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Working Paper

Burkina Faso - land, climate, energy, agriculture and development: A study in the Sudano-Sahel Initiative for regional development, jobs, and food security

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Mouhamadou Bamba Sylla, Kangbéni Dimobe, Safietou Sanfo

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Burkina Faso – Land, climate, energy, agriculture and development

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Mouhamadou Bamba Sylla, Kangbéni Dimobe, and Safietou Sanfo

Abstract

In this working paper, the biophysical factors and socio-economic conditions that led to Land Use and Land Cover Changes (LULC) and land degradation in Burkina Faso are reviewed. It is found that the country is densely populated and population continues to rise at a rate of more than 3% a year. However, nearly half of the population still lives below the poverty line. The electrification relies heavily on fossil fuels as the country has limited hydropower potential and solar energy received little investment. The rate of electrification is still very low, triggering the use of other sources of energy derived from firewood in rural areas. In addition, Burkina Faso has experienced land degradation in the North as a consequence of the 1970s and 1980s droughts that struck all the Sahel. Subsequently, migration took place from the degraded areas to the central, western and southern regions of the country causing further LULC changes. Furthermore, the country suffers from the effects of climate change and climate variability through increasing temperature trends, highly variable precipitation regimes and intensification of extreme events. Projected changes reveal prevailing conditions that indicate an increased risk of disasters in the agriculture, water and health sectors, among others.

Due to this situation, some technological responses and policy actions have been developed for sustainable land management and climate change adaptation and mitigation. The adopted technological approaches include, among others, irrigation expansion and efficiency, rainwater harvesting, crop diversification, adoption of drought-tolerant crop varieties and rotational grazing. Some policies have been put in place to facilitate the adoption of these technologies. They consist of carbon trading, land-use zoning and integrated landscape planning, payment for ecosystem services, providing access to markets and agricultural advisory services, securing land tenure and empowering women. These actions are part of broader programs and investment plans that include, but not limited to, the Strategic Framework for Poverty Reduction (SFPR), the Strategy for Accelerated Growth and Sustainable Development (SCADD), the National Rural Sector Program (PNSR), the Resilience and Support Plan for Vulnerable Population (RSPVP) and the Cereals Price Stabilization Program (CPSP) among others.

Keywords: Energy, Land Degradation, Land Management, Technology, Policies, Climate Actions

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

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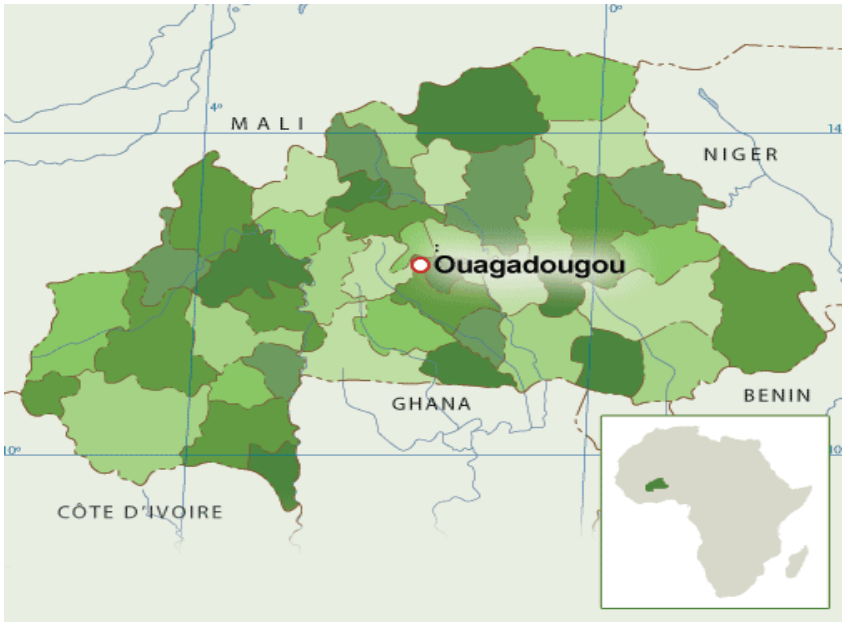
1. Introduction

Burkina Faso is a landlocked country located at the heart of the West African Sahel (see Figure 1). It is a low-income country with a limited natural resource base and low levels of human development. Its population is currently estimated at around 20 million inhabitants and is increasing at a rate of more than 3% per year (INSD, 2019). This is due to decreasing mortality rate and increasing life expectation. Progress has been made in terms of education during recent years. In fact, primary school completion rate currently exceeds 50% for both girls and boys (World Bank, 2019a). However, access to higher education remains limited.

In 2019, Burkina Faso was ranked 182 out of 189 countries on the 2018 Human Development Index, which highlights a score improvement of nearly 50% since 2000 (UNDP, 2019). A common feature in Burkina Faso is the poverty shared by a large portion of the population. Nearly half of the population still lives below the poverty line. However, between 2009 and 2014, the poverty rate declined rapidly from 55.3% to 43.7% (World Bank, 2019). In 2018, the poverty rate was estimated at 38%. It is considerably higher in rural settings than in urban areas. The main causes are the lack of rural productivity due to the low resilience (to shocks and stresses such as market volatility, climate, etc.) and modernization in the agricultural sector (lack of fertilizers, unavailability of improved seeds and low mechanization), unmanaged rural to urban migration and a fast growing population size (UNU, 2014).

According to the World Bank, such substantial progress in poverty reduction is associated with decreasing inequalities and an increasing trend in shared prosperity. It is worth emphasizing that Burkina Faso is among the very few sub-Saharan countries that have succeeded in reducing income inequality for approximately two consecutive decades. Higher inequality reduction is observed in rural areas (Odusola, 2017). The decline in the overall income inequality can be explained by structural factors such as increasing rate in education but also by impressive but still slow economic growth enabled by the development and implementation of short-term economic policies (World Bank, 2019).

Figure 1: Map of Burkina Faso highlighting its geographical location

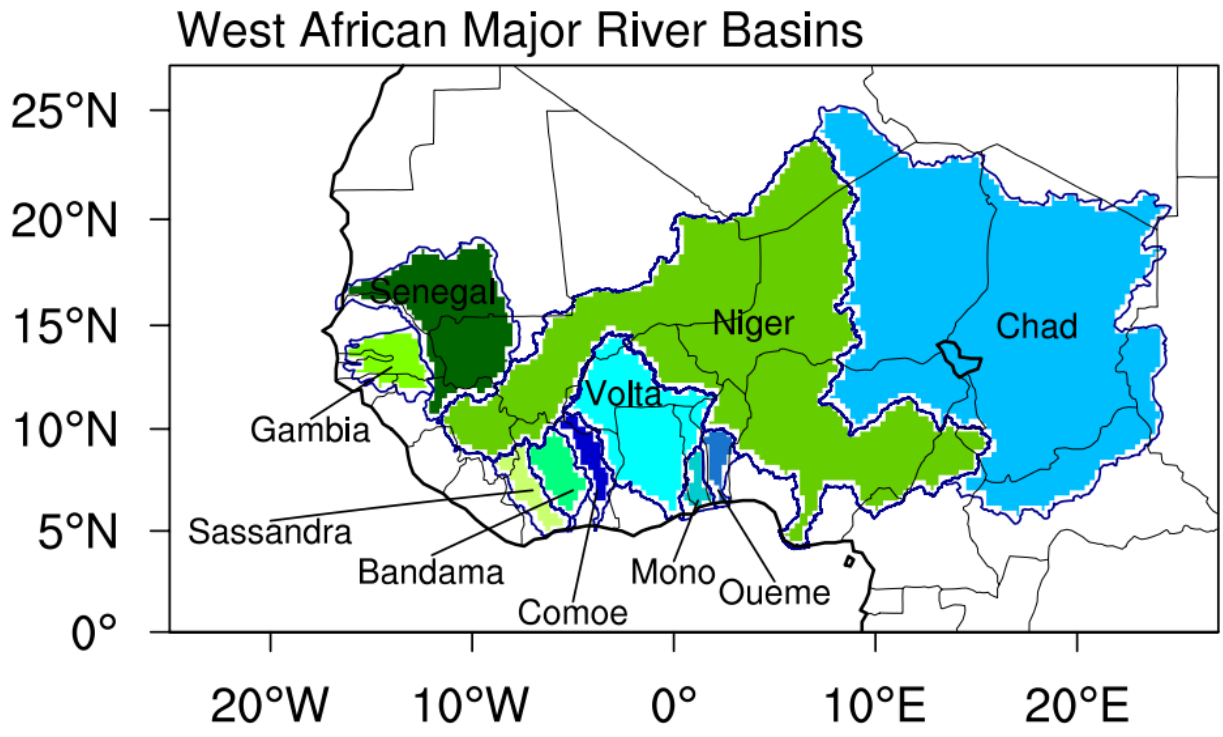


Source: African Development Bank (https://www.afdb.org/en/countries/west-africa/burkina-faso).

In fact, economic performance of the country remains resilient (IMF, 2019). Real GDP growth has increased to 7% in 2018 compared with 6.7% in 2017, indicating a stronger than expected rebound (AfDB, 2019). This is largely driven by strong performance of the agriculture sector which employs almost 80% of the population, accounts for 35% of the total GDP and 57% of export earnings (Zidouemba and Gerard, 2017). In Burkina Faso, agricultural production is dominated by rain-fed agriculture, which covers more than 90% of cultivated land. Therefore, high climate variability combined with poor access to climate information, lack of knowledge of good farming practices, poor soil quality, land degradation, limited investments in irrigation and technologies as well as limited market access make this sector very vulnerable (Zougmoré et al., 2018).

Other major concerns in Burkina Faso are energy and water access. The country's population uses a variety of energy sources including woodfire and charcoal (based on biomass), Liquefied Petroleum Gas (LPG), electricity from fossil fuels and renewable energy based on solar and hydropower. The sustainability of water resources is also crucial. The country is supplied with water from small lakes and three main transboundary river basins. They are the Volta, Comoé and Niger river basins (see Figure 2). However, the available renewable water resources per capita (852 m^3 per year) is well below the water scarcity threshold of 1,000 m^3 per year (World Bank, 2018).

Figure 2: Major West African rivers basins highlighting Volta, Niger and Comoé river basins crossing Burkina Faso



Source: adapted from Sylla et al. (2018).

It is thus clear that the decreasing poverty rate can be undermined by limited access to energy and water resources. In addition, mining, agricultural expansion, intensification and other human activities are leading to rapid deforestation and land degradation (Dimobe et al., 2015). This is further exacerbated by recurrent severe droughts and flooding due to extreme weather events. Therefore, climatic changes that increase the frequency and intensity of extreme events and land degradation or that affect energy and water access are negatively impacting food security in Burkina Faso (WFP, 2019).

These also substantially affect the livelihoods of local populations and present challenges to the achievement of the Sustainable Development goals (SDGs) in Burkina Faso.

With regard to this situation, it is thus essential to find solutions that will help Burkina Faso to advance economic growth, human development and food security. This can be done by first identifying investment opportunities and priorities for the sustainable land management, climate change and energy nexus in the country. Such an endeavour requires identification of key trends and problems related to the nexus and characterizing the current situation in terms of biophysical conditions and policies. Therefore, we document the current situation via published scientific literature search, official documents from development agencies and bodies (such as the World Bank, UNDP, AfDB WFP) and from agencies of the government of Burkina Faso (such INSD).

2. Situation and trends in rural energy and land use changes

2.1 Energy use and challenges

Burkina Faso is one of the countries in West Africa whose population uses a wide range of energy sources, including woodfire and charcoal, LPG, fossil fuel and renewable energy based on solar and hydropower.

The electrification rate in the country is still very low and relies heavily on fossil fuel. In fact, 70% of the country's power generation is based on fossil fuel and comes from 28 fossil fuel power stations (Power Africa, 2018). SONABEL (*Société Nationale d'électricité du Burkina Faso*) is the main company that produces and distributes electricity in the country. It depends heavily on subsidies from the government since tariffs are not enough to recover costs. In trying to meet the demand, the country has also established connections with neighbouring countries (Togo, Ghana and Cote d'Ivoire) and imports electricity from them.

The country has also invested in hydropower and solar energy. However, hydropower generation has limited potential because of high precipitation variability and scarcity. Burkina Faso has two hydropower plants capable of producing 22 MW and one that can produce 3 MW. The total hydropower production is on average 80 GWh per year with a range of 60 to 130 GWh per year depending mainly on precipitation (Moner-Girona et al., 2016). This represents 10% of the total generated power in the country. In contrast, the country has a high solar energy potential. However, in 2014, the installed PV (photovoltaic) capacity was estimated at only 400 kWp; the installed Solar Home Systems at 342 kWp and the three hybrid PV-diesel mini-grids each delivered a capacity of 15 kWp (REN21, 2015). In 2014, solar energy was estimated at 0.1% of the total national energy consumption. In 2017, the country connected a new solar power station of 33 MW contributing about 5% of the national electricity production (Moner-Girona et al., 2016).

Notwithstanding this, less than 5% of the rural areas are electrified and, as a consequence, nearly all energy used in rural areas is derived from firewood, which is biomass based (Bailis et al., 2015). In fact, in 2006, 93.7% of households used firewood burning in simple stoves as their main source of energy, 2.4% used firewood burning in improved stoves, 1.3% used charcoal, 0.8% gas and 0.3% petroleum (MEF, 2009).

Due to the inefficiency of wood fuel, there is a high rate of consumption (i.e. more than 1 kg per person per day). There is no formal planning for acquiring firewood by rural households (no purchase, no organized collection trips). Firewood can be picked randomly from anywhere in most rural areas as there is no scarcity in the most of the country, except in the north. Rural populations use firewood mostly for cooking (Bassirou and Souleymane, 2009) while for lighting and/or other appliances such as TVs, electricity is mostly used.

Therefore, to overcome the electricity shortage in rural areas, the country has created local cooperatives (COOPELs) (World Bank, 2015). These are consumer-owned utilities that were established to provide reliable and affordable electricity. They either run small mini-grids backed by diesel generators or extend the SONABEL grid, and deliver electricity directly to the consumer (Fond de Développement de l'Electricité, 2013). The funds are acquired from rural electrification funds (FDE in French). The COOPEL recruits builders for the generation and/or distribution assets, hires a private technical operator for operation and maintenance of the infrastructure along with metering and billing. These cooperatives have made more than 14,250 connections serving more than 120,000 people (World Bank, 2015).

2.2 Dynamics of land degradation, land use and land cover changes (and causes and impacts)

Land degradation is the product of long and short-term processes and is defined as the reduction and/or the loss of ecosystem functions and economic productivity caused by disturbances from which the land cannot naturally recover without human intervention (Adeel et al., 2005; Bai et al., 2008). According to Muchena (2018), land degradation occurs cumulatively and slowly. It has long lasting impacts on rural populations by making them gradually and increasingly vulnerable. Land cover is the biophysical cover on the earth's surface and refers to vegetation, water and man-made features (Di Gregorio and Jansen, 2000). Land use is human modification of land cover for development, conservation, or mixed uses (Ouedraogo et al. 2010).

Land degradation has mostly occurred in the northern region of Burkina Faso as a result of the 1970s and 1980s droughts. These droughts were particularly stressful socioeconomically and environmentally. In fact, the drastic decreases in precipitation over many consecutive years caused shortfalls in production and triggered serious food crises (Bonnecase, 2010). The most notable environmental consequences have been land degradation and loss of biodiversity (Doso-Jnr, 2014). Excessive exploitation of trees for fuel wood and unsustainable agricultural practices such as overgrazing and overcultivation have further exacerbated land degradation (Olsson et al., 2005), through desertification, deforestation (causing soil erosion), soil degradation and nutrient loss.

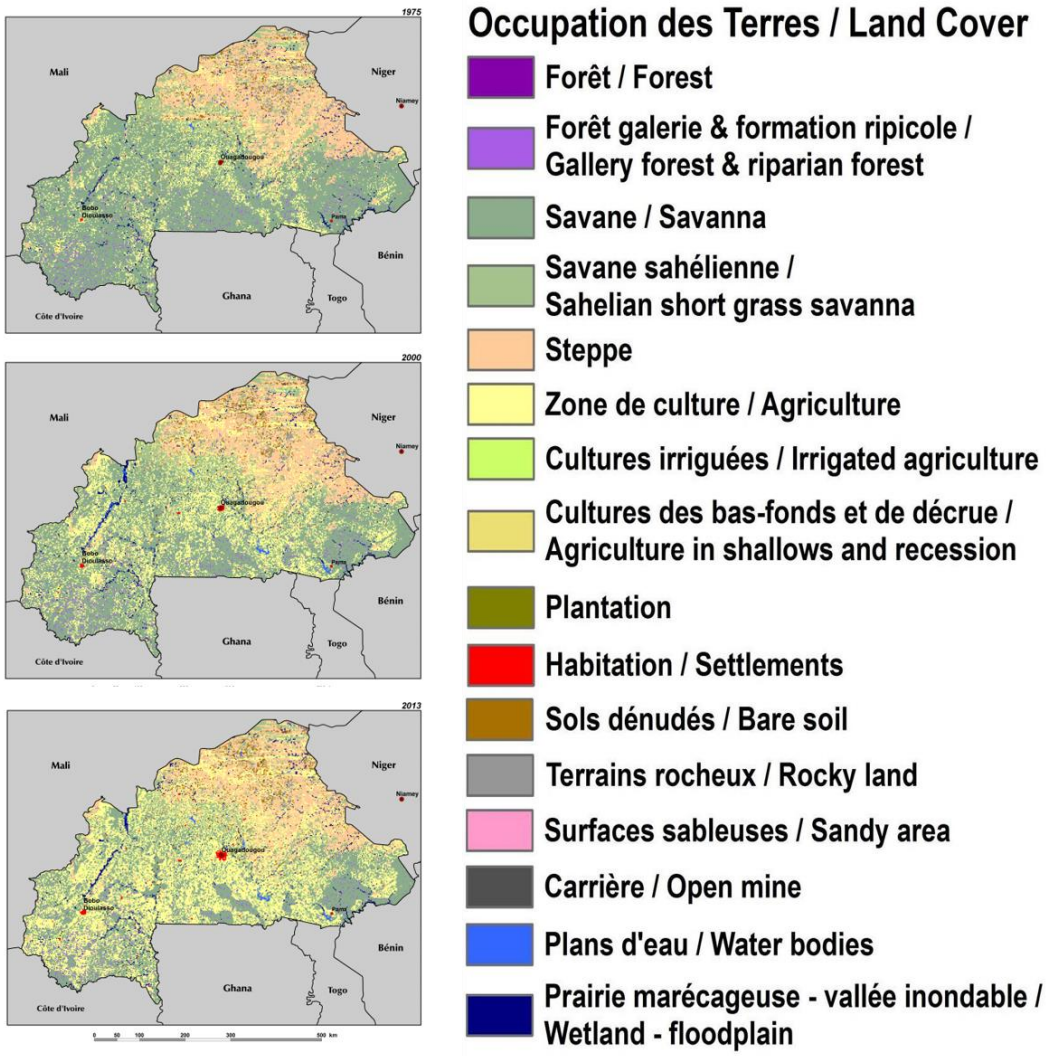
A consequence of land degradation is the migration of populations to the central and southern regions of Burkina Faso, which was encouraged by the government. Migrants are mostly Mossi farmers who migrated from densely populated and degraded areas to wetter and less populated regions endowed with a significant stock of natural resources (Ouedraogo et al., 2010; Paré et al., 2008). As a result of both migration and natural population growth, the central and southern regions have experienced strong population increases, which have caused substantial Land Use and Land Cover (LULC) changes (Ouedraogo et al., 2010). In fact, Nebié and West (2019) analysed 38 years (1975-2013) of LULC data using remote sensing data for two representative provinces in the central region (Bam) and the southern regions (Sissili). Both provinces have undergone profound changes mostly due to agricultural land expansion. In fact, although steppe and savanna remain dominant land cover classes in the Bam province, croplands have increased by replacing mainly savanna areas; the most substantial expansion occurred between 2000 and 2013 (Nebié and West, 2019). In the southern regions, Sissili LULC changes are much more dramatic. Agricultural areas have expanded throughout the whole province at the expense of savanna and dense forests (Ouedraogo et al., 2010). The highest rate of increase occurred between 2000 and 2013 and in 2013 cropland became the dominant land use type (Nebié and West, 2019). In another study that focuses on a more confined area, the Wildlife Reserve of Bontioli in southern Burkina Faso, it was found that from 2001 to 2013, gallery forests decreased by 14%, tree savannas by 22% and shrub savannas by 5%, while agricultural lands increased by 167% and woodlands by 3% (Dimobe et al., 2015).

At the country level, the United States Geological Survey undertook a LULC classification from 1975 to 2013 (see Figure 3). They found that savanna and gallery forest have been continuously decreasing while agricultural lands and settlements have been increasing. This indicates that increasing population and agricultural activities have rapidly altered the landscapes of the country.

It is thus clear that in recent years, northern Burkina Faso has undergone substantial land degradation and that central and southern Burkina Faso experienced considerable LULC changes. While in the north, changes are mostly due to environmental consequences of severe droughts, intense fire wood harvesting and unsustainable agricultural practices, in the central and southern regions of the country agricultural activities are the most important cause of LULC changes, followed by wood harvesting, settlement expansion and others as a result of the increasing population (Dimobe et al., 2015;

Ouedraogo et al., 2010). Agriculture expansion is mainly driven by smallholders, but also to a limited extent by agro-businesses. Unemployment and substantial population growth drive the intensive exploitation of wood fuel. Therefore, changes due to agricultural expansion and commercial wood fuel harvesting are thus mainly enacted by uneducated male farmers in response to lack of income, poverty and household expansion (Arevalo, 2016; Dimobe et al., 2015). However, for domestic use, wood gathering is performed mostly by women, who usually collect firewood from the fields and from forests on their way back from the farms (Arevalo, 2016; Ouedraogo et al., 2010).

Figure 3: Land Use and Land Cover classification for the years 1975, 2000 and 2013



Source: adapted from USGS (eros.usgs.gov/westafrica/land-cover/land-use-land-cover-and-trends-burkina-faso).

3. Observed and projected impacts of climate change

The climate of Burkina Faso, a Sahelian country, has evolved in recent decades in response to increasing anthropogenic greenhouse gas forcing and other climate forcing. Recent studies have confirmed that the country has experienced a trend of increasing temperature and extreme temperature (Longueville et al., 2016; Ly et al., 2013). Concerning precipitation, a wet period (1940-1970) and a dry period (1971-2000) have been identified (Lebel and Ali, 2009; Lodoun et al., 2013). The 1970s and the 1980s are marked as the famous drought episodes in the Sahel. In recent years, most of the country has recorded precipitation recovery however the amount is not at the level of the pre-drought period (Longueville et al., 2013; Sylla et al., 2016a). In addition, the annual precipitation total and the frequency of wet days have shown strong upward trends in recent decades (Ibrahim et al., 2014; Longueville et al., 2016). Furthermore, precipitation events have intensified and have led to strong extreme events causing floods in the country (Nka et al., 2015; Panthou et al., 2018; Tazen et al., 2018). In fact, it has been shown that the country experienced on average three flood events per year during the 1986-2016 period, which became five flood events per year from 2000 onwards (Tazen et al., 2018). These climate conditions have caused substantial crop yield and production losses of about 10–20% for millet and 5–15% for sorghum in West Africa in general and Burkina Faso in particular (Sultan et al., 2019).

Projected changes in Burkina Faso reveal an intensification of warming all over the country, insignificant precipitation changes and substantial increases in dry spell length and intense precipitation events in a business-as-usual world (Sylla et al., 2016a). Droughts and floods are thus set to increase in intensity and frequency. In addition, the country will shift from a dry climate in the present-day to an entirely semi-arid climate during the last decades of the 21st Century (Sylla et al., 2016b). Moreover, Burkina Faso is among the countries in which heatwaves and heat stress are projected to substantially increase in future climates to the point of dangerous risk levels for human health, agriculture and water resources (Russo et al., 2016; Sylla et al., 2018a). As a consequence, substantial yield losses of maize, millet and sorghum are projected under 1.5°C and 2°C global warming scenarios irrespective of the intensification level of fertilizers in central and southern Burkina Faso (Faye et al., 2018). In terms of water resources under future climates, projections reveal an increased risk of water deficit (10%-40% decrease of water availability) in most river basins crossing the country and a general decline in the Volta river basin-scale irrigation potential (30%-60% decrease) under 1.5°C and 2°C global warming scenarios (Sylla et al., 2018b).

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

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

4.1.1 Croplands

Expanding Irrigation

In Sahelian semi-arid zones such as Burkina Faso, irrigation is an essential climate change and climate variability adaptation strategy to secure farmers' livelihoods and their food security (Sanfo et al., 2017; Wesenbeeck et al., 2014). In Burkina Faso, the severe drought of the 1970s resulted in the need to develop a hydro-agricultural development policy through various projects and programmes. For emergency measures in response to the widespread droughts of the 1970s and 1980s, both the government of Burkina Faso and non-governmental organizations (NGOs) built thousands of small reservoirs. In total around 4,500 ha of irrigated lands and 800 ha of lowlands were developed between 1974 and 1987 downstream of major dams such as Kou, Banzon, Karfiguéla, Sourou and Douna. The development of the irrigated areas is linked to national agricultural policy and considers climate hazards and the need to ensure the population has food self-sufficiency. In 2011, irrigation schemes totalled approximately 30,000 ha, including large (13,000 ha), medium (3,000 ha) and small (14,000 ha) irrigation schemes. Developed lowlands reached 25,000 ha (FAO, 2015; SP-CPSA, 2012). The large irrigation schemes are located in the Sourou valley, in Bagré and in Samendeni, downstream of the Soum and Dourou. Large- and medium-scale irrigation schemes operated by the private sector were used for the production of sugar cane in Banfora (Cascades) and rice and maize production in the Hauts Bassins regions, which lie along the Comoé and Mouhoun rivers. Small-scale irrigation has developed throughout the country, particularly in the regions of Plateau Central, Hauts Bassins, Mouhoun, Cascades, Centre West, Centre East, Centre South and North. Small reservoirs served to expand the irrigation of vegetables (onion, tomato, lettuce, cucumber, cabbage, green beans, etc.). Vegetables are produced to supply large cities in Burkina Faso but also for export to other countries such as Togo and Ghana.

Irrigation in Burkina Faso is dominated by surface irrigation (25,000 ha). Sprinkler irrigation technology is used for sugar cane production which covers about 3,900 ha. Drip irrigation, which has been developed a decade ago for horticultural production, remains embryonic and covers only 500 ha. The development of irrigation schemes is growing rapidly; small-scale irrigation contributes to income-generating activities, food self-sufficiency and poverty alleviation, especially in rural areas (Sanfo et al., 2017).

Application of water-efficient irrigation methods

Water scarcity has long been a problem preventing farmers from producing efficiently (Cotula, 2006). In Burkina Faso, the agriculture sector uses about 20% of the total water resources. Despite water resource mobilization efforts by the government, NGOs and research centres, the agricultural water demand is not met. Agricultural water demand is still increasing and climate change and population growth (3% a year) are putting water resources under even more stress. According to the literature, the situation is likely to worsen as extreme rainfall events become more frequent and domestic, livestock and industrial water use also increases. Therefore, efficient use of water is important to sustain agricultural production. Drip irrigation, also known as "localized irrigation," allows irrigation to

be carried out with low flow at local scales. This irrigation technique has been promoted in arid zones because it minimizes water consumption and limits fertilizer losses (Venot et al., 2014). In Burkina Faso, the International Development Enterprise (IDE), and more recently IRIFASO, are pioneering drip irrigation as a water-efficient irrigation method. IDE investigated the creation of supply chains (importing drip kits, creating farm business advising teams, putting private traders in charge of direct marketing) while IRIFASO managed importation, marketing and installation of irrigation kits and after-sales services. Since 2011, IDE has sold over 4,000 drip kits. Drip irrigation significantly improved agricultural production and is therefore contributing to climate smart and sustainable agriculture. In Burkina Faso, drip irrigation reduces water losses and increases water productivity through reduced evaporation and efficient use of the resource. Despite the widespread contributions of drip irrigation in water saving systems, it still covers only about 225 hectares. Famers point to high costs, poor quality of drip kits, lack of technical support and marketing difficulties.

Rainwater harvesting

Rainwater harvesting is an old water collection system. It was the first type system for collecting and supplying water used worldwide. The literature defines water harvesting as the collection of roof water and runoff water in farm ponds, reservoirs, tanks or drums for a wide range of uses (agriculture, domestic, livestock, etc.) (Barry et al., 2008; Gadédjisso-Tossou et al., 2018; Prinz, 1996). Burkina Faso is a semi-arid region where rainwater harvesting is the backbone of agriculture. In Burkina Faso, erratic rainfall and extreme rainfall events are frequently harmful to crops and livestock and thus household livelihood, income and food security are threatened (Fox et al., 2005; Sanfo et al., 2017). With projected climate change, rainwater harvesting will gain high interest in the future. Research centres, NGOs and farmers themselves in Burkina Faso have developed roof water and runoff water collection systems to mitigate the negative effects of water stress and water scarcity. Water harvesting techniques can be categorized into four main types: Impluviums, ponds, sand dams and underground tanks.

Impluviums are simple systems that collect rainwater from rooftops and store it in a reservoir. These tanks can be completely or partially buried, or above ground. The tanks are made of an iron and cement structure, or with bricks. Water is usually accessible through a tap. By means of relatively simple procedures, water can be stored over longer periods of time. Ponds are usually dug to collect runoff and rainwater, flowing along roads and paths. The water stored is used not only to water crops and trees during the dry season, but also during the rainy season when long dry spells have occurred, and also for livestock. Ponds are generally built in a trapezoidal shape, perfectly suited for porous soils, and require a covering to avoid any loss of water. Sand dams represent an opportunity to harvest and to store rainwater and runoff. Sand dams are by far the most cost-effective method of collecting rainwater in arid regions. Sand reservoirs collect sand during floods, and this dropped sand begins to saturate with water. The water remains stored in the pores, between the grains of sand, in the riverbanks and in the riverbeds, waiting to be pumped.

Underground tanks are an alternative to surface impluviums. These tanks are made of cement and are covered with corrugated sheet metal or cement plate, thus preventing evaporation and contamination. Rain falling on roofs or on surfaces around the tanks is then directed to the storage tank by means of small ditches. The water then passes through a filtering system to remove the silt before entering the tanks. The tanks are equipped with hand pumps, positioned above the roof, or connected to a water point with taps.

Crop diversification

Crop diversification is a well-known strategy used by smallholder farmers to mitigate agriculture risk at the farm level. In Burkina Faso, farming systems are dominated by rainfed agriculture and as such

are vulnerable to climate risk. Climate hazards greatly affect smallholder farmers' livelihood and their food security (Balazs, 2006; Laube et al., 2012; Sanfo et al., 2017). Widespread poverty and lack of financial resources prevents farmers from subscribing to crop insurance schemes. To cope with climate hazards, farmers have developed crop diversification strategies(Lawin and Tamini, 2017). Crop diversification strategies developed by farmers, NGOs and research centres include intercropping systems, catch crop, relay cropping systems, crop rotation and improved fallow (Pereira, 2017; Tittonell and Giller, 2013).

The intercropping system is an agricultural practice which consists of planting at least two different species in the same plot during a given period of their growth cycle (Tittonell and Giller, 2013; Zougmoré et al., 2014). In Burkina Faso, farmers usually combine cereal-legume (sorghum-cowpea, maize-cowpea, millet-groundnuts or maize-groundnuts). Several studies argue that agronomic and socio-economic factors such as soil characteristics, farming equipment owned and farmer's preferences significantly affect the choice of intercropping system (Branca et al., 2012). Many authors have proved the success of the intercropping system compared to monocrops in Burkina Faso (Branca et al., 2012; Laube et al., 2012; Tittonell and Giller, 2013). Intercropping systems in Burkina Faso helped farmers to mitigate climate hazards' effects on crop yields and livelihoods (Branca et al., 2012).

Catch cropping systems consist of cultivating a fast-growing crop between two successive plantings of a main crop while relay cropping systems involve planting two crops of different species on the same plot, with second crop being planted just before the harvest of the first crop. Crop rotation is the practice of alternating annual crops grown on specific cropland in a plan pattern. Improved fallow involves use of fallow land for planting of species that improve soil fertility[1]. In Burkina Faso, factors such as farm characteristics, poor access to land, equipment and fertilizers influence the choice of crop diversification systems. Small farms facing constraints on land, finance and equipment prefer intercropping systems while large farms with more land reserves opt for crop rotations or even improved fallows, especially on highly degraded lands.[2]

Adoption of drought-tolerant crops and crop varieties

Similar to other countries in the Sahel region, Burkina Faso is at risk of drought and floods, which are recognized as climatic events that threaten the livelihoods and food security of rural populations. This can be explained by the fact that the country's smallholder farmers rely mostly on rain to produce staple grains (e.g. maize) and cash crops (e.g. sesame, cotton) and to raise livestock.

In Burkina Faso, poor climate conditions coupled with low soil fertility leads to low agriculture productivity. This situation is prominent in the north of the country where the mean rainfall is low (630 mm per year) compared to other regions and the environment is much more degraded as a consequence of recurrent droughts and anthropogenic pressure (Sanou et al., 2016). In such conditions, farmers practice subsistence agriculture with millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) as staple cereals and sesame (*Sesamum indicum*) as a cash crop. The secondary crops are cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*) and Bambara groundnut (*Voandzeia subterranea*). Sanou et al. (2016) reported that the mean yields of sorghum and millet (considered as the main staple crops) range between 400–500 kg/ha and vary between years depending on rainfall amount (Sanou et al., 2016).

In Burkina Faso, sorghum, which is cultivated only under rain-fed conditions, is mainly produced by small holder farmers as it is a major staple food for ca. 80% of the rural population in the country. However, a study conducted by Ouedraogo et al. (2017) stressed that the production of sorghum is

[1] http://www.iedafrique.org/Fonctions-modalites-et-defis-de-la.html.
[2] http://www.iedafrique.org/Fonctions-modalites-et-defis-de-la.html

threatened by drought during the flowering stages of growth. A study by Derera (2005) reported that drought is the main constraint to sorghum production worldwide and smallholder farmers cannot afford irrigation facilities to lessen its impact on the production of the crop.

Thus, to solve this problem related to drought, studies on sorghum breeding for drought resistance have been conducted in the early 1970s in Burkina Faso as well as in other semi-arid countries in West Africa. The main aim of sorghum breeding was to enhance the yielding varieties derived from the caudatum and kafir races. Unfortunately, a study by Ouédraogo (2005) revealed that these studies had little impact because farmers were not involved in the programme. The varieties were rejected by farmers. Besides, the cost of production of those varieties was greater compared to the existing variety because of their need for fertilizer use and improved cultural practices. Matlon (1985) reported that the level of adoption of exotic varieties in West Africa was less than 5%, indicating that farmers prefer the local variety for their sorghum production.

Indeed, the adverse effects of climate change and variability in terms of water availability have lead smallholder farmers to use early maturing and drought-tolerant crop varieties (Ouédraogo et al., 2010).

Conservation agriculture

Conservation agriculture is a method of practicing agriculture while conserving soil resources. Conservation agriculture is one of the main approaches of conservation farming systems that have been championed by different stakeholders as a route to sustainable intensification. It reduces soil disturbance and contributes to maintaining crop residues on the soil in order to reduce damage to the environment.

In Burkina Faso, farmers have a long history of practicing conservation agriculture based technologies under rainfed conditions (e.g. reduced tillage, soil cover by crops or residues, crop diversification) (Sop et al., 2012; Zougmoré et al., 2000).

Benefits of innovative practices under conservation agriculture have been documented across Sub-Saharan Africa. A study by Bayala et al. (2012) reported that in Burkina Faso, conservation agriculture (agroforestry parkland trees combined with crops, green manure, crop rotation) improved cereal yields by between 0.14 and 0.24 t/ha.

However, there is an ongoing debate on benefits of conservation agriculture. Some researchers suggest that it is more profitable and environmentally friendly, whereas others ask questions about its practicability and importance in the African smallholder context. The main criticism of conservation agriculture is about low productivity (Giller et al. 2015). According to Pittelkow et al. (2015), the use of conservation agriculture leads to yields that are 10% lower than conventional practices and restricts the use of herbicides that are not good for the conservation of biodiversity. In country like Burkina Faso, it seems difficult for smallholder farmers to apply strict conservation agriculture practices as they lack money to invest in herbicides and mechanized farm power.

Agroforestry

Agroforestry is the integration of trees in agriculture systems (Bayala et al., 2013). It is an approach that aims to maintain great levels of productivity by harnessing ecosystem services provided by trees. Although these preserved trees play important roles in agricultural systems, they can become competition for growth resources on associated staple food crops in the Sahelian zone of the country where the quality of soils is poor and the rainfall is lower than that in other zones. Studies have been conducted on the interactions between agroforestry fruit trees and crops in Burkina Faso (Jonsson et al., 1999; Kessler, 1992). For instance, studies by Bayala et al. (2002) showed that under the canopies of Shea butter trees (*Vitellaria paradoxa*) and African locust bean (*Parkia biglobosa*) the productivity

of local sorghum (in terms of grain yield) was reduced by 50 to 70%, respectively, compared to the farms where there were no trees. This result indicates that the practice of agroforestry can have a negative effect on the productivity of some crops depending on the tree species and their management.

In recent years, live hedges, also called hedgerows or windbreaks, have emerged as an agroforestry technology for the containment of animals. This technology refers to one or more rows of trees closely planted (25 cm or 50 cm apart) to form a continuous barrier around the desired area. The rows contain several multipurpose leguminous trees and shrubs such as *Glircidia sepium*. This contrasts with a live fence, which consists of tree species planted at greater distances and for which barbed wire is used (Budowski, 1987). The live hedges are most effective in controlling soil erosion (Young, 1989). This technology also provides benefits such as fodder and fuel wood when the vegetation is cut. Trees and shrubs used in live hedges are also used as windbreaks to control wind erosion in dry areas such as in Burkina Faso.

Agroforestry is one of the examples of technologies that have been successfully used for soil and water conservation in Burkina Faso and can improve yield depending on the tree species (Sawadogo, 2011). In the northern part of Burkina Faso, farmers manage (protect and regenerate) trees on their farms as a source of food, fuelwood and traditional medicine (Sawadogo et al., 2001). Trees in agroforestry parklands enhance soil fertility, as greater yields have been observed around trees like *Faidherbia albida*. In certain parts of Burkina Faso (especially in north-western areas), where there is high anthropogenic pressure on land, smallholder farmers cannot plant trees in plain sight because there is a risk that the owner of the land may reclaim the land concerned; thus they sow seeds or plant trees at night. A survey carried out by Sawadogo (2011) indicated that farmer innovators who use soil and water conservation techniques (SWCTs) regenerate and protect more trees than non-innovator farmers.

A meta-analysis conducted by Kuyah et al. (2019) found that agroforestry practices in Sub-Saharan Africa improve soil fertility, reduce runoff and soil loss, and increase soil moisture and infiltration rate. Kuyah et al. (2019) reported that average crop yield was almost twice as high in agroforestry compared to non-agroforestry, and soil loss was ten times lower in agroforestry, whereas infiltration was approximatively three times higher under agroforestry. These results indicate that agroforestry enhances provision of ecosystem services in agricultural landscapes.

4.1.2 Rangelands

Rotational grazing

In Burkina Faso, the deterioration of the environment in pastoral areas has led pastoralists to strengthen their capacity to monitor pastures and animals (Burkina Faso National Water Partnership et al., 2010). Indeed, the natural resources (pasture and water) necessary for livestock farming are often dispersed and dwindling. In order to preserve their basic activities while limiting conflicts, pastoralists have developed a grazing space monitoring system, which consists of appointing people to deal exclusively with the protection of forest species against abusive cutting of timber and exploitation of species by pruning and trimming techniques. With the scarcity of plant cover, pastoralists are more vigilant in guarding the herd to prevent animals from entering the fields thus contributing to the reduction of conflicts between farmers and herders (CILSS, 2007).

If a year is deficit on the fodder level, breeders carry out destocking, the sale of oxen and sheep, especially the oldest and the weakest ones. With the money from the sale, they purchase a stock of complementary foods consisting of bran, millet and sorghum stalks, cotton seeds and lick stones to feed and save the healthy animals of the herd. Also, we note that in times of climate crisis, there can

be a mass destocking of animals sold at low prices on local markets that could be called a clearance sale of animals (CILSS, 2007).

A study conducted by Kagone (2001) in the north-Sudanian zone of Burkina Faso showed that pastoral management in Burkina Faso should be focused on rotational grazing, which is a high stocking rate followed by 30-days rest time for grasslands. According to Kagone (2001), the use of rotational grazing could increase carrying capacity during the rainy season, maintaining a high quality of re-growth. The analysis of daily movement patterns conducted by Kagone (2001) revealed that the choice of rangelands by animals is driven by the need to maximize food ingestion and the search of dietary protein balance.

Practices such as rotational grazing could help ensure that shepherds continue to feed their animals while avoiding conflict with farmers over declining productive lands.

Addressing invasive bush encroachment

Savanna vegetation is characterized by a continuous layer of grasses, trees and shrubs (Kgosikoma and Mogotsi, 2013). Bush encroachment is the suppression of palatable plant species (e.g. herbaceous plants) by encroaching tree and shrub species in savanna areas (van Auken 2009; Ward, 2005). A study conducted by Ward (2005) reported a decrease in grassland cover over Africa mainly due to livestock impacts and/or increasing rainfall. The phenomenon of bush encroachment is perceived as a general issue in Sub-Saharan Africa as it is seriously affecting savanna vegetation in the region.

In Burkina Faso, savanna grasslands are threatened by bush encroachment via the suppression of herbaceous biomass production and the reduction of biodiversity (Thiombiano and Kampmann, 2010). The livestock/pastoral sectors are affected by the decrease of grasslands and the abundance of inedible invasive species as a consequence of bush encroachment (Graw et al., 2016). Therefore, there is an urgent need to control bush encroachment (Olson and Whitson, 2002).

Bush encroachment control consists of shifting plant communities dominated by tree species (e.g. woodland, tree savanna) to herbaceous vegetation to create a favourable habitat for grazers (Angassa and Oba, 2008). In the savanna ecosystems of Burkina Faso, different bush control methods such as hand removal of trees, use of fire (Zida et al., 2007), tree harvesting coupled with fire and grazing (Sawadogo et al., 2002, 2005), and fire combined with grazing (Sawadogo et al., 2005) are often used to increase the production of herbaceous species and their diversity. Several other bush encroachment control techniques were also identified, such as tree cutting, staining and uprooting (MEECC, 2014).

4.1.3 Forests, woodlands and shrublands: Afforestation and reforestation

Plant communities, especially forests in Burkina Faso, are exposed to great anthropogenic pressure such as poverty, demographic factors, land degradation and deforestation (Dimobe et al., 2015; Kalame et al., 2008). A previous study conducted by SP/CONEDD (2007) reported that by 2025 and 2050 using GCM (global circulation models), temperature will increase by an average of 0.8°C and 1.7°C, respectively, whereas rainfall will decrease by 3.4% and 7.3%, respectively. The vulnerability of forest ecosystems in Burkina Faso is mainly driven by abiotic factors (e.g. climatic and non-climatic factors). In this country, the adverse effects of climate change are manifested through frequent extreme weather events including (i) high variability in mean rainfall, which leads to droughts or floods, difficulties in tree recruitment and habitat degradation, (ii) high temperatures, (iii) storms, and (iv) wildfires (SP/CONEDD, 2007).

It has been reported that sustainable forest management in Burkina Faso under future climate conditions will greatly depend on artificial regeneration through reforestation and afforestation activities (Gonzalez, 2001; Kessler, 1992). Noss (2001) pointed out that climate change will greatly

affect the regeneration phase compared to mature forests. In Burkina Faso, several policies and practices that promote reforestation, afforestation, restoration and rehabilitation of degraded forests and lands exist (see Burkina Faso's 1995 forest policy and 1997 Forestry Code, Articles 8, 13, 14, 45 and 258).

Reforestation and afforestation programmes have existed for decades in Burkina Faso but were not effectively implemented. These two programmes contribute to carbon sequestration and biodiversity conservation and, according to Kalame et al. (2009), focus on large-scale projects.

Since 2003, the government of Burkina Faso has launched an annual reforestation campaign at the country level (MECV, 2006). *Acacia nilotica, Acacia senegal, Ziziphus mauritiana, Eucalyptus camaldulensis, Azadirachta indica, Prosopis juliflora, Cassia siamea, Pakia biglobosa, Mangifera indica, Khaya senegalensis* and *Anacardium occidentale* are the woody species commonly planted. In 2005, about 93% of the total seedlings planted were provided by private nurseries, while the remaining 7% were provided by the National Centre for Tree Seedlings in Burkina Faso (MECV, 2006). The main constraints to seedling growth are (i) climatic factors (e.g. occurrence of drought), and (ii) herbivory. Most of the time, reforestation programmes encounter problems that lead to the failure of the programmes. Among these problems, we can enumerate (i) failure to consider woody species to be planted, (ii) non-involvement of forest services in the reforestation programme, and (iii) insufficient financial and material support (MECV, 2006).

Due to lack of financial resources, farmers in Burkina Faso have developed their own reforestation strategies as they cannot buy seedlings and plant them during reforestation campaigns. To achieve this, most of the time, they rely on assisted natural regeneration by protecting young trees on their fields against wildfires and grazers. Reij et al. (2005) stressed that, to re-grow pre-existing tree and shrub stumps, farmers in Burkina Faso should use silvicultural and coppicing techniques through the selection and pruning of stems that sprout from tree stumps. Kessler (1992) indicated that some farmers in Burkina Faso have used vegetative propagation to grow *Acacia albida* by cutting the plant roots so that they will grow to become adult trees.

4.2 Household and community responses

4.2.1 Livelihood diversification and migration

In Burkina Faso, rural households generated their income and livelihoods from different sources (Barrett et al., 2001; West, 2013). The literature considered a wide range of factors that drive household livelihood diversification. Factors of diversification often refer to strategies developed by households to reduce the risk (Jónsson, 2010; Wouterse and Taylor, 2008). In semi-arid zones, such as in Burkina Faso, migration has been often cited as an important strategy of household livelihood diversification. It has been argued that climate and environmental extreme events (drought, flood, plant diseases, land degradation) and socio-economic factors such as extreme poverty and conflicts were the main drivers of rural-urban and cross-border migration in Burkina Faso (Bilsborrow, 2002; Henry et al., 2003; Henry et al., 2004; Sanfo et al., 2017b). Migration often results in remittances that contribute to household poverty alleviation and food security (Iom, 2009). Several authors have categorized migration in Burkina Faso: internal migration (rural-urban, intervillage and interprovincial migration) and external migration (cross-border migration). Internal migration takes place from arid to humid areas where the soils are fertile (Djiga, 2015). In 2006, cross-border migration accounted for 292,013 peoples. People in Burkina Faso usually migrate to Ivory Cost (81%), Ghana (6%), Mali (5%) and Europe (2%), though (6%) migrated to other places.

4.2.2 Community collective action

The rural population in Burkina Faso faces climate change, land and natural environment degradation and food crises (Buffle and Reij, 2012; Hassan et al., 2008; Steenwerth et al., 2014). They are increasingly being forced to join their efforts to undertake climate change and climate variability adaptation strategies and promote sustainable development (Nielsen and Reenberg, 2010). Community led actions in Burkina Faso happen in diverse contexts including household drinking water supply, the agricultural and livestock sectors, forests and biodiversity. Actions taken include equipped borehole construction for drinking water supply, building farm ponds for supplemental irrigation and livestock, crop diversification, development of soil and water conservation techniques, warning and crisis management (cereal banks, appeals for food aid), delimitation and development of pastoral areas, control of bush and logging along with delimitation and monitoring of village forests.

4.2.3 Farmer and indigenous innovations

NGOs, research centres and policymakers in Burkina Faso have developed adaptation measures to support smallholder farming systems to not only mitigate the associated impacts of rainfall variability but also to improve productivity and enhance livelihoods. Farmers themselves also developed indigenous innovations known as water and soil conservation techniques (SWC) such as "zai", "half-moons" and "stones bunds" , mulching and grassed strips (filter strips, buffer strips, riparian zones, field borders) (Ackermann et al., 2014; Zougmoré et al., 2014). These adaptation measures, including indigenous innovation practices, enabled farming communities in Burkina Faso to cope with extreme climate events. However, under the current observed climate variability and change, these indigenous innovations may become much less reliable and less useful to sustain land and labour productivity and many more innovations are now expected to follow (Barry et al., 2008).

4.2.4 Policy level responses

Facilitating carbon trading

The Law on Environmental Code adopted by Burkina Faso in 1997 does not clearly highlight topics related to climate change. However, the cooperative approaches under Articles 6.2-6.3 as well as the sustainable development mechanisms under Articles 6.4-6.7 of the Paris Agreement could be employed by parties to achieve their nationally determined contributions and increase the ambition of mitigation targets in the future (e.g. post-2020 climate regime). Therefore, it is necessary to adjust national legislation and regulations in order to create adequate conditions for potential investors.[3]

Land-use zoning and integrated landscape planning

Strategic land use planning is an important tool to mitigate and adapt to climate change effects. However, the national policy of habitat and urban development produced in 2008 failed to include aspects linked with mitigation and adaption to climate change. Its general objective was to create the conditions for improving the living environment of the population by strengthening the contribution of cities in the fight against poverty (Ministère de l'Habitat et de l'Urbanisme, 2008). Therefore, to better adapt to the adverse effects of climate change, Burkina Faso developed its national climate change adaptation plan (NAP) in 2014. The aims of the NAP are to (i) reduce vulnerability to the impact of climate change by promoting adaptation and resilience capabilities of local populations and (ii) facilitate the integration of climate change adaptation into new or existing policies, programmes or activities. The overall cost of financing the investment strategy of NAP is estimated at 3853.75 billion

[3] https://unfccc.int/sites/default/files/resource/bfanc2french.pdf

FCFA in the short, medium and long term (1 to 15 years). Key adaptation objectives and actions in the sector of infrastructure and housing were proposed, among others. These include:

- Produce planning and urban development master plans
- Produce land use plans
- Update planning tools to take climate change into account
- Produce land use plans for cities in the country
- Redevelop areas of makeshift housing in zones which are earmarked for housing purposes in planning documents
- Develop and protect flood areas
- Carry out an environmental, architectural and urban planning assessments for any urban or architectural development projects
- Promote the use of solar energy for disadvantaged areas and nearby public facilities

Through its activities, the NAP also promotes integrated landscape planning, especially in the sector of forestry to contribute to the adaptation of local people to changing climate conditions.

The adaptation priorities of the country have also been presented in its Intended Nationally Determined Contribution (INDC) that was submitted to the UNFCCC (United Nations Framework Convention on Climate Change) in 2015. The adaptation component of the country's INDC is similar to the content of its NAP and its Strategic Framework for Investment in Sustainable Land Management, which was validated in 2014. The document confirms that land use along with agriculture, water management, animal husbandry, biomass energy, and forests are key priority sectors for climate change adaptation for Burkina Faso (Crawford et al., 2016).

Recently, Burkina Faso developed a new National Plan for Economic and Social Development (PNDES) as a national reference for interventions by the state and its partners over the period 2016-2020. The overall aim of the PNDES is to structurally transform the Burkinabe economy to promote strong, sustainable, resilient and inclusive growth while creating decent jobs for all and leading to improved social well-being (Government of Burkina Faso, 2015). The PNDES plans to address the following challenges in the field of land use planning: (i) strengthening human capacity in the field, (ii) promotion of planning and management, (iii) promotion of access to decent housing, (iv) the improvement of urban governance and (v) control of the geographical extension of the city of Ouagadougou.

Payment for ecosystem services

Payments for Ecosystem Services (PES), also known as payments for environmental services, are incentives offered to farmers, communities and landowners in exchange for managing their land sustainably and for providing some ecological services, such as the conservation of natural resources by reducing land degradation, deforestation or by increasing reforestation.

Guigonan et al. (2019) recently conducted a study on reducing hunger with payments for ecosystem services in Burkina Faso through the use of a Randomized Controlled Trial (RCT) which allows for the causal estimate of PES payments on food security outcomes. According to Guigonan et al. (2019), 630 local populations living near the project forests were involved in the reforestation campaigns. The reforestation campaigns started with 33,500 new trees being planted in August 2017 across 62 reforestation places in 11 gazetted forests in Burkina Faso. Subsequently, half of 630 community members who were both interested in and eligible to participate in the project were randomly assigned to the PES scheme and the other half were assigned to the control group. Contracts were signed between each maintenance group and the implementing government agency stipulating that

each group would receive about 0.70 US Dollars for every tree still alive at verification almost a year later (in June 2018), and they made sure the payment was divided equally among all five members of each group.

Providing access to markets and agricultural advisory services

Several projects and programmes implemented in Burkina Faso are intended to enable access to markets and provide advisory services to farmers. In 2009, the government of Burkina Faso entered a five year contract with the Millennium Challenge Corporation (MCC) programme. The contract was renewed in 2018 for five additional years. Through projects (ADP, rural land governance and roads project), MCC seeks to secure farmers' livelihoods and alleviate poverty by providing equipment, infrastructure, assistance, training, strengthening of farming capabilities, and increasing access to markets (Ksoll et al., 2019; Soeters et al., 2017). According to several authors, many agricultural advisory services have been provided to farmers by agricultural extension agents, but farmers also organize themselves to share climate smart agriculture practices. Many agricultural advisory services exist, including

i) agricultural extensions which are about sharing research results and know-how with farmers,

ii) family farm advice, a comprehensive approach that strengthens the capacity of farmers and their families to monitor their activities, analyse their situation, plan and make choices, and evaluate their results,

iii) organizational advice aimed at collective organizations and farm schools that aims to promote cross-learning processes between farmers, technicians and sometimes researchers and is based on situation analysis for decision-making,

iv) management advice to family farms that aims to strengthen the capacity of farms to manage their resources according to their objectives and the means available through technical, economic and financial analyses,

v) innovation platforms, promoted by international research and non-governmental organizations which have been adopted by several institutions (FARA, CORAF/WECARD, etc.) that bring together actors in a sector to resolve technical and organizational issues,

vi) farmers to farmers council, a method of mutual learning through action where a group of twenty to thirty farmers from the same village (including women) is formed to question local agricultural practices, set up crop trials and exchange experiences,

vii) consulting, information and communication technologies (ICT) are consulting services via telephone platforms (SMS), producer WhatsApp groups, online resource centres, etc. Their main purpose is to disseminate information on prices, weather, and production techniques.

Securing land tenure

The initial version of agrarian and land reform (RAF) in Burkina Faso was promulgated in 1984. The RAF defines a national land tenure domain including all lands of Burkina Faso, which remain exclusively public property (Dialla, 2016). No transfer of land on a private basis is allowed. This has put the majority of rural stakeholders in a precarious situation. The current land legislation of Burkina Faso has been revised three times, in 1991, 1996 and 2012. Land tenure security became possible in rural areas with the passage in 2009 of a law related to rural land tenure systems and the adoption of the 2012 revised version of the RAF. Now, lands from the land tenure domain can be fully granted to individuals in rural areas. However, many problems persist in the application of land legislation in rural areas. For

example, some legal actions have not been taken and some institutions and structures have not been put in place on time (Dialla, 2016).

The elaboration of the National Rural Sector Program II (PNSR II) expresses the will of the government of Burkina Faso to deal with issues specific to rural areas. The objective of PNSR II is to ensure food and nutrition security through the sustainable development of an agro-silvo-pastoral, fisheries and wildlife sector that is productive, resilient and more market-oriented (Burkina Faso, 2018). The PNSR II is made of 6 axes of which the fifth especially targets land tenure security in rural areas. The strategic objective of the axis is to ensure secure agricultural investments, develop agricultural professional training and support the organization of the rural world. It also aims to ensure the implementation of national policy on land security in rural areas. Indeed, Burkina Faso has a national policy of land security in rural areas (PNSFMR) that aims to make sure that all rural actors have the same access to land, the guarantee of their investments, and to effectively manage land conflicts, contribute to the reduction of poverty, the consolidation of social peace and the achievement of sustainable development. However, climate change is poorly taken into account by these policies.

Empowering women

Burkina Faso has enacted several policies leading to female empowerment. Several approaches have been developed to include women in the design and the application process of the development strategy by promoting their involvement in social, economic and political activities (Midgley et al., 2012). For instance, the gender and development approach is aimed at not only reducing gender-biases but also promoting equitable development.

More recently, actions or policies carried out within the framework of women's empowerment are related to the Sustainable Development Goals (SDGs). These actions aim to improve women's living conditions. However, it should be noted that these actions, although directly related to the SDGs, are nevertheless indirectly linked to combating climate change. These include, among others:

i) promoting gender mainstreaming through its integration into planning,

ii) budgeting and policy implementation systems at all levels,

iii) improving equal access of men and women to decision-making spheres,

iv) developing opportunities for employment, self-employment and income growth in a gender-sensitive manner,

v) strengthening gender equality and equity and empowering women e.g. facilitating equal access to basic services such as healthcare, education, and safe drinking water,

vi) providing producers, especially women, with agricultural materials through the programme to strengthen agricultural mechanization in order to ensure food security, and

vii) establishing a special window of opportunities to support women's entrepreneurship in order to boost the activities undertaken by women.

5. Evaluation of existing major policies, codes and investments

For many years now, political and administrative authorities have taken appropriate measures to address the issue of climate change. Thus, the government of Burkina Faso has been committed for several decades to the protection of its environment and the sustainable management of its natural resources. The 1991 Constitution of Burkina Faso (National Assembly 1991) provides that environmental protection is a matter of law. The preamble that introduces the fundamental law affirms the awareness of the Burkinabe people with regard to "the absolute necessity to protect the environment". In its title on fundamental rights and duties, the Constitution clearly states that, "the right to a healthy environment is recognized" and "the protection, defence and promotion of the environment is a duty for all". The main policies, strategies, plans and programmes within the framework of the environmental protection dynamic in Burkina Faso are the following:

Under policies and codes, there are:

- National Environmental Policy;
- National Forest Policy;
- National Sustainable Development Policy;
- Forestry and Environmental Codes;
- Sustainable Development Policy Act;
- Country Resilience Priorities.

Under the strategies, there are:

- Strategy for Accelerated Growth and Sustainable Development (SCADD);
- National Environmental Education Strategy (NEES);
- Burkina Faso's National Biodiversity Strategy and Action Plan;
- National Strategy for the Implementation of the United Nations Framework Convention on Climate Change;
- Strategy for the Concerted Implementation of the Rio Conventions;
- National Strategy for the Prevention and Management of Risks and Disasters.

Under plans and programmes, there are:

- National Environmental Action Plan (PANE);
- Environmental Plan for Sustainable Development (PEDD);
- Forest Investment Programme Investment Plan;
- National Adaptation Plan (PNA);
- Sectoral National Adaptation Plans for the agriculture, livestock, water, environment, health, energy, infrastructure and housing sectors.

These policies and strategies have been operationalized through the formulation of the sectoral programmes and projects below:

- National Forest Management Programme (PNAF);
- National Action Programme to Combat Desertification (PAN/LCD);

- National Rural Sector Programme (PNSR);
- National Action Programme for Adaptation to Climate Variability and Change (NAPA);
- Forest Investment Programme (FIP)
- Economic and Social Development Plan (PNDES)

The last strategy, PNDES (2016-2020), in its strategic axis 3 "Boosting the sectors that are promising for the economy and jobs" has adopted a specific objective directly related to the environment entitled "Specific Objective 3.5: Reverse the trend of environmental degradation and ensure sustainable management of natural and environmental resources". In this regard, the expected effects are formulated as follows: "EA 3.5.2: Capacities to mitigate and adapt to the adverse effects of climate change are strengthened with a view to the transition to the green economy."

Some of these policies, programmes and strategies are evaluated below for the relevant sectors.

5.1 Agriculture

5.1.1 National Action Program for Adaptation (NAPA)

NAPA was developed and adopted in 2007 to enable Burkina Faso to cope with climate change (Table 1). NAPA is seen as an instrument that allows the country to anticipate and mitigate the adverse impacts of climate change on the most vulnerable development sectors including, among others, agriculture.

The development of NAPA followed a participatory process involving different actors such as experts in the sector, decision and policy-makers, field technicians, farmers and local communities (SP / CONEDD, 2007). NAPA aims at identifying priority actions based on urgent and immediate adaptation needs of vulnerable populations. NAPA initially had 12 short-term projects adapted to the priority areas and budgeted at 5,896,884 USD. Due to financial limitations, three projects were finally selected on capacity building, agricultural activity and awareness raising. These three projects operated in tandem in order to improve their implementation, as they are complementary and are respectively designed to increase awareness of the impact of climate change, test best practices or adaptation technology packages and underpin strategic planning that takes climate change into account (NAP, 2015).

Evaluation of NAPA implementation revealed that the implementation of the three projects has enabled capacity building of many local actors across the 13 regions of the country and improved inter-institutional communication. The material and technical support to the agro-silvo-pastoral sector enabled reduction of the vulnerability of this sector by implementing numerous technological packages (recovery of degraded lands, production and preservation of fodder, etc.) and reinforcing the capacity of stakeholders, including technical services and NGOs to mainstream climate change into strategic development plans. However, NAPA has encountered numerous challenges in both the formulation and implementation stages including: (i) delays during formulation; (ii) insufficient account being taken of climate change in development policies and strategies; and (iii) insufficient financing during implementation (Table 1).

5.1.2 The Strategic Framework for Poverty Reduction (CSLP)

The CSLP was adopted in 2000 and revised in 2003 (Table 1). This instrument, which aimed to reduce poverty, was also a tool against the negative effects of climate change on important sectors such as agriculture. In fact, by minimizing poverty, especially in rural areas, the CSLP contributes to enhancing the adaptation capacities of local populations to climate change. The overall cost of financing the

investment strategy during the period 2004-2006 is estimated at 1035.9 billion FCFA, or 345.3 billion FCFA on average annually (Burkina Faso, 2004). But many difficulties and insufficiencies were noted in the CSLP, leading to questions about its ability to positively influence the economic development of the country. Many groupings and instabilities were found in the choices of composition of documents, in institutional structures or in the quantitative instruments used because the solutions adopted are not satisfactory for programming and monitoring public policies. The vagueness of the recommendations actually lead to multiple technical attempts, reforms and negotiations involving national administrations and donors in the perpetual search for an operational CSLP (Samuel, B., 2009). The lack of efficient results in poverty reduction constitutes a key weakness for the CSLP. Furthermore, efforts to implement decentralization policies were considered insufficient, and coordination, monitoring and interpretability of indicators was questioned by both donors and development analysts (Samuel, 2009; Habas, 2014). The insufficiencies of the CSLP have favoured the elaboration of a new policy, the "Strategy for Accelerated Growth and Sustainable Development (SCADD)".

5.1.3 The Strategy for Accelerated Growth and Sustainable Development (SCADD)

SCADD appears as a continuity of the CSLP and was adopted in 2011 (Table 1). This instrument aimed to intensify growth and promote lasting development, and especially the building of a modern society and solidarity (SCADD, 2011-2015). The overall cost of the SCADD envelope for the period 2011-2015 was estimated at 1.483 billion euros. The SCADD integrated an important agricultural component, particularly with the development of economic growth poles, like the Bagré pilot project, BAGREPOLE, which must serve as a functional model for other hydro-agricultural zones. Agriculture is the sector in which specific measures and targets to address adaptation are proposed by the SCADD. It called for the development of a sector-specific adaptation strategy and sets a target to increase the proportion of irrigated compared to rain-fed agriculture to 50% by 2015. Achieving a growth rate of 10% and reducing extreme poverty and hunger seem to be the main actions that will help reduce the vulnerability of the agricultural sector to climate change (Crawford et al., 2016). The SCADD faced some difficulties related to lack of financial resources, lack of coordination, lack of anticipation and lack of human resources and materials.

5.1.4 The National Rural Sector Program I (PNSR I)

In order to ensure greater coherence between the different policies and strategies of the rural sector, the National Agricultural Sector Program (PNSR) was initiated in 2010 for the period 2011-2015 (Table 1). Adopted in December 2012, its goal was to contribute in a sustainable manner to food and nutrition security, strong economic growth, and the reduction of poverty (Burkina Faso, 2011). Among other goals, the PNSR aims to federate investment actions in the subsectors of crop production, animal resources, fisheries resources, wildlife and the environment. The PNSR was structured in 13 sub-programmes grouped around 5 axes. The total cost of PNSR was approximately 1,230,408 million FCFA over the period 2011-2015 (Burkina Faso, 2011). The general observation is that most of the consultation frameworks put in place for efficient implementation of the PNSR do not operate due to lack of financial resources. Also, some consultation frameworks do not associate the real actors with the discussions, and from this emerge many difficulties in the implementation of the recommendations. However, climate change is poorly considered by these policies.

Tab 1: Summary of strategies or existing major policies and investments in the agriculture sector

Sector	Existing policy	Developed/Adopted	Objectives	Period	Budget	Difficulties Faced
Agriculture	National Adaptation Action Program (NAPA)	2007	To enable Burkina Faso to cope with climate change		US $5,896,884	- Delays during formulation; - Insufficient account taken of climate change in development policies and strategies; - Insufficient financing during implementation
	Strategic Framework for Poverty Reduction (CSLP)	2000 (revised in 2003)	To contribute to strengthening the adaptation capacities of the local population to climate change	2004-2006	1035.9 billion FCFA	- Lack of efficient results in poverty reduction - Vagueness of the recommendations lead to multiple technical attempts, reforms and negotiations - Many groupings and instabilities are found in the choices of composition of documents
	Strategy for Accelerated Growth and Sustainable Development (SCADD)	2011	To accelerate growth and promote sustainable development, and especially the building of a modern society and solidarity	2011-2015	1.483 billion euros	- Lack of financial resources - Lack of coordination - Lack of anticipation - Lack of human resources and materials
	National Rural Sector Program I (PNSR I)	2012	To contribute in a sustainable manner to food and nutrition security, strong economic growth, and the reduction of poverty	2011-2015	1,230,408 million FCFA	- Lack of financial resources - Some consultation frameworks do not associate the real actors with the discussions

(authors' elaboration)

5.2 Land use

5.2.1 The National Rural Sector Program II (PNSR II)

The elaboration of the PNSR expresses the will of the government of Burkina Faso to deal with issues specific to rural areas. The first phase of the programme was in the period 2011-2015 (PNSR I), and second over the 2016-2020 period (PNSR II). The objective of PNSR II was to ensure food and nutrition security through the lasting development of an agro-silvo-pastoral, fisheries and wildlife sector that is productive, resilient, more market-oriented (Burkina Faso, 2018). The PNSR II is made of six axes of which the fifth especially targets land tenure in rural areas. The strategic objective of the axis is, among others, to ensure secure agricultural investment and develop agricultural professional training and support the organization of the rural world. It also aims to ensure the implementation of the national policy of land security in rural areas. The total cost of the first PNSR was estimated at 1376.8 billion FCFA over the period 2011-2015 and represented 18.4% of the overall cost of the SCADD (Burkina Faso, 2018). The PNSR II has a total estimated cost of around 3,620 billion FCFA over the 2016-2020 period. Despite a fairly good level of robustness of the PNSR, deficiencies in its implementation did not permit it to remove major constraints in the development of rural sectors.

5.2.2 The National Policy for Rural Land Securitization (PNSFMR)

The PNSFMR commenced in 2007 and was predicted to finish in 2017. The objective of this policy is to warrant that all rural actors have fair access to land, to guarantee their investments and to effectively manage land conflicts, to contribute to the reduction of poverty, to consolidate social peace and to achieve sustainable development. Through the adoption of the PNSFMR, the government intends to make available to all public and private actors a coherent policy framework of reference and an effective tool for action (Burkina Faso, 2014). The key positive result of the PNSFMR is the adaption of the 034-2009/AN rural land securitization law in 2009 (Bazame et al., 2017). Nonetheless, land management institutions and related tools have not been sufficiently established. Indeed, out of 351 total municipalities, only 48 have Rural Land Securitization Service (Hochet et al., 2014). Moreover, the planned Rural Land National Agency (Agence Nationale des Terres Rurales-ANTR) and Land Securitization Fund (Fond se Sécurité Foncière Rurale-FSF) are not yet established.

5.2.3 The Housing and Urban Development Policy (PHDU)

The PHDU was developed for the period 2008-2018. The general objective of the National PHDU is to create the conditions to improve the living environment of the population by strengthening the contribution of cities in the fight against poverty (Ministère de l'Habitat et de l'Urbanisme, 2008). Through this policy, in urban settlements, priority is given to land management, zoning plan establishment and housing production. Nevertheless, in several municipalities, there is an excess of land parcels and technical and legal issues in the implementation of zoning plans. In 2015, only 12 Master Plans for Urban Development had been approved and two soil occupancy plans were pending approval in cities (United Nations-Habitat, 2015). The key urbanization problems of the country are: failures in subdivision plans, widespread land speculation, uncontrolled extension of urban areas and deficiencies in urban infrastructure and services (Bazame et al., 2017).

5.2.4 The National Program for Land Management II (PNGT II)

The PNGT in Burkina Faso was established to reduce rural poverty and contribute to the promotion of lasting development in rural areas. Its objective was to break the spiral of rural poverty characterized by the degradation of natural resources, reduction of agricultural production and poor quality of life. The PNGTII started in 2002 for 15 years. The project was designed by the World Bank, which acted as the main co-financer and contributed US $66.7 million towards total costs of approximately US $114.9 million (IFAD, 2008). Regarding land use, the PNGT contributed to the establishment of land institutions at the base of management of land and natural resources. These actions of the PNGT laid the foundation for the establishment of the "Comité national de sécurisation foncière en milieu rural" (CNSFMR). On agricultural land use, the PNGT favoured the intensification of the use of soil and water conservation measures, which contributed to improved food production, soil fertility, vegetation cover and crop yields. Some insufficiencies have been observed. Certain actions to delimit the axes of movements of herds or agricultural areas to secure grazing have had undesired effects. Besides, the reflection on the use of village and inter-village areas has made very little progress. This could have negative consequences on pastoralist communities including destruction of boundaries and deterioration of relations between women and children from different communities.

Tab 2: Summary of strategies or existing major policies and investments in the land use sector

Sector	Existing policy	Developed/Adopted	Objectives	Period	Budget	Difficulties Faced
Land use	National Rural Sector Program II (PNSR II)	2016	To ensure food and nutrition security throughout the sustainable development of an agro-silvo-pastoral, fisheries and wildlife sector that is productive, resilient and more market-oriented	2016-2020	3,620 billion FCFA	- Deficiencies during implementation
	National Policy for Rural Land Securitization (PNSFMR)	2007	To ensure that all rural actors have equitable access to land, to guarantee their investments and to effectively manage land conflicts	2007-2017	---	- Problem of rural Land Securitization Service - Delay in the establishment of the planned Rural Land National Agency and Land Securitization Fund
	Housing and Urban Development Policy (PHDU)	2008	To create the conditions to improve the living environment of the population by strengthening the contribution of cities in the fight against poverty	2008-2018	---	- Failures in subdivision plans, widespread land speculation, uncontrolled extension of urban areas, deficiencies in urban infrastructure and services - Problems in implementation of zoning plans
	National Program for Land Management II (PNGT II)	2002	To reduce rural poverty and promote sustainable development in rural areas	2002-2017	US $114.9 million	- Little progress in reflection on the use of village and inter-village areas

(authors' elaboration)

5.3 Food Security

In Burkina Faso, social protection policies related to food security play a fundamental role in the population's well-being. Studying these policies and their implementation benefits organizations working on food security in the region and can help design crisis response and local development strategies.

5.3.1 Resilience and Support Plan for Vulnerable Population

From 2013 to 2014, the government of Burkina Faso introduced the Resilience and Support Plan for Vulnerable Population or *Plan de Résilience et de Soutien aux Populations Vulnérables* (PRSPV) and the Resilience and Support Plan for Vulnerable Population to Food and Nutritional Insecurity Population or *Plan de Résilience et Soutien aux Populations Vulnérables à l'Insécurité Alimentaire et Nutritionnelle* (PRSPVIAN). The programme aims at ensuring vulnerable communities have food security. The government food security programme had a budget of US $83.3 million. The programme provided for the sale at social prices of cereals in certain localities was previously identified as being at risk. The distribution of free food and food tickets, "food for work" and "cash-for-work" operations and unconditional monetary transfers have benefited more than 5 million people's food security.

5.3.2 The Cereals Price Stabilization Program

The Cereals Price Stabilization Program was run by a council of ministries from September 2013 to March 2014. In Burkina Faso, population feeding is mainly based on cereals and the main goals of the programme were to make cereals available and affordable through price stabilization and regulation. The program initiated stakeholder dialogues, including with cereal traders, to fix and control cereal prices. Laws have been established to strengthen the control of cereal prices. Regular checks were carried out throughout the country. Checks mainly concerned cereals prices, quality and units of measurement of agricultural products. A total of US $8 million has been allocated to this programme. Successes have been limited. The main challenges were fund diversion, fraud and smugglers.

5.3.3 Reduction of vulnerability to climate change by strengthening food crisis prevention and management mechanisms

The overall objective of this project was to contribute to the elimination of food insecurity related to rainfall variability, mainly in the Sahel, North, Centre-North and East regions. Specifically, the project aimed to raise awareness, to inform the population and train them to cope with the risk of food insecurity related to climate change and extreme rainfall events and to strengthen the level of food stock reserves available through the promotion, organization and establishment of operational cereal banks managed by the populations of the four regions of priority. The project also provided an improved weather monitoring system of agro-meteorological conditions and the dissemination of climate and weather information and advice in national languages on weather and seasonal forecasts. It identified and mobilized endogenous financing for the sustainability of prevention and early warning systems and strengthen the existed weak link between the national monitoring and early warning system for food security. The project also helped harmonize the sectoral databases used for food security by strengthening the means of processing, analysis and wide dissemination of data and information on the follow-up of the agro-sylvo-pastoral campaign.

5.3.4 Securing grain production by promoting supplemental irrigation

The project on securing grain production ran for 5 years (2009-2014). The project's goal was to reinforce the adaptation capacities of the population by sustainably increasing and securing grain production through supplemental irrigation and by diversifying crop production in northern Burkina Faso. The project offered the opportunity to local communities to secure food security and income. Site experimentations, training of local actors and beneficiaries and stakeholder's workshops helped exchange knowledge and build confidence among beneficiaries.

Tab 3: Summary of strategies or existing major policies and investments in the food security sector

Sector	Existing policy	Developed/Adopted	Objectives	Period	Budget	Difficulties Faced
Food Security	Resilience and Support Plan for Vulnerable Populations	2013	To ensure vulnerable communities' food security	2013-2014	US $8.3 million	- Smuggling - Fraud - Diversion
	Cereals Price Stabilization Program	2013	To make cereals available and affordable	2013-2014	US $8 million	- Problem of smugglers - Fraud - Diversion
	Reduction of vulnerability to climate change by strengthening food crisis prevention and management mechanisms	-	To contribute to the elimination of food insecurity related to rainfall variability	-	-	- Failures in delivering timely climate information - Problems in implementation of the programmes
	Securing grain production by promoting supplemental irrigation	2009	To reinforce the adaptation capacities of the population by sustainably increasing and securing grain production through supplemental irrigation	2009-2014	-	- Problem of workforce to dig farm ponds - Non adoption of supplemental irrigation

(authors' elaboration)

5.4 Climate Change

The government of Burkina Faso has approved the NAPA project; the main objective of NAPA is to implement urgent and immediate climate change adaptation measures, in particular for the marginalized and most vulnerable populations. The UNDP in collaboration with SP / CONEDD has developed some NAPA adaptation action projects that have been implemented since 2009.

5.4.1 Development, sustainable management of natural resources, valuation of non-timber forest products (NTFPs) in the eastern region of Burkina Faso

The objective of the sustainable management of natural resources project was to strengthen the adaptive capacities of rural populations to the adverse effects of climate change and variability. Specifically, the project intended to sustainably develop and manage natural resources and enhance the value of non-timber forest products. The total budget of the project was US $700,000 and the activities carried out during the lifetime of the project included training management committees; identifying non-timber forest products and the species likely to be valued by local populations; identifying possible uses of non-timber forest products (traditional, culinary, artisanal and other pharmacopoeia, etc.); promoting forest products through the media; planting and assisting natural regeneration (ANR) actions with farmers' organizations and small and medium business managers and promoting family and community businesses through market analysis and development. Though the project had significant results, consumers and others key stakeholders' behaviour has led to shortcomings.

5.4.2 Promotion of wildlife and wildlife habitat management by local communities in the Mouhoun region

The goals of the Burkina Faso PANA project on the promotion of wildlife and wildlife management were i) to create and manage forests, ii) to increase households' income and their livelihoods through sustainable management and the use of wildlife resources, iii) to strengthen the capacity of populations to adapt to the adverse effects of climate variability and climate change with training and iv) to promote non-conventional breeding and monitor animal hunting. The project was implemented by the UNDP and the total estimated cost of the project was around US $810,000. Using a participatory approach, the project was to promote stronger involvement and commitment of local communities to the governance of natural resources to help protect wildlife biodiversity and to maintain its regulatory role. The project also contributed to the achievement of environmental protection and sustainable development. However, the lack of accountability and transparency during the implementation of the project prevented the achievement of some of the project objectives.

5.4.3 Development and management of the pond of Oursi

The PANA project of developing and promoting the pond of Oursi (US $275,000) aimed to sustainably improve the living conditions of the populations around the pond of Oursi. Additionally, the project wanted to restore water storage capacity as best as possible, to combat land degradation and to ensure sustainable management of the wetland. Through its planned activities the project was able to raise awareness and train actors directly involved in the integrated management of the pond.

5.4.4 Building capacity for better integration of climate change adaptation concerns to the development and implementation of plans, programmes and projects

The PANA JAPAN project was funded by Japan. The overall goal was to integrate climate change issues in the planning and decision-making processes at the national, regional and the municipal level (PANA JAPAN). Since 2009, through the PANA JAPAN project, several training workshops have been organized at all levels, both for the local population and for decision-makers. Equally, the project provided equipment to make decisions on climate change adaptation issues. For instance, 16 weather stations (10 synoptic stations and 6 agro-weather stations) have been installed. With the PANA JAPAN project, several partnerships have been signed in order to strengthen the capacities of institutions, to build and consolidate climate change related databases and to improve adaptive capacity. The partnership with meteorological services provided climate data that have been used to support farmers' decision-making processes. The Laboratory of Mathematical Analysis (LAME) at the University of Ouagadougou (*Laboratoire d'Analyse Mathematiques de l'Université de Ouagadougou*) carried out a study on climate trends and the projections using daily data from the last 30 years of weather stations. The results of climate research carried out at the national level made it possible to formulate a national medium- and long-term adaptation strategy called the National Adaptation Plan (*Plan National d'Adaptation* (PNA)). Additionally, thanks to the development of multiple partnerships between institutions, qualitative and quantitative data on the climate (30 years of daily data on maximum and minimum temperature and rainfall) have been made available for conducting climate research and carrying out climate projections. These data were used to drive the climate trend and Regional Climate Model (RCM) projections to high resolution by Cape Town University. The reliability of the data also made it possible to conduct an assessment on the vulnerability of different sectors (Agriculture, Environment, Livestock, Energy, Health, Infrastructure, Natural Disasters).

Tab 4: Summary of strategies or existing major policies and investments in climate change

Sector	Existing policy	Developed/ Adopted	Objectives	Period	Budget	Difficulties Faced
Climate change	Development, sustainable management of natural resources, valuation of non-timber forest products (NTFPs) in the eastern region of Burkina Faso	-	To strengthen the adaptive capacities of rural populations to the adverse effects of climate variability and change	-	US $700,000	- Poor behaviour of consumers and others key stakeholders
	Promotion of wildlife and wildlife habitat management by local communities in the Mouhoun region	-	i) To create and manage forests, ii) increase households' income and their livelihoods through sustainable management and the use of wildlife resources, iii) strengthen the capacity of populations to adapt to the adverse effects of climate variability and climate change by training and iv) promote non-conventional breeding and monitor animal hunting	-	US $810,000	- Lack of accountability and transparency during the implementation of the programme
	Development and management of the pond of Oursi	-	To sustainably improve the living conditions of the populations around the pond of Oursi	-	---	
	Building capacity for better integration of climate change adaptation concerns into the development and implementation of plans, programmes and projects	2009	To reinforce the adaptation capacities of the populations by sustainably increasing and securing grain production through supplemental irrigation	2009-present	-	

(authors' elaboration)

6. Conclusion and policy implications

Burkina Faso is a landlocked, low-income sub-Saharan country with limited natural resources and a low-level of human development. A common feature is the poverty shared by a large portion of the population. Nearly half of the population still lives below the poverty line. The electrification rate in the country is still very low and heavily relies on fossil fuel. In fact, 70% of the country's power generation is based on fossil fuel and comes from 28 power stations. Burkina Faso experienced land degradation in the northern region of the country as a result of the 1970s and 1980s droughts. A consequence of land degradation is the migration of vulnerable farmers from densely populated and degraded areas to the central, western and southern regions of the country, which has caused substantial Land Use and Land Cover (LULC) hanges.

Recent studies have confirmed that the country has experienced a trend of increasing temperature, highly variable precipitation regimes and an intensification of extreme events. Projected changes in Burkina Faso reveal an intensification of warming all over the country, insignificant precipitation changes and substantial increases in dry spell length and intense precipitation events in a business-as-usual world. A consequence of climate change is an increase of disaster occurrences in the agriculture, water and health sectors, among others.

Given the intensification of land degradation and the adverse impacts of climate change on natural resources, some technological, socioeconomic and policy actions have been developed for sustainable land management and climate change adaptation and mitigation. Such actions are reviewed here and they include, among others, irrigation expansion and efficiency, rainwater harvesting, crop diversification, adoption of drought-tolerant crop varieties, rotational grazing, afforestation and reforestation, livelihood diversification and migration and community collective action. To facilitate these, different policy responses have been implemented. These responses include carbon trading, land-use zoning and integrated landscape planning, payment for ecosystem services, providing access to markets and agricultural advisory services, securing land tenure and empowering women.

To facilitate responses, major policies, programmes and investments in the fields of agriculture, land use, food security, and climate change have been developed and implemented in Burkina Faso. These policies, programmes and investments have been evaluated here. They consist of the National Adaptation Action Program (NAPA), the Strategic Framework for Poverty Reduction (SFPR), the Strategy for Accelerated Growth and Sustainable Development (SCADD), the National Rural Sector Program (PNSR), the National Policy for Rural Land Securitization (NPRLS), the National Program for Land Management II (NPLM), the Resilience and Support Plan for Vulnerable Population (RSPVP) and the Cereals Price Stabilization Program (CPSP) among others.

If these policies, programmes and investments are to improve the livelihoods of local populations, help grow the economy and reduce poverty, then stronger response is needed to face the foreseen substantial increase of the adverse impacts of climate change, and to mitigate climate change as well as to tackle growing migration and terrorism.

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