million in contributions. It has helped eight million vulnerable smallholders in 43 countries cope with the impact of climate change and build more resilient livelihoods (table 2.8a). ASAP funds activities that focus on policy, climate risk assessment, women's empowerment, private-sector engagement, climate services, natural resource management and governance and knowledge management (table 2.8b).

**List of IFAD/ASAP projects**

84. In West and Central Africa region, IFAD's portfolio is made up of 16 ASAP and 4 GEF projects in 14 countries. The total investment is estimated at US$114 million. WCA division holds the largest

[35] This project is a continuation of the National Agricultural Land and Water Management Development Project (NEMA); Total project cost: USD 76.59 million; Duration: 2012 – 2019.
The goal of this project is to reduce poverty among rural women and young people through improved productivity based on sustainable land and water management practices.

[36] IFAD's Adaptation for Smallholder Agriculture Programme (ASAP) I Description available at https://www.ifad.org/documents/38714170/40213192/asap.pdf/b5a8c1f9-f908-4a68-ad30-e3d5eeb17c31

environmental and climate change portfolio. These projects invest are testing climate resilience and environmental management.

**ASAP 1**

| Country | Project name | Status | Effectiveness | Completion date | Closing date | Grant amount (USD) |
|---|---|---|---|---|---|---|
| **Liberia** | TCEP | Startup | 08/06/2017 | 30/06/2023 | 31/12/2023 | 4 500 000 |
| **Cabo Verde** | POSER-C | Implementation | 06/06/2017 | _ | _ | 4 000 000 |
| **Mauritania** | PRODEFI | Implementation | 12/01/2017 | 31/03/2025 | 30/09/2025 | 6 000 000 |
| **Benin** | PADMAR | Implementation | 05/10/2016 | 31/12/2023 | 30/06/2024 | 4 500 000 |
| **Nigeria** | CASP | Implementation | 25/03/2015 | 31/03/2021 | 30/09/2021 | 14 949 000 |
| **Gambia** | NEMA | Implementation | 01/03/2016 | 31/12/2019 | 30/06/2020 | 5 000 000 |
| **Cote d'Ivoire** | PROPACOM-Ouest | Implementation | 21/11/2014 | 31/12/2020 | 30/06/2021 | 6 994 750 |
| **Chad** | PARSAT | Implementation | 17/02/2015 | 31/03/2022 | 30/09/2022 | 5 000 000 |
| **Ghana** | GASIP | Implementation | 18/05/2015 | 30/06/2021 | 31/12/2021 | 10 000 000 |
| **Niger** | PRODAF | Implementation | 21/09/2015 | 30/09/2023 | 31/03/2024 | 13 000 000 |
| **Mali** | PAPAM | Completed | 21/01/2014 | 31/07/2018 | 31/01/2019 | 9 942 704 |

**WCA – IFAD GEF portfolio**

| Country | Project name | Status | Effectiveness | Completion date | Closing date | Grant amount (USD) |
|---|---|---|---|---|---|---|
| **Senegal** | PAFA – E | Implementation | 31/08/2017 | 31/08/2021 | 28/02/2022 | 3 609 725 |
| **Burkina Faso** | Neer Tamba | Implementation | 03/04/2017 | 30/06/2022 | 31/12/2022 | 7 269 448 |
| **Niger** | PRODAF | Implementation | 30/11/2016 | 31/12/2021 | 30/06/2022 | 7 636 422 |
| **Chad** | PARSAT | Implementation | 02/09/2015 | 31/03/2022 | 30/09/2022 | 7 305 936 |
| **Mauritania** | PASK-II | Implementation | 03/11/2011 | 31/12/2018 | 30/06/2019 | 3 500 000 |

**Table 2.8a. Key climate change impacts faced by smallholder farmers in the Sahel and examples of proposed interventions and supported by ASAP and GEF**

| Change in climate | Impacts | Examples of interventions |
|---|---|---|

| | | |
|---|---|---|
| Temperature increase on land and in water | Heat stress on crops | Provision of access to heat tolerant crops |
| | Increased demand for water and/or reduced availability of water | Facilitating access to drought tolerant and fast maturing crops and varieties |
| | | Increasing organic content in the soil |
| | | Water conserving crop management practices (e.g. ridge planting) |
| | | Maximizing water capture and storage |
| | | Advocacy on the right of smallholder farmers to an adequate and safe water supply |
| | Heat, stress on livestock | Tree planting (shelter and fodder) |
| | | Change to more heat tolerant livestock (e.g. from cattle to goats) |
| | Declining fish stocks | Conservation of coastal mangroves and other kinds of vegetation |
| | | Sustainable agriculture techniques such as fish farming in ponds |
| | Flooding from glacial melt | Early warning systems |
| | Reduction of summer river water by glacial melt | Maximize water capture and storage |
| Sea level rise | Saline intrusion | Provision of water for households and productive use |
| | | Access to saline tolerant crops |
| | Coastal erosion | Build sea defences |
| | Increased frequency and severity of storm surges | Early warning systems |
| | | Protected areas/water and sanitation |
| | | Mangrove restoration |
| Changed seasonality | Farmers uncertain about when to plant and harvest | Appropriate, accessible and reliable seasonal and weather forecasts |
| | | Crop diversification and crop mixing |
| | | Livestock diversification |
| | Crops damaged by dry spells during growing season | Appropriate, accessible and reliable seasonal and weather forecasts |
| | | Crop diversification and mixed cropping |
| | | Sustainable agricultural techniques to improve drainage, irrigation and water catchment and use techniques |
| | | Crop insurance and social protection measures |
| | Reduced agricultural seasons | Livelihood diversification |
| | | Crop insurance and social protection measures |
| | | Access to fast-maturing drought tolerant crops |
| | | Appropriate, accessible and reliable seasonal and weather forecasts |
| Increase in intense rainfall or large increase in annual rainfall | Increased frequency and severity of floods | Improved drainage |
| | | Protected areas/water and sanitation |
| | Increased frequency and severity of drought | Rainwater harvesting |
| | | Community water management committees |

| | | |
|---|---|---|
| Decrease in annual rainfall in arid and semi-arid areas | | Access to more drought-tolerant crops |

**Table 2.9b: Five ASAP outcomes and related activities**

| Outcomes | Main activities |
|---|---|
| Improved land management and gender-sensitive climate-resilient agricultural practices and technologies | - Identify and promote crop varieties that are heat, drought and salt-tolerant, including wild varieties with high nutritional value.<br>- Optimize land-use systems, such as shifting from yield per hectare to 'crop-per-drop' systems.<br>- Develop capacities among local institutions to plan and adopt agro-ecological farming models in a changing environment.<br>- Scale up sustainable land management practices to the landscape level to increase agricultural production, improve hydrogeological functions, replenish soil nutrients, sustain floral and faunal diversity, moderate microclimates and reduce pest infestations.<br>- Strengthen expertise in agricultural research, and advisory and extension services on climate risk management and adaptation.<br>- Test prototypes of agricultural production systems that can withstand climate-induced stresses in different agro-ecological zones, and shift from extensive low nutrition agricultural productive systems to intensive high nutrition ones.<br>- Use the Geographic Information System (GIS) to better understand and monitor land use and patterns of climate and human-induced land degradation.<br>- Provide access to improved seed varieties that are resilient to climatic stresses and can be conserved in situ through seed banks.<br>- Establish robust community seed, food and forage storage that can protect harvests from extreme weather events.<br>- Rehabilitate natural systems such as mangroves, coastal wetlands, sand dunes, and coral reefs to protect agriculture in coastal areas against climate risks.<br>- Develop access to green markets and create incentives for climate-resilient products. |
| Increased availability of water and efficiency of water use for smallholder agriculture production and processing | - Analyze water use and distribution at the landscape level to design sustainable agricultural production and processing systems and nutrient, energy and water reuse systems.<br>- Use integrated water resource management to maintain and improve healthy functioning of watersheds.<br>- Combine watershed management with climate-resilient land-use planning, climate-compatible infrastructure, water recycling and grey water use.<br>- Undertake watershed management for comprehensive, climate-compatible infrastructure planning.<br>- Adopt a range of water harvesting techniques, such as low-cost groundwater recharge methods, efficient irrigation systems and communal rainwater harvesting.<br>- Improve flood risk management using mini-dams and levees to control catchment sources and reduce peak discharges. |

| | |
|---|---|
| Increased human capacity to manage short- and long-term climate risks and reduce losses from weather related disasters | - Undertake gender-differentiated vulnerability and risk assessments to appraise the resilience of livelihood systems and understand smallholder ideas for risk management and adaptation.<br>- Provide communities with access to weather and climate information to help monitor and respond to climate change impacts (for example, by switching crop varieties and/or planting calendars).<br>- Strengthen community-based disaster preparedness (including social networks and safety nets), response and rehabilitation mechanisms.<br>- Appraise the feasibility of market-based climate risk management strategies based on financial assets (savings, mutualization, insurance).<br>- Develop user-friendly data management systems and coordination mechanisms to support climate risk management across sectors and administrative levels.<br>- Develop policy frameworks that respond to increasing levels of risk in a changing environment.<br>- Improve regulatory systems to provide incentives for adaptation planning and climate-smart sustainable land management.<br>- Improve clarity of governance structures related to climate risk management and establish links between local institutions and national government structures.<br>- Strengthen capacity of women's groups, gender researchers and ministries to analyze gender perspectives of climate risk management and their practical implications. |
| Increased climate resilience of rural infrastructure | - Assess climate change impacts on key agricultural infrastructure to refine design and engineering specifications.<br>- Build or retrofit rural infrastructure to cope with climate-related risks (such as water shortages, extreme weather events) using adaptive engineering such as natural dykes, breakwaters and submersible roads.<br>- Strengthen food security systems by improving the robustness of storage and marketing facilities, incorporating the ideas and perspectives of rural women and men.<br>- Improve water collection, transfer and dissemination systems (such as flood-proofing of hand pumps) to prevent climate-induced contamination or pollution.<br>- Integrate exposure and sensitivity of critical infrastructure to climate hazards into revised land-use and maintenance schemes. |
| Knowledge on climate-smart smallholder agriculture documented and disseminated | - Document, disseminate and replicate traditional knowledge and farmer-generated innovations for management of natural resources, thereby promoting adaptation and healthier ecosystems.<br>- Develop and improve systems to collect, analyze and disseminate climate data to reduce climate risks in local investment and planning decisions.<br>- Enhance use of information and communication technologies to disseminate climate risk and early warning information (such as early warning signals through mobile phone networks).<br>- Promote South-South cooperation to exchange knowledge on climate change responses and develop multi-country initiatives that foster uptake of adaptation measures. |

| | |
|---|---|
| | - Present lessons learned and project experiences on adaptation in international forums and advocacy initiatives.<br>- Disseminate knowledge on climate-resilient smallholder agriculture in national planning processes such as poverty reduction strategies, and agricultural and climate change policies.<br>- Strengthen the capacity of women's ministries, women's groups and gender researchers to capture and document gender perspectives of climate change and their practical implications for adaptation planning.<br>- Document and share knowledge with international networks such as the Global Gender and Climate Change Alliance and the World Initiative for Sustainable Pastoralism and ensure involvement of marginalized groups. |

85. Climate change risks and IFAD regional interventions in value chains can be complex and involve considerable uncertainties, whereby actions in one part of the chain may affect other parts for better or worse, and demand trade-offs between different stakeholders or different desired outcomes in the seven countries. This short table does not include detailed IFAD methodologies and tools, but instead provides a concise set of issues and solution areas to consider in IFAD operations for the seven countries throughout the value chain interventions.

**Table 2.9b. Key climate change risks and value chain interventions in the Sahel.**

| Value chain interventions / outcomes | Climate Change / Environmental risk issues | Climate risk management activities |
|---|---|---|
| **Input supplies** | | |
| Seeds | High-yield varieties may perform poorly in higher temperatures, humidity and salinity; certain hybrid seed varieties degrade soils over the long term. | Climate-adapted varieties where available (e.g. heat-tolerant, submergence tolerant). |
| | | Seed banks, including wild plants. |
| Fertilizers | Generally positive in low-input systems, but may increase inter-annual variability in yields; there are trade-offs in terms of emissions. | Advice on fertilizers and their supply, with broader soil management and manure use. |
| | | Precision farming. |
| | | Periodic water quality analysis. |
| | | Onsite technical support to monitor use and disposal. |
| Pest management | Possible increases in pests and diseases for crops (e.g. maize stem borer, tomato flies, cassava mealy bug) and livestock (e.g. cattle ticks). | Integrated pest management (e.g. push-pull methods), develop monitoring, knowledge and applied research systems for pests and diseases of crops, livestock and fisheries. |
| | | Bio-pesticides and organic farming. |
| | | Periodic water quality analysis. |

| | | |
|---|---|---|
| | | Onsite technical support to monitor use and disposal. |
| Information Services | Advance climate information enables better decisions about the timing of planting, input application and harvesting, and the choice of varieties, labour inputs and planting or grazing locations. | Provision of seasonal and short-term forecasts in formats that are accessible to farmers and strengthen early warning systems. |
| | | Invest in country-level capacity in scaled down climate impact modelling and scenario planning. |
| Financial services | Lack of upfront capital may be a major drawback for farmers to adopt climate-resilient practices. | Investigate financial mechanism to reduce risks associated with innovation (e.g. microfinance, small grants programmes, index-based weather insurance). |
| | | Water harvesting, solar power and other GHG reduction technologies. |
| Tools and equipment | Possible damage of tools and equipment (e.g. water tanks, irrigation canals, pumps, generators, vehicles, seed storage) due to extreme weather events. | Harvesting rainwater and surface water for irrigation. |
| | | Early warning systems. |
| | | Introduce protective features for the storage of seeds, tools, vehicles, fuels and energy infrastructure. |
| **Agricultural Production** | | |
| Soil Management | Rising temperatures, greater soil moisture evaporation and more destructive interplay between dry spells and intensive rainfall events increase soil erosion and reduce organic material in the soil. | Introduce measures to counter soil erosion (e.g. terracing, contour bunds, drainage, agroforestry, perennial crops). |
| | | Carbon in the soil and improvements in the management of organic matter in the soil. |
| | | Rehabilitate degraded lands. |
| Water Management | Greater crop evapotranspiration; loss of soil water; changes in amount and timing of rainfall; more variable river run-off; reduced groundwater recharge. | Water conservation and efficiency measures such as water harvesting, efficient irrigation infrastructure, check dams, flood management and drainage. |
| | | Support riparian habitat restoration. |
| | | Water allocation systems. |
| On-farm energy | Mechanization using fossil fuels causes emissions to increase; use of fuel wood can cause deforestation and erosion. | Analysis of trade-offs. |
| | | Renewable energy sources (e.g. solar energy for heating, cooling, drying and pumping, small wind turbines and biogas digesters). |

| | | |
|---|---|---|
| Diversification | Monocultures are more prone to catastrophic losses from climate extremes than diversified systems. | Intensification and diversified cropping systems through crop rotations (e.g. staple/horticulture), intercropping, agroforestry, mixed crop/livestock systems. |
| Landscape-level management | Positive value chain outcomes (e.g. higher incomes) may incentivize greater land clearance and unsustainable water use, affecting local microclimate and hydrology and compounding climate hazards. | Participatory mapping and land-use planning. |
| | | Remote sensing-based landscape monitoring. |
| | | Exploit all available incentives (financial, regulatory, etc.) for sustainable environmental management in the project. |
| Skills base of farmers and local institutions | Local knowledge and capacity are central to managing production under rapidly changing conditions. | Invest in local capacity for planning, monitoring, decision-making and financial management. |
| | | Innovative training on climate issues and support to farmer-based research and knowledge systems. |
| | | Policy dialogue and scenario-building exercises. |
| **Post-production: storage, processing, transport and retail** | | |
| Post-harvest management | Increasing harvest losses; declining safety, quality, market and nutritional value due to rising temperatures, humidity, pests and diseases. | Waste reduction measures and value addition for by-products. |
| | | Renewable energy sources to cover changing requirements for cooling, drying, milling and threshing. |
| Siting of processing facilities | Extreme climate events (such as landslides, floods, heat waves, storms) may damage processing facilities; shifting climatic conditions may render some sites redundant or increase transport costs. | Maps to inform siting of processing facilities. |
| | | Processing facilities with protective features. |
| | | Protecting processing facilities from extreme climate events. |
| Energy processing | High dependence on local bioenergy (wood, charcoal, dung, crop residues) has trade-offs with better soil management; rising temperatures require more energy for cooling. | Renewable energy sources (such as solar photovoltaic panels for cooling / drying / milling / heating, as well as wind and biogas). |
| | | Equip processing facilities with energy-saving appliances (e.g. solar lighting, solar charging, and efficient cook stoves). |

| | | |
|---|---|---|
| | | Pollution control measures. |
| Water in processing | Declining and/or more irregular water supplies;<br>Growing competition with other domestic or industrial users. | Relocate facilities. |
| | | Water storage and distribution (water harvesting, communal ponds, groundwater recharge). |
| | | Demand-side water efficiency measures. |
| | | Support conflict resolution for different water users (e.g. water user groups). |
| Packaging materials and methods | Rising temperatures and humidity may increase or decrease post-harvest losses and waste and impact food safety. | Suitable packaging materials in parallel with waste and storage management strategies. |
| Transport hubs and routes | Routes may become seasonally or permanently impassable (or open up);<br>Extreme events will disrupt logistics. | Relocate hubs. |
| | | Co-design value addition, storage and transport components to avoid high-risk transport routes and seasons. |
| Feeder roads | The construction/rehabilitation of feeder roads may negatively impact the environment through erosion and the destruction of sensitive habitats such as IVS. | GIS, remote sensing, mapping |
| | | Culverts and side-drains to reduce erosion. |
| | | Environmentally friendly asphalt (hot mix asphalt, HMA). |
| Refrigeration and cold chains | Temperature rises increase requirements for and costs of refrigeration;<br>Rising energy requirements increase greenhouse gas emissions. | Introduce renewable energy sources for cooling and ventilation. |
| | | Optimize storage and transport management. |
| “Just-in-time” logistics | Extreme climate events (floods, storms, heat waves) can make it impossible to comply with “just-in- time” requirements. | Develop contingency plans for climate shocks and extreme events; create contingency storage opportunities. |
| | | Promotion of regional markets to avoid over- dependence on high-value export markets. |

**Table 2.9c: Sustainable Land Management techniques**

86. The table below presents the types of SLM suggested by the programme based on the conditions for use in order to improve productivity, living conditions and ecosystems in the region. These were calculated using the EX ACT tool.

| Country | degradation hotspots where the project will be active | techniques | EX ACT balance (2020-2040) | NDC mitigation target for the AFOLU sector (2030) | comments |
|---|---|---|---|---|---|
| Senegal | Groundnut Basin, Eastern Senegal, sylvo-pastoral zone | ANR: 10,000 ha; zai : 8,500 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 3,600 ha; forest management: 6,000 ha; 350 ha of FFS with improved practices | 3.61 million tons of CO2eq sequestrated | 6 million tons CO2eq | ANR is efficient on sandy soils of the Groundnut basin and zai on ferrallitic soils of Eastern Senegal, where cropland is expanding; watershed restoration in the upper part of the Gambia Basin; forest management in Eastern Senegal, nomadic routes in the sylvo-pastoral zone |
| Gambia | North Bank; River region | ANR: 10,000 ha; zai : 8,500 ha; pasture restoration along nomadic routes: 10,000 ha; watershed restoration: 3,600 ha; forest management: 5,600 ha; 350 ha of FFS with improved practices | 3.44 million tons of CO2eq sequestrated | 1.1 million tons CO2eq | link with the Groundnut Basin in Senegal with the promotion of ANR and zai in the River Region |
| Mauritania | Assaba, Gorgol and Guidimakha | ANR: 10,000 ha; half moons: 8,500 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 3,600 ha; forest management: 5,600 ha; 350 ha of FFS with improved practices | 3.57 million tons CO2eq sequestrated | 20.4 million tons | half moons are fit for the low precipitations of this zone, importance of pasture restoration in theses agropastoral zones |
| Mali | Kayes region where cropland is expanding | ANR: 10,000 ha; zai : 8,500 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 3,600 ha; forest management: 5,600 ha; 350 ha of FFS with improved practices | 3.57 million tons CO2eq sequestrated | 37 million tons CO2eq | these techniques are not well know in this region where soils are under pressure |

| | | | | | |
|---|---|---|---|---|---|
| Burkina Faso | Centre North, Eastern region | ANR: 10,000 ha; half moons : 9,000 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 4,000 ha; forest management: 6,000 ha; 350 ha of FFS with improved practices | 3.72 millions of CO2eq sequestrated | 17.8 million tons of CO2eq sequestrated | pasture restoration in the fragile northern region, half moons and ANR in Centre North region, watershed protection around the tributaries of the Niger river, management of forests in the eastern degradation hotspot |
| Niger | Tillaberi and Dosso regions | ANR: 10,000 ha; half moons : 9,000 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 3,600 ha; forest management: 5,600 ha; 350 ha of FFS with improved practices | 3.63 million tons of CO2eq sequestrated | 32.5 millions tons of CO2eq | watershed protection and forest management with a transboundary perspective, along the Burkina border in Tillaberi region, half moons and ANR in the Dosso region |
| Chad | sahelian belt (Kanem, Batha, Guera) | ANR: 10,000 ha; zai : 8,500 ha; pasture restoration along nomadic routes: 15,000 ha; watershed restoration: 4000 ha; forest management: 5,600 ha; 350 ha of FFS with improved practices | 3.62 million tons of CO2eq sequestrated | 54.5 million tons of CO2eq | promotion of these techniques not well known in Chad. Zai on ferrallitic soils and ANR on sandy soils, pasture restoration in Batha |

## Chapter 3 Description of Africa Risk Capacity (ARC) and interventions in the seven countries

### 3.1 Introduction

87. In light of the magnitude of the natural disasters and extreme weather events challenge in the seven countries, it is a humanitarian and economic imperative to develop innovative financial mechanisms and to continue investing both in risk reduction and more efficient risk management measures in order to rapidly and efficiently address risks to natural disasters. This should be centered on protecting critical investments in resilience at the sovereign and household levels. The African Risk Capacity Agency[37], established by a Heads of State decision at the African Union summit in July 2012, is a comprehensive, integrated solution that transfers weather risk away from governments – and the vulnerable households they protect – to ARC.

88. ARC's vision is to protect the livelihoods of vulnerable people in Africa against the impact of natural disasters through home-grown, innovative, cost-effective, timely, and sustainable solutions. To accomplish its mission to use modern finance mechanisms, such as risk pooling and risk transfer, to create pan-African climate response systems that enable African countries to meet the needs of people harmed by natural disasters, ARC builds on its achievements to date and works toward three key strategic objectives:

[37] https://www.africanriskcapacity.org/wp-content/uploads/2017/07/ARC-Overview_EN.pdf

- Innovate - A Dynamic Approach to Research and Development;
- Strengthen - Strengthening Disaster Risk Management on the Continent;
- Grow - Increased Scalability and Sustainability of ARC Operations and Insurance Coverage.

89. This enables governments to build resilience and better plan, prepare for and respond to extreme weather events. ARC brings together four critical elements to create a powerful and sustainable value proposition for its participants and their partners: Early warning systems (information), contingency plans (preparation), early action (response) and climate resilience (adaptation).

90. Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia are Member States of ARC. ARC develops programmes aligned with each national strategy and embedded within national programmes of each country to ensure that it is tailored to the needs of the seven given counties and complements existing initiatives, thereby strengthening national capacities. Through its rigorous and comprehensive capacity building programme and index insurance mechanism, ARC enables the seven Member States to build resilience and better plan, prepare and respond to extreme weather events by linking cutting-edge early warning technology with contingency planning and modern financial tools. With the risk pooling and transfer services offered by ARC Ltd, the continent can better manage its natural disaster risk as a group, and African sovereigns can access rapidly disbursing financing to fund emergency responses effectively.

### 3.2 Overview of ARC activities in the seven countries

91. In the context of achieving **Strategic Objective 1: Dynamic and Applied Research and Development (R&D),** ARC focuses on improving the reliability and the accuracy of Africa *RiskView*[38] as a software used to underwrite the drought risk pool and a core product supporting early warning systems in Africa. Africa *RiskView* is designed in the seven countries to interpret satellite weather information, specifically rainfall estimates, and combine it with data on crops and soil characteristics. It then translates these estimates into the number of people who may be directly affected by a rainfall deficit or drought in a given agricultural season. Using cost-per-affected-person estimates, Africa *RiskView* estimates the total response costs to a particular drought event.

92. Africa *RiskView* uses the Water Requirement Satisfaction Index (WRSI), developed by the United Nations Food and Agriculture Organization (FAO), to estimate drought risk. The WRSI index uses satellite rainfall estimates to calculate whether the water requirements of a crop were met during each phase of the development of the chosen reference crop. The WRSI parameters are defined by each country through a national process led by a Technical Working Group. The highlights of the latest Africa *RiskView* report which discusses estimates of rainfall, drought and population affected, is conducted in each country at the end of an insured agro-pastoral season. This exercise aims at reviewing the performance of the model and ensuring that each country's drought risk is accurately reproduced by Africa *RiskView* for drought monitoring and insurance coverage.

93. In addition, The Gambia served as one of the three pilot progammes for the validation of the development of a new ARC product: the river flood insurance product. Technical experts were also initiated within the country.

94. ARC made also progress in 2018 on the technical work for the Extreme Climate Facility (XCF)[39] with the finalization and dissemination of the technical reports and the development of policy briefs. Through the XCF, the seven countries will be able to gain access to additional financing to respond to the impacts

[38] https://www.africanriskcapacity.org/wp-content/uploads/2019/05/Africa-RiskView-brochure-May-2019.pdf
[39] https://www.africanriskcapacity.org/wp-content/uploads/2016/11/XCF-flyer-EN.pdf

of increased climate volatility. The XCF is envisioned as a data-driven, multi-year financial vehicle that tracks the frequency and magnitude of extreme climate shocks in Africa, and provides additional financing for countries already managing their current weather risks through the financial affiliate of ARC, the African Risk Capacity Insurance Company Limited (ARC Ltd)[40]. ARC Ltd was established in 2013 to provide insurance to participating Member states.

95. In regard to the **Strategic Objective 2: Strengthening Disaster Risk Management and Financing on the Continent**, a fundamental aspect of ARC's work involves engaging governments in the seven countries through high-level meetings, technical workshops, and scoping missions in order for governments to gain an understanding of disaster risk financing and insurance. These engagements set the direction to build disaster risk management capacities and country ownership of the ARC programme by governments. This is an important component of ARC's work in the seven countries and encompasses all interactions ARC has with each country, including supporting the technical work streams.

96. ARC provided technical support to the seven countries[41] for the development and refinement of their Operations Plans (OPs) – a contingency plan aimed at providing rapid and efficient interventions to vulnerable populations in the event of drought and at obtaining payout[42] from ARC. The OPs describe the activities to be carried out when payment is made by ARC, how these activities will be implemented as well as the mechanisms for managing any funds that may be obtained from ARC. The table below summarizes the latest ARC OPs and interventions based on three ARC payout scenarios in Burkina Faso, Mali, Mauritania, Niger, Senegal and The Gambia:

| Countries | Scenario 1: ARC payout of less than one (1) million USD (except for the Gambia two (2) million USD) | Scenario 2: ARC payout of five (5) million USD(except for The Gambia 4.8 million USD) | Scenario 3: ARC payout of 30 million USD (except for The Gambia 20 million USD) |
|---|---|---|---|
| **Burkina Faso**[43] | Free food distribution actions to assist people who have lost almost all of their agricultural production. | 40% of the funding will be allocated to free food distribution and 50% will be allocated to cash transfers. The remaining 10% will be allocated to a needs evaluation, beneficiary targeting and monitoring/assessment. | 40%, 25% and 30% will be allocated to the free food distribution, cash transfers and the treatment of moderate acute malnutrition respectively. The remaining 5% will be used for the purposes of identification, beneficiary targeting and the monitoring/assessment of actions undertaken. |

[40] https://www.africanriskcapacity.org/wp-content/uploads/2017/07/ARC-and-ARC-LTD-EN.pdf
[41] Chad has not prepared an OP as of date however the cropping calendar is similar to Niger.
[42] The payout threshold is determined by the risk transfer parameters which are selected by each country. These parameters determine the actual amount of risk to be transferred to ARC Ltd, the frequency at which payouts might be triggered and, consequently, the cost that a Government will be required to pay to purchase the insurance coverage (premium).
[43] Burkina Faso 2016 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/07/BURKINA-FASO-_Operations-Plans_2017_EN_vo2CL.pdf

| | | | |
|---|---|---|---|
| **Mali**[44] | In case of localized drought the government can seek to assist vulnerable population through target food assistance (cash or food). This sum will provide food assistance to 313 721 individuals affected by the drought. | ARC funds can be used to transport OPAM (bureau for agricultural products) warehouse stocks, valued at USD 4 million and the payment of monitoring and assessment and auditing expenses amounting to US$ 1 million.<br><br>OR<br><br>ARC funds can be used for the payment of costs related to services delivered by local NGOs to an amount of USD 600,000 and for the payment of monitoring and assessment and auditing expenses amounting to US$ 1 million. | ARC funds can be used:<br>- to replenish safety reserves up to their optimal level of 35 000 metric tons of cereals for an amount of USD 15.4 million, to replace the reserves used to assist 1 254 885 individuals beneficiaries;<br>- for the upliftment of inhabitants who have experienced crises to an amount of USD 9 million of which USD 7 million are allocated to the purchase and distribution of cattle feed (including transport and implementation costs) to 478 768 beneficiaries and USD 2 million including financial charges) for the cash transfer to 125 489 beneficiaries;<br>- for the payment of monitoring and assessment and auditing expenses amounting to USD 1 million. |
| **Mauritania**[45] | Food distribution needs of USD 20 per person for 50,000 people. | Food distribution needs of 250,000 people. | Needs of 1,000,000 people by the means of food distribution and cattle feed sale at subsidized price for around 231 481 cattle |
| **Niger**[46] | Targeted free distribution of food kits to areas severely affected by drought. | - Generalized distribution to all affected areas.<br>- Implementation of Cash for Work operations. | - Generalized distribution to all affected areas.<br>- Implementation of cash transfer operations (Cash for Work, distribution of |

[44] Mali 2015 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Mali-Operational-Plan.pdf
[45] Mauritania 2016-2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Mauritania-Operational-Plan_EN.pdf
[46] Niger 2016-2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Niger-Operational-Plan_EN.pdf

| | | | |
|---|---|---|---|
| | | | core group of small ruminants). |
| **Senegal** [47] | Food or food voucher distribution | Food or food voucher distribution | - Food or food voucher distribution.<br>- Sale of cattle feed at subsidized prices<br>- Implementation of acute malnutrition screening and management activities |
| **The Gambia**[48] | Food and Cash Distribution: USD 1 million would be needed to reach 20,000 persons and the supplementary feeding programme costing USD 1 million for 8,300 beneficiaries | In the case of a severe nationwide drought $4.8 million would be required to reach 75,000 people in immediate need of humanitarian assistance. This will be split between USD 3 million for an unconditional food/cash distribution and a USD 1.8 million supplementary feeding programme for Moderate Acute Malnutrition focussing on screening of children 6-59 months and pregnant and lactating mothers (15, 000 potential beneficiaries). | $10,000 for food or cash assistance and $10,000 for supplementary feeding. The beneficiary numbers would be 200 and 80 respectively |

97. Finally, to achieve its **Strategic Objective 3: Scalability and Sustainability of ARC Operations**, ARC has made strides in providing risk transfer services for the seven Member States and developing as a pan-African insurance institution (i.e. ARC Ltd) along with ARC's research and expansion of disaster risk management capacity on the seven countries.

98. Insurance can be an efficient tool for providing Member States with reliable financing after a natural disaster. ARC Ltd has proven it can deliver results in early 2015 following a significant drought in the Sahel, when it mobilized over USD 26 million as an early response to Mauritania, Niger and Senegal. Recently, Mauritania received another payment of USD 2.4 million from ARC Ltd following a poor rainy season in 2017. The funds were used in the first half of 2018 to provide subsidized livestock feed in the most affected pastoral areas. ARC Ltd also issued a drought insurance of USD 23.1 million to Senegal. The funds were used given in two parts of USD 12.5 million and USD 10.6 million to the Government and StartNetwork assist in providing early action to support the people affected by drought during the 2019 agricultural season[49]. Expanding Member State participation in ARC Ltd and their consistent risk transfer transactions will enable ARC to develop a more sustainable financing structure for its core operations, allowing ARC Agency to move away from dependence on donors.

[47] Senegal 2016 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Senegal-Operational-Plan_EN-1.pdf
[48] The Gambia 2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/12/OP_Pool4_Gambia_OperationalPlan_2017.pdf
[49] https://www.africanriskcapacity.org/updates/

99. ARC has seen a great milestone achieved with the approval of the Africa Disaster Risk Financing (ADRiFi) programme by the African Development Bank (AfDB)[50]. ADRiFi is a premium financing programme that will expand access to ARC's risk transfer facilities. Nine (9) Member States, including The Gambia and Niger, have expressed interest in participating in the programme. ADRiFi is a comprehensive and sustainable solution for risk transfer within the broader context of disaster risk management. ADRiFi will run from 2019-2023, and the programme aims scale up subscriptions to the mechanism in order to enhance the resilience and response to climate shocks on the continent. The ADRiFi programme helps eligible countries access risk transfer services through premium support for parametric weather insurance offered by ARC.

100. In addition to premium financing support, ADRiFi will assist countries in improving the management of natural disaster risk by strengthening national capacities to evaluate climate-related risks and disaster contingency plans; elaborating mitigation measures at national and sub-national levels; helping countries to design disaster risk financing strategies; and providing funding for rapid responses to address climate disasters at national and local levels.

101. ARC's commitment to ensuring gender equality and women's empowerment was concretized by gender assessment activities through ARC OPs, including literature reviews, in Burkina Faso, Mali, Senegal, The Gambia and Mauritania, which will be analyzed to form the basis for the elaboration of ARC Gender Equality Strategy.

[50] Africa Disaster Risk Financing Programme available at https://www.africanriskcapacity.org/wp-content/uploads/2018/12/ADRIFI_3.3.pdf

| Country | Grant justification | Financing terms for 2018* | Income Category (2017) |
| --- | --- | --- | --- |
| **Burkina Faso** | The Government of Burkina Faso requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant financing is based on Burkina Faso's status as an LDC. GDP per capita is low (~ USD 688 in 2017), while the external debt to GDP ratio is high (~24 percent in 2015). Burkina Faso is at moderate risk of debt distress (IMF, 2016) and requires significant grant financing to adapt to the effects of climate change and fulfil its commitments under the Paris Agreement, especially those related to the agricultural sector. Agriculture is one of the sectors identified as a priority for adaptation action in Burkina Faso's Nationally Determined Contribution (NDC). IFAD offers financing to Burkina Faso in accordance with the Debt Sustainability Framework, which establishes the following: 50 percent as grant and the other 50 percent, as a loan on highly concessional terms. The portion granted on highly concessional terms is free of interest. | DHC (IFAD)<br><br>ADF-only (AfDB) | Low income |
| **Chad** | The Government of Chad requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant finance is based on Chad's status as a LDC. GDP per capita is low (~USD 823 in 2017) and the external debt to GDP ratio was 18 percent in 2016. With the accumulation of external debt arrears, Chad is currently in debt distress and the IMF's debt sustainability analysis shows that debt is unsustainable without external commercial debt restructuring (IMF, 2017). Chad is highly vulnerable to climate change and has low capacity to adapt to its negative effects. The country requires grant financing sto adapt to climate change and fulfil its commitments under the Paris Agreement, primarily in the agricultural sector. Agriculture is identified as a key sector for adaptation action in Chad's Nationally Determined Contribution (NDC). All of IFAD financing (100 percent) has been provided to Chad as a grant. The country has been under these terms since 2014.<br><br>Chad is eligible to the African Development Fund (ADF) which is the concessional window of the African Development Bank (AfDB) Group. It is an ADF only country which means that it is only eligible for ADF grants and loans. | D (IFAD)<br><br>ADF-only (AfDB) | Low income |
| **Gambia (The)** | The Government of The Gambia requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant financing is based on The Gambia's status as an LDC. GDP per capita is low (~ USD 534 in 2017), whereas the external debt to GDP ratio is high (~40 percent in 2017), and the country does not have the financial | D (IFAD)<br><br>ADF-only (AfDB) | Low income |

| | | | |
|---|---|---|---|
| | capacity to manage loans or reimbursable grant financing. A recent debt sustainability analysis indicates that The Gambia is currently in external debt distress (IMF, 2017) and therefore, it requires significant grant financing to adapt to the effects of climate change. This requirement was identified in the National Adaptation Programme of Actions (NAPA), the Second National Communication (SNC) and the country's Nationally Determined Contribution (NDC). In 2018, IFAD financing terms to The Gambia changed from 50 percent grant and 50 percent loan on highly concessional terms (DHC) to 100 percent grant financing (D).<br><br>The Gambia is eligible to the African Development Fund (ADF) which is the concessional window of the African Development Bank (AfDB) Group. It is an ADF only country which means that it is only eligible for ADF grants and loans. | | |
| **Mali** | The Government of Mali requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant finance is based on Mali's status as a LDC. GDP per capita is low (~USD 762 in 2017) and the external debt to GDP ratio is high (~25 percent in 2016). Mali is at a moderate risk of debt distress (IMF, 2017). Due to this and the country's high vulnerability to climate change, Mali requires significant financing to adapt to the effects of climate change and meet the commitments it made under the Paris Agreement, especially in the agricultural sector. Agriculture is identified as a main sector for adaptation action in Mali's Nationally Determined Contribution (NDC). IFAD offers financing to Mali in accordance with the Debt Sustainability Framework, which stipulates the following: 50 percent as a grant and 50 percent as a loan on highly concessional terms. The portion granted on highly concessional terms is free of interest.<br><br>Mali is eligible to the African Development Fund (ADF) which is the concessional window of the African Development Bank (AfDB) Group. It is an ADF only country which means that it is only eligible for ADF grants and loans. | DHC (IFAD)<br><br>ADF-only (AfDB) | Low income |
| **Mauritania** | The Government of Mauritania requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant finance is based on Mauritania's status as a LDC. GDP per capita was approximately USD 1300 in 2017. The country has a high external public debt that reached 71.8 percent of GDP at end of 2016 (IMF, 2017). Mauritania's risk of debt distress is high and therefore, it requires significant grant financing to adapt to the effects of climate change and meet the commitments that it made under the Paris Agreement, especially in the agricultural sector. Agriculture is identified as a main sector for adaptation action in Mauritania's Nationally Determined Contribution (NDC). IFAD financing to Mauritania consists entirely (100 percent) of grant financing. The country has been under these terms since 2014. | D (IFAD)<br><br>ADF-Gap | Lower middle-income |

| | | | |
|---|---|---|---|
| | Mauritania is eligible to the African Development Fund (ADF) which is the concessional window of the African Development Bank (AfDB) Group. It is an ADF-Gab country which means that it is only eligible for ADF loans on hardened terms. | | |
| **Niger** | The Government of Niger requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant finance is based on Niger's status as an LDC. GDP per capita is low (~ USD 395 in 2017) and its external debt amounted to approximately 31 percent of GDP at the end of 2015 (IMF, 2016). Niger's risk of debt distress is considered moderate. The country consequently requires significant grant financing to adapt to the effects of climate change and meet the commitments that it made under the Paris Agreement, especially in the agricultural sector. Agriculture is identified as a main sector for adaptation action in Niger's Nationally Determined Contribution (NDC). IFAD offers financing to Niger in accordance with the Debt Sustainability Framework, which defines the following terms: 50 percent is awarded on a grant basis and the other 50 percent as a loan on highly concessional terms. The portion granted on highly concessional terms is free of interest.<br><br>Niger is eligible to the African Development Fund (ADF) which is the concessional window of the African Development Bank (AfDB) Group. It is an ADF only country which means that it is only eligible for ADF grants and loans. | DHC (IFAD)<br><br>ADF-only (AfDB) | Low income |
| **Senegal** | The Government of Senegal requests that 100 percent of the resources for the proposed GCF project be committed in the form of a grant. The request for grant financing is based on Senegal's status as a LDC. The country's GDP per capita was approximately USD 1134 in 2017 and it had a high external debt to GDP ratio (approximately 45 percent in 2016). Senegal requires considerable grant financing to adapt to the effects of climate change and fulfil the commitments that it made under the Paris Agreement, especially in the agricultural sector. Agriculture is identified as a main sector for adaptation action in Senegal's Nationally Determined Contribution (NDC).IFAD financing to Senegal consists of loans granted on highly concessional terms (HC) and free of interest.<br><br>For AfDB, Senegal is a blend country. It is eligible for ADB resources and for ADF loans subject to a cap and hardened terms. | HC (IFAD)<br><br>Blend (AfDB) | Low income |

*****: D: grant; DHC: grant and highly concessional; blend; ordinary and DHC.

## 5.1 Burkina Faso

### 5.1.1 Country Background: Development Context and Challenges

102. Located at the heart of West Africa, Burkina Faso is a landlocked country covering an area of 274,000 km². Bordering on six countries – Benin, Côte d'Ivoire, Ghana, Mali, Niger and Togo – Burkina is a crossroads for trade in the sub region and a country of transit between the Sahelian countries of Mali and Niger and countries along the coast. The closest point to the Atlantic Ocean is 500km away. In terms of administrative subdivisions, Burkina Faso has 13 regions, 45 provinces, 351 departments, 302 rural communes, 49 urban communes and 8,435 villages. (IFAD, 2016)[51]

103. The country's demographic dynamic presents strong internal and external migration flows. The North, Sahel and Centre provinces are affected in particular, with migrants – mainly men – leaving these areas for regions located further south where conditions are more favourable. This situation engenders an increasing imbalance between the North – with its labour scarcity, uncertain rainfall and chronic cereal deficit – and the South – with its strong land pressures, steeply increasing land occupation rates and anarchic natural resource use. There are some 60 ethnic groups speaking virtually the same number of languages. The population is characterized by its youth – 58.2% under 20 – and predominance by women, at 51.83%. (IFAD, 2016)[52]

#### 5.1.1.1 Income and poverty

104. With a strong demographic growth of 2.8% per annum over the period 2010-2015, Burkina Faso had 17.5 million people[53] in 2015, 45% of whom were under 15 and 71% lived in rural areas. The findings of the household survey on living conditions 2009/2010 shows that 43.9% of the population lived below the poverty line in 2009, and that the regions of the North, at 68%, and the East, at 62%, were the most affected. Burkina Faso generally runs a surplus in cereals, contributing close to three quarters of energy needs, but average production per capita is in decline. (IFAD, 2016)[54]

105. The findings of the three main surveys conducted by the government in 1994, 1998 and 2003 describe a worsening incidence of poverty in Burkina Faso. On the basis of an absolute threshold of poverty estimated at 82.672 F CFA in 2003 against 72.690 FCFA per adult and per year in 1998, the proportion of poor people increased from 45.3% to 46.4% between the two periods, thus indicating an aggravation of 1.1 point. Compared with 1994, poverty generally increased by 2 points, the incidence of poverty indicated 44.5% in 1994 for a threshold of 41.099 FCFA per adult on an annual basis. (MoESD, 2014)[55]

106. Areas of widespread vulnerability and food insecurity cover 20 provinces with structural deficits, located mainly in four regions of the country: North, Sahel, Centre-North and East. People living in the

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[51] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

[52] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

[53] http://data.un.org/CountryProfile.aspx?crName=burkina%20faso

[54] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

[55] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf

Neer-Tamba project area are particularly affected by monetary poverty and food insecurity: 46% of households in the North region. (IFAD, 2016)[56]

### 5.1.1.2 Temperature, rainfall, seasons and agro-climate zones

107. Three typical eco-climate areas subdivide Burkina Faso: the Sahel area in the North, the north-Sudanese area in the center and the south-Sudanese area in the South-West. The most significant climate factor is the rainfall which decreases from North to South and is subject to seasonal and inter-annual variations resulting in droughts or heavy floods some years at a higher an increasing frequency. (MoESD, 2014)[57] Temperatures are subject to significant spatio-temporal variability. The monthly averages rarely exceed 35 ° C and the extremes temperatures are found in the north with an absolute minimum value of 5 ° C at Markoye in January 1975 and an absolute maximum value of 47.2 ° C at Dori in 1984. (GoBF, 2007)[58]

108. Due to its geographical position, Burkina Faso is characterized by a dry tropical climate, which alternates between a short rainy season and a long dry season. Burkina Faso's climate is prone to strong seasonal and annual variation due to its location in the hinterland and within the confines of the Sahara. The country has three climatic zones: the Sahelian zone in the north receiving less than 600mm average annual rainfall; the north-sudanian zone in the center receiving an average annual rainfall between 600 and 900mm; and the south-sudanian zone in the south with an average annual rainfall in excess of 900mm. (UNDP, 2018a)[59]

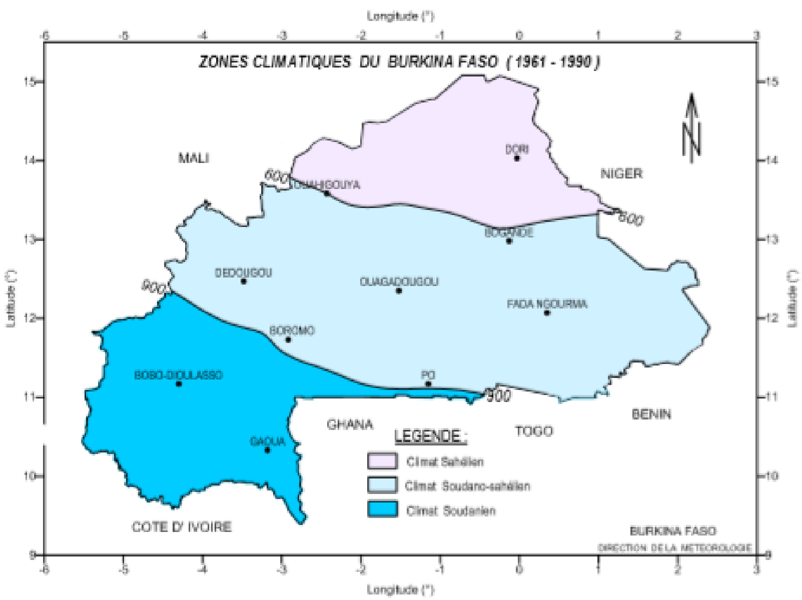


**Figure 5.1.1.2: Climatic zones of Burkina Faso (GoBF, 2007)[60]**

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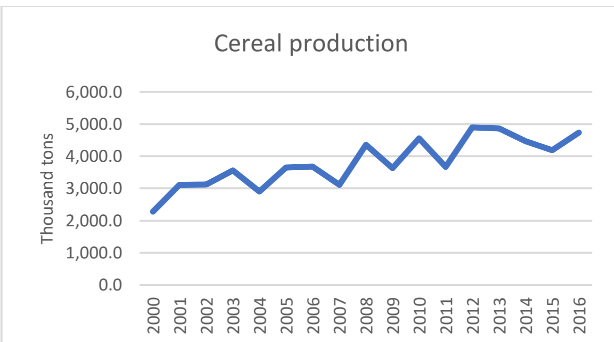
[56] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre
[57] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf
[58] http://www.hubrural.org/IMG/pdf/5._pana_burkina_faso_2013_etat_d_avancement_pana_au_burkina_faso.pdf
[59] http://adaptation-undp.org/explore/western-africa/burkina-faso
[60] http://www.hubrural.org/IMG/pdf/5._pana_burkina_faso_2013_etat_d_avancement_pana_au_burkina_faso.pdf

### 5.1.1.3 Agriculture and rural livelihoods

109. Agriculture in Burkina Faso takes place under relatively difficult ecological conditions. Rainfall generally is scarce, irregular and poorly distributed over space and time. Land, water, pastureland, forests, wildlife and fish are the main resources sustaining economic and social development. (IFAD, 2016)[61]

110. Agriculture contributes to nearly 25% of the GDP of Burkina Faso. Agriculture is practically exclusively extensive and essentially practiced in family farms of 3 to 6 ha maximum. Crops production is dominated by the rainfall system. Only approximately 24.000 ha of lands are irrigated for an irrigable potential of 233.500 ha including 130.000 ha in partial control of water and an additional 30.000 ha in total control of the water. (MoESD, 2014)[62]

111. Soil is generally fragile with low fertility, poor organic content and a substantial phosphorus deficit. Close to 46% of the territory is affected by land degradation, manifest in disappearing plant cover, increasingly fragile and impoverished soil, erosion and falling aquifer levels. Crop and livestock farming conditions are increasingly fragile and precarious, leading to food insecurity, people's inability to obtain income, and overexploitation of natural resources. (IFAD, 2016)[63]



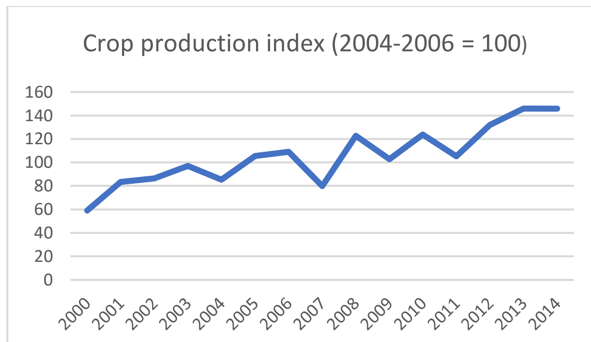




**Figure 5.1.1.3a: Total cereal production and crop production index Burkina Faso (World Bank, 2018a).[64]**

112. In terms of major agricultural activities based on the eco-climate areas, the following is the distribution: (i) livestock, cereals, transhumant pastoralism and millet in the Sahel area; (ii) cereals and market gardening in the north-Sudanese area and; (iii) fruit, cotton and cereals in the south-Sudanese area. (ARC, 2016)[65]

[61] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre
[62] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf
[63] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre
[64] https://data.worldbank.org/
[65] IFAD country profile: Burkina Faso available at https://www.ifad.org/en/web/operations/country/id/burkina_faso#anchor-1

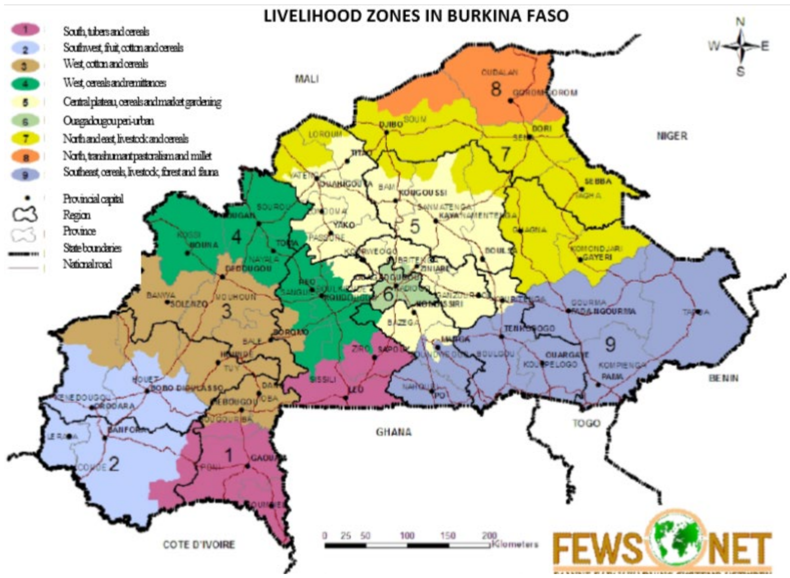



**Figure 5.1.1.3b: Livelihood areas in Burkina Faso identified with 9 seasonal calendars (ARC, 2016)[66]**

### 5.1.2 Climate change

113. This region, located largely within the sub-Sahelian zone, is characterized by a humid, semi-arid climate with a long dry season from October to May alternating with a short rainy season from June to September. Average annual precipitation ranges from 300 to 600 mm. (IFAD, 2016)[67]

114. The climate in the North region shows a trend towards increased aridity, a 20- to 30-day reduction in the growing season and a 100 mm southward shift in isohyets compared to the 1960s. Lower precipitation is observed together with significantly higher temperatures. (IFAD, 2016)[68]

#### 5.1.2.1 Temperature

115. The maximum temperature varied in average between 32.8 °C in Bobo-Dioulasso and 36.6 °C in Dori for the baseline period 1961-1990 and between 33.0°C (Bobo-Dioulasso) and 36.6 °C (Dori) over the period 1971-2000. Dori and Ouahigaya (in the Sahel area) have been hot areas while Bobo-Dioulasso, Gaoua and Niangoloko (Sudanese area) recorded the lowest average maximum temperatures. Concerning the average minimum temperature, it varied between 20°C and 22°C usually over the two periods (1961-1990 and 1971-2000). The average annual temperature increased by at least 0.5°C over the period 1961-2008 on all the synoptic stations in the country. The national average temperature of 27.5°C in 1961 increased to 28.5°C in 2008.

116. The annual average temperature in 2000 varied between 23.8°C and 30.8°C concerning the minimum temperature is between 26.1°C and 35.7°C for the maximum temperature. Compared to the

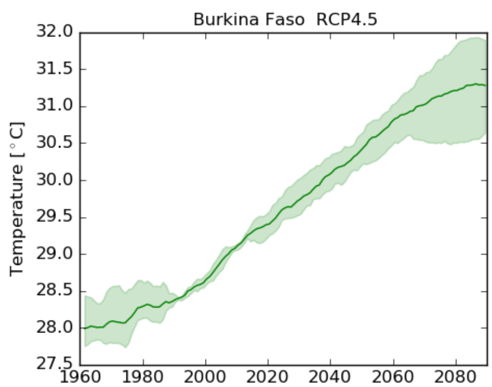
[66] IFAD country profile: Burkina Faso available at https://www.ifad.org/en/web/operations/country/id/burkina_faso#anchor-1
[67] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre
[68] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

average temperatures in 1961-1990, the minimum monthly temperature increased throughout 2000 except in February. These high temperatures vary between 0.4°C and 3.6°C. (MoESD, 2014)[69]

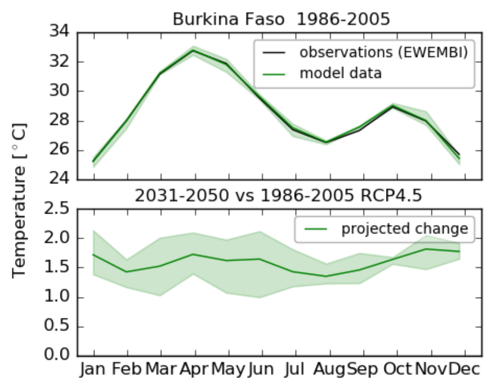
*Projections on temperature*

117. The perspective for the whole territory indicates an increase in the maximum and minimum temperatures of 0.9°C by 2025 and 1.5°C by 2050. That increase in temperature follows the current inter-season variation: the months of February, March, April and May being much hotter; while June, July, August and September are crops periods, therefore remain the least hot months. The trends are similar with minimum temperatures. (MoESD, 2014)[70]

118. The following graphics projecting temperatures in Burkina Faso are based on a Climate Analytics Tool (i.e. http://regioclim.climateanalytics.org/choices) that analyses climate projections on the national scale. However, national scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM[71].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5

**Figure 5.1.2.1: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[72]**

[69] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf

[70] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf

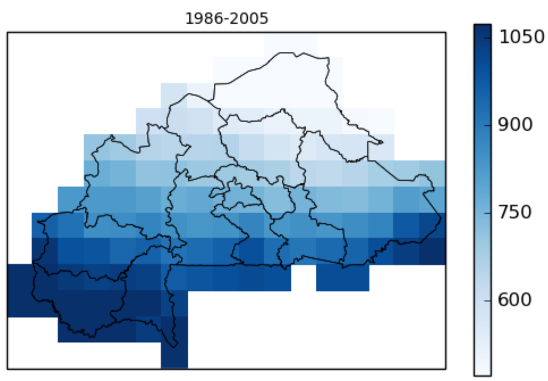
[71] The graphics of the projections are based on four basic functionalities: Period averages, area averages and ensemble mean of the model projections instead of showing the results separately for each model. Only showing the ensemble mean hides information about the discrepancies between models and the uncertainty of projections. Read more: http://regioclim.climateanalytics.org/documentation

[72] Burkina Faso Climate Analytics tool

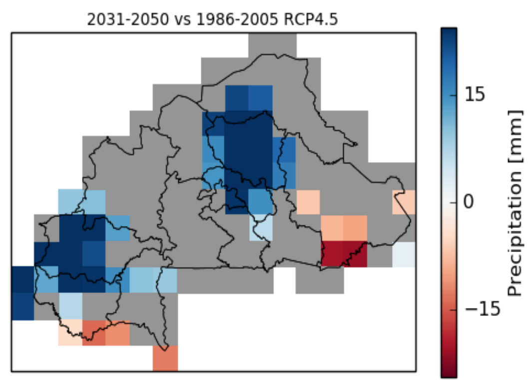
#### 5.1.2.2 Precipitation

119. The analysis of the historical data of rainfall indicates an overall situation of movements of isohyets toward the south. During the period 1931-1960, Burkina Faso could record an annual rainfall superior than 1.200 mm in its South-West region. The post 1960 period has been characterized by a significant decrease of the rainfall. The absence of isohyets 1.200 mm over the periods 1961-1990 and 1971-2000 was noticed. The lack of rainfall noticed is much more important between the periods 1931-1960 and 1961-1990. It thus confirms the impact of two droughts recorded in Burkina Faso over the period 1972- 1990. Concerning the period 1971-2000, the annual accumulation of the rainfall varies between 290mm in the North and 1170 mm in the South. The number of rainy days of the period 1961-1990 varies between 31 and 91 with an average of 58 days and a standard gap of 13 days. In average, there is a significant change in the number of rainy days over the period 1971-2000, compared with the baseline period 1961- 1990. (MoESD, 2014)[73]

120. The following graphics on precipitation in Burkina Faso are based on a Climate Analytics Tool that analyses climate projections on the national scale[74]. For the reference period map on precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

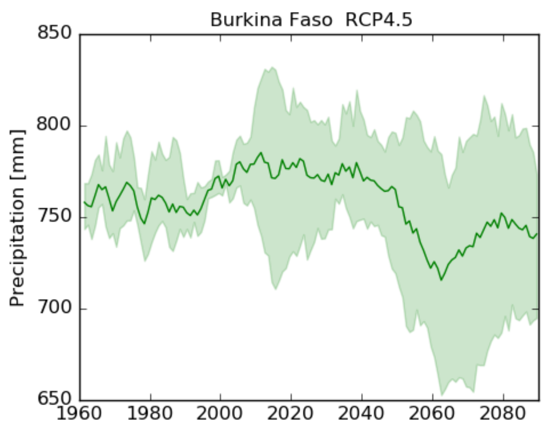
**Figure 5.1.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[75].**

[73] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf
[74] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation
[75] Burkina Faso Climate Analytics tool

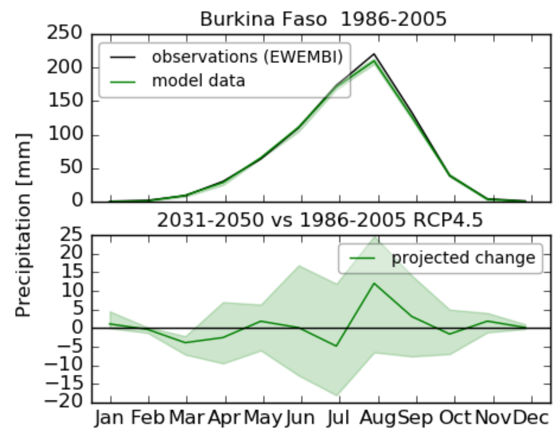
***Projections on precipitation***

121. According to the potential trends provided in the GIEC elaborated in 2007[76], the rainfall could record a decrease of -6.4% in 2025 and -11% by 2050 in the event of maximum tress, or an increase in the same proportions for the favorable situation. Between the two extreme situations, we have integrated a transitional situation which would be a moderate type of – 3.2% in 2025, and -6.5% in 2050. (MoESD, 2014)[77]

122. The following projections on precipitation in Burkina Faso are based on a Climate Analytics Tool that analyses climate projections on the national scale[78].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5

**Figure 5.1.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[79]**

#### 5.1.2.3 Climate change impacts, climatic hazards and extreme events

123. Climate changes are evident throughout Burkina Faso. The eastern and southwestern parts of the country, which generally have more favorable weather, are increasingly hit by high temperatures and

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[76] https://www.ipcc.ch/assessment-report/ar4/

[77] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf

[78] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[79] Burkina Faso Climate Analytics tool

pockets of drought. The government is helping villagers dig wells and build small water reservoirs to better utilize the country's scarce water resources. (UNDP, 2018a)[80]

*Projections on climate impacts*

124. Climate change may affect the Sahelian region of Africa through severe variations in rainfall, water shortage and low agricultural yield. This should amplify drought risks and evaporation, and reduce agricultural productivity (a 10% drop in rainfall is expected by 2050; GIEC, 1997)[81]. In addition, climate change will probably result in higher temperatures (a 1.4-1.6°C rise is expected by 2050; GIEC, 1997)[82], potentially increasing the risk for forest fires or bushfires. (UNDP, 2018a)[83]

### 5.1.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

125. Multi-model projections using Coupled Model Intercomparison Model 5 (CMIP5) call for a rise in cumulative precipitation for the period 2020-2040. The wet season will be more marked, with rains coming later in September and October, and rising accumulation on the order of +20%, but periods of drought will be longer. Severe precipitation events will be more frequent. In parallel, temperatures will rise on the order of 1°C. These changes will exacerbate the dynamics of erosion and increase the risk of flooding and damage to infrastructure. Later and heavier rainfall could threaten standing harvests. Rising temperatures coupled with higher humidity and longer periods of drought will increase crop health risks, particularly for market garden crops, as well as water requirements, especially during the off season. (IFAD, 2016)[84]

#### 5.1.3.1 Climate change impacts on agriculture

126. The combined crop and livestock farming system is widespread and based on cereals, which account for 97% of rainfed crops. In 2011, cereal production in the region, consisting primarily of millet and sorghum, provided 7% of national production (more than 320,000 tons). In the same year, livestock resources in the region consisted mainly of small ruminants (9.4% of the national herd), with close to two million head (compared to nearly 400,000 head of cattle).

127. In the course of the past decade, the degradation trend has been reversed to some extent with a number of interventions in land reclamation and sustainable natural resource management, consisting of semi-circular micro-catchments (demi-lunes), planting pits (zaï), stone barriers, contour bunds, and other improvements. (IFAD, 2016)[85]

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[80] http://adaptation-undp.org/explore/western-africa/burkina-faso

[81] https://www.ipcc.ch/publication/an-introduction-to-simple-climate-models-used-in-the-ipcc-second-assessment-report/

[82] https://www.ipcc.ch/publication/an-introduction-to-simple-climate-models-used-in-the-ipcc-second-assessment-report/

[83] http://adaptation-undp.org/explore/western-africa/burkina-faso

[84] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

[85] https://www.thegef.org/project/gef-iapparticipatory-natural-resource-management-and-rural-development-project-north-centre

128. The figure below presents IFAD Climate Adaptation in Rural Development – Assessment Tool (CARD)[86] for Burkina Faso to explore the effects of climate change on the yield of major crops.

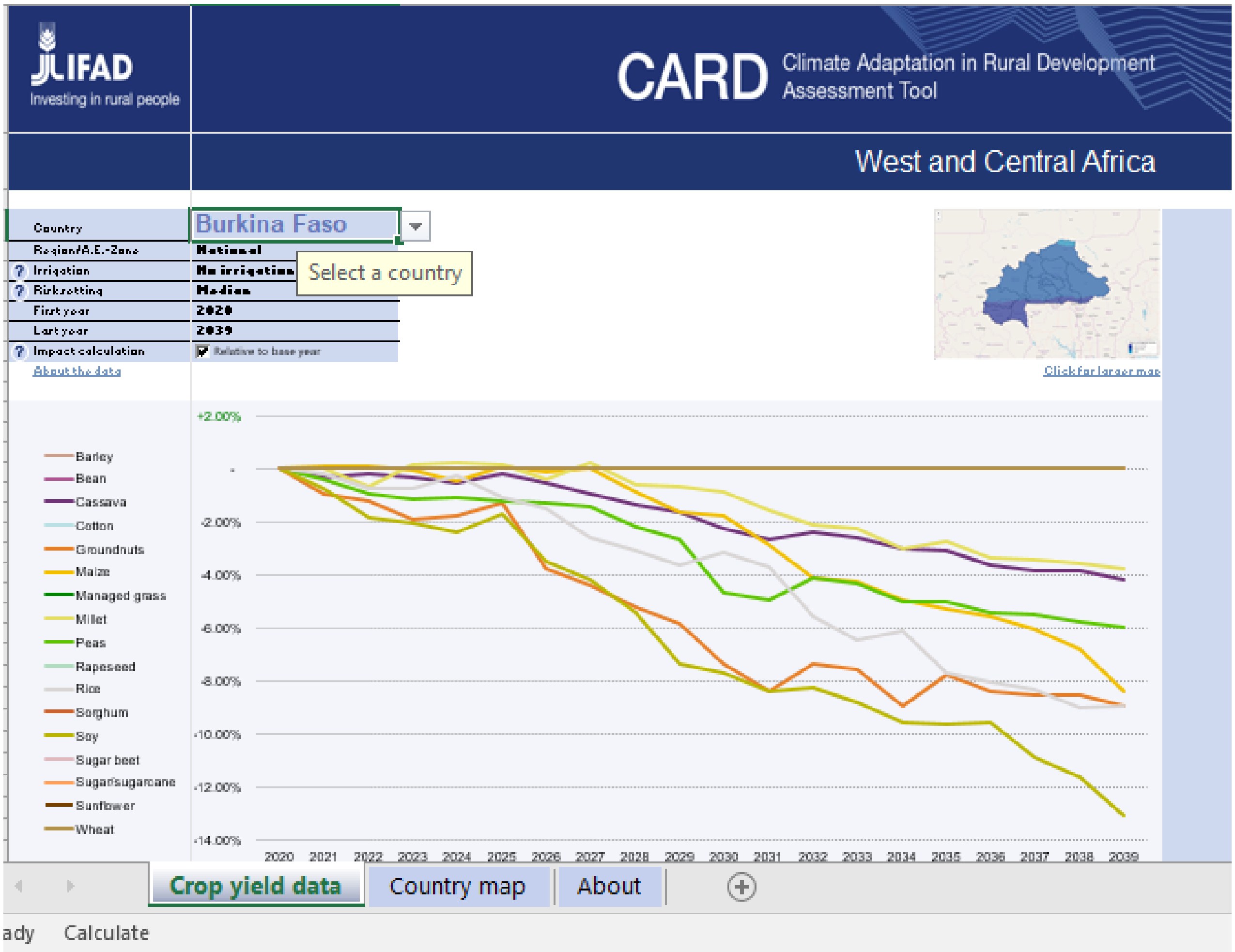


**Figure 5.1.3.1: CARD for Burkina Faso**

(Please refer to the "Climate change impacts on crop yield in specific targeted regions" document to see projections for each country region)

### 5.1.3.2 Climate change impacts on natural capital

129. Projections predict important changes in the structure and function of ecosystems, ecological interactions between species and distribution areas of species, with mainly negative impacts on biodiversity and the goods and services of ecosystems. The size of the problem is such that a specific study is needed in order to understand the domino effect of the impacts. The significant variation in rainfall from one year to the next and the increase in potential evapotranspiration (PET) represent

[86] https://www.ifad.org/en/web/knowledge/publication/asset/41085709

certain risks to the uninterrupted growth cycle of plants (loss of biomass). There is therefore a risk that the regeneration capacity of forest formations will be unable to compensate for timber cut for energy.

130. More frequent and serious flooding is to be feared, with destructive effects on biodiversity in the bottomlands and an increase in water-borne diseases among wild fauna. Furthermore, the increase in potential evapotranspiration combined with anthropogenic activities will result in faster degradation of ground vegetation and thus a reduction in infiltration to replenish the water table. Surface water will also evaporate faster and permanent water courses will tend to disappear with gallery forests. (UNDP, 2015b)[87]

#### 5.1.3.3 Climate change impacts on health

131. The impact of the vulnerability of water resources on the health sector takes the form of damage caused by excessive rainfall, especially floods, which may pose a risk to public health due to the precarious condition of water works and a gradual deterioration in the quality of water, causing outbreaks of water-borne diseases such as cholera, dysentery and salmonella. This risk of flooding might pose a risk to food security if harvests are destroyed, thereby also resulting in increased malnutrition, especially among children. The health sector will also be more vulnerable to the direct effects of flooding, such as infection and diarrhoeal diseases. (UNDP, 2015b)[88]

### 5.1.4 Vulnerability ranking and Mapping

132. Big data analytics were leveraged to identify structurally vulnerable zones. These zones of development need were calculated by averaging together all relevant and available sub-national development indicators across a broad spectrum. In all, 36 datasets, many of which were historical, were aggregated into composites, which were then aggregated into higher level composites. Geographic areas where most development indicators were negative are more red and areas where indicators were relatively better are more blue. (USAID , 2015)[89]

[87] http://www4.unfccc.int/nap/Documents/Parties/PNA_Version_version%20finale[Transmission].pdf
[88] http://www4.unfccc.int/nap/Documents/Parties/PNA_Version_version%20finale[Transmission].pdf
[89] https://www.usaid.gov/sites/default/files/documents/1860/Burkina%20Faso%20Vulnerability%20Map%20PRESENTATION%20%28FEB%202015%29.pdf

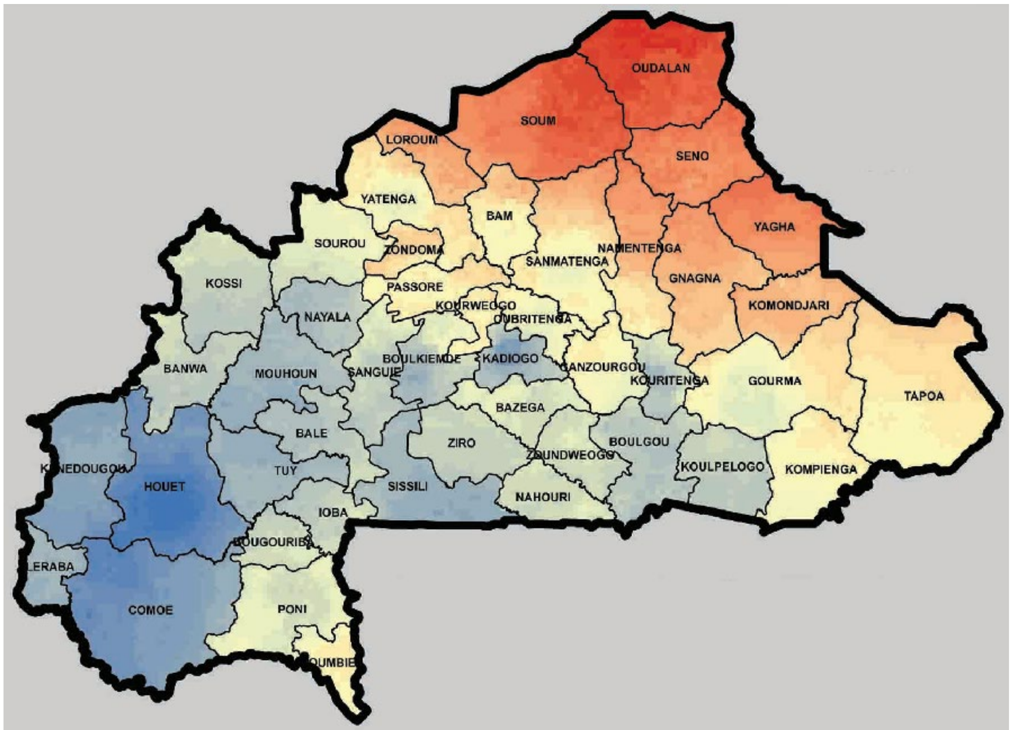


**Figure 5.1.4: Vulnerability map Burkina Faso (USAID , 2015)[90]**

90 https://www.usaid.gov/sites/default/files/documents/1860/Burkina%20Faso%20Vulnerability%20Map%20PRESENTATION%20%28FEB%202015%29.pdf

### 5.1.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| **Natural capital** | Increase ecosystem productivity and resilience | Increasing forest biomass production and promotion of new fuel wood technologies in combination with more sustainable land use management practices. This can be supplemented with the introduction of best practices have been introduced in the field of fisheries and aquaculture. |
| | Improve biodiversity conservation | Increase the protection of biodiversity (forests, wildlife etc.) and improve protection from climate change-related risks. |
| | Improve ecological research and monitoring | Establish a permanent R&D facility devoted to climate change adaptations. Climate change impacts on ecosystems are monitored on a permanent basis. |
| | Mitigate greenhouse gas emissions | Establishment of urban pollution mitigation measures and a national observatory for the environmental and natural hazards. |
| **Agriculture** | Capacity building | Provide staff and means to support the Regional Organisms of Development (ORD) initiative to boost the development of agriculture production. This would enable the regional offices to become active in conducting agriculture research and training for farmers. |
| | Climate insurance | Encourage farmers and the other stakeholders involved (mainly insurance companies) to promote climate insurance based on a predefined climate index which includes factors such as rainfall, temperature, sunshine or result from a combination of several climate parameters. The State should create a suitable framework for the emergence of that new type of insurance. |
| | Collection and conservation of water on the plot | As part of the adaptation strategy developed we need to point out the techniques of collection and conservation of water such as the zaï or the djengo and the half-moon. To reduce the run off and the erosion of the soil, several techniques such as stone bunds and grass strips have been developed. |
| | Irrigation techniques | Irrigation (supplement in the wet season, or total in the dry season) seems essential in the future for agriculture in dry or semi-dry areas, where temperatures are high and the evaporation is important. |
| | Reinforce the utilization of organic and mineral fertilizers | A few years ago, the government had launched a campaign to popularize the production of organic fertilizers through the promotion of compost pits. This initiative should continue but at the same time, the State should review its policy concerning the availability of mineral fertilizers for farmers. |
| | Popularization of improved varieties of maize | The efforts of agricultural research which has set up several varieties of improved maize adapted to the current context in the sector are strategies of adaptation for the farmers. Increased uptake would improve the productivity of the agriculture sector and make total output more resilient towards climate impacts. |
| **Water** | Creation of a favorable policy and institutional framework | Actions and strategies implemented by political powers to reduce the vulnerability of Burkina Faso to face climate variability and climate change. This entails review and adjustment of existing policies and programs to account for climate change impacts. |
| | Development and management of water resources | The development of water resources in response to declining rainfall in the context of climate change, affecting the availability of water. It is essential to develop strategies to reduce losses of bodies of water through evaporation in response to the increase in temperature, and |

| Sector | Adaptation mechanism | Description |
|---|---|---|
| | | therefore in evaporation. At this level, recent technological innovations such as the technique of subsurface dam (for example the one of Nare built in 1997) and artificial recharge, especially in fractured basement area, are highly considered. |
| | Monitoring and evaluation of water resources | Improve understanding of water resources, to promote scientific research, to develop a system of early warning of floods and an Information System on Water (SNIEau). |
| | Capacity building | This strategy requires awareness, information and communication, training and development of basic skills, equipment and technical tools, legal and administrative framework, mobilizing financing, and finally, cooperation and exchange of information |

**Table 5.1.5: Adaptation options by sector (MoESD, 2014; UNDP, 2015b) [91]**

133. Improving land quality and living standards of the rural population in Burkina Faso requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of land degradation hotspots in Burkina Faso to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country. The programme will focus on extremely high and high risks' hotspot locations in red (Figure 5.1.5.1). The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

134. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Burkina Faso, the national Land Degradation Neutrality (LDN) targets and measures that stop land degradation in Burkina Faso as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Burkina Faso.

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[91] https://unfccc.int/sites/default/files/resource/bfanc2engl.pdf ; http://www4.unfccc.int/nap/Documents/Parties/PNA_Version_version%20finale[Transmission].pdf

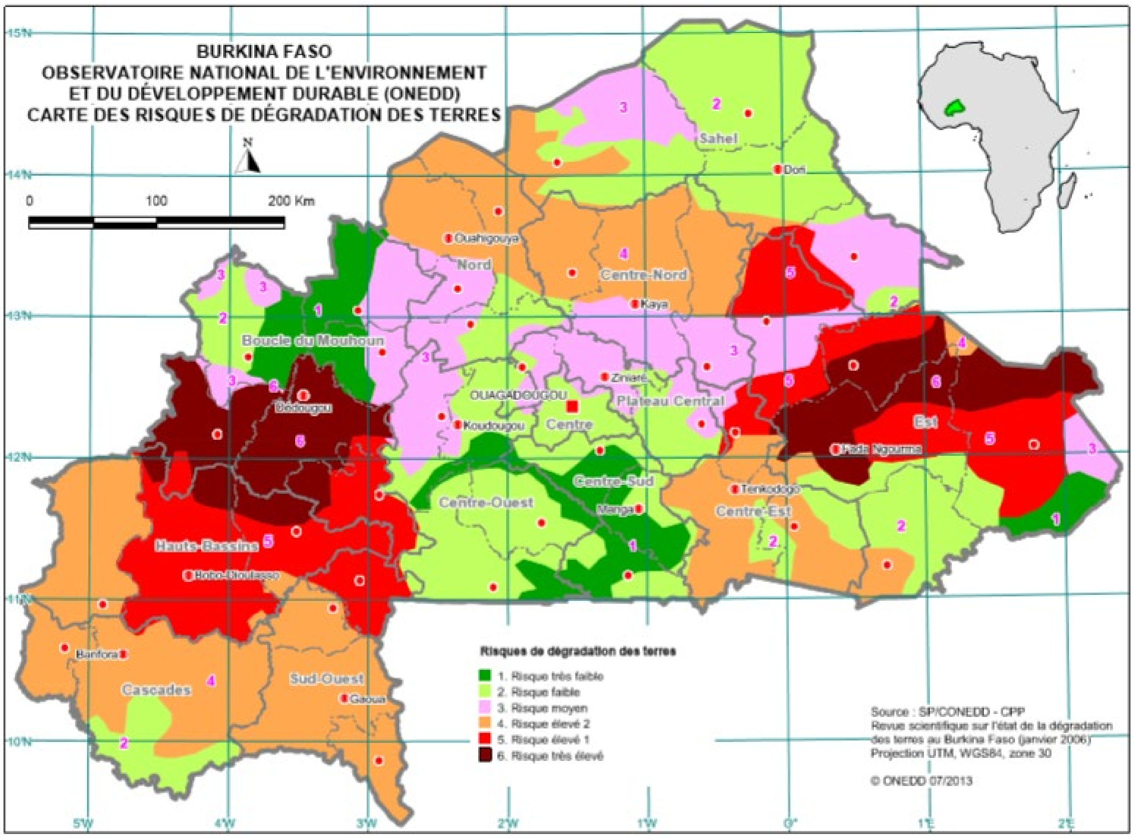

**Figure 5.1.5: Map of the risks of land degradation in Burkina Faso (ONEDD, 2013)**

## 5.2 Chad

### 5.2.1 Country Background: Development Context and Challenges

135. Chad is a vast landlocked country of 1,284,000 $km^2$, with a population of about 11.5 million inhabitants (2011), concentrated in the southern and central areas of the territory. The Population growth is 2.6% and the average population density is 8.9 inhabitants / $km^2$ (2011). The population is predominantly rural, although the urban population has increased by 16% in 1975 to 28% in 2011. More than 10% of the population lives in the city and the outskirts of N'Djamena. Its characteristics are its youth (45% under 15 years) and its rurality (72%). The isolation of country is exacerbated by its low population density and poor transport networks. (FIDA, 2014)[92]

136. GDP per capita, which was 200 USD in 2001, more than tripled in 10 years and reached 690 USD in 2011, thanks to oil production that began in 2003. The GDP growth rate in constant prices, however, show some ups and downs, 13% in 2010; 1.8%; 7.3% in 2012; 2.4% expected in 2013. The state budget almost quadrupled between 2002 and 2013, from 390 billion to CFA 1,500 billion, but the poverty rate fell very little over the same period and the country, with an index of 0.340, is ranked only 184 out of 186 countries for the index of human development (HDI 2013 - UNDP). (FIDA, 2014)[93]

#### 5.2.1.1 Income and poverty

137. According to the results of ECOSIT 2, the poverty line in Chad, base 2003, is around CFAF 144,570 per person per year, or CFAF 396 (less than US $ 1) per day. About 55% of Chadians live below this threshold, so are considered as poor. The poorest 20% live with only 153 FCFA per day while the best Fortune (20%) spend an average of CFAF 1.105 per day. To this, are added the precariousness of the state access to decent housing, the difficulty of access to drinking water and the lack of access to level of education. (RdC, 2012)[94]

138. Chad is one of the Least Developed Countries (LDCs) and Low Income Food Deficit Countries (LIFDCs). Thanks to oil production, started in 2003, GDP per capita has more than tripled in 10 years, reaching US $ 690 in 2011. However, the growth rate of GDP in constant prices has been fluctuating, oscillating over the past few years. In the last three years, GDP growth ranged between 1.3 and 1.8%, and the indicators of poverty and food insecurity remain very high: (i) Chad is ranked 184th out of 186 for the Human Development Index (HDI - 2013); (ii) the Global Hunger Index (GHI - 2012), estimated at 28.3, remains very alarming and; (iii) about 41.5% of the population, mostly located in the Sahelian belt, are in situations of severe or moderate food insecurity. (FIDA, 2014)[95]

#### 5.2.1.2 Temperature, rainfall, seasons and agro-climate zones

139. The northern, desert regions of Chad receive very little rainfall all year round. The southern, tropical savannah regions of Chad experience a wet season between May and October (receiving 150 - 300mm per month), whilst the central sub-tropical regions have a shorter wet season between June and September (receiving 50-150 mm per month). In the dry months between November and March, almost no rain falls at all. These seasonal rainfalls are controlled by the movement of the tropical rain belt (also known as the Inter-Tropical Conversion Zone, ITCZ) which oscillates between the northern and

[92] https://www.ifad.org/en/web/operations/project/id/1100001691
[93] https://www.ifad.org/en/web/operations/project/id/1100001691
[94] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[95] https://www.ifad.org/en/web/operations/project/id/1100001691

southern tropics over the course of a year. Variations in the latitudinal movements of the ITCZ from one year to another cause large inter-annual and decadal variability in wet-season rainfall. (UNDP, 2015b)[96]

140. Annually, mean temperatures are similar across most of the country at 25-30°C, and only differ substantially in the cooler mountainous regions of the north at 15-25°C. However, seasonal variations are large, and differ in their patterns for different parts of the country. In the north and central regions, summer and winter temperatures are distinct at 27- 35°C in summer and 20-27°C in winter (these temperatures are 5-10°C lower, year-round, in the northernmost mountainous regions). In the south, less seasonal variation is evident, but the summer months (JAS) are the coolest (22-25°C) due to the cooling effects of rain at this time of year. (UNDP, 2015b)[97]

141. The distribution of rainfall and plant cover makes it possible to subdivide the territory into three major agro-climatic zones: Saharan zone, Sahelian zone and Sudanian zone. Their different characteristics are described below. (RdC, 2010)[98]

- The Saharan zone occupies more than half of the national territory and is characterized by a very low rainfall (200 mm/year in the South). The vegetation consists of wadis, plains and outcrop areas of the water table while the soils are mostly poorly evolved. The fauna is dominated by the family of antelopes such as the dammah gazelle, dorcas gazelle, leptocere gazelle, addax and oryx.
- The Sahelian zone is very arid (between the 200 and 800 mm) with ferruginous tropical sandy soils and poor in organic matter. The vegetation is characterized by shrub savannahs occupying the southern part along with Acacias and Balanites, with herbaceous carpet composed of Andropogoneas. The vegetation of the northern part consists of steppe (or pseudo-steppe), which are characterized by very open woody formations, with a grass carpet dominated by Aristids. The fauna of the Sahelian zone is abundant and varied.
- The Sudanian zone is the tropical region (from the 800 mm to 1200 mm) and the vegetation is made up of open forests and tree savannahs. The soils are tropical ferruginous, rich in organic matter, with an abundant and varied fauna.

[96] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[97] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[98] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf

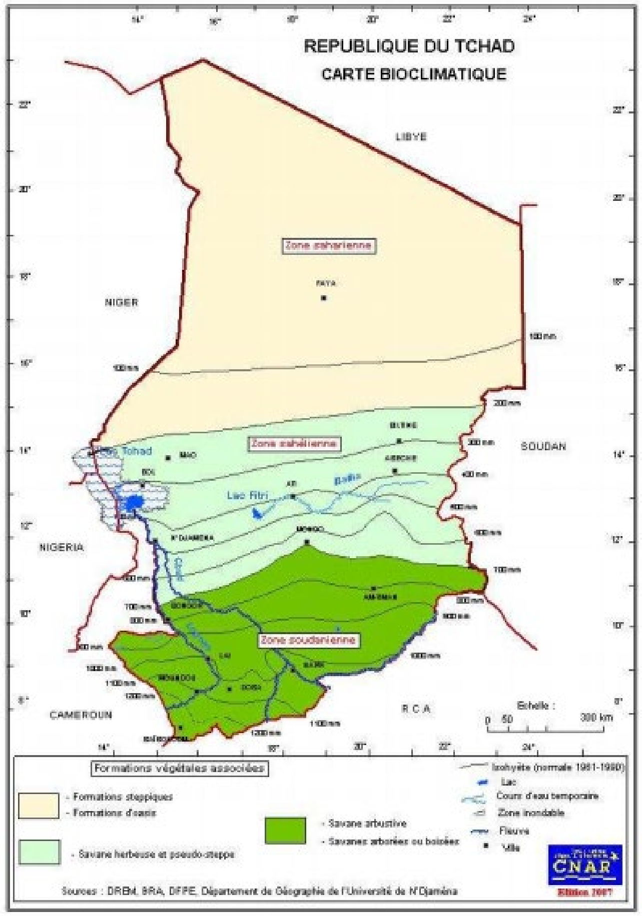


**Figure 5.2.1.2: Agro-climatic zones in Chad (RdC, 2010)[99]**

### 5.2.1.3 Agriculture and rural livelihoods

142. The contribution of agriculture to GDP, which was 21% in the early 2000s, fell to 8.7% in 2007. The agricultural sector employs more than 1.8 million people, or 65% 3 of the country's labor force, more than half of whom are women. These constitute the backbone of the rural economy. They combine agricultural work and tasks but have relatively limited access to resources such as land, housing, or financial services. Public support services tend to mainly to men and employ mostly male staff. (FIDA, 2014)[100]

143. Of a total of 39 million hectares (ha) of arable land, or 30% of only 3 million ha (7.7%) are planted annually. The cereals constitute the basis of the diet, but the levels of production are low and strongly dependent on variable climatic conditions, particularly in the Saharan Sahel. Yields for dry cereals do not exceed 1 tonne per hectare. The yields of other food crops, groundnuts, sesame, beans, cassava are also low. The production system is extensive, unproductive and based on subsistence agriculture practiced on small traditional family farms with an area of 2 to 5 ha. (FIDA, 2014)[101]

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[99] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[100] https://www.ifad.org/en/web/operations/project/id/1100001691
[101] https://www.ifad.org/en/web/operations/project/id/1100001691

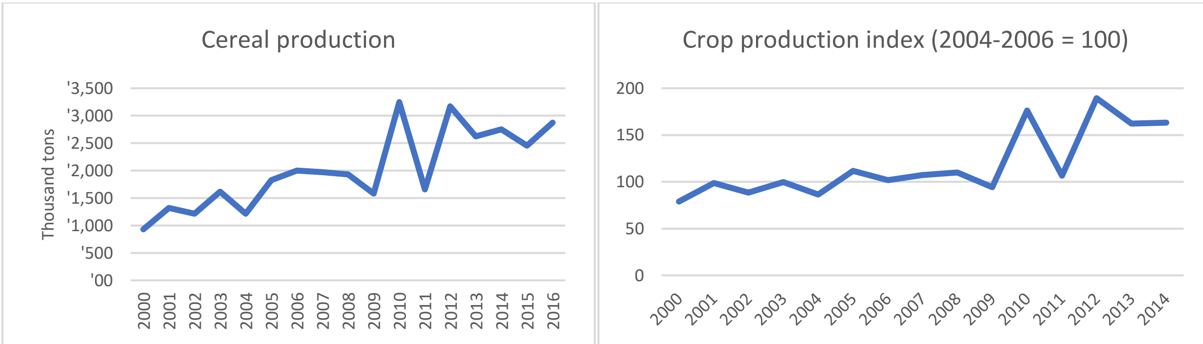



**Figure 5.2.1.3: Total cereal production and crop production index Chad (World Bank, 2018a)[102]**

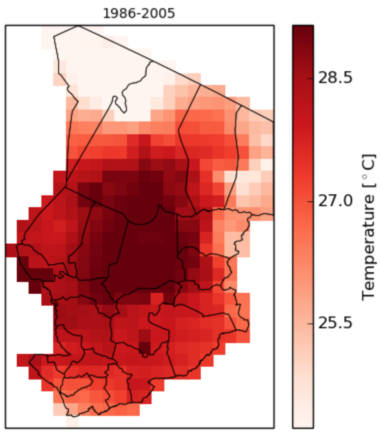
### 5.2.2 Climate change

#### 5.2.2.1 Temperature

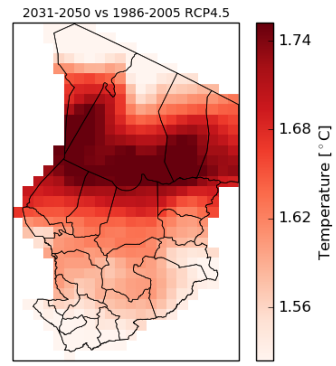
144. Mean annual temperature has increased by 0.7°C since 1960, an average rate of 0.16°C per decade. The rate of increase is most rapid in the wettest season, JAS, at 0.36°C per decade, but there is no evidence of a warming trend in the driest season, JFM. There is insufficient daily observed data to identify trends in daily temperature extremes for all seasons, but the average number of 'hot' nights per year in Chad has increased by 50 (an additional 13.6% of days1) between 1960 and 2003. Cold nights are observed to decrease in all seasons where data are available (JFM, AMJ, and OND). The average number of 'cold' nights per month in these seasons has decreased by 3.6-4.6 (11.6-14.9% of days) between 1960 and 2003. (UNDP, 2015b)[103]

145. The following graphics on temperature in Chad are based on a Climate Analytics Tool (i.e. http://regioclim.climateanalytics.org/choices) that analyses climate projections on the national scale[104]. For the reference period map on temperature indicators, hotter regions are darker than cooler regions whereas for the projection map, changes towards warmer or drier conditions are colored in red.

[102] https://data.worldbank.org/
[103] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[104] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.2.2.1a: Temperature average over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[105].**

*Projections on temperature*

146. The mean annual temperature is projected to increase by 1.0 to 3.4°C by the 2060s, and 1.6 to 5.4°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5-2°C. The projected rate of warming is similar in all seasons and regions of Chad. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annually, projections indicate that 'hot' days will occur on 17-36% of days by the 2060s, and 21-54% of days by the 2090s. Days considered 'hot' by current climate standards for their season are projected to increase most rapidly in JAS, occurring on 35-84% of days of the season by the 2090s. Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 26-49% of nights by the 2060s and 31-63% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in JAS, occurring on 48-95% of nights in every season by the 2090s. Projected increases in hot days and nights are more rapid in the south of the country than the north. All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate, and in much of the country, do not occur at all by the 2090s. (UNDP, 2015b)[106]

147. The following graphics projecting temperatures in Chad are based on a Climate Analytics Tool that analyses climate projections on the national scale[107].

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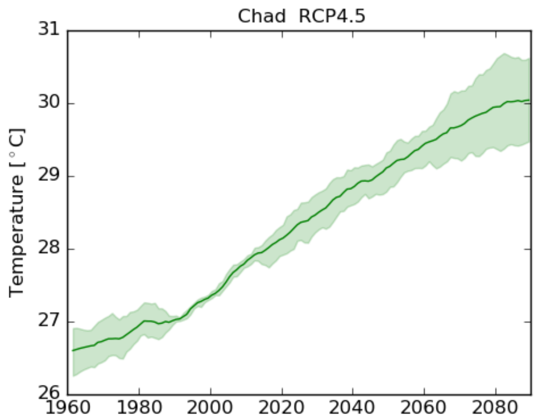
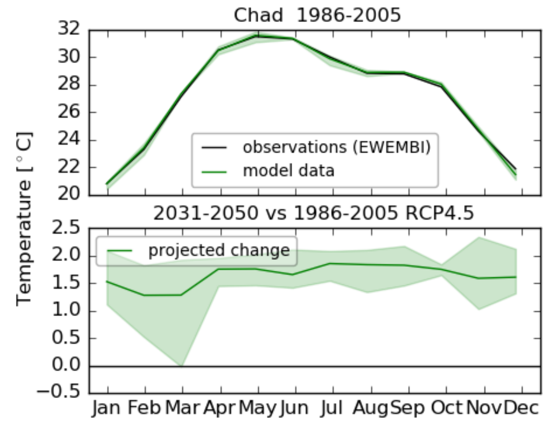
[105] Chad Climate Analytics tool

[106] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[107] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5

**Figure 5.2.2.1b: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[108]**

### 5.2.2.2 Precipitation

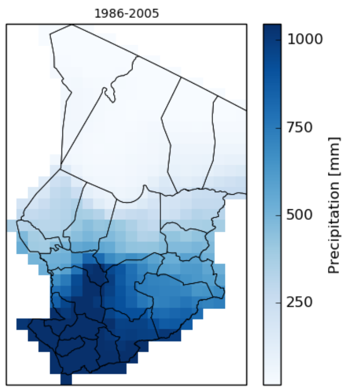
148. Mean annual rainfall over Chad has not changed with any discernible trend since 1960. Some unusually high rainfalls have occurred in the dry season in the very recent years (2000-2006), but this has not been a consistent trend. There is not sufficient daily precipitation data available to determine trends in the daily variability of rainfall. (UNDP, 2015b)[109]

149. The following graphics on precipitation in Chad are based on a Climate Analytics Tool that analyses climate projections on the national scale[110]. For precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.

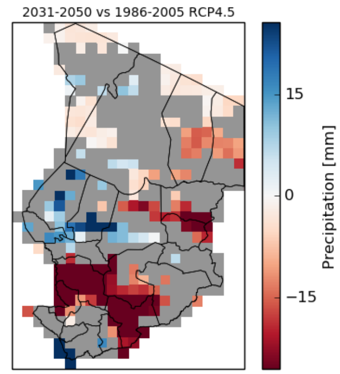
[27] Chad Climate Analytics tool

[109] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[110] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.2.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[111].**

*Projections on precipitation*

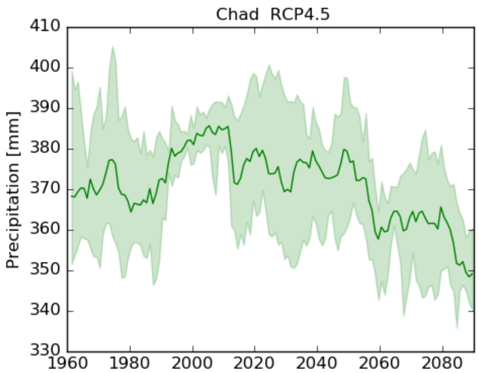
150. Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of changes in precipitation for Chad. Projected change ranges from -15 to +9mm per month (-28 to +29%) by the 2090s, with ensemble means close to zero. Whilst the range of projections across the model ensemble is large, the regional changes in rainfall more consistently indicate increases in wet-season (JAS) rainfall in the south of the country. The relative (%) changes in rainfall in the dry regions and seasons are exaggerated because of the very small rainfall totals that changes are presented as a proportion thereof (i.e. a 400% increase in JFM rainfall is equivalent to only an additional 5mm). The proportion of total rainfall that falls in heavy2 events is projected to increase in the south of the country, but to decrease in the north. Projections indicate that maximum 1- and 5-day rainfalls may increase in magnitude in the south of the country. (UNDP, 2015b)[112]

151. The following graphics projecting precipitation in Chad are based on a Climate Analytics Tool that analyses climate projections on the national scale[113].

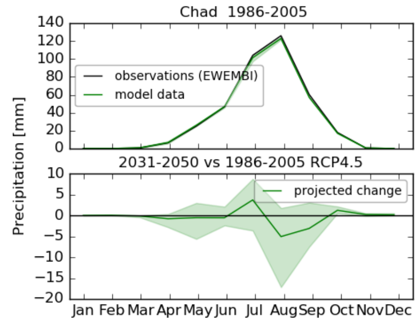
[28] Chad Climate Analytics tool

[112] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[113] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.2.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[114]**

#### 5.2.2.3 Climate change impacts, climatic hazards and extreme events

152. The synthesis of the current and future climate vulnerability of Chad shows that the sectors which constitute the basis of its economy are all subject to climatic hazards. The demonstrations of variability and climate change through the adverse effects of climate phenomena extremes constitute a great handicap for the development of the country. Indeed, the fragility of its ecosystems makes the country very vulnerable to these phenomena and the difficult socio-economic context weakens adaptability. (RdC, 2010)[115]

153. The main extreme weather phenomena in Chad are droughts, floods, sand and / or dust storms, extreme temperatures, high winds and other phenomena no less important related such as locust attacks, bushfires. The Third Assessment Report of the IPCC, states that it is expected that climate change more important in the developing countries to which Chad belongs, loss of life, effects on investments and effects on the economy. (RdC, 2010)[116]

154. The primary sector, the bedrock of the economy of the country occupies nearly 80% of the Chadian population has suffered the negative effects of drought years 70 and 80. The rural sector, it should be remembered, by its preponderant place in the economy contributes GDP (40%) with its significant development potential. The contribution of the sector rural, 1998 to GDP, through its sub-sectors is distributed as follows: food crops (20.2%), industrial crops (3.7%), livestock (11.6%), and forestry (2.8%). Given the magnitude of the changes climate change and especially its adverse effects, adaptation measures are needed to ensure sustainable development of the country. (RdC, 2010)[117]

[29] Chad Climate Analytics tool
[115] https://unfccc.int/resource/docs/napa/tcd01.pdf
[116] https://unfccc.int/resource/docs/napa/tcd01.pdf
[117] https://unfccc.int/resource/docs/napa/tcd01.pdf

*Projections on climate impacts*

155. Based on projections, the observed climate impacts in Chad are going to be reinforced and additional climate impacts are expected. Chad's economy will face reduced access to water resources as the level of rainfall decreases. Reductions in soil cover vegetation leads to higher surface water runoff rates and hence a higher occurrence of floods. In addition to the impacts of water scarcity on food production, greater food uncertainty needs to be expected due to changes in atmospheric conditions. The increase in temperature and changes in precipitation will lead to exacerbated desertification and cause an irreversible loss of biodiversity. Finally, an increase in cases of water-borne and vector-borne diseases attributable to changing climate zones is projected through the country. (RdC, 2010)[118]

### 5.2.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

156. According to the 2016 Climate Change Vulnerability Index Chad was the most vulnerable country to climate change. The country faces recurring extreme weather conditions such as droughts and floods, while lacking sufficient institutional and community capacities to adapt and mitigate consequences. In 2019, severe flooding has affected multiple provinces in Chad, with a major impact in the North and East. The size of Lake Chad, on which 30 million people depend to survive, has decreased from 25,000 km$^2$ in 1963 to a tenth of its size, due to severely depleted rainfall or rain failure linked to climate change, as well as through human water use and activities. (UNOCHA, 2019)[119] Besides, the unfavorable geographical situation due to its geographical position as a sub-Saharan country, with a territory to more than half (63%) desert, is subject to a dry tropical climate sensitive to the slightest modification of the climate.

157. After discovering oil in 2003, the country experienced an average annual growth rate exceeding 7 per cent between 2004 and 2014. However, this has not translated into a reduction of inequalities, as the Gini index, which measures income inequality, increased from 0.49 to 0.51. From 2016, Chad faced a severe economic crisis related to the global fall in oil prices and poor investments (UNOCHA, 2019)[120]. Combined, the country bases its national economy on agriculture and livestock, both sectors highly dependent on the climatic conditions that have become increasingly unstable. Indeed, for the Sudanian zone, the first five sectors considered to be the most vulnerable are water resources, agriculture, livestock farming, fishing and the forest. In the Sahelian zone, the same sectors come back and in almost the same order except that the craft comes fourth before fishing. On the other hand, in the Saharan zone, the pattern is quite different. It is rather the breeding which takes the head, followed of agriculture and commerce. From the above, it can be inferred that the people the most vulnerable people are to climate change are mainly farmers, ranchers and fishermen. (RdC, 2012)[121]

158. Austerity measures adopted by the Government since late 2016 to address the situation led to rising social tensions, with civil servants' strikes disrupting the functioning of basic social services, including school closures, and growing impoverishment of Chadian society. As a result, social indicators continued to deteriorate, with a negative impact on health, education, food security and nutrition. The chronic vulnerability of the population, further exacerbated by this situation, results in significant humanitarian need. (UNOCHA, 2019)[122]

[118] https://unfccc.int/resource/docs/napa/tcd01.pdf
[119] https://www.humanitarianresponse.info/en/operations/chad/document/chad-country-profile-september-2019
[120] https://www.humanitarianresponse.info/en/operations/chad/document/chad-country-profile-september-2019
[121] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[122] https://www.humanitarianresponse.info/en/operations/chad/document/chad-country-profile-september-2019

#### 5.2.3.1 Climate change impacts on agriculture

159. Chadian agriculture as in many African countries is a shifting agriculture on clearing and burning. Each year, thousands of hectares of vegetation are cleared for cultures. With the high proportion of the rural population (about 80% of the total population), the lack of respect for fallow periods and the practice of bushfires, this agriculture favors strongly the process of desertification. Essentially rain-fed, Chadian agriculture is highly dependent on the rainfall unfortunately, it has not been stable in recent decades. Dry years, often accompanied by high temperatures, often large decreases in agricultural production due not only to the rainfall deficit but the late installation of rainy seasons or their early termination, which crops to normally finish their vegetative cycle. Likewise, excess rainfall reduces agricultural production. This was the case in 1988 and 1998 when many fields were abandoned following the floods. To that, added the attack of pests and diseases whose development is often caused by increased precipitation and high temperatures. It should be noted that climate change affects not only food crops but also rent. (RdC, 2012)[123]

160. Recent studies of CILSS / Agrhymet (Sarr et al., 2007[124], AGRHYMET, 2009[125]) have shown that crop yields such as millet / sorghum will drop by more than 10% in the case of temperature increases of + 2 ° C and insignificant variations in 2050. An increase of + 3 ° C will lead to a decrease in agricultural yields of the order of 15 to 25%. From the foregoing, we can expect a decrease in yield for both crops rainfed than irrigated. In the Sahelian zone between the 10th and 15th parallels north, the decrease in precipitation of 5 to 20% accompanied by an increase in temperature will result in net decrease in production which can be estimated at more than 50%. (RdC, 2012)[126]

161. This is the case for cotton, the main industrial culture of the country that is suffering the effects adverse effects of climate degradation. Indeed, the geographical area of the cotton plant which extended until the Sahelian zone has gradually narrowed to be limited to the Sudanian zone. This stalling of the geographical space of cotton is essentially the fact of the conditions even if the economic difficulties are not to be discarded. Studies have shown a minimum of 700 mm of rain is needed to allow the cotton plant to finish its cycle. However, there is now a decline of isohyets from north to south, which narrows the area of cultivation of this plant. (RdC, 2012)[127]'

162. The figure below presents IFAD CARD[128] for Chad to explore the effects of climate change on the yield of major crops.

[123] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[124] Sarr B. Traoré S. Salack S. 2007. Évaluation de l'incidence des changements climatiques sur les rendements des cultures céréalières en Afrique soudano-sahélienne. Centre Régional Agrhymet, CILSS, Niamey.
[125] http://portails.cilss.bf/IMG/pdf/specialChC.pdf
[126] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[127] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[128] Climate Adaptation in Rural Development – Assessment Tool https://www.ifad.org/en/web/knowledge/publication/asset/41085709

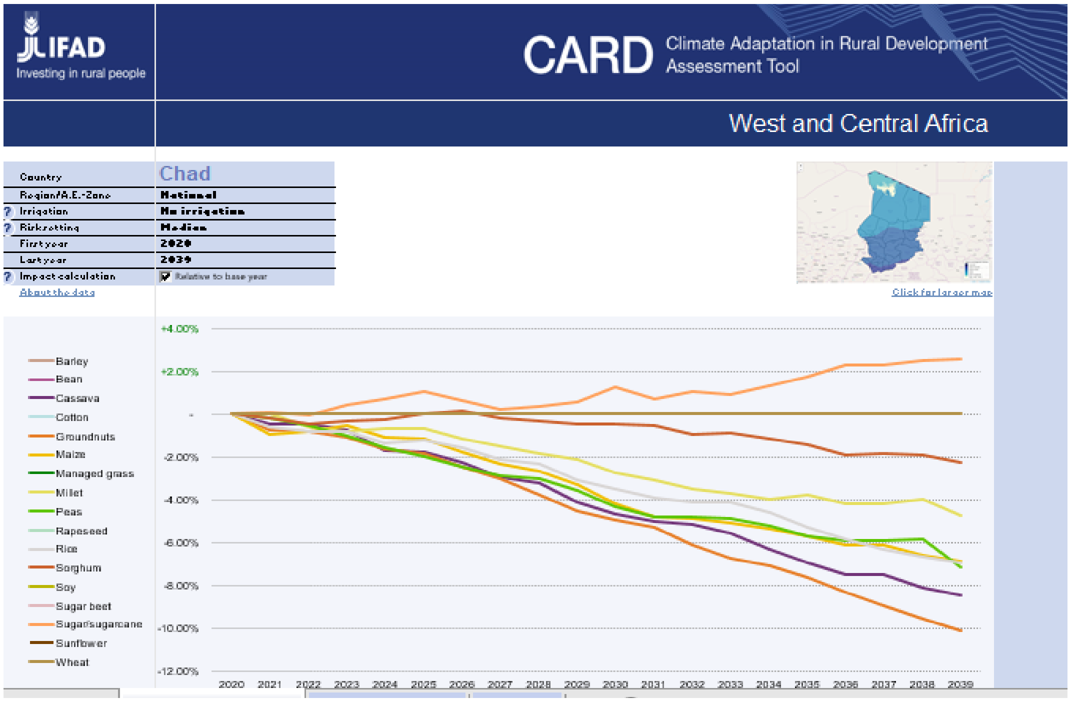



**Figure 5.2.3.1: CARD for Chad**

(Please refer to the "Climate change impacts on crop yield in specific targeted regions" document to see projections for each country region)

### 5.2.3.2 Climate change impacts on natural capital

163. The stress created by the overexploitation of the natural resources of Lake Chad are undermining the ability of the plant and animal populations to maintain their normal regenerative rate. Impacts include the loss of plant and animal species, as well as damages to ecosystem health. This is rooted in population growth, absence of sustainable development in political programs, and low environmental awareness. This reduces ecosystem productivity and thus resources availability, resulting in deepening poverty. It also contributes to the decreasing viability of biological resources. (UNDP, 2018b)[129]

164. There is an absence of appropriate and harmonized policies and plans between the Member States to regulate basin activities coupled by the insufficient awareness of the local population in the member states on environmental issues. This also contributes to biodiversity loss and increasing variability of hydrological regime and fresh water availability. (UNDP, 2018b)[130]

### 5.2.3.3 Climate change impacts on water

165. The Lake Chad Basin is one of the largest sedimentary closed groundwater basins in the whole of Africa. With its extensive pasture and arable land and rich fish stocks, it provides food and water to nearly 50 million people and supports unique ecosystems and biodiversity in Chad[131]. It is an important area both economically and environmentally for the riparian states of Chad, Nigeria, the Niger, Cameroon, the Central African Republic and Libya. Lake Chad and its tributaries form an important water reservoir in the central Sahel region. According to the United Nations Environment Programme (UNEP), half of the shrinkage of Lake Chad can be ascribed to the impact of climate change and climate

[129] http://www.adaptation-undp.org/explore/middle-africa/chad
[130] http://www.adaptation-undp.org/explore/middle-africa/chad
[131] Pham-Duc, B., Sylvestre, F., Papa, F. *et al.* The Lake Chad hydrology under current climate change. *Sci Rep* **10,** 5498 (2020). https://doi.org/10.1038/s41598-020-62417-w

variability. The other half is the result of the increased demand for water from Lake Chad's tributaries for irrigation and the needs of growing populations, particularly in Nigeria, Cameroon and Chad.

166. A study from the Federal Ministry for Economic Cooperation and Development (year) [132] analysed possible impacts of projected future climate change on ecosystems of the Lake Chad Basin under the B1, the A1b and the A2 scenarios. The A1 story line is marked by a very rapid economic growth, a global population that will peak in mid-century and decline thereafter and a rapid introduction of new and more efficient technologies.The A2 story line describes a regionally fragmented economic growth, where new technologies are introduced much slower and only locally. Population growth is continuously increasing. The B1 story line has a population growth similar as in A1, with a quicker change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies.

167. For the impacts of temperature on the Lake Chad under the B1 scenario, annual average temperatures will increase until the end of the century by an approximate 2 °C, plus/minus 0.5 °C depending on the climate zone. A significant difference in temperature increase between different scenarios does not occur before the end of the 2030ies. Latest at the beginning of 2040 in an A1b and an A2 scenario, temperatures will start increasing faster resulting in a total temperature increase of 3 °C (A1b) and 4 °C (A2) by 2099. The study indicated that future temperature increases over the next 100 years are expected to be considerably lower than the increases observed between 1974 and 2013. Temperature increase is highest in the arid (Figure 5.2.3.4a, top) and lowest in the dry sub-humid zone (Figure 5.2.3.4a, bottom). The high inter-annual temperature variation in the arid zone is related to inter-annual variations in cloud cover that are less pronounced in the semi-arid and dry sub-humid zone.

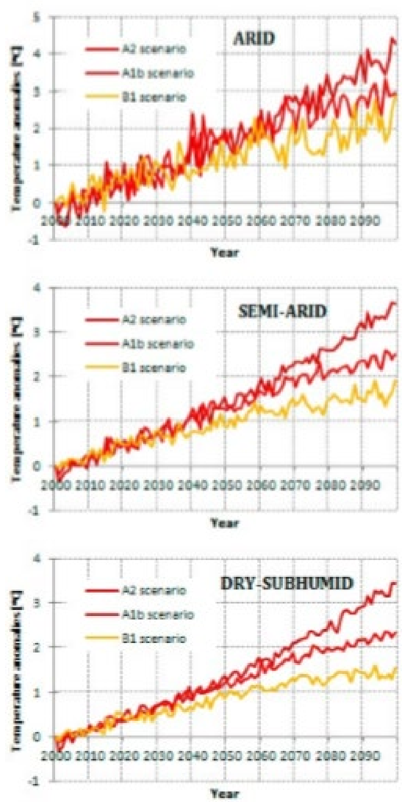


Figure 13: Temperature change between 2000 and 2099[14]

[132] https://www.giz.de/en/downloads/giz2015-en-climate-change-study-africa-supraregional.pdf

**Figure 5.2.3.4a: Temperature change between 2000 and 2099**[133]

168. Increasing temperature will lift water losses through evapotranspiration. A rough approximation for assessing the water loss to evapotranspiration in the study is as follows: Each 1 °C increase in temperature will increase evapotranspiration by about 0.4 mm per day. Assuming sufficient soil moisture will be available for about 120 days, the additional water loss amounts to 48 mm. However, the exact amount will further depend on variables such as vegetation cover, wind speed, air humidity and soils. The study also showed spatio-temporal analyses of temperature development over the next hundred years, with areas of highest temperature increase within the water productive basin are the eastern (area of Abeche) and the central Lake Chad Basin (see spring and fall panel in Figure 5.2.3.4b)

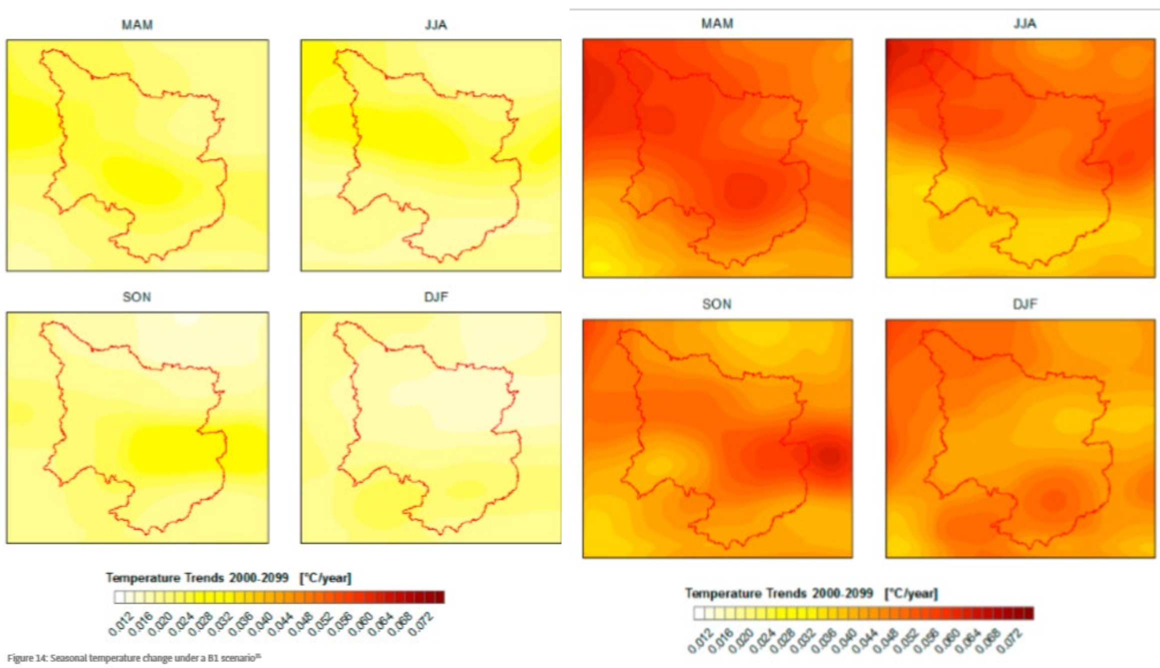



**Figure 5.2.3.4b: Seasonal temperature change under a B1 scenario (left)**[134] **and e under an A2 scenario (right)**[135]

169. In hydrological models, normally distributed rainfall in the headwaters may produce no run-off at all, because soils never saturate, which in response dramatically reduces river discharge. This may occur even if the annual total rainfall is higher than observed rainfall creating substantial run-off. Thus, temporal rainfall distribution and rainfall intensity play an important role in the partitioning of water between soil moisture and run-off (GERBAUX et al., 2009). Due to the models' weakness in the description of variability, caution is necessary in the interpretation of climate impacts on the

[133] According to different climate change scenarios and for different aridity zones: arid (top), semi-arid (middle) and dry sub-humid (bottom)

[134] According to CGSM data (CGCM3T47) from the Canadian Climate Change Scenarios Network (CCCSN). Note that color scale is not comparable with Figure 12 showing temperature changes between 1973 and 2013, due to large scale differences (~4°C/40years compared to ~2.4°C/100years).

[135] According to CGSM data (CGCM3T47) from the Canadian Climate Change Scenarios Network (CCCSN). Note, color scale is not comparable with Figure 14 showing temperature changes between 1973 and 2013, due to large scale differences (~4°C/40years compared to ~2.4°C/100years)

quantification of hydrological parameters including soil moisture, run-off, deeper infiltration and river discharge. Still, the total available water will be less.

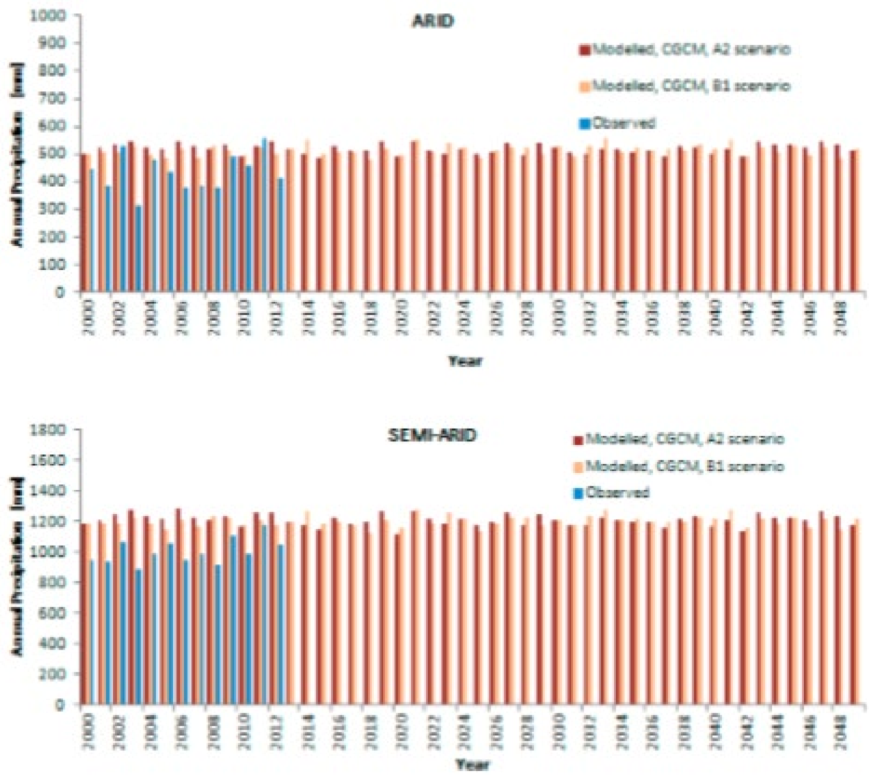



**Figure 5.2.3.4c: Annual total precipitation in the arid (top) and semi-arid (bottom) zone[136]**

170. The study also monitored the impact of projected climate change on agricultural potentials (IMPACT ASSESSMENT INC., 2006) of the Lake Chad. Based on a mean 120-day baseline line, constructed from Aridity Index (AI) values averaged over years 2000-2013, Until around 2030, there are no significant climate differences between the a B1 and an A2 scenarios. After 2030 temperatures, under an A2 scenario, are predicted to rise more quickly, while temperatures start tapering off at the beginning of 2060 under a B1 scenario. By the end of the century, the positioning of the 120-day line under a B1 scenario is predicted to show a significant southward shift indicating deteriorating conditions particularly in the central basin. The Eastern and the Western areas remain less affected. Considering surface effects only (temperature and precipitation), the displacement of the 120-day line from its current position means that an area of approximately 70,960 km$^2$ will no longer be useable for growing more water demanding crops, but only for crops such as sorghum and millet (see Table below).

[136] Discrepancies between observed and modeled precipitation amount to 100 mm (arid) and 200 mm (semi-arid). For both climate zones observed inter-annual rainfall variability is considerably higher than the modeled.

| Class | Length of growing period | Typical crops |
|---|---|---|
| Hyper-arid | 0 | No crop, no pasture |
| Arid | 1 – 59 | No crops, marginal pasture |
| Semi-arid | 60 – 119 | Bulrush millet, sorghum, sesame |
| Dry sub-humid | 120 – 179 | Maize, bean, groundnut, peas, barley, wheat, teff (suitable for rainfed agriculture) |

Table 2: Some typical crops under rainfed conditions (FAO, 2004)

171. The situation for the tree crops may be different as they are further controlled by groundwater and do not instantly respond to interannual rainfall variation. Generally, tree vegetation gradually increases to the south, e.g. as shown by continuously lower correlations between precipitation and biomass. The present situation of aquifers, including ground water levels/variations, flow and replenishment are still under investigation. A completion of this study will be a pre-condition for drawing meaningful conclusions on the impact of future climate change scenarios on groundwater.

172. Under an A2 scenario, an even larger area must be reclassified to a lower agricultural potential. Because of a retreat of the 120-day line, an area of about 135,150 km$^2$ will no longer fulfil the conditions for growing crops that are more valuable. A reduction of agricultural potentials of course does not only occur along the limits of the 120-day line but progressively causes an entire southward shift of potentials by a similar amount. An exact shift of the entire zone of variability (within which the 120-day line fluctuates) cannot be calculated from the GCM data, as models only poorly describe inter-annual rainfall variability. Although, current fluctuations of the 120-day line exceed the magnitude of retreat under both, a B1 and an A2 scenario, future fluctuations may even be larger and increase the risk for droughts.

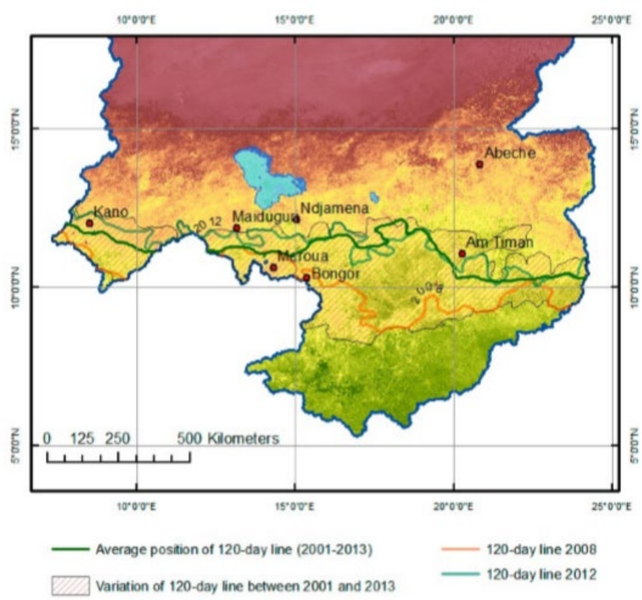



**Figure 5.2.3.4d: Average position of the 120-day line (green) between 2001 and 2013[137]**

[137] In 2012 (blue) we see a maximum in 2008 (red) a minimum extent of the 120-day line. The hatched area displays the range within which the 120-day line fluctuated between 2001 and 2013. The average 120-day line extends beyond the hatched area because small 120-day islands beyond this line were ignored for better visualization. The background

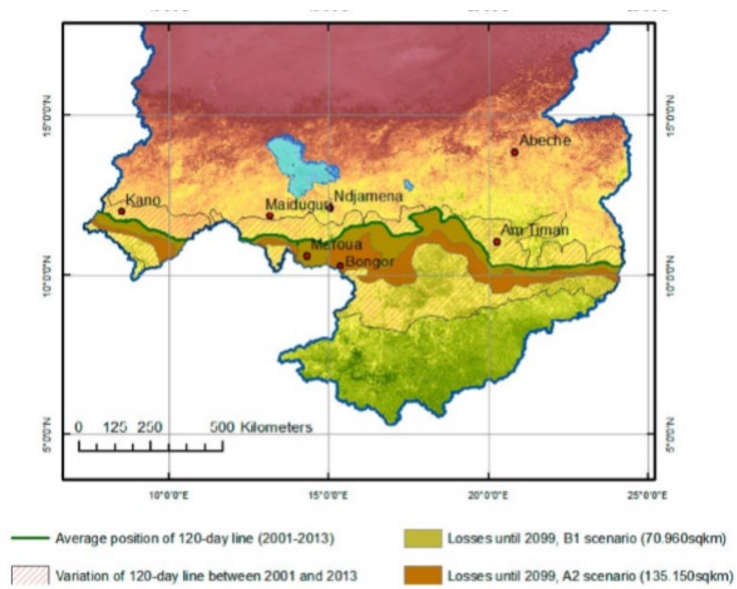



**Figure 5.2.3.4e: Retreat of the 120-day line under a B1 (yellow) and an A2 (red) scenario[138]**

173. A time-series in the study of more detailed maps for a B1 and an A2 scenario, with further sub-divisions for the length of the growing period visualizes spatially distributed effects of climate change on the Aridity Index. Impacts of climate change tend to become continuously larger – causing larger displacements of boundaries – as one moves south, towards longer growing periods. Classes 201-203 (growing days) and 231-260, approximately covering areas with tropical conditions, become increasingly fragmented or disappear (231-260 class). Climate conditions supporting the growth of tropical forests may no longer exist in these areas at the end of the century.

image shows biomass distribution with green indicating high biomass and brown bare soil (mean annual NDVI max 20002013 from MODIS)

[138] With reference to its current (green) position. The background image shows biomass distribution with green indicating high biomass and brown bare soil (mean annual NDVI max 20002013 from MODIS).

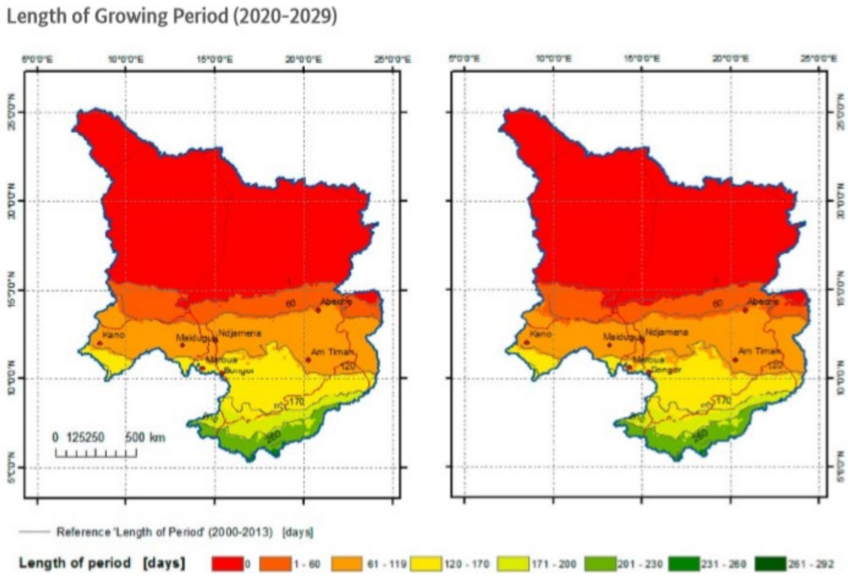



**Figure 5.2.3.4f: Average number of days an area exceeds dry sub-humid conditions in 2030-2039**[139]

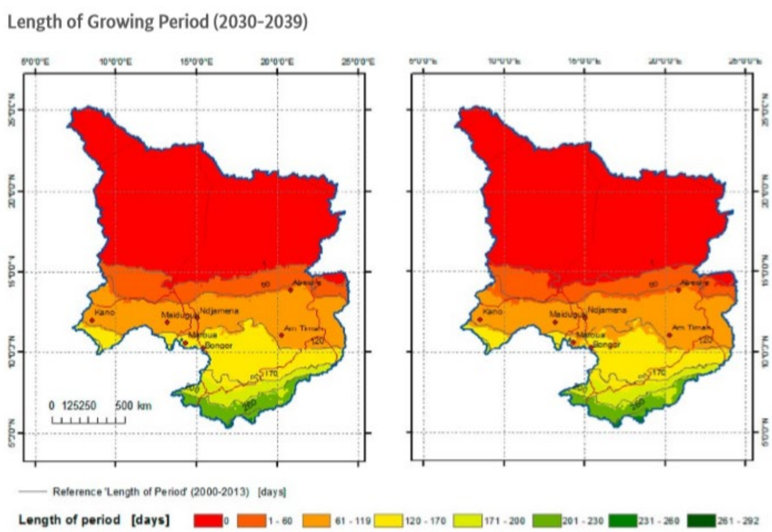



**Figure 5.2.3.4g: Average number of days an area exceeds dry sub-humid conditions in 2030-2039**[140]

174. In regards to the displacement of ecosystem boundaries, the study indicated that the strongest negative offsets are in the 120-day contour line between Maroua and Bongor including some additional areas east and west of these towns. Since the 120-day line, according to FAO definition, marks an important transition in crop suitability, these areas are likely to experience drastic changes in crop potential. They are best suited for interventions aiming at an introduction of alternative crops, more

[139] Under the assumption of a B1 scenario (left) and an A2 scenario (right)
[140] Under the assumption of a B1 scenario (left) and an A2 scenario (right)

drought resistant seeds or an adapted crop management. Parts of this area fall into the projected intervention zone of the GIZ project.

175. As discussed above, agricultural potentials in other areas will likewise be reduced with effects on productivity but less on crop potential/suitability. To better illustrate possible climate change impacts on vegetation covers, additional growing periods were identified that best describe boundaries separating distinct vegetation phenologies as classified from biomass time-series (NDVI), Figure 5.2.3.4h and Figure 5.2.3.4i. A perfect match between the distribution of vegetation phenologies and growing period contours was not found, since the parameter ‘growing period’ only depends on precipitation and PET neglecting other relevant parameters including soils, topography, additional water resources, etc. Growing periods that best describe the transition between the interpreted phenology classes are the 20-, 60-, 120- and 170-day periods. These contours were applied to visualize the projected displacement of vegetation phenologies or ‘ecosystems’ under a B1 (Figure 5.2.3.4h) and an A2 scenario (Figure 5.2.3.4i).

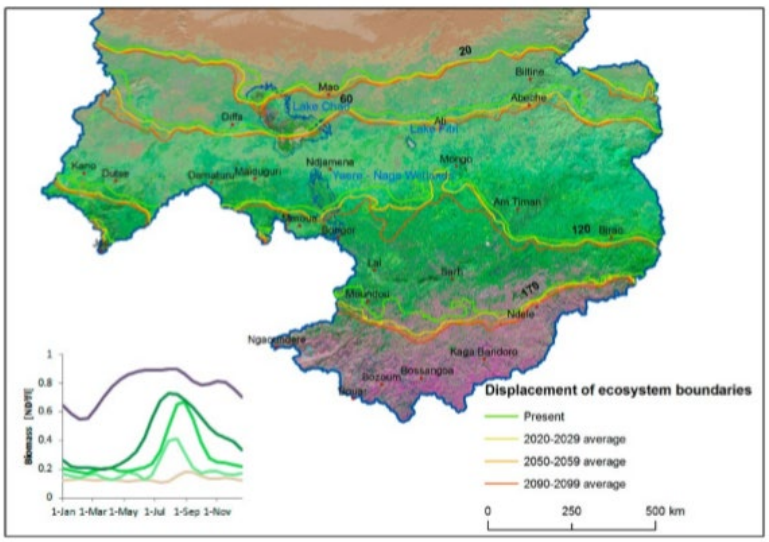



**Figure 5.2.3.4h: Shift of vegetation (ecological) boundaries - B1 scenario**[141]

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[141] Under the assumption of a B1 scenario for different phenological (ecological) classes as shown in the diagram. Growing periods that best describe selected phenology boundaries were identified as 20-, 60-, 120- and 170-day periods.

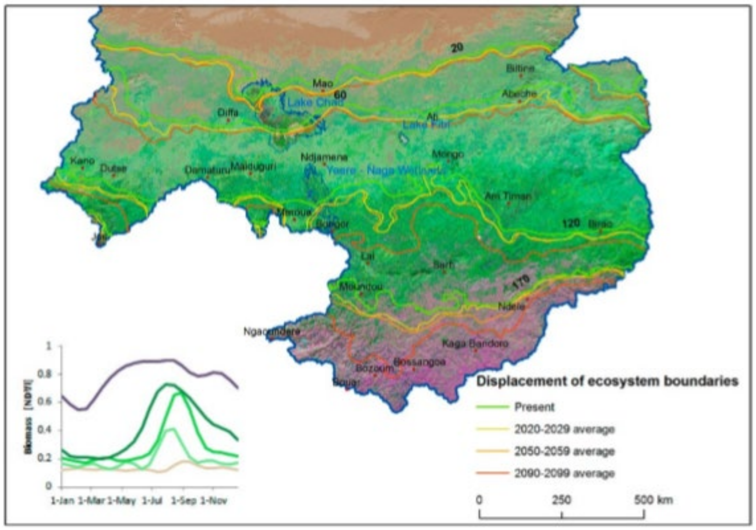


**Figure 5.2.3.4h: Shift of vegetation (ecological) boundaries – A2 scenario**[142]

#### 5.2.3.4 Climate change impacts on health

176. Admittedly, there are few reliable statistical studies linking defined pathologies to variations extreme climatic conditions. However, some studies indicate that warming significant increase in some pathologies, including outbreaks of cholera, infectious diseases, vector-borne diseases such as malaria, meningitis, as well as respiratory and cardiovascular diseases. (RdC, 2012)[143]

177. Taking into account IPCC statements on the increase of frequencies and intensities of extreme weather events (floods, drought, heat wave, sandstorm ...) reported above and considering the alternation of flood episodes and drought During the last decades, we can expect the recrudescence of certain pathologies such as that cholera, malaria and other water-borne diseases if the level of hygiene of populations did not improve. The projection of temperature variations at 2030, 2050 and 2100 lead to cardiovascular disease especially in the most vulnerable people (old men, young children and pregnant women). Increased temperatures and expected rainfall decrease in the Sahelian zone increase the risk of an epidemic of cerebrospinal meningitis and will lead to the modification of the spatial distribution of certain infectious disease vectors. There will be an increase number of deaths, illnesses and accidents due to heat waves, floods, storms, bush fires and droughts. This situation may be aggravated by disruption of sanitation, rainwater drainage and wastewater in urban centers that will be increasingly populated. Heat waves are going to make a lot of victims as was the case in 1998. (RdC, 2012)[144]

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[142] Under the assumption of an A2 scenario for different phenological (ecological). Growing periods that best describe selected phenology boundaries were identified as 20-, 60¬, 120- and 170-day period

[143] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf

[144] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf

Health services are under additional pressure when they have to respond to increased demand due to climate-related natural disasters, such as flooding. The last floods in Mayo Kebbi and Moyen Chari in 2008, by for example, destroyed homes that led to the exposure of poor people (women, children and the elderly) to bad weather conditions of accommodation of fortune. The residential areas (schools, churches, mosques, etc.) where promiscuity prevailed the dignity of people who no longer had their personal belongings. The number of patients increased significantly, health centers could not provide the services victims needed. This can cause patients to be satisfied with self-treatment which is not safe for health. (RdC, 2012)[145]

### 5.2.4 Vulnerability ranking and Mapping

178. Although production methods and lifestyles in the Sahel's vulnerable zone remains mostly very traditional, the overall environment has greatly changed over the past 30 years. The climate has become drier and the average isohyets have moved 100-150 km further south. Also, West Africa's population has grown very rapidly, from less than 130 million to nearly 300 million between 1975 and 2005. The number of cities of over 100,000 people has risen from 30 to 135 and the network of main roads has expanded more than five-fold. (OECD, 2006)[146]

179. The Sahel's vulnerable zone is now home to 8 million people — about 3% of West Africa's population — and has very few significant urban centres. Its increasing links with big urban settlement areas mean that the old Sahel lifestyles are now up against markets whose fluctuations can magnify the effect of nature's uncertainties such as locusts and lack of rainfall. This is what happened during the 2005 dry season, especially in southern Niger, whose inhabitants are heavily influenced by northern Nigeria. But this proximity to large urban centres also provides part of the rural population with opportunities and income, especially through seasonal migration to towns and to commercial agriculture areas. The connection of the Sahel with West African markets is now a reality that neither prevention nor management strategies of food shortages nor long-term development policies can ignore. (OECD, 2006)[147]

[145] https://unfccc.int/sites/default/files/resource/tcdnc2.pdf
[146] https://www.oecd.org/swac/publications/38409502.pdf
[147] https://www.oecd.org/swac/publications/38409502.pdf

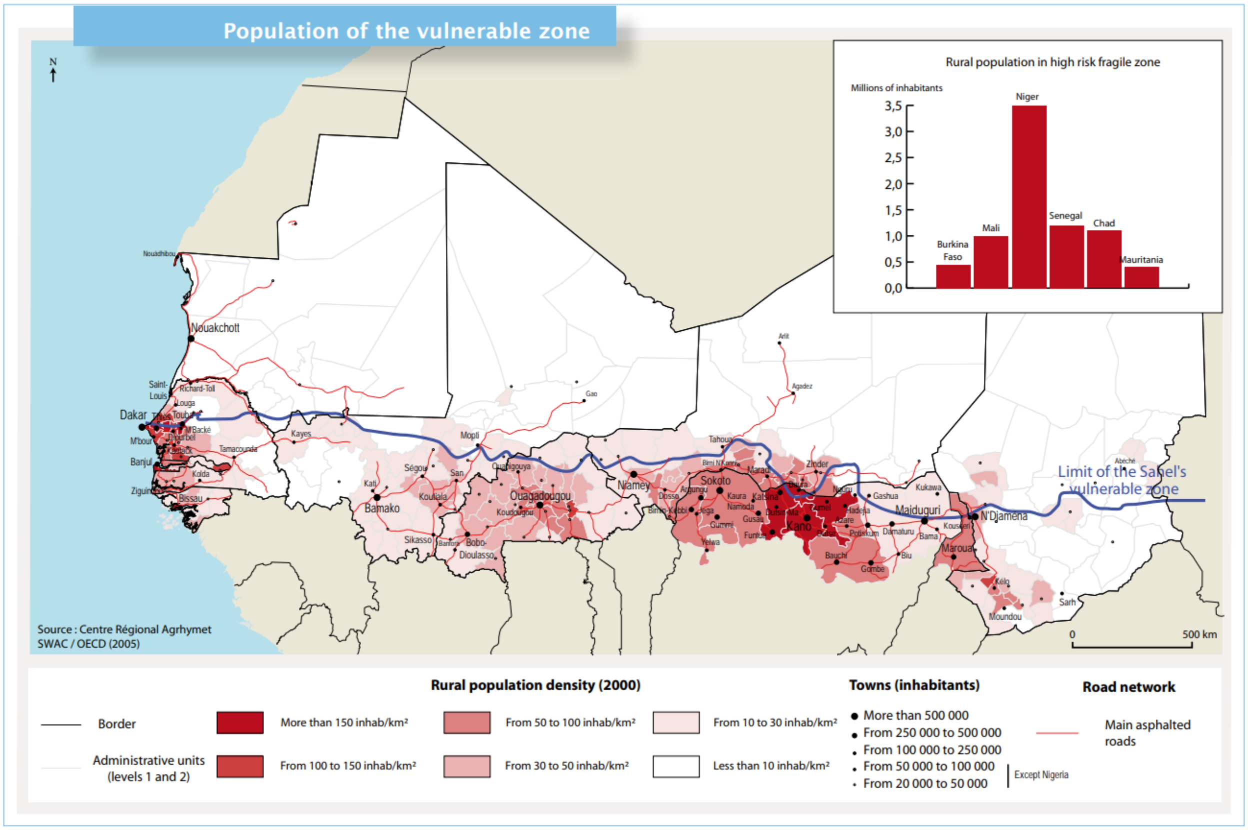


**Figure 5.2.4: Population in the vulnerable zone of the Sahel area (OECD, 2006)**[148]

[148] https://www.oecd.org/swac/publications/38409502.pdf

### 5.2.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| **Water** | Improved use of surface water for agriculture and livestock | To better use surface water resources to reduce climate vulnerabilities and improve food security among rural populations. This will be done through the development of irrigation infrastructure, reforestation programs and more |
| **Health** | Quality of and access to health care | Equipping the health centers and making them accessible geographically and financially to the entire population is a necessity. |
| | Increase preparedness | Early warning of epidemics associated with variability and climatic changes |
| | Capacity building | Promote endogenous knowledge and know-how in health matters human; |
| **Agriculture** | Irrigation systems | The irrigation system and off-season crops (berebere and vegetables) are one of the possible responses to climate variability and change. The recent increase in irrigated area deserves to be encouraged. Berber culture and other off-season crops need to be developed by increasing yield through the use of inputs. This approach will reduce the vulnerability of populations subject to the effects of droughts or floods one year out of three. For the mastery and the rational management of water, the drip irrigation system should be used especially in horticulture and sugar cane. In addition to this, other options below need to be advocated. |
| | Diversification and intensification | To reduce the negative effects of climate change and climate variability on the agricultural sector through the intensification and diversification of crops. |
| | Improving and disseminating climate-sensitive planting schedules | Contribute to better agricultural decision-making and improved yields through the dissemination of climate-sensitized planting calendars and support for better planning capacity among farmers. |
| | Soil rehabilitation for the development of agricultural activities | To improve soil fertility and agricultural yields and to prevent further soil degradation linked with the anthropogenic and climatic factors. |
| | Improving inter-community pasture zones | To improve the availability of pasture and fodder for livestock in order to reduce migratory pressures among pastoralists, promote new livelihoods and to improve their capacity to adapt to climate change. |
| | Livestock Food Bank | To establish and stock eleven national food banks for livestock to ensure animal health and improve livestock productivity. |
| | The use of processed organic matter (Compost, Manure) | The integration of agriculture and livestock farming, the merits of which are known and vaunted, requires recovery of crop residues and manure from manure and compost. Compost and manure are advanced organic materials that, when used correctly give very appreciable returns. A high rate of widespread adoption of these technologies could significantly increase agricultural productions. |
| **Climate information** | Improve forecasting capacity | To improve seasonal rainfall forecasting and models, and improve knowledge for vulnerability reduction strategies. |

| | | |
|---|---|---|
| | National Center for Climate Change Observation | To establish a national center for climate change observation |
| | Reduce climate change vulnerability | To contribute to the national strategy for climate risk management, through climate observation and modeling, analysis, policy integration and awareness-raising. |

**Table 5.2.5: Adaptation options by sector (Crawford, Hove, & Parry, 2011; RdC, 2012).[149]**

180. Improving land quality and living standards of the rural population in Chad requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of land degradation hotspots in Chad from the Land Degradation Neutrality (LDN) report to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country. The programme will focus on extremely high and high risks' hotspot locations such as Sahelian regions of Kanem, Lac Tchad and Sena Oura (Figure 5.2.5). The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

181. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Chad, the national LDN that stop land degradation as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Chad.

[149] https://www.cakex.org/documents/review-current-and-planned-adaptation-action-middle-africa; https://unfccc.int/sites/default/files/resource/tcdnc2.pdf

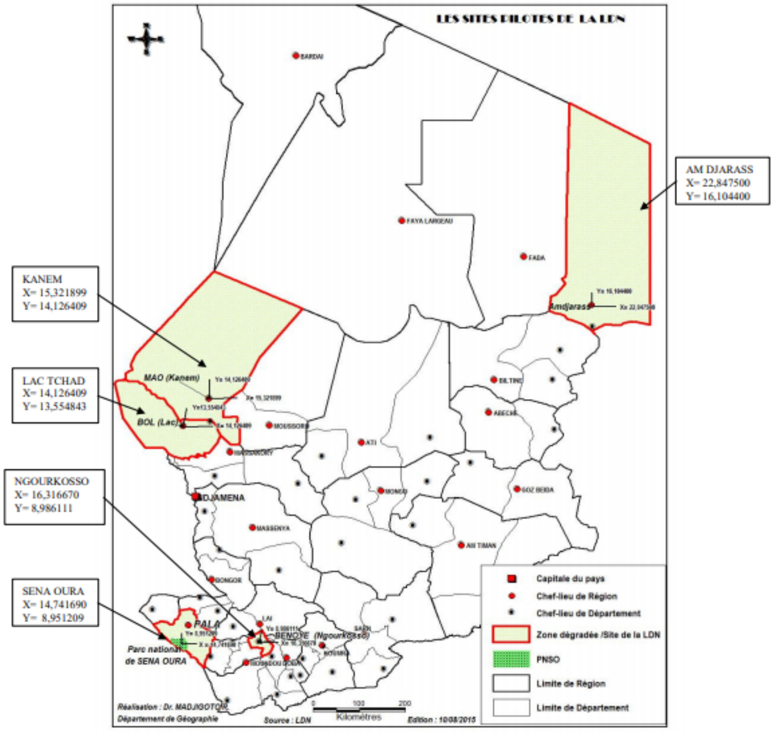


**Figure 5.2.5: LDN hot spots selected in the LDN target**[150]

[150] https://knowledge.unccd.int/sites/default/files/inline-files/chad-ldn-country-report.pdf

### 5.3 Mali

#### 5.3.1 Country Background: Development Context and Challenges

182. Mali is a landlocked country in the heart of West Africa. It has about 13.5 million inhabitants most of whom live in rural areas, with a growth rate of around 3% per year. The country shares more than 7,000 km borders with seven neighboring countries, namely Senegal and Guinea-Conakry in the west, the Mauritania in the North-West, Algeria in the North, Niger and Burkina Faso in the East, and Côte-d'Ivoire in the South. In the process of decentralization, the State is progressively transferring certain responsibilities of land management to these government structures. (RdM, 2011)[151]

183. Despite deteriorating security, economic performance is strong, with robust growth. Robust performance in the agriculture and services sectors led to a projected growth rate of 5.8% in 2016 (down from 6.0% in 2015) despite volatile security conditions. Primary sector growth fell from 7.6% to 4.8% between 2016 and 2017, due to decreased rainfall, while tertiary sector growth has been robust (around 6% since 2014) following renewed dynamism in the ICT sector. On the demand side, investment has grown sharply by 8%, partly as a result of the increase in private investments for the first time since 2012, and partly as a result of the Government's efforts to reduce infrastructure gaps. (World Bank, 2018c)[152]

##### 5.3.1.1 Income and poverty

184. With immense security and developmental challenges, Mali is one of the poorest countries in the world. Mali has a population of nearly 16.5 million (2015), Gross Domestic Product (GDP) of roughly $12 billion (2014) and GDP per-capita of $1,700 (2014). With just over 50% of the population living in extreme poverty on less than $1.25/day and a life expectancy of 55 years, Mali ranks 176 out of 187 according to the 2014 United Nation's (UN) Human Development Index. Historically, Malians have faced numerous obstacles such as lack of education and economic opportunities, chronic malnutrition and food insecurity, an inadequate health care system, endemic corruption and weak institutions, and recurring insecurity due to conflict. In the post-coup era, Mali has formed a new government and has received increased focus and support from the international community. This presents an opportunity for Malians to confront these challenges and to forge a new future. (USAID, 2014b) [153]

##### 5.3.1.2 Temperature, rainfall, seasons and agro-climate zones

185. Mali has two seasons: a dry season that lasts nine months in the north (October to June) at six months in the south (from November to April) and a wet season that lasts three months in the north and six months in the south. (RdM, 2011)[154]

186. Mali has four climatic zones that also correspond to four main ecological zones with a fairly diversified agricultural potential plus the Inner Niger Delta, namely: a Saharan (desert) climate in the North (annual rainfall <200 mm), Sahelian in the center (annual rainfall between 200 mm and 600 mm), Sudanese (annual rainfall between 600 mm and 1000 mm) and Sudano-Guinean in the south (rainfall> 1000 mm). Mali is therefore located in one of the hottest regions in the world due to the combined effects of reduced and erratic rainfall and a difficult bioclimatic context. The maximum temperature under shelter is between 34° C and 37 ° C and the minimum is between 21° C and 23 ° C. Mali experiences two seasons, which are the dry season that varies from nine months in the North (October

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151 https://unfccc.int/resource/docs/natc/mlinc2.pdf
152 http://www.worldbank.org/en/country/mali/overview
153 https://www.usaid.gov/sites/default/files/documents/1860/Mali_CDCS_2015-2020.pdf
154 https://unfccc.int/resource/docs/natc/mlinc2.pdf

to June) to six months in the South (November to April) and the wet season from May to October in the South and from July to September in North. (MOA, 2007)[155]

187. 51% of the national territory corresponds to the Saharan zone, with a surface area 632,000 km$^2$. It is located in the northern part of Mali. Then, there is the Sahelian zone, which covers an area of 285,000 km$^2$ and corresponds to 23% of the territory. It comprises two sub-zones which are: the Sahelo Saharan zone in the North and the Sudanese Sahelo zone in the South. The Sudanese zone is the one that is the most watered in Mali and corresponds to a significant agricultural potential. The Sudanese zone is also increasingly a refuge area and an area of transhumant herding and breeding. In the far south of the country, there is the Sudano-Guinean zone, which covers only 75,000 km$^2$ and corresponds to only 6% of the territory. It is generally relatively little exploited because it used to be classified as an onchocerciasis endemic area. The rainy season of the Sudano-Guinean zone is spread over a period of six months and varies from 800 mm to more than 1000 mm per year. The Inner Niger Delta and the lake region constitute a specific ecological entity as a humid region straddling the Sudanian and Sahelian zones. It extends over more than 30,000 to 35,000 km$^2$ and is extended by a strip along the Niger River where communities cultivate recession crops. (MOA, 2007)[156]

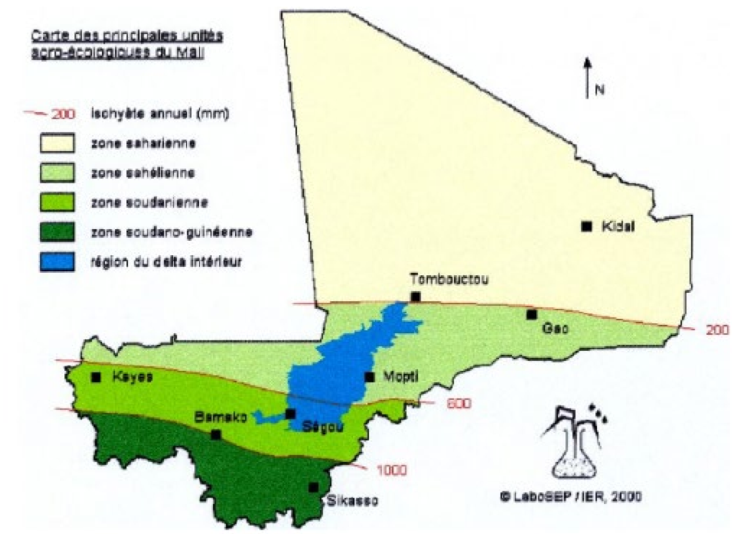



**Figure 5.3.1.2: Map of main agro-ecological zones in Mali (MOA, 2007)[157]**

188. The topography of Mali ranges from desert sand plains in the north to the great alluvial plain of Inner Niger Delta. In the north, the topography is characterized by the predominance of plateaus and sandy plains. The north-east is characterized by an extension of sandstone massifs of the Sahara central. The valleys of the massif open to the Tamesna Plain to the east, to the Telemsi Trough to the west, to the western basin of the Azaouak valley to the south, and Tanezrouft to the north. The center of the country is dominated by a vast alluvial plain, namely, the inner delta of the Niger River. In the Goundam area, the dunes and small rocky hills meet the plains of the delta where the lakes have formed. A second category includes plains stretching across the eastern delta between the northern loop of Niger and the Dogon plateau, in the south, it is known as Gourma. At this level, we can observe

[155] https://unfccc.int/resource/docs/napa/cpv01.pdf
[156] https://unfccc.int/resource/docs/napa/cpv01.pdf
[157] https://unfccc.int/resource/docs/napa/cpv01.pdf

fixed and isolated dune chains emerging from rocky plains or sandy. Incomes and poverty. (RdM, 2011)[158]

#### 5.3.1.3 Agriculture and rural livelihoods

189. Agriculture in Mali is crucial to ensure economic stability and food security. The agriculture sector employs about 75 percent of the country's population and accounts for approximately 50 percent of Mali's gross domestic product. Due to the predominance of rain-fed agriculture in the country, it is highly vulnerable to anticipated droughts, reduced precipitation, and increases in temperature. (USAID, 2012)[159]

190. The country's adverse climatic conditions, along with its political and institutional instability, threaten key sectors of agriculture and health. Mali consists of two main regions (North and South), each with different conditions for agricultural production. The North is the region most challenged by drought, desertification and population migration. Mali's population sustains itself on small-scale, rainfed subsistence agriculture and pastoralism. The agricultural sector is characterized by a predominance of cotton as a cash crop, while rice and coarse grains (maize, millet and sorghum) constitute the main food crops. Cereals represent more than two-thirds of the country's dietary energy supply. Mali is a net exporter of cotton and livestock and a net importer of rice. The main constraints in the agriculture sector are the lack of innovative technologies, irrigation, and private storage and infrastructure, combined with food price volatility. (FAO, 2017a)[160]

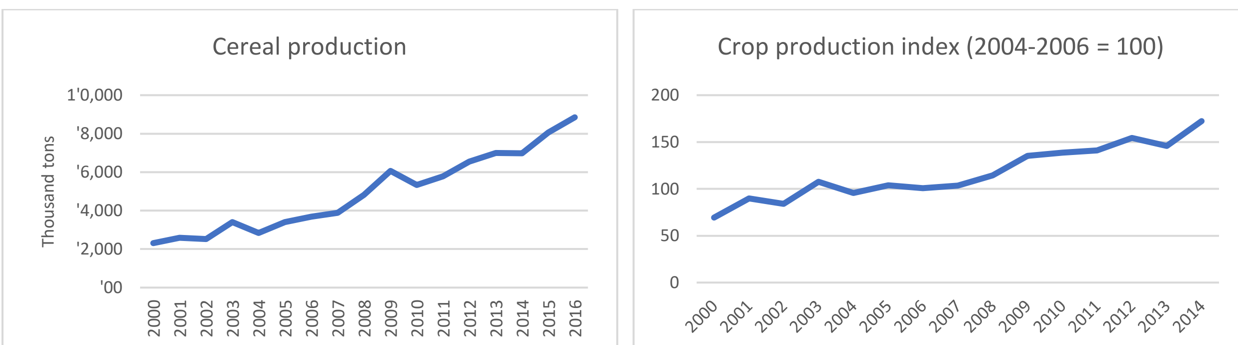



**Figure 5.3.1.3: Total cereal production and crop production index Mali (World Bank, 2018a)[161]**

### 5.3.2 Climate change

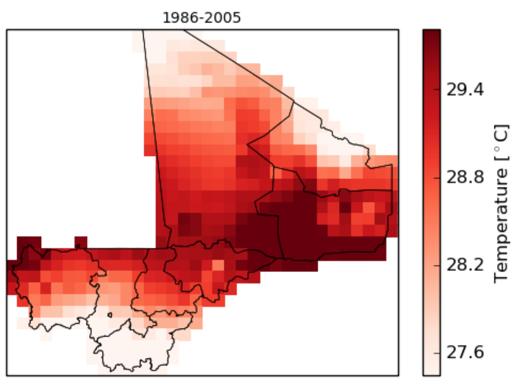
#### 5.3.2.1 Temperature

191. Mean annual temperature has increased by 0.7°C since 1960, an average rate of 0.15°C per decade. The rate of increase is most rapid in the hot, dry season, AMJ, at 0.25°C per decade, but there is no evidence of a warming trend in the driest season, JFM. Despite the observed increases in mean temperature, the frequency of days that are classed as 'hot' has not increased significantly in most seasons. The frequency of nights that are classed as 'hot' has increased significantly in all seasons except winter, DJF. The average number of 'hot' nights per year increased by 55 (an additional 14.9% of nights) between 1960 and 2003. The rate of increase is seen most strongly in JJA when the average number of hot JJA nights has increased by 5.7 nights per month (an additional 18.7% of JJA nights)

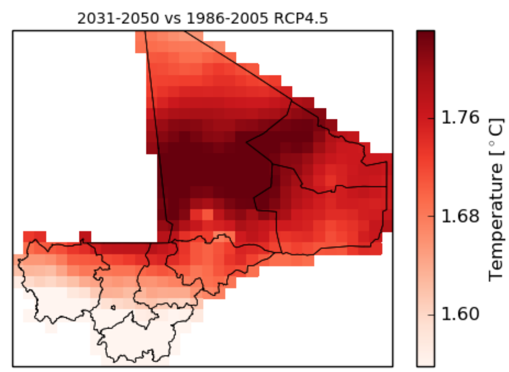
[158] https://unfccc.int/resource/docs/natc/mlinc2.pdf
[159] https://www.climatelinks.org/sites/default/files/asset/document/mali_adaptation_fact_sheet_jan2012.pdf
[160] http://www.fao.org/3/a-i7617e.pdf
[161] https://data.worldbank.org/

over this period. The frequency of 'cold' days has decreased significantly only in summer (JJA). The frequency of cold nights has decreased significantly in all seasons except winter (DJF). The average number of 'cold' nights per year has decreased by 31 (8.6% of days). This rate of decrease is most rapid in MAM when the average number of cold MAM nights has decreased by 3.0 nights per month (9.7% of MAM nights) over this period. (UNDP, 2015e)[162]

192. The following graphics on temperature in Mali are based on a Climate Analytics Tool that analyses climate projections on the national scale[163]. For the reference period map on temperature indicators, hotter regions are darker than cooler regions whereas for the projection map, changes towards warmer or drier conditions are colored in red.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.3.2.1a: Temperature average over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[164].**

*Projections on temperature*

193. The mean annual temperature is projected to increase by 1.2 to 3.6°C by the 2060s, and 1.8 to 5.9°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5-2.5°C. The projected rate of warming is similar in all seasons and regions of Mali. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annually, projections indicate that 'hot' days will occur on 18-38% of days by the 2060s, and 22-54%

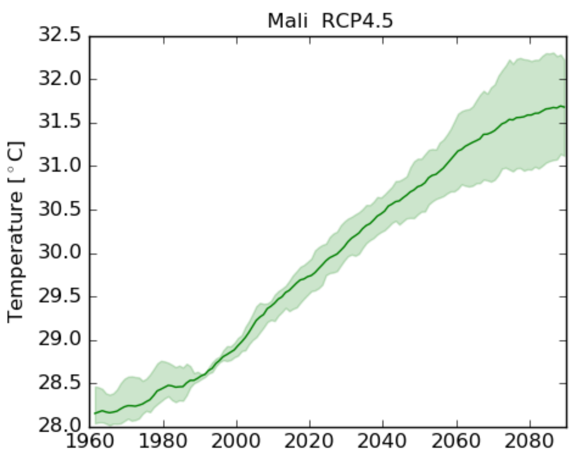
[162] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[163] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

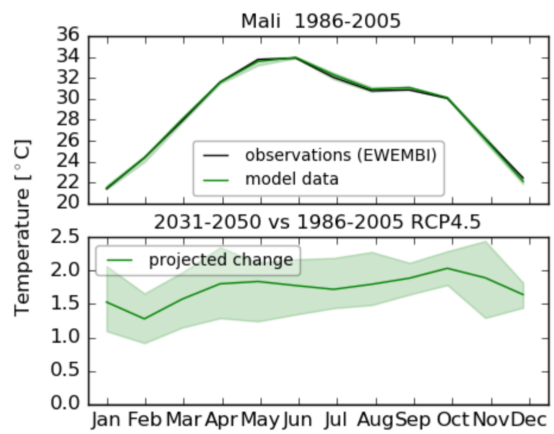
[164] Mali Climate Analytics tool

of days by the 2090s. Days considered ‘hot’ by current climate standards for their season are may increase most rapidly in JAS, but the range between model projections is large, occurring on 30-91% of days of the season by the 2090s. Nights that are considered ‘hot’ for the annual climate of 1970-99 are projected to occur on 23-40% of nights by the 2060s and 27-54% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in JAS, occurring on 47-95% of nights in every season by the 2090s. Projected increases in hot days and nights are more rapid in the south of the country than the north. All projections indicate decreases in the frequency of days and nights that are considered ‘cold’ in current climate. Cold days occur on less than 5% of days by the 2090s, and cold nights less than 3% of nights. Cold days and nights do not occur at all by the 2090s time in some projections. (UNDP, 2015e)[165]

194. The following graphics projecting temperatures in Mali are based on a Climate Analytics Tool that analyses climate projections on the national scale[166].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.3.2.1b: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[167].**

[165] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

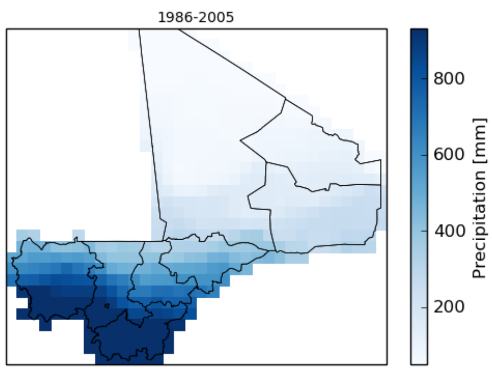
[166] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[167] Mali Climate Analytics tool

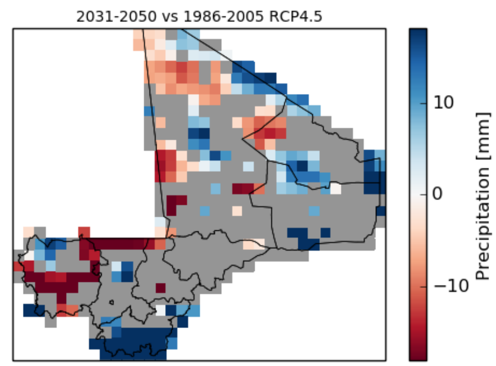
### 5.3.2.2 Precipitation

195. Sahelian rainfall is characterized by high variability on inter-annual and inter-decadal timescales, which can make long-term trends difficult to identify. A period of particularly high rainfall occurred in the early 1960s, whilst the early 80s were very dry, causing widespread dry in Mali and other Sahelian countries. Rainfall in Mali has recovered to some extent since the 80s, and the late 90s and early 00s have been relatively wet. Daily rainfall observations indicate statistically significant decreasing trends in 5-day rainfall maxima since 1960. Annual 5-day rainfall maxima have decreased by 4.0mm per decade since 1960. The largest decreases are seen in the wet season (JJA) of 4.9mm per decade. (UNDP, 2015e)[168]

196. The following graphics on precipitation in Mali are based on a Climate Analytics Tool that analyses climate projections on the national scale[169]. For precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

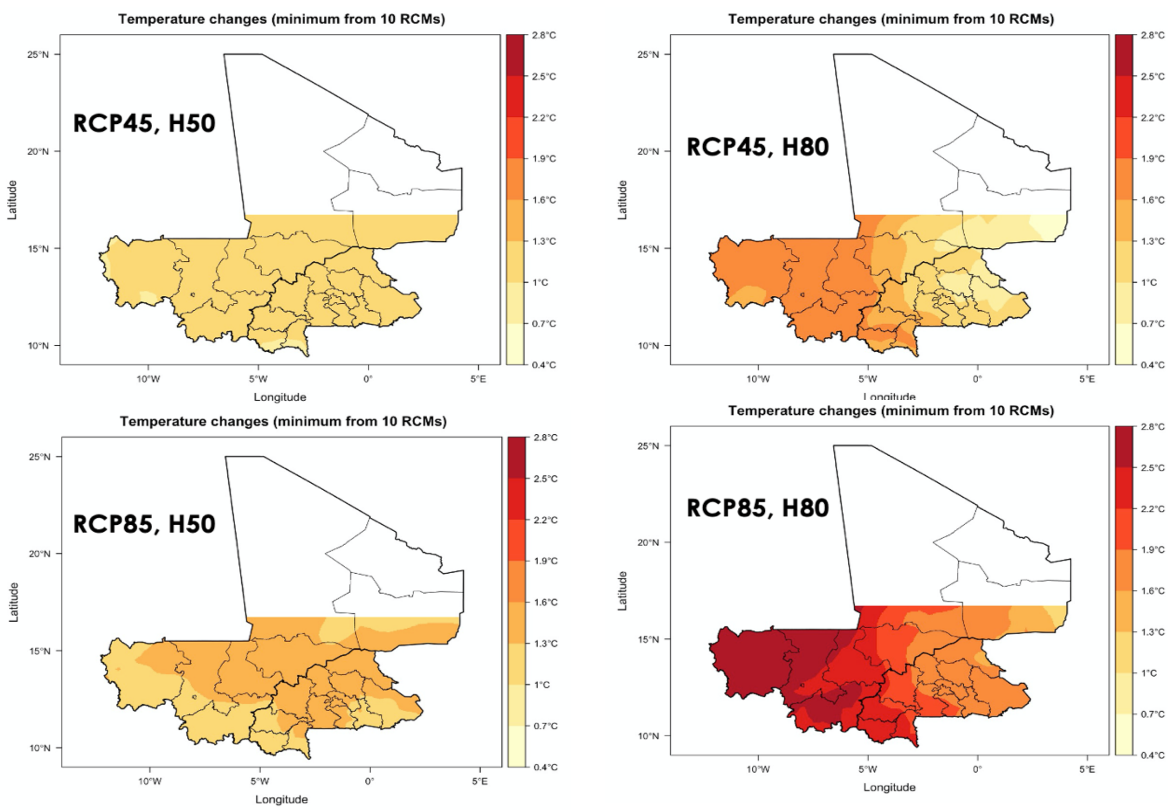
**Figure 5.3.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[170].**

[168] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[169] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[28] Mali Climate Analytics tool

**PROJECTION CLIMATIQUES (T moyenne)**



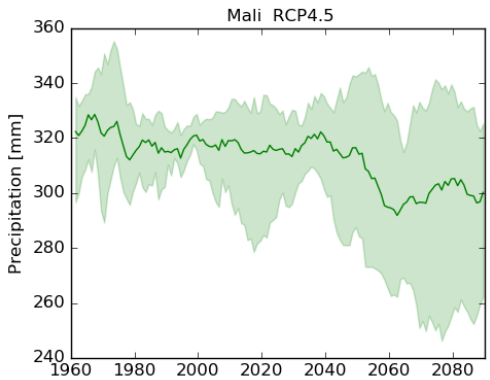

*Projections on precipitation*

197. Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of changes in precipitation for Mali but tend towards decreases. Projected change ranges from -22 to +25% by the 2090s, with ensemble means between 0 and -11%. Proportionally, decreases are largest in the north of Mali. The largest decreases in total rainfall, however, affect the south west corner of Mali in the wet season, JAS. The changes proportion of total rainfall that falls in heavy3 events range widely between increases and decreases. However, annually, these values tend to increase in the south of the country, but to decrease in the north. Decreases are largest in AMJ and increases are largest in OND. 1- and 5-day rainfall maxima in projections also tend towards slight increases in JAS and OND, and decreases in AMJ. The range of changes in projections from the model ensemble, is however, covers both increases and decreases in all seasons. (UNDP, 2015e)[171]

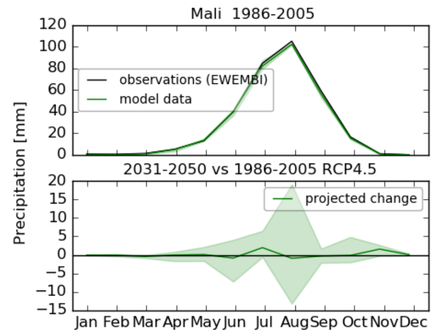
198. The following graphics projecting precipitation in Mali are based on a Climate Analytics that analyses climate projections on the national scale[172].

[171] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[172] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.3.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)** [173]

### 5.3.2.3 Climate change impacts, climatic hazards and extreme events

199. Mali is highly vulnerable to climate change and variability. Droughts, storms, strong winds, and increased temperature variability are the climate risks of greatest concern. The Malian government and international and national institutions and organizations began addressing climate-related challenges in the 1960s and have since conducted several vulnerability assessments, enhanced climate observations and modeling, and developed and implemented adaptation plans and capacity building efforts. However, adaptation needs remain, including the necessity of additional and more accessible research on climate change impacts and vulnerabilities at local community levels with particular focus on food security, water resources, and coastal resources. Additional funding for implementation of adaptation plans and strategies is also needed. (USAID, 2012)[174]

*Projections on climate impacts*

200. While the projections of changes in precipitation are unclear, certain impacts can be expected. Increasing temperatures will cause greater evapotranspiration, which will lead to drier soil conditions in many areas and coupled with an increase in demand means water availability is likely to decrease regardless of whether there is an increase or decrease in precipitation. The decrease in water availability may make conflict between agriculturalists and pastoralists more likely. Strengthening the

climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[28] Mali Climate Analytics tool

[174] https://www.climatelinks.org/sites/default/files/asset/document/mali_adaptation_fact_sheet_jan2012.pdf

synergies between agricultural and pastoral practices, for example through the traditional practice of allowing grazing for fodder on cultivated land, will help to avoid conflict. (weADAPT, 2016)[175]

201. Climate change is also expected to increase variability and the incidence of extreme weather events, such as droughts, floods and intense rainfall events, and without improved planning and management the incidence of disasters can be expected to increase. This may increase the frequency of floods in the country, which would destroy crops and property, increase erosion of already fragile soils, and require dams to cope with greater flows of water. Health is likely to be affected by increased maximum temperatures, an increase in diarrheal disease if floods become more frequent and possibly longer-term conditions related to mal-nutrition depending on the effect that climate change has on food security. (weADAPT, 2016)[176]

#### 5.3.2.4 Local dynamics in the global context: predictions for Africa

202. Africa is one of the continent's most vulnerable to climate variability and change with many multiple factors (climate and non-climate) and low capacity adaptation. In these CC processes, possible future impacts in Africa may be relevant to Mali are reported (IPCC, 1998). By 2020, 75 to 250 million people are expected to suffer from increased water stress by climate change. In some countries, the yield of rainfed agriculture could fall by 50% by 2020. It is anticipated that agricultural production and access to food will be severely affected in many countries, with serious consequences for food security and malnutrition. According to several climate scenarios, the area of arid and semi-arid lands could be increase by 5 to 8% by 2080. Mali has initiated numerous studies on vulnerability and adaptation in key sectors of development to better cope with the adverse effects of CC (CNRST, 1998, 2000, 2003). To improve the results of these sectoral vulnerability / adaptation studies Mali has built climate change scenarios that have produced climate data for future time horizons. (RdM, 2011)[177]

### 5.3.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

203. Mali is highly dependent on the primary sector, which employs 83% of the population, and comprises 50% of the GDP, and as such is particularly vulnerable to the impacts of climate change. Without adaptation measures there are likely to be adverse effects on agriculture associated with these changes in climate, although the extent of the effects varies greatly depending on different projections for precipitation. The costs of climate change have not been calculated for Mali, and it would be difficult to do so given the uncertainties in climate projections. The Stern Review, however, indicates that for developing countries the costs could be in excess of 10% of GDP with a warming of 5-6°C. It is also difficult to estimate the effects of climate change on the informal economy, which plays an important role in the livelihoods of many Malians, and there is a lack of information on the impacts on urban areas. What is clear, however, is that already vulnerable, poor rural groups will be particularly affected by the impacts of climate change and that climate change will need to be integrated in development planning in Mali if the ambitious growth plans set out by the government are to be met, in particular as the majority of this growth is based on natural resource exploitation. (weADAPT, 2016)[178]

#### 5.3.3.1 Climate change impacts on agriculture

204. There are several direct impacts of climate variability on agriculture. Mali's agriculture sector is experiencing a very variable and spread out beginning of the seasons with interruptions and premature

[175] https://www.weadapt.org/knowledge-base/national-adaptation-planning/mali
[176] https://www.weadapt.org/knowledge-base/national-adaptation-planning/mali
[177] https://unfccc.int/resource/docs/natc/mlinc2.pdf
[178] https://www.weadapt.org/knowledge-base/national-adaptation-planning/mali

ending. Variation in the normal start and end dates of the rainy season, resulting in a fluctuation in the length of the rainy season, which then translates into delays in the installation of the season as well as premature stop of the rains. Shifts in climate alter agriculture and feeding plant growth cycles with adverse influences on harvests, changes in distribution and area of arable land and large-scale deforestation. As a result, food insecurity is constituting a major constraint, which at the same time threatens livelihoods and worsens poverty. (RdM, 2011)[179]

205. Deficits in the water requirements of crops are variously felt from Sikasso to Mopti. In Sikasso and Kita, the effective rainfall is always greater than the evapotranspiration of crops. A poor distribution of the rain creating deficits by moment influences only very weakly the performance. In Ségou, the variation of the rainfall can from one year to another, to create yield decreases important. In Mopti where the rainfall can go down to 242 mm / year, the insufficiency and the bad rainfall distribution creates yield declines that can compromise the harvest. However, the results obtained are accounting for the available data. More accurate field data are often lacking (soil parameters, crop Kc values specific to each site). In these cases, we have chosen the default values proposed by FAO. (RdM, 2011)[180]

206. According to the DNSI, the area of cultivated land increased from 1,967,000 ha in 1970/71 to 3,472,000 ha in 1994/95, representing an increase of 15% in terms of clearing. This increase in area was not accompanied by an increase in yields of food crops that remained low, averaging 750 kg / ha all productions combined. Indeed, soils generally have several important constraints from an agronomic point of view which further limit the cultivable potential. The 3 to 3.5 million ha of land (PNAE, 1998) cultivated annually are marked by an average fertility level at weak, with deficiencies in phosphorus, potassium, sulfur and a high sensitivity to wind and / or water erosion. Average annual losses in arable land as a result of erosion is of the order of 6.5 tons / ha / year, ranging from 1 ton in the North to over 10 tons in the South (Bishop and Allen, 1989). Figures of 31 tons were recorded on the Sikasso in the Sudano-Guinean zone. (RdM, 2007)[181]

207. Agricultural pressure is also reflected in regions where population pressure is high by cultivating marginal and / or forest lands and reducing the duration fallows. To analyze Mali's future vulnerability to the adverse effects of the changes climate change in the sectors of water resources and agriculture, our choice fell five localities located in areas with high agricultural potential in terms of crops staple crops (which are mainly millet, sorghum, rice and maize) than like cotton. These localities are located in the Sudanese, Sudanese-Guinean areas and in the locality of the Inner Niger Delta. (Bougouni, Dioila, Sélingué (Yanfolila), Koutiala and Sikasso). Two of these localities are located in watersheds namely Sélingué in the watershed of Sankarani and Bougouni in that of Baoulé. The study showed that there would be enough water to meet the water needs of different specimens grown in the two basins, but this rainwater would be poorly distributed between the different months and the different localities. It would result for certain months and for some crops, a water deficit. (RdM, 2007)[182]

208. For all the localities concerned, a production deficit varying between 51 and 1518 tons of maize by 2025 would be found in relation to the conditions of the normal 1961-1990: i) a general decline in cotton yields between 2005 and 2025 will be observed. The production losses would be between 150 tons in 2005 and 3,500 tons in 2025 according to the localities; ii) a general decline in millet / sorghum yields between 2005 and 2025 would be observed. The production losses would be between 80 tons in 2005

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[179] https://unfccc.int/resource/docs/natc/mlinc2.pdf
[180] https://unfccc.int/resource/docs/natc/mlinc2.pdf
[181] https://unfccc.int/resource/docs/napa/mli01f.pdf
[182] https://unfccc.int/resource/docs/napa/mli01f.pdf

and 2524 tons in 2025 depending on the localities; iii) for river rice, a general decline in rice yields between 2005 and 2025 would be observed; iv) losses in millet / sorghum production would be between 150 tons in 2005 and 470 tons in 2025 depending on the localities. (RdM, 2007)[183]

209. The figure below presents IFAD CARD[184] for Mali to explore the effects of climate change on the yield of major crops.

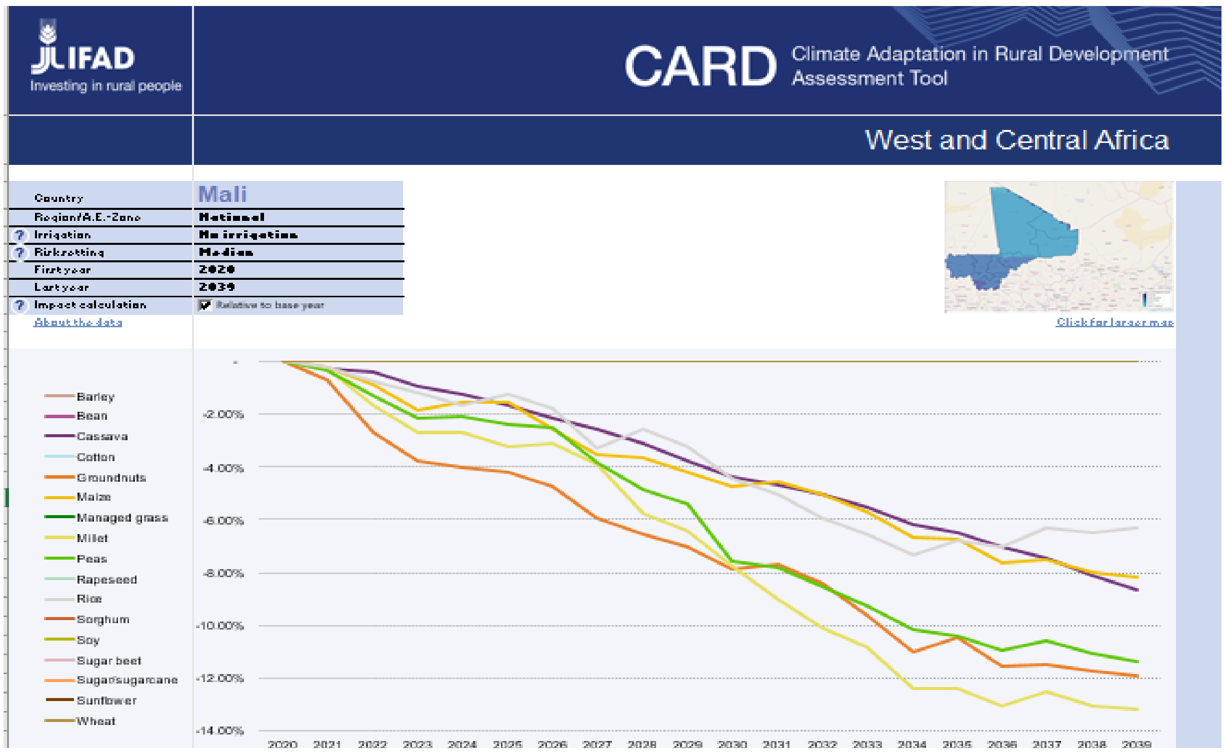


**Figure 5.3.3.1: CARD for Mali**

(Please refer to the “Climate change impacts on crop yield in specific targeted regions” document to see projections for each country region)

210. Climate projection data from 10 RCMs) based on the RCP4.5 and RCP8.5 scenarios were analyzed over two distinct time horizons H50 (2021-2050) and H80 (2051-2080).

211. The analysis of the overall average (10 RCMs) for the RCP45 and 8.5 scenarios reveals an average rainfall decrease of less than 10% for both countries. However, this overall average mask the divergence between the RCMs on future rainfall trends. For instance, greater decreases are observed in some RCMs while other RCMs project increases in rainfall. However, the increase in temperature is

[183] https://unfccc.int/resource/docs/napa/mli01f.pdf
[184] Climate Adaptation in Rural Development – Assessment Tool https://www.ifad.org/en/web/knowledge/publication/asset/41085709

a consensus for all RCMs. Thus, there is a projected increase of more than 1 degree C for all RCPs and for all time horizons.

#### 5.3.3.2 Climate change impacts on natural capital

212. Climate change has already contributed significantly to the desertification and degradation of forest resources. Reduced precipitation and longer and more severe droughts have altered forest lands and reduced biodiversity, and water scarcity has led to the degradation of trees, plants, and soil. Droughts and bush fires have turned forest areas into sandy, grassy dune, and dead wood areas and increased the frequency of brush fires that kill animals and worsen environmental degradation. (USAID, 2012)[185]

213. Mali's wealth of biological resources, rich and varied, is unfortunately under threat of disappearance. This loss of biodiversity is linked to a complex set of factors, of which the main ones are of a climatic order, in particular recurring and orderly droughts and anthropogenic pressures such as clearing, the uncontrolled exploitation of wood as a source energy, bush fires, over-harvesting of woody and herbaceous products greens, young shoots, tree mutilation, overgrazing, poaching, illegal fishing, mining, poverty, the misuse of chemicals, the introduction of exotic species, etc. (RdM, 2007)[186]

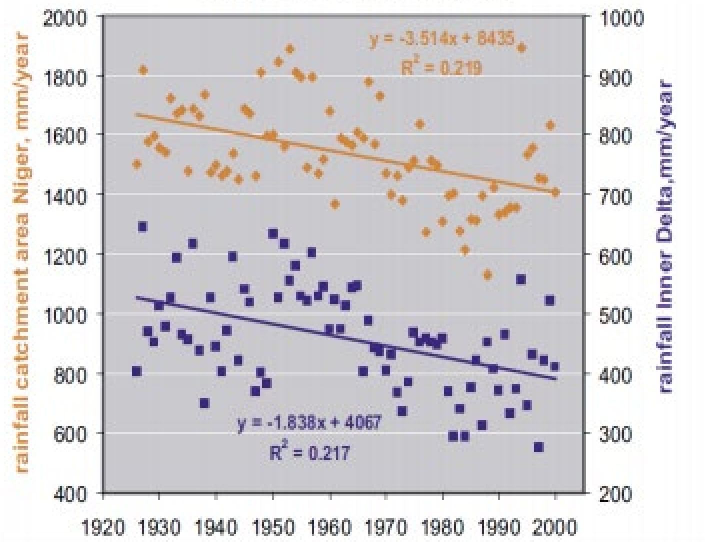
214. Frequent droughts, more than any other factor, have contributed to further weakening ecosystems, making them more vulnerable to the slightest disturbance and accelerating the rate of degradation of biological resources. The resulting water deficits, resulted in a reduction in primary production, a change in the structure of the vegetation cover and massive reduction of wildlife and livestock. The reduction of fallow has shortened the period required for regeneration processes and has increased fragmentation of the islands of natural vegetation that constitute the seeds ". By destroying herbaceous vegetation and reducing wood cover, fires degrade habitats essential to wildlife. Populations of reptiles, birds, amphibians, insects that depend on the micro-media of the herbaceous layer are reduced. The small animals like walking insects that cannot escape the fires. (RdM, 2007)[187]

#### 5.3.3.3 Climate change impacts on water

215. Rainfall trends in Mali show a consistent long-term decline over the past several decades. Figure 5 shows that both in the upper catchments (brown) and in the Inner Delta to the northeast (blue), rainfall has been consistently lower from 1920 onwards. Although this decline can be expressed as a steady decline, in reality there is considerable year-to-year variability and evidence of cyclical trends that resulted in significantly drier periods in the 1940s and in La Grand Secheresse of 1980 to 1995. Conversely, wetter periods, including the 1950s and 1970s when there were no droughts, may have led to optimistic assessments of rainfall and water resources.

[185] https://www.climatelinks.org/sites/default/files/asset/document/mali_adaptation_fact_sheet_jan2012.pdf
[186] https://unfccc.int/resource/docs/napa/mli01f.pdf
[187] https://unfccc.int/resource/docs/napa/mli01f.pdf

**FIGURE 5. LONG-TERM TRENDS IN RAINFALL IN UPPER CATCHMENT AREAS AND INNER DELTA IN MALI**




*Source: Zwarts et al., 2005*

216. Rainfall has declined significantly since about 1960, while temperatures have increased significantly during the same time period. The data have been broken down to show the degree of spatial variation, with greater decreases in rainfall in the western uplands, and greater increases in temperature in eastern and northern areas.

217. From a hydrologic perspective, higher temperatures increase the rate of evaporation from water bodies and the ground surface. They may increase transpiration, but under certain conditions higher temperatures may inhibit transpiration from temperature sensitive plants if temperatures exceed certain thresholds and plants wilt because the transpiration mechanisms shut down. One thing that is clear is that there continues to be considerable year-to-year variability with periods of below average rainfall that will have a direct impact on river and groundwater availability. Furthermore, not all parts of Mali are predicted to behave in the same fashion. Temperature increases are anticipated to be widespread, while rainfall may decrease in the wetter parts of the country and increase somewhat in the central zones[188]

218. Climate impacts on water resources are varied. A drop in groundwater levels as well as an increase in the coefficient of runoff for small ponds. Quantitative and qualitative reduction of water resources. Increasingly low water levels in rivers (early drying up of water points such as ponds, wells, etc.). Start and difficult end of the rainy season, pockets of drought (water deficit) during the rainy season, decreasing the length of the season (the number of days rainy) of agricultural production, rural exodus. Decrease in the number of rainy days and increase in rainfall intensity translating into floods in most cases. (RdM, 2011)[189]

219. Prolonged droughts and lack of rainfall have imposed limitations on water availability to communities throughout Mali. Estimates from a case study by N'Djim and Doumbia predict a 52 percent decline in per capita freshwater supplies by 2020 primarily due to projected decreases in precipitation

[188] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf
[189] https://unfccc.int/resource/docs/natc/mlinc2.pdf

and future population growth. Even as overall rainfall decreases, climate variability and the likelihood of extreme events are anticipated to increase with climate change. This may result in greater frequency and intensity of heavy rainfall events and storms such as those seen in the country in the 1960s, 1990s, and 2000s, which caused floods, contaminated surface and groundwater, and caused siltation of surface water sources. In areas like the Niger River flood plain, heavy rainfall events during the rainy season can lead to overflows of the Niger River and intense flooding, causing a loss of lives and livestock, destruction of settlements and infrastructure, and land erosion. Non-climate stressors such as pollution, inadequate management of irrigation systems, sedimentation, and siltation also threaten water resources in Mali. (USAID, 2012)[190]

220. The majority of existing studies that examine the impact of climatic change on water resources in Mali have focused on the hydrology of the Niger River and its major tributaries. The detailed hydrologic analysis, which goes back for many decades, reflects the importance of the river for providing domestic, industrial and irrigation water as well as its role in power generation. It has been supported by international initiatives that look at the hydrology of the entire Niger River basin to support the activities of the international Niger Basin Authority. By contrast, there are far fewer studies of hydrology outside the Niger basin, and there is a paucity of information on groundwater and its behavior over the same time period[191].

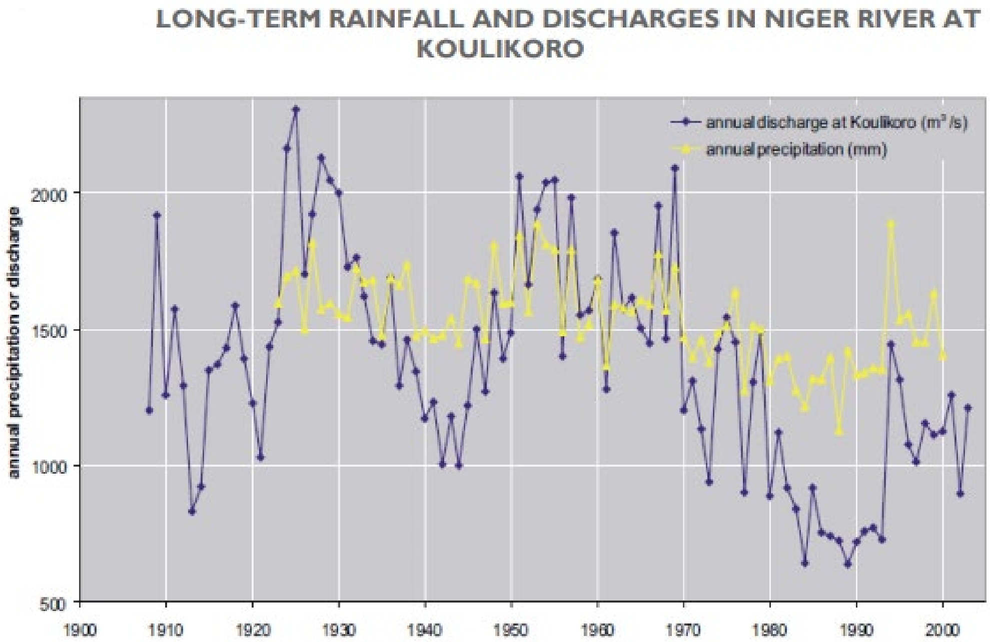
221. The overall impact of climate change in Mali is mitigated by the transfer of water from upper catchments into the drier zones of the country by the Niger River. The benefits of mass water transfers are substantial in both economic and strategic terms, and have been a major focus of investment in Mali over the past 20 years. These water transfers are still subject to the impact of declining rainfall resulting in lower than anticipated discharges in the dry season, but for the most part provide much more stability to Mali than was the case during La Grande Secheresse. However, the benefits of these water transfers are not felt in much of the country. Away from the main rivers, farmers are still highly dependent on rain-fed agriculture, and are very exposed to short and long term deviations from normal rainfall and temperature regimes. Water supply programs have substantially benefited rain-fed areas, but the impacts of climate change on agriculture have not been mitigated to any great extent. These areas that are not served by the main rivers remain very vulnerable to both rainfall and temperature changes.

222. As indicated earlier, the discharge patterns and water extractions from the Niger River are well documented. There is a well-established river gauging network that provides accurate data throughout the Niger River basin, both within Mali and in other countries included in the basin. In Mali, this information is collected by DNH, and both used nationally, and shared with NBA according to the treaty protocols[192].

223. Long-term discharge data at Koulikoro show a close relationship with annual rainfall averaged over seven stations in the upper catchment. Periods of good rainfall (when rainfall exceeds 1600 mm) result in average annual discharges in excess of 1700 m3/sec at Koulikoro (Figure 8). However, as soon as average rainfall in the upper catchment drops below 1500 mm/year, the effect on total river discharge is dramatic: the data from the 1940s indicate the high sensitivity of the river to multi-year reductions in rainfall, and also note the cumulative effect of persistent low rainfall. Six years of rainfall of approximately 1500 mm led to river discharges declining from 1500 m3/sec to 1000 m3/sec. In the 1980s and 1990s, when rainfall was only about 1300 mm in the upper catchment, average annual river discharges fell to about 700 m3/sec. In other words, a 25 percent decline in annual rainfall results in a decline of over 50 percent in annual discharge; and the longer the intensity of the dry spell, the more

[190] https://www.climatelinks.org/sites/default/files/asset/document/mali_adaptation_fact_sheet_jan2012.pdf
[191] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf
[192] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf

river levels fall. This is a consequence of widespread lowering of the groundwater table due to poor recharge, reducing the rate of replenishment of surface waters from groundwater[193].




*Source: Zwarts, 2005*

224. Despite these hydrologic relationships there currently appears to be little risk of water stress for water resource users along the Niger River until the major diversion structure at Markala. Irrigation along the river does not consume a great deal of water (the two largest schemes are 1,350 ha just below Selingue Dam and 3,500 at Banguineda, just downstream from Bamako), and extractions for domestic and industrial use are small compared to overall river flows (see Figure 9 on the following page).

225. Exposure to declining discharges in the Niger River at and below Markala Dam, however, is very much higher due to the volume of water required for irrigation by the Office du Niger. Markala Dam has no effective storage capacity: it keeps river levels sufficiently high to allow the feeder canal to run at or close to design levels. Data from Office du Niger indicate that with infrastructure in place until the mid2000's it was possible to operate the feeder canal at desired levels largely irrespective of upstream changes in climate and hydrology. The detailed analysis of Zwarts et al (2005) indicates that the operation of Selingue Dam is critical to maintaining adequate water supply at Markala[194].

226. Since the Selingue Dam started operating in 1982, discharge at Koulikoro has never fallen below 113 m3/sec, far above the minimum requirement for maintaining downstream ecological flows. Prior to operation, discharges at Koulikoro fell below 50 m3/sec roughly one year in four (Zwarts, 2005). But with release of water from the reservoir throughout the dry season, it is possible to augment the flows of the Niger River to meet demand for water from all uses throughout the dry season.

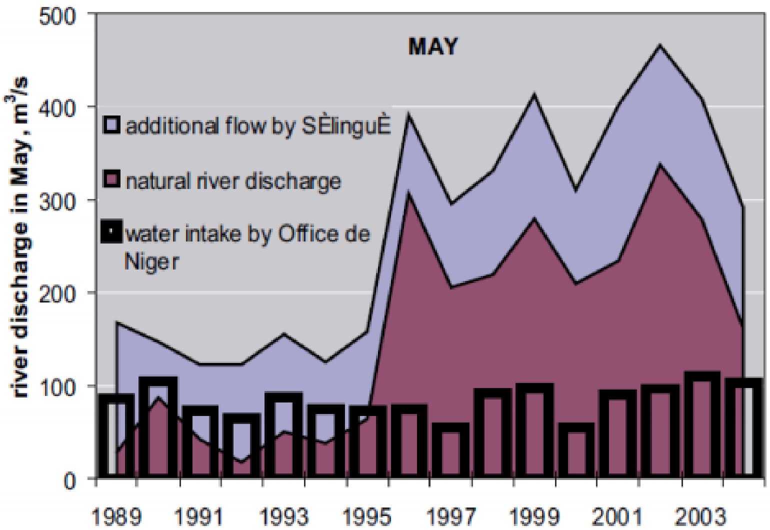
[193] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf
[194] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf

227. Analysis of supply and demand at Markala for the month of May (the driest month, and the one immediately prior to the onset of rains and increases in natural river discharge) shows that if Selingue Dam did not exist, Office du Niger would not have been able to meet its planned discharges into the feeder canal. The data show that even throughout La Grande Secheresse of 1989 to 1995 Office du Niger could divert sufficient water to meet its targets, and that those targets were not significantly different from those established when water was far more abundant in the period after 1995. If there were no changes in the irrigated area served by Markala, then there would be little cause for long-term concern about overall water availability in the Inner Delta and below. However, there have been several increases in irrigated area in recent years that require additional extractions from the Niger at Markala, including US investment of 5,000 hectares at Alatona though the Millennium Challenge Corporation (MCC), Libyan investment in the Malian rice growing system of 100,000 hectares, and Chinese investment for 50,000 ha of sugar cultivation. Were these areas all to come into full production, they would increase the total irrigated area from about 90,000 ha to over 200,000 ha, requiring more than double the amount of water to be diverted from the Niger River at or near Markala. While this increased demand can be met during the period of higher river discharges, it is clear that there would be inadequate years, and Kuper et al. (2003) believe it is impossible to reliably irrigate additional areas without more dams upstream.

228. One response to the possibility of water shortfalls is to plan the construction of new dams on the upper Niger and its tributaries. Plans exist for a major dam to be constructed in Guinea (still to be finally approved and financed) at Fomi, and two smaller dams in Mali on the Bani River. While the Mali dams would not contribute much storage and would not affect the hydrology of the Niger at Markala, they would provide some water to meet downstream minimum flows into Niger and permit somewhat greater extractions at Markala.

229. The data on extractions by Office du Niger in Figure 8 represent the requirement for extractions sufficient to irrigate between 35,000 and 50,000 ha. If the irrigable area increases to 200,000 ha, then the required extractions would rise from the approximately 100 m3/sec level to as much as 250-400 m3/sec, which would not be available in every year because of the need to maintain at least 40 m3/sec in flows to downstream riparian countries.

RIVER DISCHARGE AND IRRIGATION EXTRACTIONS AT MAKALA DIVERSION, 1980-2003




*Source: Zwarts et al., 2005*

230. Once constructed, the Fomi Dam would have enough storage to impact peak flows on the Niger River. Unlike Selingue, which has no effective year-to-year storage, Fomi Dam could reduce peak flows and this would result in significant reductions in inundation of the inner delta during the flood season. This has a direct and high impact on the populations not served by Office du Niger, their grazing lands and wetlands, and on the biodiversity of the whole delta area. The ecological, economic, and social impacts are addressed in sections 4 and 5 below. Changes in the area and intensity of flooding of the inland delta, which is an integral part of the hydrology and ecology of the entire Niger Basin, are the most contentious part of the overall water management of the Niger River. Although the Niger loses some 20 percent of its total discharge in the delta, the flooded area not only acts as a sponge and mitigates downstream effects of flood peaks, but also allows for grazing, fishing, and other economic activities.

231. The construction of Markala Dam reduced some of the inundation by diverting water away from the main portion of the inland delta. In response to the impacts of these extractions on the downstream hydrology, Mali has agreed to deliver a minimum discharge along the Niger to maintain sufficient water to meet the basic demands of the delta and serve downstream users in Niger and Nigeria[195].

232. However, the area subject to annual flooding has already decreased following the construction of Markala and Selingue Dams, and construction of additional upstream storage that would attenuate flood peaks would further exacerbate the situation (see Figure below).

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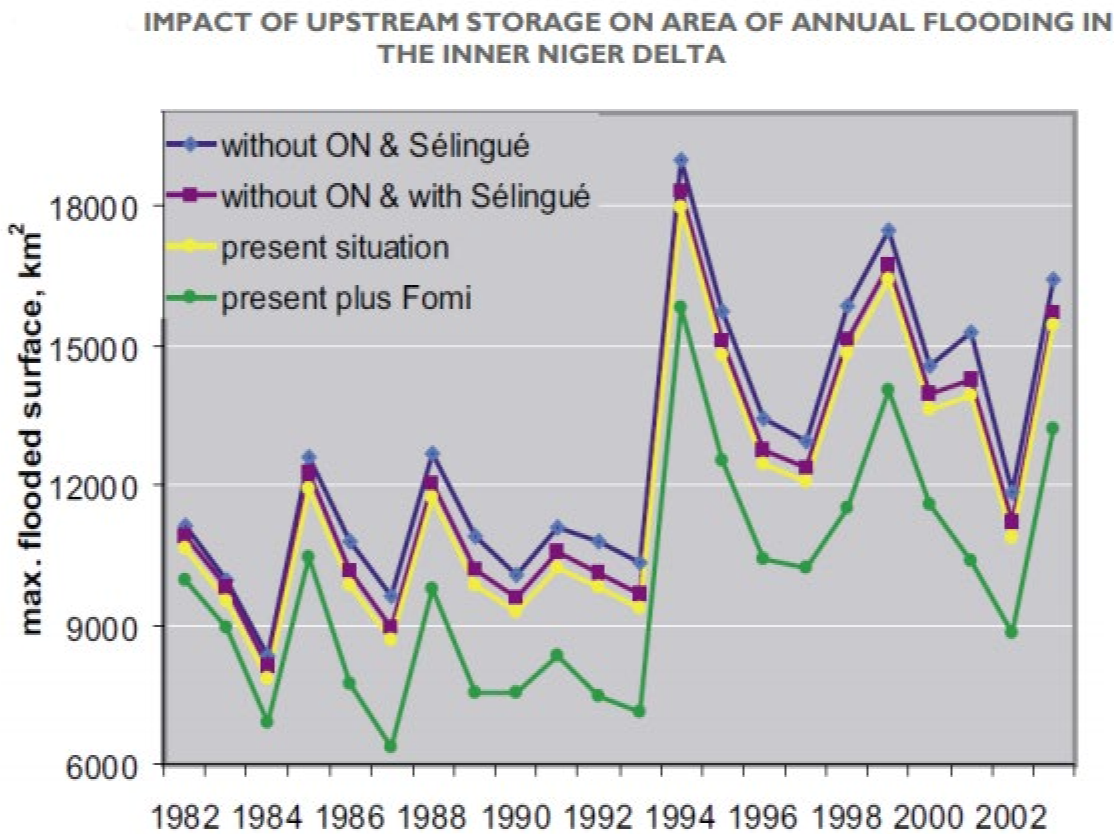
[195] https://www.climatelinks.org/sites/default/files/asset/document/Mali_Water_Resources.pdf




*Source: Zwarts et al., 2005*

#### 5.3.3.4 Climate change impacts on health

233. There are many direct and indirect climate impacts on the health sector. The exposure to thermal extremes, especially heat waves and the altered frequency and/or intensity of other extreme weather conditions (droughts, floods, storms, etc.). The changes in climate have effects on ranges and activity of vectors and parasites and alter the local ecology of water- and food-borne infective agents. Furthermore, Mali's agriculture sector is experiencing altered food (especially crop) productivity due to changes in climate, weather, and associated pests and diseases. Higher variability in precipitation and the increasing number of extreme events cause shifts in the quality, quantity, and distribution of fresh water and led to increased levels and biological impacts of air pollution including pollens and spores. (USAID, 2012)[196]

### 5.3.4 Vulnerability ranking and Mapping

234. Generally, vulnerability proceeds in a south-north gradient, with lowest vulnerability in the extreme south and around Bamako, and gradually increasing vulnerability northward with the exception of some areas of moderately low vulnerability in the Niger Delta and along the Niger River. In this map we have also included inset maps (Figure 9, bottom) that provide information on uncertainty levels in the DHS and climate data that provided the basis for seven out of 18 indicators. Although uncertainty levels cannot be assessed for all data sets, what these insets show is that error levels for the DHS and climate data are higher in regions to the west of Bamako and in the North owing to spatial gaps in

[196] https://www.climatelinks.org/sites/default/files/asset/document/mali_adaptation_fact_sheet_jan2012.pdf

measurements for both data sources (i.e., DHS sample clusters and meteorological stations). Results are more robust in areas that are white or lightly shaded in both inset maps; conversely, users should be more cautious about results in areas that are dark in both maps. Note that these maps reflect spatial gaps in measurement rather than measurement error per se (e.g., problems of survey design or instrumentation). (USAID, 2014a)[197]

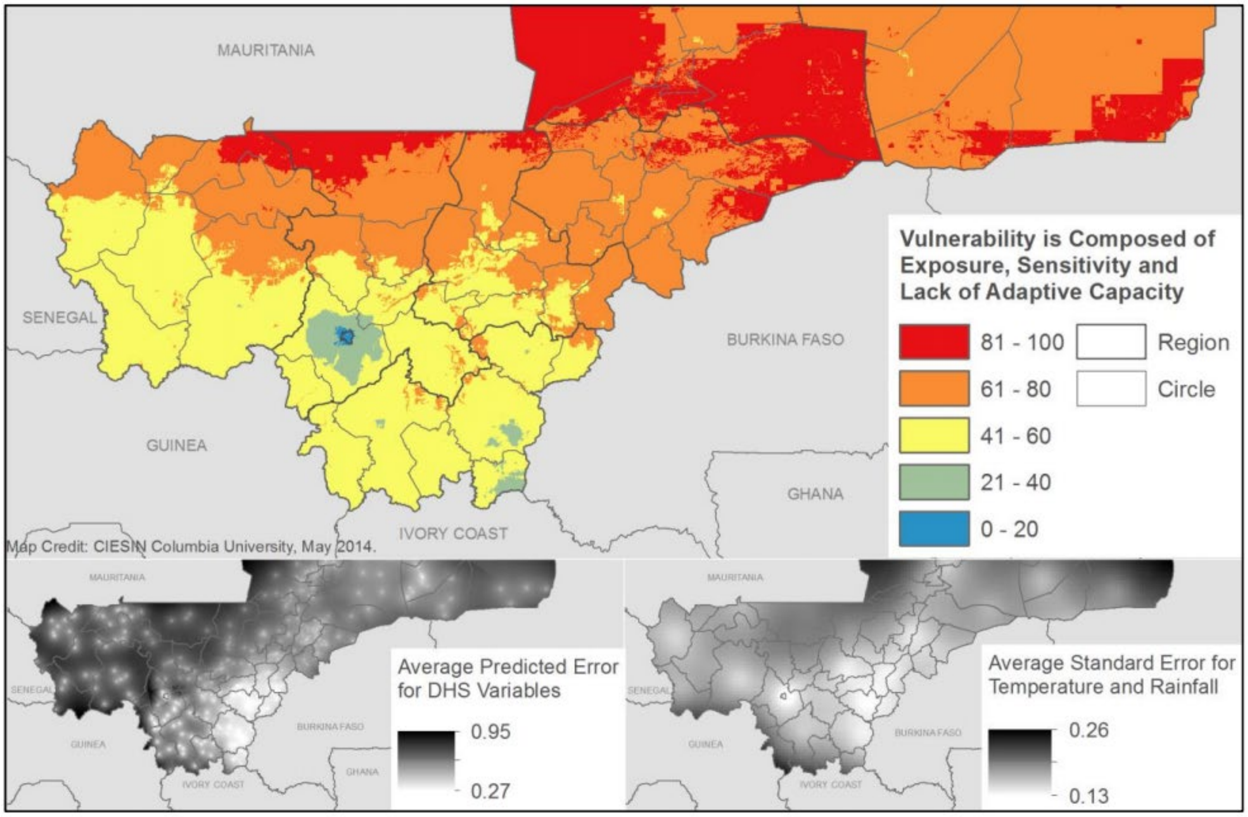



**Figure 5.3.4: Climate vulnerability Index for Mali (USAID, 2014a)[198]**

235. Approximately 40 percent of Mali's population resides in areas classified as medium vulnerability, and 32 percent reside in medium-high vulnerability. Only 6 percent reside in areas of highest vulnerability, and the population density in these mostly northern regions is only 7 persons per sq. km, compared with a density of more than 3,600 persons per sq. km for the low vulnerability category. The area of the lowest category is only 600 km$^2$, and is confined to Bamako and its environs. The medium-high category comprises the largest area at almost 310,000 km$^2$, or roughly one quarter of Mali's total land area. Two of the adaptive capacity indicators, the health infrastructure index and market

197 https://www.usaid.gov/sites/default/files/documents/1860/MALI%20CLIMATE%20VULNERABILITY%20MAPPING.pdf

198 https://www.usaid.gov/sites/default/files/documents/1860/MALI%20CLIMATE%20VULNERABILITY%20MAPPING.pdf

accessibility, are highly correlated with population density, and hence it should be noted that the vulnerability index is not completely independent of population distribution.(USAID, 2014a)[199]

199 https://www.usaid.gov/sites/default/files/documents/1860/MALI%20CLIMATE%20VULNERABILITY%20MAPPING.pdf

### 5.3.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| Forestry | National Program to Combat Desertification | |
| | Home Energy Strategy (SED) | The main objective was to contribute to the protection of the environment and the fight against desertification by limiting the removal of woodfuel to the actual regeneration capacity of the forest formation. It should be noted, however, that the results of the SED have been the subject of much controversy. |
| Water | Water supply | Focus on the control of surface water such as small dams the development of ponds and small watercourses at the village level, the creation of artificial ponds. |
| | Drilling | Development operations for the recharge of the water table, the operations of deepening wells. The costs of implementing these facilities and equipment are generally beyond means of the populations, which required a strong involvement of the state and partners in development in their implementation |
| Health | Watering courses and public places | |
| | Disaster prevention | Assessing the actual impacts of climate change and variability on the health and well-being of the Malian population and the development of warning plans for extreme weather conditions in order to prevent their effects on the population. |
| | Awareness raising | Training, awareness, information and communication on the effects adverse effects of climate change on the health and well-being of the population. |
| | Vaccination and immunization | Vaccination campaigns for the whole population and immunization campaigns against the main epidemic pathologies such as malaria, meningitis, and measles. Further, temporary closure of schools during periods of epidemic. |
| | Dissemination of information | The transmission of information from mouth to mouth, by letter, through the travelers' channel, etc. |
| | Travel restrictions | Travel restrictions and visits to patients in the same neighborhoods during periods of epidemics. |
| Agriculture | Increasing resilience | Diversification of animal and crop production, including the use of improved species that are adapted to climate change and the creation of cereal banks. |
| | Capacity building | Farmer training in the use of information and advice agrometeorological, the development of provisional timetables for the implementation of main cultural interventions and the establishment of a database in rural areas. This also entailed the reinforcement of innovation capacities and education and training on the importance of hygiene and sanitation. |
| | Reconciliation and communication | Reconciliation and improved communication helps people who compete for the same resources to use these resources effectively and peacefully |
| | Intensification and improved inputs | The use of improved seeds and other inputs, as well as agricultural intensification, will help farmers to cope with climate change effects |
| | Provision of security | Provision of security stocks free of charge or at a reasonable price to provide access to those in need when it is most needed. |
| | Use of adapted crop varieties | To cope with the deficit and the poor distribution of rainfall, many farmers use varieties whose short cycle corresponds to the water availability and water requirements are lower |

| Sector | Adaptation mechanism | Description |
|---|---|---|
| | Agrometeorological assistance | Rainfall problems led the National Meteorological Directorate to put implement a program of assistance to the rural world. This assistance concerns the awareness raising. |

**Table 5.3.5. Adaptation options by sector (RdM, 2007)**[200]

236. Improving land quality and living standards of the rural population in Mali requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of land degradation hotspots in Mali to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country. The programme will focus on the land degradation hotspots identified by the national Land Degradation Neutrality (LDN) report located in the Sahelian, Sudanian, Guinean areas and the interior delta of the Niger River[201]. The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

237. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Mali, the LDN targets and measures that stop land degradation in Burkina Faso as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Mali.

[200] https://unfccc.int/resource/docs/napa/mli01f.pdf
[201] https://knowledge.unccd.int/sites/default/files/ldn_targets/2020-03/Mali%20LDN%20TSP%20Country%20Report%20_0.pdf

## 5.4 Mauritania

### 5.4.1 Country Background: Development Context and Challenges

238. Mauritania has nearly 4 million inhabitants, about 50% of whom live from agriculture, livestock and fisheries (World Bank, 2013)[202]. The annual population growth rate was 2.8% in 2013. Its area is 1,030,700 km2, of which more than 2/3 are desert. The contribution of the rural sector to GDP formation averaged 25% during the period 2005-2010, of which 11% for the crop subsector, 9% for the livestock sub-sector and 5% for the fishing sub-sector (World Bank, 2016)[203]. The average annual GDP growth of the primary sector over this period was 4.1% per year, with significant year-to-year differences due to erratic rainfall. (FIDA, 2017)[204]

239. Mauritania is considered as a crossroad between the Arab and African world and can be seen as a good example of multicultural cohabitation. Correspondingly, Mauritania belongs to several regional and sub-regional organizations such as the African Union, the Arab League, the Maghreb Arab Union and the OMVS (Organisation pour la mise en valeur du fleuve Sénégal). Through ECOWAS (the Economic Community of West African States), the country is also currently negotiating an Economic Partnership Agreement (EPA) between the region and the European Union (EU). Furthermore, Mauritania participates in a growing economic exchange with the Gulf States. (IFAD, 2009)[205]

#### 5.4.1.1 Income and poverty

240. Mauritania is classified as a lower-middle-income country61. Its Human Development Index (HDI) increased from 0.424 to 0.487 between 2004 and 2014, but still remains below the average for sub-Saharan Africa at 0.502. The proportion of the Mauritanian population defined as poor rose from 51% in 2000 to 47% in 2004, 42% in 2008 and 31% in 2014. Despite the progress made, this percentage remains high, particularly in rural areas (where 74% of the poor live) and in the south of the country where 44.4% of the rural population is still below the poverty line against 16.7% in urban areas. A recent government study, funded by IFAD (2016), shows that literacy levels in rural areas remain low among adults (29 per cent for women and 35 per cent for men) and youth 15 at age 24 (40% for girls and 47% for boys). (FIDA, 2017)[206]

241. Mauritanian households are mostly headed by men: more than two thirds (68%) of heads of households are men against 32% of women. The analysis of poverty by sex of head of household shows an advantage in favor of female-headed households83. Indeed, 23.2% of households headed by men are poor (72.7% of poor households and 16.2% of all households), compared to 20.2% of

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[202] http://documents.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf
[203] http://documents.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf
[204] https://www.ifad.org/documents/38711624/40089492/PRODEFI_Mauritanie_Rapport_principal_et_annexes_FINAL_0024-883838456-3817_602.pdf/3b4829a6-3df8-4968-a9cb-8e8da986d781?1517983399309=
[205] https://www.thegef.org/project/sip-participatory-enviornmental-protection-and-poverty-reduction-oases-mauritania
[206] https://www.ifad.org/documents/38711624/40089492/PRODEFI_Mauritanie_Rapport_principal_et_annexes_FINAL_0024-883838456-3817_602.pdf/3b4829a6-3df8-4968-a9cb-8e8da986d781?1517983399309=

households headed by women. (i.e. 27.3% of poor households and 6.1% of all households). (FIDA, 2017)[207]

#### 5.4.1.2 Temperature, rainfall, seasons and agro-climate zones

242. Situated in the Saharan region of West Africa, Mauritania fronts the Atlantic Ocean on the West, is bordered by Western Sahara on the northwest, Algeria on the north, Mali on the east and southeast, and Senegal on the southwest. Except for the valley of the River Senegal on the south, two thirds of Mauritania is within the Sahara Desert. The worn-down relief is composed of sediments, rocky debris (regs), and of sandy deposits (dunes) from which emerge here and there massifs of low altitude, most often of a tabular shape, eroded under the force of strong winds, rare but intense rainfall and high temperature fluctuations. (IFAD, 2009)[208]

243. The rainy season in Mauritania lasts three months at the most with very uneven distribution and significant annual variations. Notwithstanding the unevenness of rainfall distribution and levels across the country, there is a clearly decreasing rainfall gradient from south to north and one can distinguish (ARC, 2016-2017)[209]:

- A dry tropical Sahelian-Sudanese type climate characterized by nine dry months in a few pockets in the far south of the country. In those parts, rainfall is at least 400 mm per year;
- A Sahelian type of semi-desert climate characterized by large temperature fluctuations and rainfall ranging between 200 and 400 mm;
- A Sahelian-Saharan type desert climate in the north characterized by an annual rainfall of between 100 and 200 mm;
  A Saharan type desert climate with rainfall varying from 100 to 0 mm (traces) which covers 75% of the territory.

#### 5.4.1.3 Agriculture and rural livelihoods

244. The contribution of the rural sector to the formation of GDP averaged 25% during the period 2005-2010, of which 11% for the crop production sub-sector, 9% for the livestock sub-sector and 5% for the fishing sub-sector (World Bank, 2016)[210]. The average annual GDP growth of the primary sector over this period was 4.1% per year, with significant year-to-year differences due to erratic rainfall. (FIDA, 2017)[211]

245. More than half of Mauritania's 3.89 million people earn a living from agriculture and livestock. However, domestic cereal production in this arid country only meets about one-third of the national food needs, forcing a reliance on imports, especially for sorghum, millet and wheat. Food prices soared in 2008 and continue to be volatile. This, combined with poor rains in 2011, which slashed agricultural output by two-thirds, pushed more farmers and pastoralists into poverty and hunger. Although cereal production has rebounded in recent years, with bumper crops registered in 2012 and 2013, food security remains shaky in parts of the country, particularly in areas where unpredictable rains in 2013

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207 https://www.ifad.org/documents/38711624/40089492/PRODEFI_Mauritanie_Rapport_principal_et_annexes_FINAL_0024-883838456-3817_602.pdf/3b4829a6-3df8-4968-a9cb-8e8da986d781?1517983399309=

208 https://www.thegef.org/project/sip-participatory-enviornmental-protection-and-poverty-reduction-oases-mauritania

209 Mauritania 2016-2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2017/03/OP_Pool3_Mauritania-Operational-Plan_EN.pdf

210 http://documents.worldbank.org/curated/en/288231531625439579/pdf/MAURITANIA-CPF-NEW-06192018.pdf

211 https://www.ifad.org/documents/38711624/40089492/PRODEFI_Mauritanie_Rapport_principal_et_annexes_FINAL_0024-883838456-3817_602.pdf/3b4829a6-3df8-4968-a9cb-8e8da986d781?1517983399309=

affected crops and grazing land. The presence of tens of thousands of Malian refugees, who fled violence in their own country, has further strained Mauritania's limited resources. (FAO, 2018)[212]

246. Mauritania is characterized by an arid desert climate and limited availability of water resources, strongly influencing agricultural production systems. The latter can be divided into 5 categories: (i) the system of extensive rainfed culture in sandy zone or "diéri", (ii) the culture system behind dams and lowlands, (iii) natural or controlled flood systems walo, (iv) the oasis system and (v) irrigated agriculture in total water control. (FIDA, 2017)[213]

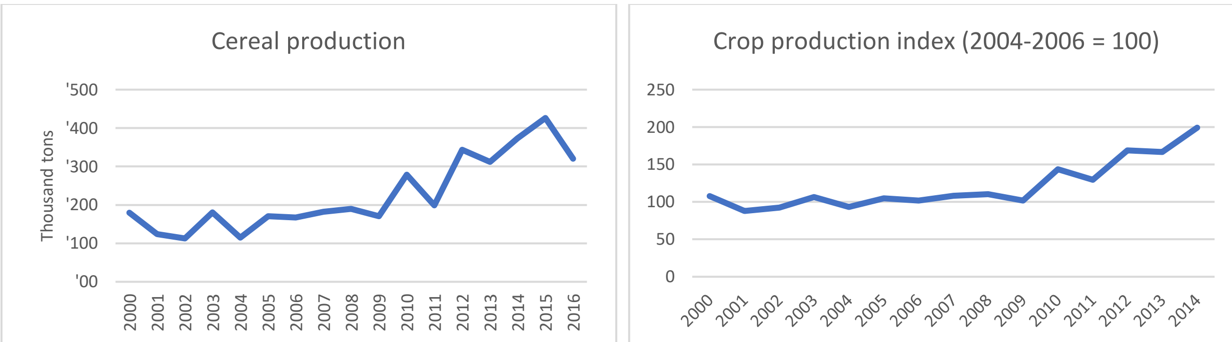


**Figure 5.4.1.3: Total cereal production and crop production index Mauritania (World Bank, 2018a)[214]**

### 5.4.2 Climate change

#### 5.4.2.1 Temperature

247. Mean annual temperature has increased by 0.9°C since 1960, an average rate of 0.19°C per decade. The rate of increase is most rapid in the hot, dry season, AMJ, at 0.34°C per decade. Despite the observed increases in mean temperature, there is no evidence of observed increases in the frequency of days that are classed as 'hot'1. The frequency of nights that are classed as 'hot', however, has increased significantly in all seasons except winter, DJF. The average number of 'hot' nights per year increased by 46 (an additional 12.5% of nights2) between 1960 and 2003. The rate of increase is seen most strongly in JJA when the average number of hot JJA nights has increased by 6.5 days per month (an additional 20.9% of JJA nights) over this period. The frequency of 'cold'3 days has decreased significantly only in summer (JJA). The frequency of cold nights has decreased significantly in all seasons except winter (DJF). The average number of 'cold' nights per year has decreased by 24 (6.5% of days). This rate of decrease is most rapid in JJA when the average number of cold JJA nights has decreased by 2.2 nights per month (7.1% of JJA nights) over this period. (UNDP, 2015f)[215]

248. The following graphics on temperature in Mauritania are based on a Climate Analytics Tool that analyses climate projections on the national scale[216]. For the reference period map on temperature

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[212] http://www.fao.org/agriculture/ippm/projects/mauritania/en/

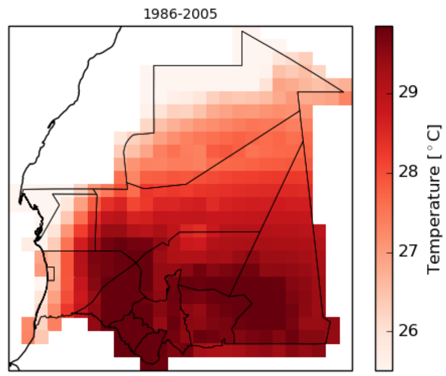
[213] https://www.ifad.org/documents/38711624/40089492/PRODEFI_Mauritanie_Rapport_principal_et_annexes_FINAL_0024-883838456-3817_602.pdf/3b4829a6-3df8-4968-a9cb-8e8da986d781?1517983399309=

[214] https://data.worldbank.org/

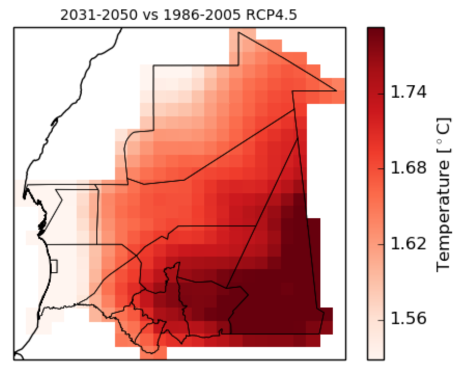
[215] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[216] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global

indicators, hotter regions are darker than cooler regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.4.2.1a: Temperature average over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[217].**

*Projections on temperature*

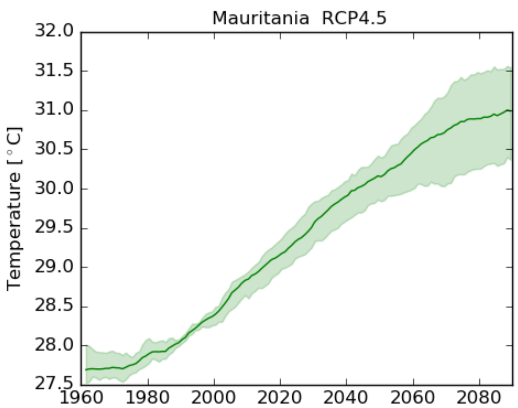
249. The mean annual temperature is projected to increase by 1.3 to 3.8°C by the 2060s, and 1.8 to 6.0°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5-2.5°C. The projected rate of warming is faster in the interior regions of Mauritania than in those areas closer to the coast. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annually, projections indicate that 'hot' days will occur on 16-32% of days by the 2060s, and 20-45% of days by the 2090s. Days considered 'hot' by current climate standards for their season are may increase most rapidly in JAS, but the range between model projections is large, occurring on 29-84% of days of the season by the 2090s. Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 19-34% of nights by the 2060s and 24-46% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in JAS, occurring on 44-92% of nights in every season by the 2090s. Projected increases in hot days and nights are more rapid in the south and east of the country than the north and west. All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate. Cold days occur on less than 4% of days by the 2090s, and cold nights less than 3% of nights. Cold nights do not occur at all by the 2090s in any projections under the highest emissions scenario (A2). (UNDP, 2015f)[218]

climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

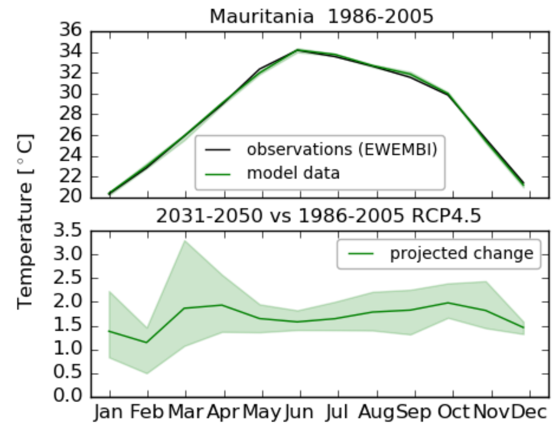
[217] Mauritania Climate Analytics tool

[218] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

The following graphics projecting temperatures in Mauritania are based on a Climate Analytics Tool that analyses climate projections on the national scale[219].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.4.2.1b: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[220]**

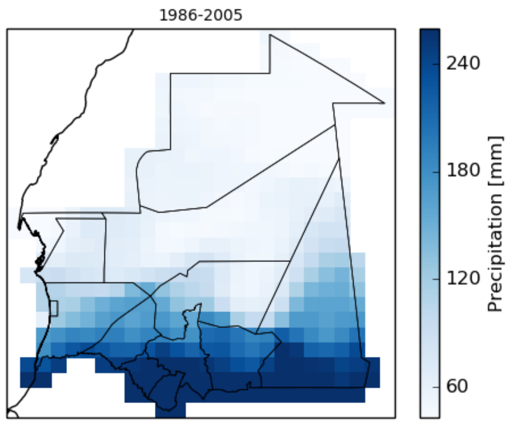
#### 5.4.2.2 Precipitation

250. Mean annual rainfall over Mauritania has not changed with any consistent trend since 1960. Some unusually high rainfalls have occurred in very recent years (2000-2006), but this has not been part of a consistent trend. There are insufficient daily rainfall observations available from which to determine changes in extremes indices of daily rainfall. (UNDP, 2015f)[221]

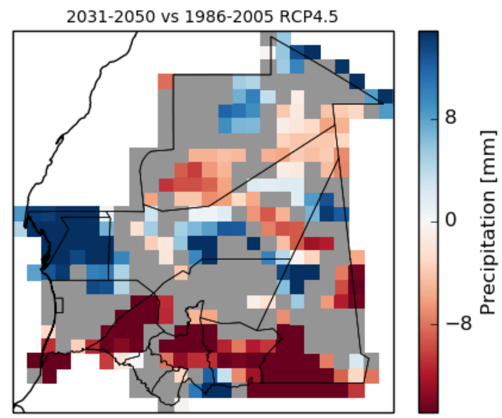
251. The following graphics on precipitation in Mauritania are based on a Climate Analytics Tool that analyses climate projections on the national scale[222]. For precipitation indicators, wetter regions are

[219] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation
[220] Mauritania Climate Analytics tool
[221] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[222] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.4.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[223].**

*Projections on precipitation*

252. Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of changes in precipitation for Mauritania but tend towards decreases. Projected change ranges from -65 to +28% by the 2090s, with ensemble means between -7 and -25%. The changes proportion of total rainfall that falls in heavy4 events range widely between increases and decreases but tends towards increases in the south in the wet season, JAS, and decreases in the other seasons. There is no consistent change in 1- and 5-day rainfall maxima in projections. The range of changes in projections from the model ensemble covers both increases and decreases in most seasons. (UNDP, 2015f)[224]

253. The following graphics projecting precipitation in Mauritania are based on a Climate Analytics Tool that analyses climate projections on the national scale[225].

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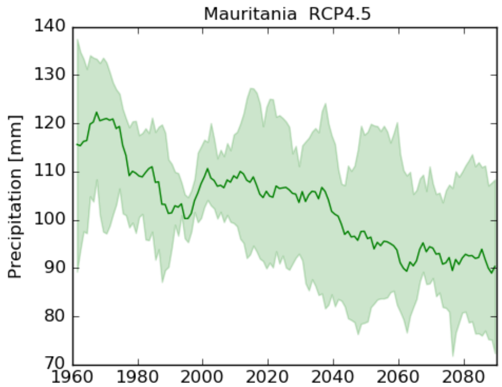
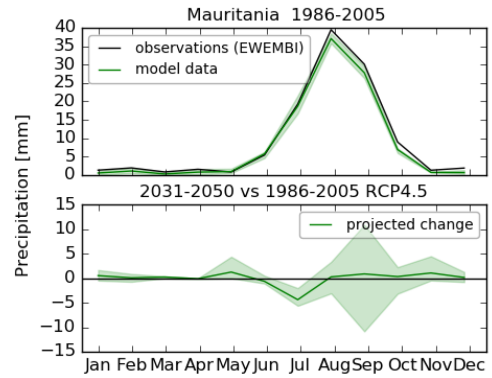
[28] Mauritania Climate Analytics tool

[224] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[225] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.4.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[226]**

### 5.4.2.3 Climate change impacts, climatic hazards and extreme events

254. Straddling the Sahara and the Sahel, Mauritania is a vast country of 1,030,700 km2 which is experiencing an advanced desertification affecting nearly 75% of its territory and an ecological profile extremely vulnerable to climatic hazards. This vulnerability is notably caused by episodes of endemic droughts that have been raging since the early 1970s and a marked alternation between a short wet season and a long dry season that lasts from 8 to 10 months. The recent manifestations of climate change, combined with various anthropogenic factors, draw the features of a territory that, in two decades, has experienced a change in its way of occupying space through the rural exodus to large urban spaces as Nouakchott and Nouadhibou, respectively administrative and economic capitals. (IRM, 2014)[227]

255. Like all the other countries in the Sahel region, Mauritania experienced severe drought during the 1970s and the 1980s. The decrease in rainfall resulted in several adverse ecological, economic, social, and even cultural consequences. In fact, the drastic reduction of the vegetation increased desertification and led to a heavy reduction of the livestock and agricultural production and triggered a process of pauperization in rural communities. These formerly nomadic communities settled either in the areas they considered most favorable (wetlands) or took part in a massive rural exodus to the main urban centers. The non-mobile and urban environment has also experienced some problems related to various forms of pollution. The quality of drinking water and sanitation has become a matter for concern regarding public health. The quality of the air in the main urban centers (Nouakchott and Nouadhibou) is being degraded by increasing quantities of vehicle exhaust fumes, all the more polluting as most of these vehicles are very old and they run on poor quality fuel. (IRM, 2004)[228]

[226] Mauritania Climate Analytics tool
[227] https://unfccc.int/resource/docs/natc/mrtnc3.pdf
[228] https://unfccc.int/resource/docs/natc/mrtnc3.pdf

*Projections on climate impacts*

256. The most obvious effects of climate change on the land ecosystem in Mauritania is desertification and its consequences. In fact, the disappearance of the vegetation gives rise to the movement of the sand and to badlands, depending on the type of substrata. In either case, climate change entails damaging consequences for both rural and urban environments and communities, which are ecological, social, and economic in nature. Climate change (weather variability) affecting water courses and resources means a reduction in production potential, increased livestock costs, restriction of the vital concept of space, generates more urban agglomerations and therefore reduces grazing lands, causes the level of the water-table to fall, and springs and other natural sources of water to disappear. (IRM, 2004)[229]

### 5.4.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

257. Three-quarters of the Mauritanian territory is covered by Saharan desert, and the remaining one quarter is a Sahelian zone. Mauritania is therefore one of the countries most vulnerable to the effects of desertification. This is the consequence of the winds activity that sweep the country. These air masses are made up of 3 main currents blowing throughout the year: marine trade wind, continental trade wind, and the summer monsoon. The precipitation bearing air masses are the marine trade wind and the monsoon. (UNDP, 2018c)[230]

#### 5.4.3.1 Climate change impacts on agriculture

258. As far as production systems are concerned, the most vulnerable, and the most affected, activities are those dependent upon rainwater, especially rain-fed agriculture. The production systems with low or even no vulnerability are pastoral systems where owners are dwelling in urban areas, and, semi- and/or intensive systems. With regard to the health of the animals and the survival of the livestock, the method of managing the herds, long-distance moves and heavy concentration of animals around wells, tend to promote contagious diseases. Furthermore, periods of shortage of fodder lead to problems associated with malnutrition and make animals less resistant to attack and other environmental factors. (IRM, 2004)[231]

259. Concerning the production of irrigated rice case in the western Sahel, outputs with the bioclimatic model DSSATv 4.0 yield a yield reduction of 4% by 2020, and a 10% increase in yields in the 2050 and 2080 horizons. Rice growing, which is a hot zone C3 plant, will take advantage of the increase in the concentration of $CO_2$ as a fertilizer, while supporting the rise in temperatures since water is not a limiting factor. In the case of irrigated wheat in Brakna during the cold season, under the experimental conditions during the 2010-2011 irrigated crop year, the yields observed varied between 2-4 tons, whereas the potential yield of the variety Karim durum is 6 tons/ha. With global warming, heatwave periods will coincide with the critical phases of wheat that are emergent, the first vegetative stages, but also during the filling of the grain. Under these conditions, wheat cultivation will be rapidly maturing, the end of the season will be poured at the end of the cycle and the yields will drop sharply, especially for the 2100 horizon with temperatures above 30°C. According to the FAO (Food climate E-newsletter, Dec. 2008) the impacts of climate change on the potential of rainfed cereals production by 2050, compared to the 1961-1990 average, will be considerable. Based on these forecasts, production declines in Mauritania will be between 20% and 50%. (IRM, 2014)[232]

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[229] https://unfccc.int/resource/docs/natc/mrtnc3.pdf
[230] http://www.adaptation-undp.org/explore/western-africa/mauritania
[231] http://www.adaptation-undp.org/explore/western-africa/mauritania
[232] https://unfccc.int/resource/docs/natc/mrtnc3.pdf

260. The figure below presents IFAD CARD[233] for Mauritania to explore the effects of climate change on the yield of major crops.

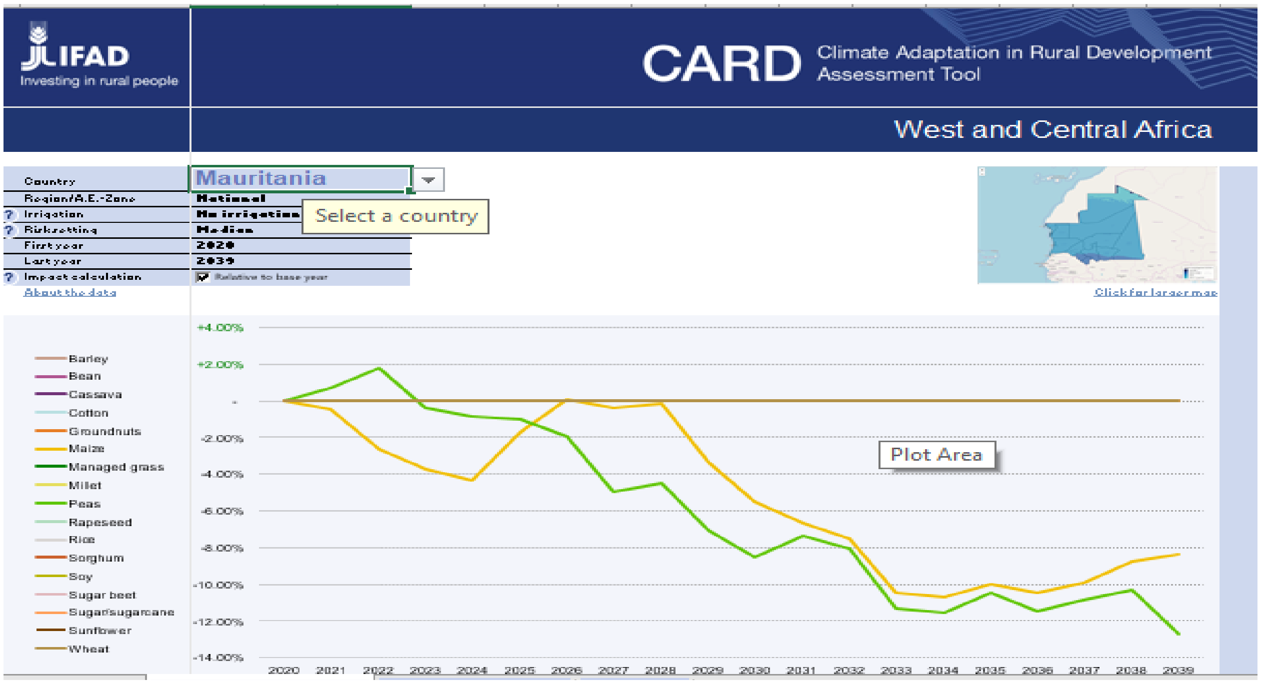


**Figure 5.3.3.1: CARD for Mauritania**(Please refer to the "Climate change impacts on crop yield in specific targeted regions" document to see projections for each country region)

### 5.4.3.2 Climate change impacts on natural capital

261. In conjunction to increasing temperatures, the possible implications for the natural resource based livelihoods have to be carefully considered: effects of climate change in Mauritania are therefore likely to include increased desertification, significant degradation of arable land, of pasture, and loss of livestock, clearly demonstrating the need for urgent adaptation and risk management measures to be undertaken with regard to remedying the present country's vulnerability to climate change and desertification. (IFAD, 2009)[234]

262. With regard to marine and coastal ecosystems, the adverse effects of climate change can be observed through the rising of the sea level and of the temperatures, the increased frequency of major storms and the consequences they generate. The rise in sea level brings with it increased flooding in the rainy season, coastal erosion, the infiltration of sea water in the water-tables, the disappearance of low-lying wet lands and all the related biodiversity, major effects on the human habitat and on all the coastal socio-economic infrastructures. Topographical maps of the different parts of the coastline reveal the existence of a number of low areas or areas made vulnerable by human activities, which are threatened by the rise in sea level. (IRM, 2004)[235]

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[233] Climate Adaptation in Rural Development – Assessment Tool https://www.ifad.org/en/web/knowledge/publication/asset/41085709

[234] https://www.thegef.org/project/sip-participatory-enviornmental-protection-and-poverty-reduction-oases-mauritania

[235] https://unfccc.int/resource/docs/natc/mrtnc3.pdf

#### 5.4.3.3 Climate change impacts on water

263. The impacts of climate change will be significant and will result in a general decrease in water resources of around 10 to 15%, with the following consequences: (i) a decrease in runoff of around 10% between 2000 and 2020, ( (ii) an increase in evapotranspiration and degradation of water quality, (iii) a decrease in piezometric levels and salinity of waters in coastal zones, (iv) a disruption of the wadis regime and a reduction in the capacity of the rivers. dams due to concentrated precipitation and accelerated siltation by erosion; and (v) warmer, less aerated surface waters with lower flow rates and thus less ability to dilute and biodegrade certain pollutions, etc. (IRM, 2014)[236]

#### 5.4.3.4 Climate change impacts on health

264. In Mauritania, life expectancy is less than 60 years. Twenty years of drought have caused a profound demographic transformation in this country, which is 90% desert. The nomadic population has rapidly declined, with people settling in rural areas and in shantytowns in cities where access to clean water and sanitation is scarce. The Mauritanian people faces serious health risks and many children suffer from diarrhoea and other diseases related to deteriorating environmental conditions. Around 2150 Mauritanians, including 1700 children under the age of 5 die each year from diarrhoeal disease. WHO estimates that nearly 90% of these deaths are directly attributed to the poor quality of water, sanitation and lack of hygiene. (WHO, 2013)[237]

### 5.4.4 Vulnerability ranking and Mapping

265. Although production methods and lifestyles in the Sahel's vulnerable zone remains mostly very traditional, the overall environment has greatly changed over the past 30 years. The climate has become drier and the average isohyets have moved 100-150 km further south. Also, West Africa's population has grown very rapidly, from less than 130 million to nearly 300 million between 1975 and 2005. The number of cities of over 100,000 people has risen from 30 to 135 and the network of main roads has expanded more than five-fold. (OECD, 2006)[238]

266. The Sahel's vulnerable zone is now home to 8 million people — about 3% of West Africa's population — and has very few significant urban centers. Its increasing links with big urban settlement areas mean that the old Sahel lifestyles are now up against markets whose fluctuations can magnify the effect of nature's uncertainties such as locusts and lack of rainfall. This is what happened during the 2005 dry season, especially in southern Niger, whose inhabitants are heavily influenced by northern Nigeria. But this proximity to large urban centers also provides part of the rural population with opportunities and income, especially through seasonal migration to towns and to commercial agriculture areas. The connection of the Sahel with West African markets is now a reality that neither prevention nor management strategies of food shortages nor long-term development policies can ignore. (OECD, 2006)[239]

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[236] https://unfccc.int/resource/docs/natc/mrtnc3.pdf
[237] http://www.who.int/features/2013/mauritania_environmental_health/en/
[238] https://www.oecd.org/swac/publications/38409502.pdf
[239] https://www.oecd.org/swac/publications/38409502.pdf

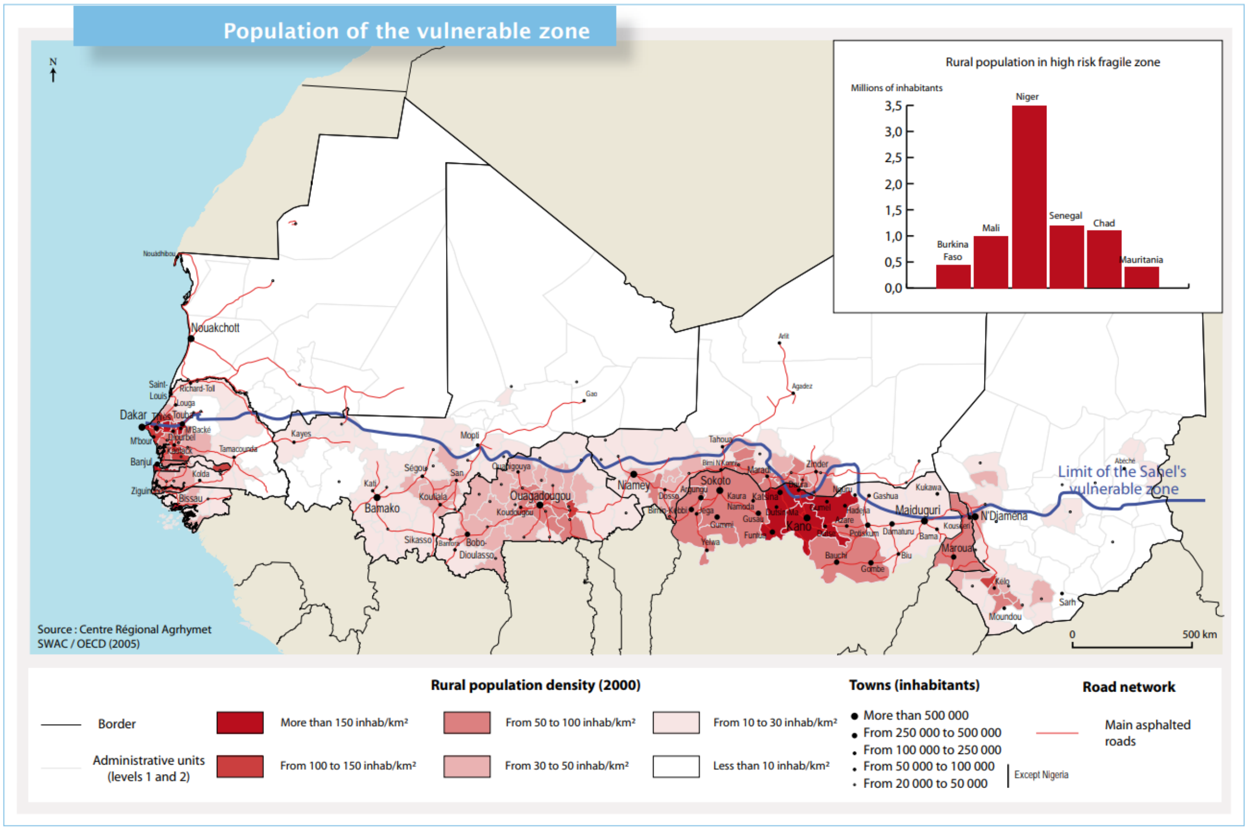



**Figure 5.4.4: Population in the vulnerable zone of the Sahel area (OECD, 2006)**[240]

240 https://www.oecd.org/swac/publications/38409502.pdf

#### 5.4.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| **Forestry** | Substitution of ligneous fuel | Raise public awareness of the necessity of using butane gas instead of wood and charcoal. Provide affordable butane gas and help the people (particularly those in rural areas and the outlying suburbs of the big urban centers). Develop income-generating activities to redeploy people who had been engaged in the business of selling wood and charcoal. |
| | Reinforce nature conservation | The general objective is to develop the capacities of the institution responsible for the protection of the environment so as to help it to fulfil its mission. The specific objective is that the institution responsible for the protection of the environment is able to fulfil its mission. |
| | Improvement of knowledge of the resource and its sustainable management | To carry out a review (plant formation, large wetlands, use of these formations, evolutive trends of these formations) and socioeconomic studies. Initiation developments for Mauritanian forests to promote sustainable use and improvement of the current state of plant formation. |
| **Water** | Demand management | Contribution to a better knowledge of the surface water regime and support for the dissemination of new irrigation technologies. Establishment of networks of operational measures and publication of monthly news bulletins during the rainy season. |
| | Monitoring | Improvement of monitoring of the piezometric networks of water tables and monitoring of quality of the water. |
| | Water management | Improvement of management of the resource and the experimental use and extension of the new adapted technologies. Carry out community awareness and activity campaigns on the use of water. Establish protection zones around water supply points. Make people participate in paying for the cost of water cost through the local communities. Organize the beneficiary communities into water point committees with manual pumps. Sign maintenance contracts with the National Agency for Drinking Water and Sanitation (NADWS) responsible for the thermal and solar DEP and SPM networks. |
| **Health** | Water control | A mobile water control laboratory supplied by WHO to Mauritania, two years ago, is an important resource to monitor water quality in the most remote rural areas. (WHO, 2013) |
| | Cleaner schools | In the El Baraka School in the capital city of Nouakchott, for example, water basins have been installed and advice provided on handwashing and hygiene in classrooms and toilets. The entire school community – students, teachers and administrative staff – are active players in creating a more hygienic school. (WHO, 2013) |
| | Incinerators of medical waste | Health centres located in these regions are also creating a healthier environment with the installation of 6 biomedical waste incinerators. Medical waste is a reservoir of infectious microorganisms that pose a health risk – not only to patients, visitors and health workers – but can also contaminate the soil, water and air with hazardous substances. (WHO, 2013) |
| **Agriculture** | Capacity building | Capacity building by means of offering training and information to the producers, their Socio- Professional Organizations (SPOs) and Community Educators (CEs). Training and capacity building of producers, their SPOs and CEs in the field of organisation (Cooperative Using Agricultural Equipment), establishment of seed-bearing trees etc), of farm management and the role of the agricultural adviser, etc. Information, by all channels on |

| Sector | Adaptation mechanism | Description |
| --- | --- | --- |
| | | communication, on technological progress recorded, particularly advances within their reach and immediately applicable to improve productivity, types of successful farming methods. improvement of the producers' and CEs' expertise, particularly concerning the use of agricultural methods respectful of the environment. Improvement of the agro-systems productivity and consequently of the standard of living environment of this fringe community. |
| | Land management | The improvements of farming techniques in pluvial zones and introduction of new varieties of high-yield drought-resistant cereal. |
| | Promotion of water-saving irrigation methods in oasis zones | The promotion of economical irrigation techniques in oasis zones (pilot scheme using the drip technique). Implementation of activities to create awareness and to identify the sites which will be covered by the project through missions, diagnostic research, etc. acquisition and the installation of pumping equipment and of the irrigation network and monitoring and the maintenance of networks |
| | Improvement of cultivation methods in pluvial zones | Acquisition of agricultural equipment for ploughing, mowing and weeding. Training of producers in efficient and effective use of the equipment through training programs, seminars, sessions, etc. Identification, then the experimental use, of high-yield, fast-growing varieties, suitable for various zones. |

**Table 5.4.5: Adaptation options by sector (IRM, 2004)[241]**

267. Improving land quality and living standards of the rural population in Mauritania requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of zones with negative ecological change and high propensity to erosion in Mauritania to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country (figure 5.4.5)[242]. The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

268. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Mauritania, the national Land Determined Neutrality targets and measures that stop land degradation in the country as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Mauritania.

[241] https://unfccc.int/resource/docs/natc/mrtnc3.pdf
[242] https://geonode.wfp.org/wfpdocs/ica-mauritania-2017-ica-areas-land-degradation-2001-2012/

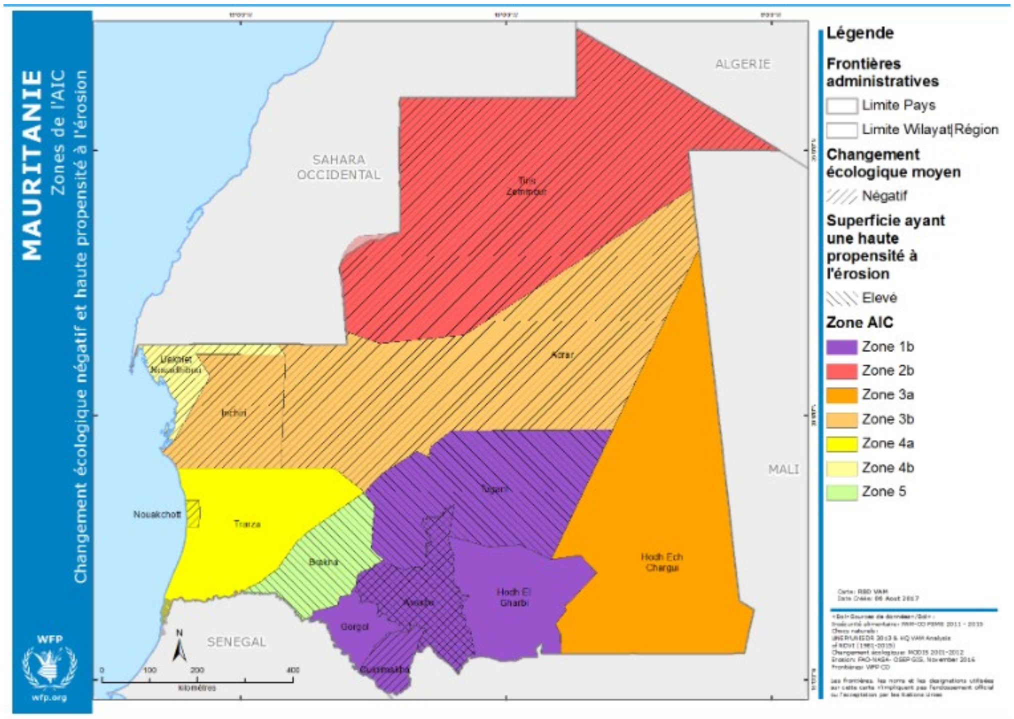



**Figure 5.4.5: CA Mauritania, 2017 - ICA Areas & Land Degradation, 2001-2012**[243]

[243] WFPGeoMode available at https://geonode.wfp.org/wfpdocs/ica-mauritania-2017-ica-areas-land-degradation-2001-2012/

## 5.5 Niger

### 5.5.1 Country Background: Development Context and Challenges

269. Niger is a landlocked country whose southern third is located in semi-arid Sahelian climate with an annual rainfall ranging between 150 and 600 mm, concentrated over three months. With a population of 15.2 million inhabitants of which 51.9% are under 15 years old and 79.6% live in rural areas, the average population growth rate of 3.8% 1. Good rainfall, recovery investments, and the implementation of the economic and financial program supported by the international financial institutions have enabled Niger to record economic growth of 8% in 2010.2 GDP grew by 57% between 2004 and 2009. The economy Niger remains vulnerable to climate shocks due to its dependence on agriculture (26% of GDP in 2009) as evidenced by the food crises of 2005 and 2010 following droughts in previous years. On the other hand, the record harvest of the crop year has had a positive impact on the 2010/2011 macroeconomic results. (FIDA, 2012)[244]

270. Food insecurity, chronic malnutrition and food crises remain recurrent for structural reasons: (i) the level of poverty of a large part of the population, especially rural; (ii) dependence on rain fed agriculture; (iii) high population growth; (iv) slow degradation of fragile ecosystems exacerbated by climate change; and (v) volatile food prices. The country has experienced serious food crises in 1973, 1984, 2005 and 2010. The Maradi region was very affected by the 2005 crisis, with a drastic reduction in food consumption, the decapitalization of livestock and other assets, an acceleration of migratory phenomena, and serious consequences for the level of malnutrition of the most vulnerable populations (young children, pregnant women and old people). The 2010 crisis also caused a 16.7% increase in the rate of child malnutrition. (FIDA, 2012)[245]

#### 5.5.1.1 Income and poverty

271. The Republic of Niger is characterized by a widely dispersed rural population in a fragile natural environment. Almost eighty percent of the population is rural, two-thirds of which live in absolute poverty. Niger remains a very poor country with a limited natural and human resource base. Social indicators compare poorly to the average in Sub-Saharan Africa. With a per capita income of US$260, the country ranked among the lowest in the world (174th out of 177 countries) in the 2007 Human Development Index. The share of the population living in poverty was estimated at 60.7 percent in 2006 mainly due to the high levels of population growth, recurrent droughts and a famine in 2004. (GEF, 2009)[246]

#### 5.5.1.2 Temperature, rainfall, seasons and agro-climate zones

272. During the dry season, the average temperature varies from 18.01° C to 31.1° C. During this season, the Harmattan (dry and hot wind) with moderate speed (5 to 10 m/s) blows from northeast or east and it is dominant throughout the country. (GoNiger, 2006)[247]

273. During the rainy season, the average temperature varies from 28.01° C to 31.7° C. The Monsoon (wet wind) blowing from Southwest to the Northeast is dominant in the main parts of the country. During

244 https://www.ifad.org/en/document-detail/asset/40123476
245 https://www.ifad.org/en/document-detail/asset/40123476
246 https://www.ifad.org/ru/web/knowledge/publication/asset/39571603
247 https://www.preventionweb.net/files/8562_ner01e.pdf

this period, the speed of the wind is generally low or moderate (2 to 8 m/s). But instant high-speed winds (> 40 m/ s) can be recorded. (GoNiger, 2006)[248]

274. The most extreme temperatures recorded are – 2.4° C (in January 1995 in Bilma) for the minimum temperature, and 49.5° C (on September 7th, 1978 in Diffa) for the maximum temperature. Rainfall is characterized by great variation in space and time. In normal years, this rainfall allows the increase of ground water, the formation of stretches of smooth water and the improvement of grassland. Since the early 1970's, rainfall has been decreasing; this is expressed by the movement of the isohyets to the south. (GoNiger, 2006)[249]

275. From the north to the south of the country, there are four distinct agro-ecological zones on the basis of rainfall, vegetation and soils. These are:

- The Sahara zone (with a desert climate) occurs in the north of the country and covers 65% of the national territory. Rainfall is scarce and remains always below 100 mm/year. The dry season is very long when average temperatures are typically over 35°C. Agricultural production is limited to nomadic herding and scattered oasis agriculture. In terms of vegetation, there are forms of discontinuous steppes. It is mostly growing in areas where moisture conditions are slightly better;
- The Sahelo-Saharian zone (a sub-desertic climate) covers 12.2% of the national territory and occurs immediately to the south of the Sahara Zone. It experiences low rainfall between 100-300 mm/year. Rivers are temporary, only flowing after significant rainfall events. Semi-nomadic herding dominates but some rainfed subsistence cropping is possible where soil and moisture conditions permit. This area is characterized by vegetation dominated by small scattered shrubs;
- The Sahelo-Sudanian zone covering 21.9% of the national territory lies to the south of the Sahelo-Saharian zone and typically receives between 300-600 mm of rainfall per year. The northern part of this zone is the drier Sahelian sub-zone devoted mainly to nomadic livestock raising, while rainfed cropping dominates in the wetter southern Sudanian sub-zone. This zone is characterized by a discontinuous herbaceous savannah vegetation with a low density shrub stratum, becoming more wooded in low lying areas with better soil moisture conditions; and
- The Sudanian zone occurs in the most southerly part of the country, covering only 0.9% of the national territory. This zone receives more than 600 mm of rainfall per year. The higher rainfall permits intensive cropping, and this zone is where most of the irrigated agriculture is carried out. Because of the higher rainfall the zone is also more wooded than the other zones. The savannah vegetation, is characterized by a more or less continuous herbaceous stratum, in which there are areas of closed shrubs and woodlands. The woody vegetation is dominated by species of *Combretaceae* and includes some valuable tree species like the Shea tree (*vitelaria paradoxum*) and the Néré (*parkia biglobosa*). (GEF, 2009)[250]

[248] https://www.preventionweb.net/files/8562_ner01e.pdf
[249] https://www.preventionweb.net/files/8562_ner01e.pdf
[250] https://www.ifad.org/ru/web/knowledge/publication/asset/39571603

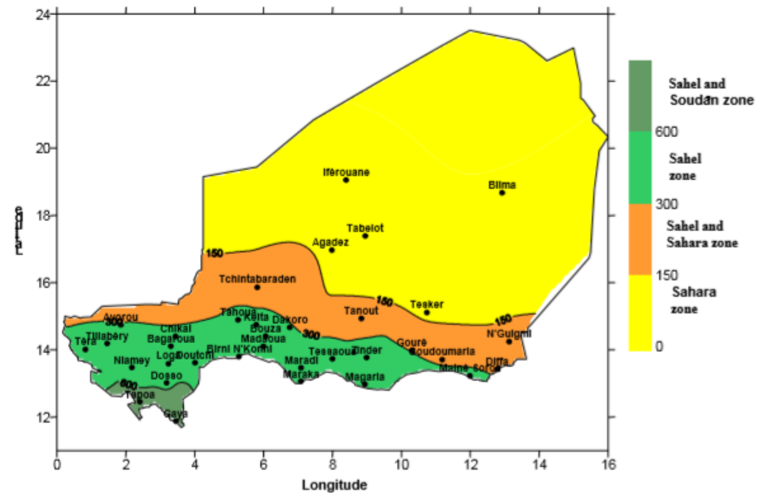



**Figure 5a: Climatic zones in Niger (GoNiger, 2006)**[251]

### 5.5.1.3 Agriculture and rural livelihoods

276. Nigerian agriculture is primarily rainfed and characterized by low productivity, low technology and high labour intensity.2 Since 2005, the value added of the agricultural sector has been growing rapidly, averaging about 7 percent annually.3 Sorghum, millet and maize are the traditional food crops in the north, whereas in the central and southern regions, cassava, yam, plantain, maize and sorghum are traditionally consumed. Rice is an essential cash crop mainly for smallscale producers, who account for 80 percent of total production but only 20 percent of consumption. Cash crops, which earned significant revenue before the oil boom of the 1970s, have experienced low investment. Prioritizing the oil sector at the expense of agriculture resulted in leaving Nigeria highly vulnerable to fluctuating oil prices on the world market. (FAO, 2017b)[252]

277. Low productivity agriculture, fragile and endangered natural resources. Food crops (millet, sorghum, rice, maize, etc.) and cash crops (onion, peanut, sesame, nutmeg, cowpea) are the basis of production systems. The herd is made up of nearly 9 million cattle, 11 million sheep, 13 million goats and 1.7 million camels (2009). For 50 years, yields have increased little and food production has been maintained by an increase in cultivated area from 3.15 million hectares in 1961 to 7.25 million hectares in 2010, and a significant extension of the agricultural frontier to the semi-arid lands of the North reducing rangeland. (FIDA, 2012)

[251] https://www.preventionweb.net/files/8562_ner01e.pdf
[252] http://www.fao.org/3/a-i7675e.pdf

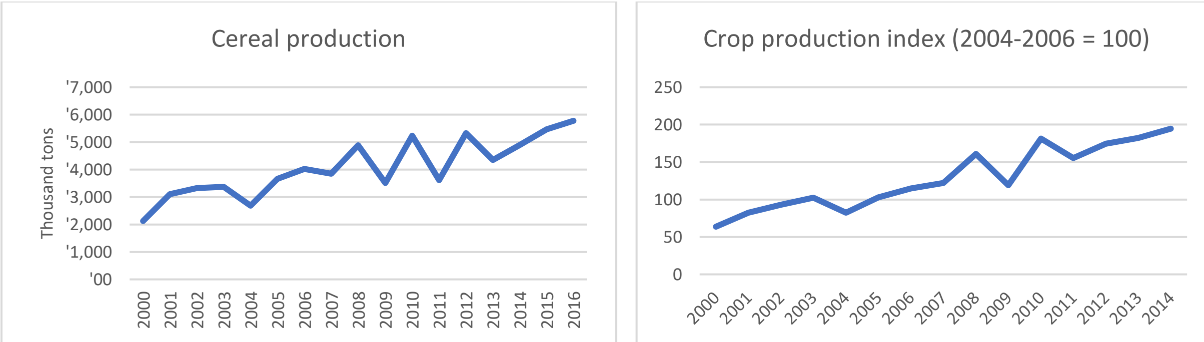



**Figure 5b: Total cereal production and crop production index Niger (World Bank, 2018a)[253]**

278. Agriculture is deeply interconnected with weather and climate, the main drivers of agricultural production, therefore the variability of food production. In west Africa, the high variability of rainfall worsen by climate changes directly or indirectly impacts many sectors of the economy and can burden food security and lead to severe human losses (Anyamba et al. 2014).

279. The onset and the length of the rainy season, and the dry spell length during the growing season are key agrometeorological factors affecting crop production in West Africa. In addition, the occurrence of climate chocs such as drought or flood can annihilate the production system. changes in the onset, duration, and end of the rainy seasons have already affected planting patterns and the farming calendar. With climate change, onset and cessation are projected to get later, with the entire wet season shifting 5–10 days later in the calendar year over West Africa (Dunning et al, 2018).

**Table 5b. Average relative yield change (in percentage) with reference to the control period (1986 – 2005) for various management conditions: the current management conditions (without (-CO2) and with (+CO2) the CO2 fertilization), Improved soil fertility and optimal management conditions for the two scenarios (RCP 4.5 and 8.5)**

| Station | Management condition | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Current | | Improved | Optimal | Current | | Improved | Optimal |
| | -$CO_2$ | +$CO_2$ | | | -$CO_2$ | +$CO_2$ | | |
| | Moderate scenario (RCP 4.5) | | | | Pessimistic scenario (RCP 8.5) | | | |
| Time horizon 2030 (period 2021 – 2040) | | | | | | | | |
| **Irrigated tomato** | | | | | | | | |
| Zinder | *(- 21)* | - 9 | + 7 | + 83 | - 22 | - 10 | + 7 | + 84 |
| Kita | *(- 15)* | - 4 | + 9 | + 139 | - 14 | 0 | + 11 | + 143 |
| Yakro | *(- 21)* | - 10 | + 8 | + 85 | - 23 | - 11 | + 8 | + 85 |
| **Irrigated rice** | | | | | | | | |
| Yakro | *(- 18)* | - 7 | + 9 | + 90 | - 19 | - 6 | + 11 | + 92 |
| Sapu | *(- 17)* | - 5 | + 11 | + 45 | - 17 | - 5 | + 12 | + 47 |
| **Irrigated maize** | | | | | | | | |
| Maradi | *(- 10)* | - 6 | - 2 | + 142 | - 8 | - 6 | - 3 | + 140 |
| **Rainfed rice** | | | | | | | | |
| Kita | *(- 25)* | - 14 | + 6 | + 182 | - 31 | - 20 | - 2 | + 170 |
| **Rainfed maize** | | | | | | | | |
| Kita | *(- 6)* | - 3 | + 1 | + 70 | - 5 | - 5 | + 2 | + 72 |

253 https://data.worldbank.org/

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kerewan | *(- 7)* | - 4 | 0 | + 198 | - 6 | - 3 | 0 | + 195 |
| **Rainfed sorghum** | | | | | | | | |
| Tahoua | *(- 74)* | - 78 | - 70 | - 59 | -62 | - 57 | - 22 | - 2 |
| **Time horizon 2050 (period 2041 – 2060)** | | | | | | | | |
| **Irrigated tomato** | | | | | | | | |
| Zinder | *(- 25)* | - 11 | + 8 | + 86 | - 27 | - 13 | + 5 | + 79 |
| Kita | *(- 17)* | + 4 | + 14 | + 148 | - 20 | - 2 | + 11 | + 140 |
| Yakro | *(- 23)* | - 9 | + 10 | + 89 | - 26 | - 13 | + 6 | + 80 |
| **Irrigated rice** | | | | | | | | |
| Yakro | *(- 22)* | - 7 | + 13 | + 95 | - 23 | - 7 | + 10 | + 92 |
| Sapu | *(- 20)* | + 13 | + 13 | + 48 | - 22 | - 6 | + 11 | + 46 |
| **Irrigated maize** | | | | | | | | |
| Maradi | *(- 12)* | - 8 | - 3 | + 139 | - 12 | - 10 | - 8 | + 126 |
| **Rainfed rice** | | | | | | | | |
| Kita | *(- 26)* | - 12 | + 10 | + 192 | - 29 | - 14 | + 10 | + 165 |
| **Rainfed maize** | | | | | | | | |
| Kita | *(- 8)* | - 5 | 0 | + 65 | - 7 | - 4 | - 1 | + 65 |
| Kerewan | *(- 10)* | - 7 | 0 | + 195 | - 7 | - 6 | - 3 | + 185 |
| **Rainfed sorghum** | | | | | | | | |
| Tahoua | *(- 73)* | - 62 | - 53 | - 45 | - 78 | - 73 | - 65 | - 63 |

### 5.5.2 Climate change

280. The major portion of the Niger Basin that is outside of the Sahelian zone is in the humid tropical zone of southern Nigeria, a region already facing high temperatures and levels of precipitation. While climate models differ, some projections suggest that Nigeria may experience an increase in both rainfall and temperature (Podesta and Ogden, 2008) as well as a rise in the frequency and intensity of extreme weather events, such as floods and droughts (Ministry of Environment of the Federal Republic of Nigeria, 2003). The extreme variability of the basin's climate, and the likely long-term evolution of the warming effect of increases in global greenhouse gases, means that one single climatic future for the basin is unlikely. Moreover, any shift to drier or wetter conditions is likely to be reversed at some point in the future. (USAID, 2011a)[254]

#### 5.5.2.1 Temperature

281. The country's climate is of the arid and semi-arid tropical type. Niger is indeed in one of the hottest areas of the globe. There are four types of seasons. A cold season (December to February) characterized by cool nights with temperatures as low as 0 ° C. A hot, dry season (March to May) with warm winds and temperatures that sometimes peak above 45 ° C. During this season, the harmattan (hot and dry wind) of moderate speed (5 to 10 m / s) blowing from the Northeast or East remains dominant throughout the country. A rainy season (June to September) characterized by often stormy rains, high humidity and average temperature between 28.1 and 31.7 ° C. The monsoon (humid wind) blowing from South-West to North-East remains dominant over most of the country. Wind speed is generally low to moderate (2 to 8 m / s) during this period, but maximum instantaneous winds (gusts) can be observed with velocities greater than 40 m / s when passing grain lines moving from east to west. And lastly, a warm season without rain (October to December), with a maximum relative humidity of between 28 and 59%; while the minimum value varies between 9 and 24% and an average

[254] https://reliefweb.int/sites/reliefweb.int/files/resources/201112NigerClimateChange_FINAL.pdf

temperature of 35 ° C. Records of recorded temperatures are -2.4 ° C (observed on January 13, 1995 in Bilma) for minimum temperatures and 49.5 ° C (observed on September 07, 1978 in Diffa) for maximum temperatures. (RdN, 2016)[255]

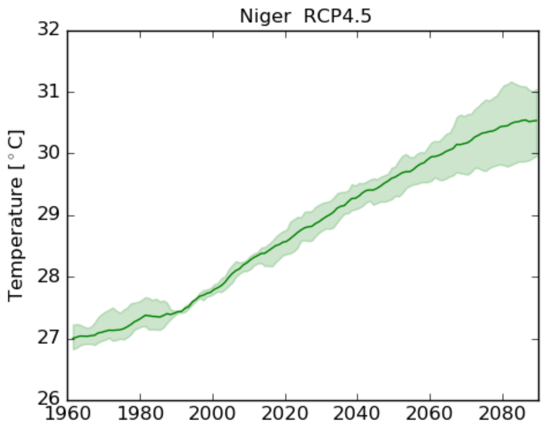
282. Niger, along with other countries in the Sahel experienced decreasing rainfall throughout the 1960s, 70s and 80s which caused severe drought and led to catastrophic failure of harvests, malnutrition and starvation. Particularly severe droughts occurred in 1966-1967, 1973-1974 and 1983-1984. Rainfall has recovered slightly since the late 1980s, however is still well below the pre-1960s level, and the drought of 2004-2005 shows that Niger is still very vulnerable to weak rains. The variability of the rains is compounded by the fact that only 12% of Niger's soils are suitable for agricultural production, the majority (over 60%) of the population live on less than $1/day and high population growth is putting increasing pressure on already fragile ecosystems and leading to problems of desertification. Many pastoral communities have been forced to become semi-agricultural because of the prolonged droughts, thus losing their way of life. (weADAPT, 2011)[256]

*Projections on temperature*

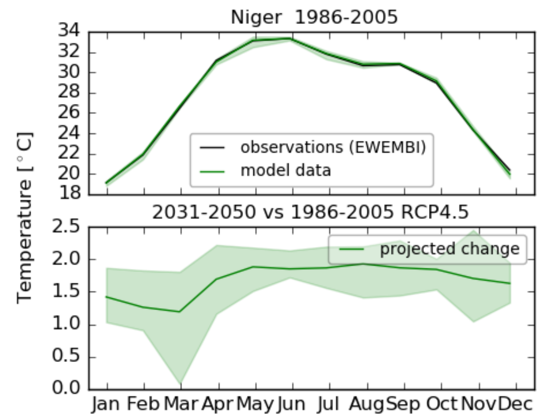
283. There is a strong consensus that increases in Sahelian temperatures will continue. Downscaled climate model projections for Niamey covering the period 2040-2060 compared to 1980-2000 anticipate an increase of between 1°C and 3°C. These projections indicate that Niger is likely to face difficult climate challenges ahead, with perhaps more total rainfall than in some previous decades but punctuated by unpredictability, soaring temperatures, dry spells, and intense storms. (GlobalSecurity, 2017)[257]

284. The following graphics projecting temperatures in Niger are based on a Climate Analytics Tool that analyses climate projections on the national scale[258].

[255] https://unfccc.int/sites/default/files/resource/nernc3_0.pdf
[256] https://www.weadapt.org/knowledge-base/national-adaptation-planning/niger
[257] https://www.globalsecurity.org/military/world/africa/ne-climate.htm
[258] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.5.2.1: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[259]**

### 5.5.2.2 Precipitation

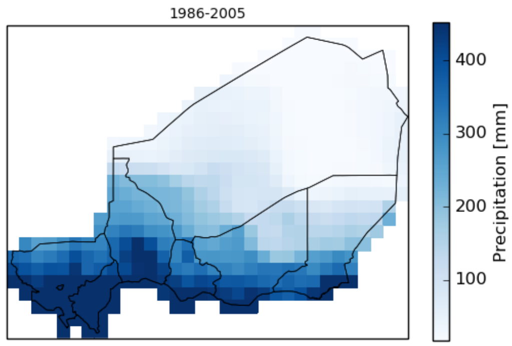
285. Precipitation has experienced in recent decades, chronic disturbances of great magnitude. The analysis of their evolution over the period 1961-2010 shows a significant decrease in rainfall since 1970 and which has continued until beginning of the 1990s, with a long deficit period between 1980 and 1990. The corresponding rainfall deficit is on average around 20%, but may exceed 30% in the west and center; a clear tendency for isohyets to slide south up to 150 km. In addition, there is a slight wet trend that began in 1990 in the Saharan and while the Sahel-Sudan zone shows a general tendency to stabilization over the same period. Furthermore, observations indicate a decreasing rainfall variability towards the South and an upward trend in temperatures at all stations, with however, a moderate increase on the Niamey and Tahoua stations. (RdN, 2016)[260]

286. The following graphics on precipitation in Niger are based on a Climate Analytics Tool that analyses climate projections on the national scale[261]. For precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.

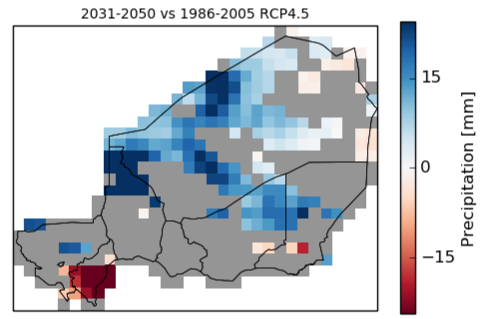
[259] Niger Climate Analytics tool

[260] https://unfccc.int/sites/default/files/resource/nernc3_0.pdf

[261] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model- disagreement is found are colored in gray. The projections are based on the emission scenario RCP4

**Figure 5.5.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[262].**

*Projections on precipitation*

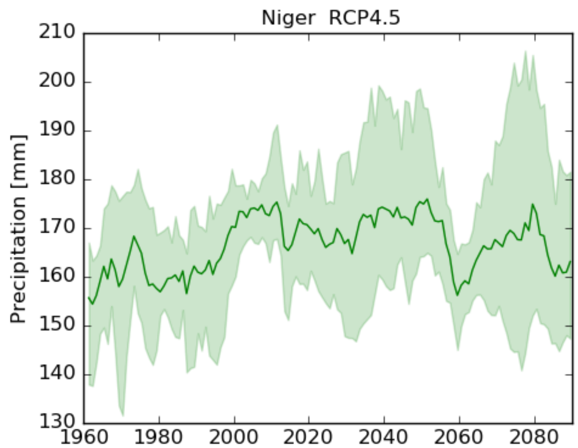
287. At sub regional, national or local scale, the high variability of rainfall and the very sparse observation network makes predictions of future climate changes difficult and uncertain. The projections given by the SDSM model for the 2050 horizon indicate, compared to the reference period 1961-1990 significant increases in cumulative rainfall by 2050 for Tahoua, Konni, Zinder, Mainé, Agadez and especially Tillabéri. Slight decreases in accumulations on the other hand are projected at the Gaya, Niamey and Maradi. But the relatively high rate of these declines is to be taken with precaution because it involves only low rainfall amounts (some millimeters). A later start of the rainy season on all the areas considered and a small variation in the duration of dry weather throughout the rainy season. Overall, a net increase in evapotranspiration in Niamey, Zinder, Tahoua and Tillabéri and an increase in number and frequency of extreme events (temperatures and rains) at all stations. Tillaberi has by far the higher increases, especially in terms of extreme rainfall. Increasing extreme temperatures can reach 3.3 ° C. (RdN, 2016)[263]

288. The following graphics projecting precipitation in Niger are based on a Climate Analytics Tool that analyses climate projections on the national scale[264].

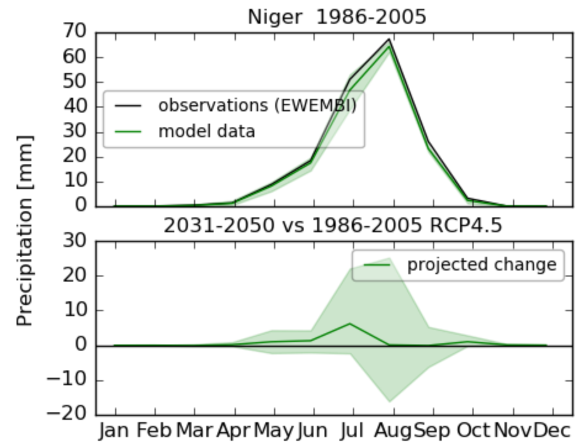
[28] Mauritania Climate Analytics tool

[263] https://unfccc.int/sites/default/files/resource/nernc3_0.pdf

[264] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.5.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[265]**

#### 5.5.2.3 Climate change impacts, climatic hazards and extreme events

289. Available evidence shows that the isohyets that delimit the agro-climatic zones shifted southward by 100–200 kilometers from 1950–90, following a decline in rainfall, with a prolonged period of below average rainfall from 1970–90. Recent analysis of long-term rainfall trends showed that this trend had reversed, with average rainfall increasing again since the 1990s. This suggests that the rainfall isohyets of 350–400 millimeters, which delimit the zones where crop production is viable, are shifting north again. As a result, the area suitable for crop production may have increased since the 1990s. (GlobalSecurity, 2017)[266]

290. While the country has received an increase in total rainfall since the 1990s, the 21st century has seen the return of a series of droughts and severe food insecurity in 2005, 2010, and 2012. Researchers also have noted what they characterize as changes in seasonal patterns (late arrival and early cessation of rains) and intense rain events. There is not a strong consensus about future rainfall in the Sahel, but scientists have recently suggested the likelihood of a somewhat wetter Sahel, with more variable precipitation on all time scales, from intra-seasonal to multi-decadal, and projected increases in daily rainfall intensity rather than frequency. (GlobalSecurity, 2017)[267]

*Projections on climate impacts*

[265] Niger Climate Analytics tool
[266] https://www.globalsecurity.org/military/world/africa/ne-climate.htm
[267] https://www.globalsecurity.org/military/world/africa/ne-climate.htm

291. Floods are a recurrent natural hazard in Niger and are projected to increase in frequency in the future, especially in the southern part of the country. They have negative impacts on agriculture, food security, GDP, endemic diseases (malaria), and contribute to rural poverty. Sandstorms are a frequent extreme event that hits Niger and adversely affects agriculture, livestock, water resources public health, and human life. Droughts are projected to increase in frequency in the coming century. Development of an early warning system, better water management, and dissemination of meteorological data will help decrease the population's vulnerability to this extreme event. (World Bank , 2018d)[268]

#### 5.5.2.4 Local dynamics in the global context: predictions for Africa

292. As in other countries in W. Africa, climate projections are uncertain regarding the change in rainfall that will occur. There is also a certain amount of confusion regarding exact changes in temperature, although it is clear that temperatures are expected to increase. The NAPA relies on the MAGICC/SCENGEN model and reports that maximum temperatures could increase by 2.9C in July in Maradi by 2025. This seems high compared to the results of downscaled models for Maradi for the period 2046-2065, which give changes in the range of +1-3C for July. Using a range of models provides a more robust estimate of change, so in this document it is estimated that both minimum and maximum temperatures in Niger will rise in the range of 1-4C for the period 2046-2065, when compared to the period 1960-1990. (weADAPT, 2011)[269]

293. Projections for precipitation change in West Africa should be 'treated with caution' (IPCC 2007) due to the range of results given by different models, and the inability of many models to accurately reproduce many elements of the region's climate, such as the recurring droughts of the 1970s. Model projections range from a large decrease to a large increase in precipitation over Niger, and it is difficult to draw robust conclusions from these projections. Station-level results for Maradi in the south of the country are discussed below, and illustrate the uncertainty in projections of precipitation. Given the uncertainty the best course of action is to plan for activities which reduce vulnerability to current climate variability, such as water harvesting techniques, and which will be useful in the future regardless of the direction of change. (weADAPT, 2011)[270]

### 5.5.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

294. Niger, owing to its climatic, institutional, livelihood, economic, and environmental context, is one of the most vulnerable countries of the world. Poverty is pervasive in Niger and it ranks low on almost all the human development indicators. Agriculture is the most important sector of Niger's economy and accounts for over 40 percent of national gross domestic product (GDP) and is the principle source of livelihoods for over 80 percent of the country's population. (GlobalSecurity, 2017)[271]

#### 5.5.3.1 Climate change impacts on agriculture

295. Excess agricultural production until the beginning of the 1970s, covered at the end of the 1980s only 86% of the food needs to become structurally deficit these days mainly because of the droughts. This deficit is related to the decrease in precipitation confirmed by the DMN since the last three decades. The study on the vulnerability of the agricultural sector has shown that the evolution of the

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268 http://sdwebx.worldbank.org/climateportalb/home.cfm?page=country_profile&CCode=NER&ThisTab=RiskOverview

269 https://www.weadapt.org/knowledge-base/national-adaptation-planning/niger
270 https://www.weadapt.org/knowledge-base/national-adaptation-planning/niger
271 https://www.globalsecurity.org/military/world/africa/ne-climate.htm

yields of millet crops are subject to a high interannual variability linked to many factors, including variations in the rainfall regime. Droughts and floods also have a negative impact on agriculture. There are various climate related impacts on the agriculture sector. Changes in climate are facilitating the upsurge of pests such as Desert Locusts, Grasshoppers, Leaf Miner caterpillars, etc. In addition, high interannual variability causes yield reductions and loss of crop production and hence increased food insecurity and malnutrition. The insecurity of food supply necessitates increased imports and food aid, which increases Niger's dependency on its neighbors and the international community. Furthermore, the increasing frequency of extreme events facilitates the erosion of productive lands and silting of rivers and causes damages to agricultural infrastructure. (RdN, 2016)[272]

296. In the dry scenario, from 2011 to 2050, the years with annual rainfall deficit compared to the normal annual rainfall over the period 1961-1990, will be predominant. The potential impacts of climate change related to this situation include a reduction in the length of the agricultural season combined with an increasing frequency of dry days during the agricultural season. The appearance of crop pests such as leaf caterpillars when several consecutive dry days occur at the time of heading of millet. Inadequate water conditions to meet the water needs of crops during their development cycle, leading to the decrease and / or total loss of agricultural production and hence reinforces food insecurity with its various socio-economic consequences.

297. In the wet scenario from 2011 to 2050, the years with excess annual rainfall compared to the normal annual rainfall over the period 1961-1990, will prevail. The potential impacts of climate change related to this situation include the abundance of rainfall with many positive potential effects that can contribute to the improvement of agricultural production and an increased frequency of flooding of crop areas. Asphyxiation and decrease in plant development due to excess water, which will increase the occurrence of diseases and some pests of crops related to excess water conditions. Floods cause damages to homes and infrastructure and lead the reduction and / or total loss of agricultural production, livestock and sometimes even human lives in the areas affected by the floods. The recrudescence of pests and climate-sensitive diseases of crops, which will increase food insecurity with its various socio-economic consequences in areas affected by floods. (RdN, 2016)[273]

298. The figure below presents IFAD CARD for Niger to explore the effects of climate change on the yield of major crops.

[272] https://unfccc.int/sites/default/files/resource/nernc3_0.pdf
[273] https://unfccc.int/sites/default/files/resource/nernc3_0.pdf

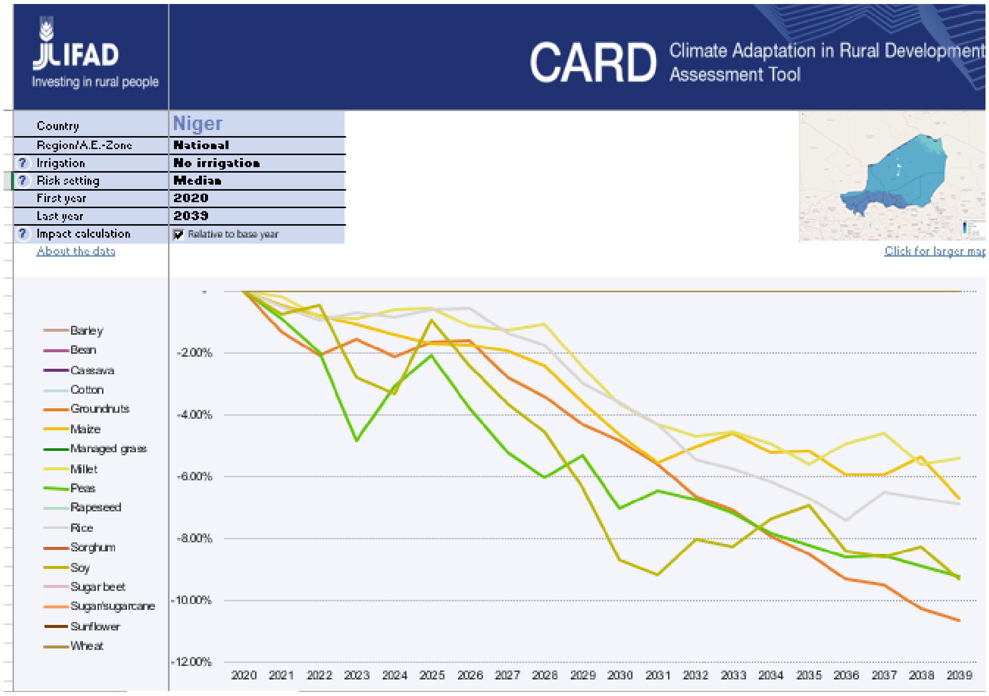


Figure 5.5.3.1: CARD for Niger
(Please refer to the “Climate change impacts on crop yield in specific targeted regions” document to see projections for each country region)

#### 5.5.3.2 Climate change impacts on natural capital

299. In Niger, recurring droughts have had irreversible consequences on the state of forest potential, affecting both the adaptability of forest species and their productivity. These extreme events, which have exacerbated aridity with the warming trend of the last forty (40) years, have probably contributed to profound disturbances in the dynamics of forest ecosystem functioning. Indeed, the degradation of forest resources in Niger has accelerated with the main consequences, the reduction and fragmentation of forest areas, the low natural regeneration and the reduction of biological diversity as well as the low productivity of forested forests often in uncultivated land. The factors of this degradation are mainly anthropic and climatic. More generally, climate change will increase the effects of all factors of desertification, which may become irreversible, especially as the environment becomes drier and soils are degraded by erosion and settlement. (RdN, 2016)[274]

#### 5.5.3.3 Climate change impacts on water

300. The most likely impacts are a further decline in the flows of the Niger River in Niamey, in relation with the decline in inflows from the Guinean flood. An increase in the volume and peak flow of the local flood, which will become more and more widespread, as observed in recent years. An increase in flows in small endoreic basins and tributaries of the right bank of the river, in relation to the anthropogenic pressure on the vegetation cover that modifies the surface states. An increase in the solid load of the flows, especially those coming from small watersheds, in connection with the aggravation of erosion due to deforestation; a decrease in the filling of lakes and dams. On the other hand, in small endoreic basins, the increase in flows and the solid load will induce a surplus of solid inputs at the level of water bodies, with significant risks of siltation. A rise in water temperature that would lead to a decline in the quality of surface water. In secondary streams, this effect could be partially offset by increased flows.

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274 https://unfccc.int/sites/default/files/resource/nernc3_0.pdf

On the other hand, in the river, the decrease of the flows could accentuate that of the water quality, which would increase the concentrations of chemical elements rejected by the industries in the city of Niamey. A shift in the hydrological regime of the river and its main tributaries on the right bank (ie the Sirba) which would continue, with peak flows from the Guinean flood in Niamey which will be shifted from February / March to December / January, or even November / December in the case of the most unfavorable scenarios. An increase in the magnitude and frequency of floods, particularly in the southern part of the country. This increase will result from the expected increase in the frequency of heavy rainfall events. Increased evaporation in line with rising temperatures, which could reduce low flow (i.e. river). (RdN, 2016)[275]

301. Concerning groundwater resources, Niger is likely to experience very significant reduction in aquifer recharge in large sedimentary basins. Their vulnerability will be accentuated by anthropogenic pressure on land and abstraction for irrigation. The increase in groundwater recharge and the increase of their piezometric levels in endorheic basins where flows could increase. A decrease or increase in the input of groundwater to the watercourse depending on the increase or decrease in recharge. The increase or reduction of groundwater resources in relation to the evolution of recharge. Lastly, the deterioration of water quality in relation to the rise or fall in groundwater recharge. The increase in flows in deforested areas favors soil leaching and the concentration of pollutants towards areas of depressions favorable to recharge. Pollution is transferred to the aquifer through the unsaturated zone. In urban areas, the poorly controlled development of housing areas and inadequate sanitation will increase pressure on water resources. (RdN, 2016)[276]

#### 5.5.3.4 Climate change impacts on health

302. For the 2030-2050 decade, the Third National Communication of Niger indicated that the dry scenario projects an increase in malaria of 13.88 ‰ over the 2001-2012 reference period. The range of likelihood is between 13.81 and 14.02 ‰. The wet scenario projects an increase in meningitis and measles respectively of the order of 2.19 ‰ and 1.76 ‰ for the same period. By 2050, if nothing is done, the number of cases of malaria would increase by about 50% and that of meningitis and measles by 76.79% and 9.74% respectively. Therefore, forecasts of future morbidity trends by 2050 predict, compared to the period 2001-2012 an increase in the order of 50% of morbidities due to malaria in the case of Dry Scenario. An approximate 77% increase in morbidity due to meningitis in the Wet scenario and an almost 10% increase in measles morbidities for Wet Scenario. (RdN, 2016)[277]

### 5.5.4 Vulnerability ranking and Mapping

303. The situation of chronic food insecurity that affects the country has profoundly undermined the means 80% of Niger's population is composed of farmers and pastoralists. Every year, between 15 to 20% of the population (2 to 3 million people) are food insecure - even in the year surplus production. According to the results of the regional technical meetings validated during the national meeting of synthesis of evaluation of the food, nutritional and pastoral situation of the year 2012 held in Maradi from 23 to 24 November 2012, One hundred and eighty-five areas grouping together 3243 villages with an estimated population of 2,483,051 will be vulnerable to food insecurity 2013. (RdN, 2013)[278]

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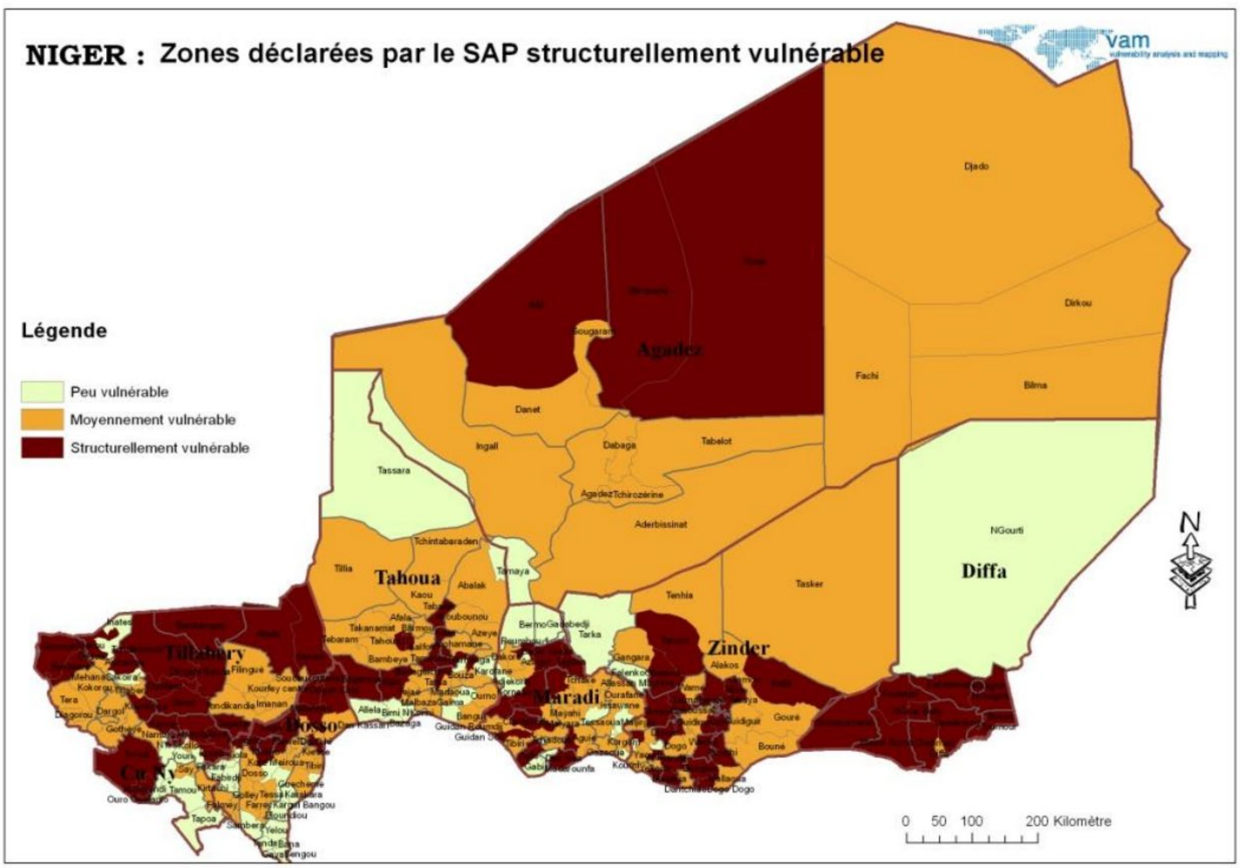
275 https://unfccc.int/sites/default/files/resource/nernc3_0.pdf
276 https://unfccc.int/sites/default/files/resource/nernc3_0.pdf
277 https://unfccc.int/sites/default/files/resource/nernc3_0.pdf
278 https://www.undp.org/content/dam/niger/docs/Publications/UNDP-NE-PLAN-NATIONAL-CONTINGENCE2013.pdf

304. In addition to food, nutrition and armed conflict issues in the subregion, Niger has was also a victim in 2012 of unprecedented floods, which affected more than half a million people people. These floods have seriously damaged housing, public infrastructure, crops and caused about a hundred casualties. The unpredictability of rainfall seasonal, the continued degradation of the environment, the precariousness of living conditions combined the effects of climate change suggest large-scale floods in recent years to come up. Efforts to prevent preventable epidemics such as measles and poliomyelitis will continue with a limited success. Cholera and malaria will increase in prevalence from year to year due to poor hygiene conditions and limited access to health services, inadequate access to safe drinking water, high promiscuity and inadequate prevention measures. (RdN, 2013)[279]

305. Locust threat and other crop pests, as well as bush fires, conflicts between farmers- and pastoralists are regular in Niger. These plagues can affect the same families during the same year, and also several years right now. Their livelihoods are continually degrading and then disappearing for some the population and their resilience diminished or lost. For these households or communities, it is necessary set up multiannual recovery programs to enable them to again the path of sustainable development. (RdN, 2013)[280]




[279] https://www.undp.org/content/dam/niger/docs/Publications/UNDP-NE-PLAN-NATIONAL-CONTINGENCE2013.pdf
[280] https://www.undp.org/content/dam/niger/docs/Publications/UNDP-NE-PLAN-NATIONAL-CONTINGENCE2013.pdf

**Figure 5.5.4: Structural vulnerability zones in Niger (RdN, 2013)**[281]

(SAP = Système d'Alerte Précoce et Prévention)

[281] https://www.undp.org/content/dam/niger/docs/Publications/UNDP-NE-PLAN-NATIONAL-CONTINGENCE2013.pdf

### 5.5.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| Forestry | Land management | Development and implementation of natural forest management and management plans. Intensification and diversification of agricultural production systems integrating climate change considerations through the dissemination of appropriate techniques for improving soil fertility, diversification of production and land security. |
| | Reforestation | Development and implementation of extensive reforestation, siltation, degraded land reclamation, assisted regeneration of agroforestry parks and enhancement of natural forest formations. |
| | Capacity building | The training of forest managers in the techniques of inventories, mapping and monitoring of resources (GIS, GPS ...) with a view to better knowledge and control of forest areas. The establishment of a functional monitoring and evaluation system for forest resources. Sensitization, training and mobilization of populations for the development of agroforestry and for a rational and participative management of their forest areas integrated into local development programs. |
| Water | Supply management | Mobilization of surface water for the increase of agricultural production and for the recharge of groundwater and the rehabilitation and strengthening of the national surface water monitoring system. The rehabilitation and reinforcement of the national system for the qualitative and quantitative monitoring of groundwater, especially alluvial aquifers and large aquifers (Illumenden, Lake Chad) in relation to the countries concerned |
| | Ecosystem restoration | Bank protection and the rehabilitation of silted ponds and regeneration of degraded natural environment of watersheds through the introduction of plant species better adapted to new conditions. |
| | Demand management | Establishing a balance between the availability of water resources and the water requirements for irrigation and the consumption of populations and livestock. Improving the knowledge of large fossil aquifers (Continental Intercalaire, Continental Hamadien, Air Paleozoic aquifers) with a view to their balanced exploitation, and in order to locate other aquifers that can be put into exploitation in the zones. urgent needs (basement areas, areas with large access depths, etc.). |
| Health | Early warning system | The establishment of a weather watch and warning system. |
| | Capacity building | Examining the factors that influence current coping capacity, including physiological, psychological (knowledge, beliefs, attitudes) and socio-economic factors, as well as the characteristics of the health system. |
| | Monitoring | The progressive implementation of biological and health monitoring measures as means of adaptation to climate change. |
| Agriculture | Increase resilience of the agriculture sector | Includes the use of improved varieties of medium or short cycle crops adapted to climatic conditions and the supply of agricultural inputs and the technical supervision of agricultural producers in order to carry out the cultivation work in good conditions. |
| | Irrigation management | The use of irrigated cultivation as a result of the supply of food to needy populations throughout the irrigated season, combined with the promotion of small irrigation with water saving (example: drip). |

| Sector | Adaptation mechanism | Description |
|---|---|---|
| | | Additionally, the mobilization of runoff water and its recovery for irrigated crops, especially market gardening and the realization of Hydro-Agricultural Improvements (AHA) where possible. |
| | Pest management | Fight against climate-sensitive enemies and diseases of crops. |
| | Disaster management | Construction of appropriate structures to protect crop areas against floods and the establishment of farmers' insurance system against risks. |
| | Meteorological services | Meteorological services to agricultural producers through the provision of products and information for decision support in the conduct of agricultural activities for rainfed and irrigated crops. |
| | Capacity building | Capacity building of specialized agents for technology transfer in agricultural production and food technology. |

**Table 5.5.5: Adaptation options by sector (RdN, 2016)[282]**

306. Improving land quality and living standards of the rural population in Niger requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of degraded lands in Mauritania to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country (figure 5.5.5). These zones are located in the South-East of the country, in the regions of Dallol Bosso, Tillabéri and Dosso. The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

307. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Niger, the national Land Determined Neutrality (LDN) targets and measures that stop land degradation in the country as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Niger.

282 https://unfccc.int/sites/default/files/resource/nernc3_0.pdf

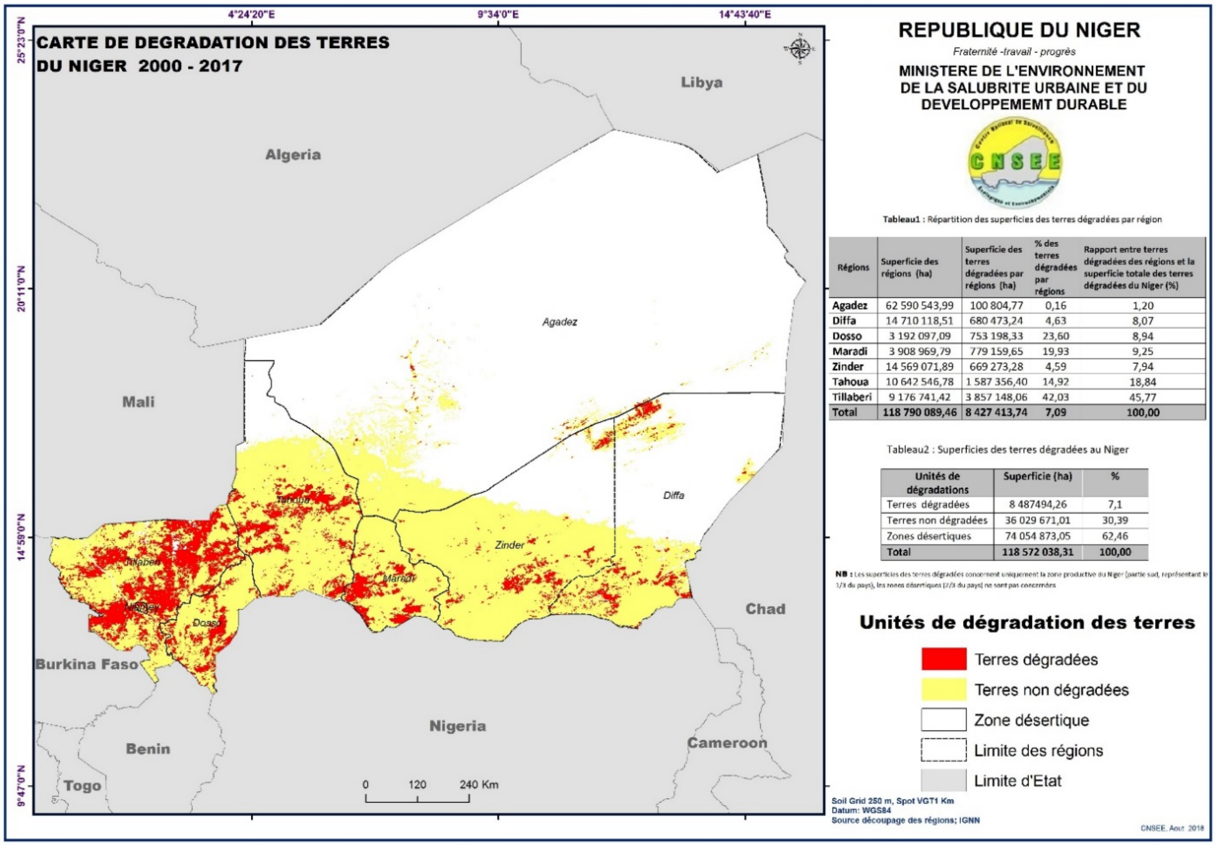



**Figure 5.5.5. : Map of degraded lands in Niger, 2001-2017 (ONDD, 2018)**

### 5.6 Senegal

#### 5.6.1 Country Background: Development Context and Challenges

308. Senegal aspires to become an emerging country by 2035. The country's economic growth started to increase in 2014 and 2015, with strong growth of 6.5%, its best performance since 2003. The main drivers of growth is strong demand from the private sector, stimulated by low energy and transport prices, as well as the ambitious public investment program put in place by the Government in 2015. At the sectoral level, services remain the main driver of growth contributing to more than a third of this economic expansion. The industry accounted for 23%, thanks to the chemical and real estate industries. The agricultural sector contributed 34% of Gross Domestic Product (GDP) in 2015 thanks to good rainfall and programs for rice and horticultural production. (FIDA, 2018)[283]

309. The population of Senegal reached 15.26 million in 2017 with a growth rate of 2.6% per year. The demographic profile illustrates the numerical importance of women (52%) and a relatively young structure with 50% of the population under 16 years of age. It is predominantly rural but with rapid urbanization and a rural exodus of young people. The proportion of the poor population has decreased from 67.9% in 1994 to 46.7% in 2011 (ESPS II, 2011)[284] but is declining more slowly in rural than in urban areas. A dual challenge for the rural world is to: (i) feed a population that is growing rapidly in a context where environmental issues and climate change are increasingly penalizing agricultural production, as well as ensuring food security and capture opportunities in the domestic and regional markets; and (ii) create new agricultural and non-agricultural employment opportunities for young people. (FIDA, 2018)[285]

##### 5.6.1.1 Income and poverty

310. At the end of 2015, the Senegalese Government announced 6.5% growth driven by agriculture and the secondary sector; in addition, the budget deficit has been reduced from 6.7 to 4.7% as a result of investment efforts. However, the announced growth rate has failed to reduce the endemic poverty rate estimated at About 46% placing the country among the 25 poorest countries in the world, and that despite all the average growth rate of 7.1% set by the PES Priority Action Plan for the period 2014-2018 has not been achieved. (FIDA, 2018)[286]

311. In 2014, the World Bank's report on the economic situation in Senegal showed that the poverty rate is estimated at 33% in Senegal, based on the international threshold of $ 1.25 per day and per capita, showing that Senegal has experienced a slowdown in poverty reduction over the last five years. The Senegalese economy has fallen back into a weak growth equilibrium, with low job creation and little progress in reducing poverty, especially in rural areas where the reduction in cultivated land, the lack of use of certified seeds and the lack of access to certified seeds. Irregular rainfall was the main cause of deficits in agricultural production. This has helped to accentuate the vulnerabilities in rural areas, which account for 94% of the vulnerable compared to only 4% in the other cities and 2% in Dakar. (FIDA, 2018)[287]

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[283] https://www.ifad.org/en/web/operations/project/id/2000001616
[284] http://anads.ansd.sn/index.php/catalog/17
[285] https://www.ifad.org/en/web/operations/project/id/2000001616
[286] https://www.ifad.org/en/web/operations/project/id/2000001616
[287] https://www.ifad.org/en/web/operations/project/id/2000001616

### 5.6.1.2 Temperature, rainfall, seasons and agro-climate zones

312. Senegal's environment is arid, yet vulnerable to pluviometric variations, with serious pressure being put on natural resources by the poor-resources population. The influence of climate and hydrology as well as the nature of the soil determine several areas of vegetation. The country is divided in four agro-climatic zones: In the north of the country, the Sahelian zone, north of Saint-Louis' region, is covered with sparse vegetation dominated by thorny trees or shrub steppe; The wooded savannah, rich in fauna, characterizes the Sudanian zones, in the regions of Fatick and Kaolack, north and center of Tambacounda region; The thick forest and the most humid zone is located in the Guinean zone, including the North of Ziguinchor and Kolda region; The sahelo-sudanian zone, in the regions of Dakar, Thiès, Diourbel, Louga, Matam, consist of trees and dry steppe; and finally the sudano-guinean zone, in the North of Ziguinchor and Kolda and the South of Tambacounda, is made up of forests and very thick savannas. (GoS, 2006)[288]

313. Senegal has the Sudano-Sahelian type of climate that is characterized by the alternation between the dry season, from November to May, and the rainy season from June to October. The analysis of climate data over the last ten years (2005-2014) in the PARFA project area shows: (i) a decline in rainfall, which varies from region to region from 0 to 9 mm /year; and (ii) a drop in temperature, which varies from 0.1 to 0.25°C over ten years. The temperature analysis shows a 30-year increase in temperature, from about 0.1 to 0.5°C per decade in the PARFA area. (FIDA, 2015c)[289]

314. On the eco-geographic level (Figure 6a), criteria that take into account a set of biophysical and socio-economic factors have made it possible to group more or less homogeneous spaces from an integrated development perspective. Thus, Senegal is subdivided from north to south, into 7 agroecological zones, namely: River (Fleuve in French), Niayes, North Bassin arachidier, South Bassin arachidier, sylvo-pastoral zone, Oriental Senegal and Haute Casamance and Basse and Moyenne Casamance. (GoS, 2006)[290]


**Figure 5.6.1.2: Eco-geographic zones in Senegal (COSOP Senegal 2019-2024)**

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[288] https://www.preventionweb.net/english/policies/v.php?id=8570&cid=151
[289] https://www.ifad.org/en/web/operations/project/id/1100001693
[290] https://www.preventionweb.net/english/policies/v.php?id=8570&cid=151

#### 5.6.1.3 Agriculture and rural livelihoods

315. Senegalese agriculture is mainly rain-fed and seasonal. It is based on both cash crops (peanuts, cotton, sesame) and subsistence food crops (millet, sorghum, maize). Rice, a traditional crop in Casamance, is growing strongly in the Senegal River valley, in the south of the country and in the center thanks to rainfed rice varieties. The peanut sector, long the engine of the Senegalese economy is in a phase of recovery after a major crisis. On the other hand, production increases in cereals (millet, rice, maize), fruits and vegetables, and cassava, responding to growing local demand. (FIDA, 2018)[291]

316. With the development of irrigation, especially in the Senegal River Valley, the performance of the rice sector has improved. Production of millet, a traditional rainfed crop that had declined sharply, is also on the rise in terms of self-consumption and marketing. Micro and small enterprises play a central role in boosting domestic production for urban consumer markets. The vast majority of agricultural producers are small farmers who cultivate land on traditional land tenure and practice traditional crop rotation. Most of them combine cash crops and subsistence food crops, while possessing a few animals, extensive and, in rare cases, intensive farming. Horticulture is developing in the Niayes zone (along the coast) and in the irrigated lands along the Senegal River where rice cultivation has also developed strongly. (FIDA, 2018)[292]

317. Livestock is an important sector of the Senegalese economy because of its contribution to the household food and nutritional security and the creation of wealth. It is practiced according to three main systems: (i) the predominantly pastoral system practiced over large areas and based on herd mobility to limit the effects of climatic constraints, (ii) the agro-pastoral system which concerns 67% of cattle and 62% of small ruminants in areas such as the Groundnut Basin, Senegal River Valley, Eastern Senegal and Casamance, and (iii) the intensive system of private and state structures supported by large investments. (FIDA, 2018)[293]

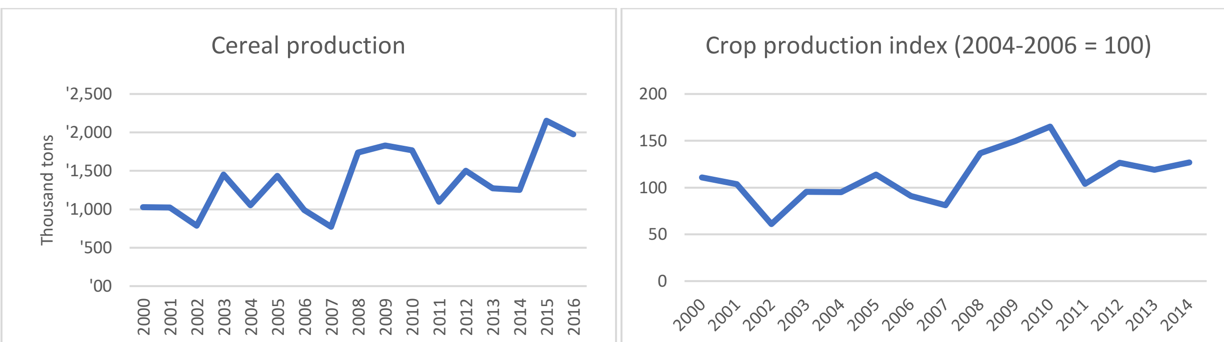



**Figure 5.6.1.3: Total cereal production and crop production index Senegal (World Bank, 2018a)[294]**

### 5.6.2 Climate change

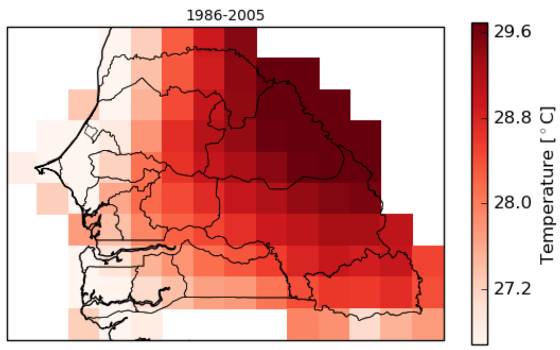
318. Rainfall is relatively high and dependable in the south, but in the north the climatic shift it has experienced during the past 25 years has resulted in crop and livestock production becoming even more difficult, as desertification extends further into the country from the Sahara. Like its neighboring countries, Senegal was hit by serious drought in the late 1960s which has affected the country's ecology and environment. Average annual rainfall and agricultural production have decreased, livestock mortality has increased, and the country's forest resources are disappearing. (UNDP, 2018d)[295]

[291] https://www.ifad.org/en/web/operations/project/id/2000001616
[292] https://www.ifad.org/en/web/operations/project/id/2000001616
[293] https://www.ifad.org/en/web/operations/project/id/2000001616
[294] https://data.worldbank.org/
[295] http://www.adaptation-undp.org/explore/western-africa/senegal

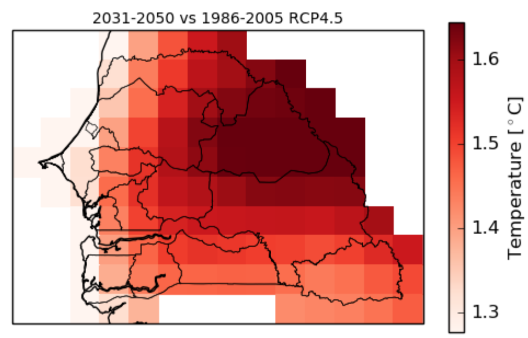
### 5.6.2.1 Temperature

319. Mean annual temperature has increased by 0.9°C since 1960, an average rate of 0.20°C per decade. The rate of increase is most rapid in OND, at 0.29°C per decade. There are insufficient daily temperature observations available from which to identify trends in most daily temperature extremes. Available data indicates that the average number of 'hot' nights per year increased by 27 (an additional 7.3% of nights) between 1960 and 2003. (UNDP, 2015h)[296]

320. The following graphics on temperature in Senegal are based on a Climate Analytics Tool that analyses climate projections on the national scale[297]. For the reference period map on temperature indicators, hotter regions are darker than cooler regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.6.2.1a: Temperature average over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[298].**

*Projections on temperature*

321. The mean annual temperature is projected to increase by 1.1 to 3.1°C by the 2060s, and 1.7 to 4.9°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.0-2.5°C. The projected rate of warming is faster in the interior regions of Senegal than in those areas closer to the coast. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annually, projections indicate that 'hot' days will occur on

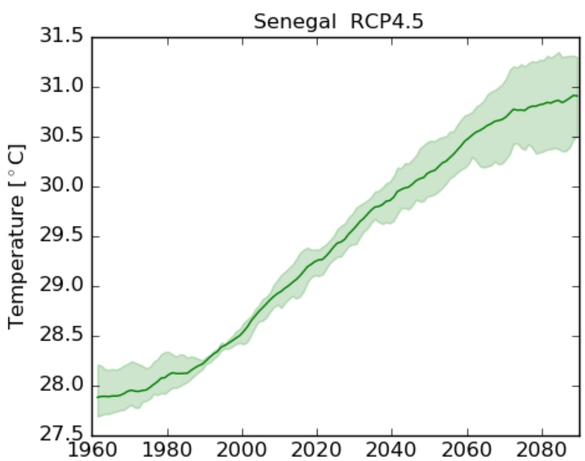
[296] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[297] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

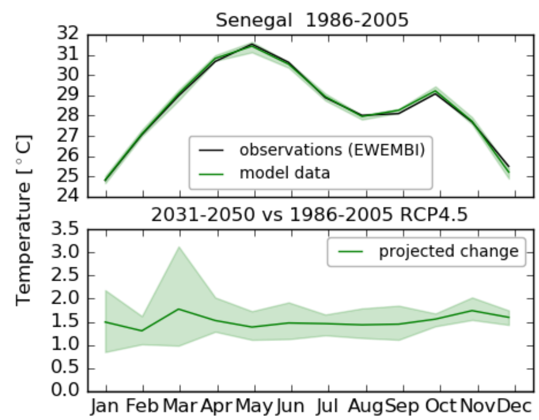
[298] Senegal Climate Analytics tool

22-46% of days by the 2060s, and 29-67% of days by the 2090s. Days considered ‘hot’ by current climate standards for their season are may increase most rapidly in JAS, but the range between model projections is large, occurring on 33-96% of days of the season by the 2090s. Nights that are considered ‘hot’ for the annual climate of 1970-99 are projected to occur on 27-51% of nights by the 2060s and 37-70% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in JAS, occurring on 65-99% of nights in every season by the 2090s. Projected increases in hot days and nights are more rapid in the south and east of the country than the north and west. All projections indicate decreases in the frequency of days and nights that are considered ‘cold’ in current climate. ‘Cold’ days occur on less than 3% of days by the 2090s, and ‘cold’ nights less than 2% of nights. ‘Cold’ nights do not occur at all by the 2090s in any projections under the highest emissions scenario (A2). (UNDP, 2015h)[299]

322. The following graphics projecting precipitations in Senegal are based on a Climate Analytics Tool that analyses climate projections on the national scale[300].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.6.2.1b: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[301]**

[299] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

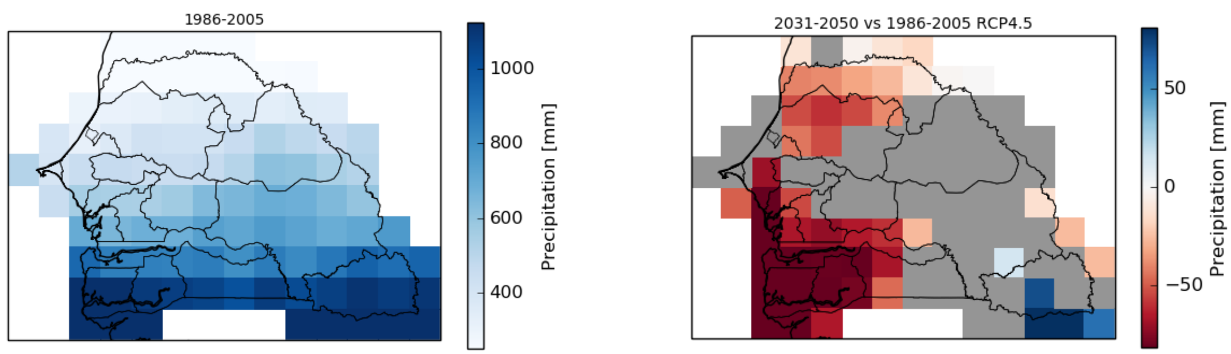
[300] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[301] Senegal Climate Analytics tool

### 5.6.2.2 Precipitation

323. Sahelian rainfall is characterized by high variability on inter-annual and inter-decadal timescales, which can make long-term trends difficult to identify. A period of particularly high rainfall occurred in the early 1960s, whilst the early 80s were particularly dry. Statistically significant decreases of around 10 to 15mm per decade have, however, been observed in the southern regions of Senegal in the wet season (JAS) between 1960 and 2006. Some unusually high rainfalls have occurred in the dry season (JFM) in very recent years (2000-2006), but this has not been part of a consistent trend. There are insufficient daily rainfall observations available from which to determine changes in extremes indices of daily rainfall. (UNDP, 2015h)[302]

324. The following graphics on precipitation in Senegal ad are based on a Climate Analytics Tool that analyses climate projections on the national scale[303]. For precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.

Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model- disagreement is found are colored in gray. The projections are based on the emission scenario RCP.

**Figure 5.6.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[304].**

*Projections on precipitation*

325. Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of changes in precipitation for Senegal, but tend towards decreases, particularly in the wet season, JAS. Projected annual change ranges from -38 to +21% by the 2090s, with ensemble means between +7 and -18%. Projected JAS changes ranges from -41 to +48% by the 2090s, with ensemble means between -3 and -18%. Despite the projected decreases in total rainfall, the proportion of total annual rainfall that falls in heavy4 events tends towards increases in the

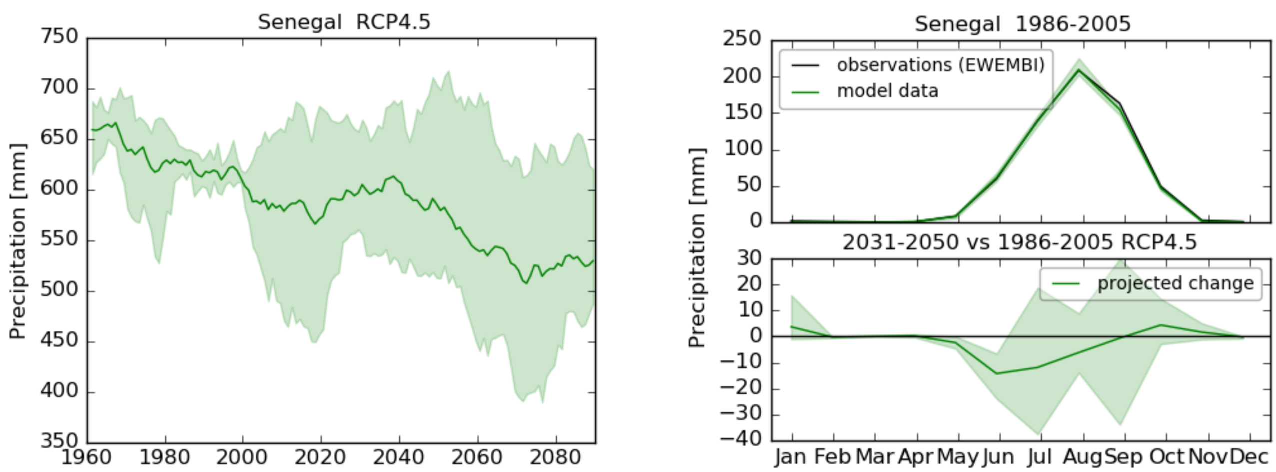
[302] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[303] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[44] Senegal Climate Analytics tool

ensemble projections. Seasonally, this varies between tendencies to decrease in JFM and AMJ, and to increase in JAS and OND. The range of projections from different models in the ensemble, however, includes both increases and decreases in all seasons. 1- and 5-day rainfall maxima in projections all tend towards increases in JAS and OND. The range of changes in projections from the model ensemble covers both increases and decreases in most seasons. (UNDP, 2015h)[305]

326. The following graphics on projecting precipitation in Senegal are based on a Climate Analytics Tool that analyses climate projections on the national scale[306].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.6.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[307]**

### 5.6.2.3 Climate change impacts, climatic hazards and extreme events

327. Senegal is vulnerable to several natural hazards, particularly coastal erosion, droughts, floods, and locust invasions. Flooding annually affects about 200,000 people and has an $89 million impact, with large-scale flooding in 2009 largely in the Dakar region causing about $104 million in damages and losses. Flood risk is exacerbated by rapid urbanization, insufficient drainage, and poor sewage infrastructure, which has resulted in the settling of low-lying areas and a reduction in soil infiltration

[305] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[306] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[307] Senegal Climate Analytics tool

potential. Droughts generally impact the arid and semi-arid Sahelian regions (northern Senegal) every three to four years. Since 1980, droughts have affected more than 3 million people. (GFDRR, 2017)[308]

328. Climate change is exacerbating hazard risk in Senegal. Rising sea levels and increasingly intense storms are the primary causes of coastal erosion and flood risks. About 74 percent of the coastal-area housing stock is vulnerable to erosion. Sea levels are projected to rise up to one meter by 2100, potentially putting more than 100,000 people in low-lying areas at greater risk for flooding. (GFDRR, 2017)[309]

*Projections on climate impacts*

329. Floods linked to climate disruption will result in damages to crops that do not support flooding, higher incidence of plant diseases in general, a deterioration of the health status of the livestock. The acceleration of current soil degradation in a context of changes in temperature and precipitation is a threat that can lead to greater mineralization of organic matter following a rise in temperature. Soil degradation affects the ability of soils to retain water and plant nutrients. Furthermore, it can cause a greater intrusion of seawater following rising sea levels in estuarine areas will contribute to the degradation of the physio-chemical properties of soils. (RdS, 2015)[310]

### 5.6.3 Vulnerabilities and Exposure to Climate Change: Key Impacts to lives and livelihoods

330. Being a Sahelian country located, on the edge of the largest desert in the world, the Sahara, the problem of water constitutes a major development challenge for Senegal. This issue is growing in a context of change where projections predict extreme events related to water (drought and flood).

#### 5.6.3.1 Climate change impacts on agriculture

331. The current vulnerability of Senegalese agriculture is mainly linked to its heavy dependence on rainfall, the inter-annual variability of which is difficult to predict. Extended rainfall breaks during the cycle can compromise harvests and affect crop yields. (RdS, 2015)[311]

332. Livestock is also affected by the effects of climate change. Forage resources are already experiencing quantitative and qualitative degradation due to the water deficit which limits the primary productivity of pastures. The less palatable species of livestock are generally the most resistant species and take over the most useful species. The effects will be felt on the production of meat, milk and herd survival. The climatic disturbances led to less reliability of the traditional indicators which guided the breeders in their movements in space and time. (RdS, 2015)[312]

333. Traditional rice cultivation, already heavily penalized by soil and water salinity, which has considerably reduced the area under cultivation in the Fatick, Kaolack, Ziguinchor and Kolda regions, will also be affected. Market gardening in the Niayes cuvettes is also exposed to the risk of saltwater intrusion. The negative effects of climate change on Senegalese agriculture will be felt more by the

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[308] https://www.gfdrr.org/senegal
[309] https://www.gfdrr.org/senegal
[310] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015
[311] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015
[312] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

decline in farmers' incomes, which will be negatively impacted by both an increase in temperature and a decrease in rainfall. (RdS, 2015)[313]

334. The figure below presents IFAD CARD[314] for Senegal to explore the effects of climate change on the yield of major crops.

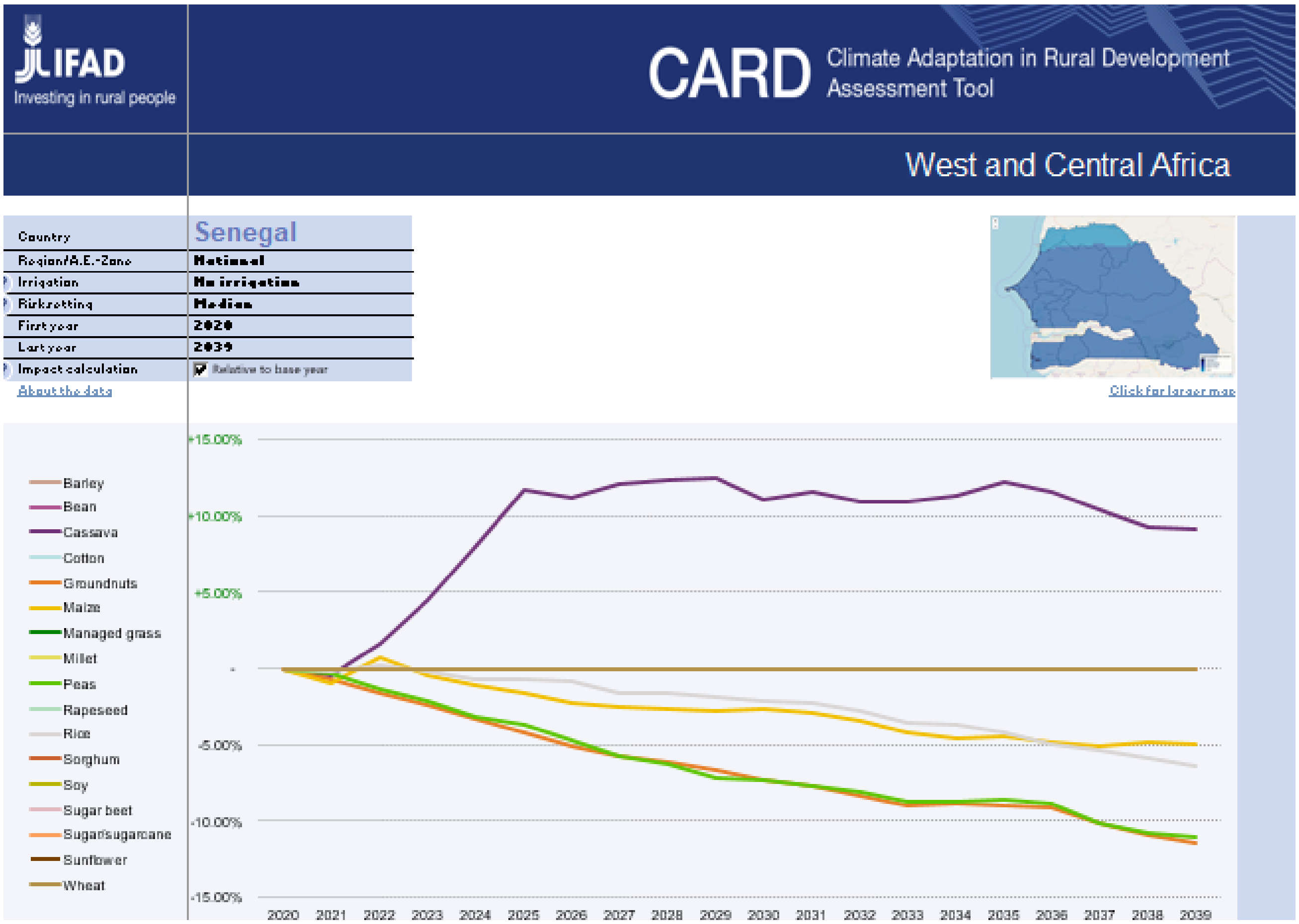

**Figure 5.3.3.1: CARD for Senegal**

(Please refer to the “Climate change impacts on crop yield in specific targeted regions” document to see projections for each country region)

### 5.6.3.2 Climate change impacts on natural capital

335. The Senegalese coast remains very vulnerable to the effects of climate change. Indeed, it concentrates a multitude of activities (economic, social, cultural) and particular ecosystems that are exposed to climate change, including coastal erosion. This exhibition also highlights the vulnerability of some human settlements and coastal sites that face severe marine intrusions in the form of floods and tidal waves.

[313] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[314] Climate Adaptation in Rural Development – Assessment Tool https://www.ifad.org/en/web/knowledge/publication/asset/41085709

336. Studies carried out on the vulnerability of Senegal's coastal zones to climate change (Dennis et al., 1995, Niang-Diop et al., 2000) have shown that sea level rise rates could lead to an acceleration of coastal erosion, flooding in low coastal areas (mangrove estuaries in particular) and increased salinization of soils and surface and groundwater. (RdS, 2015)[315]

#### 5.6.3.3 Climate change impacts on water

337. The vulnerability of water resources is a function of several parameters among which can be mentioned: rainfall variability, anthropogenic pressure, evapotranspiration, salinization, pollution, proliferation of aquatic invasive plants, etc. Water resources, although theoretically abundant in Senegal, are highly threatened, among other things, by wastage and / or non-rational management of irrigation networks (especially at the level of major irrigation systems such as the Senegal River Basin), by sedimentation and / or silting of rivers, lakes and ponds, floodplains and / or various types of pollution. (RdS, 2015)[316]

#### 5.6.3.4 Climate change impacts on health

338. It should be noted that airborne diseases, including acute respiratory infections (ARI) and cerebrospinal meningitis, have variable prevalence rates. ARIs are among the ten most prevalent diseases in Senegal. They contribute directly to mortality from cardiovascular or respiratory diseases, especially in the elderly, especially during heat waves. (RdS, 2015)[317]

339. With regard to cerebrospinal meningitis, there have been outbreaks of sero-type W135 in the subregion for a decade, with catastrophic consequences for the health of populations and state budgets. In Senegal, however, it is possible to point out a few imported cases that were quickly checked. (RdS, 2015)[318]

340. In Senegal, few epidemiological studies directly attribute changes in pathological patterns to observed changes in climate, particularly the recrudescence of malaria, which is still the first pathology. However, to assess the vulnerability of the sector, it is necessary to integrate in the analysis the results of climate scenarios to determine the evolutionary trends of development environments of these pathologies. (RdS, 2015)[319]

341. The analysis of health statistics reveals that vector-borne diseases (malaria and yellow fever), water-related diseases, including cholera and airborne diseases, including acute respiratory infections (ARI) are the most recurrent. All these diseases are among the ten most prevalent diseases in Senegal and cerebrospinal meningitis. With regard to malaria, the morbidity rates recorded in Senegal's health

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[315] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[316] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[317] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[318] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[319] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

facilities have significantly decreased. This significant reduction in morbidity could be attributed in part to the application of the various innovative strategies put in place by the NMCP and its partners. (RdS, 2015)[320]

### 5.6.4 Vulnerability ranking and Mapping

342. Senegal is vulnerable to drought, locust invasion, flooding and related health epidemics, sea-level rise, coastal erosion and its corollaries, and bush fire. Priority areas for research and adaptation measures include water infrastructure, coastal zones, and the agriculture sectors, with particular attention to reducing vulnerability to flooding and improving water management in the Senegal River basin. (World Bank, 2011b)[321]

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[320] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[321] http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_SEN.pdf

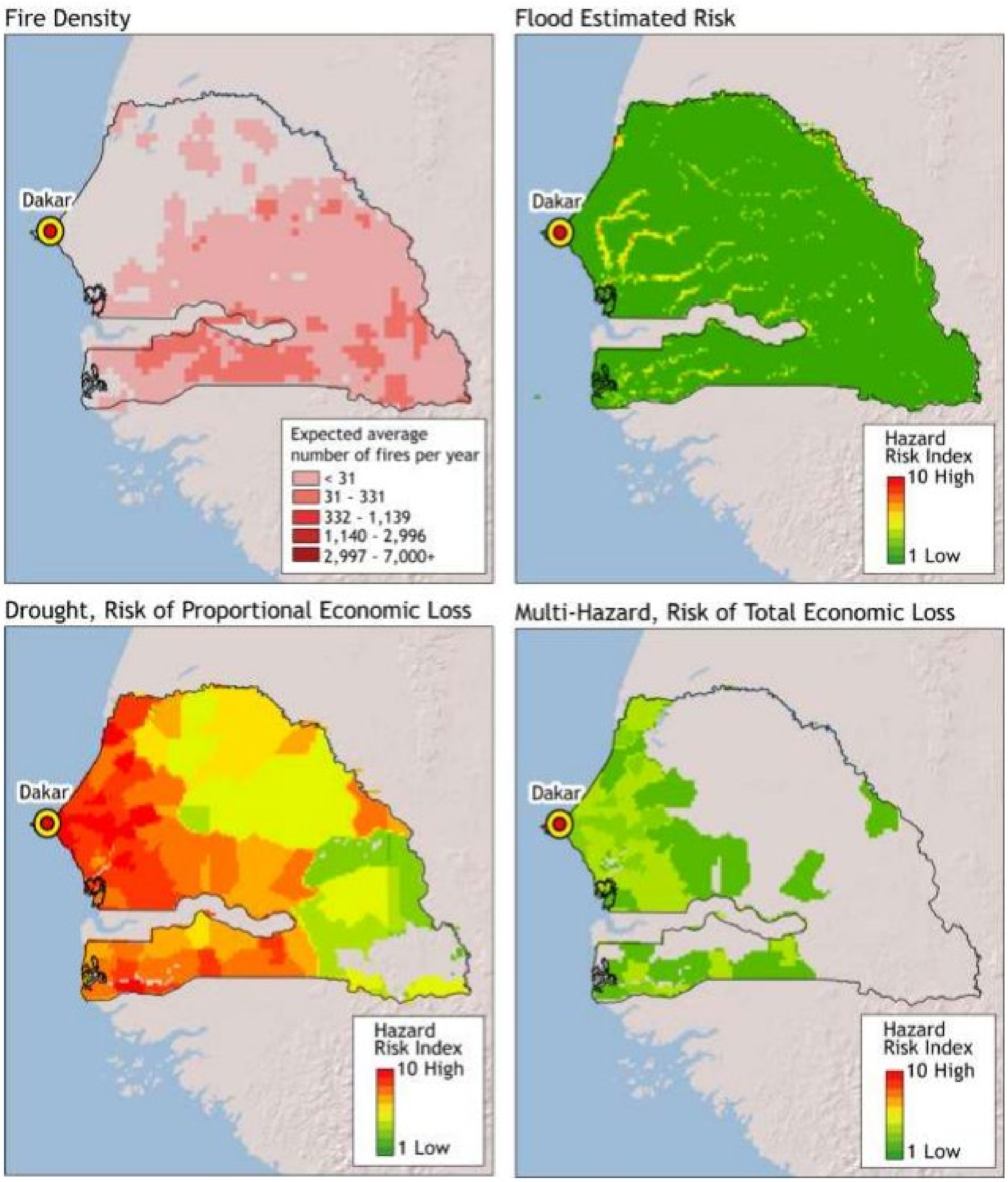


**Figure 5.6.4: Exposure to climate-related hazards across Senegal (World Bank, 2011b)**[322]

322
http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_SEN.pdf

### 5.6.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| **Water** | Increasing water resources | Among the identified actions for increasing water supply are the revitalization of the river system of lowlands, temporary pools and artificial lakes, storage of runoff water (Implementation of a storm water management strategy), reuse of wastewater, and the desalination of marine or brackish waters. |
| | Water management | The reduction of losses in urban and rural networks contributes to more economic water uses and increases water supply. |
| | Improving the efficiency of irrigation systems | Agriculture uses about 95% of all global freshwater withdrawals to meet current food demand. It is the sector that consumes the most water in Senegal. Improving the efficiency of irrigation systems should be a major objective in the search for climate change adaptation solutions to better fight against water wastage. |
| | Demand management policy | Despite the increase in drinking water production capacity, the Senegalese authorities foresee an imbalance between supply and demand by 2015. In order to cope with this, they have sought to improve demand management by implementing in place of a tariff policy. Senegal has hence chosen to adopt a progressive pricing of drinking water that depends on the volume of water consumed. |
| **Health** | Vector control | Among the prevention strategies defined by the WHO to fight effectively against malaria, Anti-Vector Control is the major component. The control plan developed in 2006 focused mainly on the use of impregnated mosquito nets and the introduction of Inner Spreading (AID) as a pilot project. |
| | Epidemiological surveillance | Early diagnosis and prompt treatment are the two essential components of any comprehensive strategy to reduce morbidity and mortality from malaria. The response to malaria epidemics and emergencies was considered a priority intervention in the two previous strategic plans but did not receive adequate implementation. |
| | Information, education and communication for behavioral change | In parallel with better environmental information for the health professions, health and environmental education remains a priority. Community mobilization in an appropriate way to guarantee the adoption of positive behaviors in the fight against these pathologies is one of the determining factors of adaptation strategies. Advocacy and multisectoral collaboration will mobilize sufficient resources for the implementation of activities. At the local level, community assessments of vulnerability and adaptation to the health impacts of climatic variations are crucial. |
| **Agriculture** | Increasing resilience | Reducing the impact of climatic, environmental, health and economic risks by controlling water, diversifying production, training rural people, in order to improve the food security of the population and ultimately achieve sovereignty food from Senegal. Introduce new species that are more tolerant to harsh climatic conditions and produce short-cycle cereal varieties adapted to local conditions from selected seeds. Promote sustainable and environmentally friendly farming practices such as: deep plowing techniques, crop rotation. |
| | Land management | Protection of the environment and sustainable management of natural resources, particularly through knowledge and improvement of soil fertility. |
| | Investments | Stimulating private investments in the agriculture sector to improve productivity and the livelihoods of farmers. Improving the environment and the quality of production so that agriculture is a |

| Sector | Adaptation mechanism | Description |
|---|---|---|
| | | driver of industrial and artisanal development to better meet the needs of the internal and external markets |
| | Increase productivity | Strengthening of equitable access to quality seeds and other inputs at remunerative prices |
| | Needs assessment and policy design | Improve the steering system of the agricultural sub-sector (by strengthening the dialogue between the State and farmers' organizations), adopt a new consensual land reform taking into account rural land, develop and implement a master plan agricultural statistics and the strengthening of the intervention capacities of management structures |
| | Erosion control and flood management | Various practices of erosion control (e.g. development of stone bunds). The setting of the dunes to protect the vegetable pans of the Niayes and the desalination of mangrove rice fields and restoration of salty soils. Setting up flood defenses and plant recession crops near watercourses. |
| | Capacity building | Provide agricultural research structures with appropriate resources (breeding and genetic improvement laboratory, plant and animal biotechnology laboratory, research station, etc.). Support climate data producing institutions to improve the weather warning system and crop forecasting. Revise the agricultural development policy with a view to better taking into account the impacts of climate change.<br>Train, educate farmers about climate change. |

**Table 5.6.5: Adaptation options by sector (RdS, 2015)[323]**

343. Improving land quality and living standards of the rural population in Senegal requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of degraded lands in red in Senegal to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country (figure 5.5.5). These zones include the regions of Thiès (bassin arachidier), Kaolack, Fatrick, Faffrine, Kolda (forest zone in the South) and Louga (sylvopastorale zone in Ferlo). The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

344. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will participate to the Nationally Determined Contributions (NDC) of Senegal, the national Land Determined Neutrality (LDN)[324] targets and measures that stop land degradation in the country as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in Senegal.

[323] https://www.cse.sn/index.php/publications/suivi-de-l-etat-de-l-environnement/rapports-sur-l-etat-de-l-environnement/send/13-rapports-sur-l-etat-de-l-environnement/39-rapport-sur-l-etat-de-l-environnement-edition-2015

[324] https://knowledge.unccd.int/sites/default/files/ldn_targets/senegal-ldn-country-report.pdf

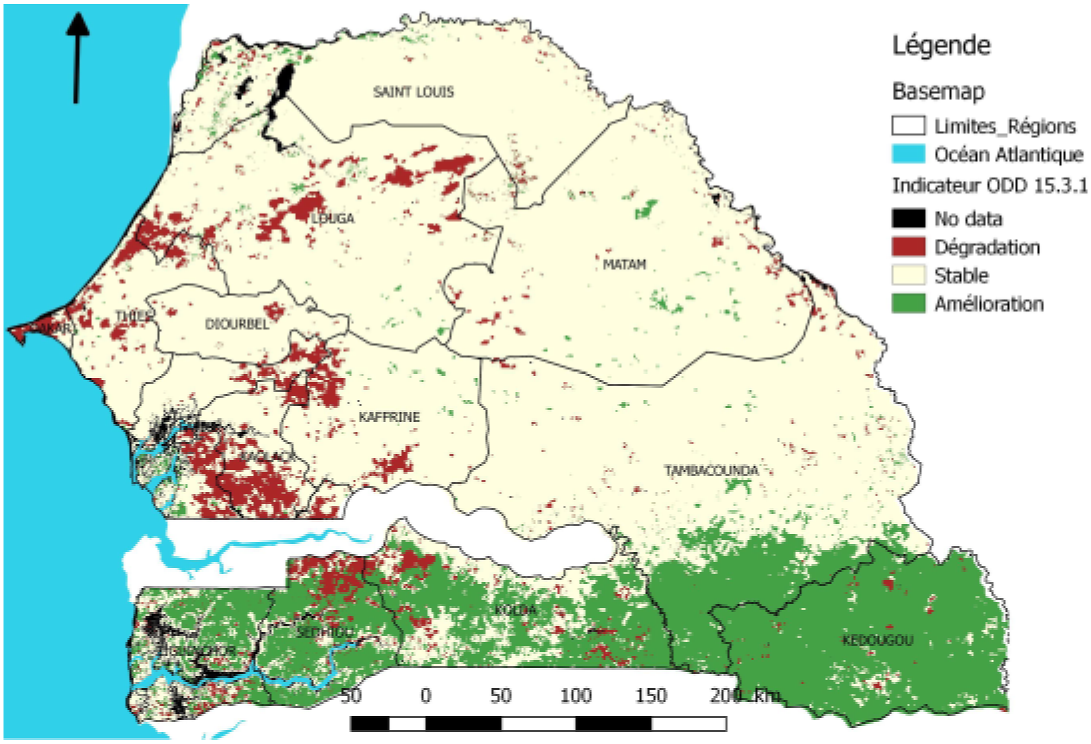


**Figure 5.6.5. Map of degraded lands in Senegal (PRAIS, 2018)**

## 5.7 The Gambia

### 5.7.1 Country Background: Development Context and Challenges

345. The Gambia has an estimated population of 1.88 million of which nearly half is rural and has greater incidence of poverty (2013 census). The main economic drivers in The Gambia are the services sector, accounting for approximately 58% of total output, followed by agriculture (30%) and industry (12%) respectively, (2nd National Communication). The potential contribution of the agricultural sector to Gross Domestic Product is limited by the rapid depletion of the natural resource base, the dependence on rainfed agriculture and the sensitivity and exposure to climate variability and change. (IFAD, 2015b)[325]

346. The Gambia experiences rapid depletion of the natural resource base as a result of increasing population pressure, extended periods of shifting cultivation, deforestation, recurrent droughts and increasing climate variability. Agricultural productivity is hindered by reduced water infiltration, high water run-off rates and the drying of inland valleys and river tributaries, which have been observed. Erosion and siltation of the Gambia River have reduced water flow and resulted in increased saltwater intrusion into the marginal lands. Siltation and sedimentation continue to threaten the viability and sustainability of lowland agriculture. These effects combined with periodic floods and epidemics place the country at risk to disasters. (IFAD, 2015b)[326]

#### 5.7.1.1 Income and poverty

347. The Gambia has a GDP per capita of USD 512 (2012) and is classified as a Low-Income Food Deficit Country, producing about 50% of total food consumption needs with the rest being met by commercial imports of rice and wheat flour coupled with food aid, (GNAIP 2011-2015). According to the World Bank database, the country has achieved the Millennium Development Goal (MDG) poverty reduction target at the poverty line of USD 1.25 but income inequality remains high in the country, especially in the rural areas, with high regional disparities based on a recent WFP assessment. (IFAD, 2015b)[327]

348. The national poverty rate was 48.4% in 2010, while the two predominantly rural regions Central River-North and Upper River had rates of 79% and 65.6% respectively, (Programme for Accelerated Growth and Employment –PAGE). Poverty is also more common when household heads are engaged in the agriculture and fishing sectors, which collectively employ almost 52% of the workforce. (IFAD, 2015b)[328]

#### 5.7.1.2 Temperature, rainfall, seasons and agro-climate zones

349. The Gambia has a Sudano-Sahelian climate, characterized by a long dry season (November to May) and a short-wet season (June to October). Average temperatures range from 18° to 30°C during the dry season and 23° to 33°C during the wet season. Mean annual temperature has increased noticeably since the 1940s. Mean annual rainfall varies from 900 mm in the south-west to about 500 mm in the northeast. Average relative humidity is about 68% in coastal areas and 41% in inland areas during the dry season and generally above 77% throughout the country during the wet season, (Agricultural National Appropriate Mitigation Actions). (IFAD, 2015b)[329]

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325 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
326 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
327 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
328 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
329 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f

In The Gambia the topography is largely unvaried consisting of riverine flats and mangrove swamps intersected by tidal creeks and savannah woodland with shrub and grass. Twenty per cent of the country is classified as wetlands (ARC, 2017)[330].

350. In the uplands the soil is largely cultivated under the responsibility of men. In this area the major crops are groundnuts (about 45 percent of the cultivated area), early millet, maize, sorghum, late millet, cotton and upland rice in decreasing order of importance; horticultural crops are also grown. The lowlands are largely the responsibility of women. The main crop is rice that is grown in the wet season using hand cultivation on approximately 20 000 ha, primarily along the middle and lower reaches of the River Gambia. In the dry season, vegetables are cultivated in the lowlands. In The Gambia the preferred staple food is rice which is usually cultivated as a subsistence crop (ARC, 2017)[331].

#### 5.7.1.3 Agriculture and rural livelihoods

351. Agriculture is the principal source of livelihood for the rural population and for the majority of households below the poverty line. The agriculture sector is characterized by: small-scale subsistence rainfed crop production mostly undertaken during a single rainy season from June to October; traditional livestock rearing; semi-commercial groundnut and horticultural production; small-scale cotton and a large artisanal fisheries subsector. Only about 6% of the irrigation potential has been utilized. (IFAD, 2015b)[332]

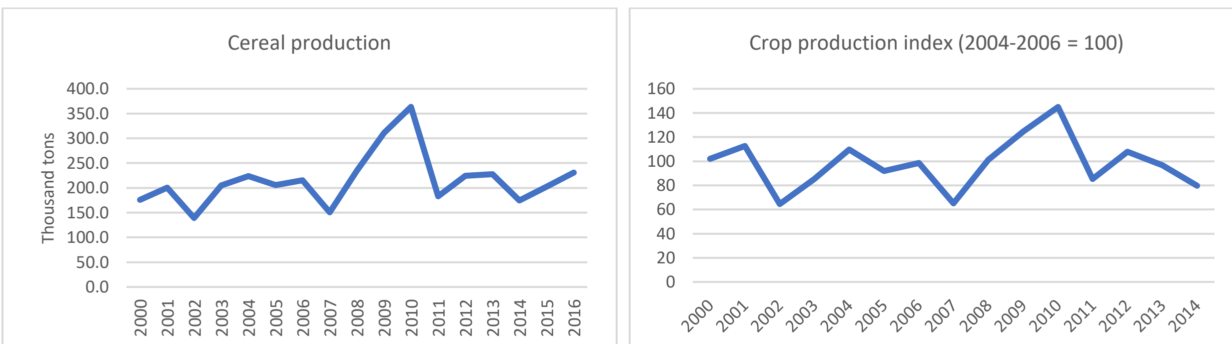


**Figure 6.7.1: Cereal production and crop production index The Gambia**

### 5.7.2 Climate change

352. According to Gambia's 2nd Communication to the UNFCCC, temperature measurements since the 1940s reveal a rising trend in the order of 0.5o°C/decade. The models agree that temperature increases will be significant with extremes in temperature becoming the norm and substantial increases in the number of hot days and nights by the 2090s, occurring more rapidly in the east of the country. The trend is consistent with the Intergovernmental Panel on Climate Change Assessment Report 5 (IPCC-AR5), which states that near surface temperatures over West Africa and the Sahel have increased over the last 50 years by 0.40° to 0.67°C per decade. In the AR5, temperatures in Africa are projected to rise faster than the global average increase during the 21st Century. (IFAD, 2015b)[333]

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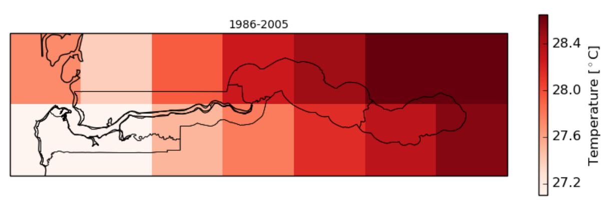
[330] The Gambia 2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/12/OP_Pool4_Gambia_OperationalPlan_2017.pdf
[331] The Gambia 2017 Operations Plans available at https://www.africanriskcapacity.org/wp-content/uploads/2018/12/OP_Pool4_Gambia_OperationalPlan_2017.pdf
[332] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[333] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f

#### 5.7.2.1 Temperature

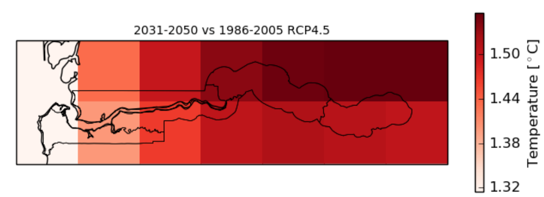
353. Temperatures in The Gambia generally increase from the coast towards the west. The exception to this is in the wet season, JAS, when the cooling influence of cloud and rainfall mean that all regions experience similar temperatures. In the hottest season, AMJ, the hottest (inland) regions have averages temperatures of up to 35°C, whilst the cooler coastal regions are 25 to 28°C. In the cooler seasons (OND and JFM) average temperatures can be below 25°C at the coast and up to 30°C in the west. Inter-annual variability in temperature in this region of Western Africa is caused by the El Niño Southern Oscillation (ENSO). In la Niña years, temperatures tend to be cooler than average throughout the year. (UNDP, 2012)[334]

354. Mean annual temperature has increased by 1.0°C since 1960, an average rate of 0.21°C per decade. The rate of increase is most rapid in OND, at 0.32°C per decade. There are insufficient daily temperature observations available from which to identify trends in most daily temperature extremes. However, available data indicate that the average number of 'hot' nights per year increased by 28 (an additional 7.8% of nights between 1960 and 2003. (UNDP, 2012)[335]

355. The following graphics on temperature in The Gambia are based on a Climate Analytics Tool that analyses climate projections on the national scale[336]. For the reference period map on temperature indicators, hotter regions are darker than cooler regions whereas for the projection map, changes towards warmer or drier conditions are colored in red.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model-disagreement is found are colored in gray. The projections are based on the emission scenario RCP4.5.

**Figure 5.7.2.1a: Temperature average over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period[337].**

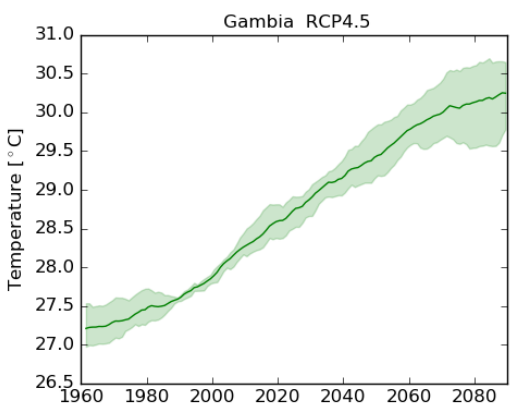
*Projections on temperature*

356. The mean annual temperature is projected to increase by 1.1 to 3.1°C by the 2060s, and 1.8 to 5.0°C by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.0-

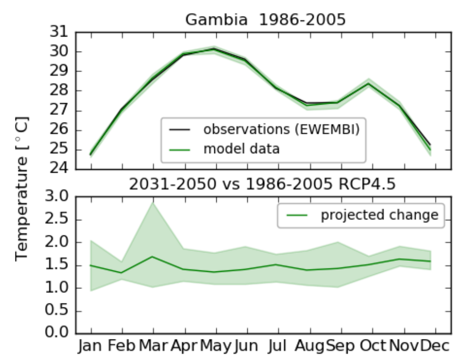
[334] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[335] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/
[336] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation
[337] Gambia Climate Analytics tool

2.0°C. The projected rate of warming is faster in the interior regions of The Gambia than in those areas closer to the coast. All projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate. Annually, projections indicate that 'hot' days will occur on 22-48% of days by the 2060s, and 25-69% of days by the 2090s. Days considered 'hot' by current climate standards for their season are may increase most rapidly in JAS, but the range between model projections is large, occurring on 26-99% of days of the season by the 2090s. Nights that are considered 'hot' for the annual climate of 1970-99 are projected to occur on 28-50% of nights by the 2060s and 36-69% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in JAS, occurring on 67-99% of nights in every season by the 2090s. Projected increases in hot days and nights are more rapid in the east of the country than the west. All projections indicate decreases in the frequency of days and nights that are considered 'cold'3 in current climate. Cold days occur on less than 3% of days by the 2090s, and cold nights less than 2% of nights. Cold nights do not occur at all by the 2090s in any projections under the highest emissions scenario (A2). (UNDP, 2012)[338]

357. The following graphics projecting precipitation in The Gambia are based on a Climate Analytics Tool that analyses climate projections on the national scale[339].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.6.2.1b: Regional climate model projections for temperature displayed as 20 year running mean (left). Annual cycle of temperature for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[340]**

[338] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[339] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

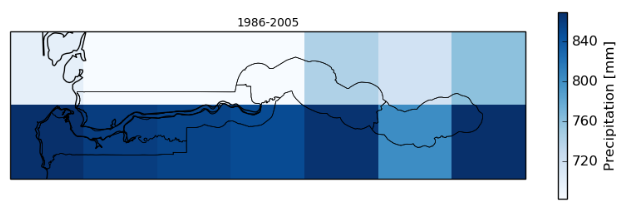
[340] Gambia Climate Analytics tool

### 5.7.2.2 Precipitation

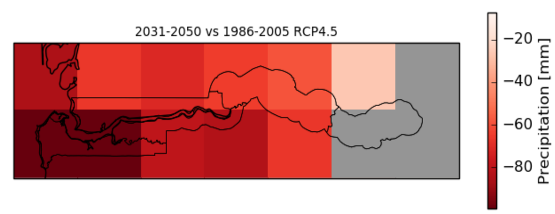
358. The Gambia has one wet season between July and September. There is a strong north-south gradient in total rainfall received at this time in this region of Africa, and this is evident even across the narrow latitudinal range of The Gambia. Mean monthly wet-season rainfall in The Gambia varies between 150 and 300mm between the northern and southern extremes. This rainfall season is controlled by the movement of the tropical rain belt (also known as the Inter-Tropical Conversion Zone, ITCZ) which oscillates between the northern and southern tropics over the course of a year, affecting The Gambia when it is in its northern position. Variation in the latitudinal movements of the ITCZ from one year to another causes large inter-annual variability in this wet-season rainfall. The most well documented cause of these variations is the El Niño Southern Oscillation (ENSO). El Niño events are associated with drier conditions in Sahelian Africa. (UNDP, 2012)[341]

359. Sahelian rainfall characterized by high variability on inter-annual and inter-decadal timescales, which can make long-term trends difficult to identify. A period of particularly high rainfall occurred in the early 1960s, whilst the early 80s were particularly dry. Linear trends do, however, indicate that wet season (JAS) rainfall in The Gambia has decreased significantly between 1960 and 2006, at an average rate of 8.8mm per month per decade. There are insufficient daily rainfall observations available from which to determine changes in extremes indices of daily rainfall. (UNDP, 2012)[342]

360. The following graphics on precipitation in The Gambia are based on a Climate Analytics Tool that analyses climate projections on the national scale[343]. For precipitation indicators, wetter regions are darker than drier regions whereas for the projection map, changes towards warmer or drier conditions are colored in red while changes towards cooler or wetter conditions are colored in blue.




This map is based on the EWEMBI dataset.




Here the ensemble mean of regional climate model projections is displayed. Grid-cells for which a model- disagreement is found are colored in gray. The projections are based on the emission scenario RCP.

**Figure 5.7.2.2a: Precipitation sum over the reference period 1986-2005 and projected change for 2031-2050 compared to the reference period 1986-2005[344]**

*Projections on precipitation*

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[341] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

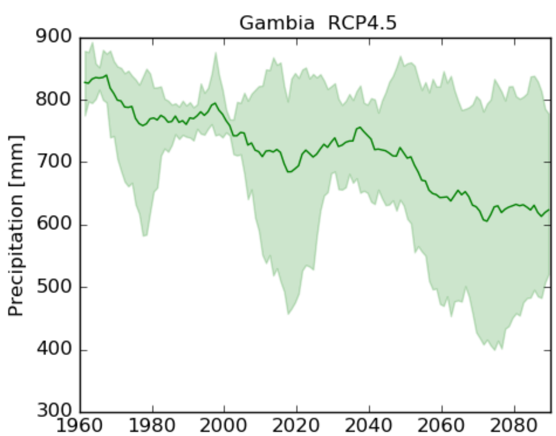
[342] http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

[343] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

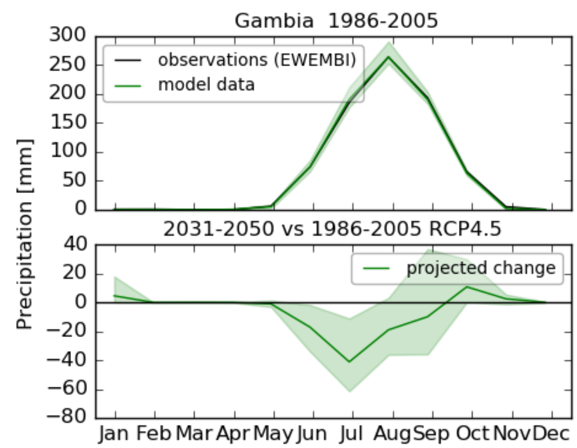
[344] Gambia Climate Analytics tool

361. Projections of mean annual rainfall averaged over the country from different models in the ensemble project a wide range of increases and decreases in precipitation for The Gambia, but tend towards decreases, particularly in the wet season, JAS. Projected annual change ranges from -23 to +18% by the 2090s, with ensemble means between 0 and -3%. Projected JAS changes ranges from -53 to +74% by the 2090s, with ensemble means between -7 and -20%. Despite the projected decreases in total rainfall, the proportion of total annual rainfall that falls in heavy events tends towards increases in the ensemble projections. Seasonally, this varies between tendencies to decrease in JFM and AMJ, and to increase in JAS and OND. The range of projections from different models in the ensemble, however, includes both increases and decreases in all seasons. -1 and -5 day rainfall maxima in projections all tend towards increases in JAS. The range of changes in projections from the model ensemble covers both increases and decreases in most seasons.

362. The following graphics projecting precipitation in The Gambia are based on a Climate Analytics Tool that analyses climate projections on the national scale[345].




The line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.




EWEMBI data is shown in black, regional climate model simulations in green. The green line represents the ensemble mean while the shaded area represents the model spread. The projections are based on the emission scenario RCP4.5.

**Figure 5.7.2.2b: Regional climate model projections for precipitation displayed as 20 year running mean (left). Annual cycle of precipitation for the period 1986-2005 (top right). Changes in annual cycle projected for 2031-2050 compared to the reference period 1986-2005 (bottom right)[346]**

[345] National scale projections requires high resolution data, which is not provided by global circulation models (GCM). For a restricted region high resolution climate projections can be obtained from regional climate models (RCM). RCMs model local impacts of changes in global greenhouse gas concentrations. Therefore RCMs require global climate simulations of GCMs as input. Thus RCM climate projections are always the result of the combination of a GCM with a RCM. Read more: http://regioclim.climateanalytics.org/documentation

[346] Gambia Climate Analytics tool

### 5.7.2.3 Climate change impacts, climatic hazards and extreme events

363. Gambia's rural communities are dependent upon the natural resource base and rainfall and therefore significantly vulnerable to climate change and worsening environmental conditions. Trend data shows that the Western end of the country is getting wetter, but with return periods for poor rainfall of between 6-10 years. The central and Eastern parts of the country are becoming drier, with return periods for poor rainfall of between 4-8 years (depending on the location) and a delayed start to the rains, but with extremely good rains every 8-10 years. (IFAD, 2015b)[347]

364. The larger overall drying trend of the last 40 years had a profound impact on water resources: dried up springs and streams and falling water tables, contraction of seasonally flooded swamps and enhanced saline intrusion. Since the 1960s, large areas of freshwater swamps in Western Gambia have been replaced by salt plains or salt-water marshes because of reduced fresh water inflow from storm run-off, preventing rice production in North Bank Region and Western parts of Central River Region. Discussions with communities during the concept design mission revealed that 50% or more of productive lowlands have been lost in some areas due to changes in environmental conditions, displacing agricultural activity to the uplands, which are already under pressure. (IFAD, 2015b)[348]

*Projections on climate change impacts*

365. According to the National Adaptation Programme of Action developed in 2007, the main climate hazards in The Gambia are: torrential rainfall, storms, drought, cold spells, intra-seasonal drought, heat waves and unseasonal rains. The last three are perceived as distinct evidence of the onset of a changing climate, which is characterized notably by increasing atmospheric $CO_2$ concentrations and sea level rise. Related hazards include a limited ability to predict the incidence of some hazards and the concomitance of multiple and mutually reinforcing hazards. (IFAD, 2015b)[349]

366. Regional model studies included in the AR5 suggest an increase in the number of extreme rainfall days over West Africa and the Sahel during May and July with low to medium confidence. Dry periods of more than five days are expected to increase and breaks in rainfall of more than one week become frequent, as will droughts. Annual average total soil moisture is expected to continue to decrease due to increased evapotranspiration and reduced rainfall desiccate soil. Annual run-off will continue to increase, linked to storms and intense rain events. The wave regime is also expected to increase though the availability of wind predictions remains limited for West Africa.

### 5.7.3 Vulnerabilities and Exposure to Climate Change: key Impacts to lives and livelihoods

367. The Gambia ranks as one of the countries highly vulnerable to climate change based on the GAIN index, ranking 163rd out of 180 countries, (or 16th most vulnerable). The food security vulnerability to climate change, which is measured in terms of food production, food demand, nutrition and rural population, is 177th out of 186 ranked countries. The indicators for the score include projected change of cereal yields, projected population growth, food import dependency, rural population, agriculture capacity and child malnutrition. (IFAD, 2015b)[350]

368. Temperatures in The Gambia (hot days and nights) are increasing with implications for crop productivity and the incidence of pests and diseases. The incidence of red spider mites, which attack vegetables and for which there is no known appropriate pest management remedy, is temperature

[347] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[348] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[349] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[350] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f

related and a more frequently occurring problem, as are snails. Pest occurrences such as armyworms and termites attack rice and are associated with dry spells. (IFAD, 2015b)[351]

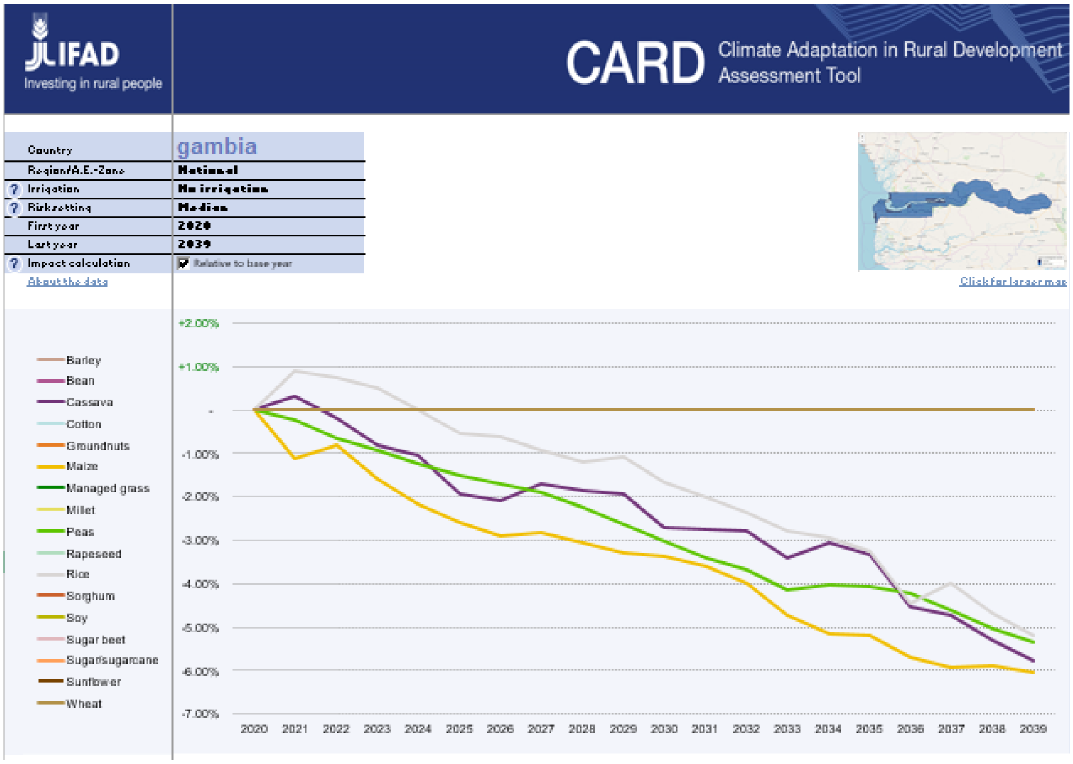
369. The most vulnerable areas from a climate change perspective will be the lower-central part of the country where saline water (see Figure 7 below for extent of salt-water intrusion and limit) meets freshwater, the balance of which is determined by rainfall conditions and, increasingly, sea level rise. However, other regions are also vulnerable. In the Western part of the country, which is more densely populated, lowland rice and horticulture are vulnerable to saline ground water resources and short return periods for low rains and heavy rains that will worsen land degradation in the uplands. In the Eastern part of the country, rainfall variability threatens both droughts and floods, and here too temperature increases will be felt more keenly. (IFAD, 2015b)[352]

#### 5.7.3.1 Climate change impacts on agriculture

370. Abovementioned climate-related stresses will magnify the effects on agriculture with impacts on the recharge of aquifers, soil erosion and sedimentation processes, changes in the amount of ground and surface water stored, and other disturbances to the hydrological cycle effects resulting in saline intrusion. Elevated atmospheric $CO_2$ concentrations are expected to increase crop yields, but higher temperatures and water shortages may act to counterbalance this beneficial effect. Recent experiments have shown that crop response to elevated $CO_2$ is relatively greater when water is a limiting factor. Well-fertilized crops respond more positively to $CO_2$ than less fertilized ones and thus the contrary is true for nitrogen. (IFAD, 2015b)[353]

371. The figure below presents IFAD CARD[354] for Senegal to explore the effects of climate change on the yield of major crops.

[351] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[352] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[353] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f
[354] Climate Adaptation in Rural Development – Assessment Tool https://www.ifad.org/en/web/knowledge/publication/asset/41085709




(Please refer to the "Climate change impacts on crop yield in specific targeted regions" document to see projections for each country region)

#### 5.7.3.2 Climate change impacts on natural capital

372. The changes in temperature and rainfall will adversely affect natural resources such as forests and grasslands. Results obtained from the Holdridge Life Zone Classification model suggest that The Gambia's forest cover will fit more into a dry forest and tropical very dry forest categories. As the temperature becomes warmer, rainfall decreases and potential evapotranspiration increases, forest cover will be approximately subdivided into tropical very dry forest (35%-40%) and tropical dry forest (45%-60%), the warmer BMRC climate scenario having the highest percentage of tropical very dry forest. (IFAD, 2015b)[355]

#### 5.7.3.3 Climate change impacts on health

373. The effects of weather and climate inclusive of extremes (droughts, floods, storms) on human health are difficult to quantify because of poor reporting and paucity of research into secondary and delayed impacts. However, no one disputes that natural disasters caused by extreme weather adversely affect human health in many ways. Climate-related hazards faced by children, elderly people and other vulnerable socio-economic groups living in specific localities within The Gambia include droughts, flooding and sea level rise. (GOTG, 2012)[356]

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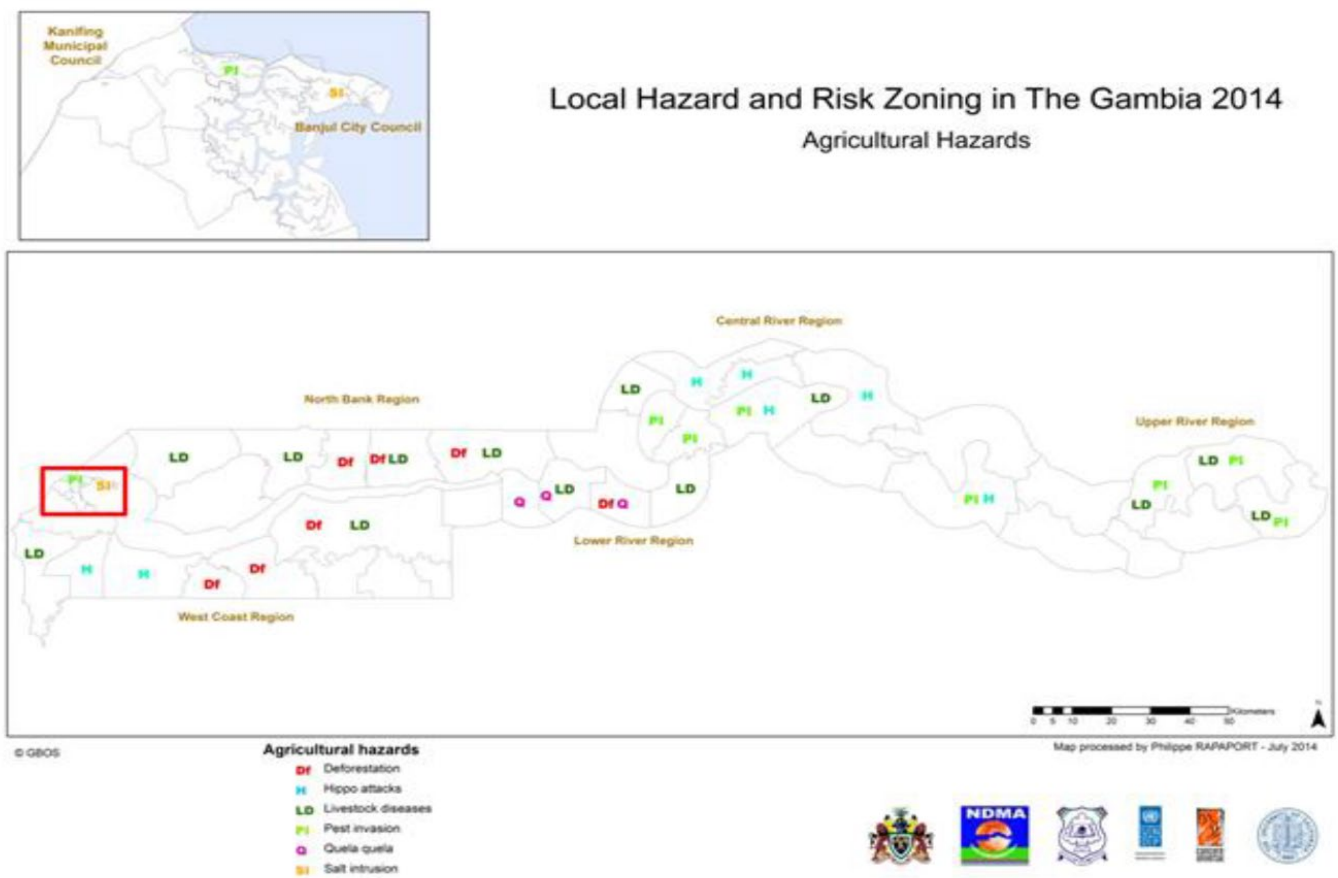
[355] https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f

[356] https://unfccc.int/sites/default/files/resource/Second%20National%20Communication%20of%20The%20Gambia.pdf

374. Malaria, for instance, is an endemic disease peaking in the rainy season (July-October). Around 1,000 children die every year from the direct effects of malaria which also accounts for 20% of medical consultations at out-patient departments of government health facilities. Diarrheal diseases also exhibit seasonal patterns. Whereas 84% of the population have access to safe drinking water and 86% live in households with excreta disposal facilities, the incidence of diarrhea remains high due to inadequate water handling practices and environmental sanitation exacerbated by uncontrolled runoff and flooding. Acute respiratory infections (including pneumonia) are second to malaria as the leading cause of morbidity and mortality especially among infants and young children. The British Medical Research Council (MRC) studies on infant mortality found out that 14% of under-five deaths in the central part of the country were attributable to acute respiratory tract infections. (GOTG, 2012)[357]

### 5.7.4 Vulnerability ranking and Mapping

375. A recent community vulnerability assessment has mapped the hot spots with high risk to both natural (bushfires, causal erosion, drought, floods, lightning storms, mangrove depletion, salt intrusion, soil erosion and wind storms) and agricultural hazards in the country (see Figure 5.7.4 below). These threats have a profound impact on the livelihood situation of the rural communities who depend entirely on their natural resource base. (IFAD, 2015b)[358]




357 https://unfccc.int/sites/default/files/resource/Second%20National%20Communication%20of%20The%20Gambia.pdf

358 https://operations.ifad.org/documents/654016/c7b4e9fa-b6df-4df1-9c31-fcfe982cf06f

**Figure 5.7.4: Climate hazard mapping for The Gambia**

### 5.7.5 Suggested geographies and sectors for intervention for climate change adaptation

| Sector | Adaptation mechanism | Description |
|---|---|---|
| **Forestry** | Establishment and expansion of community natural forests, plantations, national parks and forest parks | As an adaptation measure with mitigation co-benefits, the proposed action should enhance the resilience of forest ecosystems including provisioning functions in support of sustainable livelihood of direct beneficiaries. The activity will empower communities with the legal security, skills and knowledge necessary to rationally utilize their natural resources and conserve the remaining biodiversity. |
| | Expansion and intensification of agro-forestry and re-forestation activities | This adaptation measure which targets specific areas across the country will enhance the contributions of restored forest ecosystems to forest-based poverty alleviation, and, more broadly, to other national economic goals. The measure is expected to achieve the following: |
| | Mainstreaming climate change in forest policies and plans | In order to be fully responsive to the challenges of climate change, forestry sector policies and programs need to incorporate the realities of climate change. |
| **Rangelands** | Development and implementation of effective policies on integrated natural resources management | The negative impacts of climate change on rangelands can be attenuated through formulation and implementation of effective policies that seek to improve production and also take into consideration the needs of other natural resources-based sectors of the economy. |
| | Restoration of rangeland landscape | This adaptation option includes the manipulation and monitoring of animal stocking rates, institutionalization of strict grazing controls and management of the vegetation and soils. |
| | New management strategies | New strategies consist of a combination of measures including active selection of plant species, and stimulation of livestock economy to encourage owners to supply livestock and meat products on local/regional markets. . |
| **Health** | Vector control program | Health impacts from malaria will need investment in social mobilization and education, prevention techniques such as mosquito repellents, insecticide treated nets, (ITN) low-cost anti-malarial drugs. Use of ITNs in particular has been shown to reduce malarial morbidity and mortality in The Gambia. |
| | Continuous public health education and awareness creation program | Health education and awareness-raising are conducted at community level to help audiences in their decision-making on thematic issues. Health education and promotion programs should therefore incorporate elements of climate |
| | Integrated disease surveillance and response | Disease surveillance is a fundamental building block of infectious disease control program. In this regard, there is a clear need to create or improve on the design of health databases, and strengthening of the integrated disease surveillance program of MOHSW. |
| | Nutritional support to vulnerable groups | The National AIDS Secretariat with support from the global fund assists the ministry by providing nutritional support to vulnerable groups and their family members |
| | Public health infrastructure | Proper waste disposal should be promoted to prevent pathogenic and toxic contamination during floods. There are numerous tools and technologies that can be used to reduce the impacts of climate variability on the health of vulnerable human populations. In |

| Sector | Adaptation mechanism | Description |
|---|---|---|
| | | Kanifing Municipal Council (KMC), these include promotion of healthy housing environment and enforcement of building regulations. In areas where people depend on untreated water, reliable and safe drinking water as well as the use of simple measures such as proper storage of drinking water in narrow-mouthed vessels, filtering drinking water and use of use of chlorine tablets. |
| | Vaccination programme | Under its Expanded Programme of Immunization, The Gambia has one of the highest coverage of immunization in the West Africa sub region. Vaccination campaigns for all possible diseases need to be supported. Yellow fever vaccine is administered at the age of 9 months in all RCH clinics throughout the country. Meningitis vaccine is given only to Muslim pilgrims prior to the annual hajj and when an outbreak of the disease threatens. |
| **Agriculture** | Technical adaptation measures | Selection of drought-, pest- disease-, and salinity-resistant, high-yield crop varieties under local conditions. For this purpose the genetic potential of local crop species must be investigated and specimens stored in seed banks; |
| | | Change in planting dates and replacement of long-duration upland and lowland rice varieties with short-duration varieties |
| | | Demonstration, promotion and diffusion of improved post harvest technologies. This will have the long-term effect of reducing extensive cultivation of marginal lands |
| | Regulatory adaptation measures | Discouraging cultivation on marginal areas |
| | | Cooked food waste reduction |
| | | Diversification of eating habit (change from rice to other cereals) |
| | Livestock | Increase fodder production from intensive feed gardens |
| | | Promote crop/livestock integration; |
| | | Improve feed conservation techniques and access to supplements |
| | | Engage with other institutions, for example, the International Trypanotolerance Centre (ITC), to explore the potential of intensive livestock production systems in different areas in The Gambia |
| | | Further explore opportunities for selective/cross-breeding of Ndama cows with higher milk-producing breeds |

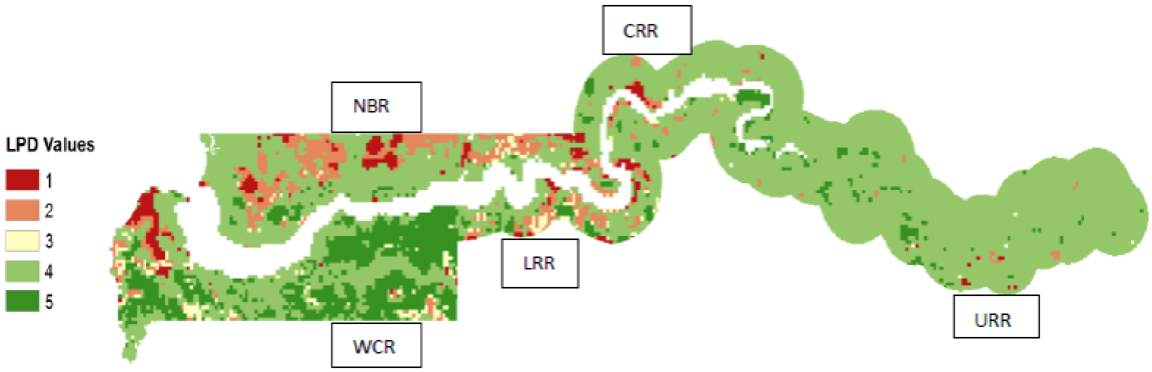
**Table 5.7.5: Adaptation options by sector (GOTG, 2012)**.

376. Improving land quality and living standards of the rural population in the Gambia requires the programme to improve the condition of terrestrial ecosystems by avoiding, reducing and reversing degraded land. The programme will use the map of potential hotspot locations in the Gambia to efficiently suggest the suitable sustainable land management (SLM) interventions for climate change adaptation in the country (figure 5.7.5). These zones are marked by a significant declining productivity and early signs of declining productivity such as in parts of the North Bank Region and the north of Central River Region[359]. The choice of SLM practices adapted to the country is determined by local stakeholders, based on local topography, soil and vegetation conditions, as well as based on the socio-economic context, such as the size of farms or particular characteristics that would make certain practices unsuitable or impossible to implement.

377. Improving the condition of terrestrial ecosystems will improve the conditions of the most vulnerable people and increase the resilience of ecosystems in the country. Thus, the programme will

[359] https://knowledge.unccd.int/sites/default/files/ldn_targets/Gambia%20LDN%20TSP%20Country%20Report.pdf

participate to the Nationally Determined Contributions (NDC) of Gambia, the national Land Determined Neutrality (LDN)[360] targets and measures that stop land degradation in the country as well as support the implementation of the Great Green Wall Initiative, which promotes land degradation and resilience to climate change in the Gambia.




| VALUE | Description |
|---|---|
| 1 | Declining productivity |
| 2 | Early signs of decline |
| 3 | Stable, but stressed |
| 4 | Stable, not stressed |
| 5 | Increasing productivity |

**Figure 5.7.5: Selected potential LDN hotspots in The Gambia**[361]

[360] LDN is achieved by 2030 as compared to 2015 and an additional 10% of the national territory has improved (net gain) available at LDN is achieved by 2030 as compared to 2015 and an additional 10% of the national territory has improved (net gain) available at
https://knowledge.unccd.int/sites/default/files/ldn_targets/Gambia%20LDN%20TSP%20Country%20Report.pdf
[361] https://knowledge.unccd.int/sites/default/files/ldn_targets/Gambia%20LDN%20TSP%20Country%20Report.pdf

## Chapter 6 Climate information systems for agricultural purposes

### 6.1 Context

378. Reliable information on precipitation at sufficiently detailed spatial and temporal scales is essential for early warning systems (EWSs). However, West Africa has an extremely low density of reliable weather stations that provide accurate rainfall measurements over long time periods. This limits the use and analysis of such data[362]. The need for external funding for the development of climate information systems for agricultural purposes is compounded by the current state of Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia economic situation as indicated in their country profiles. In addition, several major gaps and shortfalls that need to be addressed to achieve a fully operational climate information systems in agriculture are summarized as follows:

- There is a national need for human resource capacities to be enhanced through better access to basic and targeted training courses and facilities. They also need appropriate tools and guidance for customizing global and or regional products to suit national and local priorities and purposes.
- There is often little coordination among national stakeholders in contributing to and benefiting from climate service information operations, leading to minimal uptake or inappropriate use of climate information in decision-making. Thus, by developing user understanding: (i) users can better incorporate available climate information into their decision-making; and (ii) providers can produce information that is better tailored to meet user needs.
- There is also a national need to enhance climate information systems' communications, knowledge products, tools, and resources for practical application to development processes.
- Formally designated structures for climate information systems entities and functions are essential for standardization, sustainability, reliability, authenticity, adherence to policy, etc. Most of the existing or proposed entities and functions should focus on climate data, monitoring and prediction on monthly and seasonal time scales. Further research will be required to extend these climate information system capabilities to longer time scales, especially regarding predictions/projections and their downscaling.
- Absence of scientific data and long-term information, authenticated meteorological records is a key gap that prevents providing a wide range of climate services in West Africa.

379. Thus, the contribution of funds by the GCF is critical for the successful implementation of climate risks to better inform decision-making, prepare for and manage climate shocks in the seven countries. This will include an impact-based multi-hazard early warning systems and an impact-based forecasting in the different countries.

### 6.2 Weather station baselines in the seven countries

#### 6.2.1 Burkina Faso

380. The National Meteorological Agency in Burkina Faso (i.e. Agence Nationale de la Météorologie (ANAM)) provides: (i) public weather services; (ii) flash flood warnings; (iii) severe weather forecasting and forecasting services; (iv)streamflow, flood and low flow statistics and (v) tailored services to specific economic sectors[363]. In regards to its National Hydrological Institution (i.e. Direction General des Ressources en Eau), it is responsible for hydrological observations (stage and discharge, groundwater, water quality), water resources assessment, hydrological forecasting (droughts, floods, streamflow) and warnings as well as research.

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[362] Dembélé, Moctar & Zwart, Sander. (2016). Evaluation and comparison of satellite-based rainfall products in Burkina Faso, West Africa. International Journal of Remote Sensing. 37. 3995-4014. 10.1080/01431161.2016.1207258. Available from:https://www.researchgate.net/publication/305313263_Evaluation_and_comparison_of_satellite-based_rainfall_products_in_Burkina_Faso_West_Africa

[363] https://community.wmo.int/members/bfa

381. According to the World Weather Information Service of the World Meteorological Organization (WMO), there are nine synoptic weather stations that are currently operational in the country (Figure 6.2.1). Their altitude varies between 270 and 460 m above sea level (masl). Table 6.2.1 provides details of the stations' locations.

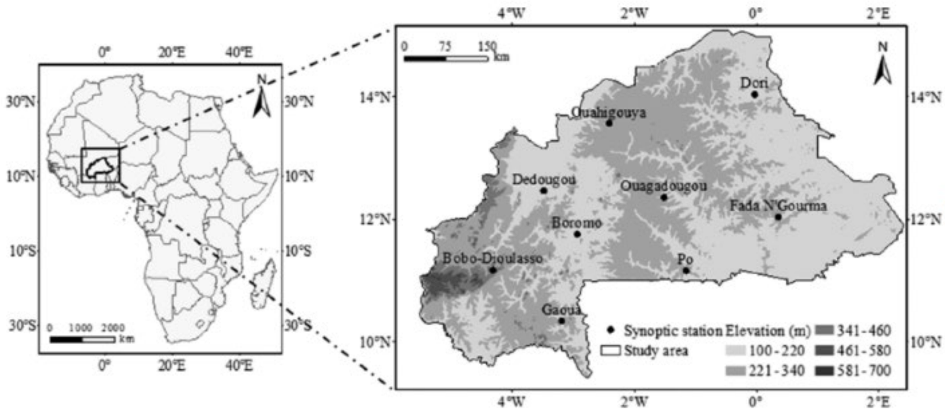


**Figure 6.2.1: Relief map of Burkina Faso with synoptic stations location and location within Africa**[364]

| WMO Station reference | Station name | Region | Latitude | Longitude | Altitude (masl) | Number of daily observations (%) Entire year | Wet season |
|---|---|---|---|---|---|---|---|
| 655100 | Bobo-Dioulasso | HB | 11.16 | −4.31 | 460 | 94 | 94 |
| 655160 | Boromo | BM | 11.75 | −2.93 | 270 | 84 | 81 |
| 655050 | Dédougou | BM | 12.46 | −3.48 | 300 | 79 | 79 |
| 655010 | Dori | Sahel | 14.03 | −0.03 | 276 | 82 | 80 |
| 655070 | Fada N'Gourma | Est | 12.03 | 0.36 | 308 | 73 | 73 |
| 655220 | Gaoua | SO | 10.33 | −3.18 | 333 | 72 | 69 |
| 655030 | Ouagadougou | Centre | 12.35 | −1.51 | 316 | 96 | 94 |
| 655020 | Ouahigouya | Nord | 13.56 | −2.41 | 337 | 81 | 79 |

The number of available daily observation is provided as a percentage of the maximum number of observations from 2001 to 2014 (i.e. 5113). The wet season is defined as the period from May to October.
BM: Boucle du Mouhoun ; HB:Hauts-bassins; SO: Sud-ouest .

**Table 6.2.1a: Overview of weather stations in Burkina Faso and 2001-2014 daily observations**[365]

382. The WMO data reporting indicates sufficient data in Burkina Faso to determine impact based forecasts and warnings, quality management system for hydrology and simultaneous monitoring and forecasting whereas there is insufficient data to determine early warnings, decadal climate predictions and emergency/public warnings (Table 6.2.1.b). These are major elements for disaster risk reduction and to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

[364] Dembélé, Moctar & Zwart, Sander. (2016). Evaluation and comparison of satellite-based rainfall products in Burkina Faso, West Africa. International Journal of Remote Sensing. 37. 3995-4014. 10.1080/01431161.2016.1207258. Available from:https://www.researchgate.net/publication/305313263_Evaluation_and_comparison_of_satellite-based_rainfall_products_in_Burkina_Faso_West_Africa

[365] This table is missing two meteorological station names: **Po**, Region: Centre South, Latitude: 11.150, Longitude: -1.150 and **Markoye**, Region: Centre-North, Latitude: 14.633, Longitude: -000.067.

**Source Table 6.2.1**: Dembélé, Moctar & Zwart, Sander. (2016). Evaluation and comparison of satellite-based rainfall products in Burkina Faso, West Africa. International Journal of Remote Sensing. 37. 3995-4014. 10.1080/01431161.2016.1207258. Available from:https://www.researchgate.net/publication/305313263_Evaluation_and_comparison_of_satellite-based_rainfall_products_in_Burkina_Faso_West_Africa

| Observations and Data | | Forecast and Warning | |
|---|---|---|---|
| **National WMO Integrated Global Observing System (WIGOS) governance mechanism**[366] | None | **Impact based forecasts and warnings** | Yes |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | None |
| **Level of WMO Information System (WIS) implementation**[367] | Not started | **Quality management system for hydrology** | Yes |
| **Knowledge of WIS** | Little to no knowledge | **Decadal forecasts** | No data |
| **Compliance with Climate System Data Management (CDMS) specifications**[368] | Fully compliant | **Monitoring and forecasting systems occurring simultaneously** | Yes |
| **Status of climate data rescue** | 75% data rescued | **Warning in Common Alerting Protocol (CAP) format**[369] | No data |

**Table 6.2.1b: WMO monitoring in Burkina Faso**[370]

383. In addition, a study by Dembélé et al. (2016) evaluated the performance of seven satellite products[371] in estimating and reproducing rainfall in the nine weather stations in Burkina Faso, using rain-gauge data for a 14 year period (2001–2014) and a point-to-pixel evaluation at daily, decadal, monthly, and annual temporal scales. The study concluded that all the daily products performed poorly due to their underestimation results in the amounts of rainfall, and they were weakly correlated with rain-gauge data ($r < 0.50$). This might be due to the loss of more localized convective rainfall regarding the type of comparison. Estimates at a daily or shorter time step are essential for driving rainfall run-off models used for flood forecasting and river management[372]. At the decadal scale, good agreements with rain-gauge data were observed for all the satellite products ($r \geq 0.80$). Except for the PERSIANN satellite, which gave an overestimation, all the other satellite products underestimated rainfall amounts. The study suggested that for operational agricultural and early warning activities, decadal time step could be used to identify periods of low or heavy rainfall that may lead to either drought or flood. In addition, good Bias scores were achieved by all of the satellite products, except for the TARCAT satellite, which had the lowest performance for both continuous and categorical statistics, but an excellent FAR. The RFE satellite was the best product, with good scores in both continuous and categorical statistics; it was closely followed by ARC and CHIRPS satellites. In light of these results, the study recommends that using ARC, RFE, and TARCAT satellites should be excellent to good for drought monitoring, whereas PERSIANN, CHIRPS, and TRMM 3B42 satellites should be preferred for flood monitoring in Burkina Faso. As for overall water resource assessment of river basins, the study suggested that monthly and seasonal time steps could provide results that might be useful[373].

[366] https://public.wmo.int/en/programmes/wigos
[367] https://www.wmo.int/pages/prog/www/WIS/overview.html
[368] https://library.wmo.int/doc_num.php?explnum_id=7867
[369] https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
[370] https://community.wmo.int/members/bf
[371] ARC 2.0, CHIRPS, PERSIANN, RFE 2.0, TARCAT, TRMM 3B42,and TRMM 3B43
[372] Grimes, Pardo-Igúzquiza, and Bonifacio,1999
[373] Bajracharya et al.2015

### 6.2.2 Chad

384. The Direction Générale de la Météorologie Nationale (DGMN) in Chad provides public weather services, flash flood warnings and forecasting services[374]. In regards to its National Hydrological Division (i.e. Division de l'Hydrologie (DHY)), it is responsible for hydrological observations (stage and discharge, water quality), water resources assessment, hydrological forecasting (droughts, floods, streamflow) and warnings, disaster risk prevention and mitigation (not including forecasting) as well as research.

385. In Chad, weather station operation is controlled by the Direction des Ressources en Eau et de la Météorologie (DREM) that administers approximately 15 weather stations, however, not all the reported stations are currently operational. An inventory of weather stations obtained from the World Weather Information Service of the WMO indicates that approximately only seven stations are currently reporting (figure 6.2.2), namely: Abeche, Bol, Faya-Largeau, Mongo, Moundou, N'djamena and Sarh[375]. Their altitude varies between 234m and 549 m above sea level.

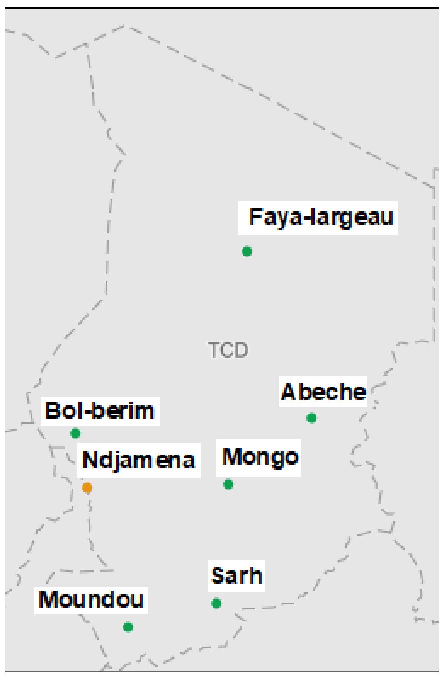


**Figure 6.2.2: Distribution of WMO weather station references in Chad (WMO, 2019)**

| Station | Latitude | Longitude | Elevation (m) |
|---|---|---|---|
| **Sarh** | N 09°09' | E 018°22' | 365 |
| **Abeche** | N 13°50' | E 020°51' | 549 |
| **Moundou** | N 08°37' | E 016°04' | 422 |
| **Ndjamena** | N 12°07' | E 015°01' | 295 |
| **Bol-berim** | N 13°25' | E 014°43' | 292 |
| **Mongo** | N 12°07' | E 018°25' | 428 |
| **Faya-largeau** | N 18°00' | E 019°10' | 234 |

**Table 6.2.2a: Description of operational weather stations in Chad[376]**

[374] https://community.wmo.int/members/tcd
[375] Available at http://worldweather.wmo.int/en/country.html?countryCode=TCD
[376] Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=TD&pn=0

386. However, the weather stations seem to lack sufficient data to determine early warnings, quality management system for hydrology, decadal climate predictions, simultaneous monitoring and forecasting and emergency/public warnings (Table 6.2.2.b). These are major elements for disaster risk reduction and to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

| Observations and Data | | Forecast and Warning | |
|---|---|---|---|
| **National WIGOS governance mechanism**[377] | None | **Impact based forecasts and warnings** | Yes |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | None |
| **Level of WIS implementation**[378] | Not started | **Quality management system for hydrology** | None |
| **Knowledge of WIS** | Introductory knowledge | **Decadal forecasts** | No data |
| **Compliance with CDMS specifications**[379] | Partly compliant | **Monitoring and forecasting systems occurring simultaneously** | None |
| **Status of climate data rescue** | 50-75% data rescued | **Warning in CAP format**[380] | No data |

**Table 6.2.2b: WMO monitoring information in Chad**[381]

### 6.2.3 Mali

387. In Mali, weather station operation is controlled by the Direction Nationale de la Météorologie du Mali (Météo-Mali), a government agency that should meet the test of being a reliable third-party observer with no financial stake in weather insurance outcomes. Overall, Météo-Mali appears to be professional and interested in new developments. Météo-Mali requires payment for the use of weather variables in excess of simple handling charges which are used to cover some operating costs, in particular since certain donor funding to support operations has ended. High data cost could negate the potential for developing these products in Mali[382].

388. Météo-Mali administers approximately 74 rainfall stations in the main agricultural regions of the country[383]. However, not all the reported stations are currently operational. An inventory of weather stations obtained from World Weather Information Service of the WMO indicates that approximately only eight stations are currently reporting (figure 6.2.3)[384]. Their altitude varies between 47m and 459 m above sea level (table 6.2.3a).

377 https://public.wmo.int/en/programmes/wigos
378 https://www.wmo.int/pages/prog/www/WIS/overview.html
379 https://library.wmo.int/doc_num.php?explnum_id=7867
380 https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
381 https://community.wmo.int/members/tcd
382 http://worldweather.wmo.int/en/country.html?countryCode=MLI
383 https://www.savethechildren.org/content/dam/usa/reports/livelihoods/mali-weather-insurance-2009.pdf
384 https://www.savethechildren.org/content/dam/usa/reports/livelihoods/mali-weather-insurance-2009.pdf

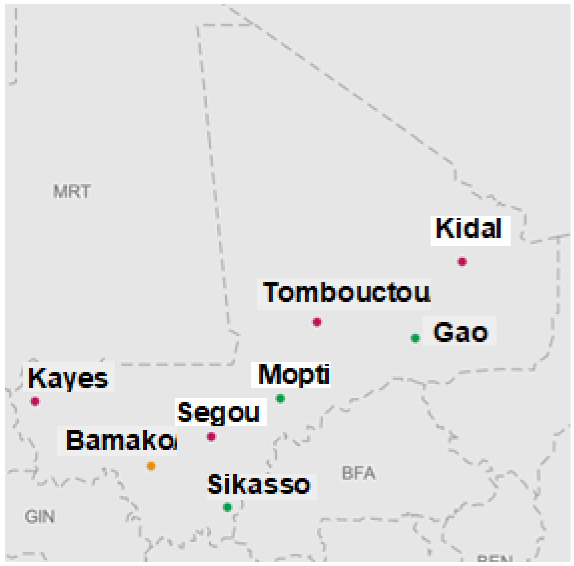


**Figure 6.2.3: Distribution of WMO weather station references in Mali (WMO, 2019)**

| Station | Latitude | Longitude | Elevation (m) |
|---|---|---|---|
| **Bamako/senou** | N 12°31' | W 007°57' | 381 |
| **Gao** | N 16°16' | W 000°03' | 260 |
| **Kidal** | N 18°25' | E 001°21' | 459 |
| **Kayes** | N 14°25' | W 011°25' | 47 |
| **Mopti/barbe** | N 14°31' | W 004°05' | 272 |
| **Segou** | N 13°24' | W 006°09' | 289 |
| **Sikasso** | N 11°20' | W 005°40' | 375 |
| **Tombouctou/timbu** | N 16°43' | W 003°00' | 264 |

**Table 6.2.3a: Description of operational weather stations in Mali**[385]

389. The WMO data reporting indicates sufficient data in Mali to determine impact based forecasts and warnings, early warnings, simultaneous monitoring and forecasting whereas there is insufficient data to determine quality management system for hydrology, decadal climate predictions and emergency/public warnings (Table 6.2.3.b). These are major elements for disaster risk reduction and to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

| Observations and Data | | Forecast and Warning | |
|---|---|---|---|
| **National WIGOS governance mechanism**[386] | None | **Impact based forecasts and warnings** | Yes |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | Yes |
| **Level of WIS implementation**[387] | Some functionality | **Quality management system for hydrology** | None |
| **Knowledge of WIS** | Working knowledge | **Decadal forecasts** | No data |
| **Compliance with CDMS specifications**[388] | Fully compliant | **Monitoring and forecasting systems occurring simultaneously** | Yes |

385 Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=ML&pn=0
386 https://public.wmo.int/en/programmes/wigos
387 https://www.wmo.int/pages/prog/www/WIS/overview.html
388 https://library.wmo.int/doc_num.php?explnum_id=7867

| | | | |
|---|---|---|---|
| **Status of climate data rescue** | 50-75% data rescued | **Warning in CAP format**[389] | No data |

**Table 6.2.3b: WMO monitoring information in Mali**[390]

### 6.2.4 Mauritania

390. The Office National de la Météorologie in Mauritania provides: (i) public weather services; (ii) severe weather forecasting, (iii) climate services; (iv) aviation services; (v) marine safety forecast and warning services for high seas; (v) coastal waters and ports; (vi) ice analysis and (vii) forecasting services[391]. There is no main institution responsible for operational hydrology services in the country, yet. In regards to weather stations, there are 12 administrated in the country based on the Aviation Meteorological Center (table 6.2.4a). Their altitude varies between 3 m and 402 m above sea level.

| **Station** | **Latitude** | **Longitude** | Elevation (m) |
|---|---|---|---|
| **Aioun el atrouss** | N 16°41' | W 009°35' | 223 |
| **Boutilimit** | N 17°31' | W 014°40' | 75 |
| **Tidjikja** | N 18°34' | W 011°25' | 402 |
| **Kiffa** | N 16°37' | W 011°24' | 115 |
| **Nema** | N 16°36' | W 007°16' | 269 |
| **Akjoujt** | N 19°45' | W 014°22' | 120 |
| **Kaedi** | N 16°08' | W 013°31' | 18 |
| **Nouakchott** | N 18°06' | W 015°56' | 3 |
| **Rosso** | N 16°30' | W 015°49' | 6 |
| **Atar** | N 20°31' | W 013°04' | 224 |
| **Nouadhibou** | N 20°55' | W 017°01' | 3 |
| **Bir moghrein** | N 25°13' | W 011°37' | 360 |

**Table 6.2.4a: Description of weather stations in Mauritania**[392]

391. The WMO data reporting indicates sufficient data in Mauritania to determine impact based forecasts and warnings, early warnings, quality management system for hydrology and simultaneous monitoring and forecasting whereas there is insufficient data to determine decadal climate predictions and emergency/public warnings in the country (Table 6.2.4b). These are major elements for disaster risk reduction and to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

| **Observations and Data** | | **Forecast and Warning** | |
|---|---|---|---|
| **National WIGOS governance mechanism**[393] | None | **Impact based forecasts and warnings** | Yes |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | Yes |
| **Level of WIS implementation**[394] | IP prepared | **Quality management system for hydrology** | Yes |
| **Knowledge of WIS** | Working knowledge | **Decadal forecasts** | No data |

[389] https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
[390] https://community.wmo.int/members/mli
[391] https://community.wmo.int/members/mrt
[392] Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=MR&pn=0
[393] https://public.wmo.int/en/programmes/wigos
[394] https://www.wmo.int/pages/prog/www/WIS/overview.html

| | | | |
|---|---|---|---|
| **Compliance with CDMS specifications**[395] | Partly compliant | **Monitoring and forecasting systems occurring simultaneously** | Yes |
| **Status of climate data rescue** | 25-50% data rescued | **Warning in CAP format**[396] | No data |

**Table 6.2.4b: WMO monitoring information in Mauritania** [397]

### 6.2.5 Niger

392. The Direction de la Météorologie Nationale (DMN) in Niger provides public weather services, severe weather forecasting, ice analysis and forecasting services as well as earthquake/seismic services[398]. In regards to its National Hydrological Institution (i.e. Direction de l'Hydrologie), it is responsible for hydrological observations (stage, discharge, water quality, water quality climatological), water assessment, hydrological forecasting (droughts, floods, streamflow) and warnings, disaster risk prevention and mitigation (not including forecasting) as well as research.

393. In Niger, weather station operation is controlled by the DMN that administers approximately 12 weather stations (table 6.2.5a). However, the weather stations seem to significantly lack sufficient data to determine impact based forecasts and warnings, early warnings, quality management system for hydrology, simultaneous monitoring and forecasting, decadal climate predictions and emergency/public warnings (Table 6.2.5b). These are major elements for disaster risk reduction and to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

| Station | Latitude | Longitude | Elevation (m) |
|---|---|---|---|
| **Birni-n'konni** | N 13°48' | E 005°15' | 273 |
| **Gaya** | N 11°52' | E 003°27' | 203 |
| **Bilma** | N 18°40' | E 012°55' | 357 |
| **Tillabery** | N 14°11' | E 001°26' | 210 |
| **Maradi** | N 13°28' | E 007°04' | 373 |
| **Niamey (civ/mil)** | N 13°28' | E 002°10' | 227 |
| **Tahoua** | N 14°54' | E 005°15' | 391 |
| **Agadez south (mi** | N 16°58' | E 008°00' | 502 |
| **Diffa** | N 13°25' | E 012°46' | 305 |
| **Goure** | N 13°58' | E 010°18' | 460 |
| **Maine-soroa** | N 13°13' | E 011°58' | 337 |
| **Zinder** | N 13°46' | E 008°58' | 453 |

**Table 6.2.5a: List of operational weather stations in Niger**[399]

| **Observations and Data** | | **Forecast and Warning** | |
|---|---|---|---|
| **National WIGOS governance mechanism**[400] | None | **Impact based forecasts and warnings** | None |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | None |

[395] https://library.wmo.int/doc_num.php?explnum_id=7867
[396] https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
[397] https://community.wmo.int/members/m
[398] https://community.wmo.int/members/ner
[399] Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=NE&pn=0

[400] https://public.wmo.int/en/programmes/wigos

| | | | |
|---|---|---|---|
| **Level of WIS implementation**[401] | Not started | **Quality management system for hydrology** | None |
| **Knowledge of WIS** | Little to no knowledge | **Decadal forecasts** | None |
| **Compliance with CDMS specifications**[402] | Partly compliant | **Monitoring and forecasting systems occurring simultaneously** | None |
| **Status of climate data rescue** | 25-50% data rescued | **Warning in CAP format**[403] | None |

**Table 6.2.5b: WMO monitoring information in Niger**[404]

### 6.2.6 Senegal

394. The Senegal Civil Aviation and Meteorological National Agency (ANACIM) provides public weather services, warning services, severe weather forecasting, climate services, aviation services, marine safety forecast and warning services for high seas, coastal waters and port, ice analysis and forecasting services, streamflow, flood and low flow statistics, tailored services to specific economic sectors, earthquake/seismic services as well as volcanological monitoring and alert services[405]. In regards to its National Hydrological Institution (i.e. Direction de la Gestion et de la Planification des Ressources en Eau (DGPRE)), it is responsible for hydrological observations (stage, discharge, groundwater, water quality), water assessment, hydrological forecasting (droughts, floods, streamflow) and warnings, disaster risk prevention and mitigation (not including forecasting) and warnings.

395. An inventory of weather stations obtained from the World Weather Information Service of the WMO indicates that approximately 20 stations are currently reporting and operational in Senegal (figure 6.2.6)[406]. Their altitude varies between 4m and 167 m above sea level (table 6.2.6a).

401 https://www.wmo.int/pages/prog/www/WIS/overview.html
402 https://library.wmo.int/doc_num.php?explnum_id=7867
403 https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
404 https://community.wmo.int/members/ner
405 https://community.wmo.int/members/sen
406 http://worldweather.wmo.int/en/country.html?countryCode=SEN

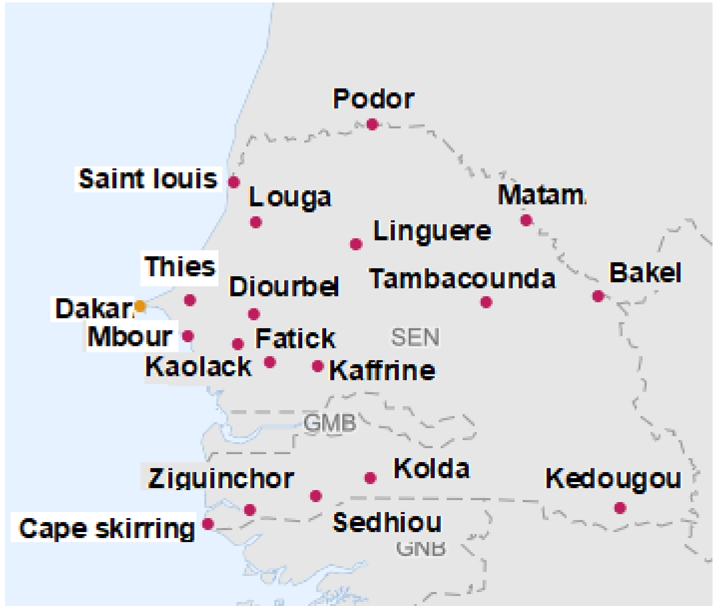


**Figure 6.2.6: Distribution of WMO weather station references in Senegal (WMO, 2019)**

| Station | Latitude | Longitude | Elevation (m) |
|---|---|---|---|
| **Ziguinchor** | N 12°33' | W 016°16' | 23 |
| **Kolda** | N 12°54' | W 014°58' | 10 |
| **Cape skirring** | N 12°24' | W 016°45' | 13 |
| **Diourbel** | N 14°39' | W 016°13' | 9 |
| **Linguere** | N 15°24' | W 015°05' | 21 |
| **Kaolack** | N 14°09' | W 016°04' | 7 |
| **Dakar/yoff** | N 14°43' | W 017°30' | 24 |
| **Matam/ouro sogui** | N 15°36' | W 013°20' | 17 |
| **Podor** | N 16°41' | W 014°58' | 7 |
| **Saint louis** | N 16°03' | W 016°26' | 4 |
| **Kedougou** | N 12°34' | W 012°13' | 167 |
| **Bakel** | N 14°90’ | W 012°46’ | 27 |
| **Fatick** | N 14°34’ | W 016°41’ | 5 |
| **Kaffrine** | N 14°11’ | W 015°54’ | 14 |
| **Louga** | N 15°61’ | W 016°23’ | 40 |
| **Mbour** | N 14°42’ | W 016°97’ | 15 |
| **Sedhiou** | N 02°70’ | W 015°56’ | 25 |
| **Thies** | N 14°79’ | W 016.94’ | 75 |
| **Tambacounda** | N 13°44' | W 013°40' | 50 |

**Table 6.2.6a: Description of operational weather stations in Senegal**[407]

396. The WMO data reporting indicates sufficient data in Senegal to determine early warnings, quality management system for hydrology, decadal climate predictions and simultaneous monitoring and forecasting whereas there is insufficient data to determine impact based forecasts and warnings and emergency/public warnings in the country (Table 6.2.6b). These are major elements to prevent loss of life and reduce the economic and material impacts of hazardous events including disasters in the country.

[407] Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=SN&pn=0. Except for Bakel, Fatick, Kaffrine, Louga, Mbour, Sedhiou, Thies data available at https://www.weather-atlas.com/en/senegal

| Observations and Data | | Forecast and Warning | |
|---|---|---|---|
| **National WIGOS governance mechanism**[408] | None | **Impact based forecasts and warnings** | None |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | Yes |
| **Level of WIS implementation**[409] | Not started | **Quality management system for hydrology** | Yes |
| **Knowledge of WIS** | Working knowledge | **Decadal forecasts** | Yes |
| **Compliance with CDMS specifications**[410] | Partly compliant | **Monitoring and forecasting systems occurring simultaneously** | Yes |
| **Status of climate data rescue** | More than 75% data rescued | **Warning in CAP format**[411] | None |

**Table 6.2.6b: WMO monitoring information in Senegal**[412]

### 6.2.7 The Gambia

397. The Department of Water Resources in the Ministry of Fisheries and Water Resources in Gambia provides public weather services, warning services, flash flood warnings, cyclones, climate services, aviation services, ice analysis and forecasting services, coastal hazards forecasting and warnings, agrometeorological services, visualization of current gauge height and discharge and well as representative values of discharges[413]. The National Hydrological Service in Gambia is combined with the Department of Water Resources in a single entity. Thus, the latter is also responsible also for hydrological observations (stage, discharge, groundwater, water quality, climatological), water assessment, hydrological forecasting (droughts, floods, streamflow) and warnings, disaster risk prevention and mitigation (not including forecasting).

398. An inventory of weather stations obtained from the World Weather Information Service of the WMO indicates that solely 1 station is currently reporting and operational in the country, located at the capital Banjul[414]. Its altitude is at 36 m above sea level (N 13°20', W 016°39')[415].

399. The WMO data reporting indicates sufficient data in the Gambia to determine impact based forecasts and warnings as well as emergency/public warnings whereas there is insufficient data to determine early warnings, quality management system for hydrology, decadal climate predictions and simultaneous monitoring and forecasting in the country (Table 6.2.7). These are major elements to prevent loss of life and reduce the economic and material impacts of hazardous events including disaster risk preventions.

| Observations and Data | | Forecast and Warning | |
|---|---|---|---|
| **National WIGOS governance mechanism**[416] | None | **Impact based forecasts and warnings** | Yes |
| **WIGOS plan adopted** | None | **Multi-hazard early warning systems** | None |

[408] https://public.wmo.int/en/programmes/wigos
[409] https://www.wmo.int/pages/prog/www/WIS/overview.html
[410] https://library.wmo.int/doc_num.php?explnum_id=7867
[411] https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
[412] https://community.wmo.int/members/sen
[413] https://community.wmo.int/members/gmb
[414] http://worldweather.wmo.int/en/country.html?countryCode=GMB
[415] Aviation Meteorological Center available at http://aviation.bmkg.go.id/web/station.php?c=GM&pn=0
[416] https://public.wmo.int/en/programmes/wigos

| | | | |
|---|---|---|---|
| **Level of WIS implementation**[417] | IP prepared | **Quality management system for hydrology** | None |
| **Knowledge of WIS** | Working knowledge | **Decadal forecasts** | None |
| **Compliance with CDMS specifications**[418] | Partly compliant | **Monitoring and forecasting systems occurring simultaneously** | None |
| **Status of climate data rescue** | More than 75% data rescued | **Warning in CAP format**[419] | Yes |

**Table 6.2.7: WMO monitoring information in The Gambia**[420]

### 6.3 Justification of climate information systems

400. The Programme will directly support the generation and application of climate information systems for agricultural purposes to farmers and decision makers engaging in climate risk preparedness. A comprehensive suite of tailored climate information system products and services will be developed in partnership with AfDB and ARC, and deployed in on-going IFAD's baseline interventions across the seven countries. These baseline interventions will provide the framework for ensuring that climate information system is mainstreamed into the decision-making process by key decision-makers themselves. This will be supported through targeted capacity development of a combination of training and mentoring, skills-based training, provision of on-line and hard copy training resources and guidance materials, real-time on-call access to a technical expert on the subject, and a scientific and technically data, information and knowledge to better understand climate risks and tailored agro-climatic information services. This will include advices on how to further transfer disaster risks, increase productivity and capacity to cope with climate change and variability. The project will also support the outreach of this new knowledge and climate information system resources for agricultural purposes to ensure that they are all communicated in multiple formats/platforms (on-line, media, hard copy etc) and local languages to ensure optimal coverage in the seven countries. With GCF contribution, the Programme will therefore strengthen the capacity of government stakeholders to support communities and smallholder farmers in preparing for climate change adaptation effectively (risk analysis and preparedness). By increasing their understanding and ability to prepare and manage risk, farmers will also be able to access unlocked weather index insurance and receive compensation in case of drought/dry spells from public and private insurance companies.

### 6.4 Implementation of climate information systems

401. Based on the Global Framework for Climate Services – Climate Services Information System[421], there are several conditions for successful implementation of climate information systems:
   - A set of primary, high-priority functions and well-defined products;
   - Formalized structures, standards and protocols;
   - Knowledge of user requirements;
   - Flows of huge amounts of data and information.

402. Most climate projection products available today are valid on global to large sub-continental scales, but additional regional and local products are needed. At the regional and national levels of the climate

417 https://www.wmo.int/pages/prog/www/WIS/overview.html
418 https://library.wmo.int/doc_num.php?explnum_id=7867
419 https://www.wmo.int/pages/prog/amp/pwsp/CommonAlertingProtocol_en.html
420 https://community.wmo.int/members/gmb
421 The Global Framework for Climate Services (GFCS) was established by WMO to provide a credible, integrative and unique platform for guiding and supporting activities implemented within climate-sensitive investment areas, notably agriculture, energy, disaster risk reduction, human health and water sectors.

information service systems, mandated centres will downscale global climate change projections and scenarios where possible, based on model outputs available from the major climate model data centres, making these products and related information available to users. It is critical that services relying on downscaling in the programme are backed by confirmation from research on the efficacy of the techniques employed and include commentary on any uncertainties in the projections.

403. A climate information system based on the inputs from the observations and research components and supported by strong capacity building activities in the programme will require physical infrastructure such as computers and communications networks. It will need institutions and centres, skilled human resources for product development and consultation and mechanisms for developing and delivering tailored products for users. Entities in the seven countries that can contribute to a fully operational climate information systems already exist but many need to be developed further and urged to adopt the standardized approaches for generating and distributing the key climate information system products.

404. To be successful, a national climate services programme embodying the principles of the Climate Services Information System of the World Meteorological Organization (WMO)[422] must be integral to the larger infrastructure supporting the implementation of national social, economic and environmental policies. The programme must connect available applications, scientific research, technological capabilities and communications in a unified system.

405. The overall infrastructure of the climate information system should: (i) Be based on a network of designated entities providing global and regional-scale climate products and services in the domains of climate data, climate monitoring, long-range forecasting, inter-annual to decadal predictions and climate change projections; (ii) Provide standardized minimum products as well as products that are highly-recommended, generating and distributing them on the basis of agreed-upon operating principles; (iii) Take advantage of as much authoritative information as possible; (iv) Help ensure that sufficient capacity exists on the national level to access, process and convert such global and regional climate information into national climate services.

### 6.4.1 Historical climate data sets

406. Developing and securing basic, historical climate data sets for characterizing past climate behaviour on all time and space scales remains one of the highest priorities for the climate information systems. Routinely collecting climate 'event' data, for example, would be one such contribution. Full event-scale data on climate anomalies like droughts, floods and heat waves, as currently categorized for Tropical Cyclones, would improve understanding of the distribution, frequency and intensity of serious hazards in the seven countries. This greater understanding is needed for better climate risk assessments as well as other products such as indices of climate extremes or more complex indices that combine several parameters with different thresholds (e.g. temperature with precipitation and humidity for the health sector).

407. Combining remotely-sensed data with traditional data to produce routine products at the national level offers a special challenge for the climate information systems. Given the resources and technical proficiency required to handle and process satellite-based data, for example, such products should be routinely generated in WMO Regional Climate Centres in each of the seven countries[423], from where they can be distributed to institutions that do not possess the required capabilities.

[422] Each of the seven countries are members of the WMO.
[423] There are National Meteorological Centres in Ouagadougou, Mali, Nouakchott, Niamey, Dakar (ANACIM), Banjul

### 6.4.2 Climate monitoring

408. Monitoring of the climate provides information that can, for example, guide appropriate preparatory actions for mitigating the effects of extreme events in the seven countries. Close and meticulous monitoring also allows for detecting long-term climate change and determining its driving forces as well as its impacts around the world. Monitoring the climate at a global scale also helps improve regional and national predictions. Local conditions do not occur in isolation from the rest of the world: regional and global scale climate drivers directly influence local weather and climate. Climate monitoring products will be a key climate information systems contribution to the programme. In this regard it is important to stress the need for ongoing programmes in the countries of re-analysis to take advantage of recovered data and evolving analysis techniques.

409. Countries producing national State of the Climate reports provide a baseline for documenting national reporting under environmentally-related conventions that include the UN Framework Convention on Climate Change, the Convention on Biological Diversity and the UN Convention to Combat Desertification. As a result, documenting meteorological settings and impacts, will be critical for developing effective national early warning systems as well as appropriate mitigation and response actions in the seven countries. Under the programme, all countries will be encouraged to develop special bulletins and advisory mechanisms that draw attention to significant features of the continuously evolving climate system either routinely or on an ad hoc basis.

### 6.4.1 Monthly/seasonal/decadal climate predictions

410. Formal WMO mechanisms for the delivery of operational climate prediction services have been developed and implemented for seasonal timescales as well as the procedures for ensuring verification standards. Similar arrangements need to be established among the seven countries that are lacking forecast activities on monthly, multi-annual and decadal timescales.

### 6.4.2 Climate projections and scenarios Information

411. Another important activity for the programme will be to promote the implementation of online climate projections as an efficient mechanism for delivering essential and consistent information to underpin national adaptation to climate change. While the databases of the fifth generation of the Coupled Model Intercomparison Project (CMIP5) and the CORDEX project of the WCRP will serve as comprehensive archives for the research community concerning climate simulations and climate change projections, they will likely not be in a suitable form to support the potentially wide range of specialized applications, especially at the national level. Consequently, a system of robust online databases at the national level should be designed and implemented to support a largely 'self-servicing' climate information system clientele via websites with mapping and navigation tools. The objectives would be to:

- o Create online regional and national sites for efficient access to climate change data and information services, supported by a robust and efficient infrastructure;
- o Develop climate change data and information services needed for adaptation and risk management that would: (i) Provide information based on the latest scientific findings; (ii) Combine historical and current climate observations with data streams projected into the future; (iii) Represent a significant shift from ad hoc servicing by the research community towards a fully-operational climate change information service; and (iv) Support policy and adaptive response at the enterprise, local, national and regional levels.

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Niamey has also a Regional Climate Data Centre, AGRYHMET Agricultural, Fire and Land Usage, Regional Specialized Meteorological Centre and Regional Telecommunication Hub. Dakar has also a Regional Specialized Meteorological Centre and Regional Telecommunication Hub.

### 6.4.3 Linking climate information systems with users

412. In regard to climate services, it is widely recognized that climate products should be primarily user-centric to ensure that the climate information provided is actionable in real-world decision-making contexts. In light of this, the programme will need to work hard in establishing mechanisms to facilitate ongoing connections between climate service users and the beneficiaries, mainly by sustainable activities being proposed. The following specific actions are expected in this regard:

- Facilitating user participation in national climate
- Developing a comprehensive framework for climate services at the national level.
- Promoting a weather and climate service concept to assist users in accessing weather and climate information they require in a seamless manner.

### 6.4.4 Building national capacity

413. Capability areas to be assessed would likely include: (i) Climate observations; (ii) Data retrieval and management; (iii) Interactions with users; (iii) Climate system monitoring; (iv) Long-range forecasting (monthly to seasonal); (v) Specialized climate products; (vi) Research and modelling; (vii) Decadal scale predictions; (viii) Long-term climate projections; (ix) Customized climate products; (x) Climate application tools.

414. Once the current capabilities of have been established and compared against desired baselines, the programme should draw a capacity building agenda to identify specific targets to achieve over 2-, 6- and 10-year periods to arrive at these baselines. National capacity development should be approached through the following interventions:

- Helping define clear roles and responsibilities within their national contexts for actions such as climate data management, climate monitoring and assessment, climate prediction and projection, and developing tailored climate products for various sectors.
- Helping establish mechanisms for national coordination of their activities concerning basic climate data, diagnostics, climate system monitoring, and in many cases long-range forecasts (LRF).
- Strengthening the infrastructural capacity for data management and to generate and disseminate climate products and services is a major issue for the seven countries. This will require robust information processing, storage and communications (such as Internet, wireless and satellite-based telecommunication), as well as computing facilities adequate for producing national climate products.
- Strengthening the capacity to participate fully in the WMO Information System (WIS) for disseminating data and products related to climate services[424].
- Establishing a capacity development strategy and implementing it to meet the needs of the countries. This strategy will identify requirements for education and training and will operate through hybrid systems that combine traditional training workshops, distance learning using modern communication technologies, manuals, guidance, best-practice documents, and technical papers.
- Undertaking a variety of training activities for enhancing the capacity in Climate Data Management Systems (CDMS), data rescue and transfer into digital format, time series quality control and homogenization, climate monitoring and assessment activities, development of climate indices, Climate Watch systems, seasonal prediction, climate change projection, downscaling and tailoring, user awareness activities, etc.

415. The qualifications and competencies for climatologists, climate services specialists, climate prediction experts, etc., must be established and a common understanding evolved of the professional,

[424]The WIS sets international standards for interfacing climate data with non-climate socio-economic data used in multidisciplinary products and socially beneficial climate services.

technical and administrative capabilities required. The capability for supporting climate risk management and climate adaptation will depend on their capacity to manage and provide climate data, to convert these data into usable information and products, and to develop decision support and decision-making tools by applying the knowledge so generated.

### 6.4.5 Strengthening regional climate capabilities

416. Regional capabilities for supporting climate services have two major objectives: (i) to provide regional scale information to enhance the detail of national-scale information; and (ii) to provide national-scale products on request to countries that do not yet have the required capacity for developing their own products. In strengthening regional capabilities it is important to take into account the global-regional and national levels of climate product generation and exchange. WMO plays a critical role in establishing the climate information system and making it sustainably operational.

417. Climate Information Services are critical for the creation of relevant, science-based information to inform decision making, enabling EWS and creating new business opportunities; (ii) Impact-Based Multi-Hazard Early Warning Systems, that is people-centered, end-to-end and important for de-risking investments, creating synergy for early action and increasing the resilience of vulnerable communities, livelihoods, assets and operations; (iii) Multi-sectoral application of CIEWS for investment and financial decisions, with a focus on adaptation; working with insurance products and Forecast-Based Action/Financing (FBA/FBF) as examples of innovative disaster risk finance mechanisms.

418. CIEWS are essential for Transformational planning and programming via policy de-risking and adaptive decision-making to deliver outcomes, building strategic partnerships to promote coherence and complementarity for impact maximization, and where robust climate science informs the development of national strategic plans and country programming. Additionally, with robust climate information's countries are able to catalysing climate innovation using the best available knowledge in climate and decision sciences and technologies that underpin the design of projects and inform implementation of outcomes. This includes adoption of e-infrastructure, decision support tools, blended finance architecture and policy de-risking to improve efficiency gains. Nowadays, new innovative financing options to leverage and scale up investments could mobilize more the private sector. The expansion and replication of knowledge through knowledge brokering would help prioritizing monitoring, evaluation and learning to ensure lessons learned and best practices inform future programming.

419. In Africa , The hydro-meteorological infrastructure capacity in Sub-Saharan Africa is the lowest of all the global regions, with observation network density (number of stations per 10,000 km sq.) as low as 0.4 in Niger, 0.5 in Mali, 1.1 in Nigeria, 1.6 in Senegal, 1.7 in the Ivory Coast, 6.2. In some post conflicts countries such as Liberia and Sierra Leone, the process of rebuilding their National Meteorological and Hydrological Services (NMHS) following decades of civil war (Usher, Phiri, Linacre, O'Sullivan, & Qadir, 2018) is ongoing. The World Bank estimates US$ 1.5 to US$ 2 billion is required to modernize CIEWS infrastructure in Sub-Saharan Africa, and US$ 400 to US$ 500 million is needed annually for operations and maintenance (Rogers & Tsirkunov, 2013)

420. Nowadays, at the centre of Forecast based Programming, initiatives are efforts to provide earlier support to at-risk communities with CIEWS. While practitioners agree on the importance of early action, there is a wide interpretation of what this means and when it can occur. Three broad approaches are used:

a. Before a hazard occurs. Practitioners including the Red Cross and WFP use forecasts of climate hazards linked to in-depth analysis of the impacts of these hazards to trigger action before and during the onset of climate or weather hazards. This means that action can be triggered days, weeks or months before the hazard occurs. For example, WFP triggered funding for an anticipatory response in September 2015 based on a forecast of high drought risk due to El Niño conditions during the main October to February agricultural season in Zimbabwe. The main humanitarian impacts of this drought were felt from mid-2016 to early 2017.
b. During and immediately following a climate hazard. An increasing number of mechanisms use seasonal monitoring of climate and agro-climatic information to detect a shock. This analysis is linked to a forecast of likely impacts, and used to create a trigger to release finance for early action and early response. The action may be triggered and implemented aftershocks such as rainfall deficits or changes in temperature have already occurred, but before they have unfolded into fully fledged disasters. This approach entails often unclear overlaps between early action and early response, especially in the case of slow-onset events such as droughts, where windows for both are longer. Mechanisms such as ARC's drought risk pooling facility and the HSNP are examples of this.

c. Across multiple time-scales (and for non-climate hazard-related shocks). Some practitioners use multiple sources of early warning information, including climate, market and conflict-related information, to forecast the impact of a shock or series of shocks. This approach blends data and uses impact forecasts before impacts emerge or become acute. All three approaches link hazards or shocks to impacts, but the emphasis is slightly different. The first approach is most often linked to automated trigger mechanisms that generate action before the hazard occurs, in order to reduce its impact.

**Financing FbA :**

421. All forecast-based early action mechanisms recognise the importance of being able to deploy funding and other resources in a predictable and reliable way. FbA programmes have applied a variety of financing tools, including dedicated funds, specific windows in emergency response funds, insurance or contingent finance and direct links to regular resource allocation processes. Acting on the basis of forecasts does not necessarily require new funding, but it certainly calls for the more rational use of existing funds. In middle-income countries funding is usually available for preparedness, but is often not allocated consistently or quickly enough to reduce disaster losses. Although many FbA initiatives do set aside resources to finance pre-determined actions, infrastructure needs to be in place to deliver support, whether cash transfers or other types of assistance. In terms of where the funding comes from, there appears to be growing interest in combining different sources, triggered at different times and used to fund different kinds of measures, from communicating information early on, when uncertainty is high, through to higher-cost activities as uncertainty is reduced. All of this requires significant planning, clarification of responsibilities, coordination and costing of anticipatory actions. As initiatives are scaled up, it will become clearer to what extent FbA can help streamline, cobenefit and increase the effectiveness of disaster risk management by donors, governments and humanitarian and development organisations.

**Insurance and contingent finance**

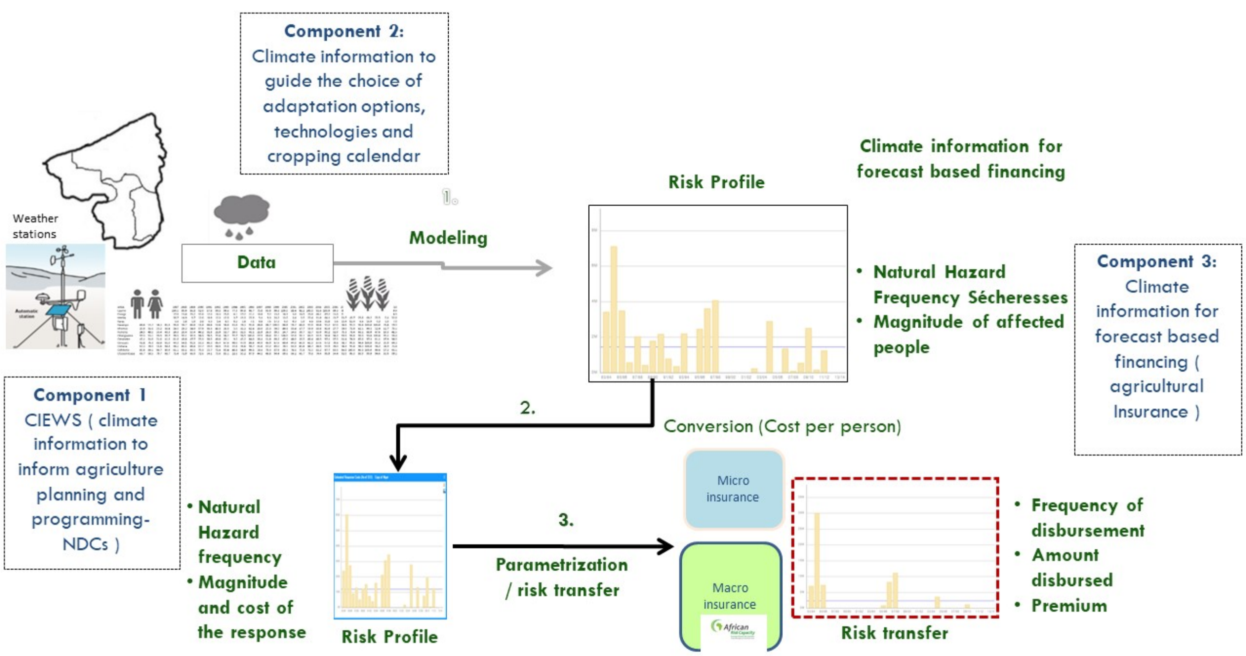
422. Another option for FbA involves market-based mechanisms (i.e. not public funds) such as insurance or contingent finance. These could pay out before disaster impacts have resulted in losses for individual policyholders or businesses, or have led to credit defaults for cooperatives, enterprises, banks or microfinance institutions (MFIs). There is as yet limited experience with integrating hazard forecast-based triggers into such risk financing and transfer mechanisms. One exception was an El Niño insurance product tested in Peru between 2012 and 2014, which released funds to MFIs and cooperatives based on forecasts, encouraging them to take anticipatory action and to increase lending before, during and after a disaster, when people were in need of additional resources to prepare and respond. Other insurance and contingent finance initiatives that are already using triggers to support early post-disaster response could be expanded to include more preventative and mitigative actions in the future. The African and Asian Resilience in Disaster Insurance Scheme (ARDIS), launched in 2018 by VisionFund International, Global Parametrics and the InsuResilience Investment fund, will institutions with access to credit and insurance-type payouts. Both financing instruments are linked to either a drought or a windstorm index that differs between countries. Disaster risk financing initiatives targeted at governments and NGOs, such as ARC's sovereign drought insurance and ARC Replica drought coverage, might represent a further opportunity to expand into even earlier action.

423. Investment in FbA is expected to bring about several positive outcomes, and significant attention has been paid to measuring the costs and benefits involved. In particular, studies have looked at outcomes related to:

• an earlier response and reduced response time, so that aid gets to people faster, averting suffering and helping to prevent more severe impacts;

• a decrease in the cost of humanitarian response through greater prepositioning and early procurement; and ;
• better-quality programme design through pre-planning with more preventative measures, and potential cobenefits in non-crisis times.

424. These outcomes would suggest that investing early through FbA is more cost-effective than waiting to provide a late response. However, it would be wrong to assume that FbA would be more cost-effective under all circumstances, and there are many possible scenarios where FbA may not be cost-effective. These are described in greater detail below. Evidence on the costs and benefits of anticipatory action is very limited, and a meta-analysis of evaluations of these initiatives was beyond the scope of this report. Key studies that have tried to quantify the costs and benefits of an early response. Since empirical evidence around the impact of earlier responses is scarce, most studies have relied on modelling and estimations to assess the impact of alternative approaches. Protocols could usefully build in damage and loss assessment, not only in areas where early action was taken but also where it was not, in order to compare the differential outcomes. However, the benefits of early action can extend well beyond reducing loss and damage. By reducing damaging coping strategies, early action can have long-term effects on malnutrition, education and health that cannot easily be captured in a short timeframe. Furthermore, the impacts of crisis are multidimensional, and teasing out attribution of outcomes to specific activities can be difficult. It is therefore critical that any assessments of the costs and benefits of early action through FbA use a mix of qualitative and quantitative approaches to the full range of potential impacts, including less quantifiable effects such as social outcomes, as well as investigating the effectiveness of different activities for different hazards.



## Chapter 8 Feasibility and Design of Insurance Programme

### 8.1 Context

425. Insurance is increasingly recognised as a tool to help build farmer resilience and improve farmer well-being. This can be understood if we consider certain challenges present in the rural economy:

- The average age of farmers is rising and the youth prefer to migrate to urban centres rather than continue in agricultural production. At the same time, there is a global increase in demand for food products as the world population is growing and demand pressure is exerted on primary materials. Thus, a situation exists where there is an increasing demand for food but a threat on supply. This threat is further exacerbated by the macroeconomic, market and climate risks that small holder farmers are forced to endure in their economic activities potentially resulting in a vicious poverty trap and placing them in a situation where they are unable to provide education for their children and do not have access to adequate housing, sufficient food or proper healthcare. Insurance can be a useful mechanism in this context to help secure farmers against these risks and encourage the pursuit of farming activities.
- Farmers are faced with a difficulty in accessing credit because of the risks along the agricultural value chain. If farmers cannot invest in their activities then they are unable to grow their businesses. Insurance is a mechanism that can help attract investment into agriculture. Insurance benefits all the actors along the value chain: farmers are able to payback their loans instead of selling off productive assets; lending institutions decrease their default risk, input providers see their buyer network secured and farmers can invest more and buy more inputs as well as agribusiness who have a more secured sourcing network.

426. It is evident that farmers are faced with risks linked to climate change, with difficult working environments and confronted to a lack of agricultural finance. These conditions perpetuate food insecurity and prevent farmers from investing in their agricultural activities. This in turn impacts entire agricultural value chains. There is a clear need to build sustainable ecosystems for farmers and improve livelihoods and resilience. Overcoming risk is an essential aspect of this and in this light, the development of insurance solutions is a useful tool in protecting smallholder farmers.

### 8.2 The impact of climate risk preparedness and adaptation

427. Disaster preparedness methods, prevention infrastructure and climate adaptation activities in Africa have been proven to mitigate the impacts of climate change. The United Nations Framework Convention on Climate Change (UNFCCC) established the national adaptation plan (NAP) process as a way to facilitate adaptation planning in least developed countries (LDCs) and other developing countries such as Burkina Faso, Chad, Mali, Mauritania, Niger, Senegal and The Gambia. To facilitate the development of NAPs, climate services can support climate risk preparedness and adaptation through the development and provision of science-based and user-specific information relating to past, present and potential future climate and address all sectors affected by climate, at global, regional and local scale. They connect natural and socio-economic research with practice. They help society cope with climate variability and change through the transformation of climate related data and other relevant information into customized products such as projections, trends, economic analysis and services to the user communities in different sectors. For example, the provision of more and better climate services will: (i) allow farmers to fine-tune their planting and marketing strategies based on seasonal climate forecasts; (ii) empower disaster risk managers to prepare more effectively for droughts and heavy precipitation; (iii) assist public health services to target vaccine and other prevention campaigns

to limit climate-related disease outbreaks such as malaria and meningitis; and (iv) help improve the management of water resources. (WMO, 2015)[425]

428. The UN World Meteorological Organization (WMO) reaffirms the vital importance of the mission of the National Meteorological and Hydrological Services (NMHSs). Indeed, the NMHS aims to help meet the demand for climate risk preparedness to address climate change and adaptation, particularly at the local level, by combining climate-change projections with local climate data and knowledge. By observing and understanding weather and climate as well as providing meteorological, hydrological and related services, countries can support relevant national needs including the protection of life and property, safeguarding the environment, contributing to sustainable development, promoting long-term observation and collection of meteorological, hydrological and climatological data, including related environmental data. Countries can also better invest in capacity-building in Africa, meet international commitments as well as contribute to international cooperation. (WMO, 2015)[426]

429. Combined, climate services such as those developed under the WMO-led initiative, the Global Framework for Climate Services (GFCS), facilitate hazard analysis and risk assessment to promote sectoral risk management and societal resilience in Africa. The GFCS includes five initial priority areas, namely agriculture and food security, disaster risk reduction, energy, health, and water. The NMHSs provide support to adaptation in the priority areas of GFCS in: (i) designing, operating and maintaining the national observing systems; (ii) handling data management, including quality analysis and quality control (QA/QC); (iii) developing and maintaining data archives; (iv) undertaking climate monitoring; (v) providing the oversight on climate standards; (vi) carrying out climate diagnostics, climate analysis and climate assessment; disseminate via a variety of media climate products based on the data; and (vii) participating in regional climate outlook forums and some interaction with users, to meet requests and gather feedback. (WMO, 2015)[427]

430. Therefore, in order to enable adaptation more widely across different sectors, many African countries undertake activities to support the integration of adaptation into national, subnational and sectoral development planning and regulatory processes at various levels of government. For example, Burkina Faso's NAP has been mainstreamed into its Strategic Framework for Investment in Sustainable Land Management, which serves as the implementation vehicle (UNEP, 2018)[428]. In addition, partnerships between NMHSs and academia, government departments, international and non-governmental organizations, and where appropriate and possible, the private sector and civil society, help society make better decisions based on more complete and accurate weather, water and climate information. These partnerships help develop appropriate national frameworks that facilitate the gathering and sharing of data, and expertise to make the information easy to access in real-time, in useful forms, and at low cost. (WMO, 2015)[429].

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[425] https://www.wmo.int/pages/prog/www/DPFS/Meetings/ET-OWFPS_Montreal2016/documents/WMOGuidelinesonMulti-hazardImpact-basedForecastandWarningServices.pdf
[426] https://www.wmo.int/pages/prog/www/DPFS/Meetings/ET-OWFPS_Montreal2016/documents/WMOGuidelinesonMulti-hazardImpact-basedForecastandWarningServices.pdf
[427] https://www.wmo.int/pages/prog/www/DPFS/Meetings/ET-OWFPS_Montreal2016/documents/WMOGuidelinesonMulti-hazardImpact-basedForecastandWarningServices.pdf
[428] https://unepdtu.org/wp-content/uploads/2019/04/agr-final-version-2018.pdf
[429] https://www.wmo.int/pages/prog/www/DPFS/Meetings/ET-OWFPS_Montreal2016/documents/WMOGuidelinesonMulti-hazardImpact-basedForecastandWarningServices.pdf

431. The UN Environment Programme (UNEP) reported in its 2018 Adaptation Gap[430] that reviewing public expenditure to determine the amount spent by the national government on adaptation and tracking budget allocations to national climate-change activities also contribute to enabling climate adaptation in Africa. This will cut countries' response costs to climate change such as in Niger, Magagi Laouan, Minister of Humanitarian Action and Disaster Management of Niger, said that 3,702 registered disasters have cost his country more than US$3 billion in the past 40 years. They have killed 10,625 people, 17 million livestock animals and destroyed 72,000 homes and 2.6 million hectares of agricultural land. Niger has now set up an early warning system and with support from the GFCS and the Climate Risk and Early Warning Systems initiative (CREWS), authorities are working to reduce weather and climate-related losses and boost productivity in agriculture and to ensure that drought does not deteriorate into famine (WMO, 2019)[431].

### 8.3 The R4 approach

432. The microinsurance component is built on the R4 approach of the WFP. WFP has already implemented this integrated risk management strategy in 8 countries on the African continent, with more than 500 000 beneficiaries insured in 2019.

433. The R4 Rural Resilience Initiative (R4) of the United Nations World Food Programme (WFP) was initiated in 2011 to respond to the challenges faced by food insecure communities enduring increasingly frequent and intense climate disasters and other shocks.

434. R4 refers to the four risk management strategies integrated in the initiative to strengthen farmers' food and income security. The initiative combines improved natural resource management (risk reduction), microinsurance (risk transfer), support to investment, livelihoods diversification, and microcredit (prudent risk taking), and savings (risk reserves).

435. Risk reduction is an essential complement to insurance, as it contributes to reducing the effects shocks have on households and communities, increasing farmers' adaptive capacity to climate change. Thus, risk reduction decreases the overall exposure to weather shocks, allowing to focus insurance on the low frequency / high impact years and thus helping to keep the cost of insurance to acceptable levels.

436. Insurance can be incorporated into an existing public social protection programme where farmers are encouraged to adopt behaviours that will improve their capacity to withstand future shocks e.g. conservation agriculture techniques, asset creation to reduce risk exposure and/or improve productivity and income generation, that can also include the introduction of climate services. In each of these cases, farmers gain access to index insurance by investing their time and labour in building assets or adapting their farming practices that decrease their vulnerability to weather-related shocks over time. Over time, a cash contribution by the farmers is introduced, until they can afford the whole premium and be graduated to the market.

437. By protecting farmers' investments with insurance when a bad season affects agricultural yields or threatens the survival of livestock, the approach enables households to invest in riskier but more remunerative enterprises, as well as in seeds, fertilizers and new technologies to increase their agricultural productivity.

438. The risk reserves component helps households cope with smaller, more frequent shocks, by building monetary or in-kind savings. For instance, participants in Village Savings and Loan

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[430] https://unepdtu.org/wp-content/uploads/2019/04/agr-final-version-2018.pdf

[431] https://public.wmo.int/en/media/press-release/global-platform-disaster-risk-reduction-we-need-drastic-change-of-course

Associations (VSLA) establish small-scale savings, which are used to build a stronger financial base for investments – but also act as a buffer against short-term needs and idiosyncratic shocks such as illness and death. In the long run, these savings could also be used to pay insurance premiums in cash. Participation in VSLA groups allows members to progressively transition to more formal financial services, increasing access to microcredit for productive investments. Saving with formal microfinance institutions (MFIs) is also a possibility, depending on the available offer and accessibility for farmers.

439. Therefore, insurance is not only a protection mechanism to respond rapidly to shocks, but by protecting investments, it allows farmers to increase production and incomes in good years, enabling them to transition from subsistence farming to producing a surplus for selling to markets. This will gradually allow farmers to access insurance commercially and contribute to the overall sustainability of the initiative. However, while insurance can promote risk taking by households, it requires complementary actions such as business advisory services, predictable market access and improved access to financial services. Therefore, it is important that WFP finds the right partners for these actions.

440. In the framework of the project, WFP will be specifically in charge of developing the insurance component and integrating with the other components, that either focus on risk reduction, or financial inclusion and income generation increase.

### 8.4 Insurance assessment

441. One of the aims of the project proposed by the IFAD and the AfDB is to strengthen the climate risk management continuum by linking adaptation measures with risk transfer schemes to build smallholder farmers' resilience to climate change.

442. In light of this objective, insurance is being proposed as a mechanism to enhance farmer resilience to climate change. The ability to implement insurance and its success in supporting farmer resilience is a function of several variables including a) the support of the government for the programme b) the identification of local champions and distribution channels to allow the programme to reach scale and sustainability c) the technical feasibility to cover the identified risks by index insurance d) the infrastructure in place including the regulation, the insurance industry and data availability.

443. Before starting the project implementation in each country, WFP will conduct an inception assessment to have a better understanding of:

i. The microinsurance, index insurance, climate and agricultural insurance context. In particular, WFP will look at who are the players, what are the products available in the market and their outreach, who are the delivery channels, what is the use of digital services, what are the pros and cons of each option.
ii. The regulatory and policy framework regarding insurance, microinsurance, agricultural and climate risk index insurance. What is the regulatory framework and what is the level of understanding by the supervisor of index insurance? Is there any policy regarding agricultural and climate insurance solutions? Is there any subsidies system in place? Is the government planning to set up any institutional scheme to support the development of such a tool?
iii. The demand (how are value chains structured, what is the level of knowledge about risk management and insurance in particular, gross margin analysis, etc.). This will require field work and focus groups with farmers in particular.
iv. The main risks faced by farmers regarding production (climate shocks, pests, diseases). It will be a good opportunity to collect additional data to support design of new products and improvement of existing ones.

v. The capacity building needs : based on the assessment, WFP will be able to present a capacity building plan for supervisors, delivery channels, insurance companies, meteorological agencies or other ministries agencies, on multiple purposes such as product design and monitoring, consumer education and protection, contract management, pricing& reinsurance, distribution & digitalisation.

vi. Understanding of the other components and existing programmes, to design operational integration of insurance as one risk management tool amongst an integrated risk management strategy.

444. Once this assessment is completed, WFP will prepare and present a plan to achieve the project goals, which will detail the following:

- Regions of interest within the project targeted area where insurance will be introduced and scaled up.
- Types of products (existing or new ones), and support needs.
- Capacity strengthening priority needs and work plan.
- Graduation strategy to ensure participants will be in capacity to afford the premium 100% in cash at the end of the process.
- Distribution strategy, including partners and commercial strategy, for farmers paying 100% in cash
- Overall business model.
- Integration of insurance with the other components in the context of that specific country.

Below, we are detailing the content of inception assessment methodology.

445. The inception phase will last the first 6 months of the project implementation before opening the operational phase. We have split countries in 2 groups:

i. Most advanced countries in terms of insurance, with existing experience, products and stakeholders (Senegal, Mali & Burkina Faso), where the project will focus on capacity strengthening (including on product design), scaling up and market expansion, and sustainability. If existing products are satisfying, the project will leverage these products and possibility develop new ones on untapped market segments. In these countries, introduction of insurance will start on year 1. Budget-wise, Burkina Faso and Mali have a very similar structure and targets (from 5000 insured people in year 1 to 45 000 in year 5), and Senegal is slightly adjusted considering how advanced the country is (from 10 000 insured people in year 1 to 45 000 already from year 3), which has better conditions for fully graduating participants.

ii. Countries with limited to no experience on index insurance (Mauritania, the Gambia, Chad and Niger) will require some capacity building at first before being able to introduce insurance. In this group of countries, the project will set up the conditions for introducing insurance, which will require external support on product design, but also on capacity building for insurance companies and delivery channels, but also on consumers education and protection. In order to ensure proper implementation, Chad and Mauritania will initiate the inception assessment and project implementation on year 2. In order to create the right conditions to introduce and scale up insurance in this group of countries (from 5000 insured people in year 3 to 25 000 in year 5 for each country), it is planned to run a small pilot in each country with 500 participants in the second year of microinsurance component implementation, before full distribution the next year. This will give us the opportunity to test the product, but also the different processes, and raise awareness on the instrument, as well as create the right linkages with the other components.

### 8.4.1 Overview of the agricultural insurance

446. In Africa, agricultural insurance is endowed with huge potential for development. It remains, nonetheless, a precarious and largely untapped sector because of the inadequacy or rather the inexistence of insurance products. The overwhelming majority of agricultural holdings are deprived of any kind of protection against climate hazards. A report published in September 2015 on the sideline of the G20 showed that out of the 178 million farmers in developing countries, having underwritten index insurance in 2014, only 450 000 are African, that is, 0.25%. The vast majority of the individuals who subscribed to this kind of coverage is located in India and China. These figures are a living proof that the African market of agricultural insurance is endowed with substantial margin of growth. Things are changing though. In Zambia, the Ministry of Agriculture, with the support of several financial and technical stakeholders, has given access to 1 million farmers to index insurance, under their Farmers Inputs Subsidized package. Although no clear figure currently exists in Africa, several millions of farmers have now access to index insurance, mostly on commercial basis.

### 8.4.2 Agricultural insurance in West Africa

#### 8.4.2.1 Micro Insurance

447. The introduction of agricultural insurance is more recent in Sub-Sahara Africa than in the Maghreb. In 2011, an insurance plan called Assurance Récolte Sahel (Sahel crop insurance) (ARS), was launched by PlaNet Guarantee (now Inclusive Guarantee), with financial support from the World Bank Group, under the Global Index Insurance Facility (GIIF) and several other local and international institutions as described in the table below. This project was designed to establish an index-based insurance for the coverage of drought risks. This scheme is now under experiment in five countries: Senegal (peanuts, corn, millet, rainfed rice), Mali (cotton, corn, however these schemes have been put on hold by Inclusive Guarantee), Burkina Faso (cotton, corn, multi cereals) and Benin (corn, although it has been dropped), Côte d'Ivoire (maize and cotton).Main stakeholders involved in this project were, apart from PlaNet Guarantee : CNAAS, Allianz Africa, Swiss Re, Hannover Re, CIRAD, EARS, and Axa Re.

448. It has so far been the main regional initiative on this topic. The GIIF has also implemented a regional strategy, focusing on (a) supporting CIMA in developing microinsurance and index insurance regulation, (b) support governments in developing index microinsurance pilots, (c) directly developing business (mostly for IFC) on meso index insurance for high potential value chains.

449. Nevertheless, most West African countries still have a very limited development of index insurance operations. Only Senegal, Mali and Burkina Faso have a growing market, with multiple stakeholders.

450. In Mali, several stakeholders are currently offering index insurance schemes : OKO (weather index through mobile channels), Pula (area yield index, through a programme of saving and support on farming practices), FARM / SOCODEVI (weather and area yield). FARM is currently supporting the government to establish an institutional system for agricultural index insurance. WFP, and IFAD (INCLUSIF) are considering supporting the process and access to insurance to most vulnerable farmers.

451. In Burkina Faso, Inclusive Guarantee was reaching out around 30,000 farmers in 2019, mostly between cotton farmers and cereals growers. It has a relatively solid position in the market, but Yelen, a microinsurance company is offering weather index schemes, based on the ARC's software (AfricaRisk View). In addition, the Ministry of Agriculture has initiated a feasibility study with Mamda (from Morocco) and Partner Re to introduce a public scheme. The scheme was expected in 2019, but is still under development. WFP has introduced an index insurance scheme for the most vulnerable

households in the Center North and East regions in 2019. In 2020, WFP is using Yelen's scheme, which itself is using the WRSI developed by the technical working group for the ARC risk profile customization.

452. Below a quick summary of the market in the 7 target countries:

| | **Index insurance products available in the market** | **insurers already distributing products** | **Pilots or feasibility studies already conducted** | **Regulation** | **Market size** | **Projects supporting index insurance /key financial & technical stakeholders** | **Key possible products** |
|---|---|---|---|---|---|---|---|
| **Burkina Faso** | Yes, Inclusive Guarantee (maize, cotton, multi cereals), Yelen (all country covered, with unique premium) | Allianz, Yelen (microinsurer),Sonar | Yes, since 2011 | Yes, CIMA | ar. 40, 000 farmers insured | i. Assurance Récolte Sahel (Inclusive Guarantee), ii. Yellen, iii. project of Ministry of Agriculture with Mamda, iv. WFP | cotton, mult cereals, maize, sesame, groundnut, millet, sorghum, pastoral index |
| **Chad** | No | No | No | Yes, CIMA | 0 | No | agricultural and pastora index |
| **Mali** | Yes, OKO (mobile insurance), Pula (area yield), Socodevi (weather index), Inclusive Guarantee | Allianz, Sunu | Yes, since 2011 | Yes, CIMA | around 20,000 farmers insured (mostly through Pula) | i. Assurance Récolte Sahel (Inclusive Guarantee), ii. FARM, iii. INCLUSIF (IFAD) | cotton, mult cereals, maize, sesame, groundnut, millet, sorghum, rice, onion pastoral index |
| **Mauritania** | No | No | No | No | 0 | No | pastoral index |
| **Niger** | No | No | Yes, IRI on non-crop specific index, for UNDP. Never implemented. WFP has also conducted a pre-feasibility study. | Yes, CIMA | 0 | No | agricultural and pastora index |
| **Senegal** | Yes, all through CNAAS | CNAAS | Yes, since 2008 | Yes, CIMA | above 100,000 | i. R4 (WFP), ii. GIIF, iii. West African | multi cereal cotton, groundnut, |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | (insurer). Rainfall indices (based on rain gauge, for maize, millet, groundnut and rice), satellite (for cotton, and all cereals), areas yield. | | | | farmers insured | Development Bank, iv. EU (OSIRIS), v. Naatal Mbay (USAID)… All stakeholders are coordinated under CDPAI (Comité pour le Développement et la Promotion de l'Assurance Indicielle) | millet, rice, maize, sorghum, livestock ar pastoralists |
| **The Gambia** | No | No | Yes, WFP has conducted a feasibility study | No | 0 | No | groundnut, millet, maiz multi cereal |

#### 8.4.2.2 Agricultural insurance in Senegal

453. In 2015, agriculture absorbed 50% of the Senegalese labor force, contributing with 17.5% of GDP. Endowed with a total area of 196 000 Km², Senegal dedicated 140 000 Km 2 to agriculture, 80 000 Km 2 of which are agricultural lands in the true sense of the word and 60 000 Km 2 designed for breeding.

454. The main obstacles to Senegalese agriculture are drought in the Sahel region, poor soil fertility, pest attacks (locusts and other harmful pests), the poor revenues yielded by agricultural holdings, agricultural value chains relatively under-structured. In an attempt to help farmers, the Senegalese State set up in the beginning of 2000's two funds attached to the Caisse Nationale du Crédit Agricole du Sénégal CNCAS (Senegal's national fund of agricultural loans). The first was tasked with the coverage of climate-related risks while the task of the second was to provide collateral for 75% of repayment defaults for agricultural loans.

455. In 2008, the Compagnie Nationale d'Assurance Agricole du Sénégal (Senegal's national agricultural insurance company, CNAAS) in which the State detains a 28% shareholding was set up. The remainder of the capital is spread out among local insurance companies and farmers' associations. The State subsidizes 50% of the written premiums. A tax relief program on agricultural insurance plans and a decrease in the interest rates on loans are also part of the measures designed by the State to support the business. In 2012, CNAAS launched its first index-based insurance products in association with the Sahel Crop Insurance (ARS) project, a drought plan for the crops of peanuts and corn. The cover may amount up to 10.5 million USD per department in the event of natural disasters. The Senegalese State intervenes when the cost of claims exceeds this amount. Agricultural micro-insurance has drawn interest among farmers more than classical insurance whose cost is relatively high. In 2014, CNAAS reported 30 000 contracts of micro-insurance, versus only 3 000 for classical insurance. Since then, CNAAS has expanded its portfolio to cotton farmers (with the support of West African Development Bank), or to most vulnerable farmers, under the R4 initiative of WFP. It reached out more than 100,000 farmers in 2019.

#### 8.4.2.3 Agricultural insurance new experiences: Gabon, Cameroon, Mauritania

456. Convinced about the importance of agricultural insurance and its bearing on economic development, several countries in West and Central Africa such as Gabon, Cameroon and Mauritania are now intent on developing this business described below:

457. **Agricultural insurance in Gabon:** Gabon features huge natural assets and a climate prone to agriculture. The oil discoveries have, nonetheless, slowed down the development of the sector which accounted for merely 4.7% of GDP in 2015, a rate that has gradually dwindled down in recent years. With 90% of city dwellers, Gabon is considered as one of the most urbanized countries in Africa. The country is suffering from food dependency, with imports of agricultural and food products accounting for 21% of the country's total imports. Nearly 40% of the population is confronted with a food security issue. In order to face this situation, the Gabonese government set up in 2017 an agricultural development fund (FDA) in which it detains a 49% stake. The remaining 51% are held by agricultural inter-professional organizations. Endowed with a capital of 2 billion FCFA (3 million USD), the institution is aiming at providing loan guarantees for the benefit of farmers, covering them against natural and environmental hazards.

458. **Agricultural insurance in Cameroon:** In late 2016, representatives of the World Bank, African Development Bank (ADB), the International Finance Corporation (IFC), along with several other insurers and representatives of the Cameroonian government met in Douala. The introduction of an index-based agricultural insurance ranked high on the agenda of the meeting. This initiative is all the more important as 60% of the population operates in the agricultural sector. Agriculture actually accounted for 22.8% of GDP in 2015.

459. **Agricultural insurance in Mauritania:** Located in an overwhelmingly desert area with very few arable lands, Mauritania has been often regarded as a country solely confined to breeding. The development of an agricultural zone along the Senegal River has pushed the authorities to seek insurance solutions in order to preserve farmers' revenues. Agricultural insurance may indeed stand as a first response to this problem. In late October 2015, a Mauritanian delegation paid a visit to Morocco in order to study the local agricultural insurance system.

#### 8.4.2.4 Macro Insurance

460. The African Risk Capacity (ARC) provides index insurance against droughts to African Union member states. As a distinctive feature of ARC, participating governments have to prepare contingency plans prior to taking out insurance. These plans determine how insurance payouts will be used when the insurance is triggered. By combining early warning and contingency planning with an insurance mechanism, ARC provides liquidity shortly after a catastrophic event, while the pre-planned activities ensure that payouts are used quickly and effectively, mitigating the detrimental impacts of disasters for the poor and vulnerable. Currently, ARC is developing two new insurance products against floods and tropical cyclones.

461. In the period 2016/17, Burkina Faso, Senegal, Niger, the Gambia, Mali and Mauretania took out insurance from ARC. Since its inception in 2014, ARC has paid out more than 34 million USD to four drought-affected countries: Mauritania, Niger, Senegal and Malawi. The funds, disbursed ahead of the UN appeal, were used to deliver rapid relief to affected populations. ARC can reach up to 150 million beneficiaries, based on committed funding under InsuResilience, by 2020.

462. ARC Replica is bringing humanitarian actors into ARC's government led risk management approach. Humanitarian institutions (e.g. NGOs) can match country policies and take out insurance, so that international resources are used cost-effectively, while also ensuring that country structures and

humanitarian aid organizations work together more efficiently. WFP and Start Network have purchased Replica policies in 2019 for Mauritania, Senegal, the Gambia, Mali and Burkina Faso.

463. In that optic and latter development, a pre-feasibility assessment is necessary to assess these conditions for the implementation of insurance.

464. A description of the aforementioned points is provided below. Prior initiating activities, the project will conduct inception assessments, covering all the items below. Specifically, for Mauritania, the Gambia, Niger and Chad, the project will work on setting up the conditions to be able to introduce index insurance on the market. Some activities will be planned with public and private stakeholders (insurance companies, delivery channels in particular) to build capacity to implement and progressively take over. Thus, the first 2 years of the project, in these 4 countries will focus on capacity building, before proper implementation.

**Drought frequency and response by country, Country risk profiles ( source ARC)**

| **Country** | **Period** | **Number of severe droughts** | **Frequency of droughts (1 in x years** | **Cost of response (average) USD million** | **Contribution per country** | **ARC payout** | **Year of the payout** |
|---|---|---|---|---|---|---|---|
| **Burkina Faso** | 2000-2017 | 4.0 | 4.0 | 20.0 | 2016/17: 1.39mln 2017/18: 1.18mln 2018/19: 1.19mln 2019/20: ***683k (replica)*** | | |
| **Chad** | 1983-2017 | 10.0 | 3.4 | 20.0 | 2019/20: 200k (AfDB) | | |
| **Gambia (The)** | 2000-2017 | 6.0 | 3.0 | 10.0 | 2015/16: 569k 2016/17: 591k 2017/18: 597k 2018/19: 394k 2019: 200k (AfDB), ***400k (replica)*** | | |
| **Mali** | 1983-2017 | 14.0 | 4.0 | 20.0 | 2015/16: 2.2mln 2016/17: 2.36mln 2017/18: 2.4mln 2019/20: 2.1mln, ***1.87mln (replica)*** | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Mauritania** | 2001-2019 | 6 | 3 | 18.8 | 2014/15: 1.4mln 2015/16: 1.76mln 2016/17: 1.74mln 2017/18: 1.48mln 2019/20: ***1.5mln (replica)*** | US $6.3<br><br>US $2.4 | 2015<br><br>2018 |
| **Niger** | 1983-2017 | 7.0 | 5.0 | 40.0 | 2014/15: 3mln 2015/16: 2.9mln 2016/17: 2.19mln 2019/20: 167k | US $3.5 | 2015 |
| **Senegal** | 2001-2019 | 5 | 3 | 17 | 2014/15: 3.6mln 2015/16: 3.59mln 2016/17: 3mln 2017/18: 3mln 2018/19: 3.2mln 2019/20:mln, ***2.6mln (replica)*** | $16.5<br><br>$12.5 (govt) US$ 10.6 (Replica) | 2015<br><br>2019 |

Note that in 2015, the government of Senegal, Mauritania, and Niger paid a combined premium of USD 8 million and received within 2 years and USD 26, 3 million pay-out from ARC Ltd.

Because of the COVID 19 impact, the federal government of Germany has provided 19 million Euros grant to support 15 countries for their premiums payments to ARC for the agricultural campaign 2020/2021.

#### 8.4.2.5 The regulatory Framework

465. Index insurance is different from traditional indemnity insurance. In particular, claims involve no measurement of loss and agreed value payouts may be higher or lower than actual loss sustained. In addition, it may be difficult to demonstrate an ‘insurable interest’ in the conventional sense (e.g. demonstration of an established crop). These matters are of interest to insurance regulators, who are typically an arm of Ministries of Finance. Their commitment to creating an enabling legal and regulatory environment is important in ensuring that the sale and management of products are fair to both buyers and sellers.

466. As a result, the purpose of this first step is to ensure the current framework allows for the development of index insurance and to identify any potential constraints. Specifically, the programme aims to understand:

- The current regulation regarding index insurance/microinsurance
- The possibility of new laws (favourable or unfavourable) emerging
- Any constraints facing the selected distribution channel.

These aspects are taken into consideration when formulating the programme.

467. The CIMA code has introduced the Book VII, a regulation for microinsurance and a decree (Circulaire N°3) on index insurance specifically, under this Book VII. All countries, but Mauritania and the Gambia are covered by this regulation. The Gambia and Mauritania don’t have a specific regulation so far. The project will specifically work with the supervisors in the Gambia and Mauritania to make sure any index insurance product introduced in the market, will have the right support and clearance.

#### 8.4.2.6 Current government and donor policies

468. In order for the insurance to be effective at a large scale, it is necessary for it to be coherent with existing government policies including the policy for rural development as well as the policy for insurance. This may involve different authorities including the Ministries of Finance and Agriculture. This information is gathered at the outset to ensure the program is formulated in taking into consideration government priorities and policies (for example, premium subsidies, favourable tax regulation etc.).

469. Moreover, the programmes of other donors will be considered to ensure there is no duplication between existing programmes and that a coherent framework of intervention is formed. Existing programmes on providing climate information to farmers or enhancing the quality of weather station networks can also be tools to strengthen the insurance programme.

#### 8.4.2.7 Insurance Industry and existing Products in the market

470. In order to build on existing experiences and avoid duplication, we aim to understand:

- The products that are already offered on the market
- The presence and risk appetite of local insurers and reinsurers
- Their needs in terms of capacity building

- Their technical capabilities to provide insurance

#### 8.4.2.8 Develop product distribution channels

471. In planning implementation of an index insurance, the first step is to set up the market arrangement of the risk transfer and distribution proposition. The programme will look for opportunities to leverage work already being done in the countries by the insurance industries and their existing products in the market. This will require an assessment to investigate possible linkages with key rural finance institutions, cooperatives, farmers' organisations, mobile banking platforms, agro dealers... or insurance companies that are relevant to the programme's objectives in order to build a platform for potential insurance distribution through the respective institutions. Access to micro insurance expanded at country level will be tailored to each of the selected countries' and regional contexts. The following table shows existing major microfinance institutions and insurance companies in the seven countries:

| | **Key non-life insurance company/network of insurance companies** | **Key MFI/network of MFIs** | **Reinsurance company** |
|---|---|---|---|
| **Burkina Faso**[432] | • SONAR IARD<br>• SUNU<br>• JACKSON SAHAM (The company's portfolio includes natural disaster insurance)<br>• GA IARD<br>• FCPB[433]<br>• UAB<br>• FONCIAS/ATHENA<br>• Ascoma | • CORIS<br>• FCPB[434]<br>• UAB[435]<br>• PAMF-B<br>• URC-Bam<br>• FAARF<br>• ADRK<br>• ECLA<br>• PRODIA | • SONAR IARD<br>• SAHAM<br>• GLOBUS RE |
| **Chad**[436] | • SAAR<br>• La Star Nationale<br>• Ascoma<br>• Assurance Tchad | • FINADEV<br>• URCOPEC N'Djamena<br>• UCEEC pala<br>• ASDEC Moundou<br>• PARCEC-MC Sarh<br>• CDCR/ONDR Moundou<br>• ASSOCEC N'Djamena | |

[432] https://www.atlas-mag.net/article/marche-de-l-assurance-au-burkina-faso-chiffre-d-affaires-2017-par-compagnie
[433] Federation des Caisses Populaires du Burkina Faso (FCPB) is part of the a regional grouping of financial cooperatives, Confederation of West African Financial Institutions (CIF), as well as KAFO JIGINEW, NYESIGISO and UM-PAMECAS that is based on the solidarity of six large national federations of savings and credit cooperatives in five countries of the West African Monetary Economic Union (UEMOA) zone.
[434] FCPB is part of a pioneering initiative as well as KAFO JIGINEW, NYESIGISO and UM-PAMECAS that embodies the desire for regional integration in West Africa in the area of micro-finance. It combines the need for consolidation at the institutional level, with the need to group together across the respective borders to tackle the major challenges of micro-finance, namely financial inclusion and the contribution to improving the living conditions of populations. especially those of the poorest.
[435] His microinsurance product, Cauri d'or's, targets small business owners in the informal sector, such as women and men who sell goods in markets, especially in urban areas.
[436] https://www.atlas-mag.net/article/le-marche-tchadien-de-lassurance

| | | | |
|---|---|---|---|
| **Mali**[437] | • SUNU<br>• SAHAM<br>• KAFO JIGINEW<br>• NYESIGISO<br>• SONAVIE<br>• AGF Mali<br>• CNAR<br>• COLINA<br>• LAFIA<br>• SABU | • MICROCRED<br>• AKF<br>• PAMF-M<br>• CVECA<br>• Solidarity group networks (crédit solidaire) in the Grameen tradition<br>• Mutualist voluntary associations<br>• KAFO JIGINEW<br>• NYESIGISO<br>• RMCR | |
| **Mauritania**[438] | • CAN sa<br>• DAMANE<br>• NASR sa | • CAPEC<br>• UNCACEM<br>• UNCECEL<br>• Beit El Maal[439] | • NASR sa |
| **Niger**[440] | • SUNU<br>• SAHAM<br>• UGAN IARD<br>• CAREN<br>• NIA<br>• SNAR LEYMA | | • CAREN<br>• SNAR LEYMA |
| **Senegal**[441] | • AXA<br>• SUNU<br>• SAHAM<br>• UM-PAMECAS<br>• Prévoyance Assurances<br>• NSIA<br>• CNART<br>• ASKIA<br>• SONAM<br>• AMSA<br>• CNAAS<br>• MAAS | • ACEP<br>• CMS<br>• PAMECAS<br>• U-IMCEC<br>• MEC DELTA<br>• Fides Senegal Microfinance<br>• MCS | • CNART |
| **The Gambia**[442] | • Appropriate<br>• Capital Express<br>• Gainako<br>• Gambia National Insurance | • NACCUG<br>• Reliance Financial Services Ltd.<br>• Supersonicz Financial Service Ltd. | • Colts Insurance & Reinsurance |

[437] https://www.atlas-mag.net/en/article/the-malian-insurance-market
[438] https://fanaf.org/rubrique/mauritanie-55/
[439] This is a nonlicensed project with, however, an important impact on the sector. Source: http://documents.worldbank.org/curated/en/833841468283142553/pdf/793310ESW0MR0P00PUBLIC00Box0377373B.pdf
[440] https://www.atlas-mag.net/en/article/the-nigerien-insurance-market
[441] https://www.senegal-online.com/assurances-au-senegal/
[442] https://www.cbg.gm/insurers

| | | | |
|---|---|---|---|
| | • IGI Gamster<br>• Global Security<br>• Sunshine Insurance Company Ltd<br>• Takaful Gambia<br>• Great Alliance<br>• ROYAL<br>• PRIME<br>• New Vision | | Brokers Company Ltd |

472. Figure 7.3.2.6 summarizes the most frequent arrangements applied in an index-based insurance for micro-level products. In general terms, these arrangements can be classified as (a) insurance policies retailed through an intermediary, such as a credit institution (bank, credit cooperative, MFI) or an agribusiness firm or a cooperative or a mobile banking platform; or (b) contracts directly distributed by the underwriting insurance company, often through the company's agents. The most suitable option will depend on local conditions, such as the nature of the supply chain for which an index insurance will be developed and the business interests of the various stakeholders, but also infrastructures and capacities to aggregate farmers. The other components of the project will help aggregating farmers differently, which will have to be taken into consideration.

473. Using an intermediary may provide access to existing retail networks, potentially reaching a larger number of clients. Such business partners may be strongly motivated to facilitate the distribution of index insurance. For example, credit institutions may be interested in linking index assurance to their lending operations in order to reduce default rates generated by adverse weather events, while agribusiness firms may see offering index assurance as a competitive advantage for their products. Farmers and cooperatives may be interested to leverage insurance to have better access to financial products as well.

474. Should insurance companies have a large outreach in rural environments (e.g. mutual or cooperative insurance companies), the programme can also plan to retail the policies directly. In this case, it is useful to carefully evaluate the interest of farmers in purchasing the stand-alone insurance product, because experience shows that selling may be easier when linked to a loan or input product[443]. We believe, though, that there is no strong offer on this basis in the 7 target countries.

475. At the macro level, index insurance contracts can also be purchased by intermediary institutions wanting to protect against their own exposure to weather risk (e.g. protect a loan portfolio). However, this kind of transaction has not been very common.

476. When setting up the risk transfer proposition, it is critical that the insurers have access to appropriate reinsurance coverage. Index insurance transactions are highly exposed to covariate risk, and in the case of a triggering event, payouts tend to be significant. Regardless of the retailing model adopted, the insurance company must have access to the reinsurance industry, usually at the international level (Figure 7.3.2.6).

[443]https://www.ifad.org/documents/38714170/40239486/Weather+Index-based+Insurance+in+agricultural+development+a+technical+guide.pdf/1bc46353-bfbd-4ae9-8446-28da834e0124

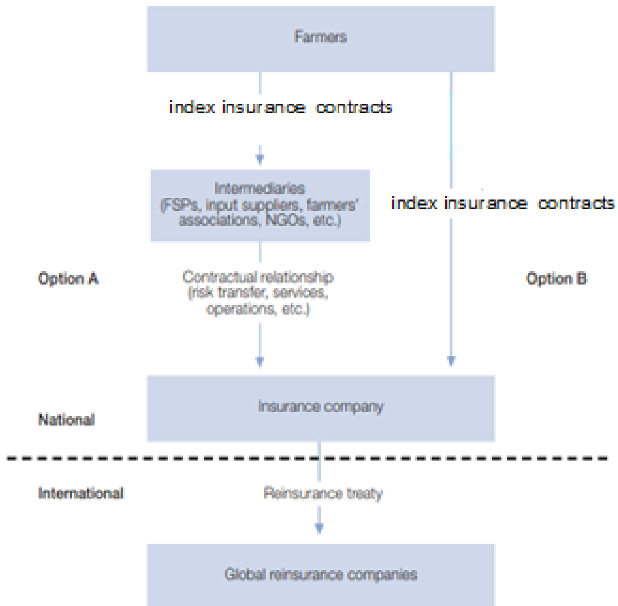



**Figure 7.3.2.6. Possible options for insurance organization and distribution of micro level index insurance**

### 8.4.2.9 Data availability

477. One of the main points in developing index insurance is the availability of highquality data. The presence of data permits the insurance and reinsurance industry to price the risk as well as lower basis risk inherently associated with index insurance. Both yield and weather data (satellite and ground stations) should be examined to ascertain if the level of data is sufficient and what methodologies exist to fill in the gaps.

478. <u>Weather data:</u>

- A mapping of the local stations and the quality of data is needed (number of stations, years of data, any years missing data, quality of network), and opportunities to install more weather stations
- Willingness of local meteorological services to participate in the programme
- Availability of remote sensing data in each country, quality of data and historical datasets availability and correlation with ground data
- Cost/benefit for each solution

479. <u>Yield data:</u>

- Analysis of the existing yield data including number of years and level of aggregation.
- Analysis of providers of yield data – government authorities, independent bodies, sector representatives – interest and capacity to participate in the programme. Cropcuts samples on some specific crops could be conducted.
- Performance assessment between yield and rainfall data to select the most efficient index

### 8.4.2.10 Role of stakeholders in the design of an index-based insurance

480. The existence and commitment of key stakeholders, especially local entities, is one of the critical success factors in a successful design of an index-based insurance. There will be an assessment in

each country of potential stakeholders might be willing to enter into partnerships. Assessing capacity, interest and commitment is key to overcoming initial index insurance's set-up challenges such as lack of highquality data. In Senegal, WFP with the insurance company, CNAAS, and the support from IRI (Columbia University) has set up an index design team, composed of experts from CNAAS, Inclusive Guarantee, ANACIM (Met Agency) and ISRA (agronomical research institute), to build their capacity to develop and improve indices, with limited to no external support. That being said, it can be economically more sustainable for insurers to use service providers. This will be considered in the development of a specific business model.

481. National or regional agricultural research institutes may be needed as stakeholders in the design of an index insurance. Their existence and capacity can be researched and assessed simultaneously as well as academia institutes through data- and information-gathering. International linkages can also be sought in order to bring additional key expertise to the collection and assessment of weather and yield data. Within these institutes, it is important to seek out individuals with applied knowledge of crop production, crop modelling, agrometeorology and crop losses.

482. Insurers play a key role in designing and underwriting the product. It is important to assess whether a trustworthy insurer exists, which is willing to issue the policy, accept some risk and play an administrative role. Sometimes insurers will join as a pool, and an association of insurers can play a facilitating role. In some pilots, the insurer has been the key element driving the pilot. In these cases, insurers have committed themselves to participating in technical education on the design of index-based insurance products. Based on the existing insurance companies in the seven countries, there will be an assessment of their experience with similar products, their capacity needs, and their level of interest could be developed into a pilot.

483. Reinsurers (which almost always operate internationally, or regionally) primarily provide financial risk transfer capacity, but they can also provide some technical support to the insurer. In many cases it is important to have at least the interest of a reinsurer in order to promote the necessary enabling environments at the macro level jointly with the government. Depending on the volume of the business, a reinsurance broker could be appointed to support pricing and interaction with reinsurers.

484. As insurers normally have limited or no business (or offices) in rural areas, distribution is best organized through a party with existing links to farmers or farmer groups (e.g. a bank, processor, cooperative or MFI). Embedding index-based insurance into a development programme, or into a package linked with credit, inputs or contract farming, can strongly add value to the proposition for farmers and other stakeholders and make it easier to sustain and eventually scale up.

485. Key stakeholder linkages for product delivery, product training and extension can include:

- **Financial service providers.** The existing client base of MFIs and rural banks, and their interest in protecting both their clients and themselves against climate risks, make rural financial institutions a natural partner for index-based insurance distribution.
- **Cooperatives and farmer organizations** are a natural focus for any new product development and as delivery channels.
- **Input suppliers and processors** are both wary of and vulnerable to covariate risks facing producers, which in turn trap smallholders in a cycle of small-scale production. These entities can thus have a vested interest in acting as an intermediary for index-based insurance. For example, inputs such as good-quality seed or fertilizer could be sold on credit if the risk were to be transferred through index insurance

- **Digital platforms & mobile money operators** are rising stakeholders as they can bring services to the doors of the clients with very limited cost. It can also simplify distribution and interaction with farmers, in particular regarding consumer education and protection.

NGOs in particular could also play an important and independent role in extension of information to farmers, possibly in conjunction with official extension services.

#### 8.4.2.11 Risks and possibility to distribute insurance

486. It is essential to understand the main risks facing the farmers and the possibility to implement insurance against those risks. The Platform for Agricultural Risk Management (PARM) has a tailored methodology for risk assessment and it will be considered for the countries of implementation. Senegal and Burkina Faso have already started working with the PARM team.

487. Moreover, one of the keys is distribution and how the insurance will effectively reach farmers. Bundling insurance with other products such as inputs or credit can provide an added value and lower distribution costs. It is imperative to understand the key actors along the value chain including:
    - Farmer's organizations and cooperatives
    - Microfinance institutions and agricultural lending institutions
    - Input providers
    - Buyers, exporters or traders
    - Agribusinesses
    - Mobile network providers

488. Moreover, in analysing the value chain and these distributors, we must understand:
    - How are the target value chains organized and financed?
    - How many farmers can be reached via each distribution channel?
    - What products and services is each channel providing to farmers? What is the capacity of each channel to integrate insurance into that offering?
    - What percentage and volume of sales or loans are towards farmers in the targeted crop?
    - What is the willingness of each channel to integrate insurance into their offer?
    - What areas and zones do each of these channels cover?

A business model will have to be developed before introduction of insurance, in particular in countries where insurance is completely new.

### 8.4.3 Implementation of an insurance programme

489. On the basis of this information, an insurance programme can be designed in consultation with National and local authorities and taking into consideration local specificities.

490. The activities to implement the programme are summarized below. Of course, on the basis of the information gathered, the steps will be tailored to account for local contexts. For example, if a product already exists in the market, it may simply need to be adapted to new zones or reviewed and there will not be a need for development of new products. Similarly, if the conditions before introducing insurance are not yet met, then the project will first focus on creating these conditions.

#### 8.4.3.1 Product development

491. *Step 1. Product design*

- o Focus group discussions with farmers and distribution channels to refine data collected at the pre-feasibility stage regarding risks and timing. A participatory approach based on farmer discussions can allow for initial definition of weather parameters In particular, worst climate shocks experienced by farmers and cooperatives will be gathered.
- o An examination of collected weather and/or yield data, will allow to define the periods to be covered, the trigger levels and the guarantees.
- o On this basis, a definition of prototype products can be developed. If reliable products are already available, then the project will focus on distribution and possible improvement of the product.

492. *Step 2: Cross reference yield and weather data*

- o Examining the correlation between the weather data and any available yield data will allow to refine the product and validate its pertinence.

493. *Step 3: Pricing of products in cooperation with reinsurers*

- o Calculation of pure premium based on data and frequency of losses.
- o Determination of loadings including insurer, distributer and broker (in any).
- o Integration of taxes and other costs.
- o Sharing of indices with reinsurers and analysis to determine final pricing.

### 8.4.4 Capacity building and raising awareness

*Step 1: Design of capacity building programme*

494. Insurance for smallholders does not exist or exists in a limited capacity in many of the countries of implementation and the penetration rate of insurance remains low. Government and private sector involvement have also been limited. The aim of the capacity building programme is therefore to increase awareness on insurance and its benefits and empower local stakeholders to provide insurance. These stakeholders are further defined in the next step but include the National Authorities, the regulatory body, the insurance industry, the distribution channels and smallholder farmers.

495. In order to properly design the programme, a first step will be the assessment of existing capacities and definition of needs per stakeholder group. The assessment will look at technical understanding of index insurance, previous experience, and priorities of each stakeholder group.

496. Workshops can be organised and will include:

- o Presentations of index insurance, methodologies for product development, presentation of specific product and technical features
- o Exercises and case studies
- o Moreover, exchanges can be organised to facilitate learning. For example, a mission to Senegal can be planned to understand the model of the local agricultural insurance company (CNAAS).
- o A capacity building plan will be developed depedning on the priorities (product design, insurance ownership, distribution, supervision, consumer education and protection)
- o Building on the experience of R4 in Africa will help create ownership of local stakeholders by the end of the project.

*Step 2: Capacity building to all stakeholders*

497. Capacity building will be provided to all stakeholders in the programme.

- The local insurance industry – the local insurance industry may require technical skills on index insurance and microinsurance.
- The reinsurance industry – in addition to international reinsurers, the involvement of the regional, and possibly local reinsurance industry can support lower costs and favorable government policies.
- Regulatory and Supervision Authorities – regulatory authorities generally have the ultimate responsibility to validate the products and ensure customer protection. It is thus essential for them to be involved in the programme and understand the technical aspects.
- Governments – Government involvement is paramount for success in order to make sure the programme is aligned with national priorities and benefits from a supportive regulatory framework.
- International organizations – other international organizations may already be running complementary programmes. Integrating insurance to those programs can help reach scale and bring down the cost for small holders.
- Distribution channels and end users **–** Ultimately, these are the end beneficiaries of the insurance and their understanding of insurance and its utility can foster uptake.

*Step 3: Raise awareness to the targeted households*

498. A variety of tools can be used to increase farmer awareness on insurance. These include:

- Radio announcements
- Flyers and posters
- Films and commercials
- T-shirts
- Events and focus group discussions
- Training sessions and manuals
- Games

Technology will be used to ensure the fastest and best outreach.

### 8.4.5 Distribution

499. *Step 1: Determine distribution channels for first sales season*

- Analysis of the distribution channels was described in the inception assessment. During implementation, participation of key distributors is formalised via agreements and the distribution process is set-up. This includes understanding of if entre portfolio is covered, if insurance is sold in inclusion with another product or as a stand-alone product, the commission for the distribution channel, the process to collect the premium etc.
- Technology will be used to improve data collection and sharing, but also secure and optimize cash management.

500. *Step 2 Contractual agreements between distribution channels and insurers*

- Policy wording and agreements are needed between insurer and distribution channels
- The analysis of regulatory framework should determine the process for obtaining approval from regulator. It should be ensured at this point that insurer has the necessary license and product approval to launch the product
- Ensure distribution channels and insurers have all the correct procedures in place regarding premium payment, claims settlement, reporting, IT systems, etc.

501. *Step 3: Track the sales of insurance products*

- Understand steps to gather the data during subscription
- Define the reporting format with insurer and distribution channel
- Collect sales data
- Share sales report with insurer/reinsurer
- Monitor index and claims

### 8.4.6 Monitoring and evaluation (M&E) of programme

502. *Step 1: Define KPIs for monitoring the success of insurance. These could include:*

| Qualitative | Quantitative |
|---|---|
| **Product Performance** | Loss Ratio |
| | Promptness in claim settlement |
| **Client value** | Number of persons insured, Utility ratio |
| **Farmer satisfaction** | Increase in access to credit |
| **Effectiveness of training tools** | Increase in area harvested |
| **Quality of Subscription Process** | Number of women and youth insured |
| **Distributer Satisfaction** | Uptake ratio |

503. *Step 2: Evaluation and adjustment*
    - Focus groups with farmers and field assessments will determine the performance of the index and the existence and level of basis risk.
    - Moreover, an assessment of the difficulties and challenges during the campaign will be undertaken and considered in order to propose improvements
    - On this basis, recommendations should be made for next season's implementation

504. *Step 3: Programme expansion*
    - In order to foster the growth and sustainability of the programme, new distribution channels can be integrated and coverage for the existing channels can be extended
    - New distribution and capacity building activities will be conducted accordingly.
    - A business case for each country will be elaborated. For each country, if the conditions are not met, a technical support plan will be presented, with a clear timeline, to create the condition, before introducing an index insurance scheme.

Climate eligibility criterias list for the selection of projects/ activities to be supported under the programme implementation

| Results | Category | Eligible activities | Screening investment Criteria's |
|---|---|---|---|
| Paradigm Shift potential for low-emission development pathway | Agriculture: energy efficiency improvement; renewable energy technologies ; carbon sequestration GHG emission reduction Forestry: GHG-emission reduction | Reduction in energy consumption in agro-pastoral value chains Use of renewable energy and energy efficiency technologies in operations<br><br>Agricultural projects that contribute to increasing the carbon stock in the soil or avoiding soil carbon loss through erosion control measures<br><br>Avoidance/Reduction of non-CO2 GHG emissions from agricultural practices or technologies | • Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome) including energy efficiency of crop production and increasing use of energy efficiency technologies for agricultural processing and storage ( Examples of operations are traction, solar irrigation, pumping, energy efficiency for crop cooling, storage and transportation.)<br>• Renewable energy shall meet the same criteria for low lifecycle GHG emissions such as increased use of bioenergy through conversion of agricultural waste to energy, use of solar-powered irrigation pumps, and energy efficiency for cooling and storage<br>• Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome such as efficient nitrogen fertilizer use (by improving the rate, type, timing, placement, or precision of application), cultivation of organic soils, inhibitor management, manure management including anaerobic digestion, drainage management, improved crop breeds and biotechnology that reduce emissions, and water management (such as in paddy rice).<br>• Degraded land rehabilitation, erosion control measures, reduced tillage intensity and cover crops, crop rotation, higher inputs of organic matter to soil, processing and application of manure, perennial cropping systems, deep rooting species, biochar, fire management, peatland restoration and avoided conversion of peatlands.Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome) with more efficient nitrogen fertilizer use (by improving the rate, type, timing, placement, or precision of application), cultivation of organic soils, inhibitor management, manure management including anaerobic digestion, drainage management, improved crop breeds and biotechnology that reduce emissions, and water management (such as in paddy rice). |
| | Forestry: GHG-emission reduction | Forestry or agroforestry projects that sequester carbon through afforestation and reforestation | • Projects shall demonstrate a substantial increase in the above- or below-ground carbon stock. Non-GHG impacts should also be considered to ensure suitability of planting species to local conditions. Evidence of human-assisted natural regeneration that increase adaptive capacity of the communities should be provided.<br>• Activities that drain native ecosystems or degrade hydrological systems should not be eligible. Leakage assessment, including displaced land-use activities outside the project area, should be considered. Potentially eligible activities include afforestation (plantations) and reforestation on previously deforested land. |

| | | | |
|---|---|---|---|
| | Forestry or agroforestry projects that reduce GHG emissions from deforestation or land degradation | | • Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome). Non-GHG impacts should also be considered to ensure suitability of planting species to local conditions<br>• Evidence of human-assisted natural regeneration should be provided. Where applicable, evidence of avoided deforestation should be provided. Activities that drain native ecosystems or degrade hydrological systems should not be eligible. Leakage assessment, including displaced land-use activities outside the project area, should be considered.<br>• Potentially eligible activities include agroforestry supply chains, restoration of degraded natural landbased habitats, biosphere conservation, payments for ecosystem services, forest-based industries substituting materials derived from fossil fuels with renewable wood, policy interventions that explicitly protect carbon stocks (e.g., through land use zoning, enforcement of sanctions for deforestation, or sustainable intensification of land use), switching from conventional logging to reduced-impact logging, and extending the rotation cycle or cutting age |
| | Livestock: GHG-emission reduction | Projects that reduce methane or other GHG emissions from livestock | • Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome) through Introduced species shall not contribute to native ecosystem degeneration.<br>• Possible detrimental non-GHG effects arising from excessive production intensification (e.g., on animal health or productivity) should be considered. Potentially eligible activities include manure management with biodigesters, improved feeding practices or improved feeds/forage to increase feed conversion efficiency and reduce methane emissions, and efficiency improvement measures to reduce the herd size |
| | Livestock: carbon sequestration | Livestock projects that improve carbon sequestration through rangeland management | • Projects shall demonstrate a substantial reduction in net GHG emissions or carbon intensity (tCO2e/unit of outcome) including improved pasture management to increase soil carbon stocks and reduce erosion; improved grazing management; promotion of silvopastoralism and nitrogen-inhibiting species in pastures; payment for ecosystem services. |
| | Renewable energy in water supply | . Use of renewable energy in water supply projects | • Renewable energy used in supplying water shall meet the criteria for wastewater, fecal sludge or septage management projects that feature cogeneration of biogas from anaerobic digestion a substantial reduction in net GHG emissions.<br>• Potentially eligible activities include installation of solar pumps, , and cogeneration using biogas from anaerobic digestion. |
| Increased climate-resilient sustainable development | **Input supplies** | Seeds | • Project shall provide access to specific climate-adapted varieties where available (e.g. heat-tolerant, submergence- tolerant).]<br>• Maintain diversity through seed banks, including wild relatives. |

| | | | |
|---|---|---|---|
| | | Fertilisers | • Project shall integrate fertilizer advice and supply with wider soil management and manure use.<br>• Project shall  Precision farming and CSA<br>• Project shall conduct periodic water quality analysis.<br>• Project shall  I support onsite technical support to monitor use and disposal. |
| | | Pest management | • Project shall promote integrated pest management (e.g. push-pull methods) develop monitoring, knowledge and applied research systems for pests and diseases of crops, livestock and fisheries.<br>• Project shall  Precision farming and CSA<br>• Project shall support onsite technical support to monitor use and disposal. |
| | | Information Services | • Project shall enable provision of seasonal and near-term forecasts in formats usable and accessible by farmers strengthen early warning systems.<br>• Invest in country-level capacity in scaled down climate impact modelling and scenario planning. |
| | | Financial services | • Investigate financial channels to reduce risks associated with innovation (e.g. microfinance, small grants programmes, index-based weather insurance.<br>• Financing should encourage the use of water harvesting, solar power and other GHG reduction technologies. |
| | | Tools and equipment | • Substitute low-cost high-efficiency systems wherever possible (e.g. rainwater harvesting plus surface water irrigation).<br>• Provide access to early warning systems.<br>• Introduce protective features to the siting and storage of seeds, tools, vehicles, fuels and energy infrastructure. |
| | **Agricultural Production** | Soil Management | • Introduce measures to counter soil erosion (e.g. terracing, contour bunds, drainage, agroforestry, perennial crops).<br>• Increase soil carbon and improve the management of soil organic matter |
| | | Water Management | • Adopt water conservation and efficiency measures such as water harvesting, efficient irrigation infrastructure, check dams, flood management and drainage<br>• Support riparian habitat restoration.<br>• Introduce water allocation systems. |
| | | Diversification | • Investigate potential for sustainable intensification and diversified cropping systems through crop rotations (e.g. staple/horticulture), intercropping, agroforestry, mixed crop/livestock systems |
| | | Landscape-level management<br>Skills base of farmers and local institutions | • Undertake participatory mapping and land-use planning<br>• Remote sensing-based landscape monitoring<br>• Exploit all available incentives (financial, regulatory, etc.) for sustainable environmental management in the project<br>• Invest in local capacity for planning, monitoring, decision-making and financial management. |

| | | | |
|---|---|---|---|
| | | | • Transfer control to local institutions; provide training on climate issues and support to farmer-based research and knowledge systems.<br>• Include smallholders in policy dialogue and scenario-building exercises |
| | Post – Production | **Post-production: storage, processing, transport& retail** | • Incentivise waste reduction measures and value addition for by-products.<br>• Provide renewable energy sources to cover changing requirements for cooling, drying, milling and threshing |
| | | Siting of processing facilities | • Use hazard exposure and crop suitability maps to inform siting of processing facilities.<br>• Retrofit processing facilities with protective features.<br>• Insure processing facilities against extreme climate events. |
| | | Energy processing | • Provide renewable energy sources (such as solar photovoltaic panels for cooling / drying / milling / heating, wind, biogas).<br>• Equip processing facilities with energy-saving appliances (e.g. solar lighting, solar charging, and efficient cook stoves).<br>• Adopt pollution control measures |
| | | Water in processing | • Re-site facilities.<br>• Increase water storage and distribution capacity (water harvesting, communal ponds, groundwater recharge).<br>• Introduce demand-side water efficiency measures.<br>• Support conflict resolution for different water users (e.g. water user groups). |
| | | Packaging materials and methods | • Design suitable packaging materials in parallel with waste and storage management strategies |
| | | Transport hubs and routes | • Re-site hubs.<br>• Co-design value addition, storage and transport components to avoid high-risk transport routes and seasons. |
| | Infrastructure | Feeder roads | • Carry out an Environmental Impact Assessment (GIS, remote sensing, mapping).<br>• Culverts and side-drains to reduce erosion.<br>• Environmentally friendly asphalt (hot mix asphalt -HMA). |
| | | Refrigeration and cold chains | • Conduct cost-benefit analyses of dependency on refrigerated cold chains.<br>• Introduce renewable energy sources for cooling and ventilation.<br>• Develop contingency plans for climate shocks and extreme events; create contingency storage opportunities. |
| | | "Just-in-time" logistics | • Link into regional markets to avoid over-dependence on high-value export markets. |
| | Gender -Sensitive Response | Involvement of women by## % in the activities | • The project will be inclusive women empowering women to improve their agricultural productivity and implement climate resilience agricultural activities with climate co-benefits |

| | | | |
|---|---|---|---|
| | | | • The Project will consider the number of women benefiting from capacity building for climate resilent agricultural practices.<br>• The project will consider ## % reduction of women affected by climate-related disasters, |
| | Increased resilience and enhanced livelihoods of the most vulnerable people, communities, and regions | Adaptive capacities of the communities toward managing climate change and related disaster risk issues. | • The project will consider Percentage reduction in the number of affected communities by climate-related disaster risk<br>• The project will consider increase number of households adopting a wider variety of livelihood strategies/coping mechanisms to climate related risks. |
| | Strengthened institutional and regulatory systems for climate-responsive planning and development | Climate change mainstreaming in policies and effective climate change institutional planning of development activities | • Projects will consider with climate mainstreaming measures in development planning and institutional regulatory systems that improve incentives for climate resilience and are accompanied by evidence of their effective implementation.<br>• The project will consider institutional coordination and information sharing mechanism on climate change planning among multi-stake holders in the countries.<br>• The project will consider tailored specific capacity building activities for different stakeholders including the most vulnerable communities and government institutions and private sector entities involve in the programme. |
| | Increased resilience of ecosystems and ecosystem services | Protection of the ecosystems-based adaptation and strengthening responses to climate change variability | • The project will consider area of agroforestry projects, forest-pastoral systems, or ecosystems –based adaptation systems established or enhanced.<br>• Area/ ha of habitat or kilometers rehabilitated to reduce external shocks such as land degradation through replanting and protection. |

**Access to Finance:**

There are many inherent risks affecting the Sahelian smallholder farming that discourage the private sector and particularly the banking sector from investing. Financial institutions often perceive small-scale agriculture as being too risky and are reluctant to lend farmers money, particularly in the context of climate change and climate variability.

The challenges of agricultural development are multiple and complex. High systemic risks: from the environment (drought, flood and disease) and from markets (price volatility, trade policy and trade practices affecting exports and market access) are critical challenges.

Financing is a major barrier to growth in West Africa 's agricultural sector, particularly for smallholder farms. Interest rate are particularly high, up to 47% in Africa and between 10 to 17 %. The lack of collaterals from farmers and businesses, combined with difficulties for banks to price the risk of loans to smallholder farmers is an important impediment to the development of the sector. Other key challenges are the lack of adequate rural infrastructure, lack of access to the range of inputs required by farmers, knowledge gaps, including financial literacy, and the lack of reliable data.

On average, only about 5% of domestic resources are being allocated to the agricultural sector. In part, a combination of perceived high risk and modest returns – as well as the costs of extending traditional banking infrastructures in rural areas – has deterred many financial service providers. The G-20 Global Partnership for Financial Inclusion's (GPFI) SME Finance Sub-Group reported that neither commercial banks nor the emerging microfinance industry are willing or able to sufficiently meet the financial needs along agricultural value chains, leaving farmers and agricultural SMEs unserved in the "missing middle".

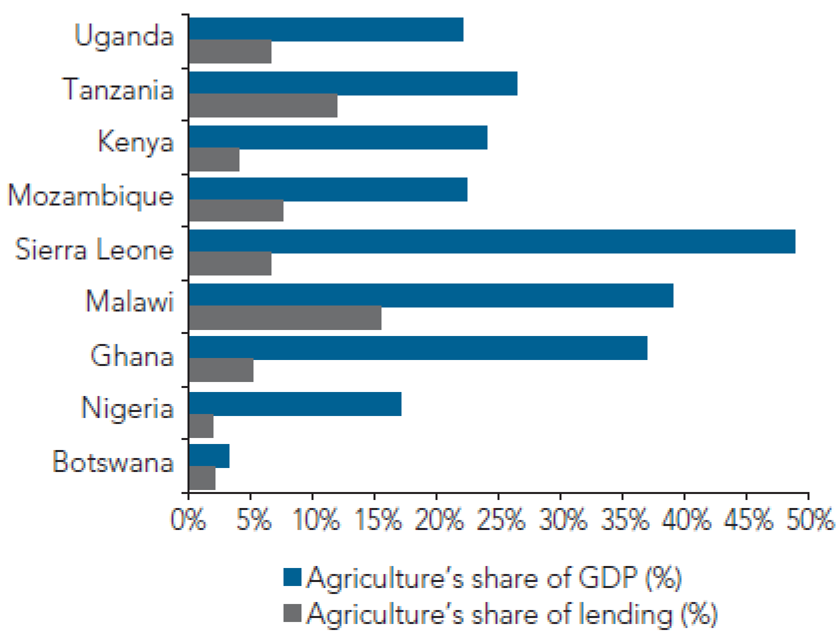



*Figure 1: Share of commercial banks' lending to agriculture relative to share of agriculture to GDP*

Despite these challenges, agricultural finance can be commercially viable. Value chain financing is widely used as a risk-mitigation mechanism for short-term finance. It works best where there is strong end-market demand, as well as transparency, trust and strong and repeated inter-firm transactions. In practice, it is important to understand how value chain governance, relations, and linkages are structured to respond to market opportunities, because these factors determine the viability of a financing arrangement.

Many innovative financing mechanisms can catalyse growth in the African agriculture sector, and several are already being deployed. For example, efforts such as AGRA's credit guarantee and risk-sharing facilities with Equity Bank and Standard Bank in South Africa have leveraged ten times their commitments of risk-sharing public capital into private lending to farmers. Other innovative financing approaches gaining attention in agriculture include risk management tools like weather index-based insurance that helps farmers mitigate climatic risk; guarantee or guarantee-like products such as warehouse receipts programs that eliminate the need for external collateral; and private partnerships like equitable outgrower schemes that link agribusinesses and farmers, enabling bank financing of productivity-enhancing farm inputs.

Some countries have also established agriculture credit guarantee schemes (e.g. Ghana, Nigeria, and Uganda) housed in their Central Banks however the performance of these schemes has been mixed. The Nigerian Incentive-based Risk Sharing System for Agricultural lending , for example has deployed its seed capital of USD 500 Million through five pillars (i.e., risk sharing facility, insurance facility, technical assistance facility, bank rating, and bank incentive). The idea is to 'de-risk' the agricultural financing value chain, build long-term capacity, and institutionalize agricultural lending. It aims to increase agricultural lending from 1.4% to 7% of total banking lending in Nigeria. This initiative has triggered interest from other countries such as Ghana, Liberia, Rwanda, and Uganda to introduce risk sharing facilities (RSFs).

Agricultural insurance is widely used in developed and emerging markets to de-risk agriculture value chains and stimulate agricultural lending, while protecting farmers. However, only a marginal proportion of smallholder farmers (roughly 2 million) have insurance cover across Africa. A growing practice is to bundle agricultural insurance with other products and services provided to smallholder farmers, through aggregators. Agricultural lease finance is another option to expand access to finance, without requiring collaterals, allowing for greater mechanization of agriculture in Africa.

While access to financial services is a frequent constraint at all segments of agricultural value chains, pre-harvest financing at the farm level is perhaps the biggest gap, as evidenced by the low usage of agricultural inputs and equipment in Africa. Improved access to pre-harvest financing is critical for farmers to use high quality inputs and equipment more quickly and on a larger scale. Key policy recommendations are:

- Avoid direct interventions such as interest rate caps, directed lending and subsidized lending to borrowers, and lending quotas on banks;

- Provide "smart" or "market friendly" subsidies to financial services providers as well as to institutions that are critical to facilitate the flow of finance to the agricultural sector (e.g.: credit information agencies, insurance schemes, training and technical service providers, producers organizations, market and data information systems, etc.);

- Support the development of rural financial service providers such as Credit Unions (Savings and Credit cooperatives – SACCOs), which are often better equipped to capture and intermediate the savings of local communities;

- Provide banks and other private lenders with partial credit guarantees and risk-sharing facilities, particularly in combination with technical assistance;

- Reform existing state-owned agricultural development banks to free management and lending decisions from political interferences;

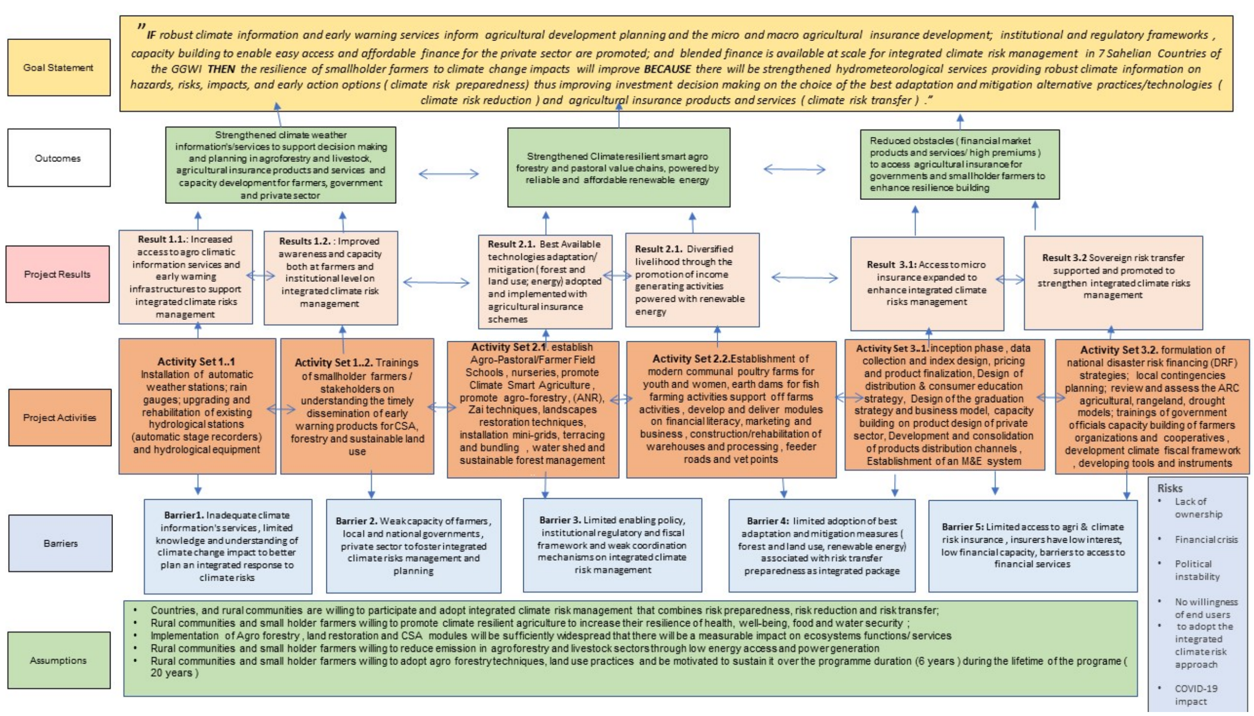
- Digital finance has the potential to scale up financial services in the agriculture sector. However, regulatory frameworks need to support the continuous innovation of digital initiatives, while at the same time managing potential risks to ensure customer protection;

- Invest in physical infrastructures underpinning the broader market for agricultural finance, either directly—such as weather stations for insurance, irrigation systems, and warehouses—or indirectly—such as with roads, railways, transport, telecommunications, and power supply, especially in rural areas. Critical information includes climate data for agricultural insurance and information on business transactions between producers and buyers for value chain financing; and

- Enhancing policy coordination among the different Government agencies (i.e., Ministry of Finance, Ministry of economy, Ministry of Agriculture, Central Bank, etc.) involved in agricultural finance policies is imperative to drive the change process.

- Finally, establishing a specific high-level coordination body and recognize a single entity as the lead advocate for agricultural finance can have a positive impact as well.

## Chapter 9 Theory of change of the Programme



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