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AMY FAYE, MOHAMADOU DIÈYE, PAPE BILAL DIAKHATÉ, ASSANE BÈYE, MOUSSA SALL, MBAYE DIOP

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## A study in the Sudano-Sahel Initiative for Regional Development, Jobs, and Food Security

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# Senegal – Land, climate, energy, agriculture and development

## A study in the Sudano-Sahel Initiative for Regional Development, Jobs, and Food Security

Amy Faye, Mohamadou Dièye, Pape Bilal Diakhaté, Assane Bèye, Moussa Sall, and Mbaye Diop

# Abstract

Located in West Africa, Senegal is classified as a least-developed country that has historically had political stability and slow economic growth compared to the rest of Sub-Saharan Africa (SSA). However, from 2012 onward, a new government has adopted new policies (infrastructure investments, liberalization of the groundnut sector and opening of the energy sector) to enhance economic growth and governance. Senegal thus experienced significant improvements in the period from 2012 to 2015. Future economic growth in Senegal can be significantly shaped by the energy sector regarding the recent oil and gas discoveries if the common resource curse can be avoided.

The country is characterized by a poverty rate of 38 percent and fairly stable food security, with only 7.2 percent of the population being food insecure. However, some localized pockets of acute food needs remain. This is in part linked to agricultural production (the main source of income and labor), which depends highly on climatic hazards. Moreover, production resources such as land are highly vulnerable to climatic and anthropogenic factors. The country has a good access rate to electricity and safe water. However, access to electricity is unequal, with rural lagging behind urban areas.

The country thus faces many challenges that threaten its economic growth: climate change and ensuring the accessibility and affordability of energy and land, which are key inputs to the main sectors of the economy such as agriculture. This report aims at investigating these interlinked challenges through a critical literature review. Results show that concerning land, its use and cover have hardly evolved over the past, except for agricultural land, which has significantly evolved from 1975 to 2013. However, the land has degraded a lot in the past several decades with up to 63-67 percent of the arable land being subject to land degradation due to climate hazards and its uses (e.g. population growth, Agro-sylvo-pastoral practices, wind and water erosion, salinization, bush fires...). Land degradation has multiple consequences, as it impacts livelihoods by limiting the availability of vital ecosystem services, increases the risk of poverty and translates into economic losses. Land degradation is estimated to cost 9 percent of the GDP annually (996 million USD).

Concerning climate change, Senegal's climate is of the Sudano-Sahelian type, marked by the alternation of a rainy season and a dry season, whose duration varies according to the region. Rainfall and its characteristics (onset and duration) and air temperature are two factors that have changed significantly since the early 1950s and 1970s. Decreased rainfall, delayed onset of rains, reduced duration of wintering and higher temperatures have adversely affected agricultural production systems and have put some risks on food security, health and livelihoods. Projections in 2035 and 2050 will accentuate the negative impacts already observed.

In the face of such challenges, several strategies have been undertaken at different levels (household, community, policy, research, etc.) to reduce the negative effects of climate shocks and land degradations. At the household level, strategies have mostly consisted of diversifying revenue sources through remittances and non-agricultural activities. At the community level, organizational dynamics have been strengthened and enabled to reduce the vulnerability of women and children, to increase access to climate information, and so on. Finally, policy responses have mainly consisted of Senegal's efforts to develop climate change adaptation and mitigation plans and strategies to protect the vulnerable key sectors from climate change and to contribute to emission reduction at the global level.

The evaluation of key policies, the Intended Nationally Determined Contribution for climate governance, the PRACAS (for agriculture and food security) and land-use policies highlights the main factors for success and failure and identifies key challenges that the government of Senegal needs to pay close attention to in order to ensure greater policy design and implementation success in the future. The main challenges are related to governance, funding and monitoring and evaluation. In terms of governance, it is important to ensure the participatory design and implementation of the policies to foster stakeholders' ownership and thus facilitate their implication. As for funding, the key is to avoid building policy objectives based on unsecured funding by making realistic plans based on already secured funding (if possible, from the national budget). Finally, in terms of monitoring and evaluation, it is key to ensure the sustained availability of good-quality statistical data to allow better targeting of areas in which to intervene, better allocation of financial resources and better assessment of gaps, progress, and impact.

**Keywords**: Sahel, energy, climate change, land degradation, innovation, policy

**JEL codes**: O30, Q24, Q25, Q42, Q54, Q55, Q58

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# Acronyms and abbreviations

| | |
|---|---|
| AFDB | African Development Bank |
| AFOLU | Agriculture, Forestry and Other Land Use |
| ANACIM | Agence Nationale de l'Aviation Civile et de la Météorologie |
| ANCAR | Agence nationale du conseil agricole et rural |
| ANSD | Agence nationale de la statistique et de la démographie |
| ASEPEX | Agence Sénégalaise de Promotion des Exportations |
| ASPRODEB | Association Sénégalaise pour la Promotion du Développement par la Base |
| BARVAFOR | Projet de Bassin de Rétention et Valorisation des Forages Ruraux |
| BIT | Bureau International du Travail |
| CAR | Conseil Agricole et Rurale |
| CARIAA | Collaborative Adaptation Research Initiative in Africa and Asia |
| CDM | Clean Development Mechanism |
| CEDEAO | Communauté économique des États de l'Afrique de l'Ouest |
| CER | Certified Emission Reduction |
| FCFA | Franc de la Communauté financière africaine |
| CILSS | Comité inter-États de lutte contre la sécheresse au Sahel |
| CNEE | Convention nationale Etat-employeurs |
| CNRF | Centre National de Recherches Forestière |
| $CO_2$ | Carbon Dioxide |
| COMNACC | Comité National Changement Climatique |
| COMRECCS | Regional Committees on Climate Change |
| CPDN | Contribution Prévue Déterminée Nationale |
| CSE | Centre de suivi écologique |
| D.E.E.C | Direction de l'Environnement et des Etablissements Classés |
| DER | Délégation générale à l’entrepreneuriat rapide des femmes et des jeunes |
| DHORT | Direction de l’horticulture |
| EIF | Enhanced Integrated Framework |
| FAO | Food & Agriculture Organisation of the United Nations |
| FCFA | Franc de la Communauté Financière Africaine |
| IED | Innovation, environnement, developpement |
| GDP | Gross Domestic Product |
| GEF | Global Environment Fund |
| GOANA | Grande offensive agricole pour la nourriture et l'abondance |
| INDC | Intended Nationally Determined Contribution |
| IPCC | Intergovernmental Panel on Climate Change |
| IRD | Institut de recherche pour le développement |
| ISRA | Institut sénégalais de recherches agricoles |
| LADA | Land Degradation Assessment in Drylands |
| LDN | Land Degradation Neutrality |

| | |
|---|---|
| LOASP | Loi d’orientation agro-sylvo-pastorale |
| LPDSE | Lettre de Politique de Developpement du Secteur de l'Energie |
| MAER | Ministère de l’agriculture et de l’équipement rural |
| MEDD | Ministère de l’environnement et du développement durable |
| MEPN | Ministère de l’environnement et de la protection de la nature |
| NAIP | National Agricultural Investment Program |
| NAP | National Adaptation Plan |
| NAPA | National Adaptation Program of Action |
| NGOs | Non-governmental organizations |
| OECD | Organisation de coopération et de développement économiques |
| PADEN | Programme d'Aménagement et de Développement Economique des Niayes |
| PAPIL | Projet d'appui à la petite irrigation locale |
| PAS-PNA | Projet d'Appui Scientifique aux processus de Plans Nationaux d'Adaptation |
| PDU | Plan directeur d’urbanisme |
| PNADT | Plan national d'aménagement et de développement du territoire |
| PNAR | National Rice Self-Sufficiency Programme |
| POAS | Plan d’occupation et d’affectation des sols |
| POS | Plan occupation du sol |
| PRACAS | Programme d’Accélération de la Cadence de l’Agriculture au Sénégal |
| PSAOP | Agricultural Services and Producer Organizations Program |
| PSE | Plan Sénégal emergent |
| RDs | Regional Directorates |
| SAED | Société d'aménagement et d'exploitation des terres du delta |
| SDAU | Schéma directeur d’aménagement urbain |
| SNACC | National Strategy for Adaptation to Climate Change |
| SNMO | Stratégie nationale initiale de mise en œuvre de la Convention Cadre des Nations Unies sur les changements climatiques |
| SNPI | Stratégie nationale de la petite irrigation |
| SODAGRI | Société de développement agricole et industriel du Sénégal |
| SRAT | Schéma regional d’aménagement du territoire |
| SSA | Sub-Saharan Africa |
| TFP | Technical and Financial Partners |
| UEMOA | Union économique et monétaire ouest-africaine |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| WB | Word Bank |
| WDI | World Development Indicators |
| WFP | World Food Program |

# 1 Introduction

Located in the West of Africa, Senegal is demarcated in the west by the Atlantic Ocean. It surrounds the Gambia and shares borders with Mauritania to the north, Mali to the east, and Guinea and Guinea-Bissau to the south. Classified as a least-developed country with a Gross Domestic Product (GDP) per capita of 1,522 USD, the country has a population of 15.85 million in 2018 and occupies 196,722 square kilometers (World Development Indicators, 2018). Its population has a life expectancy of 67 years in 2017 with a poverty rate of 38 percent[1] (World Development Indicators, 2018). The country is characterized by rapid urbanization with an urban population growth of 3.7 percent. However, the rural population remains the largest portion of the population (54.8 percent) (ANSD, 2014).

Historically, Senegal has known political stability, in comparison with its neighbors. However, it has had a slow and volatile economic growth in comparison to other countries in Sub-Saharan Africa (SSA). Indeed, real GDP per capita has only increased by 17 percent in Senegal over the period of 1990-2013/2014 compared to an average of 45 percent in SSA (World Bank, 2018). This economic slowdown can be explained by a decline of the construction and service sectors, which are the traditional economic drivers, the deficit in the balance of payments and the low levels of productivity noted in the agriculture sector (FAO, 2015).

However, the World Bank (2018) reports that since 2012 the new government has implemented policies that resulted in significant improvements between 2012 and 2015 in several international governance indicators and improved its rank to the top ten in the Doing Business reformers list (World Bank, 2018). Such policies have mainly been infrastructural investments, such as roads, and the initiation of several reforms to enhance economic governance, the enhancement of the business environment and performance of specific sectors (liberalizing the groundnut market, opening the energy sectors to competition by allowing in independent power producers, etc.). Senegal's future economic growth can be significantly shaped by the recent oil and gas discoveries. However, their potential positive impact will depend on the international market and on the ability of the country to avoid the resource curse (World Bank, 2018).

In 2018, although agriculture has contributed the lowest share of the GDP (17 percent),[2] the sector is no less important, as it constitutes the main source of income in rural areas, provides raw materials to the processing industry and employs 40 percent of the population (World Bank, 2014). The sector has been facing major challenges, including poor access to water (with only 1.3 percent of agricultural land equipped for irrigation) and vulnerability to climatic shocks (FAO, 2015) that have weakened its proper development. Senegalese agriculture is dominated by smallholders that mainly cultivate subsistence crops in rainfed areas (rice, millet, sorghum and maize) with groundnuts, cotton, and horticulture as the main cash crops and horticulture being mainly cultivated in irrigated areas.[3] Therefore, the sector is highly reliant on rainfalls that have been erratic since the 70s and highly affected by droughts. To build the sector's resilience, the government has undertaken policies and programs since the 2000s to meet food demand by strengthening local production and reducing the heavy dependence on imports, mostly of rice and vegetables such as onion and potato, through subsidies (seeds and fertilizers), investments on equipment, irrigation infrastructure, etc.

To date, food insecurity stands at 7.2 percent with regional disparities (USAID, 2019). Although it is largely stable across the country, localized pockets of acute food needs remain.

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[1] Based on the international poverty line of 1.90 USD a day (2011 Purchasing Power Parity (PPP)). See the statistics table (Table A2) in the appendices for all the figures from the following databases: World Development Indicators and International Labor Organization.

[2] Imports of goods and services occupied the largest part of the GDP (36 percent), followed by the industry (26 percent) and exports of goods and services (22 percent) (World Development Indicators, 2018).

[3] Senegalese agriculture is cultivated in six agroecological zones: mainly rainfed areas (groundnut basin, Casamance, Senegal Oriental, sylvo-pastoral zone) and irrigated areas (Senegal River Valley and the Niayes area).

In terms of employment in rural areas, the primary source of employment is agriculture. In urban areas, the World Bank (2018) states that labor income among the poor has been boosted by growth in labor-intensive sectors, such as commerce and construction. As for employment indicators, they highlight challenging labor markets characterized by high inactivity, unemployment and underemployment rates, especially among the poor, youth and women. As of 2015, the national unemployment rate was 6.8 percent with higher rates for youth and women (8.1 and 7.3 percent, respectively, compared to 6.4 percent for men) (ILO, 2020). The highest rate being for the youth can be explained by the very limited economic opportunities they face. Also, they are characterized by high inactivity and underemployment rates, at almost 60 and 22 percent, respectively (World Bank, 2018).

Concerning basic services, Senegal has good access rates to electricity: 64 percent (USAID, 2018), which is over 20 percent higher than the SSA average of 42.8 percent (World Bank, 2018). Lower access is noted in rural areas (43.5 percent access rate) against 90 percent in urban areas (USAID, 2018). As for water, the access is nearly universally safe with a 92 percent access rate nationally and 98 percent in urban areas, positioning Senegal above all of its neighbors (World Bank, 2018).

The observed ups and downs in the economy and its key sectors are highly linked to Senegal's dependence on climatic hazards that, combined with anthropogenic actions, lead to the degradation of natural resources (including land and water), thus limiting the ecosystem services they provide. Therefore, maintaining natural resources to strengthen key economic sectors is one of the country's challenges. In the face of these multiple interlinked challenges, it becomes urgent to investigate the key sectors and challenges of the Senegalese economy. Therefore, this paper's objective is to undertake a critical literature review on: i) past and future dynamics in terms of climate-related events and their effects on key sectors of the economy, including agriculture; ii) trends in the energy sector; iii) land use and degradation dynamics over the years; and also iv) how the country has responded to these challenges and threats at all levels (policy, research, community and household). The review concludes with a brief evaluation of the main policies on agriculture, land use and climate change and a brief discussion on jobs for youth and women and the role of infrastructure in rural development.

This review of literature has been carried out mainly by searching through literature using different sources: a web search using Google and Google Scholar, and interviews with resource persons in ministries (mainly agriculture and environment). The documents are of different types: journal papers, local and international institutional reports and governmental (ministry) reports that mainly consist of grey literature. The criteria applied for the literature search were mainly guided by the orientation of each section. In addition to providing us with additional literature, interviews allowed us to evaluate selected prominent policies that constitute Senegal's response to challenges. These policies mainly consist of the PRACAS for the agriculture sector, the land-use policies (the 1964 law and the national development and territorial plan) and Senegal's Intended Nationally Determined Contribution (INDC) for climate change and mitigation policies. Before each interview, we designed an interview guide (see appendix).

# 2 Situation and trends in rural energy, and land-use changes

## 2.1 Energy use and associated challenges and opportunities

### *2.1.1 Energy use and sources*

Per-capita energy consumption varies according to background, wealth level, gender and population growth (Dia et al., 2009; Ba, 2018a; Diop et al., 2011). Energy demand comes mainly from households that consume 54 percent of the energy produced at the national level for cooking, lighting, refrigeration and ventilation (Dia et al. 2009). However, the use of different energy types depends on the level of households' wealth. Indeed, according to Ba (2018b), wealthier households use more modern and cleaner appliances such as improved stoves for cooking needs whereas poorer and more rural households use more biomass, such as wood and charcoal. Uses also differ between men and women in rural areas. Indeed, Diop et al. (2011) has shown that men in the Fatick region use forest plant resources for service wood, phytotherapy, and livestock feed while women use them for energy wood (Diop et al., 2011). Dia et al. (2009) also showed that wood is the main energy resource used by Senegalese households.

The literature shows that energy demand has evolved in line with population growth. According to Dia et al. (2009), Senegal's per-capita energy consumption increased on average by 3.6 percent between 2000 and 2009. This growth rate corresponds roughly to the annual population growth. At the same time, energy consumption reflects the level of electrification in the country.

The country's main source of energy supply is dominated by biomass at about 57 percent in 2009 (Dia et al., 2009). According to Dia et al. (2009), the Jatropha program on production of cereals and pulses in 2007 and the transformation of biofuel into ethanol by the Senegalese Sugar Company (CSS) increased national energy production. However, the limitation of available land for Jatropha production and the lack of a regulatory framework for ethanol production and marketing are the main obstacles to supply (Dia et al., 2009).

Senegal produces solar energy. According to Dia et al. (2009), Senegal has an average of 3,000 hours of sunshine per year that can make up the country's energy deficit. However, solar energy accounted for 0.01 percent of national energy production in 2006 (SIE Statistics, 2007). According to Camblong et al. (2009), the cost of installations is often put forward as an obstacle to production.

### *2.1.2 Challenges and opportunities*

The main challenges of the energy sector are highlighted in the Senegal Emerging Plan (PSE) with the LPDSE as the main policy document. The energy sector constitutes a major sector for the development of Senegal and a key sector in the PSE (PSE, 2014). The specific challenges of the sector are, as reflected in the LPDSE, to ensure sufficient and stable access to electrical energy at low cost with a vision to ensure universal access to electricity by 2025 (Ba, 2018b; APIX, 2018).

Concerning stable access, unequal access to electricity across the country is one of the main challenges. Indeed, the rate of electrification in urban areas (90 percent) far exceeds that observed in rural areas (43.5 percent) (USAID, 2018). Another challenge is the stability of the electricity to ensure zero power cuts across the country.

As for the cost of energy, the main challenge of the sector is to maintain the current efforts in diversifying the sources of electricity production and opening the market to other private entities. Indeed, in the past, the energy sector in Senegal has been characterized by a high dependence on oil imports (Dia et al., 2009). Senegal's oil bill increased from 185 billion FCFA (i.e. 310 million USD) in 2000 to 623 billion FCFA (i.e. 1060 million USD) in 2008 (EIS, 2009). However, with recent openings of the market and the diversification of the energy sources, the country has reduced its dependence on imports considerably. This also helps in ensuring stability.

Last but not least, Senegal's energy sector enters a new era with the recent oil and gas discoveries that enable the prospect of the country exporting petroleum products from 2020 onward (World Bank, 2018; APIX, 2018). This constitutes a great opportunity for the country. For instance, the World Bank (2018) states that "the SNE deep offshore oil field, expected to start producing around 2021-2022, with an estimated life of around 25 years, has a maximum daily production estimated at around 100,000 bpd.[4] This level of output is expected to generate government revenues between 0 and 3.8 percent of GDP annually [...] with a baseline scenario (60 USD per barrel) of 1.6 percent of GDP annually". However, the country needs to avoid the common resource curse to turn these resources into economic advantages.

## 2.2 Review of dynamics of land degradation, land use and land cover changes over the previous 30 years: satellite-based remote-sensing observations, local ground-truthing studies, biophysical modelling-based studies

### *2.2.1 Dynamics of land use and land cover changes over the past*

Several studies have shown the dynamics of land use and land cover in Senegal (Tappan et al., 2016; CILSS, 2016; IRD, 2016; CSE, 2015). These studies review the activities of the West Africa Land Use Dynamics project launched in 1999, which was an effort to map land use and land cover, characterize trends over time and space and understand their effects on the environment in West Africa, particularly in Senegal.

The project produced time-series data on land use and cover in three distinct periods (1975, 2000 and 2013) in the Sub-Saharan region of West Africa, including Senegal, which allows the analysis of land-use changes in the region (Tappan et al., 2016). The project data (see Figure 1 below and Table A1 in appendices) show that as of 2013 the main classes of landcover in Senegal are, by order of importance, Savanna, Sahelian short grass savanna and Agriculture (including agriculture in shallow, recession and irrigated agriculture), which occupy 35, 26 and 22 percent of the territory, respectively. Forests of all types and water bodies, which are mainly located in the Senegal River Valley, part of the center and the south, occupy a negligible part of the territory, with a share of only 1.3 percent of the territory for each.

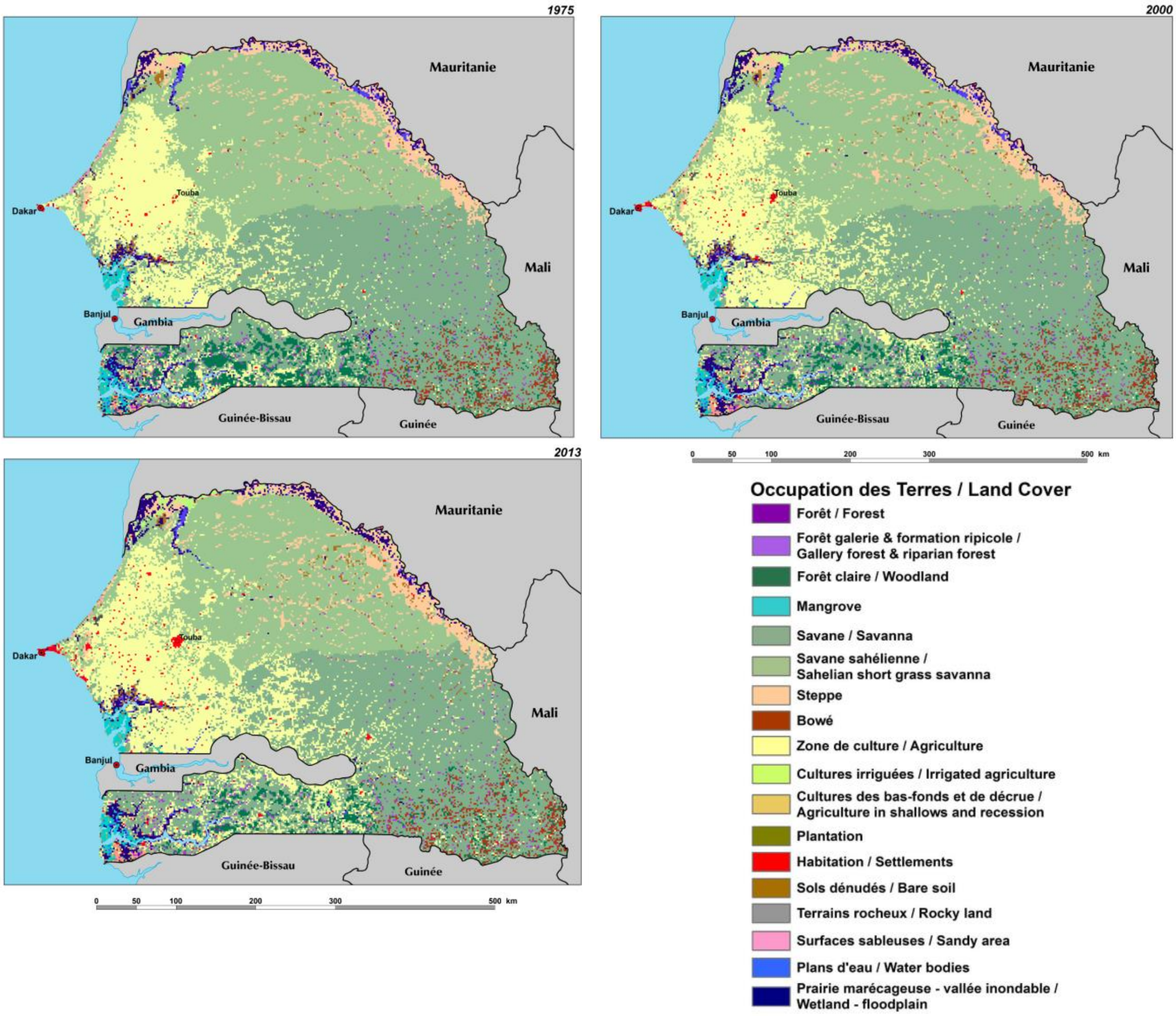
This land cover partition has almost remained the same over the period 1975-2013. The main changes have occurred between 2000 and 2013 and touched mainly total agricultural land, which almost continued to occupy the same space between 1975 and 2000 and then increased by 26 percent, from 32,600 km² in 1975 to 32,900 km² in 2000 and 41,000 km² in 2013. Within agriculture land, the area occupied by irrigated agriculture has almost doubled between 1975 and 2000 and nearly doubled again in the period 2000-2013. This can be explained by the governments' efforts since the 1970s-era droughts to increase irrigated areas across the country.

However, the distribution and expansion of agricultural land within the territory have significantly altered the landscape. The development of agriculture has led to the fragmentation of savannah and open forests, resulting in a loss of natural habitat and a decline in the quality of the remaining natural ecosystems. While the average annual increase in cultivated area was rather low between 1975 and 2000 at about 10 km² per year, it increased dramatically between 2000 and 2013, to an average of 630 km² per year. However, this trend masks disparities within the Senegalese territory (CILSS, 2016).

[4] Within the same range of Ghana's production, but far below major African producers, such as Nigeria and Angola, which produce around 2 million bpd per day (World Bank, 2018).

In terms of space occupied, agricultural land increased by 4 percent between 1975 and 2013, with more changes occurring between 2000 and 2013 as previously stated. The space occupied by Savana decreased by around 3 percent between 2000 and 2013. As for Savana short grass, changes are negligible. The occupation of forests, on the contrary, have been declining over time, decreasing from 1.66 percent to 1.43 and 1.28 percent in 2000 and 2013, respectively.

Figure 1: Historical land-use trends in Senegal (1975-2013)




Source: Tappan et al. (2016).

Moreover, according to the national report on Land Degradation Neutrality (LDN) (MEDD, 2018a) within the framework of the United Nations Convention on Desertification in 2018, it is noted that FAO, through the AFROCOVER[5] project and the Global Land Cover Network, has produced land cover and land use maps from LANDSAT satellite images from the 1990s and 2005. The statistics obtained made it possible to assess the evolution of vegetation cover in Senegal and note an increase in the amount of cultivated areas and a decrease in the amount of forest areas as found by the previous studies. These land-use changes are linked to natural (climate) and anthropogenic (wood energy exploitation, urbanization, deforestation, and agricultural clearing) actions. There has been a sharp increase in the amount of cultivated areas in the regions of Kolda, Kaffrine and Louga.

[5] AFRICOVER is a project set up by FAO in developing African countries with the aim of mapping land cover and producing geographic databases.

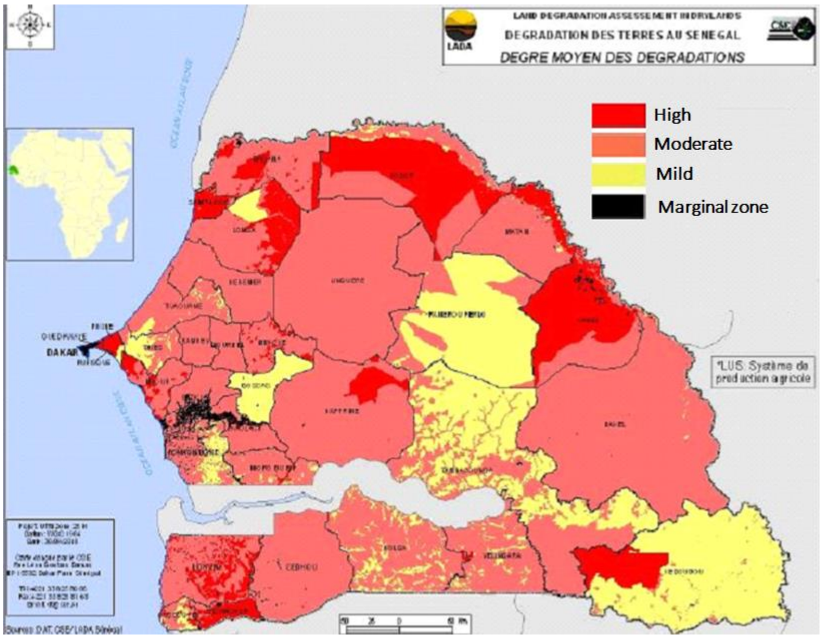
### *2.2.2 Dynamics of land degradation*

> "Land is a source of well-being for the present and future generations -it provides a wide range of ecosystem services that sustain human needs. Land degradation can severely influence livelihoods by limiting the availability of vital ecosystem services (including food and water), increasing the risk of poverty and ultimately forcing people to migrate. A recent study shows that the state of the land, whether it is improving or degrading, can to a large extent influence the impact of a country's economic growth on poverty alleviation, making land an accelerator (or decelerator) of poverty eradication" (MEDD, 2018a, p.4).

Studies carried out by the CILSS in November 2010 indicate that, out of the 3,805,000 hectares of arable land available in the country, 2,400,000 hectares, or 63 percent, are severely degraded. (IED, 2015). Within the same range, (i) IRD (2016) shows that soil degradation affects 2/3 or 67 percent of the country's arable land, generating a loss equivalent to 1 percent of the GDP; and (ii) the Senegal Country Environmental Assessment (World Bank, 2008) reports that nearly 65 percent of total agricultural land is degraded. A CILSS study (CILSS, 2016) shows land degradation in the Ferlo region (central Senegal) between 1994 and 2011 as well as a decline in vegetation cover and biodiversity in central-eastern Senegal between 1984 and 2013. Moreover, the LDN report (MEDD, 2018a) shows that at the biophysical level, the land area of Senegal measures 20,179,118 hectares, of which the Project "Assessment of Land Degradation in Drylands" estimates the level of land degradation at 34 percent, which represents a degraded area of 6,860,900 hectares.

The monitoring of bush fires shows that the size of afflicted areas increased from 224,920 ha in 2016-2017 to 246,951 ha in 2018, or an increase of almost 9 percent (CSE, 2018). In terms of spatial representation, figure 2 shows that moderate to high levels of land degradation is noted in almost all the agroecological zones of the country. Only the eastern region of Kedougou and some spots in the north and the center display mild degradation levels.

Figure 2: Land degradation in Senegal




Source: FAO and CSE (2011).

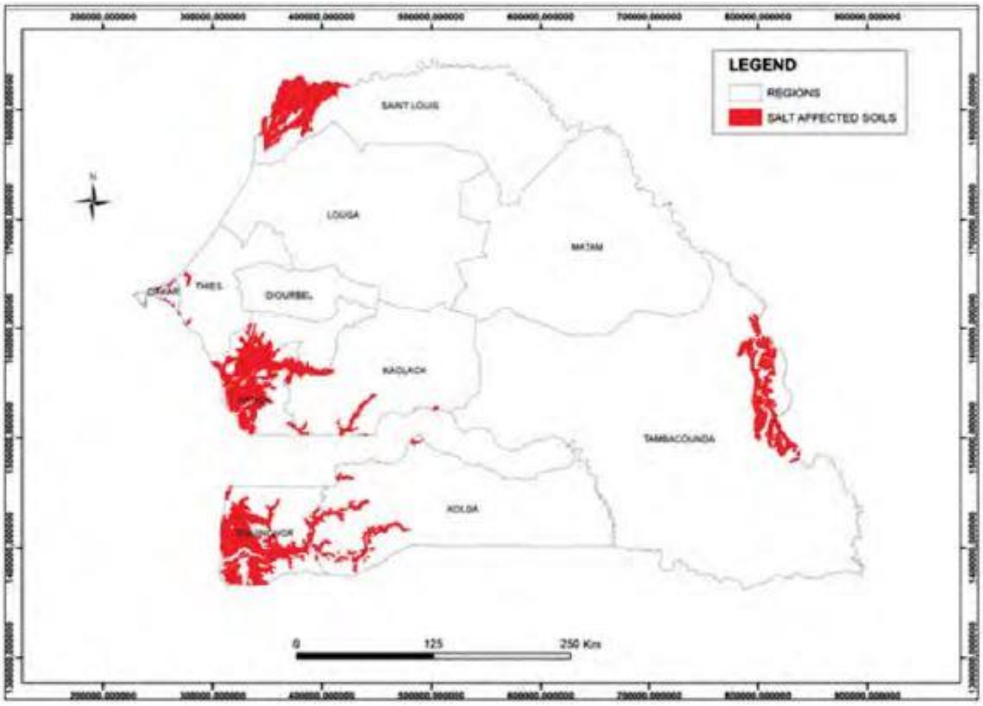
The CSE also points out in its report on the state of the environment (CSE, 2015) that land degradation also significantly affects the availability of agricultural land, soil fertility, settlement areas, and infrastructure, as well as the balance of ecosystems.

### *2.2.3 Types, causes, and impacts of land degradation on dimensions of sustainable development*

IRD (2016) reports that there are several types of land degradation to varying degrees:

- **Wind erosion**, which affects 77 percent of degraded land and affects, to varying degrees, all of Senegal's eco-geographical zones. The World Bank (2008) reported much lower figures on wind erosion. Indeed, they stated that wind erosion, which is more pronounced in the country's northern regions (Senegal River Valley and northern parts of the Peanut Basin), accounts for 3 percent of degraded soils. These figures are closer to the ones reported in ANAT (2016) that considers a total amount of degraded land of 2,442,000 hectares at the national level, among which, wind erosion accounts for 287,000 ha, or 7.5 percent of arable land and 100,000 hectares or 8 percent of arable land in the Senegal River Valley.
- **Salinization of land** to which the extent has not yet been properly assessed. Indeed, estimates of the areas affected by salinity vary between 925,000 and 1,700,000 ha, with the land considered to be severely affected estimated at 625,000 ha.
- **Water erosion** is another type of land degradation that, according to ANAT (2016), affects 1,510,000 ha or 39.68 percent of total arable land and 100,000 and 30,000 hectares, or 8.6 and 10.9 percent of arable land in the Senegal River Valley and the Niayes area, respectively. According to the World Bank (2008), water-related erosion is responsible for the degradation of 9,080,100 hectares or 77 percent of total degraded soils.

Figure 3: Locations of areas affected by salinization

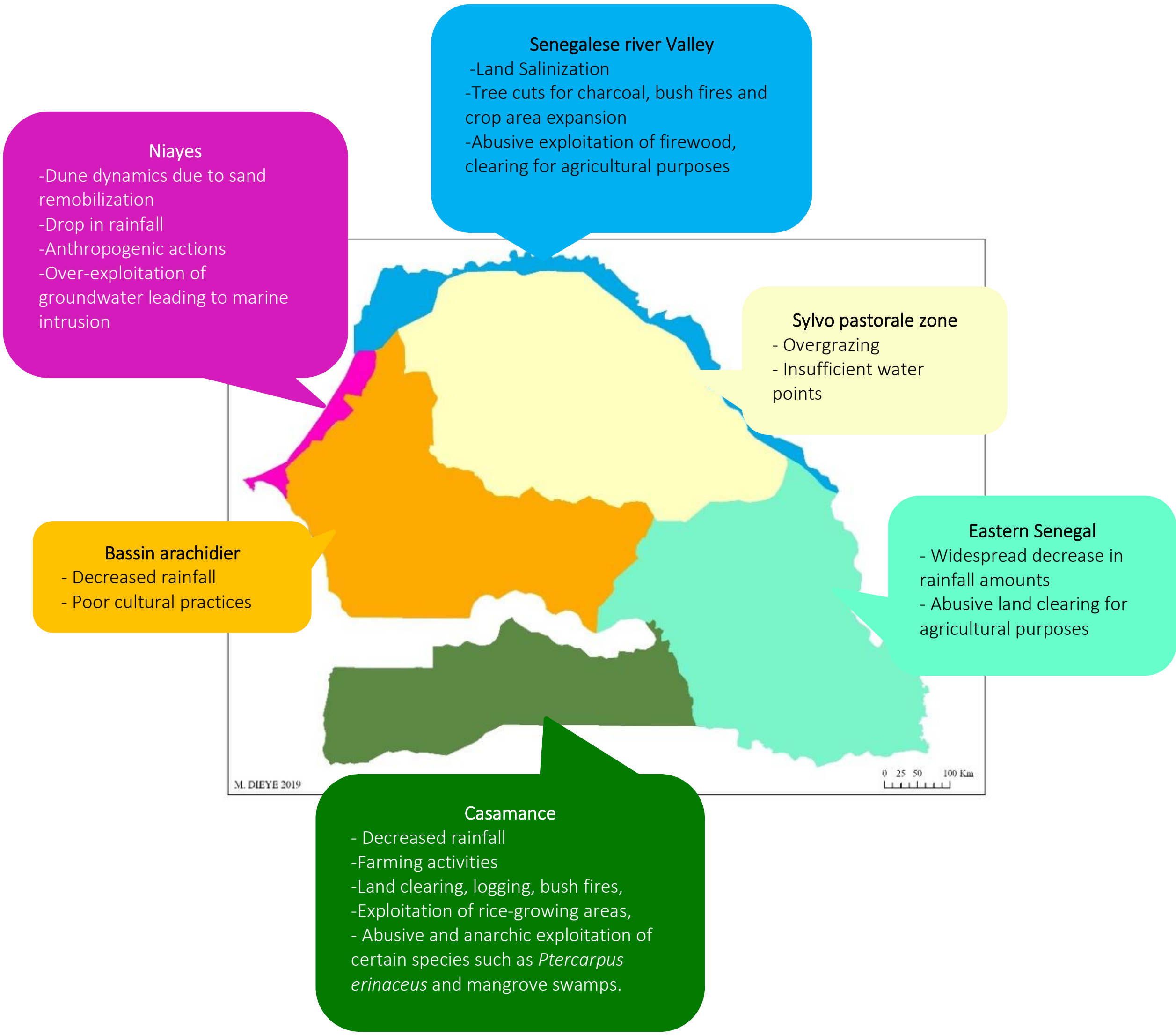



Source: ANAT (2016).

Factors explaining land degradation include population growth leading to increased demand for agricultural land and increased demand for fuelwood for urban centers and resulting in massive deforestation and degradation of vegetation cover. Poor agro-sylvo-pastoral practices with shifting cultivation and the abandonment of fallow land have also led to an expansion of agricultural areas. This expansion of agriculture has led to the encroachment of the savannah and woodlands in the central and southern parts of the country and to the insecurity of land tenure (CSE, 2015).

Figure 4 illustrates the different causes of land degradation in the different agro-ecological zones of Senegal.

Figure 4: Causes of land degradation in Senegal




Source: ANAT (2016).

According to the Land Degradation Assessment in Drylands (LADA) report (FAO and CSE, 2003), land degradation has now reached such proportions that it dangerously compromises certain rural activities, particularly those related to agricultural, forestry and pastoral production, while in Senegal, 50 percent of the rural population derives its livelihood from land (ANSD, 2014). The intensification and expansion of land degradation can severely affect labor productivity and jeopardize agricultural livelihoods in the country (MEDD, 2018a). Indeed, land degradation can have serious impacts on livelihoods by limiting the availability of vital ecosystem services (deterioration of food and water availability, soil fertility), increasing the risk of poverty and forcing people to migrate. Between 2000 and 2010, the number of people living in remote agricultural areas undergoing degradation and with limited market access increased by 37 percent, reaching 257,000 people (MEDD, 2018a).

According to the LDN report (MEDD, 2018a), the annual cost of land degradation in Senegal is estimated at 996 million USD or 9 percent of GDP. Land Use/Cover Change (LUCC) is the leading cause of land degradation in SSA, since high-value biomass are replaced with low-value biomes (Nkonya et al., 2015). Sow et al. (2016) show that the cost of land degradation due to Land Use/Cover Change (LUCC) is about 0.412 billion USD or about 4 percent of the GDP. They also show that (i) the annual cost of land degradation on rice, millet, and maize —which account for 45 percent of cropland area— is 103 million USD or 2 percent of the country's GDP and (ii) the on-farm cost of grazing land degradation is about 9 million USD or 0.1 percent of the GDP. The low cost of grazing degradation is a reflection of low livestock productivity. These figures show that LUCC accounts for the largest cost of land degradation.

In 2000, the rural population living on degraded agricultural land was estimated at 24 percent (1.8 million people). Between 2000 and 2010, this population increased by 504,000 people, which is an increase of 28 percent over this decade.

Each year, large areas are affected by bush fires. Monitoring carried out between 1992 and 1998 using remote sensing reveals that the areas burnt annually vary between 740,000 hectares (1994) and 180,000 hectares (1997) (FAO and CSE, 2003). Areas repeatedly affected by fire show the highest number of signs of degradation as manifested by:

- A decrease in floristic diversity and regeneration potential
- Significant emissions of greenhouse gases (CO2)
- A reduction in wood stock and carbon sequestration potential

Concerning the impacts of land degradation on energy, the LADA report (FAO and CSE, 2003) points out that firewood is the most widely wood-energy used in rural areas. It represents 50 to 60 percent of the national exploitation of ligneous fuel, of which a good part is subject to self-consumption and 20 percent of the wood production is exchanged through the market.

# 3 Observed and projected impacts of climate change

## 3.1 Observed and projected trends in extreme weather events: droughts, floods, heatwaves, heavy precipitation events

### *3.1.1 Observed trends*

Senegal is located in the Sudano-Sahelian zone of West Africa. Its climate is characterized by a rainy season from June to October, depending on the region, and a dry season from November to May. The rainy season first settles in the south-east of the country with the arrival of the monsoon and gradually extends northwards. More than 75 percent of the rains are linked to grain lines, or disturbances that arrive from the east (Sagna, 2005).

Average temperatures are generally high in the interior of the country (28°C) and lower on the coast, particularly in the Dakar region (24°C).

Several studies on the evolution of rainfall in Senegal have highlighted the succession of a wet period before the 1950s, followed by a dry period from the 1970s on, and then strong rainfall variability since the 1990s (Sané et al., 2008). For instance, based on data from Kolda and Bakel meteorological stations, Malou (2004) notes three phases in the evolution of the country's climate: i) the wet period 1960-1970; and ii) the period 1970-1990, which is marked by climatic instability with a continuous decrease in rainfall. This period corresponds to the drought of the 1970s in the Sahel, which led to the current hydrological deficit; and iii) a third period that begins with abundant rainfall from the 1990s.

With slightly similar results, at the national level, Mcsweeney et al. (2010) report a period of heavy rains in the early 1960s, while the 1980s were dry. Between 1960 and 2006, they note a significant decrease in rainfall ranging from 10 to 15 mm per decade in the southern regions of Senegal during the rainy season (July, August and September).

Therefore, climatic irregularities are manifested, among others, by rainfall variability and temperature intensities over time and space as demonstrated by Milleville et al. (1997) and Sarr (2009). They are also reflected by the degradation of the quality of the rainy season (Sané et al., 2008), which starts with delay and has a reduced duration (Diop, 1996), but also by the recurrence of intra-seasonal droughts.

Concerning temperatures, their evolution has resulted in an increase in the minimum values and the average annual temperature has also increased by 1.6°C since 1950; a stronger increase of 3°C on average has been observed in the North of Senegal (CSE, 2010). With slightly lower figures, Mcsweeney et al. (2010) report that average annual temperatures have increased by 0.9°C since 1960, with an average growth rate of 0.2°C per decade.

### *3.1.2 Projected*

Given the current vulnerability of agricultural production systems, some studies have looked at future climate change to better anticipate the resilience strategies of such systems.

In terms of climate projections, the most recent report for Senegal is the vulnerability study of Camara et al. (2019), which considered two climate change scenarios (rcp 4.5 and rcp 8.5). These two scenarios showed a continuous increase in temperature, although the temperature increase in the rcp 4.5 scenario is less significant from 2030 onwards. The report reveals that "temperatures will continue to rise by 1.1 to 1.8°C by 2035 and by 3°C by 2060"(Camara et al., 2019). The expected warming will be faster inland than in coastal areas.

These results are more or less in line with previous studies that also predicted a rise in temperatures by 2050 with a minimum of 1°C to 1.5°C (Khouma et al., 2013). The highest predicted temperature is obtained with the Echam 5 model and reaches 3°C (Khouma et al., 2013). Mcsweeney et al. (2010) also predicted a temperature increase of 1.1 to 3.1°C by the end of 2060 and 1.7 to 4.9°C in the 2090s. In the Second National Communication to the United Nations Framework Convention on Climate Change (D.E.E.C., 2010), temperatures in West Africa and Senegal, in particular, are projected to increase by up to 3°C over the period 2031-2050.

While rainfall decreased by 30 percent between 1950 and 2000 (CSE, 2010), Faye et al. (2019) show that the cumulative rainfall of the rainy season could decrease by 2035 (compared to the cumulative rainfalls of the baseline season in 2006) and 2050 (compared to the cumulative rainfalls of the baseline scenario in 2036), with the decrease by 2050 and for the rcp 8.5 being even starker. The decrease will amount to -9.40 mm by 2035 and -14.00 mm by 2050 for the rcp 4.5 and to 21.86 mm by 2035 and -24.21 mm by 2050 for the rcp 8.5 (Camara et al., 2019). These results show that the future evolution of rainfall will experience a spatial variability with varied intensity, as it is currently the case.

Contrary to temperatures, the results of previous studies for rainfalls are somewhat different in terms of the magnitude of change. According to Khouma et al. (2013), rainfalls in Senegal in 2050 are expected to remain more or less stable in many parts of the country. The magnitude of change would vary between - 50 mm and + 50 mm, depending on the general circulation model used. However, Khouma et al. (2013) found that this does not apply to the Casamance region and eastern Senegal, where two general circulation models (3.2 Miroc medium resolution and C.N.R.M. C.M.3) show that rainfalls would increase by about 50 mm to 100 mm in Casamance in 2050. These forecasts seem to contradict the NAPA (2006), which states that the south will dry up more than the north. For eastern Senegal, the Echam 5 model projects a rainfall trend of about -50 to 200 mm. Mcsweeney et al. (2010) predict that rainfall will be more likely to decrease, especially during the rainy season, although they noted a wide range of changes in rainfall (41 to 48 percent in the 2090s during the rainy season).

### *3.1.3 Extreme events*

ANACIM et al. (2013) show that extreme events such as floods or droughts affect different sectors of the economy, particularly the agricultural sector. These events would result from climate variability. Indeed, the decrease in the frequency of seasonal rainfall from the late 1960s to the mid-1990s led to a decrease in the number of rainy days, a shorter rainy season and longer drought events (Le Barbé and Lebel, 1997). However, it has been difficult to estimate the frequency of drought occurrences (ANACIM et al., 2013). Some sources report that since 2000, there have only been droughts in 2002 and 2011, while other sources indicate that there have been droughts in 2000 and 2006/2007 (ANACIM et al., 2013). The drought of 2011/2012 is considered to have affected the largest number of people.

The frequency of floods has also increased in recent years due to, among other things, a greater occurrence of heavy rains. ANACIM et al. (2013) report that between 2000 and 2012, floods occurred at least once every eight years and had negative effects on infrastructure and facilities (public and private). An increase in diseases due to stagnant water is also noted. Roudier et al. (2011) report that since 2000, the majority of floods have been linked to inter-seasonal variability during the monsoon season, which would be linked to climate change as a long-term effect.

## 3.2 Observed and projected impacts on agricultural productivity, disease vectors, and health, biodiversity, livelihoods and incomes, food security, conflicts, and migration

### *3.2.1 Impacts on agricultural productivity, livelihoods and food security*

The impact of these climatic changes is documented by various studies. Studies on the Senegalese agricultural sector show that it is highly vulnerable to climate change and variability (NAPA, 2006;

D.E.E.C., 2010; ANACIM et al., 2013; Khouma et al., 2013; Sall, 2015). Sall (2015) argues that climate variability is one of the most difficult risks for farmers to control.

Considering the period 1960-2010, ANACIM et al. (2013) observe that food production is higher in wet years than in years with fewer rainfalls. To illustrate this observation, they use production data during the period 1960-2010 to show the relationship between climate variability and production. Their results show that interannual variation in rainfall alone accounts for 50 percent of the variation in total production of groundnuts, millet, sorghum, rice and maize. However, the study does not include other climatic and non-climatic factors, such as inputs used, irrigation techniques and economic context, that could explain yields.

At the regional level, correlation calculations between rainfall and production allowed ANACIM et al. to conclude that there is a strong correlation between rainfall and cereal production with the lowest correlation noted in St. Louis, mainly with flood recession and rice (Pearson coefficient = 0.34). The highest correlations are noted, in decreasing order, in the regions of Thiès, Kaolack, Louga, and Ziguinchor (Pearson coefficients, respectively: 0.73, 0.63, 0.57 and 0.56). These regions thus seem to be the most vulnerable to climate variability. Indeed, the positive correlation means that precipitation and production are moving in the same direction.

These results are similar to those found in the Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC, 2010) for the central regions. For the southern regions, the results appear to be distinct. D.E.E.C. (2010) compares the evolution of annual rainfalls with that of yields at the regional level during the period 1960-2008: in southern Senegal (Kolda) and the center (Diourbel). In Kolda, where they report an average annual rainfall of 1,003 mm over the period, they noted a declining trend in rainfall, which is nonetheless accompanied by an increasing trend in millet and groundnut yields. This result seems to contradict the correlation previously found in Ziguinchor (ANACIM et al., 2013).

This contradiction is not observed in the centre at Diourbel, which is characterized by high temperatures and an average rainfall of 501 mm during the period 1960-2008, where groundnut production follows the same trend as rainfall. Nevertheless, millet yields have remained constant during the period 1960-2002, despite the decrease in rainfall. D.E.E.C. (2010) explains this result by the fact that millet is less water-demanding and is reported to be more drought-resistant as compared to groundnut. The results on the positive correlation between rainfall and groundnut production in the centre are consistent with the analyses of Sall (2015), who notes that out of the last twenty-five years in Senegal, six years have experienced rainfall disruptions. This has led to a decline in groundnut production, especially in the Groundnut Basin. Sall (2015) also refers to rain breaks, which, regardless of the type of rainy season ('good' or 'bad'), can negatively affect production.

Rainfalls also have an indirect effect on production. Indeed, flooding due to excess precipitations could lead, among other things, to losses for crops that cannot withstand flooding and an increase in the frequency of plant diseases (D.E.E.C., 2010). This is supported by Sall (2015), who argues that "climatic constraints are often linked to the development of diseases or insect proliferation." Floods are more frequent, particularly in the lowlands of Dakar and north-western Senegal (CSE, 2010) and extreme droughts in 2002 and 2011 have worsened food insecurity for more than 200,000 and 800,000 people, respectively. This insecurity is further exacerbated as changes in biomass production, particularly in the sylvo-pastoral zone, reduce fodder production for livestock.

Moreover, the frequency of drought is negatively correlated with yield, particularly for millet, sorghum, and groundnuts (ANACIM et al., 2013). Thus, ANACIM et al. (2013) point out that groundnut production in Senegal declined significantly in the drought years of 1972, 1977, 1984, 2002 and 2007. However, these effects can be mitigated through adaptation measures. Indeed, ANACIM et al. (2013) observe increases in production after the droughts of the 1970s and early 1980s and after the droughts of 2002 and 2007. These observations suggest a government response to drought, notably through adaptation policies and strategies.

Concerning the effect of temperatures, a rise in these will lead to an increase in the water requirements of plants, whose deficit will worsen; this will have repercussions on yields and biomass production (D.E.E.C., 2010). Some areas that face salinity problems, notably the cultivated areas of rainfed rice in the groundnut basin and the south (Fatick, Kaolack, Ziguinchor and Kolda regions), will be further disadvantaged. Furthermore, a study funded by GIZ identified current and future vulnerabilities in the Fatick region (Faye et al., 2019). Rising temperatures have led to increased evapotranspiration and reduced crop cycles. The results of the rcp4.5 and rcp8.5 scenarios showed a heightening of the current impacts.

These climate impacts on production threaten food security. Indeed, among the pillars of food security, availability and access (both financial and physical) are important. In Senegal, markets, particularly rural markets, play an important role in both financial and physical access to food. Indeed, they constitute a source of income for farmers through the sale of agricultural production and livestock and allow them to purchase food and agricultural inputs. Most Senegalese households purchase the food they consume in markets (87 percent of rural households and 97 percent of urban households). Consumption from own production is the second most common food source, consisting of around 10 percent of all food in rural households (USAID, 2015), and is highly dependent on agricultural production, whose availability is threatened by climatic shocks as discussed above. In addition to the climate's impact on production, the effect of extreme events such as floods on infrastructure (e.g. roads) can render difficult access to markets (ANACIM et al., 2013). Also, doing a spatial correlation between rainfall statistics and livelihood indicators, they found (i) a positive correlation between rainfalls and food consumption score suggesting that higher rainfall results in larger diet diversity and quantity and (ii) a negative correlation between rainfall and food expenditure (ANACIM et al., 2013).

In terms of projections, a modelling work conducted by ISRA, as part of the USAID-funded vulnerability study in the north-eastern quarter of Senegal, has shown that under the rcp4.5 and rcp8.5 scenarios, millet and groundnut yields will decline in the departments of Matam and Bakel (Ndour et al., 2014).

Khouma et al. (2013) estimated future yields for some cereal and leguminous crops: groundnut, maize, millet, sorghum and rice. Under the assumption that crops with the same photosynthetic metabolism will react identically to climate change in the same area (Nelson et al., 2013), they assumed that the effects of climate change are the same for maize, millet, and sorghum in the same geographical area. In their study (Khouma et al., 2013), the majority of models predict a decrease in groundnut yields between 5 and 25 percent. For maize (and millet), yields will vary (decrease or increase) between 5 and 25 percent by 2050, with an evolution mainly below 5 percent in absolute value terms. Finally, yield predictions are more optimistic for rainfed rice, which will experience yield increases and variations of no more than 5 percent. Yield decreases are barely noticeable for rainfed rice in the areas where it is grown (Groundnut Basin, Casamance, and Eastern Senegal).

The late start and early end of the rains are already resulting in delayed germination of crops, reduced growth and difficulty in completing the crop cycle. The reduction in the duration of the rainy season will be amplified in 2035 and 2050 and will increase the impacts already observed (Faye et al, 2019). The observed decrease in rainfall will be accentuated in 2035 and 2050, according to the results of Faye et al. (2019). Among the effects are the disruption of crop growth and reproduction phases and the decrease in the productive capacities of crops. These impacts will be accentuated by the rcp4.5 and rcp8.5 scenarios, which predict a decrease in rainfall in 2035 and 2050.

### *3.2.2 Impacts on health*

Concerning the health sector, the effect of climate (rainfall, temperature, and humidity) on disease is not straightforward (USAID, 2015). Indeed, many non-climatic factors also affect health. The main diseases that are at risk with climate change in Senegal are vector-borne diseases such as malaria, lymphatic filariasis, yellow fever, dengue fever, the fever of the Rift Valley, and cholera/diarrheal diseases, undernutrition and others (RNDH, 2010; USAID, 2015).

### a. Vector-borne diseases

Mosquitoes are vectors for malaria, which is still a leading cause of morbidity and mortality in Senegal, lymphatic filariasis and other diseases of less prominence, such as dengue fever. In Senegal, the favorable transmission conditions of vector-borne diseases such as malaria are noted during the rainy season, particularly in the southern parts of the country (USAID, 2015), where the rainy season lasts 4 to 5 months. In the centre and northern parts, the rainy season lasts around 2 to 3 months. USAID (2015) analyzed the survival of the mosquito under both wet and dry future scenarios.

Under a "wet" future scenario, rainfalls would be sufficient to allow the proliferation of mosquitoes across the country. Also, this scenario is characterized by slightly lower increases in temperature, which, particularly in the south, would remain suitable for the survival of mosquitoes. Given the reduced temperature increase in the "wet" scenario, it is likely that the north may at best remain suitable for mosquitoes or at worst become more suitable because of the increased rainfall. Under the "dry" future scenario, the risk may still exist for the south, because, even under the driest scenario, the average monthly rainfall is not lower than 80mm. This, combined with an average maximum temperature of between 35oC and 38oC in the dry scenario, suggests that the south may still be suitable for the survival of mosquitoes. However, in a dry year in the north, there may not be sufficient rainfall to support the survival of mosquitoes every year. In addition, the potential for the maximum temperatures in the north to exceed the 40$^{o}$C threshold for the viability of mosquitoes means that the risk of these diseases under a dry scenario may decrease in the north.

**Cholera/diarrheal diseases** are also health risks for Senegal. These diseases mainly spread through contaminated water or food. Non-climatic factors such as inadequate sanitation, poor hygiene, and overcrowding play a major role in the spread of both types. However, climatic conditions play an important role, both in the spread and multiplication of the responsible bacteria. Heavy rainfall can lead to flooding, which increases the chance of freshwater being contaminated. Dry periods, on the other hand, can lead to stagnant water in ponds and rivers, creating more favorable conditions for the bacterium to grow (USAID, 2015). Also, if flooding or drought takes place in overcrowded areas that lack proper hygiene and sanitation, it can be difficult to manage and contain outbreaks.

In 2005, Senegal experienced one of the largest cholera outbreaks of its history, for which the temporal dynamics of precipitation (sudden and heavy rain) was one of the likely driving factors (USAID, 2015). Dakar and Diourbel, which are the most densely populated regions, were the most impacted out of the regions affected.

### b. Future trends

Projections indicate that the frequency of extreme or heavy rainfall and dry periods may increase and may therefore increase the burden of waterborne diseases. This possible change in extreme rainfall events is consistent across the country. However, the best scientific evidence on rainfall changes suggests that the total average rainfall is projected to increase in the south more than the north, and the risks of these waterborne diseases may therefore be higher in the south (USAID, 2015).

Other diseases such as Schistosomiasis infections and Meningococcal meningitis are also affected by climate (wind, temperature), together with non-climatic factors. Undernutrition may also be at risk as both socio-economic (e.g. poverty and access to services) and climatic factors shape people's food intake.

### c. Impacts on migration

Climate change by itself is not the sole driver of migration, as other socio-economic factors play also an important role in the decision to migrate (Diallo, 2018). However, in Senegal, internal migration has been identified as an adaptation strategy that grew during the late 1970s and early 1980s, corresponding to the two major droughts that occurred in the county. When considering historical trends in the different agro-ecological zones of Senegal, it appears that from the 1970s-1980s, there were migration movements from the Groundnut Basin, which is characterized by rainfed and semi-subsistence to subsistence agriculture, to the coastal north (the Niayes area), where agriculture is mainly irrigated and market-oriented. The Peanut Basin has gone from a net immigration zone to a net emigration zone since the first manifestations of climate change (Diallo, 2018).

In other agro-ecological zones, such as the agro-sylvo-pastoral zone where pastoralism is predominant, the deficit migration dynamics are explained by the constraints imposed by the heavy rainfall deficits of the 1970s and 1980s that have affected pastoral resources (Diallo, 2018).

Contrary to the other agro-ecological zones of the country, the droughts of the 1970s and 1980s and their subsequent negative consequences on the living conditions of the population resulted in a massive movement of rural populations towards the Niayes zone, particularly the Dakar region due to its attractiveness based on horticulture and the informal economy. The direct consequence is rapid urbanization, whose consequences are beginning to be felt with recurrent flooding occurring in Dakar since 2000 (Diallo, 2018). However, in the regions of Thies, the northern Peanut Basin and Louga, Diallo (2018) shows a deficit in the migratory balance.

# 4 Technological, socioeconomic and policy actions for sustainable land management and climate change adaptation and mitigation

In Senegal, several strategies have been implemented to reduce the negative effects of climate shocks. Actions undertaken have been done at different levels: research technologies, community and household responses and policy responses. This section will cover these different levels of responses.

## 4.1 Technological responses categorized by land-use types (given as selective examples)

### *4.1.1 Croplands*

#### a. Expanding irrigation

Since the droughts of the 70s, investing in irrigation has been considered a channel through which production could be secured, with irrigation policies and programs that have targeted different agroecological zones at different scales to account for the specificities of the different types of farms and the technical/physical and financial resources available to them. These actions have mainly targeted the Senegal Valley, which has always been considered by the public authorities as the location that can most reasonably achieve the objectives of rice self-sufficiency, regardless of the fact that the country has other regions with strong potential, such as Casamance in particular (Belières et al., 2013 in Brauckman, 2018). In the Senegal River Valley, large- to medium-scale public irrigation projects have equipped more than thousands of hectares of land with the means to achieve rice self-sufficiency. Some other projects targeted high-value crops such as vegetables through the promotion of water user associations in almost all the agroecological zones of Senegal (SNPI, 1999). In addition to government initiatives, there were private initiatives by private entrepreneurs mainly in the Delta of the Senegal River Valley and private initiatives by smallholder horticulture farmers in the Niayes area. Figure 5 summarizes the types of irrigation schemes in the different agroecological zones.

Such projects have slowed down in the 1990s yet have resurged in the early 2000s since the 2008 food crisis with projects and programs such as the GOANA, the PNAR and the PRACAS, which targeted irrigated rice and off-season fruits and vegetables. The area occupied by irrigated agriculture has increased and will probably continue in that direction as many more recent and ongoing initiatives are noted. These include the small irrigation support project (PAPIL), the food security support project (PASA LouMaKaf), and the Sahel incentive project of the World Bank (see Figure 5 for more details).

Figure 5: Illustrative initiatives and realizations to expand irrigation area in Senegal

**Public irrigation schemes and private initiatives**

**Senegal River Valley**

Four types of irrigation schemes
- large collective irrigated farms (GPI) : 400 to a few thousand hectares and designed with total water control
- intermediate irrigation schemes (AI) : 60 to less than 400 ha and of identical design to that of GPI
- small private irrigated farms (PIP) : few dozen hectares and installed on strictly private initiative
- small horticultural WUAs-- Lac de Guiers and Bas-Ferlo : few hectares in size and generally financed by the beneficiaries outside women's groups which are supported by NGOs

**Niayes**

Two types of irrigation schemes
- small and medium private farms (PMPP) (from a few dozen to several hundred hectares) initiated by the private sector and destined for horticulture
- private micro-irrigation (PMPP) (with plots of less than one hectare to a few hectares) with various water mobilization schemes (ceanes, concrete wells) and water extraction mechanisms (human-powered pumps, small motor pumps, ...).

**Casamance (Anambe)**

Large irrigation scheme has been developed to retain water and irrigate 3,600 ha especially for rice production.

**Eastern Senegal**

Two types of irrigation schemes
- Irrigated « perimeter » du Sénégal Oriental (PISO) (superficie de 35 ha en moyenne);
- aménagements de bas-fonds pour la maîtrise de l'eau et l'utilisation des intrants pour l'atteinte de bons résultats agronomiques.

**Recent development actions**

**Multiple zones**
- PAPIL : reduce poverty and food insecurity through the promotion of irrigation infrastructure and climate change adaptation measures in the regions of Fatick, Kolda, Tambacounda and Kedougou
- PASA LouMaKaf : improve food security and incomes through access to infrastructure, especially for water management, storage, and access to adapted technologies and services in the regions of Louga, Matam and Kaffrine
- PARIIS : increase the irrigated area in six countries of the Sahel including Senegal in the period 2018-2020. The targeted areas in Senegal are the Senegal River Valley, the Casamance (regions of Kolda and Sedhiou) and the Peanut Basin

Source: SNPI (1999), CEDEAO, CILSS, UEMOA (2016) and FAO (2016).

### b. Application of water-efficient irrigation methods

In Senegal, irrigation is practiced in a difficult socio-economic context characterized by low financial resources and high investment costs.[6] Where irrigation is practiced, the main sources of irrigation water are surface and groundwater resources, which are highly impacted by climate change (recharge, evaporation). In addition to that, water withdrawals increase with high and competitive demand from agriculture, industries and households, leading to lower levels of groundwater over the years, salinization, and other issues. Since agriculture is the highest consumer of water, there is a need to promote the use of water-efficient irrigation techniques to ensure the sustainable use of water resources for irrigation and other uses, s. Indeed, apart from sustaining resources, they can contribute to higher yields, translating to better livelihoods (FAO, 2016; Diouf et al., 2018). In Senegal, water-use efficient techniques have been mainly promoted in irrigated areas such as Niayes and Senegal River Valley, with a focus on small-scale private irrigation in the Niayes (FAO, 2016) and a focus mainly on WUAs in the other agro-ecological zones.

[6] https://www.ctc-n.org › sites › www.ctc-n.org › files › UNFCCC_docs.

Currently, more than 90 percent of the irrigated area of Senegal is irrigated with superficial systems with minimal use of sprinklers or localized irrigation, which form a combined value of 2 percent of the irrigated area of Senegal (FAO, 2016). Small farmers use flood irrigation and small-scale irrigation techniques for rice (FAO, 2016). Such irrigation techniques have very low efficiency at less than 50 percent (TNA report). Hence, the drip system for the efficient use of water was developed, particularly for use in horticulture farms (individual or WUAs). The limitation of this system is its high level of investment, its adaptability to the areas where it has been introduced and the low technical know-how among most users (TNA report;[7] Diouf et al., 2018). Indeed, in the main irrigated areas such as the Niayes, Diouf et al. (2018) compared three types of irrigation methods (localized, sprinkling and manual irrigation) and have shown that drip irrigation is not only more water-efficient, but also leads to higher yields. However, drip irrigation is not suitable in most parts of the Niayes due to iron concentration, which is very high in some places. Diouf et al. (2018) recommend drip irrigation in areas where the iron concentration is less than 2.5 mg/l.

### c. Rainwater harvesting

With rainfall variability that has become increasingly more common in recent years, rainwater harvesting strategies have been developed to minimize the consequences of seasonal variations in water availability due to droughts and arid periods on agricultural production. In Senegal, the 2011-2016 BARVAFOR (Borehole Retention and Development Basins)[8] project has been among the main initiatives towards the promotion of rainwater harvesting to meet the growing agricultural demand due to sustained population growth and widespread urbanization. It was set up to guarantee farmers and stockbreeders sustainable access to productive water so that they can increase their production in the following regions: Diourbel, Fatick, Kaffrine, Kaolack, and Thiès. One of the objectives to accomplish this is to construct water retention basins (semi-filtration dikes and retention dikes) to store runoff water. To ensure the successful and conflict-free use and management of the basins, the project adopted a participatory approach and promoted user-based management of the infrastructure and its use (MAER et al., 2017). The project enabled the construction of 24 schemes, among which eleven were retaining dikes, three semi-filtration dikes, five anti-salt dikes. The retention dikes were planned to be able to store nearly seven million cubic meters of water, which would allow producers to cultivate rice and horticulture crops on about 1000 ha year-round by carrying out two or even three agricultural seasons per year. The semi-filtering dikes would help to recharge the aquifer, thus enabling easier access to water for producers. The anti-salt dikes that were built enable farmers to recover nearly 650 ha of land that could be used for rice cultivation (CTB, 2016).

### d. Crop diversification

To cope with climate variability and vulnerability, the populations of the Sahel have always diversified their activities. For agriculture, the strategy has often focused on the complementarity of dry cereals and legumes with food and cash crops and, increasingly in recent years, diversification crops with cassava, watermelon and horticulture crops mostly facilitated by development irrigation projects.

Indeed, crop diversification has been promoted through the irrigation projects discussed above to fully exploit the domestic market, improve food security and help farmers in rainfed areas diversify their revenue sources in the face of climatic hazards. Irrigated horticulture crops, as well as rainfed rice, have been among the main crops that Senegal promoted in those initiatives that mainly targeted rainfed areas. Also, policy programs such as the PRACAS have contributed to the increasing production of onions for the domestic market and off-season fruits and vegetables for the export market.

### e. Adoption of drought-tolerant crops and crop varieties

Numerous studies on the water requirements of rainfed crops have been carried out by ISRA to obtain a varietal selection through working on the characterization of plant behavior concerning water deficits

[7] https://www.ctc-n.org/sites/www.ctc-n.org/files/UNFCCC_docs/ref11x06_3.pdf.

[8] PROJET DE BASSINS DE RÉTENTION ET DE VALORISATION DES FORAGES.

(ISRA, ITA, CIRAD, 2005). Research made it possible to create varieties adapted to different drought conditions for about twenty crops in different agro-ecological zones. For instance, "ISRA has selected and released adapted short-cycle crop varieties. For rice, in 2009 ISRA released five varieties of rainfed rice (America) and eleven varieties of irrigated rice adapted to drought conditions. In 2011, the Institute released a 95-day millet variety [...]"(Mamouda & Barry, 2013: p. 16). However, the main challenge of such technologies is that their adoption by smallholder farms is still low.

### f. Conservation agriculture[9]

In Senegal, agricultural practices are implemented to prevent the loss of arable land while regenerating degraded land. The main practices of conservation agriculture are reported to be mulching, corralling livestock on cropland, regeneration of agroforestry parkland, Faidherbia albida parklands, rotation and association (CSE, 2010; ICRAF, 2011).

For most of these, the extent to which they are practiced is hardly found in the literature, as studies have mainly focused on experimental aspects such as their effect on yields.

The study carried out by CSE in 2010 within the framework of the project "Land Degradation Assessment in drylands" (LADA) provides a somewhat detailed overview of the situation of technologies used for conservation agriculture in the different agro-ecological zones of Senegal without necessarily providing adoption rates. For example, the study revealed that along the Coastal North of Senegal (Niayes area), the planting of *Casuarina equisetifolia* (Whistling Pine Tree) stopped the movement of sand dunes caused by wind erosion. Moreover, the fight against water erosion in the Fallémé (semi-arid zone) has led farmers to apply stone barriers[10] associated with living hedges and gabions to slow down the runoff rate. The study also showed that fallowing combined with crop rotation and mulching enables coping with reduced soil fertility resulting from the high intensity of land use without adequate nutrient replacement. However, this technique is constrained by the limited time of fallow, which lasts about one year. ICRAF (2011) reported that mulching is not that common in the country. Indeed, "in general, there are fewer crop residues left on the fields. In the north, they are collected to feed animals or used as construction materials. When left in the field, the straw constitutes feed for roaming livestock, and at the end of the dry season, the remaining straws are collected in heaps and burned. Therefore, these residues only reduce wind erosion but not water erosion during the rainy season as they are burned" (ICRAF, 2011).

Also, Faidherbia albida ("Kadd"[11]) parks installed in Bambey (centre of Senegal) with crop rotation have improved soil fertility and agricultural production.

The study reported that the ADPIE[12] method (Sustainable Agriculture with Low External Inputs), which combines market gardening and agroforestry in the form of orchards, is an environmentally sustainable and economically profitable measure for farmers.

### g. Agroforestry

"The introduction of the tree into the agricultural system was seen as a necessity to curb the degradation of resources" (ISRA et al., 2005). Agroforestry research has focused on the functioning of agroforestry systems, particularly the parkland system that is the dominant land-use system in the Sahel, and agroforestry technologies capable of removing constraints.

**Agroforestry technologies:** a variety of technologies have been developed, including:

- The defensive living hedge, which is used to fight against the wandering of cattle and human incursions into fields and market gardens but also to delimit plots to avoid land conflicts. As

[9] CSE. 2010. "Best practices: recueil d'expériences de gestion durable des terres au Sénégal", Rapport de projet, Land Degradation Assessment in drylands (LADA), 102p.
[10] "cordons pierreux".
[11] Local name.
[12] "Agriculture durable avec peu d'intrants extérieurs".

an example, Sanogo et al. (2000) reported that the Village Organization and Management Project (P.O.G.V[13]), with the help of village groups, established a network of *Euphorbia basalmifera* hedges of over 4,860 hectares in the Peanut basin from 1995 to 1996 with one hectare per farmer. On a sample of 175 farms in the Peanut Basin, Sanogo et al. (2000) tried to assess the extent of living hedge adoption and the factors explaining such a decision. They found that 60 percent of the sample were adopters. The main species found in the area are spiny plants (*A. nilotica, P acculéata, Z. mauritiana, P juliflora, A. albida, B. rufescens etc ...), euphorbiaceae (E. basalmifera and 1. curcas)* and exotic species *(A. holocericea, Eucalyptus sp.*).

The non-adopters report the following reasons in order of importance: lack of labor (31.1 percent of farms), lack of fields (24.6 percent), and lack of seeds or seedlings (16.8 percent). This is in line with Kurtz (1993)'s findings, which show that property rights and availability of labour are important in the choice of agroforestry;

- The windbreak, which is mainly intended to protect the soil and plants from the wind and thus mitigate wind erosion.

**Agroforestry parks:**

- Assisted regeneration is a strategy for the protection and management of tree or shrub rejects to allow a generalized reconstitution of the plant cover. Assisted natural regeneration is a practice that has existed in Senegal for a very long time, but its practice had become more and more popular around the 1990s. It was developed in the context of the very rapid degradation of forest resources due to a drop in rainfall, uncontrolled land clearing, the disappearance of certain practices for integrating trees into production activities and an inappropriate natural resource governance system (IED and World vision, 2013);
- The promotion of assisted natural regeneration has been facilitated through programs and by organizations such as NGOs. For instance, the project PREVINOBA (Village Reforestation Project in the North-West of the Peanut Basin) recorded considerable achievements in natural regeneration with local species (*Combretum glutinosum, Faidherbia albida and Balanites aegyptiaca*) between 1986 and 1999 in the department of Tivaouane;
- Another project, the Diourbel Agroforestry Project (PAGF), also recorded interesting results between 1989 and 2010, with a particular emphasis on the protection of natural rejects and seedlings. However, IED and World vision (2013) reported that despite all the efforts made and the results achieved by support programs and local populations, the scaling up of the practice and its institutionalization are still weak due to low diffusion of research results, which are not well known by policy-makers, clandestine abusive cutbacks, low involvement of local authorities in assisted natural regeneration initiatives, poor communication around success stories, and so on. Under this framework, the African Regreening Initiative (ARI), a regional initiative, aims to promote agroforestry approaches, such as assisted natural regeneration, to help reduce rural poverty and build populations' capacity to adapt to climate change (IED and World vision, 2013);
- The interaction between trees and crops influences soil variables and agricultural yields depending on the species. For example, *Acacia albida* is beneficial for the soil and crops and *Cordyla pinnata* can reduce the yield of nearby millet, but appropriate tree management can increase this yield;
- Fallow land is a practice for the regeneration of depleted or degraded environments, but also the production and exploitation of wood, fodder, food and medicinal resources.

[13] "Projet organisation et gestion villageoise".

### 4.1.2 *Rangelands*

#### a. Rotational grazing

In terms of grazing-related responses, rotational grazing is not commonly practiced in the Senegalese livestock sector, which is mainly dominated by pastoralism in the eastern and northern parts of the country, particularly in the agro-sylvo-pastoral zone. Grazing strategies in Senegal can be different depending on the agro-ecological zone. In the agro-sylvo-pastoral zone, grazing strategies have mainly consisted of grazing in and around the villages as long as fodder is available. As the availability of fodder decreases, most households practice transhumance, which has historically been a seasonal practice mainly during the dry season in a north-south direction. This practice consists of "seasonal movements that allow pastoralists to make use of predictable variations in pasture quality and availability. Mobility thereby optimizes the use of a resource base that varies in space and time, with demonstrated benefits to livestock productivity and rangelands" (Kitchell et al., 2014).

In other agro-ecological zones such as the southern Peanut Basin, Diop (1993) has shown that natural and post-cultivation pastures are exclusively reserved for domestic animals, especially cattle. The author also considers that the fallow plots in the Sereer ethnic group make it possible to keep village animals during the rainy season. Thus, during the dry season, all areas of the land are open to local livestock and the transhumance of Peulhs from the sylvo-pastoral zone. However, the disappearance of fallow land in these areas forces the transhumance of cattle herds outside the territory during the third quarter of the year. Similarly, the work carried out by Piraux et al. (1996) in the Peanut Basin showed that the rotation of grazing at the village level made it possible to stockpile the sedentary family herd to ensure fertility of the agricultural plots. However, changes are increasingly observed due to an imbalance between agricultural and pastoral areas, individual and speculative fattening operations.

### 4.1.3 *Forests, woodlands, and shrublands*

#### a. Afforestation and reforestation

The choice for reforestation focuses on fast-growing species to allow the rapid rehabilitation of the stands. To do this, several stand densities have been proposed, depending on the species. Depending on the agro-ecological zone, a variety of choice of reforestation species is proposed to promote the sustainability of the stands with an optimal harvesting age. Also, tools for evaluating standing timber production have been developed for the rapid determination of stocks for different species.

In Senegal, the first reforestation actions date back to the 1930s. They consisted mainly of operations to enrich classified forests. After independence in 1960, these actions were pursued and became more extensive with the launching of vast operations to fix the coastal dunes using *Casuarina equisetifolia*. Between 1971 and 1990, the reforested area was estimated at approximately 169 841 ha. Over time, reforestation actions have been conducted in a more "participatory" way with communities instead of the traditional method, where the government would be the sole actor undertaking reforestation actions. Also, the species used have evolved over time with the increased usage of exotic species such as Eucalyptus being gradually associated with local species such as *Acacia albida, Prosopis Africana*, and others. Finally, the institution of a "national tree day" in 1979 has undoubtedly contributed to the promotion of local species in reforestation activities. In addition to reforestation actions, forestry research also plays an important role in the identification of appropriate species for each eco-geographical zone and the reintroduction of the tree into land-use systems through the use of agroforestry technologies, and the improvement of the production and productivity of forest formations through research into genetic improvement, microbiology, and the management of natural stands (MEPN, 1998).

An example project is the *Projet de reboisement communautaire dans le bassin arachidier* (PRECOBA), which is part of the actions carried out by the Senegalese Government since the 1970s in order to combat desertification. To better integrate communities' needs, PRECOBA, which was introduced in 1981, is the first project centered on community-based reforestation that aimed at meeting the growing needs for service and firewood (FAO, 1998, pg. 14).

## 4.2 Household and community responses

### *4.2.1 Livelihood diversification and migration*

External financial resources are used to cope with climatic shocks (McDemott et al., 2015; Burgess and Pande, 2005; Karlan and Zinman, 2010; Kaboski and Townsend, 2012; Grosh et al., 2008). McDemott et al. (2015) studied the responses of poor households for the management of climate risks in West African countries, particularly Senegal. Their results showed the importance of access to credit to reduce the vulnerability of farmers. According to these authors, access to credit has made it possible to increase the income and consumption of poor households. However, according to Burgess and Pande (2005), Karlan and Zinman (2010), Kaboski and Townsend (2012), microfinance institutions have a role to play in facilitating access to credit for poor farm households. They have also shown that where risk frequency is low, savings and insurance can play a key role, but where risk frequency is high, public investment in infrastructure becomes necessary. In a similar vein, Grosh et al. (2008) highlighted the role of social safety nets in increasing the livelihoods of poor households exposed to climate shocks. Their study showed that income redistribution policies in favor of poor households increase their investment capacity and enable them to cope with unexpected shocks.

Moreover, remittances allow farm households to cope with climate shocks (Yang, 2008; Yang and Choi, 2007; Arezki and Bruckner, 2012; Tall et al., 2018). According to Yang (2008), Yang and Choi (2007) and Arezki and Bruckner (2012), remittances provide private insurance against negative shocks for households in developing countries. Thus, they have shown that remittances reduce households' income deficit when the domestic financial sector is inefficient. Similarly, a study by Tall et al. (2018) highlighted the key role of financial and non-financial remittances in mitigating the effects and shocks associated with climate risks. Their results showed the important role of migration as a buffer against economic shocks induced by climate vulnerability. Migration enables households to ensure consumption needs and diversify economic activities by investing in less risky sectors. For example, Dimé et al. (2017) studied the impacts of remittances and the contributions of migrants within the context of resilience to climate change in the Senegal River Valley, the Groundnut Basin, and the Niayes area. Their results showed that 71 percent of migrant remittances are destined for regular household consumption and a small proportion is allocated to productive investments, most of which are directed towards real estate and commercial activities. These results show that migrants prefer to invest in sectors with fewer risks. However, it is worth mentioning that migration reduces the amount of labour available for agriculture (USAID, 2014).

### *4.2.2 Community collective action*

Collective initiatives at the village level strengthen the resilience strategies of members and reduce their level of vulnerability (Gueye, 2008; Diop et al. 2010; Diouf et al., 2014). The study conducted by Gueye (2008) showed that organizational dynamics at the community level have been strengthened with the establishment of different types of local civil society structures, including frameworks for dialogue between producers' organizations and women's associations on the reduction of the vulnerability of women and children.

According to Diouf et al. (2014), these associations formed at the village level have made it possible to pool resources and set up savings groups. Similarly, they have access to climate information that

[14] http://www.fao.org/tempref/FI/CDrom/aquaculture/a0845t/volume2/docrep/field/383923.htm.

informs their decision-making. The work of Diop et al. (2010) highlighted the various initiatives of local communities for the diversification of agricultural practices and sources of income. Thus, they have shown that collective action can facilitate crop diversification with the introduction of new crops.

### *4.2.3 Farmer and indigenous innovations*

Climate change has prompted farmers to adopt new practices (Oumarou, 2011; Diouf et al. 2014; USAID, 2014). The study carried out by Diouf et al. (2014) on the practice of intelligent agriculture in the face of climate change showed an evolution of agricultural practices in the different agro-ecological zones of Senegal. These practices include the use of high-quality certified seeds and short-cycle varieties, crop diversification, good agricultural practices such as fire control and weeding, intercropping with cowpea and groundnut, agroforestry, assisted natural regeneration, the use of stone bunds[15] for water management, the application of organic fertilizers, mulching and composting, and the use of "*neem*" as an organic pesticide, particularly in horticulture and arboriculture.

Moreover, a USAID study conducted in Senegal in 2014 on vulnerability assessment and the analysis of options for resilience to climate change showed that the inhabitants of the communities of Matam and Tambacounda have changed their agricultural practices in response to climate shocks. Observations gathered as part of this study showed that many of the practices that the communities use to manage climate risks have spread following the droughts observed in the 1970s. As such, farmers have adopted new technologies to manage moisture and maintain soil health. For example, they have shifted cultivation to lower, wetter lands. They have also diversified into less climate-dependent sources of income, such as handicrafts, commerce, and gardening. In 2013, the West African Agricultural Productivity Programme announced the successful development of new varieties of sorghum and millet. However, despite these advances in the creation of new varieties, extension and adoption remain the major constraints. Only about 15 percent of planted cereals and leguminous crop seeds are purchased, and less than 10 percent are certified (USAID, 2014). The vast majority of the remaining seeds come from previous harvests.

In the same vein, with a sample of 532 producers located in the departments of Koungheul, Mbour, Thiès and Tivaouane, Faye (2017) found that few producers have adopted certified millet and sorghum seeds; Only 13 percent have adopted certified millet seeds, while 18 percent have adopted certified sorghum seeds. This can be explained by the lack of information, the low level of incentives that can motivate farmers to use certified seeds for food crops as opposed to cash crops, among other factors. However, Faye (2017) found that the number of adopters is higher for improved seed varieties: 20 percent for millet and 27.7 percent for sorghum.

## 4.3 Policy-level responses

### *4.3.1 Historical and current policy responses*

Historically, Senegal does not have a specific climate change policy and/or law in place (Zamudio and Terton, 2016). However, it has been actively engaged in the issue of climate change for a number of years through the development of climate change plans and adaptation and mitigation strategies in line with climate change adaptation and mitigation strategies at the international level. Figure 6 summarizes the main policy responses of Senegal and its institutional infrastructure to support climate responses. Like most countries in the world (developed and developing), Senegal has ratified the United Nations Framework Convention on Climate Change in June 1994, the Framework Convention

[15] „diguettes de pierres“.

to Combat Desertification (UNFCCC[16]), which entered into force in 1996 (Braun, 2010), and the Kyoto Protocol in July 2001.

As part of the implementation of the conclusions of the World Conference in Rio de Janeiro in 1992, the *Stratégie Nationale de Mise en Œuvre de la Convention Cadre des Nations Unies sur les Changements Climatiques* (UNFCCC) (SNMO[17]) in 1999 has been a pioneering action towards the inclusion of the climate change dimension in its economic and social development policy (SNMO, 1999). Moreover, Senegal has undertaken two communiqués for the UNFCCC. The first national communiqué, issued in 1997, explored vulnerable sectors such as the coastal zone and water resources. The second communiqué, published in 2010, considered other strategic sectors, such as health, agriculture, and fisheries. It also reported estimates of Senegal's greenhouse gas emissions and recalled the adaptation actions undertaken to deal with the impacts of climate change. Among these actions, Senegal submitted its National Adaptation Plan for Action (NAPA) in 2006, which identifies water resources, agriculture, and coastal zones as the country's most vulnerable sectors to the UNFCCC. Priority adaptation measures for each of these sectors were identified. Other actions such as the National Strategy for Adaptation to Climate Change (SNACC), as well as greenhouse gas mitigation measures, are also reported in the communiqué. A third national communiqué was issued in 2017 (Noblet et al., 2018).

Since 2014, planned policy responses towards climate change are framed by the Senegalese emerging plan (PSE) adopted by the government in 2014, which constitutes the framework of Senegal’s development policy until 2035.[18] In the PSE, climate change is recognized as a threat to the country’s economic growth and the need to adapt to its impacts is acknowledged in the document. The document considers climatic risk as being among the main risks that can hinder the success of the implementation of the plan. It notes that adaptation to climate change, specifically the occurrence of extreme events, coastal erosion and land salinization, constitutes a challenge and states the need to find sustainable solutions to enable populations to develop a culture of prevention and adaptation to climate change. The action plan component of the document makes a specific financial commitment on behalf of the government of Senegal in the amount of 36.4 billion FCFA (i.e. 62 million USD) (PSE, 2014). This amount is part of Senegal’s contribution to the financing of the PSE and comes from three main projects that are already implemented: (i) the project for integrating Climate Change Adaptation into the country's sustainable development path[19] in the period 2010-2012; (ii) the Senegal Integrated Ecosystem Management Project[20] during the period 2012-2015; and (iii) the project on the consolidation and extension of marine protected areas[21].

In 2015, Senegal published its National Adaptation Plan (NAP) process. In September of the same year, the country issued its Intended Nationally Determined Contribution (INDC) as part of the Paris Agreement. Currently, the INDC, in line with the PSE, constitutes the main document identifying specific adaptation objectives for the country for the period between 2016 and 2035 (CPDN, 2015). It expresses the will of the government to take part in climate change mitigation and adaptation strategies at the international level. It discusses the main channels to contribute to emissions level reduction and adaptation options during the period 2016-2035. Senegal’s INDC also discusses the principal obstacles and factors for success in implementing its intended adaptation measures, among which are the country’s ability to conduct adaptation planning at a national level, the need to simplify current legislation for easier implementation, the development of a multisectoral approach that

[16] Convention cadre de lutte contre la désertification (C.C.D.).

[17] „Stratégie Nationale Initiale de Mise en Œuvre de la Convention Cadre des Nations Unies sur les Changements Climatiques“.

[18] More information will be given in this plan in Section 6.

[19] "projet d’intégration de l'Adaptation aux Changements climatiques dans la voie d'un développement durable" (see sn.undp.org/content/senegal/fr/home/operations/projects/environment_and_energy/intac.html).

[20] "projet de gestion intégrée des écosystèmes du Sénégal".

[21] "projet de consolidation et d’extension des Aires marines protégées".

impacts key sectors of the economy, and the need to develop an effective communication strategy so that political figures and the public are aware of the risks of climate change (Zamudio and Terton, 2016).

Following the INDC, the Nationally Determined Contribution (NDC) has been technically validated and is awaiting its political validation.

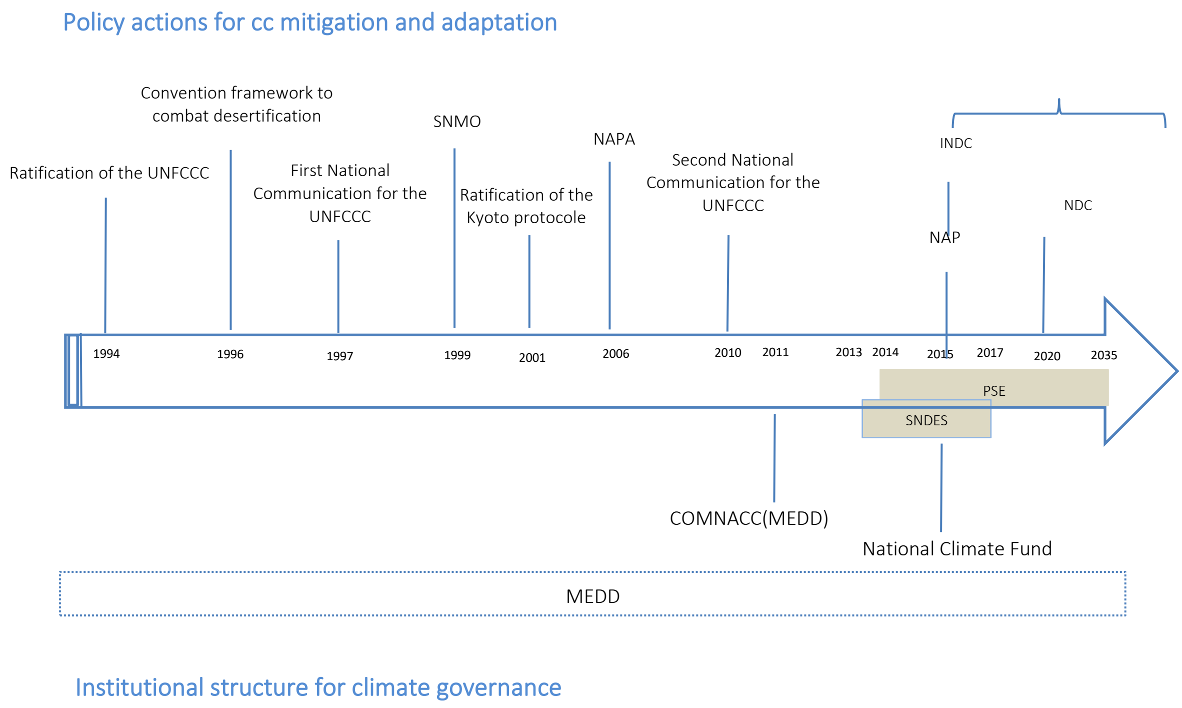
### *4.3.2 Institutional structure for climate and environmental governance*

To accommodate climate governance in Senegal, the MEDD (formerly MEPN), which is the climate change focal point, has been in charge of the development of the previously mentioned responses. The MEDD and its Directorate for the Environment and Classified Establishments (D.E.E.C.) are in charge of implementing the government's policies on the environment. The DEEC is also the focal point of the Global Environment Fund (GEF) and is designated as the national authority for the Clean Development Mechanism (CDM). The focal point of the Intergovernmental Panel on Climate Change (IPCC) is the National Agency for Civil Aviation and Meteorology (ANACIM).

Senegal established its National Climate Change Committee (COMNACC) and Regional Climate Change Committees (COMRECCs) in 2011. The COMNACC federates all the actors involved in climate change issues (technical administrative services, private sector, NGOs, civil society, research structures, associations of local elected officials, universities, etc.) and is in charge of monitoring the activities developed for the implementation of UNFCCC (DEEC, 2010). The DEEC acts as the secretariat for the COMNACC. COMRECCs aim to promote synergies between local- and national-level actions on climate change issues (MEPN, 2012). However, their effective functionality has suffered financial resource limitations.

In 2015, the National Climate Fund has been established with the objective of mobilizing 60 million USD per year to finance climate projects and sustainable development, taking advantage of international sources of climate finance such as the Green Climate Fund. It is expected that part of the fund (10 million USD per year) will come from the government and the remaining amount will be provided by development partners (Zamudio and Terton, 2016). This fund is currently administered by the CSE. Senegal is also heading towards the decentralization of climate funds under the framework of the project Décentralisation des Fonds Climat (DFC), which aims to render local populations resilient to climate change through locally controlled adaptation funds (BRACED et al., n.d.).

Figure 6: Institutional responses to climate change




Source: Authors.

### 4.3.3 *Specific policy actions for mitigation, adaptation, and resilience*

#### a. **Facilitating carbon trading**

The carbon market refers to the selling and buying of reductions in greenhouse gas emissions known as carbon credits (Gueye, 2019). It constitutes the main channel through which developing countries such as Senegal participate in the carbon market. The CDM promotes sustainable development in developing countries, while enabling developed countries to participate in the reduction of greenhouse gas emissions (Gueye, 2019). The mechanism allows developed countries to buy emission reductions from developing countries or invest in emission reduction projects in those countries (Gueye, 2019). These projects allow them to earn Certified Emission Reduction (CER) credits, with each equivalent to one ton of carbon dioxide ($CO_2$), that can then be sold and used by industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol (CDM, 2016). Senegal got its first CDM in 2007 and has had in total a number of 8 CDMs, which is far ahead of its neighboring countries (Gueye, 2019).

It is worth mentioning that from December 2020, the CDM might be replaced by a new mechanism, as stated in article 6 of the Paris Agreement (Gueye, 2019). However, this might not prevent the country from continuing to allow such carbon trading mechanisms. Indeed, concerning the use of market mechanisms as an emission reduction strategy, the government stated in its INDC that "Senegal does not intend to purchase emission reduction units from any existing or future market mechanism. Nevertheless, Senegal will be a host country for projects from any international climate mechanism [...] meeting its sustainable development objectives. In addition, Senegal supports the continuation of the Clean Development Mechanism (CDM) established under the Kyoto Protocol and its continuation in a form to be defined under the new Agreement" (CPDN, 2015). This suggests that Senegal intends to continue facilitating any mechanism that facilitates carbon trading.

Senegal is also among the beneficiaries of the Carbon Initiative for Development (Ci-Dev), which is another mechanism that somewhat extends the CDM mechanism to low-income countries. According to the fund's website, it is a "World Bank trust fund that mobilizes private finance for clean energy access in low-income countries. The fund has committed to purchase carbon credits (emission reductions) from 12 energy access projects in SSA. To quantify, verify and certify the emission reductions, the fund will use the CDM as a methodological framework".[22] Therefore, it allows private entities in low-income countries to get carbon credits via clean energy access projects that can be monetized and used to finance such projects. Senegal has benefited from this fund through one of 12 projects financing part of its Rural Electrification program (see Box 1).

Box 1: Senegal Rural Electrification Program through the Ci-Dev initiative

| |
|---|
| "Access to sustainable, reliable, and affordable electricity is a vital component for development. It affects everything from income generation to the delivery of health services. Ci-Dev is helping to expand electricity access and reduce emissions through carbon finance in rural Senegal.<br><br>The local utility will use carbon revenues from Ci-Dev to help low-income households who were previously unable to afford the fee for new grid connections. The carbon finance is funding an innovative voucher scheme, where each voucher can be redeemed by the household for the service level and connection technology that best fits their needs. The program has helped 72,000 Senegalese villagers gain access to electricity by covering a significant portion of the initial cost for connection with a cash voucher. The project is expected to connect another 180,000. The cash voucher system is accelerating the pace of connections and stabilizing the market, while the program's unique design offers a valuable model for rural electrification efforts in other developing countries." |

Source: Ci-Dev website (https://www.ci-dev.org/SenegalRE).

Moreover, as part of the policy options to reach the objectives of its Intended Nationally Determined Contribution (INDC), Senegal has begun to consider the introduction of carbon pricing instruments for its climate action, as provided in its INDC under the Paris Agreement. To that extent, the government organized a consultation workshop in 2018 with stakeholders in both public and private sectors to reflect on the possibilities to design a carbon pricing policy adapted and applicable to its economy. The main conclusions of the workshop were to impose a tax on large greenhouse-gas emitters. The sectors identified as the most suitable were: i) Electricity generation; ii) Industrial supply, including cement manufacturing; iii) Oil and gas production; and iv) Solid and liquid waste. One of the propositions was also to extend the applicability of the tax, which could be used in conjunction with carbon credits, as some sectors could be sources of demand, while others could benefit from investment (e.g. forestry sector). Also, it has been pointed out that the tax should be revenue-neutral. The need for additional analyses to explore the main elements in designing a potential carbon tax in detail was raised[23] (World Bank, 2019b).

### b. Land-use zoning and integrated landscape planning

In Senegal, multiple policy responses have been developed for land-use zoning. For instance, the Land Use and Allocation Plans (POAS) for rural areas were designed to limit farmer-pastoralist conflicts by zoning the territory with appropriate management rules accepted by all stakeholders. Also, the Government of Senegal, through Law No. 64-46 of 17 June 1964, which defines the National Domain, demonstrated the willingness of the political authorities, from the early years of Senegal's independence, to democratize access to land and ensure land tenure security. The latter is a process by which land rights are recognized, guaranteed and protected by law for better land management in Senegal.

[22] https://www.ci-dev.org/sites/cidev/files/documents/Ci-Dev-Brochure%20-%20May%202013.pdf.
[23] See also this workshop report: CI-ACA, Validation workshop of the opportunity study on the implementation of a carbon pricing instrument in Senegal, December 20, 2018.

Article 4 of this law classifies land in the national domain into four categories according to its vocation; Namely, urban areas whose purpose is to serve as reserves for urban development, classified areas consisting of ecological and forest reserves, areas of land corresponding to land that is regularly used for rural housing, cultivation or livestock farming, and pioneer areas intended to receive rural development and planning programs. This classification will enable the government, with the help of deconcentrated services, to control certain areas where there is often an uncontrolled practice of the abusive use of wood resources, which, in the context of climatic deterioration, contributes to the degradation of land.

Other land management policies have been set up by the government, such as the Irrigated Domain Chart (CDI), with the main objective of securing the realized irrigation schemes and optimizing production in irrigated areas through the elaboration of rights and duties for the beneficiaries of land allocations. The rural cadaster defines property titles, natural resource exploitation contracts, and other important aspects.

### c. Payment for ecosystem services

To date, payments for ecosystem services have been developing very slowly in Africa and the main initiatives that exist are noted in eastern and southern countries (AFDB, 2015).

### d. Providing access to markets and agricultural advisory services

#### *i. Providing access to markets*

As already shown, Senegal is vulnerable to climate change and this will increase with increasing climate change. The ability of communities to adapt to and mitigate climate change depends on their level of development and their access to resources such as land and water. Therefore, strategies should favor securitization of access to resources, markets, and infrastructure, both physical and institutional, and empower the most vulnerable, among which are women. In terms of access to markets, recent policy actions have been undertaken in the PRACAS that have axes focusing on the marketing of agricultural products. The main measures in the PRACAS aimed at facilitating access to the market were:

- providing support for the quality management of agricultural products for consumption and export and for the monitoring of the environmental impact of phytosanitary treatments;
- the creation and rehabilitation of access roads;
- the construction of infrastructure for the storage, processing, packaging, and conservation of products targeting the domestic and export markets;
- the promotion of the valorization of domestic products and their labeling;
- the widespread adoption of a contract-based marketing strategy along value chains;
- improving the small-scale processing of agricultural products, in particular by supporting women's groups, in conjunction with the Ministry of Women, SMEs, and Trade

In addition, other related policies have enabled cash crop producers of vegetables to better conquer the domestic and international markets. Indeed, for horticulture products sold in the domestic market, regulatory measures were imposed to favor domestic production. "The government has imposed temporary bans on imports of specific commodities" whenever the national supply was sufficient to cover local demand in order to protect local farmers from competition from imported goods, reduce post-harvest losses and thus "incentivize the production and marketing of local products" (FAO, 2015). The main crops targeted by those policies are onions since 2003, potatoes since 2013, and carrots since 2017.

For exported vegetables, Senegal has made efforts to increase export shares. Indeed, in 2010, the Senegal Origin Foundation was created for fruits and vegetables in order to support the development of horticulture exports. For instance, in 2011, the national export promotion agency (ASEPEX) pointed out mango as an important product that has the potential to increase exports due to its increasing production. This resulted in the development of a project to improve the competitiveness of Senegalese mangos in 2014, which was approved by the Council of the Enhanced Integrated Framework (EIF) in collaboration with the government. The project was designed to last three years in order to increase mango exports as well as its derivative products (FAO, 2015).

Apart from government efforts, farm organizations such as Association Sénégalaise pour la Promotion du Développement par la Base, au Sénégal (ASPRODEB) adopt strategies to accompany their members in contract farming schemes with industrial processors of crops such as groundnut, rice, and dry cereals (MAER, 2014).

#### *ii. Agricultural advisory services*

As for the institutional structure of advisory services in Senegal, the National Agency of Agricultural and Rural Council (ANCAR) created in 1999 is the main body that is in charge of offering advisory services. The Agency's agricultural and rural advisory services are provided through a system of Agricultural and Rural Advisers (CAR[24]) managed in eleven Regional Directorates (RDs) (FAO, 2005).[25] There are other localized organizations, such as the Agency for the Development of the Delta and the Senegal and Faleme River Valleys (SAED) in the Senegal River Valley and the Agency for Agricultural and Industrial Development of Senegal (SODAGRI) in the southern part of Senegal, that also provide advisory services to farmers in those agroecological zones.

The main document that frames the role of ANCAR is the PSAOP,[26] for which rural advisory is the seventh component.

### e. Securing land tenure

The securing of productive resources such as land is not yet effective. The land is one of the most important production factors in agricultural production. In Senegal, as already stated, access to land in rural areas is governed by the law on the National Domain (1964). Under this law, producers are not owners of their land. The insecurity associated with the possibility of losing the right to use does not encourage investment. The law is thus considered to be unsuited to the traditions and realities of rural populations (FAO, 2003). Mendelsohn (2012) points out that when producers do not own the land they cultivate, they have no incentive to safeguard their quality. Land reform has been consistently proposed in a participatory way to the government since 2016 but has not yet been adopted.

### f. Empowering women

In terms of climate change, women along with youth are considered to be particularly vulnerable and of high priority for support through adaptation projects (Zamudio and Terton, 2016). Policies towards women's empowerment have mainly consisted of the integration of gender equality into national policies such as the PSE and the elaboration of specific strategies such as the National Strategy for Equity and Equality of Genders for the period 2005–2015, which was adopted in 2008 (Zamudio and Terton, 2016). However, climate change issues do not appear to be integrated into this strategy.

Additionally, in their review on climate change in Senegal, Zamudio and Terton (2016) found that in terms of climate change and adaptation projects, while a few projects include a designated gender component, projects specifically designed to address the needs of women were not identified.

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[24] „Conseil Agricole et Rural".
[25] http://www.inter-reseaux.org/IMG/pdf/EvaluationPSAOP-ANCAR_avecannexes_FSchorosch_2005.pdf.
[26] „Programme des Services Agricoles et Organisations de Producteurs".

# 5 Evaluation of existing major policies and investments

## 5.1 Brief description of the Emerging Senegal Plan

As previously stated, the Emerging Senegal Plan (PSE) has been the reference framework since 2014 for economic and social policy in the medium and long term. The PSE aims to increase the well-being and prosperity of the Senegalese populations by 2035 and is divided into three strategic pillars, including (i) structural transformation of the economy and growth, which aims to sustainably create wealth and eradicate poverty in all its forms, (ii) human capital, social protection and sustainable development, which should make it possible to considerably improve the supply and demand for social services and social security cover and (iii) the governance of institutions of peace and security meeting the requirements of good governance, local development, promotion of peace, security and African integration. The PSE is carried out using five-year Priority Action Plans (PAPs) backed by strategic pillars and sectoral objectives with development projects and programs set within a budgetary framework, the first of which covering the period 2014-2018. In its first phase, the PAP1 is valued at 9685.7 billion FCFA (i.e. 16.48 billion USD), of which 5737.6 billion FCFA (i.e. 9.76 billion USD) (59.2 percent) are acquired, while the funding gap to be sought is 2964 billion FCFA (5.04 billion USD) (30.6 percent), and that to be covered by additional revenue and savings on expenditure is 984 billion FCFA (1.67 billion USD), corresponding to 10.2 percent.

At the end of the PAP1, the budget had been executed at a rate of 52.59 percent of the total 9685.7 billion FCFA. The execution rate is detailed according to the different sources of financing in Table 1. The share of the budget that was contributed by the government has the highest execution rate, followed by the one from technical and financial partners and the private sector, which only has an execution rate of around 25 percent (MEFP, 2018).

Tab 1: Financial execution of the first Priority Action Plan of the PSE

| Sources | Needs (billions of FCFA) | Executed amount (billions of FCFA) | Percentage of budget executed |
|---|---|---|---|
| **Government** | 4202.60 | 2989.237 | 71.13 |
| **Technical and Financial partners** | 3909.00 | 2104.704 | 53.84 |
| **Private sector** | 1574.00 | 397.805 | 25.3 |
| **Total** | 9685.60 | 5491.74 | 52.59 |

(MEFP, 2018)

The main constraints of the PSE have been related to governance issues, the country's administrative issues and the poverty situation. Indeed, the MEFP (2018) reported that constraints such as the lack of evaluation culture, the slow modernization of the administration, the weak capacity of monitoring-evaluation, the burden of administrative procedures, and the weak financial structure of PAP projects with a private funding component have been the major ones. They also reported other types of constraints, such as low access to energy in rural areas, the low consideration of innovation and research, insufficient ICT coverage, insufficient local governance and low development of technical education and vocational training. The MEFP also points out weak constraints, such as the persistence of poverty, unsustainable production and consumption patterns, high levels of informality, vulnerability to the effects of climate change and low sophistication of exported products.

All these constraints, which all relate to governance, weaken the foundation on which the pillars of the emergence strategy rest and put the achievement of development objectives at risk.

## 5.2 Evaluation of selected sectoral policies

To better take into account the PSE in public interventions, sectoral policy documents have been drawn up with all stakeholders. The Senegalese Agriculture Acceleration Program (PRACAS) is considered to be the agricultural component of the PSE. It is perfectly in line with the National Agricultural Investment Programme (NAIP), the Loi d'orientation (French Law), and the Agro-Sylvo-Pastoral Law (LOASP) and simultaneously takes over the priorities defined in the PSE under the first axis on "structural transformation of the economy and growth" (MAER, 2014). It aims to (i) modernize family farms through the professional training of farmers and provision of suitable equipment and (ii) develop an agricultural and rural entrepreneurship based on an intelligent synergy between agribusiness and family farming that is respectful of the environment, sensitive to climate change adaptation and based on a value chain approach. It should be noted that Senegal's food policy is essentially linked to agricultural policy, particularly within the dimension of combating food insecurity and malnutrition.

Concerning climate-related policies, as already discussed, the most recent actions towards climate governance are the INDC and the NAP, which are in line with the PSE and allow Senegal to meet its commitments to the international community and strengthen the most vulnerable sectors to climate change (rain-fed agriculture, water resources and coastal areas). As for the land-use sector, Senegal has, since 1996, made efforts to implement a new land tenure policy adapted to current changes in the rural environment, but successive attempts to reform the system have not yet succeeded, raising questions about the methods used so far (World Bank, 2019a). In the Emerging Senegal Plan, the government of Senegal recognizes that a good land policy is one of the conditions for economic emergence. Therefore, it includes land reform among the 6 reforms[27] to be implemented to foster economic growth. Moreover, the difficulties observed in the operationalization of land use planning prompted the government of Senegal to promote the viability of the territories not only through the development of integrated economic poles and the reconfiguration of the territorial division scheme in a participatory and consensual manner, but also the development of urban centers favorable to the development of economic, cultural and tourist activities (PSE, 2014). The objective of this section is to discuss the most prominent national-level policies, along with their associated investment amounts, their impacts, reasons for successes and failures, and lessons learned through interviews with the key actors responsible for their implementation.

### *5.2.1 Agricultural policy*

Agriculture is a key sector of the PSE focusing on the structural transformation of the economy and the creation of growth. The PRACAS is the agricultural policy of the Emerging Senegal Plan. Its vision is built around the medium-term achievement of food and nutritional security by concentrating on priority products with high development potential and added value. In its first phase (2014-2017), agricultural investments were concentrated on (1) rice self-sufficiency in 2017 with a production of 1,600,000 tons of paddy; (2) self-sufficiency in onions in 2017 with a production of 350,000 tons; (3) optimizing the performance of the groundnut sector with the production of 1,000,000 tons in 2017 and an export volume of 100,000 – 150,000 tons; and (4) the development of off-season fruit and vegetable sectors with an export target of 157,000 tons in 2017.

The rice self-sufficiency program aimed to cover national demand by 2017, which is estimated at 1,080,000 tons of white rice and therefore, 1,600,000 tons of paddy rice, from local production and with a balanced contribution from both the irrigated (Senegal River Valley in the north and Anambe Valley in the south) and rainfed systems. Investments with an overall cost estimated at 424.7 billion FCFA (720 million USD) are distributed mainly between fertilizers (45 percent), irrigation schemes (19 percent), lowland schemes[28] (14 percent) and seeds (10 percent). The funds were planned to come

[27] Among other reforms, we have the modernization of public administration, the mining sector, public universities, real estate and justice.
[28] „aménagement de bas fond“.

from public funds (State), technical and financial partners (TFP) and public-private partnerships (State, family farms and the private sector). Despite a surge in rice production, which increased from 469,649 metric tons in 2012 to 1,135,034 metric tons in 2017, Senegal did not reach the goal of self-sufficiency in rice in 2017, reaching an annual gap of around 450,000 metric tons.

Several factors have been cited to explain this failure, including governance, funding and the reliability of statistics. With regard to governance, the three technical structures involved did not cover the whole territory. Indeed, the SAED was responsible for implementing the program in the irrigated system of the Senegal River Valley, the SODAGRI in the irrigated system of the Anambe Basin and the National Program for Rice Self-sufficiency (PNAR) aiming to focus on the rainfed system. According to the experts interviewed, certain regions with high potential did not benefit from the program, notably local initiatives in the rainfed system. Yet, a good functionality of the monitoring and evaluation component would have made it possible to not only correct these institutional limits, but also to realize that the self-sufficiency objective was too ambitious for 2017. Unfortunately, this monitoring and evaluation committee, despite its importance indicated in the document of the project, had never been functional. The financing of the PRACAS also displayed some problems, as some donors preferred to finance producers directly at the local level, thus making resource mobilization more challenging. The availability and collection of statistical data also posed a problem in the implementation and evaluation of the PRACAS. Indeed, good quality statistical data is needed to assess the gaps, better target the areas in which to intervene and refine financial resource allocation. As a result of insufficient statistical information, there were drawbacks in the allocation of financial resources across the targeted areas.

In the onion sector, the PRACAS objective was to achieve self-sufficiency with a production of 350,000 metric tons through the renewal of seed capital and the establishment of storage infrastructure to meet the challenge of conservation and post-harvest losses. Despite the production of 400,000 metric tons in 2017, higher than the estimated national demand, local production only covered 8 to 9 months' worth of demand due to post-harvest losses estimated at more than 30 percent of total production and informal exports to neighboring countries (MAER, 2018). Also, it should be emphasized that the lack of respect of technical itineraries through premature harvests and the overuse of urea, a fertilizer that allows an increase in the size of onions but also the water content, does not facilitate the conservation of production, which makes it difficult to store production and thus ensure its availability over the whole year. However, the monitoring system implemented by the direction of horticulture (DHORT) through the *Programme d'Aménagement et de Développement Economique des Niayes* (PADEN) has greatly facilitated the achievement of production targets.

Concerning the groundnut sector, the objective previously stated was to achieve a production of 1,000,000 metric tons by 2017 through the reconstitution of seed capital, intensification with better use of technological packages and generalization of mechanization. With an overall cost estimated at 92 billion FCFA (160 million USD), investments are divided between the reconstitution of peanut seed capital (54.04 billion FCFA or 92 million USD), seed subsidies (27.96 billion FCFA or 47 million USD) and the fulfilment of agricultural equipment needs (10 billion FCFA or 17 million USD). The proposed financing method was as follows: 75 percent of the cost would be borne by the State (69.76 billion FCFA or 120 million USD) against 25 percent borne by the private sector and the Technical and Financial Partners (TFP) (22.24 billion FCFA or 38 million USD). From an initial production of 693,000 metric tons in 2012, production reached 1,411,574 metric tons in 2017, of which 149,505 metric tons were exported. This increase in production is mainly explained by good rainfall, more dynamic supervision/training and rural council, but also the significant intervention of projects and programs like the West African Agricultural Productivity Program (WAAPP), which have greatly contributed to the dissemination of research results on agricultural inputs.

The development program for the off-season fruit and vegetable sector mainly aimed at growing cherry tomatoes, mangoes, melons, watermelons and sweet corn for export to reach 157,500 tons by 2017. The program required an investment of 43.5 billion FCFA (74 million USD) through targeted zerorating and/or a reduction in taxation. Finally, 104,645 tons were produced in 2017, out of a targeted amount of 157,500. The objectives were mainly not achieved due to the low availability of air freight during periods of high export activity and the difficulty of spreading production over the entire off-season.

In the agricultural sector, the PSE has brought up broadly satisfactory results with the implementation of PRACAS. Even if the majority of production objectives were reached in this first phase, the problems concerning the development of global value chains still persist with very low levels of transformation and a lack of coordination between activities. The large investments made in the production chain would have had a better impact if a good monitoring-evaluation and coordination system for resource mobilization had been set up for regular collection of reliable data throughout the chain. It should also be noted that in its first phase, the PRACAS only involved a few priority products with high added value, while under the objective of food security, efforts should have been made in the staple food sector. The sequence of PAPs constitutes another limitation of the PSE program, as the second has been slow to start. However, according to the interviewees, the assessments of PRACAS 1 and formulation of PRACAS 2 has been done with all the stakeholders and validated by the technical structures, but political validation is still slow.

### 5.2.2 Land use policy

The Senegalese government has attempted to reform its land tenure policy several times over the years: i) in 1996, an innovative and relevant Land Action Plan made propositions that were not followed; ii) in 2004, Senegal's Agro-Sylvo-Pastoral Act considering land reform was voted in but has not been enacted; iii) in 2005, a National Land Rights Reform Commission was implemented and put forth proposals that went no further; and iv) in 2012, a National Commission on Land Reform (CNRF) formulated land tenure policy orientations that were never officially validated.

According to the World Bank (2019a), this chain of events demonstrates that reform processes based on administrative commissions, long consultation procedures, studies, and successive workshops did not succeed. Instead, it would be preferable to draw on past experiences and current field practices to rekindle the debate on the basis of innovations tested and evaluated by stakeholders. The PSE is thus considering a set of priority actions between 2019 and 2023 to establish a land management system that is efficient, transparent, sustainable, and accessible at a cost to the government and to its users.

In terms of land use planning, the PSE aims to ensure better planning and management of territories through the updating of "*Schémas régionaux d'Aménagement du Territoire*" (SRAT), the generalization of "*Schémas Directeurs d'Aménagement Urbain*" (SDAU), "*Plans Directeurs d'Urbanisme*" (PDU) and Land Occupancy Plans (POS). This is how the National Territorial Planning and Development Plan (PNADT, 2018) was drawn up to "*promote the development of Senegal from its territories by proper structuring of space and sustainable development of resources.*"[29] However, the implementation of the program is very slow and the absence of a rural cadaster and the weak territorialization of public policies do not facilitate the development of integrated economic poles, despite the implementation of urban poles conducive to the development of economic activities.

### 5.2.3 Climate change policy

In Senegal, the INDC was developed in a participatory and inclusive process under the supervision of the Direction of Environment and Listed Establishments (DEEC) and the Ministry of the Environment and Sustainable Development (MEDD) in collaboration with the COMNACC. In order to contribute to the collective challenge of combating climate change, an assessment of the environmental situation along with sectoral experts, local communities and the civil society allowed the identification of a set

[29] See official website of the National Agency for Spatial Planning ("*Agence nationale de l'Aménagement du Territoire*") at http://www.anat.sn/article_anat.php?id=84.

of actions to be carried out by the government for mitigation and adaptation in strategic sectors such as rain-fed agriculture, water resources, and coastal areas.

Because of the numerous opportunities the Senegalese coastal zone offers to economic sectors such as tourism, fishing and subsistence activities for vulnerable populations, it constitutes a major asset for development. Despite coastal erosion that threatens both habitats and facilities along the coasts, the establishment of a coastal observatory originally announced as an adaptation measure for the INDC has been slow to materialize. On the other hand, efforts are noted in the protection of vulnerable coastal areas, with the construction of dikes at Rufisque and breakwaters for the recovery of beaches at Saint-Louis. It is clear that global warming is an aggravating factor for coastal loss, particularly in the context of rising sea levels, as coastal erosion will affect 3/4 of the Senegalese coastline (Climate Analytics, 2018). However, the limits linked to the lack of precise data on topography, the uncertainty of climate projection models, the lack of data on the evolution of the shore, bathymetry and sedimentology do not facilitate public intervention.

In the agricultural sector, good practices in Sustainable Land Management are identified through scientific studies, but scaling up is still slow. The absence of reliable soil data does not facilitate the creation of varieties adapted to climate change. However, efforts are noted in the diversification of production with the provision of watermelon and horticultural seeds. The contribution of the government to Insurance Risk Capacity (IRC) in the amount of one billion FCFA (1.7 million USD) to collect premiums in order to support pockets of food insecurity during periods of crisis constitutes a notable advance in the management of climatic extremes. However, the supply of agricultural insurance poses some concerns of adequacy with the demand from producers for good coverage of needs such as post-harvest loss activities.

In the forestry sector, the Senegalese government intends to respect its mitigation and adaptation commitments in three areas, which are (i) the fight against deforestation and land degradation; (ii) the conservation of biodiversity and the management of protected areas; and (iii) the fight against pollution, nuisances and the harmful effects of climate change (MEDD, 2018b). In terms of actions, reforestation and awareness campaigns have enabled the establishment of community-based nature reserves (RNC) that take into account economic activities. Likewise, conventions for the establishment of buffer zones for ecosystem reserves have enabled better monitoring of the evolution of ecosystems. In order to reduce the pressure on forest wood, initiatives to diversify energy sources through improved stoves and biogas have enabled a reduction of 5 percent in the number of bushfire cases and a decrease of 85,000 ha of burned areas in 2018 compared to 2017 (MEDD, 2018b).

Senegal has taken ambitious commitments to fight against climate change through the leadership of the PSE and subsequent operation by the INDC. Interviews with actors revealed some limitations that weaken public interventions. First, in terms of governance, the lack of coherence and coordination in the interventions often create maladaptation due to the absence of a baseline to assess the impacts of the actions undertaken. Then, the constraints of access to quality data due to the constraints of training on certain tools like Collect Earth and FAO tools could allow more efficient interventions through the application of knowledge on technologies or actions adapted to each area. Finally, the appropriation of the interventions by local populations and their awareness constitutes an ultimate challenge for the sustainability of the interventions.

# 6 Discussion on jobs for youth and women and infrastructure in rural areas to foster rural development

The above review on climate, land, energy has shown to which extent Senegal and particularly its agriculture sector is vulnerable to climatic shocks that lead to many issues affecting the agriculture system's resilience and thus threatens livelihoods in rural areas. Jobs and rural infrastructure are among the factors that can build rural communities' resilience.

## 6.1 Jobs for youth and women

### *6.1.1 Employment challenges faced by youth and women in rural areas*

As stated in the introduction, agriculture is the main employer in the rural areas of Senegal, and its vulnerability challenges rural populations' livelihoods, especially those of youth and women who, compared to men, are more vulnerable due to their lower access to resources.

As stated in the introduction, youth and women are also more affected by unemployment than men. There is also spatial heterogeneity in youth unemployment: North-Western areas are characterized by the highest unemployment rates, somewhat lower unemployment rates are found in the Eastern and Western parts of Senegal, and the South has the lowest rates. Unemployment is therefore mainly observed in areas dominated by the tertiary sector with the rates being comparatively lower in the areas dominated by the primary sector (FAO, 2020), thus highlighting the importance of agriculture in providing rural employment. The preference for the tertiary sector is linked, on the one hand, to the low productivity of the primary sector, which is strongly affected by climate change, and, on the other hand, to the low capacity of the secondary sector to absorb the surplus of workers from the primary sector. This low productivity has resulted in the development of the informal sector. Indeed, jobs in Senegal are highly informal with almost 70 percent of the working population (and 90 percent of the youth) being active in the informal sector (FAO, 2020). Other figures are even higher stating that 89 percent of the employment remains informal (MEFP, 2018). Agriculture (MEFP, 2018) and the textile sector are represented the strongest in the informal sector together accounting for around 99 percent (BIT, 2018). This results in low wages, underemployment, and limited social protection.

A lack of technical and entrepreneurial skills is among the reasons for the low employability in the agriculture sector. This is mainly explained by the limited supply of professional training that is furthermore unequally distributed across the regions and often inadequate for local employment needs. Youth and women face additional difficulties in their access to productive, financial, and social resources such as land, credit, social capital. This is mainly due to the high proportion of households headed by adult men in rural areas. Also, cultural barriers limit access to resources for both youth and women. Young women in rural areas are more unprivileged compared to their male counterparts due to their low level of education that can be attributed to their involvement in housework. Also, youth face employment insecurity due to the seasonality of jobs with low wages. As a result, they usually migrate to urban areas or rural areas with higher employment opportunities (FAO, 2020).

This situation clearly calls for policy and community-level strategies to ensure secure and decent jobs for the rural population, especially for youth and women. This is especially important due to the very young population of Senegal with 20 percent of the population being between 15 and 24 years old and 63 percent of the population being less than 24 years old (UN DESA, 2019).

### *6.1.2 The road to improving jobs in rural areas*

**a. Recent policy actions**

During the PAP1, various strategies were implemented to meet the growing demand for employment, in particular the National Agreement between the State and Employers (CNEE), the National Programme of Community Agricultural Domains (PRODAC), the *nouvelle Délégation générale à l'entrepreneuriat rapide des femmes et des jeunes*[30] (DER), etc.[31] But with the increase in demand for employment, especially on the part of the youth, the need to provide employment remains the main challenge for public authorities. Indeed, each year, more than 100,000 young job seekers enter the labor market and by 2030, this number should reach the threshold of 300,000 individuals.

**b. Community and household level actions**

At the household level, livelihood diversification and migration are among the strategies of adapting to climate change and fostering better jobs in rural areas, particularly for youth and women. Indeed, remittances allow infrastructure investments that benefit producers and rural migrants (Mboup, 2017). According to Mboup (2017), in the groundnut basin of Senegal, remittances from international migrants have contributed to the implementation of village community facilities such as the construction of middle school buildings to increase the schooling rate of producers in the village of Ndande. The author also shows that rural migrants have benefited from the restoration of urban functions in some towns to increase their opportunities for integration. For example, in the department of Kébémer, out of the 563 shops or canteens in the city, 168 are occupied by rural people, 52 of which belong to rural migrants.

Also, the AGRIDAPE report (AGRIDAPE, 2017) showed that diversification of livelihoods leads to job creation among rural women. The report highlights the production of *Cassia italia*, known as "Leydour" (a plant adapted to drought), by women in central-western Senegal. This activity involves more than 300 women and generates more income than the production of millet and groundnuts.

At the community level, collective actions facilitate the creation of infrastructures in rural areas (Thior et al., 2019; Feed the Future, 2017). According to Thior et al. (2019), in the lower Casamance, rice farmers in the rural community of Diembéring planted filaos along the shoreline to protect rice fields from coastal erosion to sustain rice cultivation, which is an integral part of the cultural identity of Joola farmers. The Feed the Future (2017) report also showed the important role of producers' associations in setting up agricultural work such as storage warehouses and processing units. These facilities have also led to an expansion of cultivated areas and the extension of the marketing period.

## 6.2 Role of infrastructure development for rural development

Besides jobs, infrastructure is a key factor in rural development and agricultural sector growth. "Infrastructure has been categorized as: (i) hard or tangible infrastructure that refers to the transport system (roads, rails, ...), public utilities (energy, water supply, irrigation...), the communication network (e.g. telecommunication), and social infrastructure (including schools, hospitals); (ii) soft infrastructure that refers to institutions and regulations" (Luo and Xu, 2018, p.2). Infrastructure can lower both production and transaction costs and thus commercialization costs. Infrastructure can also increase total factor productivity. Indeed, good infrastructure can increase input efficiency (Duggal et al., 1999). Also, interconnections and complementarities between infrastructures (for example combined

[30] The new delegation for the Rapid Entrepreneurship of Women and Youth program.

[31] A more exhaustive list of the initiatives to support youth and women employment in rural areas can be found in FAO (2020).

irrigation and electricity infrastructure) can help support innovative technologies adoption (Luo and Xu, 2018).

### 6.2.1 *Some achievements in rural infrastructure in Senegal*

Over the years, the Senegalese Government has invested money and effort in the development of both hard and soft infrastructure in rural areas.

Concerning hard infrastructure, most of the recent programs (PRACAS) and projects in the agriculture sector (PADAER, PASA LouMaKaf,...) have developed village roads to facilitate farmers' access to markets and offer them the possibility to improve both their productivity (via input access) and revenues (via an increase in productivity resulting in input use and via the commercialization of their production). Also, regarding public utilities, the energy and water sectors have benefited from public interventions as discussed in Sections 2 and 4 of this paper. For greater water control and improved productivity, a range of structuring infrastructures has been completed or is in progress in the main irrigated rice-producing areas of the country (MAER, 2014). These include (but are not limited to): (i) hydro-agricultural infrastructure in the Senegal River Valley and the Anambé Basin; (ii) integrated programs for the revitalization of farming areas and the control of run-off water. Also, advancements in the telecommunication network have fostered greater access to communication tools (e.g. phones) by farmers which enhances their access to information (e.g. via Market Information Systems – MIS and early warning systems sending messages to inform farmers on market prices or rainfall predictions).

Besides hard infrastructure, rural Senegal is characterized by the existence of several institutions of collective action (see in de Janvry and Sadoulet, 2004) (including farm organizations, water user associations...) that have been playing a huge role in, among others, farmers' access to market, women, and youth access to productive resources.

### 6.2.2 *Persistent challenges*

Despite these achievements, Senegal faces many challenges for rural infrastructure development. Indeed, the country needs to increase the accessibility of rural areas, especially beyond areas close to the main urban cities and coastal lines. Besides, the rural areas are still marked by insufficient and poor quality hard infrastructures that can hinder its development. Indeed, the insufficiency of infrastructures affects the profitability and competitiveness of agricultural value chains due to higher production and transaction costs and thus limits production and commercialization opportunities. In addition, insufficient and sometimes non-compliant post-harvest equipment, market infrastructures lead to difficulties in marketing agricultural production. Other than that, there has been noted a degradation of hydro-agricultural infrastructures in the Senegal River Valley and the Anambe Basin, the main production areas of irrigated rice (MAER, 2014). Concerning access to information and communication technologies, there is still a need for improvement in remote rural areas. Last but not least, soft infrastructure such as institutions of collective action may suffer from governance issues that could lower their possible impact on improving farmers' production and commercialization performance.

# 7 Conclusion

The objective of this report was to perform a literature review on the key challenges and sectors of Senegal's economy, particularly energy, climate change, land use and agriculture, and to assess the specific policies targeting these areas. The report also discussed briefly jobs for youth and women and the role of infrastructure in rural development.

Several studies have shown the dynamics of land use and land cover in Senegal. In Senegal, the main land use and cover classes are, by order of importance, Savanna, Sahelian short grass savanna and agriculture. The literature shows that the different uses of land and landcover have hardly evolved in the past. For instance, only agricultural land has significantly evolved during the period 1975-2013, increasing from 32,600 km² in 1975 to 41,000 km² in 2013. Within agriculture land, the area occupied by irrigated agriculture has almost quadrupled between 1975 and 2013, which is probably explained by the governments' efforts to increase irrigated areas across the country since the droughts in the 1970s. However, the land has degraded a lot in the past, with up to 63-67 percent of arable land being subject to land degradation. In terms of spatial representation, moderate to high levels of land degradation are noted in almost all the agroecological zones of the country. Only the eastern region of Kedougou and some spots in the north and the centre display mild degradation levels.

Land degradation can be of different types, including wind erosion, water erosion and salinization. Its causes can be anthropogenic or environmental. It is mainly explained by population growth, which leads to increased demand for agricultural land and fuelwood for urban centres, resulting in massive deforestation and degradation of vegetation cover. Agro-sylvo-pastoral practices such as shifting cultivation and abandonment of fallow land have also led to an expansion of agricultural areas, which has led to the decrease of the savannah and woodlands in the central and southern parts of the country and to the insecurity of land tenure.

Land degradation has multiple consequences: it impacts livelihoods by limiting the availability of vital ecosystem services through the deterioration of food and water availability and soil fertility, thereby increasing the risk of poverty. As a result, populations adopt strategies such as migration, mostly by people living in remote agricultural areas. Land degradation is estimated to cost 9 percent of Senegal's GDP annually (996 million USD).

Concerning climate change, Senegal's climate is of the Sudano-Sahelian type, which is marked by an alternation of a rainy and a dry season, the duration of which varies according to the region. Rainfall's characteristics (onset and duration) and air temperature are two factors that have changed significantly since the early 1950s and 1970s. Decreased rainfall, delayed onset of rains, reduced duration of wintering and higher temperatures have adversely affected agricultural production systems, food security and health. Projections in 2035 and 2050 will accentuate the negative impacts already observed.

In the face of such challenges, several strategies have been undertaken at different levels to reduce the negative effects of climate shocks and land degradations. Actions have consisted of technological responses: i) irrigation expansion through projects, programs and private initiatives; and ii) promoting innovative technologies/practices for crops and natural resources such as forestry, water and rangelands (from research or endogenous populations). At the household level, strategies have mostly consisted of diversifying revenue sources. At the community level, organizational dynamics have been strengthened and allowed, among others, the pooling of resources and setting up of savings groups that participate in the reduction of the vulnerability of women and children, access to climate information and sources of income, and diversification of agricultural practices. Finally, policy responses mainly consisted of Senegal's efforts to develop climate change adaptation and mitigation plans and strategies to protect the key vulnerable sectors from climate change and to contribute to emission reduction at the global level.

Senegal's 2015 Intended Nationally Determined Contribution is the most recent policy action in terms of climate governance and targets actions planned to cover the period 2016-2035. The evaluation of these actions undertaken thus far shows that the INDC builds upon the already existing adaptation and mitigation initiatives of the different directions and ministries of all sectors and communities that are scheduled to be upscaled at carefully targeted areas.

Apart from climate policies that benefit all the sectors of the economy, the government of Senegal has also set sectorial policies to ensure food security and sustained economic activities in the agriculture sector (PRACAS) and on land use. For the PRACAS, the evaluations show fairly satisfactory results. Even if the majority of production objectives were reached in this first phase, the problems concerning the development of global value chains still persist, with very low levels of transformation and a lack of coordination between activities. Concerning land-use policies since the 1964 law relating to the national domain, the Senegalese Government has seen the necessity to reform its land-use policy. Over the past years, several attempts have been made without effective concretization.

For all the policies, there are some challenges related to governance, funding and monitoring and evaluation that could have hindered success. The challenges faced for the implementation of all the policies are mainly: i) in terms of governance, to ensure participatory design and implementation of policies to foster stakeholder ownership and thus facilitate their implication; ii) in terms of funding, to avoid creating policy objectives based on unsecured funding by making realistic plans based on already secured funding (if possible, from the national budget); iii) in terms of monitoring and evaluation, to ensure sustained availability of good-quality statistical data to allow better targeting of the areas in which to intervene, better allocation of financial resources and better assessment of gaps, progress and impact.

Finally, jobs and rural infrastructure could offer promising opportunities for rural development. However, although Senegal has made efforts in improving their access in the rural areas, there are still important challenges to adress jobs, particularly for youth and women, and infrastructure development.

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# Appendix

Tab A1: Land use and cover dynamics (1975-2013)

| Land cover classes | 1975 | | 2000 | | 2013 | |
|---|---|---|---|---|---|---|
| | Area ($km^2$) | Percent of total area | Area ($km^2$) | Percent of total area | Area ($km^2$) | Percent of total area |
| Agriculture | 32,644 | 16.51 | 32,904 | 16.65 | 41,112 | 20.8 |
| Agriculture in shallows and recession | 684 | 0.35 | 712 | 0.36 | 800 | 0.4 |
| Irrigated agriculture | 336 | 0.17 | 628 | 0.32 | 1,004 | 0.51 |
| Total agriculture | 33,664 | 17 | 34,244 | 17 | 42,916 | 22 |
| Bare soil | 1,048 | 0.53 | 1,224 | 0.62 | 1,488 | 0.75 |
| Bowe | 3,388 | 1.71 | 3,388 | 1.71 | 3,388 | 1.71 |
| Forest | 204 | 0.1 | 80 | 0.04 | 76 | 0.04 |
| Gallery forest and riparian forest | 3,008 | 1.52 | 2,720 | 1.38 | 2,436 | 1.23 |
| Swamp Forest | 24 | 0.01 | 24 | 0.01 | 24 | 0.01 |
| Total forest | 3,236 | 1.63 | 2,824 | 1.43 | 2,536 | 1.28 |
| Mangrove | 1,964 | 0.99 | 1,576 | 0.8 | 1,676 | 0.85 |
| Open Mine | 24 | 0.01 | 56 | 0.03 | 92 | 0.05 |
| Plantation | 108 | 0.05 | 116 | 0.06 | 108 | 0.05 |
| Rocky land | 52 | 0.03 | 48 | 0.02 | 48 | 0.02 |
| Sahelian short grass savanna | 54,744 | 27.69 | 55,320 | 27.98 | 52,168 | 26.39 |
| Sandy Area | 224 | 0.11 | 68 | 0.03 | 80 | 0.04 |
| Savanna | 74,764 | 37.82 | 74,880 | 37.88 | 69,156 | 34.98 |
| Settlements | 532 | 0.27 | 844 | 0.43 | 1,448 | 0.73 |
| Steppe | 9,964 | 5.04 | 10,404 | 5.26 | 10,720 | 5.42 |
| Thicket | 172 | 0.09 | 244 | 0.12 | 252 | 0.13 |
| Water Bodies | 2,864 | 1.45 | 3,116 | 1.58 | 2,548 | 1.29 |
| Wetland – floodplain | 3,516 | 1.78 | 4,112 | 2.08 | 4,800 | 2.43 |
| Woodland | 7,416 | 3.75 | 5,216 | 2.64 | 4,256 | 2.15 |
| Total mapped area ($km^2$) | 197,680 | | 197,680 | | 197,680 | |

Note: Colour code decreases from green to red.
(Tappan et al., 2016)

Tab A2: Country Statistics

| Indicator | Year | Value | Source |
|---|---|---|---|
| **Employment** | | | |
| **Share of agriculture in total employment (%)** | 2015 | 33.2 | |
| **Unemployment** | | | |
| **Unemployment rate (%)** | 2015 | 6.8 | |
| **Unemployment rate, men (%)** | 2015 | 6.4 | ILO |
| **Unemployment rate, women (%)** | 2015 | 7.3 | |
| **Youth unemployment rate (%)** | 2015 | 8.1 | |
| **Youth unemployment rate, men (%)** | 2015 | 7.4 | |
| **Youth unemployment rate, women (%)** | 2015 | 8.9 | |
| **World view** | | | |
| **Population, total (millions)** | 2018 | 15.85 | |
| **Surface area (sq. km) (thousands)** | 2018 | 196.7 | |
| **Poverty headcount ratio at national poverty lines (%)** | 2011 | 46.7 | |
| **Poverty headcount ratio at 1.90 USD a day (2011 PPP) (%)** | 2011 | 38.0 | |
| **Life expectancy at birth, total (years)** | 2018 | 67 | WDI |
| **Urban population growth (annual %)** | 2018 | 3.7 | |
| **Economy** | | | |
| **GDP (current USD) (billions)** | 2018 | 24.13 | |
| **GDP growth (annual %)** | 2018 | 6.8 | |
| **GDP per capita (current USD)*** | 2018 | 1,522 | |

Note: * Calculated (GDP (current USD) (billions)/population, total (millions))
(World Development Indicators database, accessed 14 JAN 2020; International Labour Organisation database, accessed 14 JAN 2020)

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