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

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Mali – Land, climate, energy, agriculture and development

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Ousmane Coulibaly

Abstract

Mali is a Sub-Saharan African country with 19.1 million people. Almost half of this population lives in poverty, due to the dysfunction of activity sectors (agriculture, energy, education, employment, services, etc.). Natural resource management especially land and water together with corollaries remain one of the greatest challenges for this dryland region to sustainably face climate change, meet food demand and improve its economy. The social crisis (especially in the northern region) is significantly affecting development and human security as well. This study had been carried out to review the current state of affairs, key trends, problems, solutions and their implications for sustainable development of Mali under changing climate and the impacts of land degradation. Likewise, investment opportunities in the priority areas are highlighted in this report.

Keywords: Mali, poverty, agriculture, economy, climate change, land degradation, sustainable development.

JEL codes: O1, O2, O3, Q1, Q2, Q4, Q5, J43

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Abbreviations

AfDB	:	African Development Bank
ANPP	:	Aboveground Net Primary Productivity
ARCC	:	African and Latin American Resilience to Climate Change
FFS	:	Farmer Field Schools
GDP	:	Gross Domestic Product
GEF	:	Global Environment Facility
GHGs	:	Greenhouse gases
GIZ	:	German Corporation for International Cooperation
ICRAF	:	World Agroforestry Center
ICRISAT	:	International Crops Research Institute for the Semi-Arid Tropics
LOA	:	Agricultural Framework Law
MW	:	MegaWatt
PEN	:	National Energy Policy
PES	:	Payments for environmental services
PV		Photovoltaic
RRCs	:	Rural Resource Centers
SDGs	:	Sustainable Development Goals
SSA	:	Sub-Saharan Africa

1. Introduction

The current Malian population of 19.1 million is projected to double by 2030 at an annual growth rate of 3% according to the World Bank (2018). The population is mainly young (over 5 million people have a median age of 16 years). Over 60% of Malians do not have a formal education, and the life expectancy is 58 years (UNDP, 2016). The country ranks among the poorest in the world (182nd out of 188 countries) (World Bank, 2019). The Gross Domestic Product (GDP) per capita is 901 USD (IRENA, 2019).

The level of poverty in Mali has decreased over the past three years from 43.4% in 2017 to 41.3% in 2019 due to an exceptional increase in agricultural production (World Bank, 2019). Agriculture is reported to be one of the biggest drivers of economic growth, employing 80% of the population. Together with pastoralism, agriculture contributes to more than 40% of the GDP (UN Comtrade, International Trade Statistics, 2016). The Malian economy relies on both primary and tertiary sectors for 6% of its annual growth.[1]

The energy sector could drive economic growth. Biomass accounts for 76% of primary energy, followed by 20% of hydrocarbon imports and 4% for electricity. In Mali, the energy demand increases annually with an average rate of 7.8% while only 42% of the population (19% and 94% in the rural and urban areas, respectively) have access to it (DNE, 2016). The access to energy by rural households is very poor as the available sources (kerosene and batteries) are expensive and unreliable.

The employment sector is characterized by a weak job creation potential, the expansion of the informal sector and the increase in youth unemployment (Bastagli and Toulmin, 2014).

Land degradation has negative impacts on economic activities and livelihoods (IPBES, 2018). In Mali, land degradation is caused by poor farming practices leading to water scarcity (IPCC, 2019) and the heavy reliance on domesticated annual grasses for feed. The soils degrade through seasonal mechanical disturbances. Land degradation includes habitat deterioration, induces community exposure to wildfire and floods and the costs related to these disasters (IPCC, 2019). The impacts of land degradation on food security and poverty have also been assessed. They include the annual loss of productivity estimated at 145 million USD (4.06% of GDP), leading to hunger and an increase of food prices, thus limiting access to food (IPCC, 2019; WFP, 2019).

Moreover, despite the importance of resources committed by the Malian government to the water, hygiene and sanitation sector, the access to safe water and sanitation remains insufficient (WaterAid, 2016).

In West Africa, especially in Mali, economic growth is mainly driven by agriculture (Benjaminsen, 2002; Sanchez, 2002). However, there is a high level of food and nutritional insecurity in this country due to disadvantageous agro-climatic conditions, mainly droughts and erratic rainfalls (WFP in Mali, 2019). More than half (60%) of the population live on degraded lands (WFP in Mali, 2019).

The food industries generally use fossil-based fuel for their activities (FAO and USAID, 2015). The supply of this kind of energy is expensive and requires land and natural resources use, and contributes to climate change. A small proportion of the rural population in Mali relies on diesel generators while the majority (80%) does not have access to electricity at all.

This study focuses on a literature review that analyzes the different challenges and potential solutions faced by Mali.

Different types of documents (articles, reports and action plans) have been consulted to carry out this literature review. A critical review of the past and current research and development policies, as well as strategy and action plans dealing with land degradation, energy use, and climate change effects in

[1] www.africaneconomicoutlook.org/fr/countries/west-africa/mali/

Mali was carried out. Documents were collected from universities, research and/or development institutes as well as relevant Malian databases such as that of the National Institute of Statistics (Institut National de la Statistique, INSTAT). All informative sources were thoroughly checked to avoid mistakes. Informal discussions were held through phones, skype and emails with individuals and institutions in charge of research, development, policies for mitigation and adaptation to climate change and land management.

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

2.1. Energy use and associated challenges and opportunities

Despite the increased supply of energy in Mali in the past 15 years (Figure 1), this sector is still facing many challenges. According to the African Development Bank (AfDB, 2015), the nation-wide electricity supply enterprise Énergie du Mali SA (EDM SA) cannot sustain itself financially. Since 2013, the government has been subsidizing EDM SA despite the annual increase of electricity prices to households and enterprises. The cost of energy supply affects the poor, especially women and youth, due to gender disparities in accessing energy mainly in rural areas.

The energy situation in Mali is as follows:

The oil and gas sub-sector is mainly dependent on petroleum imports (Coulibaly and Bonfiglioli, 2018). Petroleum products account for 20% of energy sources, mainly gasoline and diesel for the transport sector. This has increased due to an ever-growing population demand and the economic opportunities. In addition, burning fossil fuels in power plants causes heavy damages to human health and climate. Climate change threatens food security in Mali through drought and floods (Goodes, 2011; Schlenker and Lobell, 2010).

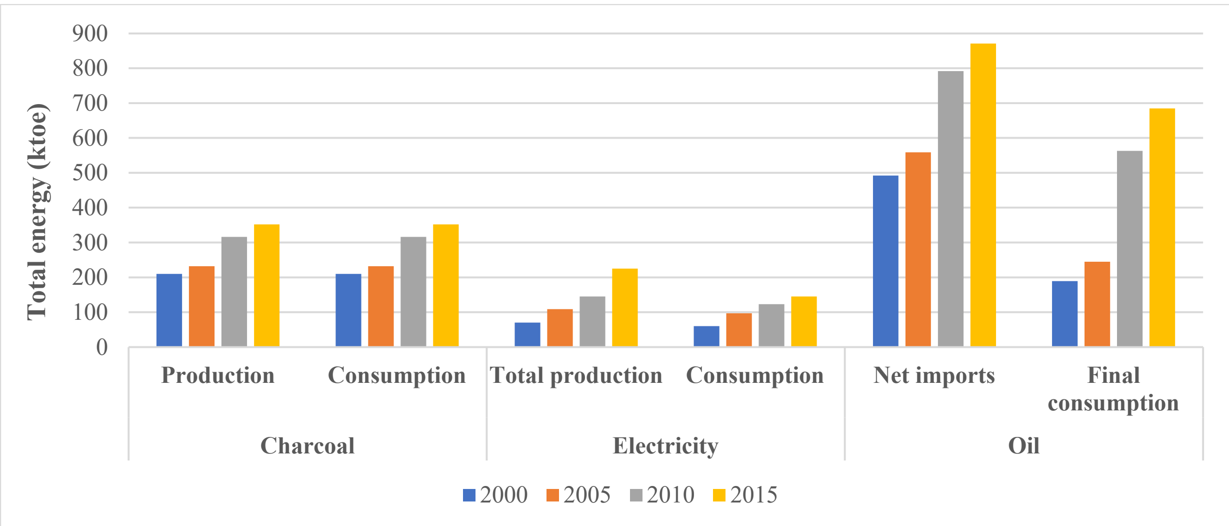
Projections regarding biofuels, mainly *jatropha,* are being challenged at the national level for their vulnerability to fluctuating oil prices as well as low grain yields which have compromised the cost effectiveness of the entire value chain. Furthermore, the overall reduction in oil price levels since 2013 has affected the financial competitiveness of biofuels as an alternative to imported fossil fuel (IRENA, 2019).

Tab 1: Electricity distribution in Mali

	National					**Urban**	**Rural**	**Population without access in 2019 (million)**
	2000	**2005**	**2010**	**2015**	**2019**	**2019**	**2019**	
Africa	36%	40%	44%	49%	56%	81%	37%	579
SSA	24%	28%	33%	40%	48%	76%	29%	578
Mali	10%	15%	27%	36%	50%	78%	28%	10

(IEA, 2020)

Figure 1: Energy statistics for Mali for the period 2000 – 2015



Source: Adapted from the African Energy Commission (AFREC, 2015)

Biomass resources such as wood and charcoal (AfDB, 2015) are the main sources of energy for about 78% of the households in Mali. Mali's total primary energy supply in 2014 was 5.1 million MT of oil equivalent, out of which 3.6 million MT (69%) stemmed from firewood and 7% from charcoal. Yet the use of biomass is reported to degrade the environment, especially forests and agricultural lands (AfDB, 2015). Malian forest areas are reported to be in perpetual decline, mainly as a result of firewood use, pastoralism and forest clearance for agriculture (SIE, 2014). Forest areas are estimated to cover approximately 33,000,000 ha (Coulibaly and Bonfiglioli, 2018). According to Mali Forest Information and Data, the consumption of fuel wood and charcoal as the main sources of household energy is estimated to be 5 million MT a year (i.e. exploitation of 400,000 ha). These figures are expected to exceed 7 million MT or 560,000 ha equivalent in the near future. The same author also forecasted that by 2030 air pollution will cause more deaths than those from tuberculosis and AIDS, and the Kerosene use for cooking and lighting will lead to respiratory infections and the risks of poisoning and fires (Morrissey, 2017). The main challenge is to ensure the sustainable use of this resource which should include the partial switching from fuelwood to modern energy sources to keep pace with the productivity of natural forests (IRENA, 2019).

The Malian energy provider services (*Énergie du Mali SA*, i.e. EDM SA, and local energy agencies) are working following a public-private partnership (PPP) framework. The electricity generation cost averages 0.24 USD/kWh at EDM SA, and about 0.47 USD/kWh at the private energy service companies (specifically the two decentralized energy providers under the AMADER mandate in Mali, *SSD Koray Kurumba* and *SSD Yeleen Kura)* (Coulibaly and Bonfiglioli, 2018).

Despite the diversity of energy sources in Mali, the electricity supplied does not meet the demand. The energy consumption across the major economic sectors, mainly the industrial sector, is low (IRENA, 2019). Around 86% of the total supply of electricity in 2014 were consumed by the residential sector (72.5%) and the transport sector (13.5%) (IRENA, 2019). The low level of energy demand in Mali's agriculture sector is reflective of traditional rain-fed agriculture practices, characterized by low productivity and production. This indicates that there is potential to mechanize the sector, increase output and therefore contribute to sustainable economic growth and transformation. Mechanization of the sector in this manner would likely increase the demand for energy. Energy also plays an important role in the quality, accessibility and reliability of health services delivered to rural communities, a major challenge in Mali and Sub-Saharan Africa (SSA) where one in four health facilities does not have access to electricity (WHO, 2014). Thus, the national electrification rate of Mali is estimated at 26% (below the SSA average of 32%) (Table 1), leaving 11 million people without electricity, mostly in rural areas (IEA, 2015). Another 800,000 people only have access to an unreliable grid (AfDB, 2015). Electricity demand increases by 10% annually but the rate of access is around 55% and 14% in urban and rural areas, respectively. The various electrification projects under the National Energy Policy (PEN) have increased the electrification rate from 1% in 2005 to 12% in 2010 and 55% in 2015 (Coulibaly and Bonfiglioli, 2018).

The energy demands in Mali can be subdivided as:

- 300 MW of electricity demand to be satisfied immediately or in the short-term network;
- 200 MW of thermal power to be replaced by other sources of energy;
- 500 MW to be satisfied in the long term for big industrial extractive and food-processing units;
- 150 MW to be rehabilitated and a fast-expanding network to support the development of the import and/or export of electric energy (EDM-SA data, 2017; BOAD, 2019).

The potential of renewable energy is important in Mali. Despite this potential, the actual use of renewable energy represents only 3% of the conventional energy use with 12 megawatts (MW). PEN has planned to increase the level of use of renewable energies in comparison to conventional energies from 3% to 6% in 2010 and 10% in 2015 (Coulibaly and Bonfiglioli, 2018).

The adoption of renewable energy-based-technology by poor people is low due to their limited financial resources. Other factors include the lack of a financial framework to promote access to renewable energy and the poor access to information on credit to access renewable energy.

Given the unreliability of some energy sources, solar energy (particularly solar photovoltaic, PV) has the greatest potential and is preferred by many consumers. The Malian National Renewable Energy Action Plan (NREAP) has set ambitious objectives for grid and off-grid systems. For a connected system, the installed capacity for renewables, including large hydro, should reach 1416 Megawatts (MW) by 2030, a nine-fold increase compared to 2010. For off-grid renewables, the installed capacity should increase from 20 MW in 2010 to over 600 MW by 2030, a thirtyfold increase over the period of 20 years (IRENA, 2019). The energy mix underwent significant changes, with the contribution of hydroelectric power dropping from 80% in 2005 to 45% in 2015 and the contribution of thermal plants doubling to reach 41% over the same period (BOAD, 2019). The hydroelectric potential capacity is estimated at 1,050 MW with an annual average energy generation of approximately 5,000 GWh (IRENA, 2019). The level of funding of electrification projects is highlighted in Table 2.

Tab 2: Selected investments in Mali's energy sector

Plant	**Technology**	**Investment (millions of USD) or supports**	**Status**
Scatec solar (Ségou region)	Solar PV	55	BOOT signed 2015
Akuo Energy	Solar PV	105	BOOT signed 2015
Sikasso area	Solar PV	55	Procurement ongoing
Koutiala area	Solar PV	27	Procurement ongoing
Markala	Hydro	35	BOOT signed 2010
Kénié	Hydro	120	BOOT signed 2015
Sotuba II	Hydro	30	BOOT signed 2015
Mali's Rural Electrification Fund (REF)	Solar PV	182	-
	Hydro	210	-
Country level	Renewable Energy	3.3	2008
		6.7	2010
		8.9	2011
		21.2	2018
Total subsidy received by EDM		106.7	2014
		78.5	2015
		62.9	2016

(API, 2017; IRENA, 2019; GlobalData, 2019)

GSMA (2017) concluded that there is a major opportunity for Mali to develop its energy resources to cover the needs of the remaining 12 million people living without electricity. GSMA had carried out surveys which results show that:

(i) Mali has a robust network of mini-grid installations across the country but mainly in the southern regions of Kayes, Sikasso, and Koulikoro with a high population density and many businesses requiring energy for their operations.

(ii) While mini-grids have been installed since the 1990s, a few decentralized energy providers have been exploring the opportunities of using solar energy to cover household needs during the past 2 decades.

(iii) The usefulness of mobile network in both the business model and development of technology for mini-grids and solar home systems is proven. Leveraging mobile money and machine-to-machine (M2M) platforms, as well as strong mobile network operator (MNO) brands and marketing expertise are valuable devices providers that could help to scale services in Mali.

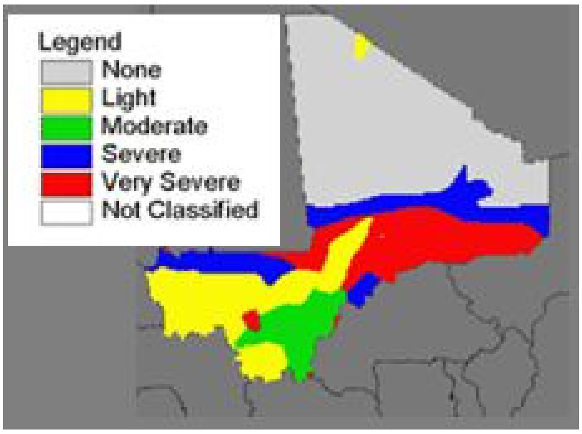
2.2. Dynamics of land degradation, land use and land cover changes over the previous 30 years

Anthropogenic activities are key sources of environment degradation around the major cities in Mali (PANA, 2006). Thanks to land and water resources, the country has agricultural potential (DLEC, 2018). With 6.4 million ha of arable land, Mali is ahead of its neighbors Senegal (3.2 million ha) and Côte d'Ivoire (2.9 million ha). Similar to other SSA countries where agriculture is the main economic growth driver (Benjaminsen, 2002; Sanchez, 2002), the land degradation and the connected loss of soil fertility (Figures 2-3) lead to the decrease of yield and food production (Sanchez, 2002; Drechsel et al., 2001; Kaya et al., 2000). The increase of areas under cotton mono-cropping since the late 1950s is decreasing soil fertility. The consequent decrease in soil fertility is projected to drop below the threshold at which the agricultural viability becomes vulnerable (Kidron et al., 2010). The irrigation initiative in Mali to extend cotton production during the period 1935–1965 led to significant land degradation (Figure2). The excessive irrigation of 55,000 ha in the River Niger area, especially in the "Delta Mort", without effective drainage systems influenced the groundwater rising from 30–40 meters to the land surface 20–30 years later. Resulting chemical disorders have been widely reported. A study by Bertrand (1985) found that the unsuitability of the land irrigation systems caused severe soil instability in addition to alkalinization, salinization and sodification. Several other publications such as N'Diaye (1987), Sidibe (1987), Dicko and N'Diaye (1994) confirmed Bertrand's results. It is concluded that secondary salinization is mainly caused by irrigation (ICBA, 2015).

A key challenge in Mali is natural habitat protection. Between 1975 and 2013, the population increase in combination with agricultural expansion caused the decrease of both gallery forests and savannas. This deforestation contributes to the removal of the topsoil due to water erosion which finally leads to the reduction of land productivity (Figure 3). Approximately 90% of Malians use forests resources as their source of energy (600,000 tons of wood are transported to Bamako each year). Pastures used for livestock lead to degradation and deforestation (100,000 ha per year) (Atkins, 2006). However, the swamp forests located in natural depressions are not affected.[2] Dust storms are an important factor of land degradation. According to Liniger and Studer (2019), 25% of dust storm events are caused by anthropogenic activities. This rate is expected to increase due to the reduction of vegetation cover and unsustainable land use. The lack of grasses and other plant species favors wind erosion moving topsoil particles. The dust storms from the alluvial sediments of the inland region of Niger River near Mopti are caused by livestock disturbance (Nickling and Gillies, 1993). The major dust storms in Mali are observed along this region (Al-Dousari et al., 2013). Data collected from the major dust trajectories of the desert of the western and southern Sahara have shown that the Niger River has the highest rate.

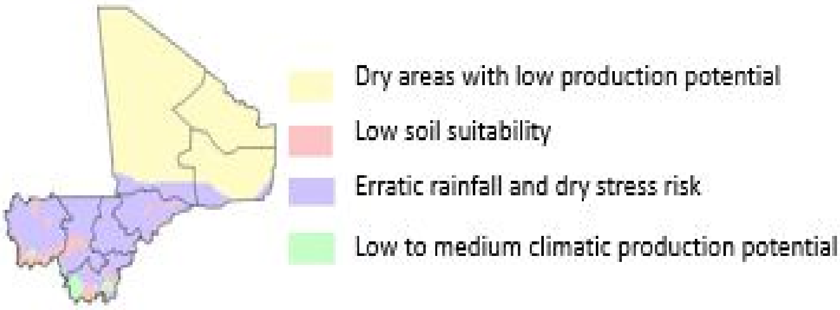
[2] https://eros.usgs.gov/westafrica/land-cover/land-use-land-cover-and-trends-mali

Figure 2: Severity of human induced soil degradation in Mali



Source: ARCC, 2014

Figure 3: Mali's productive land



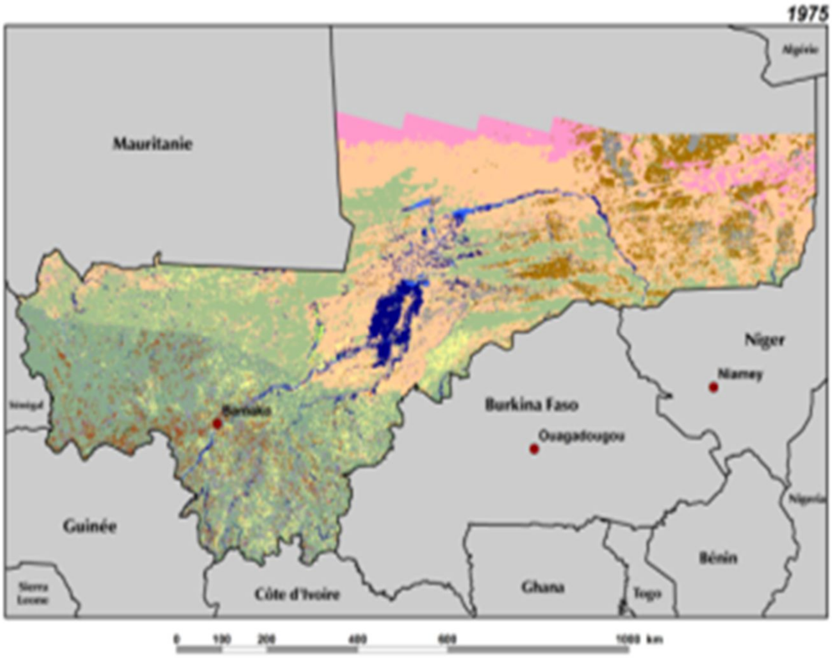
Source: ARCC, 2014

The Agricultural LAnd DYNamics (ALADYN) model developed by Grinblat et al. (2015) and tested in the savanna around Kita, Mali (Kidron et al., 2010), aimed to establish the relationships between landscape and socioeconomic factors (Lambin and Geits, 2001). This study concluded that agriculture cannot meet the needs for food security due to land degradation. Food security will require remittances from emigration and other sources of income for access to food. This model, compared to the remote sensing data of 2003, showed a gap between the projected area to be cultivated and the area that is actually being cultivated (Kidron et al., 2010).

Satellite imagery showed that more than 90% of available land is in use (IFAD, 2017). According to a recent mapping, important losses have occurred over the past 38 years in the Malian predominant land cover classes: Steppes (30%), Sudanian savannas (18.5%) and Sahelian short grass savannas (15%) (IFAD, 2017) (Figures 4-6). Dardel et al. (2014) demonstrated that herbaceous vegetation was resilient to mass collection during the period 1984-2010 in the Gourma region by using the long-term field observations approach combined with the remote sensing (GIMMS-3g Normalized Difference Vegetation Index) to test the Aboveground Net Primary Productivity (ANPP), RUE (Rain-Use-Efficiency) and the ANPP residuals.

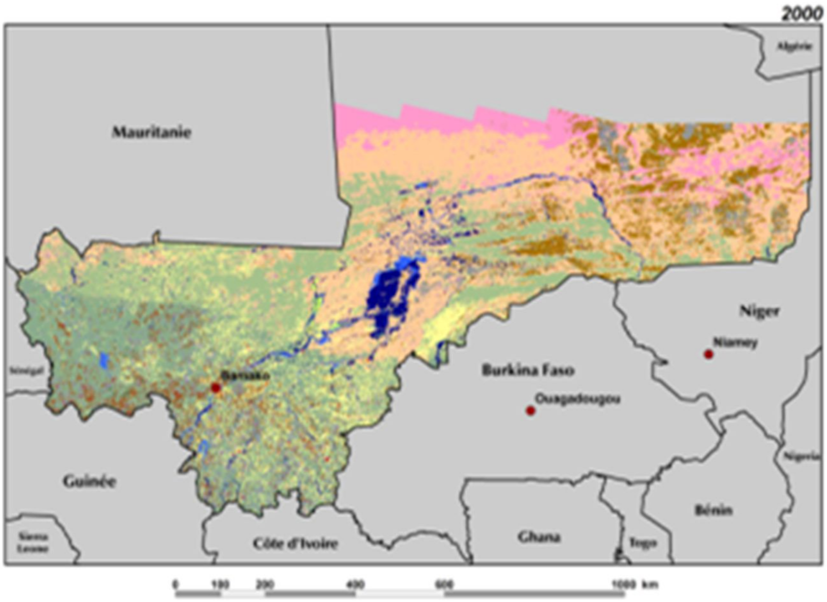
According to the FAO (2001), the northern semi-arid belt between Gao and Mopti, including the whole Seno zone and parts of the Gourma and Office de Niger Zone, are the most susceptible to degradation. Long-term field observations of the herbaceous layer mass of the Gourma region in Mali (1984–2011) showed a variability of 59%. Re-greening is observed on sandy soils in the Gourma, which is a more pastoral zone, confirming the resilience of ecosystem to the 1980s' drought and an ability to respond to the more favorable rainfall of the 1990s and 2000s.

Figure 4: Mali land cover 1975



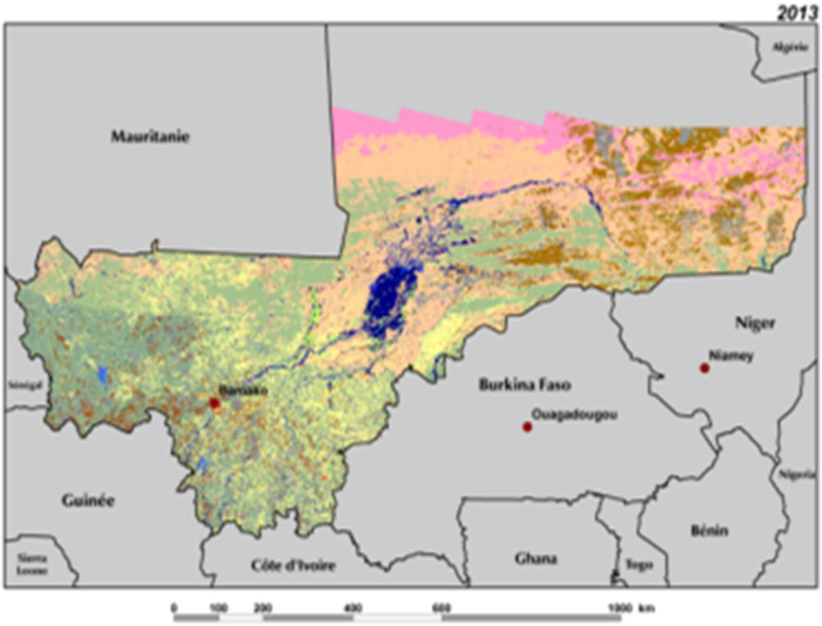
Sources: African and Latin American Resilience to Climate Change (ARCC, 2014)

Figure 5: Mali land cover 2000



Sources: African and Latin American Resilience to Climate Change (ARCC, 2014)

Figure 6: Mali land cover 2013



Sources: African and Latin American Resilience to Climate Change (ARCC, 2014)

2.3. Causes and impacts of land degradation on dimensions of sustainable development

External factors are the main drivers of land degradation directly or indirectly affecting land and its associated resources, especially soil, water, and biodiversity (UNCCD, 2017). The unsustainable use of these resources leads to local land degradation (UNCCD, 2017). Land degradation, climate change and loss in biodiversity are damaging human wellbeing and constantly reducing land resources productivity and availability (CSD, 1996). Over the period 2010–2050, climate change, agriculture, including slash and burn practices and infrastructure development, are projected to induce heavy biodiversity loss (Van der Esch et al., 2017). Agriculture is the biggest cause of biodiversity loss to date in Mali, followed by infrastructure, urban encroachment and climate change. The land degradation drives risks such as increased habitat degradation, wildfire, floods and high costs of disasters and their management. Food insecurity can result from land degradation and manifests as exposure of the population to hunger risks, soaring food prices and stunted growth among children (IPCC, 2019).

Based on climatic, geographical and soil conditions, Mali can be divided into four zones, including the Saharan zone (covering 51% of the national territory and corresponding to the northern part of the country); the Sahelian zone covering 23% of the territory including the Sahelo-Saharan zone in the north and the Sahelo-Sudanese zone in the south; the Sudanian zone accounting for 17.5% of the territory representing the most suitable agricultural area; and the Sudano-Guinean zone in the extreme south of the country covering 6% of the territory (IFAD, 2017).

3. Observed and projected impacts of climate change

3.1. Observed and projected trends in extreme weather events

Mali can be divided into four climatic zones: the Sahara with less than 200 mm of annual rainfall; the Sahel and the Sudan receive between 200 to 600 mm and 600 to 1000 mm, respectively; and the Sudano-Guinean, almost disappearing, has over 1000 mm. During the period from the late 1960s to the mid-1980s the level of rainfall has decreased while the temperature has increased, entailing severe drought (Birkel and Mayewski, 2015). The rainy season in Mali is between June and September, with more than 500 mm of rainfall received in this period, providing water to crops and livestock (USAID, 2012). This level has significantly decreased over time, especially in the west of the country (USAID, 2012). According to USAID (2018a), the annual mean temperature increase was 0.7°C since 1960. The weather conditions varied (hot night and dry spell frequency increase and cold nights every time except December–February decreases) but rainfalls are projected to increase in the South and decrease in the northern part of Mali with a less certain trend. This translates to Mali becoming drier overall, with rain in the southern part of the country being delivered in fewer days of higher rainfall, and more evenly but at a reduced rate in the northern part of the country (FEWSNET, 2016; Johnston et al., 2011). Temperatures in Mali are projected to rise by 1.2°C to 3.6°C by 2060, especially in the central regions (Mopti, Gao) and southwest (Kayes) (USAID, 2018a). Heat wave duration will also rise while the length of cold spells will reduce. Heavy rainfall is known as a trigger for flood events and land degradation phenomena (Padgham et al*.,* 2015).

Moreover, Northern Mali is projected to be subjected to accelerated desertification and the South to more frequent heavy weather events including floods and droughts (USAID, 2018a). In the review by Druyan (2011), while some studies project a wetter Sahel (e.g. Maynard et al., 2002), others clearly project evidence of drying during the second half of the 21st century leading to increasing drought risk (Held et al., 2005), intensified by the climate-dependent livelihoods and low asset bases.

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

Mali's agriculture is predominantly rainfed (95%). Reforms in the agriculture sector have increased the annual cereal production from 2,6 million tons to 6,4 million tons between 2001 and 2011. However, food insecurity remains due to population growth, informal trade and unregulated exports to nearest countries (Reuters, 2017). Livestock is likely to experience heat stress and a drop in productivity due to increasing temperatures (IRIN. 2012). In Mali, 25% of the households are considered gravely food insecure, and one in three children under the age of five is affected by stunting. The susceptibility to diseases is also increased by malnutrition. Predictive figures show that 250,000 children will suffer from stunting while another 200,000 will be malnourished and over 100,000 will become anemic in the pastoral-farming transition zone of Mali by 2025 (Jankowska, 2012). The climate change effects on human health are manifested through climate-sensitive diseases, food and waterborne illnesses. The diarrheal disease rate is high in Mali. This is due to the fact that only 25% of the population use improved sanitation facilities (CDC, 2012). While incidences of diarrheal disease declined by 32% between 2005 and 2016, higher temperatures and elevated flood risks may have enhanced pathogen transmission (Mellor et al., 2016). Decreased agricultural production as a result of climate stress has increased household food insecurity (USAID, 2018c). Bamako, the capital city of Mali, and surrounding cities source potable water from the Niger River, which is threatened by pollution (artisanal mining, industries, plastic bags, etc.).

Increased irrigation raises the demand for water during the dry season, but the longer-term implications of water allocation decisions and climate change on water availability need further study (USAID, 2013). Reduced run off is expected in the basin of the Bani River, a branch of the Niger River crossing Mali, due to declining rainfall and increased evaporation.

Desertification, drought, and the expansion of armed groups in northern Mali has altered pastoralists' range and pasture access which, again, contribute to more herder-farmer conflicts (Sogoba et al., 2014). Higher temperatures and lower rainfall may contribute to decreased vegetation, affecting grazing potential and fodder production.

Land fisheries are affected by increasing temperatures, which alter water quality and dissolve oxygen content in lakes, harming fish reproduction, survival and virility. The vulnerability is also demonstrated by migration in West Africa, as female-headed households are left by male relatives who migrate to other regions to find work and do not send remittances back to their families (Simonsson, 2005). Water stress leads to internal migration and conflict between farmers and pastoralists (USAID, 2013). Conflict constrains pastoralists' mobility and affects agricultural production and market access by disrupting supply routes and causing a shortage of labor, including among agricultural extension agents.

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

4.1. Technological responses categorized by land use types

4.1.1. Croplands

Expanding irrigation

Investment in irrigation amounted to 982 million USD between 1990 and 2014 and came with the introduction of new technologies that were important for a substantial rise in crop productivity in Mali (FAO, 2017a). To enhance food security and increase incomes, the government of Mali has launched an initiative to develop 200,000 ha of irrigated land by 2020, with an annual investment of 20 million EUR (Hertzog et al*.,* 2012). About 96,000 ha of land has been irrigated and cultivated by family farmers, with an average area of 3 ha per family in 2011 (Bélières et al., 2011), while 4,000 ha are exploited by sugar companies. The government of Mali opened access to land and water resources from the Niger River basin by providing administrative and fiscal incentives to national and foreign investors. The ON (Niger River Authority) holds the largest irrigated area in Mali and West Africa (Consultants for Development Programmes, 2004).

Dittoh et al. (2010) showed that micro-irrigation in the Sahel, including Mali, is useful to farmers. Yet, the irrigation extension potential is highly sensitive to irrigation costs and crop prices (Xie et al., 2014). Investments should be done in order to increase productivity and induce rural development (Xie et al., 2017) suiting the urbanization (Barbier et al., 2011).

Application of water-efficient irrigation methods and rainwater harvesting

The agricultural water demand in Mali is high because of the long dry season (FAO, 2018a; FAO, 2012a). Rainwater is the main water resource in Mali, providing on average 415 billion m^3 of water per year (Sidibé, 2013). The rainfall trend curves show a decline in rainfall from 1990 to 2010. For rain-fed agriculture, other than depending on direct rainfall for water supply, there are rainwater catchment harvesting systems designed to collect runoff water (Biazin et al*.,* 2012).

Soil particles transported by wind can be reduced by 42-63%, equivalent to 1 to 1.5 t ha of rush (Sterk and Stroosnijder, 1998). The technique consists of making bunds following the contour lines. The distance between the curves is determined depending on the slope of the land. Bands between the bunds are plowed. The technique reduces runoff and promotes infiltration of rainwater. Gigou et al. (2006) recommend the contour line management to reduce the runoff of rainwater in order to increase yields. Grass strips in the fields reduce runoff and increase the infiltration of rainwater.

Crop diversification

Agricultural diversification reduces risks to income generation and food security in Mali. It is a mix of farming systems (Abdullah et al., 2017) and important for the improvement of smallholder farmers' livelihoods because of its potential to provide a reliable source of food and income. Diversification means growing more than one single crop at the same time, and can be also a mix of crop-livestock production to yield higher income. Monocrop food production may fall short of enhancing the well-being of smallholder farmers. In addition, its contribution to rural livelihoods is hampered by the high per unit cost of production (FAO, 2014; Gautam and Andersen, 2016). The poor access to agricultural inputs, credit and equipment are important obstacles to diversification in Mali. The lack of diversification causes a decline in production of the main cash and food crops (cotton, maize, millet, sorghum) and livestock. The results can be lower income, food insecurity and poverty among smallholder farmers and herders in Mali (Makate et al., 2016).

Adoption of drought-tolerant crops and crop varieties

The agricultural research for development (AR4D) partnership between the National Institute of Agricultural Research (IER) and international institutes of agricultural research like the International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the World Agroforestry Centre (ICRAF) has achieved significant success in the development and dissemination of drought tolerant improved varieties of pearl millet, sorghum, groundnut, cowpea and agroforestry techniques to cope with climate change (Coulibaly personal communication, 2019).

Conservation agriculture

Conservation agriculture helps maintain soil health while reducing pest and disease problems as well as improving soil fertility and structure, capturing and retaining rainwater, and reducing erosion (Milder et al*.,* 2011). Wind erosion, mainly caused by overgrazing and deforestation, affects 38% of land and 18% of the population in SSA, including Mali. It causes soil fertility and nutrient depletion to all SSA land as well as its population (Kirui and Mirzabaev*,* 2014). Agricultural intensification is mainly due to population pressure. It requires both technological and institutional innovation which may reduce natural resource degradation (Nkonya et al., 2008; Tiffen et al., 1994). The use of such technologies in Mali has been documented. Introducing a legume as a sole or improved fallow in the rotation can ensure a better tree-crop-livestock integration. Protecting the soil and seed productivity are the main limitation (Sidibé, 2013).

Soil protection and water conservation techniques found in the literature included stone rows, mulching, ridging (ploughing), half-moons and the contour line management technique. Improved land use systems are green fences, grass strips, forage-based fallows, natural regeneration and associations with cereals and legumes.

Agroforestry

Agroforestry is based on trees and perennial shrubs combined with herbaceous species into agricultural systems to increase specific agro-ecological processes. Trees and shrubs are often harvested for fencing and building materials. The combined systems prevent soil erosion enhancing the habitat for beneficial arthropods. They provide also animal fodder, food, shade, fuel, medicine or fertilizer for other crops (Nair, 1993).

Agroforestry has shown lasting results when implemented in a thoughtful and sustained manner, in Mali and throughout Africa. From improved soil fertility, enhanced crop yields and food security, agroforestry demonstrates that simple measures can have profound positive effects on communities (Nair, 1993).

A series of tests on improved fallows were conducted by IER and the World Agroforestry Centre using mainly nitrogen fixing trees (Yossi et al., 2002).

4.1.2. Rangelands

Rotational grazing

Liniger and Studer (2019) defined rotational grazing as the movement of livestock from one pasture unit/range to another for regeneration after livestock passage. It allows grasslands to be totally grazed for few periods and to be recovered over long time. This approach of sustainable grazing means that a maximum livestock population can be supported on a space sustainably without exceeding the land's capacity. Significant increase in livestock productivity in Mali is possible by supplementing natural vegetation with deep-rooted pasture species (FAO, 2018b).

In Mali, rural land is estimated to include 30 million ha of grazing land (Ministry of Agriculture, 2008). Various projects are assisting pastoralists/livestock farmers to improve water points for livestock.

Sustainable livestock farming will require improved grazing and rangeland management practices. (DLEC, 2018).

Rotational grazing is not widespread in Mali. Several years ago, Tilemsi, a Northern region in Mali, has reserved some part of their pasture areas for drought periods (Gallais, 1972). This practice has since been stopped due to toxic plant encroachment.

Addressing invasive bush encroachment

Mali is currently facing natural resources degradation due to anthropogenic activities resulting in a severe decrease of the vegetation cover averaging 100,000 ha annually (FAO, 2000). The bush encroachment involves weed invasion which ranks among the harmful agents, causing 35–50% of agricultural production losses (MEA, 2009). Traditional management approaches include weeding, coppicing, tilling, and bushfires (Butz, 2009; FAO, 2003).

The capacity of Mali's grazing areas (the Delta Niger such as Debo and Macina, and the central Gourma) to accommodate livestock is limited to only 2 to 4 months.

Opinions on the impact of fire on vegetation and biodiversity diverge: The the effect of fire on the dynamic of the vegetation in northern Mali is lower on woody and herbaceous plants. Many other authors (Sheuyange et al. 2005; Ghermandi et al., 2004; Roques et al., 2001; Angassa and Baars, 2000; Bloesch, 1999; Hudak, 1999; van Vegten, 1984; Chandler et al., 1983) support that the interdiction of fire use in a context of over-grazing affects negatively plant diversity, fodder production and bush encroachment and positively soil erosion management. The fire commonly practiced by farmers in the Delta Niger region of South Mali stimulates fodder availability but destroys natural resources. These results are backed by Anderson (1999).

4.1.3. Forests, woodlands and shrub lands, afforestation and reforestation

According to FAO (2018a), 10.2% or roughly 12,490,000 ha in Mali is covered by forest. Mali lost an average of 79,100 ha or 0.56% of forest area per year between 1990 and 2010. During the same period, Mali has lost a total of 11.2% of its forest cover or around 1,582,000 ha. Mali's forests contain 282 million m^3 of carbon in living forest biomass. The causes mainly lie in poor governance which includes inadequate land-use and a lack of capacity for enforcing forest policies and combating illegal logging. Other factors are inadequate involvement of local communities in decision-making, corruption and incoherent legal or regulatory frameworks (Rademaekers et al., 2010).

It was also shown that land-tenure security is a necessary condition for preventing deforestation (although insufficient on its own) (Robinson et al., 2013). Insecure land tenure reduces the value of future forest compared with the immediate income from agricultural production, thus creating an incentive for forest conversion (Barbier and Burgess, 2001). Natural forest expansion may occur when agricultural land is abandoned. Forest policies will be useful to encourage tree planting for meeting future needs like fuel wood, timber and environmental services (carbon sequestration, biodiversity conservation, the protection of soil and water resources).

4.2. Household and community responses

4.2.1. Livelihood diversification and migration

In Mali, crop diversification and seasonal migration are the key livelihood strategies. The rural population experienced several instances of extreme weather during the 1970s and 1980s, allowing them to increase their adaptability (Giannini et al., 2016).

According to a Climate Vulnerability Mapping performed in 2014, the high level of poverty in Mali is due to the high vulnerability to climate change across the country (USAID, 2014). It is also demonstrated that those farmers with agriculture as main subsistence are more susceptible to climate change and food insecurity (Bakhtsiyarava et al., 2018). It is necessary to adopt adaptive strategies to face the effects of climate change on smallholder farmers' livelihoods in Mali. The Malian government, in partnership with regional and international organizations, is involved in various projects and programs to support climate change adaptation and mitigation strategies. Migration is a key source of income diversification in Mali through remittances used to buy food, education and health expenses.

4.2.2. Community collective action

The actions carried out by the communities are shown in Table 3 below.

Tab 3: Causes, impacts and local initiatives for the management of land degradation in Mali

Region	**Causes**	**Impact**	**Local initiatives**
Sahara	- Low rainfall - Overgrazing of transhumant livestock - Collection of woody vegetation as fuelwood or for construction	- Fragile soil structure - Rising temperature - Vulnerabilities of local communities to climate change	- Sand dune stabilization - Controlled grazing
Gourma	- Water and wind erosion - Deforestation due to human practices and animal overgrazing - Reduced rainfall - Soil acidification - Removal of woody vegetation for use as firewood	- Depletion of natural resources - Low yield of farm and pastures - Low soil fertility - Continuous soil erosion	- Practices favoring the conservation of soil and water - Farmer participation to natural regeneration (FMNR) - Agroforestry - Crop diversification
Kaarta	- Increase of soil acidity - Unsustainable management of soil and land resources - Decrease of rainfall - Wind and water erosion - Overexploitation of pastures - Clearing of crop residues	- Depletion of natural resources - Low yield of farm and pastures - Low soil fertility - Continuous soil erosion	- Use of improved seed - Soil amendment techniques - Soil and water conservation - Plantation

Region	Causes	Impact	Local initiatives
The Malian Company for Textile Development (La Compagnie Malienne de Développement des Textiles, CMDT)	- Population increase - Abusive land use for agriculture - Overgrazing - Clearing of crop residues - Extraction of woody vegetation for use as fuelwood - Acidification and low level of stable manure production	- Low yield of farm and pastures - Low soil fertility - Continuous soil erosion	- Use of improved seed - Soil amendment techniques - Soil and water conservation - Agroforestry and tree planting
Office de la Haute Vallée du Niger (Upper Niger Valley Rural Development Authority, OHVN)	- Overconcentration of livestock in this area - Raised demand of forest resources leading to deforestation around cities having reached a new peak	- Depletion of natural resources - Low yield of farm and pastures - Low soil fertility - Continuous soil erosion - Decrease of arable areas leading to seasonal migration	- Use of improved seed - Soil amendment techniques - Soil and water conservation - Plantation
Niger office	- Alkalization and salinization of irrigated land - High population pressures	- Decline in soil fertility - Soil pollution - Loss of water - Degradation of resources - Social conflicts between local communities	- Regeneration of pasture - Reduced used of chemical fertilizer
Seno	- Overgrazing - Clearing of crop residues - Soil acidification - Mismanagement of soil and land resource - Water and wind erosion - Climate	- Considerable decline in soil fertility - Reduction in vegetation cover, arable land and viable rangelands - Low-yielding soil cultivation	- Pasture land restoration - Soil fertility - improvement - Water harvesting techniques

4.2.3. *Farmer and indigenous innovations*

Many approaches have been used to ensure sustainable land management and rise to the challenge of climate change. These include:

- ***Tree management:*** Malian farmers adopted the use of trees in agricultural land as windbreak (UNEP et al., 2016). According to Young (1989), this practice provides many other ecosystem goods and services. Farmer-managed natural regeneration of Ttees (FMNR) or re-greening is an initiative by which farmers re-plant trees in farmlands, mainly to contribute to mitigating climate change, boosting agricultural productivity and enhancing food security. It was first adopted in Niger in 1983 (Francis et al., 2015) but introduced today in many SSA countries including Mali (UNEP et al., 2016) where 500,000 ha have been recently planted with trees. The program is still ongoing (McCabe, 2013).
- ***Soil and water conservation:*** Application of organic fertilizer, crop waste burying, composting and water harvesting are traditional techniques developed for soil and water conservation (Biazin et al., 2012; Schwilch et al., 2014). Technologies such as Organic Soil Fertility Management (OFSM) and Integrated Soil Fertility Management (ISFM) are being adopted at 39% and 18% of farmers, respectively, in Mali. They contribute to improved soil fertility and vegetation cover. Research conducted in Koutiala (Southern Mali) pointed out that perennial trees (*Gliricidia sepium* and *Pteocarpus erinaceus*) and nitrogen-fixing shrub (*Stylosanthes hamata*) could be used in short-term fallow to enhance soil fertility and improve yields (Kaya and Nair, 2001).

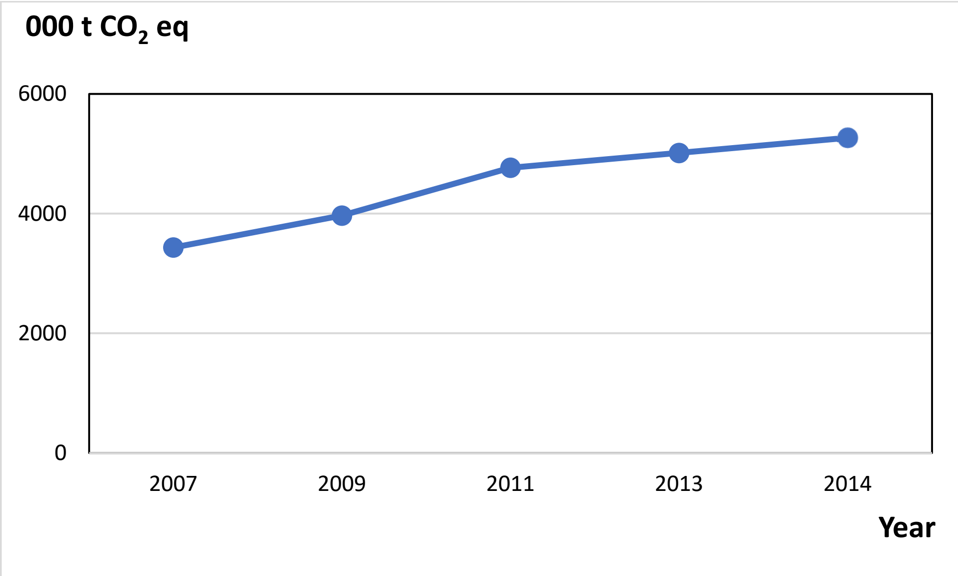
4.3. Policy level responses

4.3.1. *Facilitating carbon trading*

In Mali, 94.33% of greenhouse gases (GHGs) are made up of carbon dioxide, corresponding to 15.45 million tons.[3] The GHG emissions are primarily caused by the energy sector, emitting 3.43 to 5.26 million tons of CO_2 from 2007 to 2014, with an average increase of 6.4% per year (GoM, 2015). Over 82.2% of these GHGs come from residential energy consumption (GoM, 2015). The carbon sequestration initiative includes two World Bank carbon finance projects. A total of 6,000 ha of degraded natural dry forest have been planted with Acacia, intercropped with cultivated species, thanks to the Acacia Senegal Plantation Project funded by BioCarbon Fund. A total of 190,000 tons of CO_2 emissions have been reduced due to this project. The project entitled “Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) Felou Regional Hydropower Project” financed by the Spanish Carbon Fund has induced the CO_2 emission reduction by 280,000 tons. This project produced an additional 60 MW through the installation of a hydroelectric power plant on the Senegal River. Since 2005, Mali Biocarburant (MBSA) has further been researching the possibility to generate carbon credits by producing biofuel from *Jatropha* based hedges planted by farmers to protect their crops against goats and other cattle damage and to protect the soil against erosion. Biofuels also contribute to carbon sequestration. Mali case studies and achievements on carbon credit and finance mechanism are not well documented as noted by NEPAD-OECD (2009).

[3] Renewable Energy in Mali: Achievements, Challenges and Opportunities, 2011

Figure 7: Evolution of GHG emissions in Mali from 2007 to 2014



Source: Adapted from IRENA, 2019

4.3.2. Land-use zoning and integrated landscape planning

The acquisition of small-scale lands is affecting long-standing land tenure in West Africa. The population growth has pushed land tenure to become more formalized with market-based transfer (Becker, 2013). The formal sale and purchase of land, while granting security of land ownership, disrupts traditional land tenure and leads to many conflicts in peri-urban and rural areas.

The community land management system (Gestion des Terroirs (GT), in French) has been applied in French speaking West Africa, especially in the nine countries of the Sahelian Drought Mitigation Organization (CILSS), including Mali, to solve the increasing number of land related conflicts. The community land management system is reported to be an effective development tool for social, economic and ecological sustainability (GIZ, 2011). It enables the adequate use and protection of private or public areas (GTZ, 1995) anticipating rapid urbanization (Xu et al., 2015). The government of Mali has elaborated a national land-use planning policy approved by the legislative and consultative bodies. Despite technical and financial support from development partners including the United Nations Development Programme (UNDP), the German Corporation for International Cooperation (GIZ), the French Development Agency (AFD), the African Development Bank (AfDB) and the World Bank, the land use planning did not succeed. The technical services did not have an effective system for data collection and analysis. Key indicators and data related to GIS were lacking. The available data (monographic reports, maps, satellite photographs) were obsolete or inaccurate. The land use planning becomes more realistic but the ambitions of its objectives decreased due to the absence of technical and financial abilities (GTZ, 2011).

Many policies and strategies for a land planning process at different scale (national, provincial and local), land governance and use have been developed during the last decade (Becker, 2013; Bertrand, 2012; Farvacque-Vitkovic, 2007; Djiré, 2004) but have failed to live up to their expectations.

4.3.3. Payment for ecosystem services

The payments for environmental services (PES) are necessary to enhance the sustainability of forest service management, the use for food production and the maintenance of agricultural landscapes (FAO, 2016a; FAO, 2012b). PES schemes are a new driver of economic resources for sustainably managing, restoring, conserving, and using land and thus promoting sustainable management of ecosystem. They involve the public sector and non-governmental organizations (Herbert et al., 2010).

In 2013, these projects provided 9,000 jobs; protected 3 million ha of habitat from disappearing species; and raised 41 million USD for education, health care and infrastructure.

Despite actors' (investors, local communities, governments, etc.) proven interests in PES schemes for development, SSA countries' engagement is still weak. The 2013 Ecosystem Marketplace included 39 countries, with only five from Africa, including Mali (Peters-Stanley et al., 2013).

4.3.4. Providing access to markets and agricultural advisory services

The following methods and approaches are reported to be used in EAS in Mali (DLEC, 2018):

- Demonstration Plots and Showcase Methods: This approach was developed in 1983 by the Regional Agricultural Research Station of Cinzana (Segou). Plots are installed along major main roads with explanatory signs but without initial producer buy-in. It is already used by research centers and extension services in Mali.
- Integrated Agricultural Research for Development Approach (IAR4D): This approach capitalizes knowledge and diffuse innovations and technologies achieved by R&D to ensure food security through agriculture and value chain development. It is widely adopted by USAID, World Bank, IER and other research institutes in Mali.
- Farmer Field Schools (FFS): This field-based capacity building of farmer trainers and/or farmers was introduced in Mali in 1996 by the FAO (Ton et al., 2010). 85,054 farmers (one third of them women) have been trained in Mali since 2001. By 2017, around 52 FFS master trainers and 1,773 facilitators were trained in Mali, with women representing 12% (FAO, 2018 a,b). This approach is reported to take into account youth and gender mainstreaming (Harande, 2010).
- Champion Farmers/Farmer-to-Farmer Extension: In this farmer-to-farmer approach farmers train their peers. In Mali, the SmAT-Scale project collaborated with around 4,500 champion farmers. Organizations like ICRAF/World Agroforestry Centre, Catholic Relief Services, World Vision and the DNA used this approach by backstopping champion farmers in the field (ICRAF, 2017). The USAID Harande Program integrates this approach within the FFS.
- Rural Resource Centers (RRCs): These centers for training, demonstrations and experience sharing are managed by local organizations and supported by extension service offices. They facilitate access to inputs. Fourteen RRCs have been established in the Sikasso, Mopti and Tombouctou regions to implement SmAT-Scaling project. They use income from selling plants to fund their activities.
- Agricultural Entrepreneurship: Extension agents use these methods to develop farmers' entrepreneurship. It improves competitiveness across the different segments of the value chains. GIZ uses Agricultural Entrepreneurship in their projects in Mali.
- Value Chain Approaches: Extension services and donor-funded projects (USAID, IFAD) use this approach to identify the most outstanding value chains based on their profitability. It develops business relationships.
- Radio Programming: This is the most inexpensive and effective way to inform rural households, which has been used in Mali since the 1960s to improve literacy and expand agricultural extension (Perkins et al., 2011).
- Radio Community Listeners Clubs: The most effective Community Listeners Clubs are identified and used as Green Innovation Center to reach farmers. These clubs are made of value chain actors (researchers, agricultural extension agent, input suppliers, farmers, agricultural products traders and processors, etc.) dealing with the development of specific sectors (crops).

- The Participatory Media Methods including ICTs, especially smart phones are adopted in Mali to share information in extension services and during the implementation of several projects in various regions of Mali.
- Video and Television: These tools are often used by Access Agriculture, the Ministry of Communication and ICRISAT, an international agricultural research center, to reach farmers.

4.3.5. Securing land tenure

There are two land access patterns in rural areas in Mali: intra-lineage access (the most widespread) and inter-lineage access. In an intra-lineage access context, land is distributed by inheritance or by assigning a portion of land owned by a lineage to one family or individuals who belong to this same lineage but cannot gain access to land. Inter-lineage access is subordinated to arrangements such as gifts, loans, rent and more rarely, sharecropping and sale giving permanent or temporary rights (Keita and Djiré, 2009).

Currently, Mali is facing a land ownership problem compounded by difficult access to agricultural lands by small scale-farmers, agricultural entrepreneurs and young and migrant populations (USAID, 2010). The main reasons are population growth, unsustainable land use practices, climate change, the non-complementary relationship between traditional and modern statutory land tenure systems and poor public awareness of legal rights. Other factors are poor governance and incompetence within the land management offices, slow decentralization, land expropriation and non-performance of the land market (USAID, 2010).

Policies and legislation for land tenure have been developed since 1993. They include the Land Tenure Code set in 2000, the Pastoralist Charter (Charte Pastorale) of 2001 and the Agricultural Framework Law (LOA) of 2005. The law on LOA will enhance land governance in the *Office du Niger* area and beyond (Djiré et al*.,* 2012). A prime motivation in this context is to provide greater incentives for farmers to invest in their land for higher agricultural productivity (Cotula, 2007).

Effectiveness in access to land is key to land security. Long-term access is an incentive for investment in the *Office du Niger*. Investors have to invest to keep land productive but pay annual water fees (USAID, 2010).

4.3.6. Empowering women

Most Malian women are poor, have no formal schooling and live in rural areas with limited access to education and health care (UNDP, 2012). They are marginalized by development policies and are not well represented in the public administration, with less access to professional development opportunities than men. Nevertheless, 6 out of 10 women are participating in economic activities (Permanent Household Survey, 2007). Women make up 51% of the labor force but only 3.6% are salaried, the others are self-employed. Women are 1.5 times more likely than men to earn less than USD50/month (Nabalamba, 2018).

Marriage confers some basic rights to women, such as housing, food and access to land for farming, while she has responsibilities toward her husband and his family for childcare, domestic and farm work and preparing daily subsistence food (Duflo, 2011).

Despite family heads' desire to exert authority over their wives' property, women are reluctant to comply and manage their property successfully and independently. However, women's access to land in Mali is difficult to put a figure on and is furthermore linked to intra-household conflicts managed by customary rules. This is partly explained by traditional land laws which do not favor land ownership by women (USAID, 2010). Many legal women's associations are emerging and fighting for women's rights, including access to land ownership (USAID, 2010).

5. Evaluation of existing major policies and investments

This section discusses most prominent national level policies on agriculture, land use, food sector, and climate change with their associated investment amounts (Table 3), their impacts, reasons for successes and failures and lessons learnt.

5.1. Agriculture

The LOA is a key tool that was adopted in 2006 to develop the agricultural sector, especially family farming, in Mali. It was the appropriate framework to achieve the sustainability goals by modernizing the sector and making it more competitive (FAO, 2017b).

The government of Mali has elaborated policies in different activity sectors which it aims to achieve together with its development partners. Thus, the production of some key crops (rice, cotton, etc.) is extending as land access improves. Rice farmers have been provided with subsidized seeds and fertilizers and the access to credit. This initiative has been extended to maize, wheat, millet and sorghum in 2009 (World Bank, 2015). The cotton sector has been restructured in 2001 and the government engaged the privatization process that was suspended in 2005 (Serra, 2012; World Bank, 2015). Mali also implemented a five-year strategy from 2013 to 2018 (MAFAP, 2013) in order to improve its cotton production. However, a World Bank diagnostic study has concluded that additional reforms are required for this purpose (World Bank, 2015).

The Comprehensive Africa Agriculture Development Program (CAADP), an investment plan expected to last ten years, has been validated together with the National Program for Investment in the Agriculture Sector (PNISA) in 2015 in the same context of agricultural development (FAO, 2017a).

The Strategic Framework for Economic Recovery and Sustainable Development in Mali 2016–2018 (Cadre stratégique pour la Relance Économique et le Développement Durable du Mali, CREDD) pursues the goal of strongly developing the agriculture sector to achieve the Sustainable Development Goals (SDGs) by 2030 (République du Mali, 2016).

Despite the numerous policies and programs developed during the last decade, the agriculture sector in Mali is challenged by land insecurity. The government should also explore alternative water supply options to compensate for water deficits due to the dramatic drop in rainfall. In addition, effective agricultural input supply mechanisms need to be strengthened.

5.2. Climate change

Climate change is also one of the governments' priorities: The National Climate Change Policy has been elaborated to reduce pressures on forest resources and, in so doing, combat poverty (Mali Ministry of Environment and Sanitation, 2008). The Ministry of Environment and Sanitation of Mali created a National Climate Change Strategy (NCCS) in 2011 to enhance agricultural potential, ensure energy access and train researchers to successfully meet climate change challenges (Mali Ministry of Environment and Sanitation, 2011).

To successfully mitigate climate change, the government adopted three key instruments in 2011: the National Climate Change Policy, the National Climate Change Strategy and the Action Plan.

The Green Climate and Adaptation Fund (realized through the United Nations Framework Convention on Climate Change, UNFCCC) was granted in 2006 to help Mali implement its climate change policy by enhancing water management to secure agricultural production. In the same context, the AfDB piloted two flagship projects aiming to develop irrigated cultures and to strengthen food and nutritional security in the Koulikoro region (Southern Mali).

This strategy was implemented over the period 2012-2017 with financial support from the Trust Fund Office of the United Nations Development Programme, together with contributions from the public and private sectors (UNDP, 2013).

Most climate-related projects carried out in Mali have been funded through grants and loans from donors with a low contribution from the government. The country has practically no self-funded action plans, which may compromise the achievement of the SDGs.

5.3. Land access and use

Started in 2006, the Malian Agriculture Land Policy (*Politique Foncière Agricole*) has been adopted in December 2014 for an equitable and secure access to land in rural areas. The LOA has taken decentralization and women's access to agricultural land into account but has not resolved conflicts related to land and land utilization (World Bank, 2015).

The evaluation of the land access policy by the Analysis Framework of Land Governance in Mali (*Cadre d'analyse de la gouvernance foncière au Mali, CAGF*) in 2016 concluded that land access remains governed by tradition in rural areas. In addition, land management is constrained by several limits, including poor legal provisions to local realities and legal and institutional incompleteness. Other factors are the high cost of registration and acquisition of land and the lack of communication between institutions involved in land management.

5.4. Food and nutrition security

The National Food Security Strategy (SNSA) of Mali was adopted in 2002 to ensure sustainable food security for all by strengthening the rural economy and creating appropriate social network markets. For this purpose, the National Program for Food Security (PNSA, 2006–2015) was launched in 2005 to ensure food security for all households in the country.

Another National Food and Nutrition Security Policy was elaborated in 2017 to improve the coordination of sectoral policies to enhance food security and nutrition, and the integration of regional and sub-regional level programs (FAO, 2017b).

In 2013, the Malian government and the World Bank led a program called Tree of Hope, which provided poor households with health and education information and monthly cash payment of 20 USD (10,000 CFA). The Ministry of Health and its partners, including WFP and UNICEF, has provided enriched monthly rations to 2- to 6-year-old children, pregnant women and nursing mothers through the Blanket-Feeding Program.

The National School Feeding Policy adopted by the government in 2009 provided around 354,000 schoolchildren with daily hot meals in 2013, increasing schooling rates and improving nutritional status (WFP, 2013). The adoption of the School Feeding Sustainability Strategy in the same year increased the capacity to implement this feeding program. The government allocated more than 18 million USD to school feeding programs during the period 2014–2016 (Drake and al., 2016). The National Nutrition Policy (PPN) was adopted in 2014 for the development of nutrition approaches across different sectors to reduce malnutrition by 2021, (FAO, 2017b): (i) halving the prevalence of acute malnutrition in children 0 to 5 years old and of school age; (ii) reducing by two-thirds the prevalence of chronic malnutrition in children 0 to 5 years old and of school age (6 to 14 years); (iii) reducing by a third the prevalence of anemia in children 0-5 years of age, school age and women of reproductive age; etc.

The Malian National Plan on Responses to Food Problems, adopted in 2016, and the National Food and Nutrition Policy, elaborated in 2017, are expected to be reference documents to improve emergency responses and build resilience through food and nutrition security and social protection programs in line with the SDGs (République du Mali, 2016).

Tab 4: Some projects/programmes and associated investments

	Projects/Programs	Funding	Periods	Investments
Agriculture	Agriculture development projects	International Fund for Agricultural Development (IFAD)	Currently	534.9 million USD
Land use	Three projects (sustainable agriculture, solar energy and land restoration)	Sweden	2013-2014	-
	Great Green Wall Initiative	World Bank, SCCF, Multi Trust Fund, AfDB	-	-
	Land degradation	Global Environment Facility (GEF)	Since 1994	8.1 million USD
Food	Food Security	USAID's program Feed the Future	-	-
Climate change	International Climate Funds	Climate Finance	2004 - 2014	31.2 million USD
	Water resources management project	Dutch Embassy	2015 - 2019	-
	Climate change adaptation project	German Ministry of Environment	2011	10 million EUR
	Biodiversity	GEF	Since 1994	13.7 million USD
	Climate change	GEF	Since 1994	32.4 million USD
	Climate Investment Fund	World Bank	-	40 million USD
	Reforestation and carbon sequestration	Global Climate Change Alliance	2010 - 2017	6.215 million EUR
	Climate change mitigation	EU	2013	1.28 billion Euros
	Strategy for climate change adaptation	GIZ	2014-2019	-
	Small-scale irrigation program	GIZ	2008-2023	-
Poverty	Tree of Hope: Monthly cash transfer to poor households (10,000 CFAF per household)	World Bank	2013- 2015	70 million USD

(GIZ, 2015; USAID, 2015; GEF, 2015; European Comission, 2015; GEF, 2013; Gestion Durable de Terres, 2011)

The cash and food provision programs could not be sustainable. The government would rather implement micro-credit granting to vulnerable households.

Micro-credit is a young effective approach with a positive impact on its beneficiaries both economically and socially. It is an instrument in the fight against poverty, which allows vulnerable people excluded from the traditional banking system to obtain a loan to develop an activity.

The low profitability of the agricultural sector, the lack of willingness to repay loans by some farmers and the high risks associated with agricultural production, limit the financing of activities linked to this sector. This explains the scarcity of microfinance structures in rural areas leading to the application of high interest rates and the absence of support and assistance to farmers' organizations and cooperatives. The few existing establishments finance the activities of young people and women (Maiga et al., 2019). However, limited access granted to poor farmers is reported (Sidibé et al., 2018).

By developing and promoting micro-credits the Malian government will increase people's capacity to sustainably address not only food needs but also productive capacities.

6. Conclusion

Long-standing instability and interconnected challenges continue to hinder sustainable development in the Sahel region including efforts to mitigate climate change and land degradation, and hence food insecurity. In addition, efforts to address development challenges such as climate change, land degradation and other development challenges needs to be “conflict-sensitive” and should not result in generating new tensions. There is a need for locally driven recommendations which provide a basis for engaging in an evidence-based reforms for sustainable strategies for peace and development in the region. This includes promoting indigenous conflict resolution mechanisms and support of the participation of women and youth in key economic activities. Particularly, addressing immediate needs of the vulnerable groups to climate change and security shocks through the provision of productive safety nets while focusing on long-term development is key to move forward. The COVID-19 pandemic together with political crises has severely undermined development activities by affecting the supply chains of inputs and products for farmers, small and mid-level scale enterprises and hence lowering incomes and access to food. Conducive policies and diffusion of appropriate technologies are important to mitigate the impacts of COVID-19.

7. References

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