THE REPUBLIC OF GUINEA-BISSAU

Third National Communication

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Ministry of Environment and Sustainable Development

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Republic of Guinea-Bissau

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Photo in page cover: Archipelago Bolama-Bijagós in Guinea-Bissau is a UNESCO Biosphere Reserve.
Image: Powell.Ramsar (http://www.nationsonline.org/oneworld/guinea_bissau.htm)

Foreword

On behalf of the Government of The Republic of Guinea-Bissau I wish to present the Country's Third National Communication to the United Nations Framework Convention on Climate Change. As a signatory to the UNFCCC, the Republic of Guinea-Bissau considers the publication of this report not only as an effort to meet our obligation under the convention, but to showcase the domestic policies and actions to tackle climate change.

Given the small, low-lying areas of the country including the UNESCO Man and Biosphere Reserve Bijagós Archipelago, Guinea-Bissau is particularly vulnerable to the impacts of climate change. The climate change related risks impacting on the country have been identified and they are: sea level rise, extreme rainfall events, dry spells, flooding and drought episodes. As such, adapting to the effects of climate change becomes a national priority

The findings of this Third National Communication reveal the main drivers of vulnerability and sectoral priority areas in need of specific adaptation measures as well as the current gaps in terms of training and capacity, data acquisition and storage. In this context, this report represents the most recent comprehensive outlook of climate change in the country. It embodies an important milestone in our commitments under the UNFCCC and our efforts in raising climate change awareness to influence domestic policies and strategies. This will ensure a green economic growth trajectory for the country and at the same time enhance environmental protection for years ahead for the benefit of Guinea-Bissau future generations.

Hon. António Serifo Embaló
Minister, Environment and Sustainable Development

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I would like to take this opportunity to thank all the sectorial ministries, government departments, local government authorities, research and academic institutions, private sector, nongovernmental organizations, civil society and other keys institutions for participating in the development of this TNC.

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Acronyms and Abbreviations

AD	Activity data	INDC	Intended Nationally Determined Contribution
AfDB	African Development Bank	IPCC	Intergovernmental Panel on Climate Change
AFOLU	Agriculture, Forestry and Other Land Use	IPPU	Industrial processes and product use
BADEA	Arab Bank for Development African States	INE	National Institute for Statistics
		INM	National Institute of Meteorology
BAU	Business as usual	ITCZ	Inter-Tropical Convergence Zone
CAIA	Environmental Impact Assessment Cell	LEDS	Low Carbon Development Strategy
CBOs	Community Based Organizations	LULUCF	Land-Use Change and Forestry
CDM	Clean Development Mechanism	MDGs	Millennium Development Goals
CH4	Methane	MADS	Ministry of Environment and Sustainable Development
CILSS	Permanent Interstate Committee for Drought Control in the Sahel	MNRE	Ministry of Natural Resources and Energy
CO2	Carbon dioxide	MRV	Measurement, Reporting and Verification
COP	Conference of Parties	NAMA	Nationally Appropriate Mitigation Action
DNA	Designated National Authority for the Kyoto Mechanisms	NAP	National Adaptation Plans
		NAPA	National Adaptation Programme of Action
DGA	Directorate General of the Environment	NCCC	National Climate Change Committee
		NEMP	The National Environmental Management Plan
DGP	Directorate General of Livestock		
DGP	Directorate-General of Planning	NGO	Non-Government Organisation
DGSD	Directorate General of Sustainable Development	NIS	National GHG Inventory System
		N2O	Nitrous oxide
EAGB	The National Electricity and Water Corporation	NOx	Nitrogen oxides
		NMVOCs	Non-methane volatile organic compounds
ECOWAS	Economic Community of West African States	OMVG	Regional Organization for the Valuation of the Gambia River
EEZ	Exclusive Economic Zone	PA	Protected Areas
EF	Emission factor	PAC	Project Advisory Committee
EU	European Union	PRCPTOT	Annual total precipitation
EWS	Early Warning System	QA	Quality Assurance
FAO	UN's Food and Agriculture Organisation	QC	Quality Control
FIAL	Fund for Local Environmental Initiatives	RCPs	Representative Concentration Pathways
GEF	Global Environment Facility	SIDS	Group of Small Island Developing States
GCF	The Green Climate Fund	TL-GHGI	Team Leader for GHG Inventory
GDP	Gross Domestic Product	SIDS	Group of Small Island Developing States
GHG	Greenhouse Gases	UNEP	United Nations Environment Programme
GIS	Geographical Information System	UNFCCC	United Nations Framework Convention on Climate Change
GoGNB	Government of Guinea-Bissau		
GNI	Gross National Income	UNICEF	United Nations International Children's Emergency Fund
HDI	Human Development Index		
INC	Initial National Communication		

Chapter 1: Executive Summary

1.1. Introduction

Guinea-Bissau is a non-Annex-I Party and a signatory to the United Nations Framework Convention on Climate Change and the Kyoto Protocol and as laid down in Art. 2, Paragraph 1 of the Kyoto Protocol, is committed to engage and seek to achieve quantified emission limitations and reduction of GHG emissions in order to promote sustainable development, minimizing the social, environmental and economic impacts of anthropogenic activities that contribute in emissions of greenhouse gases and thus to global warming. In order to meet its reporting obligations, Guinea-Bissau has already prepared and submitted systematically: i) The First Inventory and the Initial National Communication in 1996, the reference year 1994; ii) The Second Inventory and subsequent Second National Communication in 2011, the base year 2000 and now the Third Inventory and consequently, within this framework, the reporting guidelines, adopted during COP 8 for the preparation of National Communications from Parties not included in Annex I to the Convention and contained in decision 17/CP.8 have been adopted for the preparation of this Third National Communication, In 2015 the country has been submitted the INDC serving as the basis for the Paris Agreement.

1.2 National Circumstances

Geography and Climate Profile

Guinea-Bissau, located in Western Africa (12° 00' N, 15° 00' W), between Cape Roxo (latitude 12º 20' N), the Cajete Ponta (latitude 10° 59' N) and the meridians 13° 38' and 16° 43' W bordering the North Atlantic Ocean, between Republic of Guinea and Senegal is relatively small in size (36,125 km^2 – Land 28 000 km^2, Water 8,120 km^2) and estimated population of 1.6 million (2011), with a low-lying land mass and an archipelago comprising a large number of islands. The country shares borders with Senegal (338 km) to the north and Guinea-Conakry (386 km) to the south and east (Figure 1.1).

Rainfall varies from South Tombali, Quinara e Bolama-Bijagós Region (>2000 mm / year) to Northwest Regions of Bissau, Biombo, Cacheu e Oio (1400-1800 mm / year) and the Eastern regions of Bafatá and Gabú (1300-1500 mm / year). Temperatures range between 21.6°C and 39.3°C (monthly average: 30.5°C) in April and May, just before the rainy season, between 21.1°C and 31.5°C (monthly average: 26.3°C) in August and November and between 16.5°C and 38.5°C (monthly average: 27.7°C) in December to March. Spatially, monthly values of maximum air temperature range from 29.5°C to 39.3°C across the regions with minimum temperatures ranging from 16.5°C to 24.3°C.

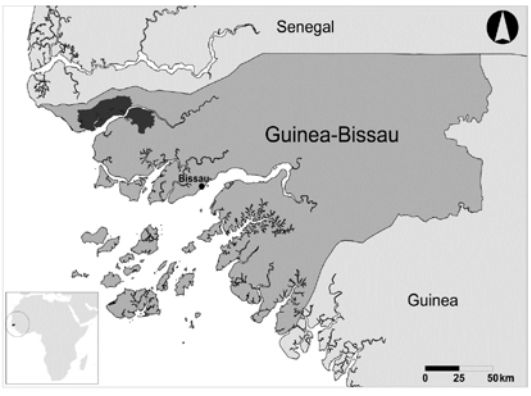


Figure 1.1 - Geographic Location of Guinea-Bissau including the Bijagós archipelago.

Its territory is divided between continent and islands, the latter including a contiguous chain of seven islands (Jeta islands, Pecixe, Sands, Caiar, How and Melo), including the Bijagós archipelago made up of 88 islands and islets of which only 21 are inhabited (NAPA, 2006), now recognized for its high biodiversity. These characteristics render the country highly vulnerable in particular to sea level rise, flooding, and related saline intrusion associated with climate change.

Demography and Socio-Economy

The population of Guinea-Bissau grew steadily from 1.67 million (2011), to 1.80 million (2014) and was estimated to be 1.82 million in 2017. In 2015 the population age distribution was such that 39.6% of the population is under 15 years old, 55.0% between 15 and 60 years old and 5.4% of the population is 65+. Predominantly, the population of Guinea-Bissau is rural-based but 49.3 percent of Guinea-Bissau's population lives in urban areas[1] and the number of urban residents is around 743 402. GDP per-capita of Guinea-Bissau has reached 692.60 US dollars in 2011 and went through a mostly stable period picking up to 614 in 2010 then reaching 620.21 US dollars in 2016 and this represents a GDP per Capita equivalent to 3% of the world's average. The vulnerability of the economy is twofold. In one hand, the high dependence on agriculture (almost 60% of GDP) in particular, the cashew industry alone, the main source of export revenue and a significant share of government revenue. On the other hand the long period of political instability.

Agriculture and Livestock

Most the country's population is employed in low-productivity agriculture focused on cashew production which has superseded the production of rice. The agricultural sector is the mainstay of Guinea-Bissau economy, a source of income for 85% of the population. Agricultural exports account for over 98% of total exports of goods[2]. Production and export of cashew nuts and rice cropping are the major activities coupled with extensive livestock. In 2012, the area under cashew cultivation was 223 000 ha with an annual production of 130 000 tons of raw cashew nuts (FAO, 2015)[3]. Commercial cashew nut growers have 15% of cashew plantations (15 000 hectares) whilst the remaining 85% (88 000 hectares) belong to traditional farmers. Rice is another strategic crop in Guinea-Bissau and is the staple food of more than 95 percent of the population. In 2014, the country produced 133 000 tonnes of this cereal. However, for over ten years, there has been a growing deficit, which was estimated at over 100 000 tons in 2009/2010, with domestic production covering only 47% of consumption. In Guinea-Bissau, the livestock sector contributes 17% to the national GDP and 32% of the agrarian sector GDP. According to the livestock census conducted in 2009 by the Directorate General of Livestock (DGP) under the PRESAR / BAD, it is estimated that the total number of cattle rounds 1 325 412, distributed mainly in eastern and northern areas[4].

Forestry

Preliminary data from a more recent programme (CARBOVEG Project, 2007) estimate that the forest area of the country is around 2 072 000ha. However, this is a considerable departure from the forest inventory of 1985 when results indicated a forest area covering 2,4 million hectares and the reserve of wood was 48.3 million m3. Several authors put forward several figures on the rate of forest degradation in Guinea-Bissau. For example, FAO points out that during the period 1981-1985 there was a loss of about 34 000 ha / year. Bianchi et. al., in 1986, put forward 60 000 ha / year. The degradation of the forest ecosystem is more pronounced due to expansion of cashew monoculture.

Water Resources

According to the National Report Rio + 20 (2012) the water potential of the country is estimated at 14 billion cubic meters / year. The country's water resource consists of rainwater, surface water and groundwater. The surface water includes major rivers and its tributaries (the main ones being from north to south, Cacheu, the Mansoa, the Geba, the Corubal, the Rio Grande de Buba, the Cumbijã and

Cacine) and estuaries. The Geba River, the Farim and Corubal Rivers are the most important in the country, and the first two almost cease to flow in the dry season. The Corubal River, with annual average volume of 130 000 million m3 has an important dry season flow (11 m³/ s on average) becoming the most important surface water resource in the country. In addition, there are important stationary water bodies including lakes (like Cufada pond with an area of 35 000 hectares), lowlands (bas-fonds) and often temporary water bodies (Vendus) a common structure found in the East of the country. The country has a huge hydroelectric potential, but are unevenly distributed, as 90% result in six months and are distributed only in the eastern part of the country.

Energy

Energy consumption in Guinea-Bissau is mainly based on biomass (90%), oil products (8%) and electricity (2%). Biomass energy resources encompasses wood, coal and agricultural / forest products. At the level of subsistence communities, the collection and use of wood / coal for heating and cooking uses enormous resources in biomass and hand labour. The hydroelectric potential of Guinea Bissau is high, however only 33.84MW of hydropower capacity has been identified so far (including Saltinho (14MW) and Cusselinta (13MW)) in studies carried out in the 1980's. Therefore, in Guinea-Bissau the production of electricity is excessively dependent on imported diesel fuel. The country's energy strategy pursues to increase reliance on local energy sources, by placing more emphasis on the utilization of renewable energies to gradually lessen the dependency on the traditional energy sources, especially oil importation. Guinea Bissau has only one solar photovoltaic power plant of 314kW to produce electricity (which was expected to start operating in 2014), and a pilot projects for energy cogeneration with cashew shells, whose energy sources or resources are abundant in the country. In addition, there are projects being developed in the context of hydroelectric plants, for example, the OMVG, Saltinho/Cusselinta and Banbadinga.

Biodiversity and Coastal Zones

Guinea Bissau's biodiversity constitutes a significant natural asset for the country that, if protected, has the potential to serve as the back bone of a future tourism industry. Possessing an incredibly diverse set of eco-systems ranging from dense tropical forests to mangrove swamps, Guinea-Bissau has become increasingly more conscious of the value of its natural wealth, investing substantially in conservation to the extent that approximately 26% of its national territory is protected[5].

Guinea-Bissau's Bijagós Archipelago is one of these protected areas made of a collection of 88 islands that guard the country's capital Bissau. A UNESCO Man and Biosphere Reserve[6], the archipelago contains both national protected areas (Orango, João Vieira-Poilão) and community reserves (Urok)[7] all haven for hundreds of species of birds, fish, and mammals. Poilão is amongst the 10 most important nesting sites for green turtle population (Figure 1.2) making one of the greatest biodiversity values of Guinea-Bissau.

Figure 1.2 - Green turtle in Poilão protected area - Guinea-Bissau's Bijagós Archipelago[8].

At the same time, the coastal zone also provides valuable ecosystem services now, including nursery and breeding grounds for commercial fish stocks, carbon stocks and a buffer to mitigate against the impacts of climate change. Two additional terrestrial national parks (the Dulombi and Boé parks) and three environmental corridors (the Tche-Tche, Salifo, and Cantabane Corridors), which connect areas

and permit wildlife movement while buffering human communities, are on the brink of being added soon. At present, vegetative cover along the coastline in the identified hotspots have been degraded for several climate and anthropogenic-driven reasons. In Guinea Bissau mangroves are exploited to smoke fish and have reduced mangrove cover that otherwise function as a natural protective barrier to coastline erosion and sustain fishing activity.

The Fisheries Sector

Guinea-Bissau has 105 740 square kilometres of Exclusive Economic Zone (EEZ) for a continental shelf of 45 000 km².along 270 Km of coastline. The fisheries sector is one of the most important for the country's economy and directly or indirectly employs 120 000 workers. Fishing contributes to about 3% to GDP and around 3.9% in exports contributing with 40% to the state budget[9]. It has been estimated that 4 percent of the artisanal catch comes from continental waters and is mainly done by women and youngsters who fish without vessels.

The Waste Sector

Per recent past data (MICS4, 2011) only 11% of the population has access to adequate sanitation system. Less than a fifth of the population (18%) have improved sanitation facilities; 12% have improved latrines, 4% latrine without toilet and only 2% have a pour-flush latrine. Much of waste in Guinea-Bissau is made up by solid waste, waste water and sludge. The disposal system and recycling of solid waste is undeveloped: throughout the country there is only a single landfill. Waste Management is one of the major problems facing the country, considering not only the environmental risks arising from inadequate disposal / recovery of waste, but also the need of the country to create acceptable conditions for the development of responsible tourism.

1.3 Summary of GHG Emissions

The inventory estimate covers anthropogenic emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol and greenhouse gas precursors and include carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) and the indirect gases nitrogen oxides (NOx). The emissions/removals from the following five economic sectors were estimated: (1) Energy, (2) Industry, (3) Agriculture, (4) Land Use, Land-Use Change and Forestry (LULUCF) and (5) Waste. The main findings are:

- Most GHG were emitted (Gg CO2 eq) in the Energy (6899.36) and the Agriculture and Livestock (3942.71) sectors. The contributions from the Industry (0.1) and the Waste (51.42) sectors were marginal.
- Most CO2 emissions are generated by the LULUCF sector (-10718 Gg CO2 eq), followed by the Energy sector (6899.36 Gg CO2 eq), while CH4 are mostly generated by AFOLU (Agriculture, Forestry and Other Land Use). N2O emissions, 4805.00 Gg CO2 eq, were linked to the Energy sector primarily and represented more than 44% of national emissions.
- Overall the sectoral breakdown of the national GHG Emissions in 2010 indicate that the Energy sector contributed with 63% of the total (10893Gg CO_2 eq) followed by the Agriculture and Livestock sector which emitted 36% of the total. The Land Use, Land-Use Change and Forestry (LULUCF) was the highest single sector acting as a net sink of -10718 Gg for the year 2010.
- This sink contribution of the forest stands in Guinea-Bissau was seconded by the CO2 sequestration of 2510 Gg CO2 (3%) from abandonment of cropped land (natural regeneration of arable land, pastures or other farmed land). The total carbon released by the conversion of forests to other uses was estimated at 28,147 Gg CO2.

1.4 Scenarios of GHG Projections

GHG emissions for 'Business as usual' (BAU) Scenario were obtained from the evolution of the variables usually responsible for emissions or removals: Fuel demands to meet the future energy requirements, projected number of vehicles, expected land use changes, forest management and amount of waste generated, and the socio-economic dynamics are some of these variables considered. The latest inventory (for the Third National Communication) has again revealed that most CO2 emissions are generated by the LULUCF sector (-10718 Gg CO2 eq), followed by the Energy sector (6899.36 Gg CO2 eq), while CH4 are mostly generated by AFOLU (Agriculture, Forestry and Other Land Use).

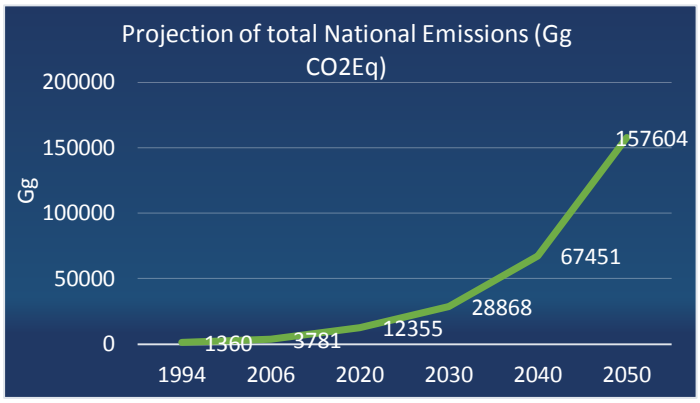


Figure 1.3 – Total GHG emissions in Guinea-Bissau without mitigation measures will more than triple by 2030 from the level of emissions in 2010.

Estimation of GHG emissions and CO2 removals covered by all the sectors including the Land Use, Land-Use Change and Forests (LULUCF). The projections for Agriculture and Livestock and Industry resemble exponential variations entailing that the level of total GHG emissions in Guinea-Bissau without mitigation measures will more than triple by 2030 from the level of emissions in 2010 reaching a staggering 157604 Gg CO2 eq by 2050 (Figure 4.6).

1.5 Climate Change Trends and Projections

The new climate scenarios project significant changes in the climate of Guinea-Bissau. These scenarios systematically indicate increases in average daily temperature up to + 1.4°C for the period 2016-2045 and which could potentially reach up to + 2.2°C in 2046-2075 horizon, per the low emissions scenario (CRP4.5). According to the RCP8.5 scenario (high emissions) the changes expected are still higher with temperature increases of the order of + 1.6°C to + 3.1°C for the period 2046 to 2075 respectively. In summary, climate variability will remain a dominant aspect of climate in Guinea-Bissau and therefore in light of these uncertainties, planning for increases in temperature alongside development of resilient planning for extreme events of drought particularly in the eastern portion of the country (Bafatá) and flood along the coastal zone and uncertainty over precipitation levels will be required.

1.6 Vulnerability and Adaptation to Climate Change

The vulnerability analysis was based on the variation of climatic parameters (P, T, SLR) in the subsector of agriculture and livestock sub-sector for the three types of ecosystem under consideration (mangrove, bas-fond and plateau) and cultivated soils.

Agriculture Sector —The main impacts of climate change in the Agro-livestock sector range from: erratic rainfall in terms of intensity and onset/end of season, temperature increase, mean sea level rise. The productivity and yields in these sectors are clearly vulnerable to climate change impacts unfolding in adverse effects and sensitivities. Rice crops are vulnerable to both erratic rainfall in terms of intensity and sea level rise which affects production due to excessive salt water invasion,

particularly in the mangrove swamp rice fields due to high and strong tides and consequent destruction of anti-salt dykes. Rice crops are also vulnerable to extreme rainfall events which invariably causes waterlogging and predispose the plant to root rot[10]; and to droughts. Other relevant crop vulnerable to climate change impacts is the cashew crop which production and productivity are negatively impacted by drought episodes.

Table 1.1 - Key Adaptation measures in the Agriculture Sector per type of ecosystem

Ecosystems	Climate Change Adaptation Measures of Agriculture Sector
Mangrove ecosystem	• Construction of micro dams and small dams for water retention • Enhance mangrove planting • Implement no take zones for mangrove management~
Bas-Fonds Ecosystem (freshwater)	• Construction of micro dams and small dams for water retention • To improve current water management in small valleys; • Support small scale mechanization of agriculture particularly rice farming; • Support the development of small scale irrigation systems; • Provide incentives to farmers to farm in the basin of the Geba River.
Plateau Ecosystem	• Popularize new varieties adaptable to the environmental stresses, in particular seed varieties with shorter cycle, more productive and resistant to drought; • Improve the genetic material of vegetable and cashew trees and palm groves; • Develop and implement programs for water management that encompasses construction of micro dams, reservoirs and promotion of small irrigation systems; • Improve techniques and agricultural practices in order to intensify and diversify production; • Strengthen the research and dissemination of results;
Backyard Farming Ecosystem	• Develop and implement programs for water management namely increasing storage capacity at local level with construction of micro dams, reservoirs and promotion of small irrigation systems; • Improve techniques and agricultural practices in order to intensify and diversify production;

Livestock Sector —In terms of key economic sectors, the Livestock Sector is greatly affected by temperature increases and declining rainfall which invariably translates into widespread lack of water for pasture, Decrease pasture areas, Severe decrease in milk and meat production, Encouragement to transhumance in search of better pasture conditions and conflict between pastoralists and farmers. Adaptation measures — Develop a Master Plan for Livestock Management. Encourage the breeding of short cycle species. Support the creation of transhumance corridors and increase pastures.

Energy Sector —The vulnerability of the Energy Sector is intertwined with that of the Forestry Sector. This vulnerable situation is driven by poverty and low financial capacity of the Guinea-Bissau population, the low energy generation capacity and low electrification rate of the country (about 12%), becomes a stressor on the forest cover as the irrational use of woody resources for energy in Guinea-Bissau is a growing problem, especially in rural areas as there are no immediate alternative solutions leading to desertification threats in various parts of the country.

Adaptation measures — Still, there are few alternative technologies that enable natural resources to be used rationally by these communities in Guinea-Bissau. The adaptation strategy prioritizes increasing the capacity of electricity generation, and specifically highlights the OMVG interconnection (Sambangalou facility) as a medium-term priority to access lower cost electricity. Examples of alternative techniques of rational management of resources being vulgarized in the tabancas is the

introduction of improved furnaces allowing only few quantities of firewood to be used reducing the quantities of wood to be cut.

Forest and Biodiversity Sector —The vulnerability of the Biodiversity Sector is again entwined with other sectors such as the Forestry and the Fisheries. The core driving force behind the common vulnerability trails is the unsustainable anthropogenic activities (widespread illegal logging, deliberate willed forest fires, forest clearance for land use, etc.,) in the different forest ecosystems and an also the increase of demographic growth in which the communities putting pressure on the natural resources coupled with inappropriate forest management programmes, and lack of law enforcement for forest protection.
Adaptation measures — Reduce uncontrolled expansion of cashew plantations and the effect of forest fires on the vegetation cover. Implement massive forestation programme coupled with expansion of National Protected Areas systems, covering more fragile and important ecosystems and organize grazing and transhumance corridors.

Water Resources Sector — In the future scenarios of increased temperature and decreased precipitation (according to the projected scenarios of climate in Guinea-Bissau for the time being shown in Chapter 5), groundwater the source of freshwater, the main source of drinking water for the population in the country, captured at depths of 30m to 80m could be heavily impacted. In addition, water resources show also high vulnerability due to the irregularity of rainfall and high temperatures triggering decrease in river flow, a significant decrease in groundwater level and the progression of saline wedge. The current situation of the Geba River and adjacent aquifers sectors where this river maintains a hydraulic route serve as an example of this phenomenon.
Adaptation measures — Establish coherent and consistent strategy based on preservation, exploitation and rational use of water resources, applying the approach of integrated management of water resources. Increase storage of rainwater, for augmentation of the surface water and groundwater reserves including construction of small dams to hold water for agriculture use and livestock breeding.

1.7 Main Gaps

Capacity building and training will be an on-going effort at the institutional and technical level. Institutions generating the activity data will need to be trained in GHG inventory and data formats. National experts lack technical capacity to estimate the inventory hence training of national experts on the IPCC 2006 guidelines and inventory software should be a priority before the next inventory is prepared. There was no continuity in the estimation of the inventory as there was no data updating from the last inventory calculation due to lack of an institutional framework for data base management, deficient archiving system.

Create and maintain an environment conducive to the effective and efficient transfer of technologies through the implementation of incentive measures particularly towards the development of national framework for promotion of renewable Energies as a major entry for Guinea-Bissau to lessen its vulnerability to climate change. Rationally valued, biomass and other renewable energy resources can be an important lever in the fight against poverty, particularly in rural areas, thus contributing to the improvement of quality of life and sustainable development.

Chapter 2: National Circumstances

2.1. Introduction

Guinea-Bissau is a non-Annex-I Party and a signatory to the United Nations Framework Convention on Climate Change and the Kyoto Protocol and, as laid down in Art. 2, Paragraph 1 of the Kyoto Protocol, is committed to engage and seek to achieve quantified emission limitations and reduction of GHG emissions in order to promote sustainable development, minimizing the social, environmental and economic impacts of anthropogenic activities that contribute in emissions of greenhouse gases and thus to global warming.

The Guinea-Bissau as a member / Part of LDCF receive financial support from the Fund for Global Environment Facility (GEF), for preparing its Third National Communication to the COP. On this basis, the National Circumstances fall into the first step in the preparation / development of the Third National Communication in view of reinforcing its commitment as a signatory of the United Nations Framework Convention on Climate Change and the Kyoto Protocol. On the other hand, it is a scientific instrument to sensitize policy makers on the need to promote, encourage policies and low-carbon development initiatives, green economy, ways to promote sustainable development.

This Chapter presents the national circumstances of Guinea-Bissau, also includes information on features of its geography, demography, climate and economy as well as key features of the main economic sectors (Agriculture, Livestock, Forestry, Water Resources, Public Health, Energy and Waste) to provide a sense of the overall national context in which climate change mitigation and adaptation challenges are being addressed detailing the national development priorities, objectives and circumstances that serve as the basis for addressing issues relating to climate change.

2.2 Institutional Arrangements

The country ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 27 October 1995 and ratified also the Kyoto Protocol on 18 November 2005 (IGEE, 2008) thus becoming a contracting Party to the Convention, committed to develop, update, publish the National Communications on Climate Change and other strategic documents on the same theme and participate in the Conferences of the Parties (COP). In order to meet its reporting obligations, Guinea-Bissau has already prepared and submitted systematically: i) The First Inventory and the Initial National Communication in 1996, the reference year 1994; ii) The Second Inventory and subsequent Second National Communication in 2011, the base year 2000; and iii) now the Third Inventory and consequently, within this framework, the reporting guidelines, adopted during COP 8 for the preparation of national communications from Parties not included in Annex I to the Convention and contained in decision 17/CP.8 have been adopted for the preparation of this Third National Communication (reference year is 2010) always steered by the Guidelines and / or Good Practice Guidance 2003 Intergovernmental panel on Climate Change (IPCC) for the Preparation of National Communications from Parties not included in Annex-I of the Convention.

In the new organizational structure of the government of the Republic of Guinea-Bissau the Ministry of Environment and Sustainable Development (MADS), is the Government entity entrusted with the overall responsibility for the development of environmental Policies, including those on Climate Change. The organizational structure of MADS is made of two directorates (see Diagram below):

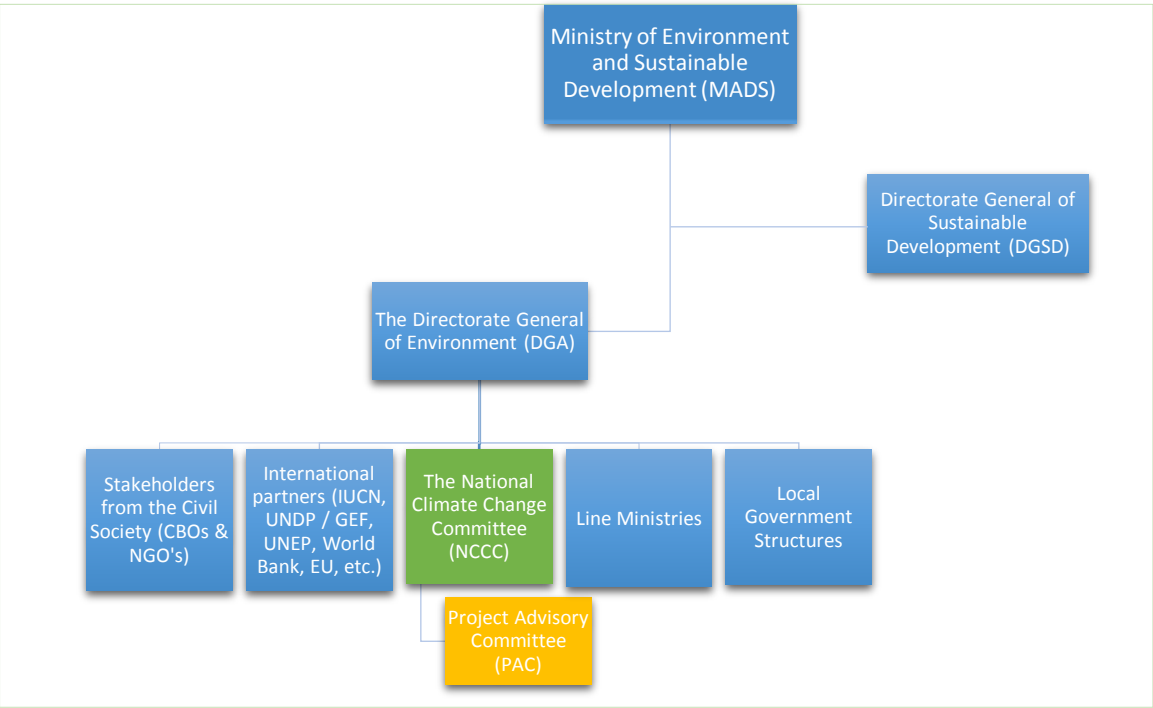


Diagram of Institutional Arrangements of the TNC project

The Directorate General of Environment (DGA) and the Directorate General of Sustainable Development (DGSD), being however the DGA with the overall responsibility for the coordination and implementation of the environmental policy through the different departments, programs and projects in a centralized system, since there are still no regional offices. Taking into account the limited DGA capacity in terms of resources (human, material and financial), for effective implementation of its policy, it has enjoyed significant support from numerous national and international partners, including: UNDP / GEF, UNEP, World Bank, EU, IUCN, punctually Wetlands International etc.

The National Climate Change Committee (NCCC), chaired by the MADS and involving a wide-ranging representation of stakeholders, provided the overall oversight and advisory role for the implementation of the TNC project. The upper tier of the project structure is the Project Advisory Committee (PAC) which was the highest decision-making body for national communication and provides overall direction and oversight.

2.3. Geography

Guinea-Bissau, located in Western Africa (12° 00' N, 15° 00' W), between Cape Roxo (latitude 12º 20' N), the Cajete Ponta (latitude 10º 59' N) and the meridians 13º 38' and 16º 43' W bordering the North Atlantic Ocean, between Republic of Guinea and Senegal is relatively small in size (36,125 km^2 – Land 28 000 km^2, Water 8,120 km^2) and estimated population of 1.6 million (2011), with a low-lying land mass and an archipelago comprising a large number of islands. The country shares borders with Senegal (338 km) to the north and Guinea-Conakry (386 km) to the south and east (Figure 2.1).

Figure 2.1 - Geographic Location of Guinea-Bissau (Source: PNGA, 2010).

Its territory is divided between continent and islands, the latter including a contiguous chain of seven islands (Jeta islands, Pecixe, Sands, Caiar, How and Melo), including the Bijagós archipelago made up of 88 islands and islets of which only 21 are inhabited (NAPA, 2006), now recognized for its high biodiversity. These characteristics render the country highly vulnerable in particular to sea level rise, flooding, and related saline intrusion associated with climate change. Administratively the country is divided into eight regions: Bafata, Biombo, Bolama, Cacheu, Gabu, Oio, Quinara and Tombali and an autonomous sector of Bissau (SAB). By having an insular part (the archipelago Bijagós), Guinea-Bissau is part of Group of Small Island Developing States (SIDS).

The morphology of the territory of Guinea-Bissau has a very smooth relief, with most of the country lying below the 50-m elevation bathed daily by tidal waters that reach as far as 62 miles (100 km) inland. In the southeastern part of the country, the Fouta Djallon plateau rises approximately 600 feet (180 metres). The Boé Hills extend from the western slopes of the Fouta Djallon to the Corubal basin and the Gabú Plain. The northern coastal areas and South are mostly lowlands. Thus, with high amplitude tides occurring locally, often reaching 6 m height, large coastal areas are therefore exposed to its impact. Plains cover a large part of the territory in the Central and Northeast regions. The southeastern inner zone is the most rugged area of Guinea- Bissau. However, even so the hills of Boe, are the highest part of the territory, they do not go further than 298 m altitude. The coastal area is demarcated by a dense network of drowned valleys called rias. The Bafatá Plateau is drained by the Geba and Corubal rivers. The Gabú Plain occupies the northeastern portion of the country and is drained by the Cacheu and Geba rivers and their tributaries.

The interior plains are part of the southern edge of the Sénégal River basin. The uniform elevation of the mature floodplain allows rivers to meander and renders the area susceptible to flooding during the rainy season. Some eastern portions of Guinea-Bissau form a part of the upper basin of the Gambia River system[11].Tidal penetration into the interior, facilitated by Guinea-Bissau's flat coastal topography, carries some agricultural advantage: the surge of brackish water can be used to irrigate the extensive drowned rice paddies called bolanhas.

Over the years there was a devastating effect on Guinea-Bissau's soils with arable land that fell out of use being subject to soil erosion, and, with the destruction of protective riverine dikes, the arability of some soils was compromised by excessive salination. The islands of the archipelago of Bijagós present a similar morphology of mainland, with a line of rather indented coast and low elevations. These coastal features of low altitude and being an archipelago confer to Guinea-Bissau a high degree of vulnerability to the adverse effects of climate change.

2.4. Climate Profile

The country lies in the humid tropics within the tropical zone, between the equator and the Tropic of Cancer, and between the Atlantic Ocean and the Sudanese-Sahelian continental block. The country is subject to the movements and impacts of the Intertropical Convergence Zone (ITCZ), which migrates between the equator and the Tropic of Cancer over the course of the year broadly dictating its seasons.

There are two pronounced seasons in Guinea-Bissau: the hot, rainy season, which lasts from May to November, and the hot, dry season from November to April. The weather throughout the year is mainly conditioned by the situation of the territory in relation to the ITCZ and the subsidiary actions of the semi-permanent High-Pressure cells, commonly known as anticyclone of the Azores in the Atlantic North and anticyclone of Santa Helena in the South Atlantic, and also by the summer thermal low that establishes over the Sahara Desert.

2.4.1 Rainfall

The local climatic features induce rainfall variations in relation to the country's geographical location[12] (South: Tombali, Quinara e Bolama-Bijagós Region >2000 mm / year; Northwest Regions of Bissau, Biombo, Cacheu e Oio: 1400-1800 mm / year; Eastern regions of Bafatá and Gabú: 1300-1500 mm / year).

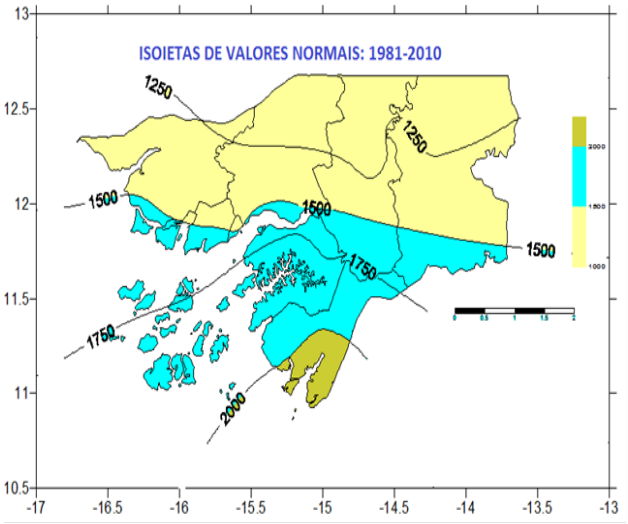


Figure 2.2 – Average (1981-2010) rainfall values for Guinea-Bissau. Source: Climate profile of Guinea-Bissau (2014) report

Precipitation does not vary greatly with elevation in Guinea-Bissau, although it does vary between coastal and inland areas; the coast displaying a tropical maritime condition receives some 60 to 120 inches (1,500 to 3,000 mm / year) of precipitation, whereas the interior is influenced by the tropical savanna climate, with greater variation in precipitation and temperature (Figure 2.2). Notably, the NE of the country displays a climate Sudan type with hot and dry conditions and in the North rainfall can reach 1400 mm whilst the South displays a more Sub-Guinean type of climate characterized by high rainfall totals and lower temperature than the NE.

On average, about 80% of annual rainfall occurs during the months of July, August and September. Precipitation during monsoon seasons can be intense, with 300mm per month recorded in August. The least amount close to zero (0.1 mm) occurs during the months of December to April (dry season).

2.4.2 Temperature

The climate in general is tropical maritime with an average temperature of 20ºC. However, the crossing by intertropical convergence zone through the country places Guinea-Bissau under the influence of the monsoon (hot and humid air from the Atlantic Ocean) during the rainy season and the Harmattan (hot and dry air that comes from the Sahara) during the dry season. Therefore, although temperature in Guinea-Bissau is less variable than rainfall, monthly average temperature varies between 24°C and 30°C. Over the course of a year, the daily temperature typically varies from 18°C to 35°C and is rarely below 17°C or above 37°C.

Thermal environment of Guinea-Bissau can be divided into four major periods during the year:

1- Fresh Period: December, January and February;
2- First warm period: March, April and May;
3- Period of rain: June, July, August and September; and
4- Hot period: October and November.

Absolute temperatures range between 21.6°C and 39.3°C in April and May, just before the rainy season, between 21.1°C and 31.5°C from August to November and between 16.5°C and 38.5°C in December to March. Spatially, monthly values of maximum air temperature range from 29.5°C to 39.3°C across the regions with minimum temperatures ranging from 16.5°C to 24.3°C (Table 2.1). The climate of Guinea-Bissau is humid on the coastal central and southern territory (relative humidity between 62 and 87%) and drier in the rest of the territory (relative humidity between 58 and 68%). The highest temperature ranges take place in the months of January and February when clear skies are frequent and smallest amplitude of the diurnal variation during the rainy season.

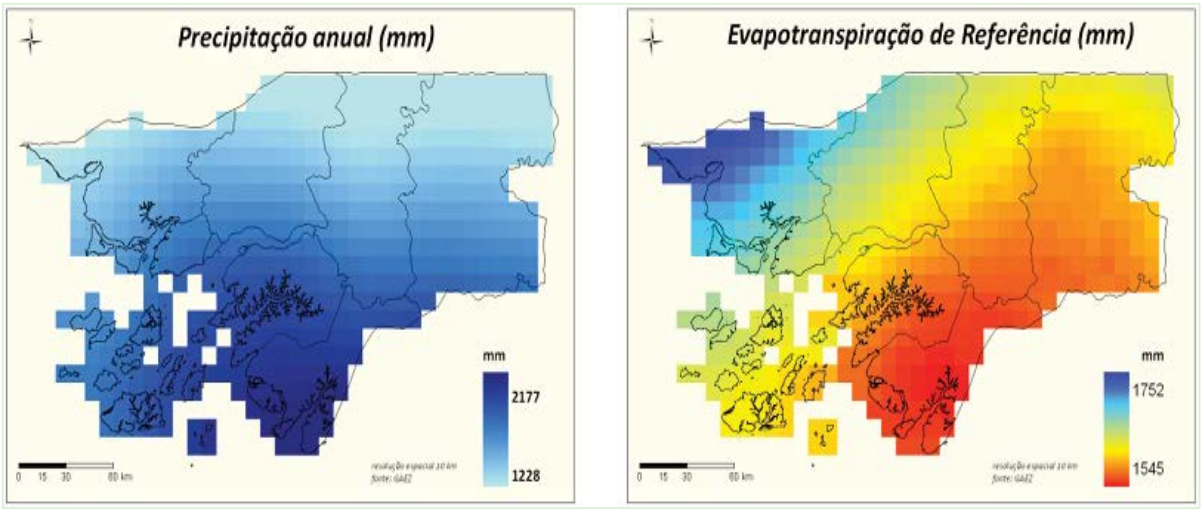
Table 2.1 - Average annual temperature values for climatic regions (1971-2000).

Average Values	Centre North (Sab, Biombo Cacheu and Oio)	South (Tombali, Quínara and Bolama-Bijagós)	East (Bafatá and Gabú)
Temperature (°C)			
Annual temperature	26.0 – 28.0	25.0 – 28.0	25.0 – 31.0
Monthly maximum temperature	29.7 – 33.0	29.5 – 34.0	30.7 – 39.3
Monthly minimum temperature	19.8 - 24.3	19.1 – 23.9	16.5 – 23.2

The warm season lasts from February 18 to May 5 with an average daily high temperature above 34°C. The hottest day of the year takes place in April, with an average high of 35°C and low of 22°C. The cold season lasts from about July 15 to September 18 with an average daily high temperature below 31°C. The coldest day of the year takes place in January, with an average low of 18°C and high of 32°C. Consequently, the climate induced hydrological balance displays a water surplus from July to October, during the rainy season, and leads to a deficit during the dry season.

2.4.3 Water Balance

Annual variations of main climate variables for Guinea-Bissau are shown in Figure 2.3. The water balance (Precipitation-Evapotranspiration, P-E) in the country shows a water surplus for four months in the year, between July and October and a water deficit for six months, from December to May.



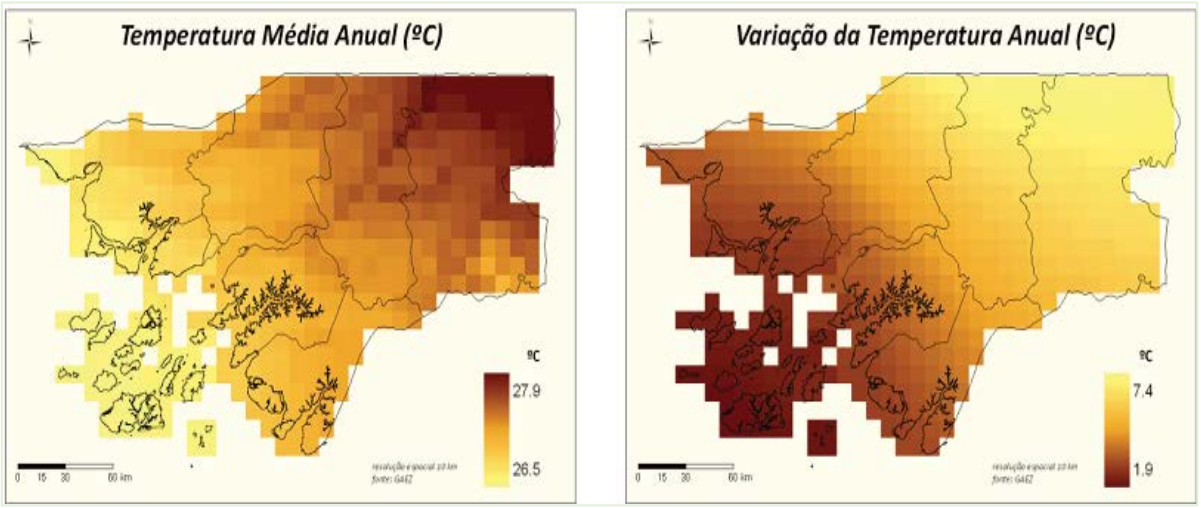


Figure 2.3 - Main Climate variables of Guinea-Bissau: (i) Annual Rainfall (mm); (ii) evapotranspiration (mm); (iii) Average annual temperature (°C) and (iv) the variability in intra-annual temperature. Source: Letter Agroclimatic and Vulnerability of the Gabu Region, Project NAPA (SEAT/UNDP, 2013)[13]

The months of June and November are transition periods, where there is almost a balance. The extent of water surplus in the rainy season is higher in the southwest and coastal areas than in the north and east of the country. By contrast, the deficit in the dry season displays an opposing pattern. Therefore, rainfall and specifically the water surplus during the rainy season are climatic factors that enable to best differentiate the climatic regions of Guinea-Bissau.

2.5. Demography

Guinea-Bissau's population is dominated by more than 20 African ethnicities, including the Fulani 28.5%, Balanta 22.5%, Mandinga 14.7%, Papel 9.1%, Manjaco 8.3%, Beafada 3.5%, Mancanha 3.1%, Bijago 2.1%, Felupe 1.7%, Mansoanca 1.4%, Balanta Mane 1%, other 1.8%, none 2.2% (2008 est.). Although there are some 20 languages and dialects, Portuguese is the country's official language and the formal language is Crioulo—a creole that emerged during the slave trade—that is spoken as the lingua franca and exerts a unifying influence in the rural areas.

Figure 2.4 - The population growth (1960-2014) in Guinea-Bissau[14].

The population of Guinea-Bissau grew[15] steadily from 1,673,509 (2011), 1,714,620 (2012), 1,757,138 (2013), 1,800,513 (2014) and was estimated to be 1,815,698 people people on 1 January 2017[16] (Figure 2.4). This is an increase of 2.55 % (45 172 people) compared to population of 1,770,526 the year before and is expected to reach 2 068 362 in the beginning of 2020[17]. Current male population (49.6%) 937 388 is outnumbered by the current female population (50.4%) 951 041[18]. In 2010, the proportion of the population below the age of 15 was 41.3%; 55.4% were aged between 15 and 65 years of age, while 3.3% were aged 65 years or older. Although the population growth in Guinea-Bissau is lower than that of the rest of the African continent there has been a significant change over the last few years. On the whole, the population of Guinea-Bissau continues to be very young: about two-fifths of the population is under age 15 and about two-thirds under 30. However, estimates from the beginning of 2016 (Figure 2.5) show that in 2015 the population age distribution was such that 39.6% of the population is under 15 years old, 55.0% between 15 and 60 years old and 5.4% of the population is 65+[19]. Therefore, there was a major change in the pattern of population distribution in recent years from 2010-2015.

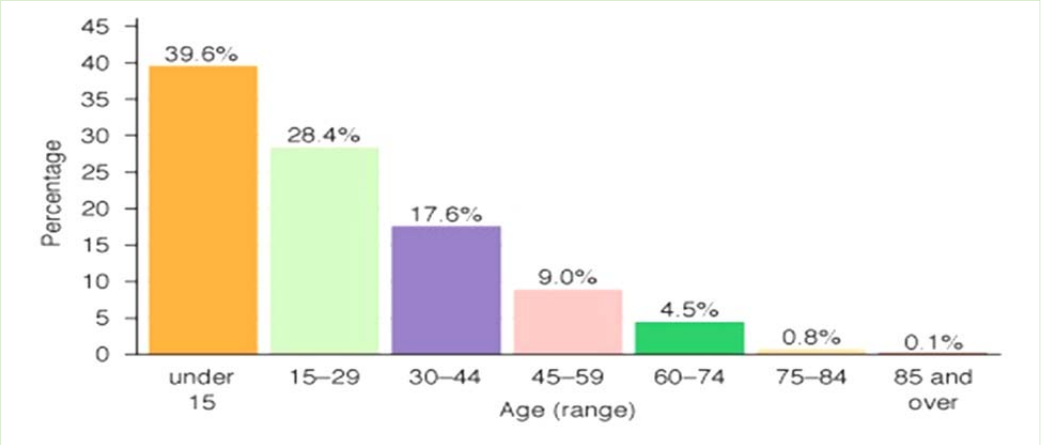


Figure 2.5 – Age breakdown of the population of Guinea-Bissau (2015)[20].

These latest records also indicate that the Guinea-Bissau population pyramid has an expanding type common for developing countries with high birth and death rates.

The nature of the sequential population pyramids for the past census years portray a distinctive scenario in developing countries, with a wide-ranging base indicating a youthful population, and a constricted apex, showing a reduced number of aged persons in the country (Figure 2.6). However, life expectancy for both men and women is still well below the African average and substantially lower than the world average, and infant mortality is high. This is also below the average life expectancy at birth of the global population which is about 71 years[21].

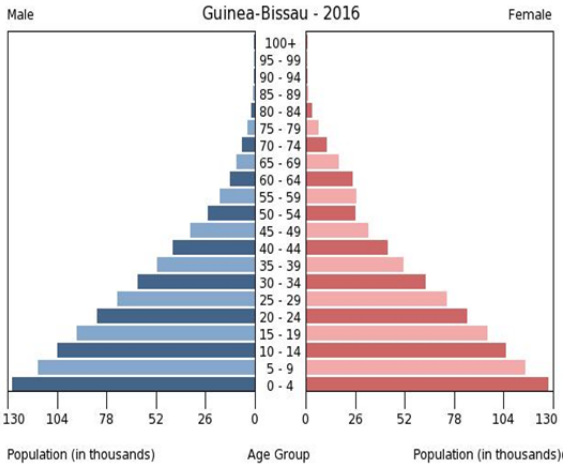


Figure 2.6 – Population pyramid of Guinea-Bissau for 2014[22].

By contrast, the current fertility rate in Guinea-Bissau is still high for Global levels, notwithstanding the recent fall. During last 3 decades, Global fertility rate decreased from 3.7 (6.74 1980's for Guinea-Bissau) to 2.5 contrasting with 4.99 (4.56 2015 est.)[23] children per woman in 2012 for Guinea-Bissau. Guinea-Bissau's young and growing population is sustained by high fertility; approximately 60% of the population is under the age of 25. Its large reproductive-age population and total fertility rate of more than 4 children per woman offsets the country's high infant and maternal mortality rates. The latter is among the world's highest because of the prevalence of early childbearing, a lack of birth spacing, the high percentage of births outside of health care facilities, and a shortage of medicines and supplies[24]. It is known that fertility rates of above two children indicate populations growing in size and whose median age is declining. Higher rates such as those for Guinea-Bissau may also indicate difficulties for families, in some situations, to feed and educate their children and for women to enter the labor force[25]. Fertility rate has been found to be directly linked to women school enrollment rate. School enrollment rate among women in developed countries is almost 100%, and fertility rate is below 2 children per woman. School enrollment rate for female and primary school for Guinea-Bissau now stands at 68.2% (2010), having increased increase from 27.6% (1988)[26]. Literacy rate for adult male population is 71.78% (368 910 persons) meaning that 145 071 are illiterate clearly in contrast to the adult female population literacy rate of 48.28% (269 746 persons) i.e. 288 943 are illiterate. The same pattern is observed for youth (ages between 15 and 24 years) literacy rates which levels are 80.85% and 73.71% for males and females respectively[27].

Predominantly, the population of Guinea-Bissau is rural-based. However, about 49.3 percent of Guinea-Bissau's population lives in urban areas[28] and according to population size data of Guinea-Bissau, the number of urban residents is around 743,402. The current Guinea-Bissau population density is 51.7 people per square kilometer as of April, 2016[29]. The only city with a population of more than 100 000 is Bissau, the capital, with an estimated population of 492 000 in 2015[30]. Concentration of urban population is also taking place in other major cities such as Gabú 43,556 (2009) and Bafatá 34,760 (2010). In fact, the population of urban areas in Guinea-Bissau has been growing at considerable rate and recent data indicate that urbanization stands at 4.13% (2010-2015 est.)[31]. This means that considerable amount of people is migrating to urban areas (Table 2.2) either due to poor economic conditions and lack of employment opportunities in villages; and/or poor agricultural conditions and greater population pressure on land. These are the main push factors that drift the rural population to the urban areas, testing on one hand the capacity of urban centers to absorb the incoming population and provide them sufficient livelihood and; on the other hand, contributing to steady decline of agriculture productivity.

Table 2.2 – Trend of percentage urban and rural population in Guinea-Bissau (2009-2014).

Indicator	Years				
	2009	2011	2012	2013	2014
% Urban Population	39.57	40.44	40.87	41.30	41.73
% Rural Population	60.43	59.56	59.13	58.70	58.27

Source:INE / Estatísticas Básicas da Guiné-Bissau 2014

2.6. Socio-Economy

Human Development Index in Guinea-Bissau continues to be weak and precarious. This is gauged by the Human Development Index (HDI) which is a summary measure for assessing progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. A long and healthy life is measured by *life expectancy at birth*. Knowledge level is measured by mean years of *education among the adult population*, which is the average number of years of education received in a life-time by people aged 25 years and older; and access to learning and knowledge by expected years of schooling for children of school-entry age, which is the total number of years of schooling a child of school-entry age can expect to receive if prevailing patterns of age-specific enrolment rates stay the same throughout the child's life. The *standard of living* is measured by Gross National Income (GNI) per capita expressed in constant 2011 international dollars converted using purchasing power parity (PPP) conversion rates. Guinea-Bissau has one of the lowest Human Development Index scores (0.420) ranking 178 out of 188 countries and territories in 2015. Between 2005 and 2015, Guinea-Bissau's HDI value increased from 0.388 to 0.424, an increase of 9.2 percent (Table 2.3) [32].

Table 2.3 - Guinea -Bissau's HDI trends based on consistent time series data (1990 -2015).

Year	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2011 PPP$)	HDI value
1990	49.1	3.7		1,309	
1995	50.6	5.2		1,322	
2000	51.5	6.7		1,277	
2005	52.4	8.3	2.3	1,266	0.388
2010	53.8	9.0	2.6	1,349	0.410
2011	54.2	9.1	2.7	1,415	0.416
2012	54.5	9.1	2.8	1,329	0.415
2013	54.9	9.2	2.8	1,342	0.419
2014	55.2	9.2	2.9	1,339	0.421
2015	55.5	9.2	2.9	1,369	0.424

The two factors that contributed to Guinea-Bissau's low HDI are: widespread poverty with very low monetary income and limited life expectancy (55.5 years old) resulting from the lack of income generating opportunities and access to quality health care. Between 1990 and 2015, Guinea-Bissau's life expectancy at birth increased by 6.4 years, mean years of schooling increased by 0.6 years and expected years of schooling increased by 5.5 years. Guinea-Bissau's GNI per capita increased by about 4.6 percent between 1990 and 2015. In 1998 alone, the GDP per-capita of Guinea-Bissau was only 173 US dollars compared to the per-capita GDP of the United States at 29 683 US dollars. GDP per capita in Guinea Bissau averaged 444.23 USD from 1970 until 2014, reaching an all-time high of 589.77 USD in 1997 and a record low of 380.45 USD in 1980[33]. Lately GDP per-capita of Guinea-Bissau has reached 692.60 US dollars in 2011 and went through a mostly stable period picking up to 614 in 2010 then reaching 620.21 US dollars in 2016 and this represents a GDP per Capita equivalent to 3% of the world's average. Due to this economic situation, the population of Guinea-Bissau has suffered from a life expectancy of only 48 years in 2012 increasing steadily pairing with the GDP to a current figure of 55.5 years (2014)[34]. Most recent statistical records in local currency (CFA Franc) are shown in Table 2.4.

Table 2.4 - Indicators of National Accounts, 2010-2015

Indicators (million CFA Franc)	2010	2011	2012	2013	2014	2015
Nominal GDP	419.713	520.776	547.183	572.032	597.987	639.116
Real GDP (at the 2005 price)	363.464	396.764	387.903	391.394	402.551	421.428
Real GDP growth	4.4%	9.0%	-2.2%	0.9%	2.9%	4.7%
Nominal GDP per capita	283.392	344.042	353.706	359.822	382.771	400.998

Source: National Statistics Institute of Guinea-Bissau (INE – Estatísticas Básicas da Guiné-Bissau)

Guinea-Bissau has been stuck in a fragility trap that permanently hindered economic growth. Indeed, economic growth has stalled since 2000[35]. Having spent a long period of recession in the early 2000s, followed by a slight recovery in 2007, Guinea-Bissau's economy enters a new growth from 2008. The real growth rate between 2008 and 2009 averaged 3.1%, a marked improvement compared to the results of 2006 and 2007 (1.2% on average). Thereafter came a period of transition, marked by a slowing of the economy. However, the return to constitutional order led to growth estimated at 2.9% in 2014, against 0.9% in 2013 and -2.2% in 2012[36]. Growth could surpass 4.7% in 2016 and a notable increase in 2017, depending on the socio-political climate, the outcome of the push for food production, the promotion of cashew-nut farming, as well as improvements in economic and fiscal governance[37].

The primary, tertiary and secondary sectors represented 49%, 38%, and 13%, respectively, of GDP in 2013. The contribution of the primary sector (agriculture, livestock, forestry and fisheries) for the formation of GDP on that year was very expressive. Indeed, most of the period of growth that have occurred has been largely propelled by agriculture (6.3% in 2009), including the chain of production and export of cashew nuts (DENARP II, 2011)[38]. The latest records on sectoral contribution of the economy to the GDP are shown in Table 2.5.

Table 2.5 - Sectoral contribution of the economy to the GDP, 2009-2012

Sectoral contribution to GDP	2009	2010	2011	2012
Primary	43.7	44.9	44.5	46.5
Secondary	12.8	12.7	12.7	14.4
Tertiary	40.0	38.3	38.7	35.3

Undoubtedly, the private sector in Guinea-Bissau is weak and consists mainly of informal activities. In 2009, there were no more than 75 registered firms. Therefore, the growth drivers are limited to the agro-food sector and the production of cashew nuts, which remains the backbone of the economy: in 2013, it accounted for 87.7% of total exports[39]. Unquestionably the primary sector remains the pillar of the Guinea-Bissau economy. This sector concentrates 67% of GDP and 80% of jobs. The cashew contributes on average 30% to the value added of this sector, which still suffers from structural limitations undermining its potential. The lack of infrastructure and poverty in rural areas are the main barriers to diversification of primary production.

2.6.1 Emerging Sectors in the Economy

The country's history of chronic political instability has led to policy discontinuity which is a powerful deterrent to reforms. Nevertheless, the reforms undertaken in the last three years have produced some concrete results, particularly in terms of macroeconomic stabilization and improving public financial management. The newly established peaceful atmosphere has made the economy to expand by 5.1% in 2015, up from 2.9% in 2014[40]. The vulnerability of the economy is twofold. In one hand, the vulnerability of Guinea-Bissau's economy is mainly due to its dependence on agriculture (almost 60% of GDP) in particular, the cashew industry alone, which is the main source of export revenue and a significant share of government revenue. On the other hand, Guinea-Bissau's economic depression is largely the result of a long period of political instability. The proof is that due to the last 2012 unrest the country's GDP has contracted 1.5% according to the African Development Bank Group. In order to diversify its economy and foster growth Guinea-Bissau should prioritise economic diversification if the country is to increase its resilience to external shocks.

Industry

Industry constitutes a small part of Guinea-Bissau's economy, contributing approximately 15% a year to GDP. Industries include a sugar refinery and a rice and groundnut processing plant. Guinea-Bissau ranks sixth in the world in cashew production. Brewing and urban construction are also represented in the industrial sector. In the late 1980s, Guinea-Bissau attempted to attract foreign interest in several enterprises—a fish-processing plant, a plywood and furniture factory, and a plastics factory. The government moved to raise producer prices and to partially privatize parastatal trading companies during the 1990s, but civil war in 1998 disturbed these plans. In 1999, production resumed with foreign aid[41].

Fisheries

Some new economy sectors are emerging, and Guinea-Bissau's fishing industry has great potential. Fishing has an annual potential estimated at 275 000 tons, but its current level of exploitation is located around 120 thousand tons which is 5.3% of GDP and contributes 40% in the state budget - through fishing license sales (INE, 2009 & PRSP II, 2011). Only 25 000 tons are consumed at the country level. However, new fishing infrastructure being built in Bissau, should help diversify rural revenues away from cashew nuts. The World Bank estimates (2009) that well managed commercial fisheries in Guinea-Bissau's could provide fish catches with an annual gross value of production of $191 million, yielding potential annual public revenues of almost $30 million[42].

Forestry

The forestry sector is another potential driver of the economy. Guinea-Bissau has 2 million hectares of forest, i.e. a little over 55% of the national territory. Timber reserves were estimated at 48 million m3. According to the forestry sector Feasibility Study Report carried out in 2011, (i) the Northern region has an area of 9,484 ha, yields a total volume of 139,044 m3 leading to 14.66 m3 / ha followed by (ii) the eastern region with 10,800 ha, carries 166,240 m3 (15.39 m3 / ha); and (iii) the South, with a total area of 16,666 ha, producing a total volume of 194,700 m3 (11.68 m3 / ha)[43]. However, these resources faced an accelerated destruction, estimated at 50 000 ha / year in 2006 (NAPA, 2006). Most recently the depletion of forestry resources has been considerable but at lower rate with a total tree

cover loss (2001 - 2014) estimated at 79,882 ha with a peak loss of 20,689 ha in 2013. However, there has been some faint gains in tree cover (tree cover and loss with >30% canopy density) estimated at 6,529 ha (2001 - 2012)[44]. Depletion and degradation of forest resources has its main causes in the illegal logging and deforestation for charcoal production. Last estimates indicate that about 90% of energy consumption in Guinea-Bissau comes from wood in the form of charcoal or wood products. According to the document of the Forest Policy of May 2010, the biomass fuel needs for energy consumption (firewood and charcoal) of the rural population is estimated at about 1.5 million m3 /year at national level[45].

Energy and Mining

Guinea-Bissau is utterly dependent on import of oil products for the generation of essential electricity solely generated by power plants. Although with hydropower generation potential, the country still does not have a dam for this purpose. The country has unexploited natural resources such as the mineral sector. There are considerable deposits of minerals including bauxite and phosphates. The oil potential is unclear, but current oil reserves are estimated at 1.1 billion barrels. Production of bauxite, phosphates and oil could double or triple Guinea-Bissau's foreign exchange and fiscal revenues. However, there are some drawbacks in this sector linked to the main risks to the environment particularly in related to mining projects, which may threaten rivers and the fishing industry in the south. The Government has already put forward environment laws that cover issues ranging from the use of toxic substances to extraction in protected areas.

Tourism

Guinea-Bissau has an abundance of high quality land and favourable rainfall. Its rich mineral deposits, exotic bio-diversity, and fishing and tourism potential, particularly in the coastal zone, where approximately 80% of the population lives, could provide diverse sources of income[46]. The Government authorities believe that tourism can be a tool to achieve the Millennium Development Goals (MDGs) of poverty reduction and environmental sustainability. The focus on the environment and local natural ecosystems can be a theme that will help creating the country's image as an attractive destination for tourists. Indeed, the country has a huge but untapped tourism potential, starting with the Bijagós Archipelago, which UNESCO has declared a Biosphere Ecology Reserve. Nonetheless, political stability and basic infrastructure and services such as transport and roads need to be in place for tourism to develop and be considered as a driver of the economy[47] and a job creation sector.

2.7. Agriculture

Most the country's population is employed in low-productivity agriculture focused on cashew production which has superseded the production of rice. Economic growth has stalled since 2000 and poverty has widened in the years after. Indeed, poverty has increased in the last decade, in sharp contrast to the regional evidence Guinea-Bissau's social gap to peer's countries has been increasingly widening as social progress has stalled in the last decade. The prevalence of poverty is higher in rural areas than in urban areas. The last recorded estimate indicates that approximately 64.7% live in a situation of poverty, with less than two dollars per day[48]. The agricultural sector is the mainstay of Guinea-Bissau economy, a source of income for 85% of the population. Agriculture plays an important role in the country's external accounts,

and therefore has a significant impact on macro-economic stability of Guinea-Bissau. Agricultural exports account for over 98% of total exports of goods[49]. Production and export of cashew nuts and rice cropping are the major activities coupled with extensive livestock.

The cashew nut is the first export crop (Figure 2.7). Indubitably, cashew nuts represent over 90 percent of total exports and about 17 percent of government revenue, hence the vulnerability of the economy to cyclical fluctuations in the market price of cashews. The area cultivated with cashew and cashew nut production has increased continuously in the last decades. The data on cashew nut production and cultivated area for the country in the period 1978-2012 (FAO, 2015)[50], indicate that for 2012, there was an estimated area under cashew cultivation of 223 000 ha with an annual production of 130 000 tons of raw cashew nuts. Commercial cashew nut growers have 15% of cashew plantations (15 000 hectares) whilst the remaining 85% (88 000 hectares) belong to traditional farmers. Regarding to the traditional farmers, the north of the country comes first with 48 000 hectares (55%), followed by Eastern region with 23 000 hectares (27%) and then the south including the archipelago of Bijagós with about 16,500 hectares (18%).

Figure 2.7- The cashew nut, the first export crop in Guinea-Bissau.

The annual growth rates estimated for the period 1978-2012 were 8% in area under cultivation and 12 % in production (FAO, 2015). However, since then, annual production has increased and in 2014 Guinea-Bissau exported 150 000 tons of cashew nuts employing some 80% of the workforce of the country, making the country the world's fourth-ranked producer and the second in Africa after Côte d'Ivoire. A bumper cashew harvest supported by increased international demand for the commodity was the main factor underpinning the pickup in activities.

Since most households in Guinea-Bissau, especially the poor, rely on cashew production, the 2015 cashew campaign augurs well for poverty reduction. However, the economy remains vulnerable to shocks due to high export concentration and the country's fragile status. The business environment remains difficult. To safeguard external stability in the medium term, policies targeting the diversification of the economy combined with improvement in non-price competitiveness will be critical.

Rice (Figure 2.8) is another strategic crop in Guinea-Bissau and is the staple food of more than 95 percent of the population. Average annual consumption is estimated at 190 000 tons. In 2014, the country produced 133.000 tonnes of this cereal. However, for over ten years, there has been a growing deficit, which was estimated at over 100 000 tons in 2009/2010, with domestic production covering only 47 percent of consumption.

According to the Letter of Agricultural Development Policy (1997), at the national level, the cultivated area was estimated at about 200 000 hectares. Of this, an area of approximately 68 000 ha was cultivated with rice, of which 37% with upland rice ("N'pam-pam") and 63% with rice "bas-fonds" ("lalas") and mangrove rice. Rice production is essentially guaranteed by family farmers (estimated at nearly 90 000, who account for about 90 percent of production).

Figure 2.8 - Rice a strategic crop and staple food in Guinea-Bissau. Source: FAO, 2010

For both of these crops, cashew nut and rice, the main features are the extremely low yields given to the rudimentary production techniques and obsolete working methods, which mostly require manual and physical labour from elderly farmers. In addition, there is the impact of the climate change hazards such as droughts, erratic and extreme rainfall events, and sea level rise affecting yields and quality of the produce.

In the case of cashew nut, less than 5% of the cashew production is processed locally. This economic concentration has direct impacts on the poorest segments of the population in terms of inclusiveness and food security: for example, the producer price slumped to 43% of the export price in 2013 compared to 57% in 2012 seriously affecting households and plunging over a third of the population into under-nutrition status. Therefore, the country remains vulnerable to exogenous shocks, such as fluctuations of international cashew prices. It is anticipated that 46,368 ha of rice fields (27,088 ha of mangrove areas, plus 19,280 ha in rice paddy areas)[51] will be cultivated over the next five years. The opportunity costs for preserving mangroves and converting them to rice cultivation will be considered. The government is aware that it is important to identify and demarcate areas to be converted and those to be preserved, in a context where the potential risk of climate change impacts is real.

2.7.1 Livestock

In the Guinea-Bissau agriculture system still dominates the practice of extensive cattle ranching. In Guinea-Bissau, the livestock sector contributes 17% to the national GDP and 32% of the agrarian sector GDP. According to the livestock census conducted in 2009 by the Directorate General of Livestock (DGP) under the PRESAR / BAD, it is estimated that the total number of cattle rounds 1,325,412, distributed mainly in eastern and northern areas[52] (Table 2.6).

The east region has the highest concentration of livestock where the regions of Gabu and Bafata appear with 71% of cattle herds (49% and 22%); 75% of sheep (50% and 25%); 45% goat (30% and 15%); equines 72.55% (57.45 and 15.10%); donkeys 85.60% (60.08% and 25.52%)[53].

Table 2.6 - Total number of animals in the livestock sector of Guinea-Bissau.

Category	2010	2011	2012	2013	2014	2015	2016
Cattle	1.365.174	1.406 .130	1.448.313	1.491.763	1.536.516	1.582.611	1.630.090
Sheep	309.316	313.956	318.665	323.445	328.297	333.221	338.220
Goats	658.820	668.703	678.733	688.914	699.248	709.737	720.383
Piggery	345.398	347.125	348.861	350.605	352.358	354.120	355.891
Poultry	1.534.534	1.588.243	1.643.832	1.701.366	1.760.914	1.822.546	1.886.335

Source: DEA/Ministério de Agricultura, Floresta e Pecuária

The region of Gabu has the highest livestock concentration with 49.41% of cattle (654,543 animals) 50.4% of sheep (153,349 animals) and 29.9% goats (193,445 animals). The number of heads per family is variable and it rounds between 50 and 1,000 animals, which shows the economic and social importance of the sector. The eastern side is responsible for supplying 96% of cattle to the capital Bissau, and the cattle beef accounts for over 90% of all revenue from Gabu livestock. This practice of extensive cattle ranching has caused many conflicts between cattle breeders and farmers and other impacts (positive and negative) in the agricultural system.

Figure 2.9 - Cattle ranching is practiced as a contributor to poverty reduction in Guinea-Bissau. Source: NAPA[54]

To maximize the positive impacts, it is urgent to organize the chain of transhumance, with a view to promoting a balanced exploration and high yield of livestock, as a contribution to poverty reduction (Figure 2.9). The total area of pasture is estimated at 1.268 million hectares, or about 35% of the total area of the country, that is, about 300 000 hectares in the north, 800 000 hectares in the Eastern Region and 168 hectares in the south. The biggest limitation of the sector is the absence of sufficient technical resources able to support livestock farmers, lack of infrastructure for water supply, and poor animal health control.

2.8. Forestry

Previous studies (NEMP, 2005) indicated that the country has considerable forest resources covering 2 030 284 hectares of surface with diverse ecosystems spanning from sub-humid forests, dry galleries, savannas, palm groves and mangroves. Preliminary data from a more recent programme (CARBOVEG Project, 2007) estimate that indeed the forest area of the country is around 2 072 000 ha. However, this is a considerable departure from the forest inventory of 1985 when results indicated a forest area covering 2.4 million hectares and the reserve of wood was 48.3 million m3 (Table 2.7).

Table 2.7 – Guinea-Bissau forest resources with diverse ecosystems spanning from forests, to savannas, palm groves and mangroves.

Forest type	Mean Annual Increment (m^3/ha/year)	Area (ha)	Total annual production of timber (m^3/year)
Compact Stands	0.994	90,400	89,858
Degraded Compact Forest Stands	0.404	62,400	22,210
Mix Compact/Degraded Stands	(0.404)	20,000	8,080
Dense Forest Stands	0.474	189,600	89,870
Degraded Dense Forest Stands	0.288	747,200	170,362
Savannah	0.245	926,000	226,870
Palm/Coconut Stands	-	80,000	pm
Mangrove stands	-	248,400	unexploited
Riverine Forest Stands	(0.474)	93,200	44,177
TOTAL		**2,457,200**	**654,427**

Several authors put forward several figures on the rate of forest degradation in Guinea-Bissau. For example, FAO points out that during the period 1981-1985 there was a loss of about 34 000 ha / year. Bianchi et al., in 1986, put forward 60 000 ha / year. It is assumed that the annual degradation was situated at 30 000 ha (estimate not including mangroves and palm) from 1995 to 1999, resulting in 420 000 ha of forest cover degraded, so now the area is estimated at 1.605 million ha (Dias, C and Correia, C. 2000). This area includes 8% of Guinea-Bissau's territory which is also covered by mangrove type of vegetation distributed along its coastline, estuaries, rivers and riverine tongues penetrating the inland. The latest data (CIRAD, 1990), indicate total area of 2484 square kilometres, while it was 4760 square kilometres (Edwin, 1987) i.e. there is a regression in the order of 48%. This ecosystem is among the most "productive in the country (Da Silva, A., 2001). The current situation is that with an annual growth rate estimated at 1.5 million m^3 / year, it is estimated that the forest capital degradation rate is approximately 600 000 m^3 / year, excluding the surface losses caused by deforestation in Tabancas[1], evaluated at 30 000-60 000 ha / year.

The use of wood energy from the forest through illegal logging, wild fires and charcoal production gained important dimensions in Guinea-Bissau (Figure 2.10). The wood is the dominant biomass fuel for domestic consumption, with a demand that probably exceeds 500 000 tonnes per year. Charcoal follows with 137 000 tons of annual domestic consumption, mainly in urban areas, with special emphasis on the city of Bissau (NEMP, 2003). The environmental costs of alternative use of wood energy for domestic activities are enormous and are jeopardizing the proper ecological balance of the country.

The degradation of the forest ecosystem is more pronounced due to expansion of cashew monoculture. The area under cashew cultivation has increased at a rate of 20% per year between 1986 and 1995 and was estimated to be about 103 000 hectares in 1995. This and the indiscriminate cutting of forest trees is leading to the degradation of forest resources, which leads to loss of biodiversity and also land degradation. The Government has recently

[1] Traditional villages in Guinea-Bissau.

launched the Community Forest Management initiative which uses Integrated Land Management Approaches in Tabancas (GITT) as the most effective ways of giving a response to environmental and land degradation. Simultaneously, the new forestry law, recently approved, encourages the creation of community forests, which are under the control of the local population.

Figure 2.10 - Guinea-Bissau forest resources with diverse ecosystems

This legal framework paves the way for creation of a framework of Community management of forests at the level of Directorate General of Forest Management.

2.9 Water Resources

The water resources sector is undoubtedly one of the most important sectors as it affects all other institutions and infrastructure necessary to the development of the population. According to Catarino (2004) the hydrography of Guinea-Bissau's territory is complex and extensive. In addition to the climate, it is conditioned by smoothness of much of the territory and the sea water intrusion (Ribeiro, 1950; Teixeira, 1962). The country has a huge hydroelectric potential, but is unevenly distributed. According to the National Report Rio + 20 (2012) the water potential of the country is estimated at 14 billion cubic meters / year. The country's water resource consists of rainwater, surface water and groundwater. The surface water includes major rivers and its tributaries (the main ones being from north to south, Cacheu, the Mansoa, the Geba, the Corubal, the Rio Grande de Buba, the Cumbijã and Cacine) and estuaries. In addition, there are important stationary water bodies including lakes (like Cufada pond with an area of 35 000 hectares), lowlands (bas-fonds) and often temporary water bodies (Vendus) a common structure found in the East of the country.

Freshwater courses have a highly seasonal flow and many streams and rivers can dry up during the latter part of the summer. Consequently, they are intermittent freshwater flows in Guinea-Bissau. The Geba River, the Farim and Corubal Rivers are the most important in the country, and the first two almost cease to flow in the dry season. The Corubal River, with annual average volume of 130 000 million m3 has an important dry season flow (11 m^3/ s on average) becoming the most important surface water resource in the country. The hydrological contribution of the Geba River is more modest, and the average annual volume is estimated at Bafata to be 800 million m^3, with dramatic reduction of the flow of some of its tributaries during the dry season.

Groundwater and surface water reserves (free aquifers) are estimated to be several hundred m^3 / year (from 10 to 250 m^3 / year, depending on the zone), but with low rates exploitation and salinity problems. Indeed, much of the river network is actually an estuary with tides and a significant salt water intrusion extending 175 km up river within the territory. This causes significant salt water intrusion into the aquifer, which can cause problems during the dry season, if the extraction exceeds the water filling the aquifer. There is a huge water potential in the regions of Biombo and Cacheu Oio. However, cases of pollution of aquifers by salt water, are most common in these regions. Deep aquifers, though little known in the south, have more limited exploitable renewable resources in the order of 10 to 30 Mm^3 / year. The current exploitation of aquifers is estimated at 15 Mm^3 / year and only 14% of deep aquifers are exploited in the region (DGRH, 2012)[55]. Groundwater is mainly used for agriculture and supply of drinking water for rural and urban populations. In agriculture sector groundwater is mainly used for livestock consumption, irrigation and horticulture and rice production.

These groundwater and surface water reserves are a regulatory factor and important source for agriculture. The renewal of these resources depends largely on the intensity and regularity of rainfall, whose parameters have been worsening gradually over the years. River and ground water recharge is estimated to be 45 million m^3 annual average distributed variably from north to south.

2.10 Public Health

The health sector remains weak due to socio-political instability and poor sanitation conditions that facilitate propagation of some diseases, particularly respiratory, malaria and diarrhoea /cholera. Indeed, malaria, diarrheal diseases and acute respiratory infections are the diseases with highest occurrence. Malaria, caused by Plasmodium falciparum in more than 90% of the cases is widespread throughout the country and the leading cause of hospital mortality.

Malaria accounts for about 50% of cases of hospitalization in all health facilities (health centres and hospitals) (MINSAP, 1998)[56], a number which increases substantially during the rainy season and varies with each age group. Children are usually the most affected, with about 65% of cases in the paediatric wards. In addition to these, tuberculosis, sexually transmitted diseases, measles, malnutrition, neonatal tetanus, leprosy, hookworm disease and onchocerciasis make up other important entities for public health in Guinea-Bissau (Figure 2.11).

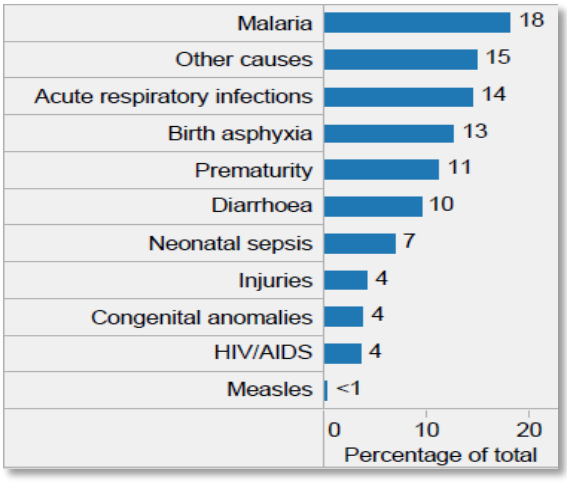


Figure 2.11 - Distribution of causes of deaths in children under-5, 2013. Source: WHO[57].

Most households use water from protected wells (28%) and pump or fodder (18%). Only 10% have access tap water and 9% have public tap water. At national level, only 8% of the population have access to water within the site. In total, about 13% of the population need to walk 30 minutes or more to reach the nearest source of drinking water and 6% have access to an inappropriate source of water. In Guinea-Bissau, the water and environmental sanitation conditions have a prominent position among the causes of infectious diseases diarrhoea, dysentery and fever Enteric; viral diseases. The rate of access to drinking water in the country is 66% in 2010. Most of the population drinks water from wells usually poorly maintained and easily contaminated by torrential rainwater. According to the report (MICS4, 2011)[58] only two-thirds, or 65% of the Guinean population use an improved source of water supply for drinking. Of this percentage, 84% in urban areas and 53% in rural areas.

Undernutrition is another major public health challenge in Guinea-Bissau, and is due mainly to food insecurity, inadequate health services, poor water and sanitation, poor infant and young child feeding practices, and high illiteracy rates among women. According to the 2014 Multi Indicator Cluster Survey (MICS 5), countrywide the chronic malnutrition rate is over 25 percent[59]. The main climate change driver on the health sector is the rainfall variability. The rainy season corresponds to greater proliferation of mosquitoes, flies and other insects, which contributes to the appearance, as well as malaria, of other infectious diseases. In general, the greater the rainfall amount the greater is the occurrence of diarrhoea and other illnesses. Increasing temperatures simultaneously with changes in rainfall availability also acts as climate change driver by altering the locations that are sensitive to vector-borne diseases such as malaria, dengue fever and schistosomiasis, also known as bilharzia, through affecting the habitat range for the vector (Chaves, 2010[60]).

The government and international partners is currently pursuing the implementation of a national plan towards the improvement of the quality of public health by, among others, promoting health education, providing minimum sanitation conditions, increase the number of latrines, improve the quality of drinking water, and increase the number of sanitation centers particularly in the capital.

2.11 Energy Sector

2.11.1 Energy Resources

There is a variety of energy resources from which Guinea-Bissau can potentially produce energy including biomass, hydrocarbons, hydropower, solar, wind, bioenergy and ocean energy. Up to date these are all undeveloped due to inadequate financial, regulatory and technical capacities. Therefore, the current energy capacity of the country is extremely limited. Energy consumption in Guinea-Bissau is mainly based on biomass (90%), oil products (8%) and electricity (2%)[61]. Biomass energy resources encompasses wood, coal and agricultural / forest products. At the level of subsistence communities, the collection and use of wood / coal for heating and cooking uses enormous resources in biomass and hand labour.

The hydroelectric potential of Guinea Bissau is high, however only 33.84MW of hydropower capacity has been identified so far (including Saltinho (14MW) and Cusselinta (13MW)) in studies carried out in the 1980's. Therefore, in Guinea-Bissau the production of electricity is excessively dependent on imported diesel fuel. This strong dependence of a non-oil producing country on energy imports (mainly petroleum products) is an important factor that

has negative impacts on the economy. The first step towards reducing over-reliance on fossil fuels with high import costs is to complete the total change of diesel for power generation to other cleaner sources.

2.11.2 Electricity Generation and Consumption

The national energy sector has been severely affected in recent times by the difficult economic situation of the country and the energy consumption per capita in the country is about 0.25toe/year; indicating the low level of development of the sector. The means of producing electricity are virtually non-existent; the government authorities have been forced to resort to rental groups that concentrate mainly in Bissau. In the remaining villages electricity production is very uneven, causing an ongoing imbalance between urban and rural areas. Distribution networks and marketing system are also scarce for most sectors and villages, leading to significant hardship to farmers with regard to meeting their basic needs, especially in the so-called conventional energy sources (commercial). Understandably, the energy consumption in Guinea-Bissau is in the region of 0.3 toe / person / year, being one of the lowest in the world. Even in the capital Bissau, only 40% of the population has access to electricity, while in the country as a whole, this proportion is 20% (DENARP II, ANO 2011)[62].

Currently the production of electricity is mostly thermal and marginally based on new and renewable energy (solar PV and biofuels). It is predominantly of diesel-based generators that do not exceed 2.5MW each. Lately some heavy fuel oil-based generation sets of 2.5MW each have been installed. The installed capacity for generating electricity has been reducing gradually since 2002, but the corresponding energy production has increased from 2010 reaching a maximum of 32.25 GWh in 2011. The historical electricity production and consumption in Bissau city is shown in Table 2.8.

Table 2.8 - Historical production and consumption of electricity in Bissau[63]

Year	Installed Capacity (MW)	Available maximum power (MW)	Max. power reached (MW)	Energy production (GWh)
2002	12.945	6.125	5.481	**15,694**
2003	17.51	7.8	4.8	**12,090**
2004	17.51	7.8	5.3	**19,875**
2005	17.51	7.8	4.25	**16,239**
2006	17.51	5.3	4.00	**20,360**
2007	14.67	2.8	2.6	**4,714**[64]
2008	14.95	4.350	4.25	**12,480**
2009	16.07	5.190	3.879	**14,489**
2010	7.36	4.1	3.89	**12,399**
2011	10.68	5.8	6.312	**32,250**
2012	**10.68**	**8.95**	**6.947**	**27,490**

The trends for the consumption of electricity in Guinea-Bissau are increasingly growing and are worrisome given that what is produced, despite the investments in the sector, is insufficient to meet the demand. There are interesting individual and collective initiatives that have emerged in the sphere of production of electricity to meet communities' needs and

with the surplus production being distributed through the neighbourhoods through a 220V unsafe and unsustainable network. At present, the country self-producers and not independent producers surpassed the public production and it is estimated that there is nearly 21MW of installed power according to the investigations conducted recently by DG where effective production needs are around 30 MW of electricity. The effects of drought and climate change, as well as pressure on the environment caused by the production of charcoal needed for domestic consumption and export, have created great difficulties to the people of northeast which are obliged constantly to straddle increasing distances to face energy demand and production activities.

2.11.3 Strategy of the Energy Sector

Currently there is no regional interconnection, even though the country is inserted in the sub-regional organizations of electricity interconnection, such as: OMVG (regional organization for the valuation of the Gambia River) coming from neighbouring Guinea-Conakry, passing through Guinea-Bissau, Gambia and Senegal later, and the WAPP (West Africa Power Pool), which is expected to be developed in the near future. Thus, the strategy that is being put forward for the development of the energy sector in urban and suburban areas will be based primarily on two main principles:

i) Consolidation and development of the infrastructure sector, so as to facilitate people's access, the implementation of a policy to reduce energy costs, guarantee quality of service, and sustainable economic development;
ii) Reorganization / reform of the institutional framework in order to establish, consolidate and separate the role of the state as an entity responsible for the development of sectoral policy and environmental protection, being the other functions assigned to other regulators, management, control heritage and private operators.

On the other hand, the country's energy strategy pursues to increase reliance on local energy sources, by placing more emphasis on the utilization of renewable energies to gradually lessen the dependency on the traditional energy sources, especially oil importation.

However, the investment required in the renewable energy sector is considerable. Nevertheless, besides the diesel generators, Guinea Bissau has also a solar photovoltaic power plant of 314kW to produce electricity (which was expected to start operating in 2014), and the pilot projects for energy cogeneration with cashew shells, whose energy sources or resources are abundant in the country. In addition, there are projects being developed in the context of hydroelectric plants, for example, the OMVG, Saltinho/Cusselinta and Banbadinga (Figure 2.12).

Figure 2.12 - Solar photovoltaic power plant of 314kW to produce electricity Banbadinga Sector (Banbandinga castaclaro).

2.12 Ecosystems and Biodiversity

Guinea Bissau's biodiversity constitutes a significant natural asset for the country that, if protected, has the potential to serve as the back bone of a future tourism industry. The coastal zone includes mangroves, sandbanks and mudflats, shallow estuarine waters and sub-humid Guinean forests that are known to be among the richest on the West African coast in terms of biodiversity (i.e. an abundance and variety of living organisms)

Figure 2.13 - Natural Park of Tarrafes (mangrove) of Cacheu River in the northern coastal zone of the country, around the estuary of the river Cacheu.

Possessing an incredibly diverse set of eco-systems ranging from dense tropical forests to mangrove swamps, Guinea-Bissau has become increasingly more conscious of the value of its natural wealth, investing substantially in conservation to the extent that approximately 26% of its national territory is protected [65] (Figure 2.13). More specifically, several species are considered globally significant, including 5 species of sea turtles, oceangoing hippos, chimpanzees and several species of migrating birds.

Indeed, results from earlier research indicates that Poilão is amongst the 10 most important nesting sites for this species in the entire world and the most important site in Africa. In addition, the Orango National Park has the only population of hippos across the West African coast, which lives mainly in salt water (Figure 2.14). According to some authors, most hippopotamuses in West Africa are found in Guinea-Bissau and The Gambia.

Figure 2.14- Population of hippos in Orango National Park (Guinea-Bissau) near rice fields of local communities[66].

The Government's vision for these protected areas is that they both (i) conserve valuable biodiversity and ecosystem functions and (ii) serve as "sustainable development poles" for the local communities and regions. For this reason, the Government established the Fund for Local Environmental Initiatives (FIAL) to complement biodiversity conservation efforts and demonstrate tangible benefits to local communities from the parks[67]. Guinea-Bissau's Bijagós Archipelago is one of these protected areas made of a collection of 88 islands that guard the country's capital Bissau. A UNESCO Man and Biosphere Reserve[68], the archipelago contains both national protected areas (Orango, João Vieira-Poilão) and community reserves (Urok)[69] all haven for hundreds of species of birds, fish, and mammals.

This makes Poilão and its green turtle population one of the greatest biodiversity values of Guinea-Bissau (Figure 2.15). At the same time, the coastal zone also provides valuable ecosystem services now, including nursery and breeding grounds for commercial fish stocks, carbon stocks and a buffer to mitigate against the impacts of climate change. Two additional terrestrial national parks (the Dulombi and Boé parks) and three environmental corridors (the Tche-Tche, Salifo, and Cantabane Corridors), which connect areas and permit wildlife movement while buffering human communities, are on the brink of being added soon.

Figure 2.15 - Giant sea turtles found in the protected areas of Poilão in Guinea-Bissau [70]

The Government of Guinea-Bissau through the Institute for Biodiversity and Protected Areas (IBAP) consider protected areas as the key to lifting the country out of poverty. IBAP is working to ensure the conservation of plant and animal species that can then increase fish stocks and tourism, and also provide food security for local populations[71].

The protected areas in Guinea-Bissau are set up on a zoning system, where central zones are completely untouched and oftentimes overlap with sacred areas determined by inhabitants' traditional beliefs. Then there are zones where limited activities can be practiced, as long as they are sustainable and are compatible with conservation interests. Lastly, there are zones where villagers reside, fish, and farm. A participative management of the protected areas with local inhabitants has played a big role in the success of these conservation efforts.

By allowing the protected zones to be inhabited, the country give value to the communities, encouraging local populations to also work towards its protection[72]. Therefore, linked to Guinea Bissau's biodiversity and the network of protected areas, tourism is high on the list of sectors to be developed. Eco-tourism has already taken root in the Bijagós and there are hopes that this will attract visitors, developing a high-end responsible eco-tourism services that will allow generations and generations of Bissau-Guineans and tourists alike to enjoy its natural treasures of the country.

2.13 Coastal Zones

Guinea-Bissau has an approximately 270 Km of coastal line where almost 80% of the population is concentrated and where most economic activity occurs. Guinea Bissau's current and future economic development is highly dependent on its natural resources: the sale of cashew nuts and fisheries activities are currently the country's two highest income earners and represent two-thirds of the GDP and 90% of the country's export earnings. Increasing population pressure on coastal and marine resources is a primary cause of biodiversity loss. Shifting agriculture, rice production, artisanal over fishing and the extraction of fuelwood from forests and mangroves to produce charcoal and the smoking of fish are the major threats to biodiversity particularly in the coastal zones.

Guinea Bissau, with its low altitude above sea level, it is estimated that the country risks losing much of its territory including mangrove coasts and islands due to the rising of sea level. Coastal erosion is a significant issue in Guinea Bissau. While climate change induced erosion is a threat to coastal activities, anthropogenic activities are also a major cause of coastal erosion in the country. Indeed, recent results indicate that anthropogenic activities are a major cause of coastal erosion in the country[73]. Therefore, Guinea Bissau believes that combining conservation and poverty alleviation can be an effective strategy in making protected area networks effective. However, there is a need to reduce anthropogenic stresses and preserve habitats, resulting in the preservation of threatened species of plants and animals. For example, the coastal fringes of Bijagós Archipelago in Guinea Bissau (Figure 2.16) represent some 1% of the world's bird species and is home to 11 species of primate, 85 species of reptile and 31 amphibian species. What makes the Bijagós so unique is three-fold. First is its sheer size. As Africa's largest archipelago, the region encompasses 30 000 sq. km. of largely protected saltwater wilderness.

Figure 2.16- Archipelago of Bijagós, Guinea-Bissau[74] .

Of the 78 major islands, only 20 are inhabited with a total population of less than 5 000 residents. Second, the region is one the largest estuarine environments in Africa, fed by four massive hyper trophic river systems. The result is a biological marvel where in places clear

waters team with brown clouds of plankton attracting incomprehensible quantities of baitfish, and an all-star cast of predators that prey upon them , and lastly the region has a remarkable diversity of water and habitat types that include murky tarpon rich waters, sand spits surrounded by crystal clear waters, mangrove channels and immense inner bays, mud flats covered with molluscs, and beautiful white sand beaches studded with rugged dark lava outcroppings. When seen in its entirety the role the region plays as one of Africa's most significant spawning grounds for baitfish and sport fish alike is easily understood[75]. In addition, it is in the coastal areas around the Islet of Porcos, also in Guinea Bissau, that is the habitat of five species of turtle, two of which (Atlantic green and loggerhead) are threatened at the global level.

Over-fishing is also leading to the destruction of mangroves, and other natural barriers which are again contributing to coastal erosion. This in turn is undermining the stability of coastal ecosystems. At present, vegetative cover along the coastline in the identified hotspots has been degraded for several climate and anthropogenic-driven reasons (Figure 2.17). On the one hand, anthropogenic activities, particularly due to fuel wood demands (in Guinea Bissau mangroves are exploited to smoke fish), have reduced mangrove cover that otherwise function as a natural protective barrier to coastline erosion and sustain fishing activity.

Figure 2.17 - Ruins resulting from severe coastal erosion at Varela Beach. Guinea-Bissau[76].

Mangrove habitats are also under threat as trees are cut down for timber and firewood or to clear land for agriculture including rice farming, an important coastal agriculture activity. However, the coastal waters of the country have the highest levels of primary fish productivity in the world so that industrial and artisanal fishing fleets intensively exploit a significant part of these resources.

2.14 The Fisheries Sector

Guinea-Bissau has 105.740 square kilometres of Exclusive Economic Zone (EEZ) for a continental shelf of 45 000 km².along 270 Km of coastline. The fisheries sector is one of the most important for the country's economy and directly or indirectly employs 120 000 workers. Fishing contributes to about 3% to GDP and around 3.9% in exports contributing with 40% to the state budget[77].

According to the 2010 Fisheries Management Plan, the fishery potential of the Guinea-Bissau is around 523 160 tons, corresponding to a pelagic potential of around 212 500 tons and demersal (bottom dwelling) species equal to 310 660 tons. However current total catch adds to about 107.147 tons, split between Industrial Fishing (72.145 t) and Artisanal Fisheries (35 000 t). In a country where the fish contributes 24% of total animal protein, per capita

consumption of fish average 26 kg / year. Regrettably, the country awards a total of 177 licenses to industrial fishing fleets, of which only 3 ships are national or chartered. As for artisanal fishing, there are 2,500 fishing fleets, of which only 20% is motorized[78]. It has been estimated that 4 percent of the artisanal catch comes from continental waters and is mainly done by women and youngsters who fish without vessels (Figure 2.18).

Figure 2.18 - Artisanal catch comes from continental waters and is mainly done by women and youngsters who fish without vessels.

About half of artisanal fishermen are foreigners (most from Guinea-Conakry), and about 80% are part-time fishermen who also farm[79]. The number of artisanal fishermen has increased in recent years, from nearly 4 500 in 1989 to 9 800 in 2000. The growth is linked to high immigration of fishermen from the sub-region (27% of the total), youth interest in fishing, conversion of continental fishermen to maritime fishing and the beneficial impact of various fishing projects[80]. Industrial fisheries are mainly carried out by foreign vessels which pay the corresponding quotas or licences.

The catches of the Guinea-Bissau artisanal fleet increased from 7100 tonnes in 1950 to a peak of 33000 tonnes in 2000, subsequently declining due to over-exploitation. At the same time, the catch of the industrial fleet reached a maximum of 387000 tonnes in 1989 and subsequently dropped to 73000 tonnes in 2010 (Belhabib and Pauly, 2015)[81].

Guinea-Bissau's seafood sector has enormous potential. There is significant biomass in both marine and estuarine areas, much of which is not being exploited[82]. There is a large variety of available fishing including game fish. These include five species of Barracuda, six species of snapper, twenty species of shark (five of which commonly exceed 400 pounds), Amber jack, Senegalese jack, incredible numbers of Jack crevalle, Cobia, Kob, Bonefish, Permit, Pompano, Grouper, Guitar fish, Ladyfish, Leer fish, Sierra[83].

Existing industrial fisheries in Guinea-Bissau can be divided into several categories, according to the primary target of fish comprising[84]:

- Highly Migratory Species: including main species of tuna – yellowfin, skipjack and bigeye tunas, as well as swordfish and sharks (predominantly mako and blue sharks).
- Small pelagic fisheries: including sardinellas, anchovies and shad. Many of the small pelagic species are highly migratory and move throughout the North West African region.
- Cephalopod trawls fisheries: dominated by the common octopus and cuttlefish. Estimated catches in 2009 were 4,385 tonnes of octopus and 955 tonnes of cuttlefish.
- Demersal fish fisheries: Being in tropical waters Guinea-Bissau has abundant species of demersal fish such as species of shark, bream and snappers.

About 90 percent of the artisanal fisheries catch is conserved on ice and commercialized by women, being the remaining processed. Basically, there are three types of fish processing: (a) smoked (mainly in the south of the country); (b) salted (fermentation before dried, in the north) and (c) dried[85].

2.15 The Waste Sector

Much of waste in Guinea-Bissau is made up by solid waste, waste water and sludge. The disposal system and recycling of solid waste is undeveloped: throughout the country there is only a single landfill. There are no incineration facilities, composting or waste sorting, almost non-existent waste recovery practices. Per recent past data (MICS4, 2011) only 11% of the population has access to adequate sanitation system. Less than a fifth of the population (18%) have improved sanitation facilities; 12% have improved latrines, 4% latrine without toilet and only 2% have a pour-flush latrine. According to the same source, the majority of the population 61% use traditional latrines, which are not considered appropriate sanitation facilities, and 21% did not use any installation and defecating in nature. The percentage of people who make outdoor needs (in nature) is higher in rural areas (35%).

The sewage system is based on septic tanks and latrines for the clear majority of citizens. It is estimated that only 4.2% of the urban population is connected to sewer or septic tank. There is a system of black and storm water sewers and the quality of the urban environment degrades gradually due to lack of compliance with the rules and conditions of urbanization, (Rio + 20 Report, 2012). Therefore, the waste sector in Guinea-Bissau is still underdeveloped with large amounts of garbage being discharged directly into the soil and large water ways (Figure 2.19).

The disposal system and recycling of solid waste is undeveloped: Throughout the country there is only a single landfill and too small in relation to the dynamics of the country development, population growth and the production of waste. Consequently, for all of these reasons the Waste Management is one of the major problems facing the country, considering not only the environmental risks arising from inadequate disposal / recovery of waste, but also the need of the country to create acceptable conditions for the development of responsible tourism.

Figure 2.19 - Artisanal catch comes from continental waters and is mainly done by women and youngsters who fish without vessels[86].

http://saoi.webs.com/bissagos/bissagos.html

Chapter 3: Information on the National GHG Inventory

3.1 Introduction

Guinea-Bissau is a non-Annex-I country and a signatory to the United Nations Framework Convention on Climate Change in 1995 and as laid down in Art. 2, Paragraph 1 of the Kyoto Protocol, is committed to engage and seek to achieve quantified emission limitations and reduction of GHG emissions in order to promote sustainable development, minimizing the social, environmental and economic impacts of anthropogenic activities that contribute in emissions of greenhouse gases and thus to global warming. The country ratified the Kyoto Protocol through Resolution No. 14/PL/ANP/2005, dated March 2, and undertook to commit to develop, update, publish and report the results of national emission inventories and removal of Greenhouse Gases (GHG) at the Conference of the Parties (COP). The country already produced two National Communications on Climate Changes and is drafting this Third. Guinea-Bissau has already prepared and presented systematically:

i) First Inventory and the First National Communication in 2003, with reference year of 1994;
ii) Subsequent National Communication in 2008, base year of 2000;
iii) Intended Nationally Determined Contributions (INDCs) in 2015

This section of the report presents a summary of the GHG results for the period 2006[87]-2012 (based on emission inventory statistics from 2010[88]).

3.2 Institutional and Legal Arrangements

For the implementation of the United Nations Framework Convention on Climate Change (UNFCCC), institutional, legal and regulatory provisions have been observed these include the strategies, policies, programs and action plans designed to underpin the country's commitment to the global effort to protect the environment. This framework is structured as follows:

- Focal Point to the United Nations Framework Convention on Climate Change (UNFCCC) under the Ministry of Environment and Sustainable Development through the Directorate General of the Environment (DGA), which is also the Green Climate Fund (GCF) and Global Environment Facility (GEF) Political and Operational Focal Point. This General Directorate for the Environment (DGA) also assumes the role of Designated National Authority for the Clean Development Mechanism (CDM);
- The National Climate Change Committee (NCCC), which brings together all actors involved in climate change issues (administrative technical services, private sector, NGOs, civil society structures and research, local elected associations, universities, etc.), is responsible for monitoring activities carried out in the framework of the implementation of the Convention. For this purpose, NCCC takes a Scientific and Technical Advisory role;
- A Focal Point for the Intergovernmental Panel on Climate Change (IPCC), represented by the National Institute of Meteorology (INM).

A certain expertise was developed in the framework of planning exercises carried out during the elaboration of National Communications I and II and in the preparation of the National Adaptation Plan of Action (NAPA) on Climate Change, as well as on INDC and NAP. Most of the key national institutions, CBOs and NGOs, among others participated in the different stages of the process.

Climate change being a cross-cutting area implies the direct or indirect participation of various institutions. In addition to the Ministry of Environment and Sustainable Development that manages the Convention, the Ministry of Agriculture, Forestry and Livestock, which is in charge of Forests, the Ministry of Natural Resources, the National Institute of Meteorology and certain NGOs are also active in this area. These different structures and their district and local representations have accrued gains and developed specific skills for their staff so to ensure the planning, management, monitoring and evaluation of activities related to climate change.

The framework under which the GHG inventory system of the country is set include also an ancillary legislation with specific laws enacted on the environment sector. Among other it is worth highlighting the following:

- *Law 10/2010 dated 24/09*. Approval of the Environmental Impact Assessment, which establishes the rules of law relating to the study and evaluation of environmental and social impact, as well as audits, licensing and environmental monitoring, related to projects, programs, public or private policies that impact on the environment and on human health. It defines the general rules of administrative

management of the environmental assessment process and establishes the general and specific principles, methodologies and techniques to be applied in these processes, to promote sustainable development and equitable management of natural resources, ensuring the best environmental protection. Although it defines strategic environmental assessment and states the type of policies and plans that should carry them out, the law does not regulate the process, as it does for Environmental Impact Assessments;

- *Law 1/2011, dated March 2*, approves the Basic Law for the Environment. The Law establishes the concepts, rules, and basic principles relating to policies and actions for the protection, preservation and conservation of the environment, promotion of the quality of life and the rational use of natural resources, in order to optimize and ensure the continued use of those resources, as a basic premise for sustainable development. The Law establishes the Environmental Fund which integrates allocations of the General Direction of Budget, compensations, donations and funds from fines applied due to the violation of environmental regulations. The Law prohibits polluting, it establishes what constitutes environmental offense and establishes as criminal offenses that specific legislation will qualify as such;
- *Order 21/03/2011.* Creates an Environmental Impact Assessment Cell (CAIA), an entity that aims to support companies and institutions throughout the process of environmental impact assessment, ensure the monitoring of implementation measures to minimize the impacts, ensure assessment and advise on environmental impact studies, and request and obtain technical consultation for the environmental field.
- *The new Forestry Law, Decree-Law 5/2011*, establishes the rule of law relating to Management of Forest Heritage, Forestry Planning, the Sale of Forest Products, Forest Management and Exploitation Contracts, Forest Clearing, Prevention and Combat of Forest Burning and the Community Forests.

Ministry of Environment and Sustainable Development (MADS), is the Government entity entrusted with the overall responsibility for the development of environmental Policies, including those on Climate Change. It is responsible for the policy making on conservation and environmental protection, sustainable management of biological, natural resources and minerals, including water resources and; policies, laws and regulations of the sectors of environment, energy, water and mining in general. It is also responsible for monitoring, supervision and environmental management of the Convention by the two Directorates General of direct administration and two Directorates of indirect adminstration that make up the MADS:

- Directorate General of Environment (DGA);
- Directorate General of Sustainable Development (DGSD);
- Directorate of the IBAP and;
- Directorate of Competent Environmental Assessment Authority (CAIA)

The technical coordination is provided by the Directorate General of the Environment. Even though led by the MADS, the GHG inventory system in the country benefits at the national level from government departments and ministries that take a lead role on climate change coherently with support from other institutions that have capacity on climate change. These national institutions are:

- Ministry of Environment and Sustainable Development (MADS): General Direction of Environment and General Direction of Sustainable Development;
- Ministry of Fisheries and Maritime Economy;
- Ministry of Agriculture, Forestry and Livestock: (General Directorate of Livestock, General Directorate of Forests and Fauna, General Directorate of Agriculture;
- Ministry of Transport and Telecommunications / National Institute of Meteorology;
- Ministry of Economy and Finance: State Secretariat for Planning and Regional Development and National Institute for Statistics (INE)
- Ministry of Foreign Affairs, International Cooperation and Communities
- Ministry of Trade and Industry;
- Ministry of National Education;
- Ministry of Public Works, Construction and Urban Development;
- Ministry of Public Health
- Ministry of Tourism;
- Ministry of territorial Administration: 8 regions (Autonomy Sector of Bissau, Administratives regions (Gabu, Bafata, Oio, Catio, Fulacunda, Biombo and Bolama Bijagós)

These are all inserted within a strong legislative and policy framework and a strengthened National Climate Change Committee, as the organising institution under the auspices of the Designated National Authority for the Kyoto Mechanisms (DNA). The engagement of these stakeholders benefits dissemination and validation of results in addition to facilitation of data and information collection. The roles of some of these Institutions in the national GHG inventory system are shown in Table 3.1 and described below. Their roles and mandates in the environment and climate change sector is further highlighted.

Table 3.1- Institutions involved in monitoring, prevention and GHG emission reduction inventory system.

Roles	Institutions	Organization
Monitoring	• Ministry of Agriculture (General Directorate of Livestock and General Directorate of Engennering and Rural Development); • Ministry of Environment and Sustainable Development – C.A.I.A/A.A.A.C. (Competent Environmental Assessment Authority)	Specialised NGO's and CBO's
Prevention	• Ministry of Agriculture (General Directorate of Livestock and General Directorate of Engennering and Rural Development); • Ministry of Environment and Sustainable Development – C.A.I.A/A.A.A.C. (Competent Environmental Assessment Authority) • Ministry of Transport and Telecommunication (National Institute of Meteorology); • Permanent Interstate Committee for Drought Control in the Sahel (CILSS) and; • Local Authorities (Administration and tradicional)	Specialised NGO's and CBO's
Emission Reduction	• Ministry of Agriculture (General Directorate of Livestock and General Directorate of Engennering and Rural Development); • Ministry of Environment and Sustainable Development; • Ministry of Economy and Finance.	Specialised NGO's and CBO's

Institutions Roles and Mandates

- *Ministry of Agriculture - General Directorate of Livestock*
  Has jurisdiction over the definition of policies in the livestock sector; Formulation of sector legislation; Census and quarantine of livestock; Veterinary Inspection.
  Supports the activities of rural development, collection and dissemination of innovations and best practices in animal production, marketing, storage and processing; Support in the training of farmers with regards to animal production; and capacity building of Community Based Organizations (CBOs).
- *Ministry of Agriculture - Directorate-General of Forests and Fauna*
  Its responsibilities lie in the definition of policies for the forest sector; the Formulation of forest legislation; Control and supervision of forestry; Organization ranks of coal and firewood exploitation; Provide support to rural development activities, collection and dissemination of innovations and good practices with regards to production and forestry exploitation, trade and forest fire prevention; Training support to farmers regarding the production forest species; Strengthening of the capacity of Community Based Organizations (CBOs). Should undertake a forest and fauna inventory, which is fundamental.
- *Ministry of Environment and Sustainable Development (MADS)* - Competent Environmental Assessment Authority (C.A.I.A./A:A:A:C:)
  The C.A.I.A. was officially established by Order of the Prime Minister on 21/03/2011 under the control of the Environmental Advisor to the Prime Minister but has been operating since 2005. The objective of the C.A.I.A. is "to effectively respond to the political supervision of major projects in the environmental area" and by competences: (a) support companies/institutions in adhering to the entire process of environmental impact assessment; b) ensure monitoring, in collaboration with the appropriate entities, of the implementation of measures to minimize impacts; c) ensure assessment and advise on the environmental impact studies; d) request and obtain technical consultation for the environmental field for appropriate action.
- *National Institute of Meteorology of Guinea-Bissau (INM-GB);*
  Is the national authority in the field of meteorology and climatology, responsible for national policies in these areas, ensures the collection, processing, analysis and archiving of meteorological observation results, making the regular dissemination of weather predictions. The capacity for climate modelling and more sophisticated analysis is limited.
- *Permanent Interstate Committee for Drought Control in the Sahel (CILSS)*
  Coordinates drought control actions in Guinea-Bissau
- *Ministry of Economy and Finance*
  The Directorate-General of Planning (DGP) is responsible for coordinating the Poverty Reduction Strategy Paper (PRSP) which defines objectives and national priorities, as well as the economic and social integration models within the national space. The Directorate prepares the three-year programme for public investment; it prepares the implementation of the annual stimulation plans, monitors the implementation of these plans and proposes the necessary corrective measures; it also monitors the implementation of public development aid. Integrated in the Directorate-General of Planning, the Directorate for Coordination of Development Aid is responsible for coordinating aid according to the Paris Declaration on aid effectiveness and guides donor programs. The Directorate consists of the Bilateral Aid Division, which includes

the Monitoring and Evaluation of Donations section and the Loan Monitoring and Evaluation section; and the Multilateral Aid Division, which includes the section for the African Development Bank (AfDB), World Bank (WB), the Islamic Development Bank (IDB), the Arab Bank for Development African States (BADEA) portfolios and the section for the European Union/United Nations System portfolios.

- *National Institute for Statistics (I.N.E.)*
  Institution under the Ministry of Economy, the main mandate of I.N.E. is: coordination, conception, collection, compilation and dissemination of Statistical Data in accordance with the annual plan of statistical activity. Furthermore, I.N.E. provides collection, fact-finding and dissemination services of other statistical data to satisfy, in economically viable terms, the specific needs of public and private entities that rely on statistics, whose need for those statistics is specifically requested by them.
- *Platforms or Networks of NGOs in Guinea-Bissau*
  NGO networks and platforms are consulted in matters of Climate Change, and NGOs active in Climate Change actions or subjects relevant to adaptation and mitigation collaborate in matters linked to GHG data collation and information on Monitoring, Prevention and Emission reduction.
- *Local Authorities (Local Administration and Traditional)*
  Many local government departments focused on agriculture, forest and livestock, as well as water and sanitation service have expressed strong support for climate-change related activities which are integrated into the many other existing activities on agriculture, Forestry, livestock and water development in their area of influence. With the assistance of local government and NGOs experienced in the region, all the above Government Departments and Institutions build on existing and previous successes, as well as facilitation on data collection incorporating a climate-proofing mechanism on GHG actions of Monitoring, Prevention and Emission reduction.

3.3 The National GHG Inventory System

The National GHG Inventory System (NIS) includes all institutional and legal arrangements associated with the national greenhouse gas inventory preparation process, as well as reporting this information on the national and international level. This process implies preliminary planning and preparation activities such as for example, identifying the right institutions through their mandates and defining specific responsibilities within the inventory preparation process (such responsibilities, role and mandate are described in Section 2 'Institutional and Legal Arrangements'). The main bodies constituting the chain of the process of preparation of the GHG Inventories include in a hierarchical order (see Figure 3.1):

1. MADS /DGA - UNFCCC responsible entity and National lead institution in charge with preparation of the National Communication and of the GHG Inventories;
2. UNFCCC National Focal Point the Head of the MADS;
3. Expert Group Team Leader for GHG Inventory;
4. Advisory Panel[2] and
5. The Five Task groups (Industry, Energy, Agriculture, Land Use, Land-Use Change and Forestry (LULUCF) and Waste).

[2] Quality Assurance (QA) &Quality Control (QC)

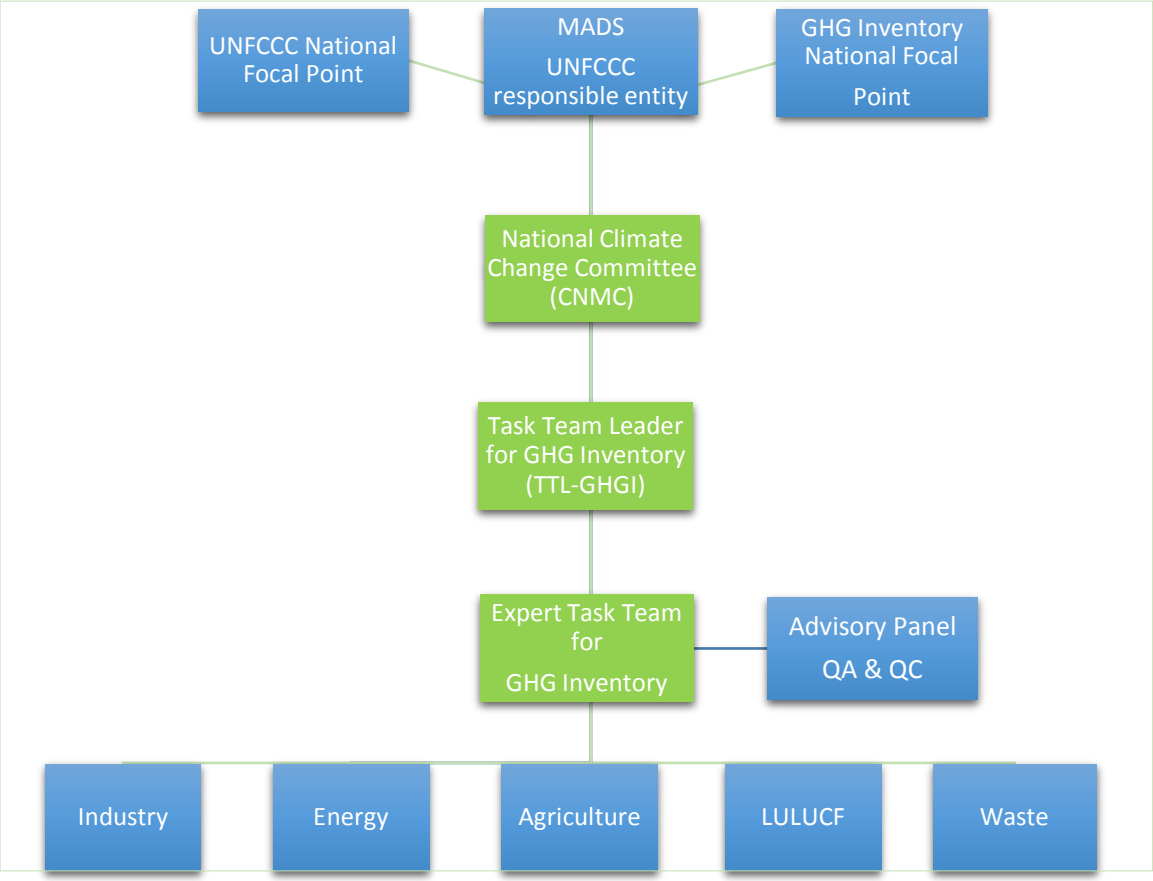


Figure 3.1- Hierarchical order of the Institutional structure of the National GHG Inventory System (NIS) responsible for developing the National GHG Inventories.

- Within the MADS - UNFCCC the National Climate Change Committee (NCCC) is totally responsible for the activities related to preparation of National Communications (NCs) and National Inventory Reports (NIRs). Inside the National GHG inventory system, The Team Leader for GHG Inventory (TL-GHGI) will lead the Expert Group for GHG Inventory working in direct and constant contact with the GHG Inventory National Focal Point and will be full time employee in the NCCC, and is responsible for the inventory preparation process coordination, including supervision of estimating emissions by individual categories of sources and removals by individual categories of sinks, uncertainty analysis interpretation, Quality Assurance (QA) & Quality Control (QC) activities coordination, documentation and archiving the data used in the inventory preparation process, synthesis of sectoral reports - serving as basis for the NIR compilation.

- The Team Leader for GHG Inventory (TL-GHGI) also coordinates the 5 task group leaders and national experts (hired on a contract basis) that are responsible for estimating emissions by individual categories of sources and removals by individual categories of sinks at sectoral level (Energy, Industrial Processes, Agriculture, LULUCF and Waste). National experts are responsible for the activity data collection, application of decision trees in terms of selecting suitable assessment methods and EFs, estimating emission uncertainties by individual categories of sources, as well as for taking correction measures as a response to QA&QC activities. The task group leaders of the 5 Task groups that are responsible for completing inventory for the five sectors are: Industry, Energy, Agriculture, Land Use, Land-Use Change and Forestry (LULUCF) and Waste.

3.4 Methodology

The national GHG inventory has been prepared following the IPCC 1996 Guidelines for National Greenhouse Gas Inventories. In addition, and encouraged by decision 17/CP.8, the IPCC Good Practice Guidance on Land Use, Land Use Change and Forestry (IPCC 2003) has been also used adapted to national circumstances, especially in the estimation of uncertainties.

The preparation of Communications is a constant exercise that should be performed to illustrate the circumstances, i.e. as the macroeconomic sectors of the country that contributed to national emissions per capita and their reflection in global GHG emissions. Considering the knowledge already accumulated from the first exercise, this document also includes a recompilation of emission estimates for 2006, which entails consistency of the data and results, therefore allowing comparisons between inventories already made, and anticipates projections for the years 2020, 2030 and 2050.

The national GHG inventory has been compiled by a team of twelve local experts from different relevant Government ministries and institutions led by a Team of two International Experts. These national experts were selected and trained based on the methodology proposed by the IPCC to undertake further data collection in most polluting and / or emitting sectors and they were thus introduced to the calculation methodology of national and per-capita emissions.

The methodology used therefore included a dedicated literature review, surveys, sample collection, semi-structured interviews and questionnaires addressed to different target groups. This inventory was conducted with the purpose of quantifying the emissions of carbon dioxide CO2 and other non-CO2 greenhouse gases from anthropogenic activities, taking the year 2010 as a reference. Generally, the method adopted to compute emissions involved multiplying activity data (AD) by the relevant appropriate emission factor (EF), as shown below.

Emissions (E) = Activity Data (AD) x Emission Factor (EF)

All the methodologies and tools recommended by IPCC within the inventory cycle have been used and followed to be in line with Good Practices. In addition, Global Warming Potentials (GWP) as recommended by the IPCC have been used to convert GHGs other than CO2 to the latter equivalent. Based on decision 17/CP.8, the values adopted were those from the IPCC Second Assessment Report for the three direct GHGs, namely:

GAS	GWP
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310

This Section presents data collected on secondary sources in the five macroeconomic sectors considered as emission sources for calculating the national balance of gas emissions that cause greenhouse effect for 2010. Despite the effort to cover all existent sources and sinks, the inventory still carries some gaps, most being determined by lack of activity data needed to estimate certain emissions and removals. Therefore, emissions evaluated under the Guinea-Bissau's GHG Inventory reflect current best estimates; in some cases, however, estimates are based on approximate methodologies, assumptions, and in some cases incomplete data. As new information become available in the future, the Guinea-Bissau's National Inventory Team will continue to improve, revise and recalculate its GHG emission estimates. However, key activity data for the various targeted sectors in the inventory have been collected from the yearly reports, reviews, studies and brochures of the concerned ministries (Secretary of State of Environment, Ministry of Energy and Industry, Ministry of Natural Resources, Ministry of Agriculture and Rural Development, etc.) public and private institutions such as the National Institute of Statistics, National Institute for Agronomic Research, National Institute of Meteorology, etc. The collected information of the industrial sector has been complemented by a field survey of selected national industries. Wherever possible, activity data have been complemented by the results of the various specialized and ongoing projects and national initiatives contributing to the intention to reduce GHG emissions such as:

- The Rational Use of Forest Heritage Project - Carbonization (1997-2000) implemented in the context of the Low Carbon Development Strategy (LEDS);
- Nationally Appropriate Mitigation Action (NAMA) developed in 2013 that refers to a set of policies and actions that Guinea-Bissau pledges to undertake as part of a commitment to reduce greenhouse gas emissions;
- Measurement, Reporting and Verification (MRV) actions that the country has embarked on and includes National Inventories of GHG emissions base year (2000 and 2006), according to the recommended methodology set by the Convention and the IPCC Guidelines;
- The CARBOVEG-GB project, which carried out the first stored carbon quantification and sink capacity of forest vegetation of Guinea-Bissau.

3.5 Data and Ancillary Information

3.5.1 Energy Sector

As stated in Chapter 2, Guinea-Bissau is extremely dependent on importation of oil products for the generation of essential electricity. In Guinea-Bissau, the energy consumption reflects the amount of fuel imported. Based on this assumption all liquid fuels used in land transport, sea and air sectors as well as in industry, agriculture, fisheries and household electricity self-generation, etc. have been computed and the result is displayed in Table 3.2.

The quantity of imported products in 2012, was obtained through data provided by the DGE / DSDP (State Planning and Statistics), DGA (Customs General Directorate), Petromar Petroleum Company, Total Petroleum Company and "Étude de Ethanol" (UEMOA / WAEMU

Ethanol Study). The conversion factors and the carbon emission and the fraction of oxidized carbon were extrapolated from the IPCC manual (1996).

Table 3.2 - Data used to calculate the CO2 emissions from the burning of fossil fuels (Source: DGE/DSDP/ DGA, 2012).

Products	Imported Quantity (Ton)	Conversion Factor (TJ / Unit)*	Carbon Emission Factor (tC / TJ)*	Fraction of carbon oxidized*
Diesel	40093	0.04316	20.2	**0.99**
Gasoline	5250	0.04495	18.9	**0.99**
JET	1814	0.04387	19.6	**0.99**
GPL	529	0.04786	17.2	**0.99**
Oil	-	0.04387	19.6	**0.99**
Lubricant	-	0.0409	18	**0.99**
Tarmac	**-**	**0.04057**	**17.2**	**0.99**

* Adapted from IPCC Manual (1996)

Assuming then that all the products that are consumed are imported, emissions of CO2 coming from the burning of fossil fuels were estimated using the data of all liquid fuels as shown in Table 3.3.

Table 3.3 - Structure of consumption of petroleum products by activity sub-sector (tonnes)

Consumption		Diesel	Gasoline	GPL	Jet	Kerosene	Firewood	Charcoal
Transport	Total	25.172,07	4200	0	1814			
	Terrestrial	22.450	2730	0		0		
	Maritime	2.722,07	1470	0	0	0		
	Air	-	-	-	1814	0		
Electricity Production		3.136,72	-	0	0	0		
Industry		1.630	0	0	0	0		
Agriculture and fisheries		299,46		0	0			
Household Energy		52,5	1050	529	0	-	774.584,7	**85.736,4**
Other Activities (including Electricity Self-Generation)		9.802,25	-	0	0	0		
Total %		**84,1**	**11,01**	**1,12**	**3,8**	**0**		

Source: DGE, DEPPE,DGA Estatistica da DGE para 2012, Anuário da DGA 2012.

3.5.2 Industry Sector

The Industrial processes and product use **(IPPU)** component in Guinea-Bissau is driven by the operational capacity of the process of industrial production of alcoholic beverages and food (mainly bread and cashew processing). The bakery sector occupies a prominent place in all the agro-food industries. In the analysis of this sub-sector consideration was given to modern and traditional bakeries. The total amount produced, and the emission factor is shown in Table 3.4.

Regarding the cashew nut, processing industry accounts for 23 processing plants, 150 cutting machines, with a production capacity of 12 000 kg nuts / day, and employing 750 workers. In

2010, the country managed to export 113 332 tons of cashew. Based on information from the National Cashew Commission in Report No. 54145 GW May 2010, the total amount of production considered in 2010 is shown in Table 3.4.

Table 3.4 - Food Sub-sector and respective emission factors

Category	Quantity Produced (ton)	Emission Factor (kg NMVOC/t of food produced)
Bread	171,360,000 (**20,399.68**)	8
Cashew nut processing	127.12	18

Alcoholic beverages production activities in Guinea-Bissau consist of transformation of sugar cane into brandy and cashew fruits into juice, which naturally further transforms into wine. This is the oldest industrial activity in Guinea. Data from this activity sub-sector were collected from the DGI and commercial companies operating in this sector. In this inventory micro and small wine and brandy production units in the North, East and Mid-Country have been considered. The alcoholic beverage production is in a remote location allowing for the emission of greenhouse gases during their production process. Currently the production of wine in the country is also carried in a small plant located at the industrial zone in Bra, which production capacity is estimated at around 2 035 hl. It is worth noting that there are additional micro production units using traditional processes. Given that since 2002 the processing plants to produce beer and soft drinks have not been operational, these were not considered in this study. Data collect in this sub-sector and corresponding emission factor is shown in Table 3.5

Table 3.5 - Alcoholic Beverages Sub-sector and respective emission factors

Category	Quantity Produced (**hl**)	Emission Factor (kg NMVOC/hl of beverages produced)
Cashew nut Wine	3,150,630	0.035
Cashew nut Brandy	3116.63	15
Sugar cane Brandy	1,280.00	15

3.5.3 Agriculture and Livestock Sector

Livestock is an important activity for the Guinean-Bissau's economy and is practiced as extensive cattle ranching. Cattle rearing is the dominant component of the sector followed by the smaller ruminant goats, sheep, horses, donkeys and pigs. Commercial poultry production is also practiced extensively, particularly in rural areas.

Data used for the calculation of GHG emissions from the livestock sector were based on the number of animals which growth data from 2005 through 2010 are presented in Table 3.6. The data from 2005 to 2008 were estimated using average growth value for CILSS[3] countries (CILSS Report), while the data for 2009 were obtained from the national animal census

[3] The Permanent Interstate Committee for Drought Control in the Sahel.

financed by the PRESAR project (P-GW-AA0-008) of the Ministry of Agriculture. This census was held at the end of 2009 and the data were used to calculate the GHG inventory that has 2010 as reference year.

Table 3.6 – Data of animal growth from 2005 through 2010

Mapping of Animal Growth (2006 – 2010)							
Year	**Cattle**	**Sheep**	**Goats**	**Piggery**	**Poultry**	**Horses**	**Mules and Asses**
Average growth factor*							
	0,025	0,03	0,03	0,04	0,07		
2005	593864	361130	310054	40205	671087	2000 (F)	5000 (F)
2006	608.711	371.972	319.356	41.814	718.063	2000 (F)	5000 (F)
2007	623.928	383.131	328936	43.486	768.327	2000 (F)	5000 (F)
2008	639.526	394.624	338.804	45.225	822.109	2000 (F)	5000 (F)
2009	1.325.412	303.745	649.084	343.680	1.481.642	4.356	34.770
2010	**1.365.174**	**309.316**	**658.820**	**345.398**	**1.534.534**	**4.356**	**34.770**

*Average growth factors from The Permanent Interstate Committee for Drought Control in the Sahel (CILSS)

(F): Estimated from FAO Annual Report - 2005/2006

However, this demonstrates clearly and justifies the difference in the considerable increase of actual animals in 2009 compared to 2008, prior to the census. Data used to calculate emissions associated with enteric fermentation during 2010 and respective emission factor are shown in Table 3.7.

Table 3.7 - Data used for the calculations of emissions associated with enteric fermentation and emission factor

Category	Nº of Animals	Emission Factor (kg/animal/year)
Cattle	1.325.412	32
Sheep	304.745	5
Goats	649.084	5
Horses	4.356	18
Donkey	34.770	10
Pig	343.680	1
Poultry	**1.481.642**	NE*

*NE: Not estimated

The effective number of animals set out in Table 3.7 was estimated using the average growth rate in the countries of The Permanent Interstate Committee for Drought Control in the Sahel (CILSS) with a pastoral type of farming and purely extensive. The emission factors considered were proposed by default by the IPCC (1996). GHG were also calculated from cropped land using the knowledge of type of Fertilizer incorporated into the soil, the amount of N incorporated (kgN / year) using respective emission factors as shown in Table 3.8.

Table 3.8 - Fertilizer types used and their respective emission factors

Type of Fertilizer incorporated into the soil	Amount of N incorporated (kgN / year)	Emission factor for direct emissions of kg N2O N / kgN
Chemical fertilizer (FSN)	2,160,000	0.0125
Manure (FAW)	64,341,720.62	0.0125
Crops with no nitrogen fixation (BNF)	180,000	0.0125
Crop residues (FCR)	3 018 828.66	0.0125

The amounts of nitrogen N incorporated were obtained from the formulas contained in the IPCC Manual (1996) for these rubrics, including emission factor for direct emissions that happens to be constant for all the categories. As described in Chapter 2, rice is another strategic crop in Guinea-Bissau and is the staple food of more than 95 percent of the population. Data used for the estimation of GHG from paddy practice in the flooded lands (bas-fonds and saltwater bolanhas[4]) are shown in Table 3.9.

Table 3.9 - Data of surface area cropped with flooded rice and emission factors used in the calculation of GHG.

Water Management Regime	Irrigated – Paddy rice (bas-fonds e bolanhas de água salgada)
Cropped Land (1000ha)	72,67
CH_4 emission factor	0.5
Correction factor for organic fertilizer	2.5
Integrated seasonal emission factor for paddy rice without the use of organic fertilizer (g / m2)	20

Data of surface area cropped with flooded rice were obtained from the Agricultural Statistics Division (DEA) and FAO (2009/10) and the scale, correction and emission factors were taken by default (IPCC, 1996[5]).

Burning the savanna and agricultural residues

The area burned was estimated averaged 22 years, i.e., 1985 (996 ha, Atlanta consult project) to 2007 (775 ha, CARBOVEG-GB 2007 project), based on the total area of savanna in the year of inventory, verified under the CARBOVEG-GB Project, multiplied by the percentage of annual savanna burned for agricultural purposes-25% (communication of several national experts). The biomass density of the savanna, fractions burned, and fractions of live vegetation biomass burned, were taken by default (IPCC, 1996).

Data were also collected of "in situ" burning of agricultural residues to calculate the GHG from burning in situ agricultural waste. The annual production data of the main local crops in 2010 were obtained from DEA / FAO, the ratio waste / product, the fraction of dry matter burnt fraction in the field and the oxidized fraction were taken from the IPCC Manual (1996).

[4] "Bolanha" - Empoldered land (bolanha) in Coastal region inserted between salt-water creeks and mangroves for rice cultivation deliberately flooded with sea water at high tide for weed control.
[5] 'Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories'

3.5.4 Land Use, Land Use Change and Forest (LULUCF) Sector

Data used for the calculation of GHG emission from the LULUCF sector included the i) quantified evolution / change of biomass stocks in forests and other woody plants; ii) conversion of forests and grasslands to other uses using a 15.9 ha / year conversion rate for twenty years; iii) the combustion of biomass *in situ* in 4 of existing forest categories (dense forest, open forest, wooded savannah and mangrove); iv) Abandonment of exploited land (natural regeneration of cropped land, pastures or other farmed land); v) emission and CO2 removal by abandonment of cropped land.

3.5.5 Waste Sector

Solid waste

Daily, in Guinea-Bissau's main urban centres large amounts of garbage are discharged directly into the soil and large water ways. Data used to estimate CH4 emissions from solid waste deposited in landfill were based on the number of urban population depositing waste at the dump, per capita production and fraction of solid waste deposited. These data are shown in Table 3.10.

Table 3.10 - Data of the urban population waste dump depositor, per capita production and fraction of solid waste deposited.

Number of urban population depositing waste at the dump	Per-capita production of solid waste, kg/person.day	Fraction of solid waste deposited in landfill
931728	0.32	0.4

The annual amount of solid waste deposited in the landfill was obtained by multiplying the number of population served by municipal solid waste treatment system, per capita waste production and 365 days a year. The CH4 correction factor (Table 3.11) and the fraction of degradable organic matter considered were those proposed by the IPCC (1996).

Table 3.11 - Data used to estimate CH4 emissions from solid waste deposited in landfill.

Annual Quantity of solid waste deposited (GgMSW)	CH4 Correction factor	Fraction of degradable organic matter	Current Fraction of degradable DOC	Fraction carbon CH4 obtained
43.00	0.6	0.11	0.77	0.5

Waste water and sludge

A considerable proportion of the Guinean population still uses traditional outdoor toilets which do not even have simple ventilation, or any cleaning service for septic tanks. The CH4 emitted from wastewater and sludge was estimated based on population data per 1000 inhabitants of the city of Bissau from the census conducted in 2009 by the National Institute of Statistics (INE). Bissau was used as is the only urban city that offers conditions of sanitation facilities (latrines and improved septic tanks) that enable the calculation of waste. CH4 emissions from industrial wastewater were not considered in this inventory due to low or insignificant number of industrial units in the country (Table 3.12).

Table 3.12 - Data used for estimating CH4 emitted by waste water and sludge

Population (1000 people) City of Bissau	Degradable Organic Component (Kg CBO/1000 people/year	Fraction of Degradable Organic Component removed from sludge
365097	13505	0

Human waste

GHG emission from human waste was calculated based on the number of the total population of the country in the reference year, obtained by the last census carried out by the National Institute of Statistics (INE, 2009) as shown in Table 3.13. The nitrogen in the protein fraction was proposed by IPCC (1996).

Table 3.13 - Protein consumption, total population and nitrogen fraction in protein.

Protein consumption (kg / person / year)	Total population of country	Fraction of nitrogen in protein (kg N / kg protein)
1.7885	1449230	0.16

3.6 Summary of GHG Emissions

This inventory estimate covers anthropogenic emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol and greenhouse gas precursors and include carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) and the indirect gases nitrogen oxides (NOx).

The emissions/removals from the following five economic sectors have been estimated: (1) Energy, (2) Industry, (3) Agriculture, (4) Land Use, Land-Use Change and Forestry (LULUCF) and (5) Waste. In addition to the mandatory 'top-down' approach to estimating GHG emissions from fuel combustion, the 'bottom-up' methodology was used as much as possible for key categories in the inventory by using the available current information databases in Guinea-Bissau.

The summary result sheet based on the 2010 compilations is shown in Table 3.14. Most GHG were emitted (Gg CO2 eq) in the Energy (6899.36) and the Agriculture and Livestock (3942.71) sectors. The contributions from the Industry (0.1) and the Waste (51.42) sectors were marginal.

Table 3.14 - Summary of national net emissions and removals (by sector and by gas) in 2010.

Sector	Sub-sector	CH_4 (Gg)	CO (Gg)	N_2O (Gg)	NO_X (Gg)	NMVOCs	CO_2 (Gg)
Energy	Fuel and oil products						150.14
	Transport						96.43
	Commercial and institutional Self-generation						9.14
	Household electricity self-generation						8.46
	International Bunkers						5.69
	Agriculture and Fisheries						0.95
	Industrial Sector						1.41

	Residential sector	86.52	78.15	15.5	1.14	7.46	5.14
	Converted GHG CO2 eq	1817.00		4805.00			6622.00
	Total CO2 eq emissions in the Energy sector (Gg)						**6899.36**
Industry	Cashew nut wine	0	0	0	0	0.11	0
	Cashew nut spirit	0	0	0	0	0.05	0
	Sugar cane Brandy	0	0	0	0	0.02	0
	Bakery	0	0	0	0	0.16	0
	Cashew nut processing						
	Total CO2 eq emissions in the Industry sector (Gg)						**0.00**
Agric & Livestock	Enteric fermentation	50.26	0	0	0	0	0
	Cropped soils	0	0	7.45	0	0	0
	Rice cropping	18.17	0	0	0	0	0
	Burning of savannahs for cultivation	1.16	24.46	0.01	0.42	0	2179
	in situ burning of agriculture waste	5.82	122.31	0.15	5.50	-	-
	Converted CO2 eq	15 83.61		2359.1			3942.71
	Total CO2 eq emissions in the Agric. & Livestock sector						**3942.71**
LULUCF	Change in stock biomass in forests and other woody plants	0	0	0	0	0	-48954.00
	Carbon released by the conversion of forests to other uses	0	0	0	0	0	28147.00
	Emission of other non-CO2 gases from the "on site" combustion	89.00	781.00	1.00	22.00	0	0
	Converted CO2 eq	1869.00		310.00			2179.00
	CO2 sequestration from abandonment of cropped land (natural regeneration of arable land. pastures or other farmed land)	0	0	0	0	0	-2510.00
	Emissions and CO2 removal by soil						10420.00
	Total CO2 eq sink in the LULUCF sector (Gg)						**-10718**
Waste	Solid waste	2.31	0	0	0	0	0
	Waste water and sludge	0.05	0	0	0	0	0
	Human waste	0.006	0	0	0	0	0
	Converted CO2 eq	51.42					51.42
	Total CO2 eq in the Waste sector (Gg)						**51.42**
Total			**1005.92**		**29.06**	**7.80**	**175. 49**
Total net GHG emissions of CO2 eq in 2010		**175.49 Gg CO_2 eq** (10893.49-10718)					
per-capita CO2 eq emissions (1.449.230 inhabitants)		0.000121Gg CO_2 eq					

Most CO2 emissions are generated by the LULUCF sector (-10718 Gg CO2 eq), followed by the Energy sector (6899.36 Gg CO2 eq), while CH4 are mostly generated by AFOLU (Agriculture, Forestry and Other Land Use). N2O emissions, 4805.00 Gg CO2 eq, were linked to the Energy sector primarily and represented more than 44% of national emissions.

Overall the sectoral breakdown of the national GHG Emissions in 2010 indicate that the Energy sector contributed with 63% of the total (10893Gg CO_2 eq) followed by the Agriculture and Livestock sector which emitted 36% of the total. The Land Use, Land-Use Change and Forestry (LULUCF) was the highest single sector acting as a net sink of -10718 Gg for the year 2010.

3.7 Greenhouse Gas Emissions by Sector

3.7.1 Energy sector

The Energy sector represented the largest single source of GHG emissions in the country in 2010 with a total of 63.33% share. Within the energy sector, energy combustion and the transport sectors are the key categories of GHG emissions (Figure 3.2).

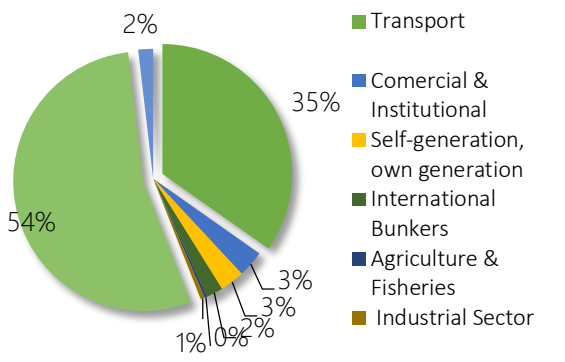


Figure 3.2 - GHG emissions in the Energy sector – 2010

The residential sector has a high contribution of non-CO2 emissions (CH4, CO and N_2O). This share of oil products, all liquid fuels used in industry, agriculture and fisheries, household electricity self-generation, etc. (gasoline, diesel oil, etc.) is 54%. This share is followed by emissions from mobile combustion (land, transport, sea and air sectors) accounting for 35%. The remaining 11% is distributed over minor components of the energy sector such as the household (2%) and other sources associated with commercial, institutional and communities' self-generation (6%) and International bunkers emission which include aviation and navigation activities. However, emissions from marine were not estimated due to lack of data.

Given the current economic situation of the country the sub-sector of Agriculture & Fisheries and Industry had the least share of the GHG emission of this sector. Therefore, the energy consumption of the industry as well as the agricultural and fisheries sector is insignificant, and diesel remains the most widely used fuel in the country.

3.7.2 Industry sector

The contribution of the industry sector is insignificant with very little participation about 1 Gg of NMVOCs (non-methane volatile organic compounds), which corresponds to 0,18Gg from alcoholic beverages and 0,16Gg industries food processing industries (Figure 3.3).

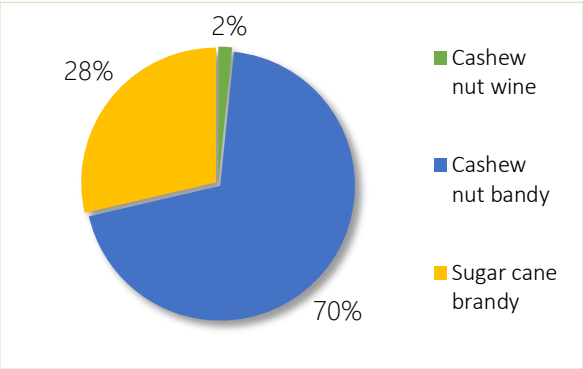


Figure 3.3 - Contributions of NMVOC emission in the Industrial processes sector – 2010.

Sources of emissions of gases with indirect greenhouse effects include: 1. Industrial production of alcoholic beverages; and 2. Food (mainly bread and cashew processing).

3.7.3 Agriculture and Livestock sector

The share of the Agricultural and Livestock sector of the total GHG emission amounted to circa 36% in 2010 (Figure 3.4).

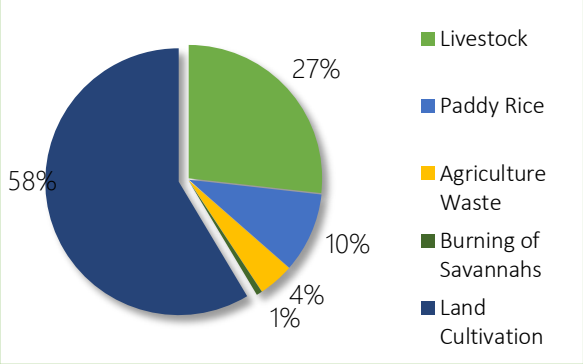


Figure 3.4 - Proportional contribution of activities to GHG emissions in the Agriculture & Livestock sector in 2010.

Results from the inventory indicates that Land cultivation was the single most contributor to the overall GHG emission in the sector with 58% followed by livestock (27%) and paddy rice cropping (10%). Inventory results point out enteric fermentation as the component that most contributes to the emission of methane with 50.26 Gg / year.

GHG emission from manure management have not been calculated due to the nature of the traditional and extensive animal production system practiced in the country where manures are not stocked.

The contribution of agricultural soils on GHG amount to a total of 7.45 Gg of N2O.

The total methane (CH4) emissions in the Agricultural and Livestock sector were estimated at 75.41 Gg CH4 (1583.61 Gg CO2 eq) representing 30% of the total GHG methane emissions (5,321.03 Gg CO2 eq) in 2010 mostly originated from the enteric fermentation and anaerobic decomposition of organic matter in the paddy rice fields. It appears that overall the Agriculture and Livestock sector emitted a corresponding amount of 235.71 Gg of non-CO2 GHGs (Figure 3.5).

Hence, using the conversion criterion it is concluded that 3942.71 Gg CO2 were emitted in 2010. The cultivated soils are the largest single source of CO2 emissions with 2309.5 Gg. The CO and NOx gases are not included in the total calculation of CO2 emissions of Agro-livestock sector.

From the calculations made there are indications that, Carbon Monoxide (CO) emitted in agricultural waste corresponds to 122.31 Gg and 24.46 Gg cultivated soils. On the other hand, nitrogen oxide (NOx) emitted in the same activities corresponds to 5.50 Gg and 0.42Gg respectively.

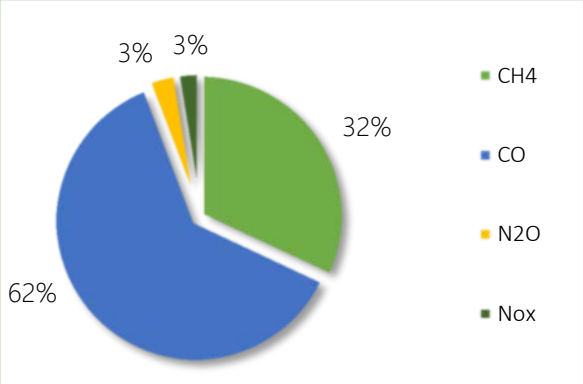


Figure 3.5 - Emission by type of gas for the Agricultural and Livestock sector in 2010.

Burning of savannahs for agricultural purposes

Wild fires can be controlled, and it is a common practice of the type of agricultural system. However, a significant proportion of these wild fires are uncontrolled and some of anthropogenic origin and are one of the factors of degradation of forest resources in Guinea-Bissau.

The gases (CH4 and N2O) resulting from these fires are released into the atmosphere playing a significant role as GHGs. Therefore, the total GHG emissions attributable to the burning of savannas in 2010 are illustrated in Figure 3.6.

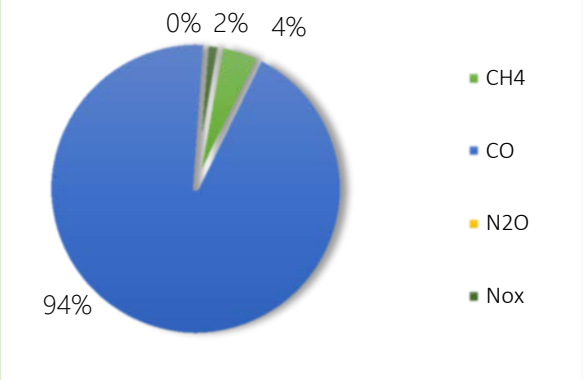


Figure 3.6 - Emission by type of gas from burning of savannahs in 2010.

Carbon Monoxide (CO) represents the great share with 94% followed by methane (CH4) emissions representing only 4% of the total.

"In-situ" burning of agricultural waste

Agricultural waste burning activities are a major source of emissions of methane (CH4), carbon monoxide (CO), Dinitrogen Oxide (N2O) and nitrogen oxides (NOx) in Guinea-Bissau. The results from the inventory calculation are shown in Figure 3.7.

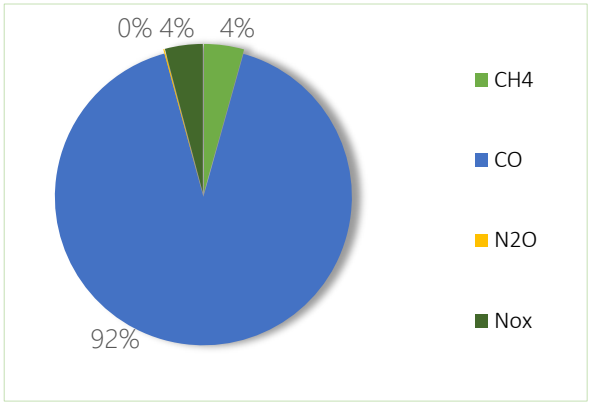


Figure 3.7 - Partitioning of GHG emission from burning of Agricultural waste – 2010

3.7.4 Waste Sector

The total GHG emissions in the waste sector corresponds to 51.42 Gg of CO2. This includes emissions from solid waste, water and sludge and Human waste. The category of solid waste displays the highest share (94%) with the equivalent of 48.51 Gg CO2 (Figure 3.8).

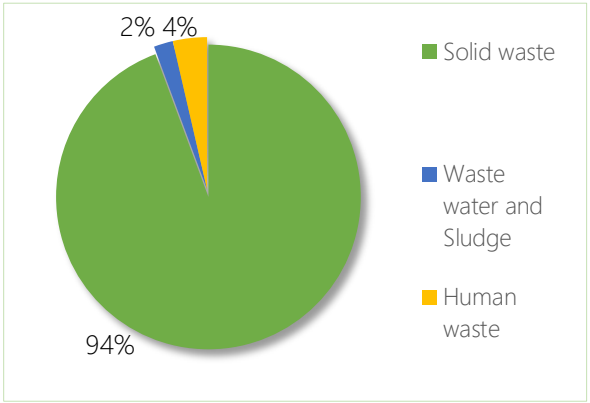


Figure 3.8 - Partitioning of GHG Emissions from the Waste sector – 2010

3.7.5 Land Use, Land-Use Change and Forestry (LULUCF)

The activities linked to Evolution / Change Stock biomass in Forest and Other Woody formations have acted as sink and were those which have contributed the most for the removals of 48954 Gg CO2 (54% of total) in Guinea-Bissau. This sink contribution of the forest stands in Guinea-Bissau was seconded by the CO2 sequestration of 2510 Gg CO2 (3%) from abandonment of cropped land (natural regeneration of arable land, pastures or other farmed land). The total carbon released by the conversion of forests to other uses was estimated at 28,147 Gg CO2 (Figure 3.9).

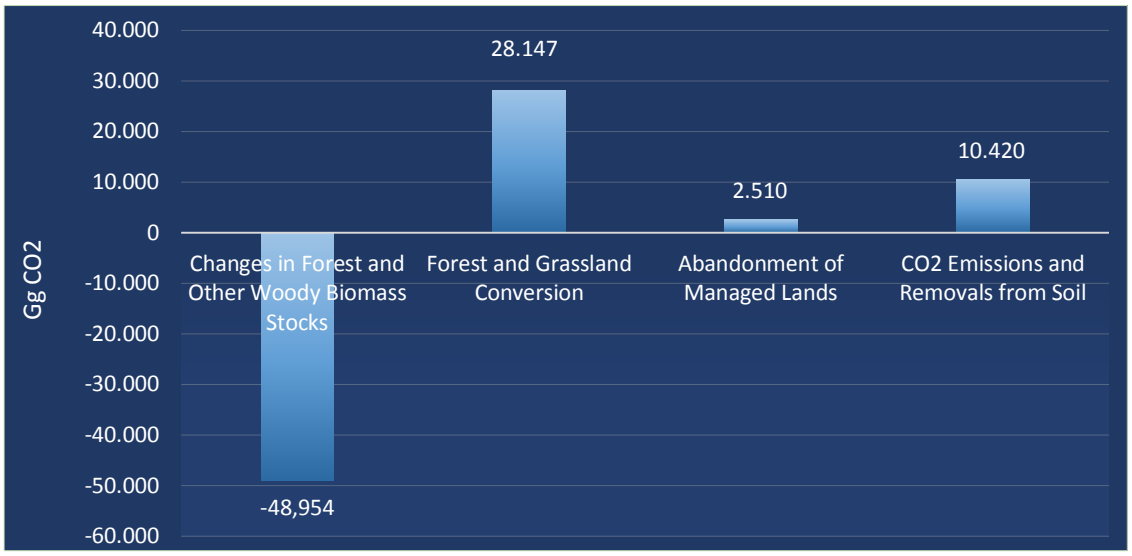


Figure 3.9 - Partitioning of GHG emission from Land Use, Land-Use Change and Forestry (LULUCF) sector 2010.

Regrettably this is an expected outcome from the inventory as the country does not have more than one single landfill being the waste produced in excess deposited in the open without any treatment.

Chapter 4: Information National GHG Trends, Mitigation, Policies and Measures

4.1 Introduction

Guinea-Bissau as a non-Annex-I country has no obligation to reduce its GHG emissions as a signatory to the United Nations Framework Convention on Climate. However, Guinea-Bissau is committed to engage and within its capacities seek to achieve quantified emission limitations and meet the objectives of Article 2, the ultimate objective of the Convention, specifically the *"stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".*

Therefore, to contribute towards this endeavour the Government of Guinea-Bissau has developed various policies and strategies guiding its development agenda promoting sustainable development, minimizing the social, environmental and economic impacts of anthropogenic activities that contribute to emissions of greenhouse gases and thus to global warming. Guinea-Bissau has been engaged on various projects and activities targeting at curbing GHG emissions and increasing its sink capacity, particularly through its Energy, Forestry and Biodiversity Sectors.

4.2 Institutional and Legal Arrangements for Mitigation

The National Mitigation System in Guinea-Bissau consist of all of the institutional, legal, and the chain of processes and arrangements made for estimating emissions reduction, as well as the reporting and archiving of mitigation information. The Directorate General of Environment (DGA) of the Republic of Guinea-Bissau is the designated mitigation assessment agency and host of the UNFCCC and GEF focal points. Is responsible for National Communications on Climate Change and is also the state authority responsible for development and promotion of policies and strategies addressing mitigation/attenuation measures for greenhouse gas emissions in the country on short, medium and long-terms through environment protection, rational use of natural resources and biodiversity conservation. The other main national bodies that are relevant to climate change mitigation legal framework are:

1. *The Designated National Authority for the Kyoto Mechanisms (DNA)* - established by Decree No. 11/2006, dated August 22. The DNA is a national body that deals with the approval and monitoring of implementation of projects under the Clean Development Mechanism and REDD framework.

2. *The National Climate Change Committee (NCCC)* - is overseen by the MADS and consist of an Advisory Board, a Scientific Board and a Technical Committee. The role of the NCCC is to stimulate the awareness of and mobilize the Guinean society for discussion and taking a position regarding the phenomenon of Climate Change, with the following main mitigation objectives:

    a) Discuss and validate mitigation/attenuation measures for greenhouse gas emissions in the country on short, medium and long-terms;
    b) Discuss and validate measures for adaptation to the adverse effects of Climate Change;
    c) Discuss and validate the implementation of instruments and incentive measures for mitigation of the impacts of Climate Change and natural disasters;
    d) Discuss and validate ways to stimulate consumption or use of products with zero carbon content;
    e) Promote the implementation of projects under the Clean Development Mechanism (CDM), as well as other innovative ways for financing mitigation/attenuation.

Within MADS, the NCCC unit undertakes the daily supervision of the mitigation assessment and is responsible for the organisation and development of the activities inserted in the annual work plan for the sectoral mitigation teams, assisting in data request and ensuring that the deliverables are submitted on time. This unit is also responsible for the identification of the various institutions constituting the mitigation assessment-working group. The National mitigation-working group includes Ministerial representatives of the main sectors involved in the national mitigation inventory such as the Energy, Waste Management, AFOLU and crosscutting issues.

The legal framework sustaining the processes and arrangements for estimating emissions reduction as well as monitoring of results is mainly underpinned on:

- *The new Forestry Law, Decree-Law 5/2011*, establishes the rule of law relating to Management of Forest Heritage, Forestry Planning, the Sale of Forest Products, Forest Management and Exploitation Contracts, Forest Clearing, Prevention and Combat of Forest Burning and the Community Forests.

4.3 Main Drivers of GHG Emissions

4.3.1 Structure of Mitigation/Projections Assessment

This section reports the results and description of the processes of GHG mitigation assessment in Guinea-Bissau. Given the inherent limitations on the technical and economic data monitoring and data gathering as well as the non-availability of appropriate mitigation tools, the mitigation assessment could not be carried out but instead only projections were performed and limited to the following categories:

1. Energy sector;
2. Agriculture and Livestock;
3. Industrial Processes and Product Use (IPPU); and
4. Solid waste management.

The base year adopted for this analysis is 2010 and the time horizons spanning across 2020, 2030 and 2050 have been used for the projections.

4.3.2 Scenarios of GHG Projections

'Business as usual' (BAU) is the scenario for GHG emissions considered for the projections assessment of elected categories of GHG emission sources. This scenario assumes the continuation of overall practices and relationships on the national level. Estimates of GHG projections were therefore obtained from the evolution of the variables usually responsible for emissions or removals. Fuel demands to meet the future energy requirements, projected number of vehicles, expected land use changes, forest management and amount of waste generated are some of these variables considered. Other factors that potentially can affect the underlying stability on the evolution GHG emissions and removals are the socio-economic dynamics. Projections on the BAU basis for industrial production are associated with growth in GDP, as it is such a dynamic sector with new industries starting operations and others closing down as the country progresses. Once the activity data have been generated for the different options such as fuel combusted, waste produced, wood removals or area reforested amongst others, these were fed in the IPCC 2006 software to compile emissions or removals for the year being assessed.

4.3.3 Population Size and Growth

The population of Guinea-Bissau is predominantly rural-based. Nonetheless about 49.3 percent of Guinea-Bissau's population lives in urban areas and according to the latest population census the population of urban areas in Guinea-Bissau has been growing at a rate 4.13%. This means that in the next two decades there will be a sizeable amount of people migrating to urban areas either due to poor economic conditions and lack of employment opportunities in villages; and/or poor agricultural conditions and greater population pressure on land. Currently the capital, Bissau has an estimated population of 492 000 in 2015[89] and concentration of urban population is also taking place in other major cities such as Gabú 43 556 (2009) and Bafatá 34 760 (2010). Surely as it stands, the rural-urban movement will continue to intensify over time and soon the percentage of population living in urban areas will surpass that of rural population, putting further stress on the energy supply/demand and Agriculture and food sectors. Additionally, at national level, assuming that beyond 2016 the population will continue to increase at a rate similar to that which prevailed for the period

2010 to 2014, at an exponential growth rate of 2.55%, the projected population will reach over 2 million in 2020.

4.3.4 Economic Growth

Guinea Bissau's economy has been sluggish for a number of years with averaged GDP of about 444.23 USD from 1970 until 2014. In 2016, the GDP per-capita of Guinea-Bissau has risen to 620.21 US dollars. It is expected that growth standing at 4.7% in 2015 could be well above this number in 2016 and beyond, depending on the socio-political situation. This anticipated economic growth will be the driving force for generating further development in rural and urban areas. If this growth is not based on a green path concept, emissions generated by energy and non-energy industrial activities will certainly soar.

4.4 Sectoral GHG Projection

4.4.1 Energy sector

The GHG Inventory has shown that Energy is the main source of GHG emissions in Guinea-Bissau, accounting for *circa* 63% of all national emissions. Notwithstanding, the Energy sector has the greatest potential for reducing GHG emissions. If this potential could be attained even if at small percentage, it would be a major contribution to climate change mitigation processes on the national level. Within the Energy sector, the source sub-category with the largest specific weight in the national direct GHG CO2 emissions is the item "Oil products" (Fuel combustion activities) representing the major portion of the total with 54% share followed by the Transport sub-category with 35% share.

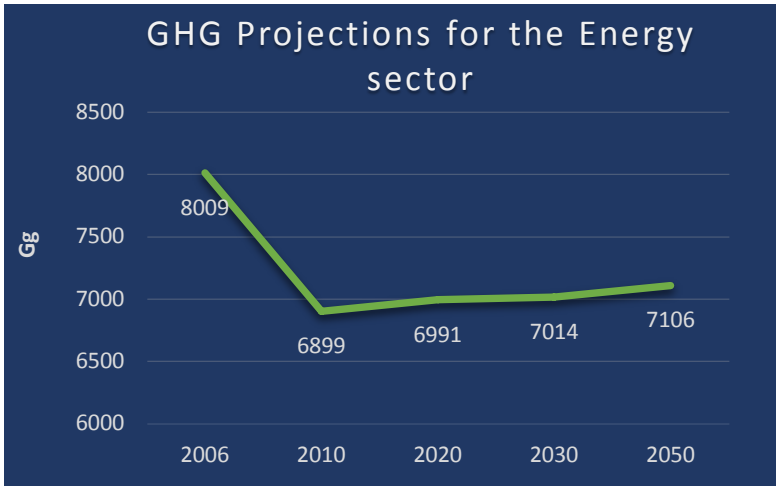
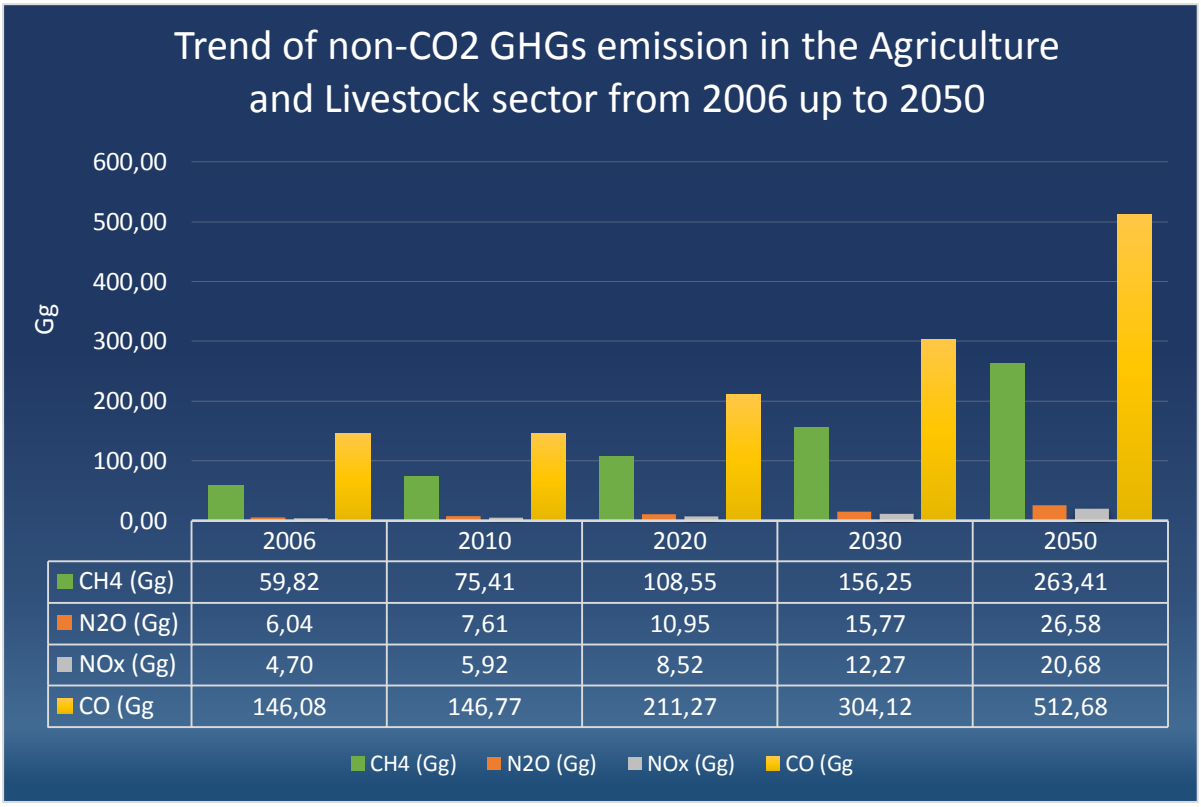


Figure 4.1 - GHG emission projections for the Energy sector (fuel and oil products) from 1994 up to 2050

Between 1994 and 2010, the total GHG emissions from the Energy Sector tended to lower values, decreasing by about 15.7 per cent (Figure 4.1), in particular, because of the economic decline induced by political unrest in the Guinea-Bissau during this period. Given the weight share of Fuel combustion and Transport activities in the overall GHG emission in the Energy sector and the underlying socio-economic evolution in the next decades the projection for the GHG emission in the Energy sector is a tendency for a rise through 2050. In this growth, the use of charcoal of wood by the rapidly growing population in cities is not accounted for. Every year, there are approximately 50 000 hectares of forest disappearing as fuelwood accounts for over 90% of final energy consumed by the Guinean families. Firewood and charcoal are the most popular fuel source in urban centres and demand exceeds 500 000 tons a year.

4.4.2 Agriculture and Livestock Sector

The Agriculture and Livestock sector is responsible for emission of 3942.71 Gg of CO2 eq. This is mostly generated as CH_4 originated from Rice cropping: 18.17 CH_4 Gg (24.1%) and enteric fermentation: 50.26 CH_4 Gg (66.6%). Between 2006 and 2010, the total GHG emissions from this sector increased 26.05% and it is assumed that this increased will carry on for the decades ahead (Figure 4.2). This assumption owes to foreseen demand on rice and meat products for a steadily growing population.



	2006	2010	2020	2030	2050
CH4 (Gg)	59,82	75,41	108,55	156,25	263,41
N2O (Gg)	6,04	7,61	10,95	15,77	26,58
NOx (Gg)	4,70	5,92	8,52	12,27	20,68
CO (Gg	146,08	146,77	211,27	304,12	512,68

Figure 4.2 – Trend of overall non-CO2 GHGs emission in the Agriculture and Livestock sector from 2006 up to 2050.

Much of Guinea-Bissau's agriculture involves rice farming. Rice is a strategic crop in Guinea-Bissau providing the staple food for more than 95 percent of the population. Rice is cultivated in diverse forms and systems according to the physiographic and edaphoclimatic conditions ranging from[6] N'pam-pam, Bas-fond to Mangrove. Some of these main cropping modalities consist of paddy rice cropping involving flooding of rice fields throughout the growing season, meaning that methane (CH_4) is produced by microbes underwater as they help to decay any flooded organic matter.

Though rice is primary food for the majority of Guinea-Bissau population here has been a growing deficit, which was estimated at over 200 000 tons in 2009/2010, with domestic production covering only 47 percent of consumption. Therefore, as a staple foodstuff in Guinea-Bissau, rice accounts for most of its food imports.

[6] N'pam-pam i.e., Bas-fond i.e. Mangrove i.e.

However, cultivated area and production has steadily increased from 2005 to 2010 (Table 4.1) and it is expected that production will increase further in the near future. There are several areas well suited for rice cultivation in Guinea Bissau's eight regions and rice cultivation has already transformed the landscape along two coastal rivers, the Mansôa River and the Gêba River with areas of intensive rice cultivation bordering the mangrove belts.

Table 4.1 – Rice cultivation modalities and trend of rice production from 2005 to 2015.

Year	Rice cultivation modality				Total
	N'pam-pam	Bas-fond	Mangrove	SAB	Rice production (Ton)
2005	43242	32872	18225	4000	98339
2006	48400	36400	17200	4000	106.000
2007	40759	54573	31918	4000	131.250
2008	47750	54190	47520	4000	153.460
2009	52490	54050	44700	3000	154.240
2010	66328	55134	83779	4000	209.241
2011	74067	64550	92791	4000	235408
2012	81810	73970	102746	4000	262526
2013	89556	83396	113643	4000	290595
2014	97307	92826	125484	4000	319617
2015	105061	102260	138267	4000	349588

GHG emission from enteric fermentation from Livestock sector will also keep its growing pace as the Guinea-Bissau agriculture system is still dominated by the practice of extensive cattle ranching characterised by sedentary livestock breeding as well as transhumance livestock production. The east region has the highest concentration of livestock where the regions of Gabu and Bafata appear with 71% of cattle herds (49% and 22%); 75% of sheep (50% and 25%); 45% goat (30% and 15%); equines 72.55% (57.45 and 15.10%); donkeys 85.60% (60.08% and 25.52%). However main contribution of GHG emission from enteric fermentation comes from the region of Gabu which has the highest livestock concentration with 49.41% of cattle (654,543 animals) 50.4% of sheep (153,349 animals) and 29.93 goats (193,445 animals). The outlook for the livestock sector in Guinea-Bissau (using quantitative indicators originating from official sources) seems positive if the current limitations that this sub-sector faces such as absence of sufficient technical resources able to support livestock farmers, lack of infrastructure for water supply, and poor animal health control are addressed. Therefore, the scenario for the sector is that of a steady growth and a sustainable increase of herds and GHG emission.

4.4.3 Industrial sector

In the 2010 national inventory, the industrial sources of gases in Guinea-Bissau with indirect greenhouse effects were from: (i) Industrial production of alcoholic beverages and; (ii) Food processing (mainly bread and cashew processing). The contribution of these sources to GHG emission in Guinea-Bissau is insignificant with very little participation about 1 Gg of NMVOCs (non-methane volatile organic compounds), which corresponds to 0.18Gg from alcoholic beverages and 0.16 Gg industries from food processing industries. Compared to the 1994 inventory there was a negligible increase of about 4.5% in GHG emission in 2010 (Figure 4.3). However, the expectation is that GHG emission for the next decades will suffer a sharp increase in the 2020 and 2030 decades reaching a record maximum of 13.89 Gg in 2050. In

Chapter 2 it was seen that the economy expanded from 2.9% in 2014[90] to 5.1% in 2015 as a reflection of the recently established peaceful atmosphere. Projections on the BAU basis for industrial production are somewhat associated with GDP growth as it is such a dynamic sector with new industries starting operations and others closing down as a country progresses.

Therefore, the expectation is that, with the population growth and the technological advance expected to see happening in the current industry sectors and those new emerging activities, the GHG emission in the Industry sector of Guinea-Bissau will increase. In addition to this detail is the plea that the Government has made to prioritise economic diversification to foster growth in Guinea-Bissau in order to increase its resilience to external shocks which will certainly boost the Industry Sector particularly in the processing and transformation of local resources such as the cashew nut.

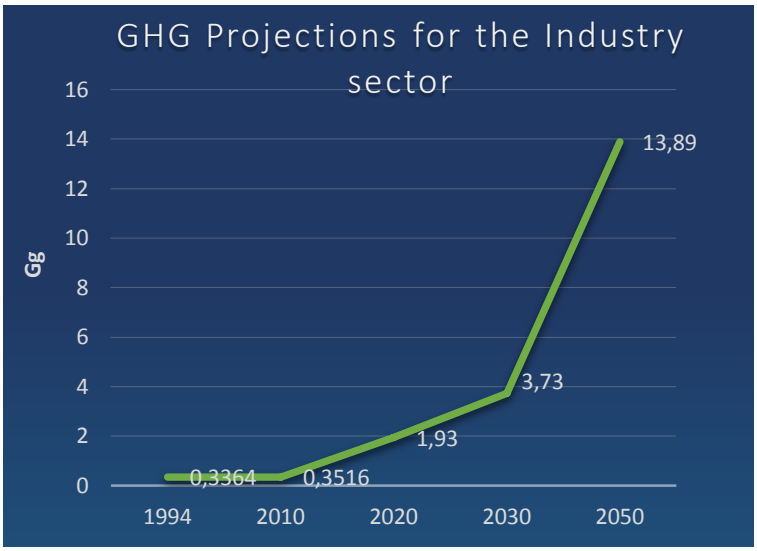


Figure 4.3 – Trend of overall non-CO2 GHGs emission in Industry sector from 1994 to 2010 and projections up to 2050.

In this context, it is expected that some new industrial activities will be emerging in Guinea-Bissau such as in the fishing industry, Energy and Mining and Tourism. The country has unexploited natural resources in the marine and mining sector and has a huge but untapped tourism potential which will drive on the industrial sector.

4.4.4 Waste sector

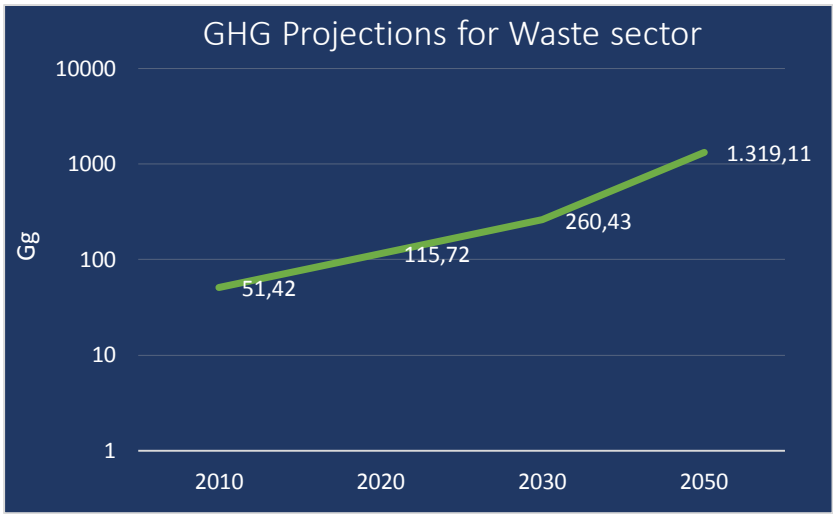


Figure 4.4 – Projections of overall non-CO2 GHGs emission in the Waste sector from 2010 up to 2050.

The 2010 inventory of GHG emissions indicate that the waste sector contributes to 51.42 Gg of CO2 eq. of which solid waste had the highest share (94%) with the equivalent of 48.51 Gg CO2 Emissions of greenhouse gases, especially methane (CH4) are derived from wild dumps scattered across all Bissau quadrants and slaughterhouse waste.

The projection of GHG emission in this sector is that methane (CH4) emission will increase dramatically over the next decade to 2020 (Figure 4.4). Projections of GHG emission were based on the projections of solid waste growth and municipal wastewater volumes are based on predicted population growth, while industrial wastewater volumes were calculated according to the growth projections of respective industries. GHG emission projections were made using the "business as usual" scenarios", that is maintaining the current practices in the future and considering that currently there are no programmes for the establishment of sufficient landfills and/or wastewater treatment stations.

4.5 Total National GHG projections in Baseline scenario

4.5.1 GHG emission projections in key sectors

The results of GHG emissions resulting from the BAU scenarios for the base year 2010 and the projections for 2020, 2030 and 2050 are shown in Table 4.2 for the predominant gases. Under the baseline scenario, all GHG emissions are projected to gradually rise from the base year (2010) to 2050. Notably the sectors expecting to experience a dramatic increase in GHG emission are the Agriculture and Livestock and the Waste sectors. These GHG emission increases are made from an accentuated growth in CH4 gas. The rising demand for food (paddy rice crop and meat production) will drive the expected increases in emissions of CH4 in the baseline scenario especially in the Agriculture & Livestock sector. The release of CH4 will stem mainly from the decay of flooded organic matter in paddy rice crop and from enteric fermentation from the livestock sub-sector.

Table 4.2 – Rice cultivation modalities and trend of rice production from 2005 to 2015.

Sectors	2010	2020	2030	2050	GHG (Gg)
Energy[7]	150.00	152.00	152.50	154.50	CO2
Agric. & Livestock	237.71	420.50	750.19	2387.64	CH4
Industry	0.35	1.93	3.73	13.89	NMVOCs
Waste	51.42	115.72	260.43	1319.11	CH4

Additionally, the growth in CH4 will be heightened by the Waste sector through the production of solid waste particularly in urban areas. The rising demand for energy resources will drive the expected increases in emissions of CO2 in the baseline scenario especially in the transport and residential (household energy and burning of biomass fuel) sectors.

4.5.2 National GHG Emission and Removals

Systematically, the successive GHG inventories (1st National Communication, Second National Communication (2006) and the CARBOVEG-GB Project (2010)) have indicated that the main

[7] Only the data for combustion of fuel and oil products are included.

responsible for GHG emissions at national level is the LULUCF sector. Deforestation is responsible for emitting large amounts of CO2 into the atmosphere. The latest estimates (2010) show an annual decline of around 625 000 m^3 of forest wood.

The latest inventory (for the Third National Communication) has again revealed that most CO2 emissions are generated by the LULUCF sector (-10718 Gg CO2 eq), followed by the Energy sector (6899.36 Gg CO2 eq), while CH4 are mostly generated by AFOLU (Agriculture, Forestry and Other Land Use). Estimation of GHG emissions and CO2 removals covered by all the sectors including the Land Use, Land-Use Change and Forests (LULUCF) Sector were described in Chapter 3 and summarised in Figure 4.5.

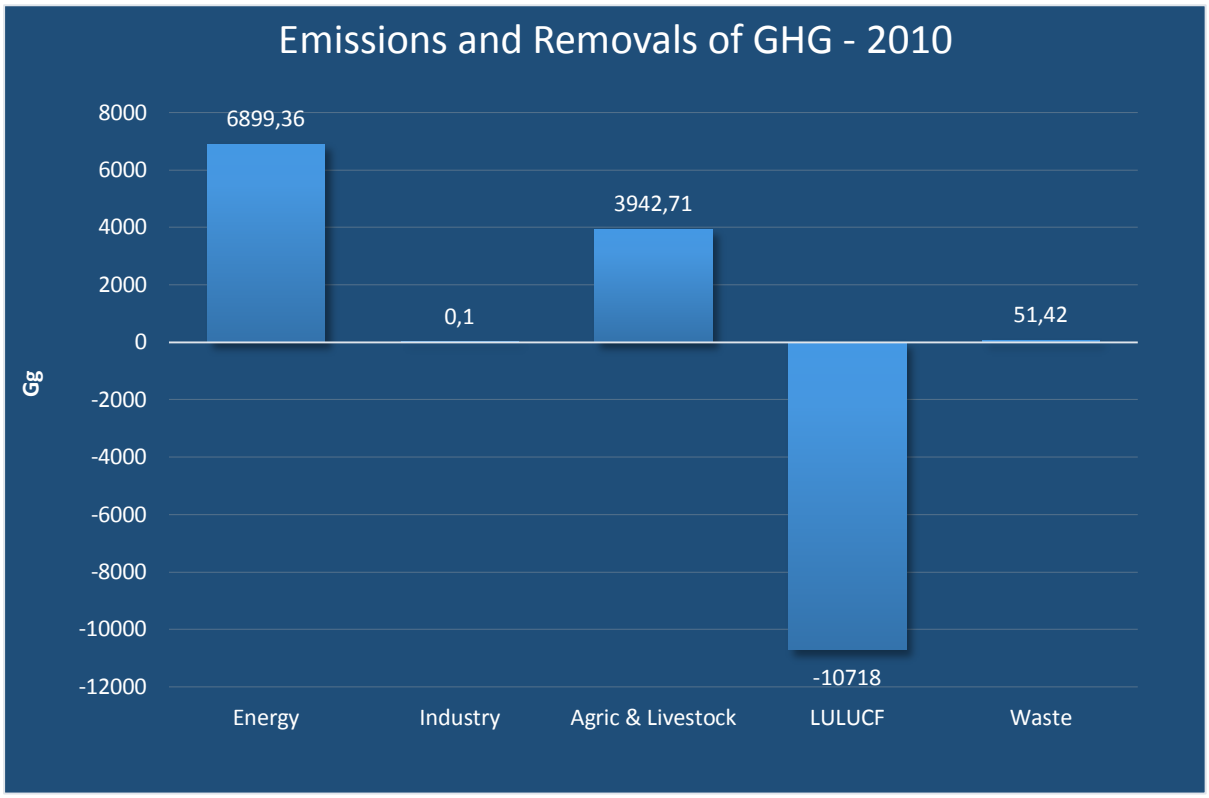


Figure 4.5 – Estimated GHG emissions and CO2 removals values covered by all the sectors including the Land Use, Land-Use Change and Forests (LULUCF) Sector.

GHG emissions/removals within LULUCF sector were estimated following the Good Practice Guidance for Land Use, Land- Use Change and Forestry (IPCC, 2003), 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and other relevant methodological publications. A total of 10893.49 Gg CO2 eq were emitted by the Energy, Agriculture and Livestock, Industrial Processes and Product Use (IPPU) and Waste sectors. The Land Use, Land-Use Change and Forestry (LULUCF) was the highest single sector acting as a net sink of -10718 Gg for the year 2010. Therefore, Guinea-Bissau is and will remain as an absolute sink of greenhouse gases, given the high potential for sequestration by the Forestry sub-sector.

4.5.3 Projection of Total GHG emission

The projections for Agriculture and Livestock (Fig. 4.2) and Industry (Fig. 4.3) resemble exponential variations and this entail that the level of total GHG emissions in Guinea-Bissau without mitigation measures will more than triple by 2030 from the level of emissions in 2010 reaching a staggering 157604 Gg CO2 eq by 2050 (Figure 4.6).

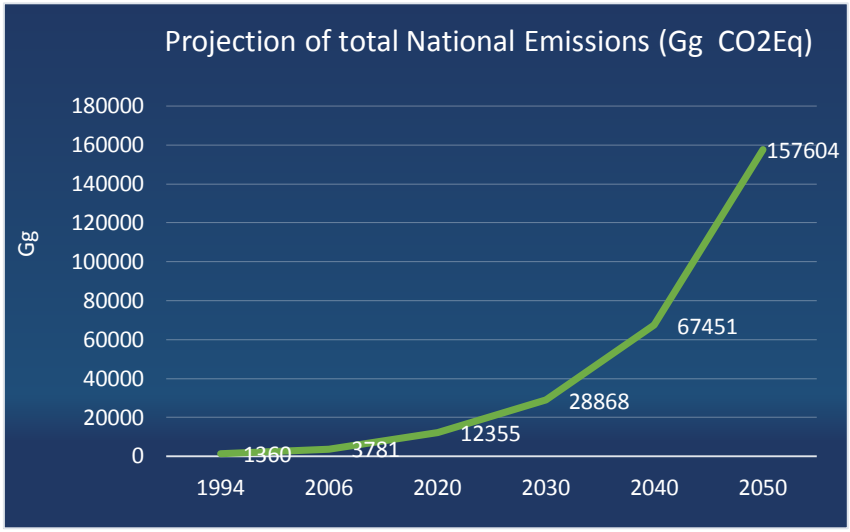


Figure 4.6 – Estimated projections of total GHG emissions (excluding LULUCF) from 1994 up to 2050

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A great percentage of these emissions would come from the Energy and Agriculture & Livestock sectors making these the privileged areas for the development of mitigation options for Guinea-Bissau.

4.6 Mitigation Strategy and Policy Measures

The mitigation assessment carried out for Guinea-Bissau's TNC involved the exercise of mapping of emissions inventory estimates of key sectors of the mitigation analysis and also the documentation of business-as-usual (BAU) emissions projections for these key sectors as described in the above sections.

Due to lack of technical/economic data and non-availability of appropriate mitigation tools, the mitigation assessment was limited to the following categories: (a) energy sector - (which include electricity supply and demand side management covering transportation, residential and commercial, industry categories) and (b) non-energy sectors (forest management and solid waste management).

As seen in above sections the assessment indicated that LULUCF and the Energy sector were the privileged areas for the development of mitigation options, followed by other non-energy sectors such as the Waste sector. Additionally, the mitigation analysis on the inventory category of Energy CO2 emissions for Guinea-Bissau can be broken down into other important sub-sectors such as the electricity generation (power supply), transportation, residential/commercial, and industrial sectors, all based on where fossil fuels are combusted.

4.6.1 Mitigation Policy measures

The Guinea-Bissau mitigation strategy encompasses implementation of unconditional actions and policies complemented by other conditional measures mainly supported by bilateral or international sourced funding. The Unconditional mitigation actions include legislative initiatives (Laws, Acts, policies, regulations and mandates) that are enacted to protect and manage the environment and they are adopted by the Government of the Republic of Guinea-Bissau to facilitate GHG emission reduction. In addition, this is further complemented by national implementation of specific energy-saving policies and extended use of alternative sources of energy pursuant to measures envisaged in existing national strategy documents. These strategy documents include the National Poverty Reduction Strategy (PRSP II) and National Strategic Document – TERRA RANKA 2015-2025.

Mitigation measures that are presented in this section are based on the published documents and consultation undertaken by the Third National Communication Development Team with stakeholders. Due to the nonexistence of detailed preliminary studies to formulate concrete quantifiable actions, the period until 2020 should be devoted to in-depth studies to enable the implementation of measures in the forestry, industry and energy. For example, reforestation, conservation of other forests and a programme for the inclusion of renewable energy sources in the country's energy mix.

4.6.2 Mitigation measures in the Agriculture & Forestry Sector

In comparison with other countries in the sub-region, Guinea-Bissau seems to have preserved its environmental balance. However, the intensification of economic activities in certain areas such as agriculture and fishing, and in the extractive industries in particular, may be a real threat to the ecosystem and the sustainability of natural resources. The problems of this specific sector are related to deforestation (via wild fires, illegal logging, removal of fuel wood used directly or for making charcoal), overgrazing, soil erosion, irregularity and decreased rainfall and increased population in forest areas, in short, the pressure on forest and soil degradation and consequently loss of biodiversity. Therefore, there is an urgent need of acting towards adaptation and mitigation to adverse effects of climate change and anthropogenic damage to the country's natural resources.

Because the available mitigation actions such as natural regeneration, short rotation forestry and bio energy for fossil fuel substitution, are currently not practicable mitigation options, the Government of Guinea-Bissau capitalised mitigation efforts on Forest protection mitigation action focusing on establishment and effective management of Protected Areas (PAs). Two programmes are being used to start the construction of critical and lasting foundations, at the level of biodiversity in Guinea-Bissau: the framework law on sustainable development and the strengthening of The Institute of Biodiversity and Protected Areas (IBAP) under the State Secretariat for Environment (SEA) and the BioGuinea Foundation which will complement the current funding model for continued financial support by sustainable financial flows. IBAP is responsible for managing the National System of Protected Areas (SNAP) and for implementing the country´s biodiversity protection policy. The entire set of protected areas and their respective range of influence covered a significant part of the territory in 2015 (15% of the country and was expected to rise to 24% by 2015[91]), containing the most relevant forest, woodland and mangrove patches of the country.

The mitigation action involves the effective management and enforcement of regulations on PA's to improve biomass volumes and including the updating of exiting deforestation and carbon emission baselines and collection of field data for monitoring in two protected areas: Cacheu and Cantanhez through the National System of Protected Areas (SNAP). This implies that the incremental carbon benefit would be gathered through increases in above ground biomass and soil carbon densities. The Annual Incremental Carbon (AIC) have not been estimated yet but the assumption is that above ground biomass and soil carbon densities would increase annually and will be considered as carbon abatement potential resulting from forest protection or conservation. Which concerns to this and additional mitigation measures undertaken by the Government of Guinea-Bissau in this sector it is worth highlighting the following key milestones:

Forestry

- The creation of the Protected Areas for the conservation and management of natural resources, one of the greatest achievements of the country that currently correspond to 15% of the country and was expected to rise to 24% by 2015[92] and now set at 26.3% in 2017;
- In addition, despite all shortcomings in combating illegal logging and forest degradation, the Guinea-Bissau government has engaged by signing the UN Convention to Combat Desertification, which led to set up of the Action Plan of the Fight against Drought and Desertification, in order to develop strategies and actions to fight desertification phenomena in the country[93];
- The development of the National Forestry Action Plan in the 90s at the legislative level;
- The recent launching of the Community Forest Management initiative which uses Integrated Land Management Approaches in Tabancas (small villages) (GITT);
- The approval of the new forestry law, encouraging the creation of Community management of forests at the level of Directorate General of Forest Management;
- The current extension process of Protected Areas, at National level with the specific inclusion of Dulombi Boé forests and the respective corridors that interconnects, in progress.

Livestock

Livestock products represent about 30% of agricultural GDP. Despite the importance of livestock in the economic, sociocultural and nutritional plan, the share of public investment planned for this sub-sector remained relatively low and steadily shrinking for the last 30 years. However, the Government has taken some measures contributing for mitigation of climate change effects.

- The drafted of the Charter of Livestock Development Policy which provides, among others, pastoral vocation areas and the design of water retention mechanisms;
- The development of studies to support the development of production of short-cycle animals ensured mainly by women which may also lessen the emission of CH4 from enteric fermentation.

4.6.3 Mitigation measures in the Energy Sector

The widespread lack of basic infrastructure is, for many years, one of the most serious constraints with which the national economy is confronted. The consumption of electricity in Guinea-Bissau is one of the lowest in the world: about 0.3 toe / person / year, and only 40% of the capital's inhabitants Bissau have access to electricity compared to 20% of rural areas (PRSP II, 2011). Generally, GHG emissions in the residential sub-sector are extremely dependent on one side on the pace of population growth and the number of household and on the hand on the rate of electrification, which generally determine the level of emissions category. Therefore, the projected growth in the emissions of this sector corresponds to demands for energy from the urban households, followed by emissions from rural households and energy use in transportation (land, sea and air). In Guinea-Bissau, wood and charcoal-based fuel stoves for cooking constitute the largest emission source thus becoming a prioritised mitigation area.

The overall objectives of the Government approach for the implementation of the prioritised mitigation measures are to ensure continuous reduction of GHG emissions while safeguarding sustainable growth and development. At this stage implementation of these actions is through:

i) mainstreaming of these mitigation objectives into national, district and sectoral plans and programmes;

ii) promote tailored specific actions involving mobilization of adequate funding from international sources; and

iii) facilitation of implementation of specific actions in Energy production and consumption, Domestic energy and Renewable energy sub-categories.

Energy production and consumption

- The recent approval of the Charter of the Energy Sector Development Policy;
- The formulation of the National policy for the promotion of renewable energy (wind, solar, biomass);
- The implementation of programs funded under the CILSS and through the Global Environment Facility, UNDP which allowed the installation of solar panels to provide electrical power to small-scale and collective country needs (basic health centres, schools, and telecommunications);
- The ongoing construction of a new power plant to replace the current central Bissau power station which does not meet environmental regulations particularly in terms of GHG emissions;
- Finalization of the Energy Master Plan supporting the restoration and promotion of electricity production system funded by the World Bank and the EU.

Domestic energy

The wood fuel (firewood and charcoal) provide about 90% of the energy consumed in the country. Currently the forest formations of the country suffer strong pressure due to increasing demand and population growth, especially in rural areas, which are heavily dependent on traditional energy (85-95% of population uses coal and wood for cooking). The following steps have been undertaken towards the mitigation of GHG release associated to wood fuel production:

- In this context, national authorities, NGOs and grassroots associations, have carried out several actions, such as, monitoring, dissemination of improved stoves and braziers, improvement of carbonization techniques and forestry and promotion of other types of fuel such as butane gas, solar energy, etc.;
- The Government has also integrated its domestic energy policy into the NEPAD-Energy strategy, which could substantially improve the achievement of domestic energy poverty reduction goals.

Renewable energy

Renewable energy (hydro, solar, wind, biomass) are potential sources for Guinea-Bissau, as the resources are abundant. In this sector, the following steps have been undertaken towards the mitigation of GHG release:

- Three pilot units of energy production based on biomass built with the support of UEMOA (Union Economique et Monétaire Ouest Africaine)[8];
- The Charter of Domestic Energy Development Policy, now in force was drafted in 2007, for (i) speeding up rural electrification through local initiatives; and (ii) preparing the Guidelines for wood fuel supply scheme;
- Organization of the program for investment in the construction of the hydroelectric dam in the framework of the Gambia River Basin Organisation (OMVG) Energy Project in West Africa;
- Three solar energy and biofuels based rural electrification projects financed through the mechanism of the Facility for Energy II (European Union);
- The planned development of two hydroelectric plants identified so far that of Saltinho (14MW) and Cussilintra (13MW)) dams.

Specific and key impacting mitigation actions

GHG mitigation options in energy sector with the implementation of the LEAP SCREENING program based on the scenarios referred to above, the following have been selected:

- The mitigation scenario through the substitution of traditional three-stone stoves or carbon stoves, for gas stoves the country would avoid the emission of 163,038 TE CO2 at $ 5.2 sale price of carbon);
- The mitigation scenario, through the construction of Saltinho and Cussilintra Dams (the country would divert the emission of 1,130,338 TE CO2 at $ 7.78 sale price of carbon);
- The mitigation scenario decentralized rural electrification using a photovoltaic system (the country could safeguard against the issuance of 47,312 TE CO2 at $ 6.24 sale price of carbon of);
- The mitigation scenario for the interconnection of the electricity grid and Sambagalou and Kaleta (the country would avoid the emission of 645,170 TE CO2 at $ 126.72sale price of carbon).

[8] West African Economic and Monetary Union.

4.6.4 Mitigation measures in the Waste Sector

In the solid waste category, the rising trend in the emissions is closely linked to population growth, urbanization rate and standard of living of population. With a projected national population in Guinea-Bissau to be well above 3 million by 2050 and at current per capita waste generation of 0.32kg/day the total solid waste annually is expected to reach over 1 million tonnes every year. Therefore, the management of such volumes of waste generated poses a major logistical hassle and defies the municipal financial capacity to address the waste problem.

The main problem currently facing urban centres of major cities in Guinea-Bissau is the design of Clean Development Mechanism (CDM) projects for the construction of controlled dumps and sanitary landfills. Hence, the Government should soon be able to complement the current efforts of building landfills with that of exploiting the potential of recycling and derive energy production from waste. The recycling of waste is a source of emission reduction, contributing to the development of agriculture, to produce electricity from biogas and briquettes fuel for cooking. Indeed, local communities that are already aware of the problems related to waste do not readily accept the creation of dumps / landfills in their respective communities. Thus, the degree of hazard awareness of waste in the open help them to play a very important role in the acceptance / or not of the project development.

Currently the technology used in Guinea-Bissau for the treatment of waste is rudimentary and restricted to the burning of debris in the open, with the emission of CO2, CO, N2O to the atmosphere. Therefore, there is a great need to implement technologies for composting and sophisticated incineration if possible depending on the cost-benefit analysis and also involvement of the private sector.

4.6.5 Mitigation Policies

The Government of Guinea-Bissau has drafted and implemented a wide-range of policies that directly or indirectly relate to climate change and GHG mitigation.

- *The Law Land* was approved by the National Assembly. This instrument regulates the management of space in the national territory and in particular brings discipline and minimizes the problems associated with land grants, for different purposes. However, this law recognizes two fundamental aspects. Forest reserves and the recognition of customary law of the community land management.

- *Framework Law on Protected Areas (PA),* an instrument that seeks above all to create a legal framework conducive to conservation of fragile ecosystems in Guinea-Bissau. It also regulates the classification system and the downgrading of protected areas at national level.

- *The Forestry Law*: rules and forest taxation were updated and is being applied throughout the national territory. This new forestry law attaches great importance to aspects of reforestation, overexploitation in areas where there are sawmills and areas with problems of land degradation potential.

- *The Mining and Minerals Law*. This law, regulates the different forms of exploitation of mineral resources in the country. Most of the existing minerals in the country are in forest areas susceptible to degradation in case of mismanagement. The law can contribute for meeting standards of environmental protection concerns. The exploration permit holder must, under penalty of sanctions, strive to reconcile the exploration work with the environment. For example, the operating licenses that are granted for quarrying in general will only be issued if it is found that does not adversely affect the environment.

- *The Executive National Forestry Plan* (National Plan of Forest Action), contains a detailed analysis of the situation on the basis of which policies are defined, strategies, actions, and goals to achieve, for use durable forest resources, as also defines the means necessary for their implementation in the following main issues:
    - Techniques using forest space by the population to fight food insecurity;
    - Burning for shifting cultivation and hunting;
    - Extensive livestock and increased transhumance;
    - The use of fire as a main tool of land clearing and renewal of pastures;
    - The process of land clearing to create new agricultural land for cash crop (especially cashews, peanuts and cotton);
    - Overexploitation of forest species of high commercial value;
    - Increase in hunting camps and poachers;
    - Increasing population density and appearance of new tabancas (small villages) in the wildlife corridors.

- *The National Environmental Management Plan* (NEMP), parent document and regulator of environmental issues in Guinea-Bissau. This document contains the main concerns of other development sectors, not only in terms of conservation, but also of development itself. The Plan, through programs and projects, seeks solutions to ensure food security, poverty eradication, pollution control and environmental sanitation; conservation of natural resources and control of the spread of desertification and soil erosion, as well as minimizing the anthropic impacts that influence climate change. (NEMP, 2002).

4.6.6 Projects in Mitigation Scenario

A mitigation scenario reveals a future in which explicit policies and measures are adopted to reduce the sources (or enhance the sinks) of GHGs. These measures may be undertaken as form of projects to be implemented in a specific GHG Sector or subsector. In this section, the list of projects that Guinea-Bissau has proposed during the Initial Communication is shown below (Table 4.3). Amongst them there are several mitigation projects worth highlighting which still require funding in order to be implemented and contribute for potential GHG emission abatement. Based on this GHG emission assessment and projections from this inventory it is required a renewed costing and prioritisation of the mitigation projects and assessment of the potential GHG reduction or enhancement during the horizon of 2020, 2030 and 2050.

Table 4.3 – List of projects that Guinea-Bissau has proposed during the Initial Communication.

Order of priorities	Project Designation	Area of Geographic Intervention
1	Project to support the diversification of production and the Dietary Food	Southern Province (Quinara and Tombali Regions)
2	Improve Drinking Water Supply Project in Rural Areas	Southern Province (Quinara and Tombali Regions) Eastern Province (Bafata and Gabu Regions)
3	Capacity Building Project for Prevention and Protection of Mangrove Fields Against Water Invasions	Southern Province (Tombali, and Quinara Bolama / Bijagós Regions) Northern Province (Cacheu Region)
4	Centre for Monitoring and Evaluation of Mangroves Project	Northern Province (Cacheu) Region Southern Province (Bolama / Bijagós Region)
5	Coastal Erosion Zone Follow-up Project	Northern Province (Cacheu Region) Southern Province (Bolama / Bijagós Region)
6	Evaluation of Impact Climate Change on Producers' Sectors Project	Throughout the National territory
7	Promotion of Small Irrigation in the Geba and Corubal River Margins Project	Eastern Province (Bafata and Gabu Regions) Northern Province (Oio Region)
8	Prevention of Natural Disasters Project	Throughout the National territory
9	Protection, Conservation and Enhancement of Coastal and Fisheries Resources Project	Coastal Zone (Northern and Southern Province)
10	Integrated Information System on Food Security (SISA) Project	Throughout the national territory
11	Environmental Education and Communication in the Coastal Zone Project	Coastal Zone (Northern and Southern Province)
12	Small Perimeters of Mangrove Soil for Growing Rice in Tombali, Quinara, Bafata and Oio Rehabilitation Project	Eastern Province (Bafatá Region) Northern Province (Oio Region) Southern Province (Quinara and Tombali)
13	Short Cycle Animal Production Support Project	Eastern Province (Bafatá Region) Northern Province (Oio Region) Southern Province (Quinara and Tombali Regions)
14	Resettlement in Degraded Forest Zones Project	Eastern Province (Bafatá Region)

Chapter 5: Climate Change Trends and Projections

5.1 Introduction

Under the UNFCCC, climate change is defined as "*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*". Human activities change atmospheric concentrations and distribution of greenhouse gases and aerosols. These changes can produce a radiant forcing by changing the solar radiation reflection and absorption, or emission and absorption of terrestrial radiation (IPCC, 1996).

To understand the conversion process is necessary to first identify the impacts of climate change. Therefore, this chapter introduces fundamental concepts related to weather, climate variability and climate change in Guinea-Bissau, concepts which are important for placing the challenge of adaptation in context.

5.2 Description of the Study Area

5.2.1 Physiographic characterization of Guinea-Bissau

The landscape of Guinea-Bissau comprises lowland coastal plain and mangrove swamps, rising to Guinean forest savanna in the east. Satellite images of the land use in the country show the majority to be wooded savannah and forest, with areas of mangrove (Figure 5.1)

(CARBOVEG, 2007). Two thirds of Guinea-Bissau's land area are less than 50 m above sea level, with the highest point at 298 m (Colinas do Boé). As tides can reach six meters high, large areas of agricultural land and coastal ecosystems are vulnerable to erosion and flooding.

The hydrological network of Guinea-Bissau is large and complex, comprising rainwater resources, surface-water resources and underground-water resources. Significant stationary water bodies comprise lakes (such as the 35 000 ha Lake Cufada), inland valley depressions (bas-fonds), temporary water bodies (vendus) in the east, and aquifers. Much of the river network is, in reality, a tidal sea estuary with significant tidal saline intrusion up to 175 km inland. This introduces salt water into aquifers which can cause problems during dry seasons if extraction exceeds recharge rates. The low altitude of most parts of the country increases the risk of flood events near watercourses and coastal areas, particularly during and following the rainy seasons. Drainage in the interior of the country is problematic due to the limited permeability of many soils, exacerbating impacts of floods[94].

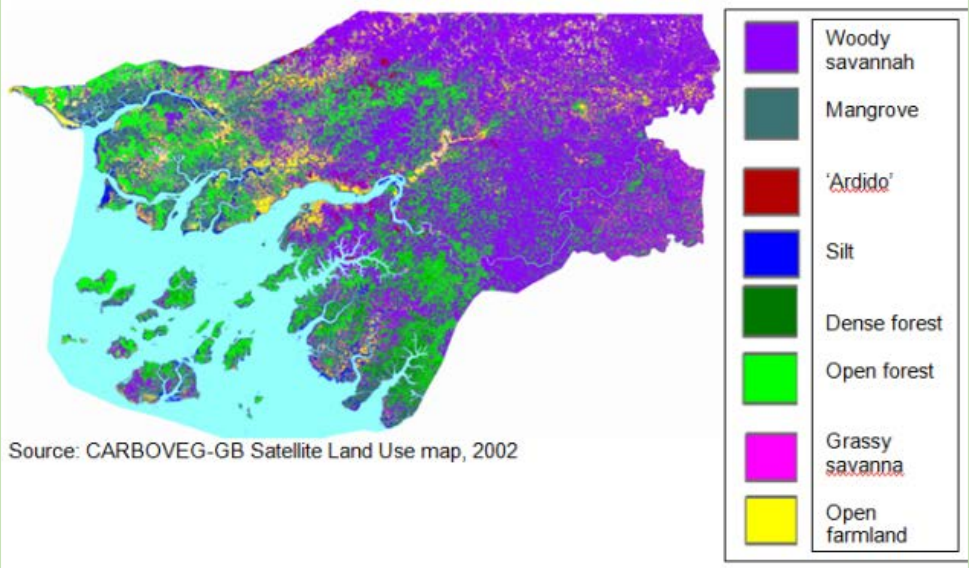


Figure 5.1 – Map of Land Use in Guinea-Bissau, Source: (CARBOVEG Project, 2007)

Few freshwater courses in Guinea-Bissau are perennial, leading populations to rely on groundwater resources during the dry seasons. One exception is the Corubal River, the principal national surface water resource with average annual water volume of 130 bn m^3, whose rocky estuarine threshold protects the river from saline intrusion. Uses of perennial water courses are very important to populations. A second exception is the considerably smaller Geba (0.8 bn m^3). Water is extracted from the Geba upstream in Senegal for irrigation and diverted due to dam construction, rendering dry-season volumes half of this total, exacerbating saline intrusion and threatening agriculture downstream. Recognising the need for transnational planning in order to minimise conflict and make efficient use of available resources, the Gambia River Basin Development Organisation (OMVG), plans water management in the basins of the Geba and Corubal rivers which flow to their estuaries in Guinea-Bissau (Rangley et al 1994)[95].

5.2.2 Climate characterization of Guinea-Bissau

Guinea-Bissau falls within two climatic regions. The sub-Guinean region covers the coastal zone and is characterised by intense rains (1.500-2.500 mm / year), relatively limited variations in temperature, and high humidity. The drier eastern part of the country is characterised by low rainfall (1.000-1.500 mm / year) and large variations in both temperature and humidity between rainy and dry seasons. This eastern part of the country, home to much of the population, is vulnerable to desertification due to intensified farming practices and climate change. Administratively, the country is divided in eight administrative regions including the autonomous capital, Bissau and the smallest groupings of 'Tabancas' (villages), are combined in increasing levels of aggregation into 'Sections', 'Sectors' and 'Regions' (Figure 5.2).

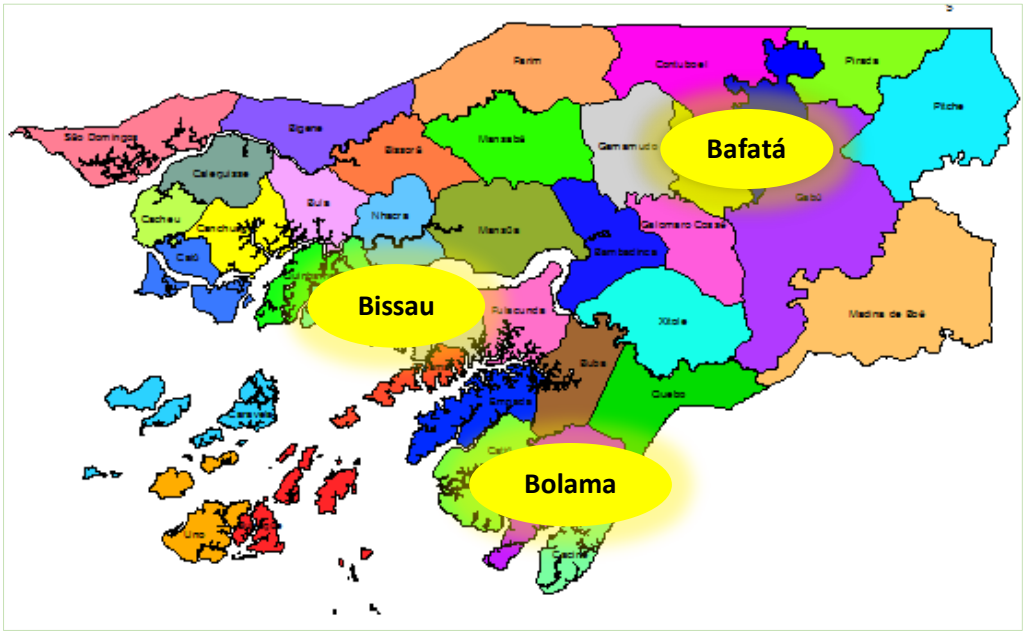


Figure 5.2 - Map of Guinea-Bissau showing main administrative locations (Adapted from GEF, 2011)[96].

Climatically Guinea-Bissau lies in the humid tropics and the country is subject to the movements and impacts of the Intertropical Convergence Zone, a belt of converging trade winds that circles the Earth near the Equator, which broadly dictates its seasons. Therefore, Guinea-Bissau experiences one rainy season and one dry season as the Inter-Tropical Convergence Zone (ITCZ) migrates between the equator and the Tropic of Cancer over the course of the year. These two pronounced seasons in Guinea-Bissau are the hot, rainy season, which lasts from May to November, and the hot, dry season from November to April (Figure 5.3).

The climate in general is tropical maritime with an average temperature of 20ºC and monsoon conditions (May to November) and the "Harmattan" winds (hot, dry, dust-laden air from the Sahara) during dry season (November to April). These climatic features induce rainfall variations in relation to the country's geographical location (South: >2000 mm / year; Northwest: 1400-1800 mm / year and East: 1300-1500 mm / year).

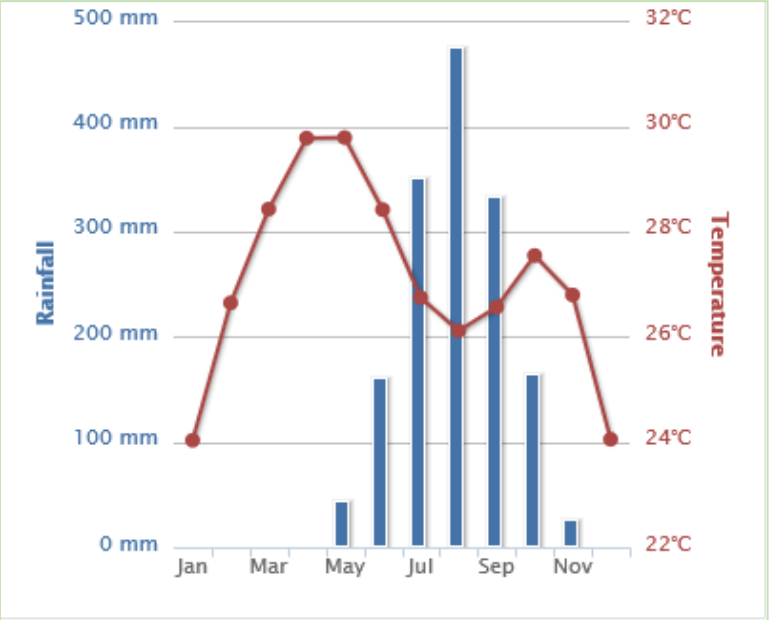


Figure 5.3 - Average monthly temperature and rainfall for Guinea-Bissau from 1901-2012[97]

Precipitation does not vary greatly by elevation in Guinea-Bissau, although it does vary between coastal and inland areas; the coast displaying tropical maritime conditions receives some 60 to 120 inches (1 500 to 3 000 mm/year) of precipitation, whereas the interior is influenced by the tropical savanna climate, with greater variation in precipitation and temperature. Markedly, the NE of the country displays a Sudan type climate with hot and dry conditions and in the North rainfall can reach 1400 mm whilst the South displays a more Sub-Guinean type of climate characterized by high rainfall totals and lower temperature than the NE. Precipitation during monsoon seasons can be intense, with 300mm per month recorded in August.

Temperature

The warm season lasts from February 18 to May 5 with an average daily high temperature above 34°C. The hottest month of the year is April, with an average high of 35°C and low of 22°C. The cold season lasts from July to September with an average daily high temperature below 31°C. The coldest month of the year is January, with an average low of 18°C and high of 32°C. Consequently, the climate induced hydrological balance displays a water surplus from July to October, during the rainy season, and leads to a deficit during the dry season.

Temperature in Guinea-Bissau is less variable than rainfall and monthly average temperature varies regularly throughout the year, peaking maximum values in April and May and a minimum during December to January (Figure 5.4) with monthly average temperature varying between 24°C and 30°C. Over the course of a year, the daily temperature typically varies from 18°C to 35°C and is rarely below 17°C or above 37°C.

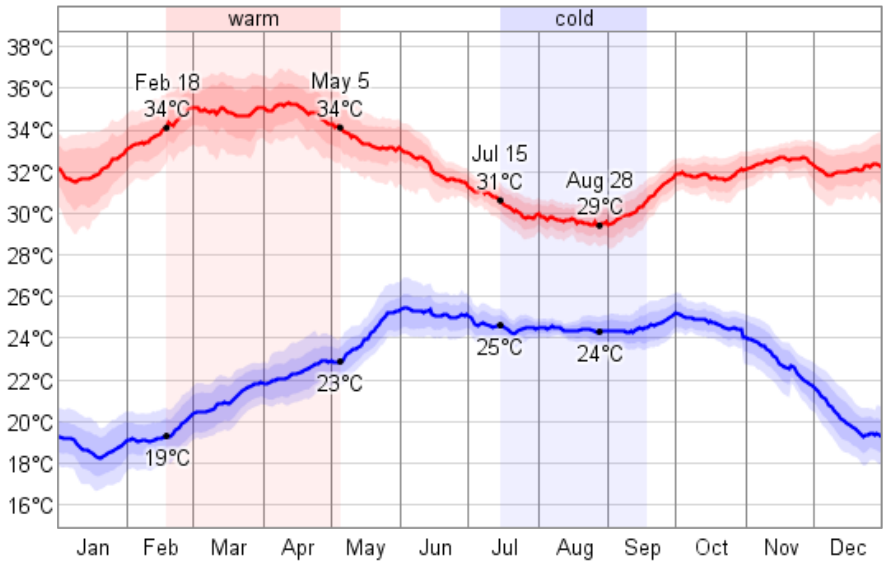


Figure 5.4 - Daily average low (blue) and high (red) temperature with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile)[98].

Spatially the average values of maximum temperature (Figure 5.5) range from 34.6ºC in Bafatá (Centre-East 30.9ºC to 39.3ºC); 32.1ºC in Bissau (Centre-Coastal 30.1ºC to 34.3ºC) and 32.0ºC in Bolama (Centre-South 29,8ºC to 34,2ºC). The average values of the minimum air temperature range between 20.5ºC in Bafatá (16.0ºC to 23.2ºC); 22.2ºC in Bissau and Bolama (19.4 to 23.9ºC and 19.1ºC to 23.7ºC), respectively.

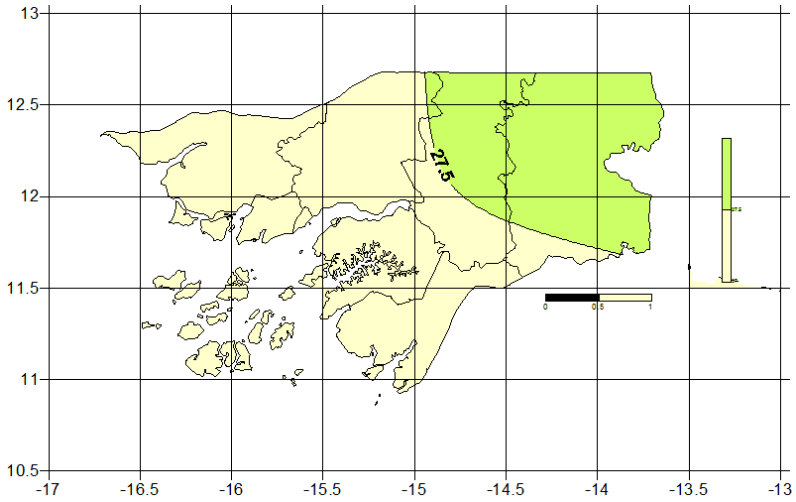


Figure 5.5 - Long-term air temperature (° C) average values (1981-2010) for Guinea-Bissau, Source: (INM-GB, 2014)[99].

From the point of view of temperature regime, the year can be divided into four distinct periods:

1. Cool Season: December, January and February;
2. Warm Season: March, April and May;
3. Rainy Season: June, July, August and September; and
4. Hot Season: October and November

Rainfall

During the 60s and 70s, the first rainfall usually would occur during the 2nd half of May. However, recent data indicate a shift with the rainy season starting in June reportedly with regular concentration and uniformity in terms of distribution throughout the month. October marks the end of the rainy season preceding the month of transition that of November. Rainfall during the year may be divided into two different seasons:

- Dry season: December to May (included); and
- The rainy season: June to November (included)

The greatest rainfall amount is observed in the southern region of Guinea-Bissau decreasing with latitude, with increasingly reduced rainfall moving northwards.

The average annual rainfall in Guinea-Bissau, in the study period (1981-2010), displays a great spatial variability (Figure 5.6), with values observed between 1000 mm to 1500 mm, in the Central Zone and North Regions of Cacheu, Biombo, Oio, and most of the regions of Bafata and Gabu.

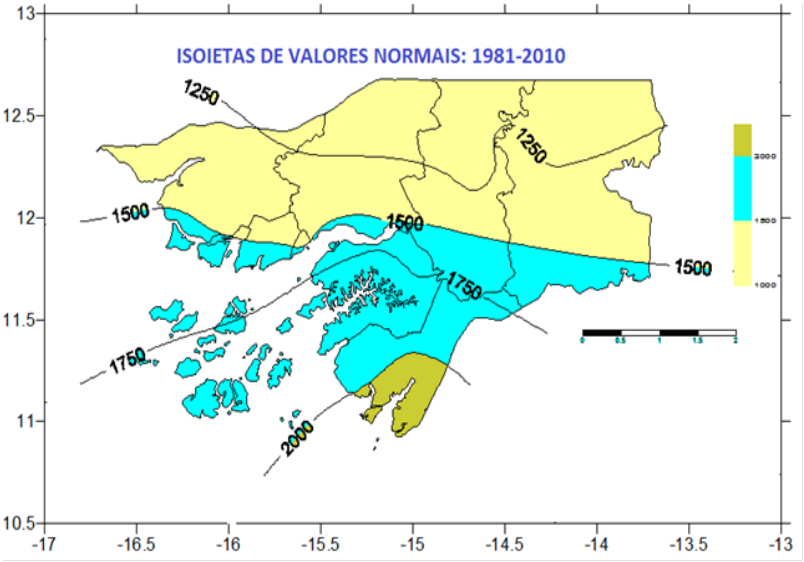


Figure 5.6 - Long-term rainfall (mm) average values (1981-2010) for Guinea-Bissau, Source: (INM-GB, 2014)[100].

The rainfall values range from 1500 mm to 2000 mm in Regions of Quinará and Bolama / Bijagós, in the southern part of the regions of Bafata and Gabu, as well as in coastal areas of Biombo Region, Oio and Cacheu. Higher rainfall values > 2000 mm are found in the southern part of the Tombali Region.

Rainfall Intensity

On average, about 76% of annual rainfall occurs during the months of June, July, August and September (Figure 5.7). The maximum precipitation >300 mm (25% of total monthly fall) occurs in August, and the least amount close to zero (0.0 mm), occurs from the months of December to April (dry season).

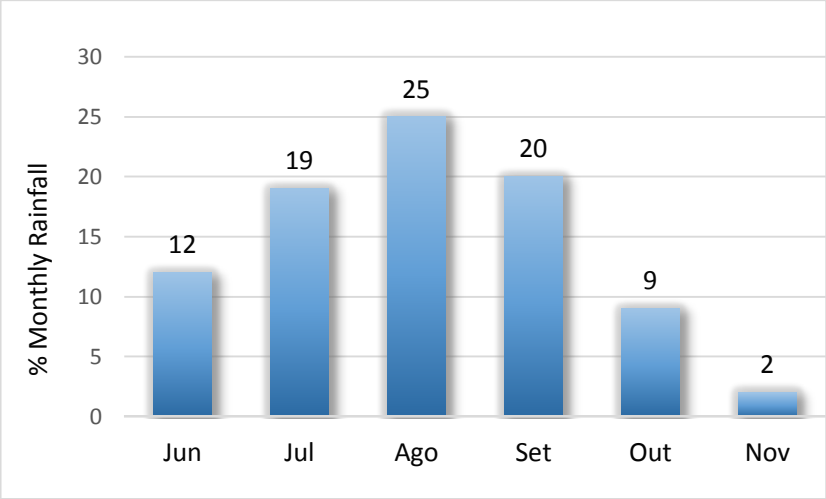


Figure 5.7 – Monthly rainfall (%) during the months of June, July, August and September (1981-2010) for Guinea-Bissau, Data Source: (Nicholson et. al., 2000[101])

Relative Humidity

The average values of Relative humidity (%) of the air (Figure 5.8), on the coast, centre and south of the country during the period 1981-2010, range between 54% and 86% (more wetland, due to the influence of the ocean). In the eastern zone these values range between 39% and 86% (drier zone due to continental influence and the influence of the Sahel band).

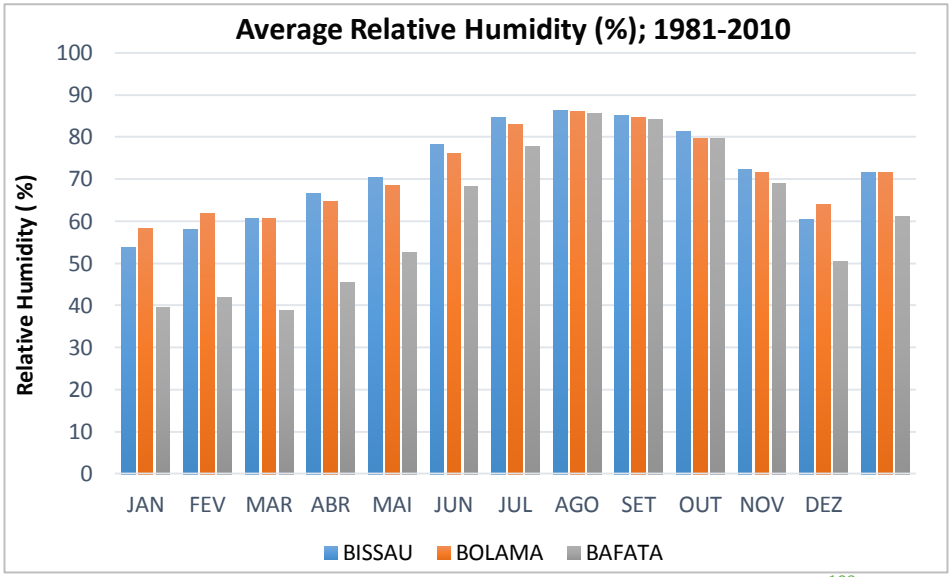


Figure 5.8 - Average Relative Humidity (%); 1981-2010, Source: (INM-GB, 2014) [102.]

Wind

The wind regime in Guinea-Bissau is related to the general circulation of the atmosphere. During the dry season (November to April) the atmospheric circulation is dominated by the winds blowing from the northern (N) and Northeast (NE) quadrants. These trade winds are known in the Northern Hemisphere, as the "Harmattan", blowing from the Sahara. Over the course of the year typical wind speeds (Figure 5.9) vary from 1 m/s to 6 m/s (light air to

moderate breeze), rarely exceeding 8 m/s (moderate breeze). The highest average wind speed of 4 m/s (gentle breeze) occurs around February, at which time the average daily maximum wind speed is 6 m/s (moderate breeze). The lowest average wind speed of 2 m/s (light breeze) occurs around September, at which time the average daily maximum wind speed is 4 m/s (gentle breeze).

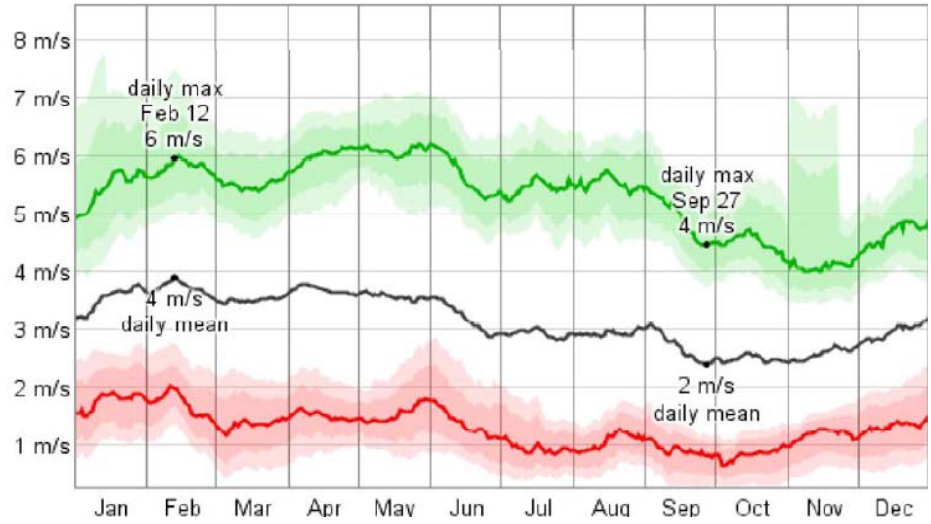


Figure 5.9 - The average daily minimum (red), maximum (green), and average (black) wind speed with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile)[103].

From the end of April, beginning of May, the prevailing wind quickly turns to the West (W) and Southwest (SW) directions, from where it blows until June. July to October (rainy season) is dominate by the trade winds in the Southern Hemisphere, which after crossing the Ecuador under the influence of the Coriolis force leave their original Southeast (SE), direction towards South (S) and West (W) components. This Trans-equatorial flow loaded with moisture is the monsoon regime on the continent (Figure 5.10).

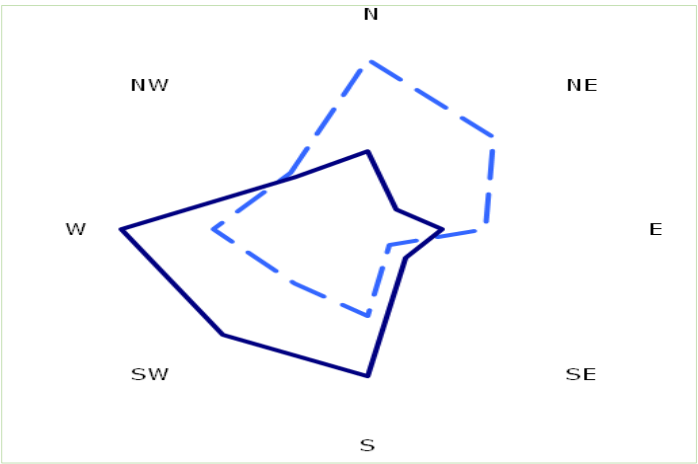


Figure 5.10 - Average (1981-2010) frequency of prevailing wind direction (in %) in Guinea-Bissau during the rainy season (full dark blue line) and dry season (broken light blue line). Source: (INM-GB. 2014)[104].

5.3 Climate Change Trends

Recent climate extreme events and meteorological records from the country and the region provide glaring evidence that climate change is actually taking place in Guninea-Bissau. During the NAPA consultation process communities involved in the study confirmed through

participative questionnaires that there have been frequent assertions by witnesses on the local changes of parameters related to rainfall, temperature, relative humidity, sea level and water resources. Namely, it is assured that in the last few years there has been:

- late onset of the rainy season (mid-June) compared to the usual (early May);
- less regular distribution of rainfall than in the past;
- shortening of the mild temperatures period, often called the "cold season" (Guinea-Bissau's "winter"), which use to last for three months (December to February), to only two months (December to January) nowadays;
- warmer and drier environment;
- frequent dust clouds;
- more frequent occurrence of high-tides of greater magnitudes impacting on dikes and rice fields;
- decrease in water quality due to saline water intrusion and water point infestation by aquatic plants;
- reduction of the wetland areas and resettlement due to frequent drought episodes.

The evolution of rainfall over the past 30 years (1961-1990), or even in the last 45 years (1954-2000) shows a downward trend and irregular rainfall pattern, based on the observed variations: in the South, 2.440-1.800 mm; Mid-Country, 2.200 to 1.600 mm and the North, 1.600 to 1.200 mm[105]. Furthermore, for the period 1953-1983, past findings[106] reveal extreme rainfall events that have occurred in the North, close to the border with Senegal, where the total rainfall in just over 70 days amounted to 1.300 mm (18.6 mm/day). Similarly, in the deep south end of the country rainfall fell more than 3.000 mm in more than 120 days of rain (25 mm/day). In addition, average rainfall season (1961-1990) which use to run from May to November have been constricted to 162 days between June to October. This Section presents results from the study carried out using PRCP Climate Indices RR1 (Total annual number of precipitation days exceeding a given threshold ($Rday \geq 0.1$ mm) and RR20 (Total annual Number of very heavy precipitation days (when $Rday \geq 20$ mm) for Bissau and Bafatá regions to illustrate the current climate change trend.

5.3.1 Methodology

The information used in the Guinea-Bissau's climate profile study results from climatological normal of 26 stations integrated into the core network of the National Institute of Meteorology of Guinea-Bissau: 4 Main Stations (Bissau / Observatory Bissau / Airport Bafata and Bolama) and 22 Pluviometry posts (Bedanda, Bissorã, Buba Bubaque, Bula, Buruntuma, Cacheu, Cacine, Caius, Canchungo, Catió, Patty, Farim, Fulacunda, Gabu, Mansaba, Pirada, Puerto Gole, Sonaco, Tite, Varela and Xitole); for the period 1981-2010, including monthly and annual values of the main climatic elements in graphical and numerical form. It also lists the average values of the maximum and minimum temperatures of the air and the total precipitation, as well as the respective extreme values. All these datasets have been quality controlled and adjusted for inhomogeneity and inconsistencies. Then, in order to include a given observation station, the following general criteria have been used: (i) from the entire 1981-2010 period data must be available for at least 19 years, (ii) missing data cannot be more than 10%, (iii) missing data from each year cannot exceed 20%, (iv) in each year more than 3 months consecutive missing values were not allowed.

The climate indices, PRCP Climate Indices RR1 (Total annual number of precipitation days exceeding 1 mm) and PRCP Climate Indices RR20 (Total annual number of precipitation days exceeding 20 mm) for Bissau and Bafatá regions were computed to illustrate the current climate change trend between 1981 and 2010.

5.3.2 Results on Climate Change Trends in Guinea-Bissau

The results of the study on climate classification of Köppen for Guinea-Bissau using the normal climatological 1981-2010, the latest available, allow the identification of climate types for the different regions of the country. The mapping of the results for climatic classification does confirm that the climate of the territory of Guinea-Bissau is indeed Tropical, type A, validating the Subtype Am (Tropical climate Monsoon).

Trend of temperature changes

There are two climate regions: the sub-Guinean humid tropical region and the Sudanese tropical one. The first coincides with the coastal zone and is characterised by intense rains (1.500-2.500 mm/year), variations in average temperature and heavy air humidity throughout the year. The second region (Sudanese type), covering the country's eastern half, is characterised by weak rainfall (1.000-1.500 mm/year), high temperature variations, heavy air humidity throughout the rainy season and light humidity over the dry season.

There is no trustworthy continuous long-term record of temperature time series to illustrate the temperature changes taking place in the country. However, an analysis of the evolution of more recent time series (1950-2001) indicates a steady rising of temperature across the years.

This increase applies for both air temperature measurements: Maximum Temperature (Tmax) and Minimum Temperature (Tm).

According to these calculations mean temperature values rose at a rate of 0,0155 °C / year (Figure 5.11)[107] in the past 50 years leading to an approximate Mean Rate of Change (°C/Century) of 1.55°C.

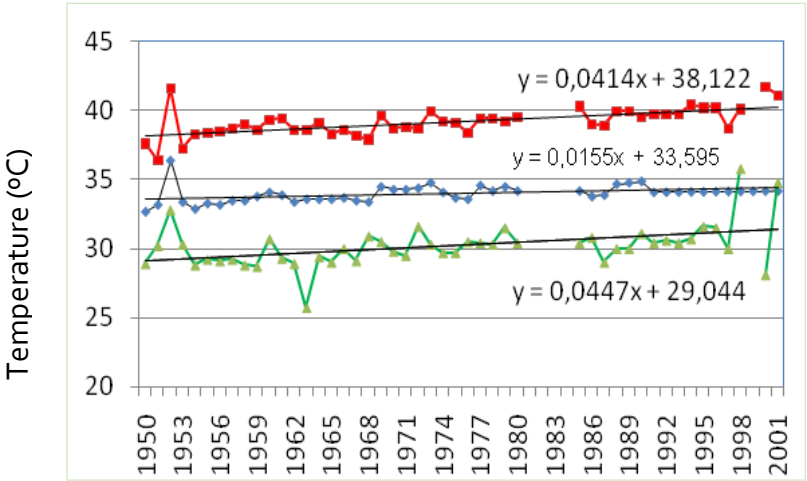


Figure 511 - Evolution of temperature of (a) Maximum temperature (red), (b) Minimum temperature (green) and (c) Mean temperature (blue) time series (1950-2001) for the centre-east location of Bafatá.

This temperature behaviour reflects the regional pattern of temperature variation in the last decades which indicates that temperatures have been increasing faster than the global average. This increase has varied between 0.2 and 0.8°C since the end of the 1970s. This trend is stronger in terms of minimum rather than maximum temperatures[108] Other sources looking at the climate trend such as The Berkeley Earth used a method that takes

temperature observations from a large collection of weather monitoring stations and produce an estimate of the underlying global temperature field across all of the Earth's land areas. Once this temperature field has been generated, it was possible to estimate the temperature evolution of individual regions simply by integrating the field over the region in question.

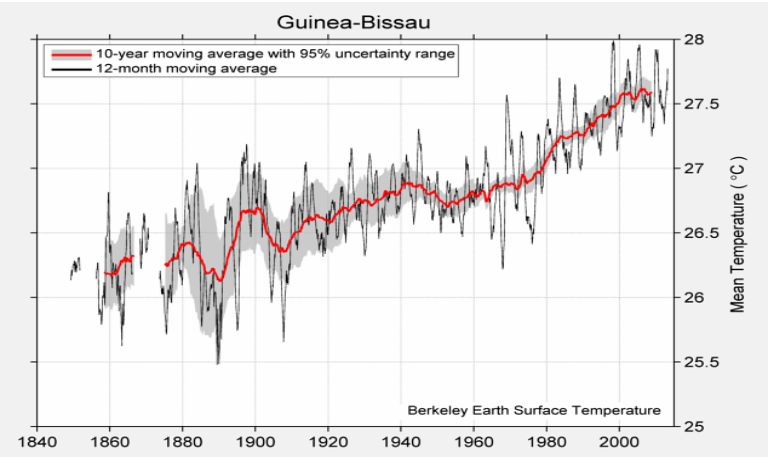


Figure 5.12 -month moving average and 10-year moving average mean temperature evolution for Guinea-Bissau region[109] .

The Berkeley Earth results on regional estimate of land-surface temperature complete dataset records for Guinea-Bissau region going back 250 years, about 100 years further than previous studies, indicate that both the 12-month moving average and 10-year moving average mean temperature have been increasing steadily for the past century and half (Figure 5.12).

Not surprisingly, these results yield Mean Rate of Change (°C / Century) varying from 0.89 to 1.85 for Guinea-Bissau compared to Western Africa, the whole Continent and Global (Table 5.1).

Table 5.1 – Mean Rate of Change (°C / Century) of temperature in Guinea-Bissau as compared to other regions.

Region/ Location	1760	1810	1860	1910	1960	1990
Guinea-Bissau	-	-	0.89±0.17	1.00±0.17	1.85±0.37	1.19±0.82
Western Africa	-	-	0.92±0.20	0.86±0.13	2.02±0.31	3.09±0.54
Africa	-	-	0.83±0.20	0.92±0.12	1.99±0.21	2.49±0.45
Global Land	**0.43±0.18**	**0.79±0.13**	**0.91±0.08**	**1.11±0.03**	**2.16±0.11**	**2.78±0.13**

Source: http://berkeleyearth.lbl.gov/auto/Regional/TAVG/Figures/guinea-bissau-TAVG-Trend.pdf.

Trend of precipitation changes

Recent research results have indicated great variability of spatial and temporal distribution of rainfall in the country, reflecting trends in atmospheric conditions responsible for excessive extreme rainfall events that are associated with the intertropical convergence zone (ITCZ), with well-marked annual cycles. The highest annual average maximum rainfall intensities were observed in southern and southwestern regions. Analysis of the spatial distribution of rainfall in Guinea-Bissau was carried by overlapping two different time series of 1961-1990 (full line) and 1981-2010 (dashed line). The results of this study shown in Figure 5.13 indicate a clear recession of isohyets south-westwards pointing to a process of drying.

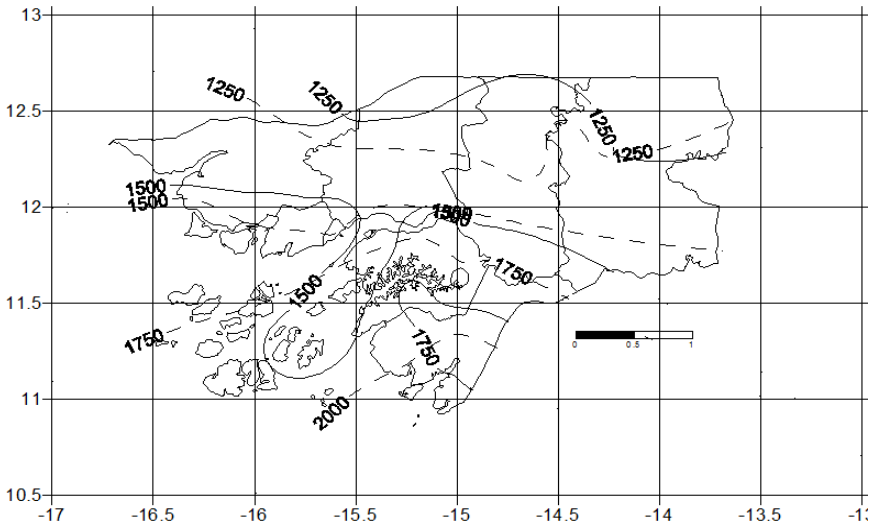


Figure 5.13 - Overlapping two rainfall time series of 1961-1990 (full line) and 1981-2010 (dashed line). Source: (INM-GB, 2014)[110] .

When the time series of 1971-1990 (full line) and 1981-2010 (dashed line) is used the recession of isohyets south-westwards is no longer so evident, but only in the most southern tip of the country (Figure 5.14).

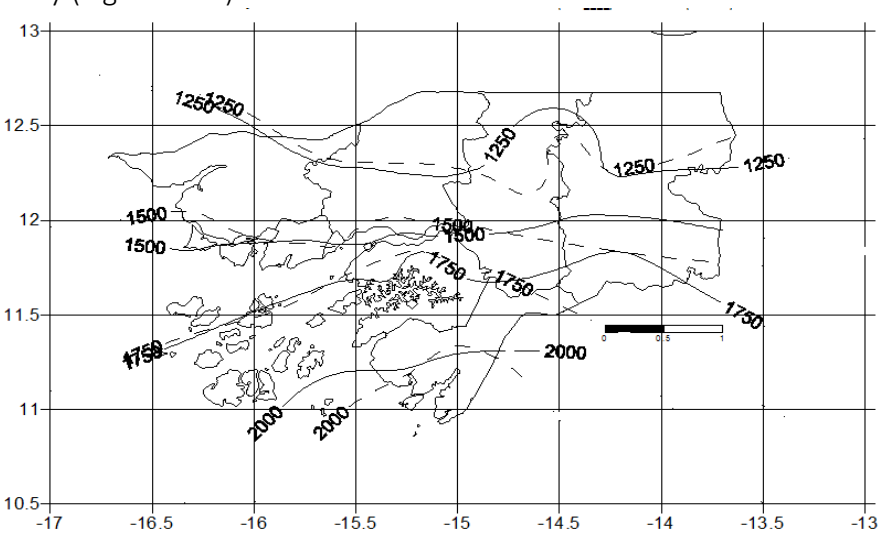


Figure 5.14 - Overlapping two rainfall time series of 1971-1990 (full line) and 1981-2010 (dashed line), Source: (INM-GB, 2014)[111]

This may indicate that the rainfall that was recorded between 1961 and 1971 had the greatest contribution to the drying process which now is only depicted in southern tip of the country.

PRCP Climate Indices RR1 & RR20

The climate indices PRCPTOT *Climate Indices RR1 & RR20* i.e. the total annual number of humid days greater than or equal to precipitation of 0.1 mm and total annual number of days with rainfall higher than or equal to 20 mm show a slight tendency to display lower values than the long-term average, in the north and central region (Bissau). These indices show (Figure 5. 15a.b) important declining trends in eastern and southern zones of the country (Bafatá and Bolama, respectively).

The spatial variation of PRCPTOT *Climate Indices RR1 & RR20* is similar to that of annual rainfall, with an absolute maximum in the south and islands (Bolama) with values of the order of 110 days. Annual rainfall totals linked to these indices does indicate a decreasing trend in both Bissau and Bafatá regions (Figure 5.15). The lowest values are observed in the North and East zone: such as Bissau, with values in the order of 90 days, and Bafatá with values in the order of 71 days (this analysis was made based on the number of days from 1971 to 2013).

PRCPTOT Climate Indices RR1 (precipitation ≥ 1 mm/day) shows a declining linear tendency between 1960 and 2010 from around 1,750 mm to ~1,450 mm annual rainfall for Bissau (Figure 5.15a) and from approximately 1,500 to ~1,250 mm annual rainfall for Bafatá (Figure 5.15b). These tendencies clearly hint the advent of a drier climate in the future with potential occurrence of hydrological deficit across the central northern and eastern portions of the country.

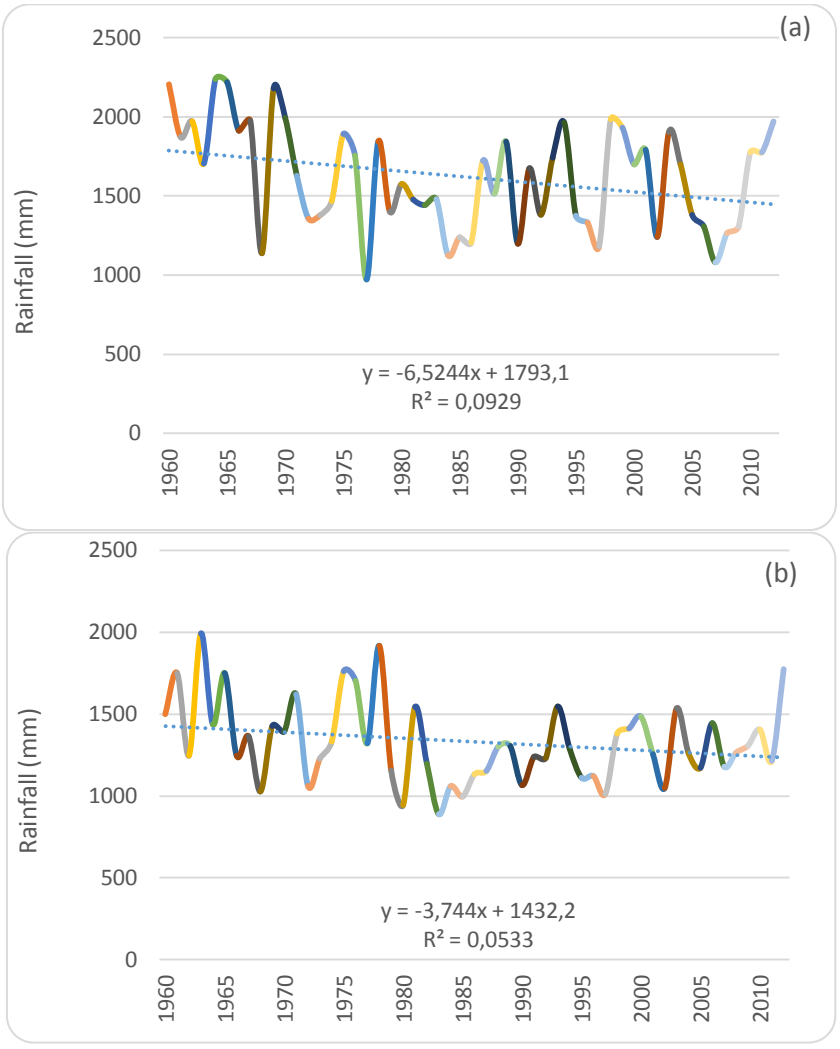


Figure 5.15 – PRCPTOT Climate Indices RR1 & RR20 (Total annual number of precipitation days exceeding 1 mm and 20 mm) for (a) Bissau and (b) Bafatá. Data source: (INM-GB, 2014)[112]~

However, an analysis of the evolution of more recent time series (1950-2001) from eastern region of the country (Bafatá) indicate a steady decrease of total rainfall across the years from 1,500 mm in 1950 to about 700 mm in 2001 (Figure 5.16). This represents more than 50% reduction in total rainfall.

There is a clear tendency for mean temperatures to increase in the future following the trend observed during the last decades/century. This temperature increase may vary between an approximate Mean Rate of Change of 1.19 (±0.82) and 1.85 (±0.37).

The inter-annual rainfall changes have shown a tendency for a steady decline over the past 50 years with increasing variability regarding the onset and duration of the rainy season.

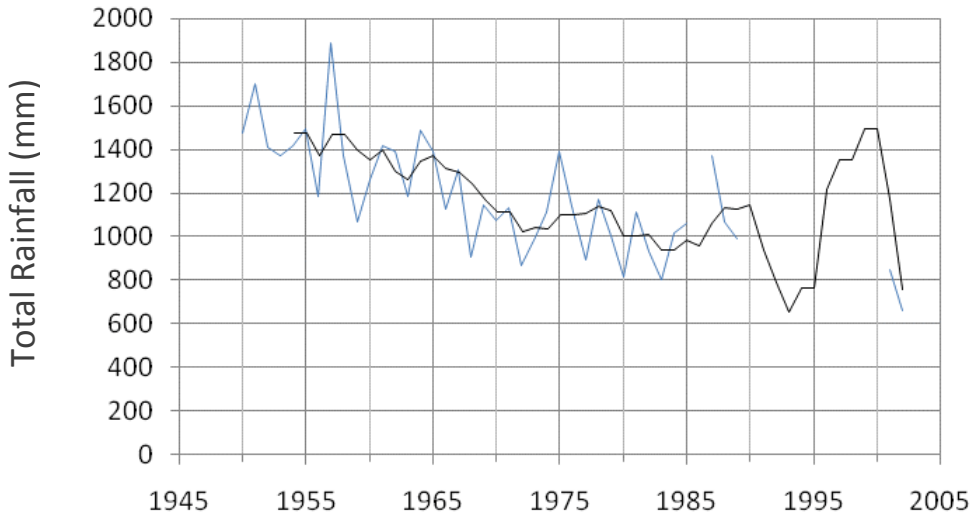


Figure 5.16 - Evolution of (a) total (light blue line) and (b) 5-years moving average (dark blue line) rainfall time series (1950-2001) for the centre-east location of Bafatá in Guinea-Bissau[113].

5.4 Climate Change Projections

This section reports the preliminary results of the study on climate projection scenarios developed under the IIIª National Guinea-Bissau Communication Project in the implementation of the United Nations Framework Convention on Climate Change (UNFCCC). The aim of the study was to carry out an analysis of new climate projection scenarios for Guinea-Bissau, at the short [2016-2045] and medium term, [2046-2075].

5.4.1 Methodology

In attempting to assess future impacts of climate change in Guinea-Bissau, a series of climate change models have downscaled global climate predictions to the national level. Climatological data from the National Institute of Meteorology of Guinea-Bissau (INM-GB) were used for climate profile update and the reference period (1961-1990). The reference period was chosen as the most reliable observation period of historical data from INM-GB. For this study, the time horizons of interest used were: 2016-2045 and 2046 to2075.

A set of 14 combinations of simulations of 4 Regional Climate Models conducted by 8 Global Climate Models (Table 5.2), were used based on two scenarios of Representative

Concentration Profile (RCP-Representative Concentration Pathways, acronym in English). Unlike the SRES scenarios, these new scenarios are not defined by the IPCC itself, but were established by the scientific community to meet the IPCC needs. Scientists have identified patterns representative of greenhouse gases varying concentration, ozone precursors and aerosol, representative of an increase in the energy balance, called RCPs (Representative Concentration Pathways - Representative Concentration Profiles). RCPs are therefore reference scenarios of the evolution of radiative forcing in the period 2006-2300. Four families of RCPs were determined: RCP8.5, RCP6, RCP4.5 and RCP4.2. The value following the RCP letters correspond to radiative forcing reached in 2100, in W / m2 (Table 5.2).

Table 5.2 – Main features four RCPs scenarios (Moss et al, Nature 2010).

Designation	Radiative Forcing in 2100 (current: 2.1 W/m^2)	Concentration CO2eq (ppmv) in 2100 (current: 442ppmv)	Trajectories
RCP8.5	>8.5W/m^2	>1370	Rising
RCP 6.0	~6W/m^2	~850	Stabilization - not exceeding
RCP 4.5	~4,5W/m^2	~660	Stabilization - not exceeding
RCP 2.6	Peak at ~3W/m^2 before 2100 then declining	Peak at ~490 before 2100 then declining	Peak and then declining

The radiative forcing, expressed in W / m2, is the change in the radiative balance (downward radiation - radiation that rises) at the top of the troposphere (10 to 16 km altitude) due to the change of climate evolution factors such as the concentration of gases with greenhouse effect. The value for 2011 is 2.1 W / m2. Therefore, Representative Concentration Profiles are trajectories of concentration of gases with greenhouse effect recommended by the IPCC for its Fifth Assessment Report (AR5) in 2014. They describe possible developments in the future climate, which are considered possible to take place depending on amount of greenhouse gases emitted in the coming years. The four RCPs (RCP2.6, RCP4.5, RCP6 and RCP8.5) are named after a possible range of values of the radiative forcing by the year 2100 compared to the values of pre-industrial levels (2.6, 4, 5, 6.0, and 8.5 W/m2, respectively). Two emission scenarios were selected for this study:

- **Emission scenario 1**. RCP4.5: without overcoming, via stabilization to 4.5 W/m2 stabilization after 2100;
- **Emission scenario 2.** RCP8.5: Increased radiative forcing that leads to 8.5 W/m2 in 2100.

The method "delta" was used for the development of future climate projections. This method "delta" consists of calculating the difference or the ratio between the average climatological future period (2016-2045 or 2046-2075) and the reference period (1961-1990) of the simulation model[114]. For variables such as the temperature, the calculated difference (additive factor) is added to 30 years of monthly observations of the reference period to obtain a realistic situation of the future climate. The delta method is simple and easy to implement but has some limitations. For example, there is the assumption that the variability will not change in the future, which does not come to be the real situation. Climate projection scenarios produced by the various global climate circulation (regionalized), models

using different assumptions for the expected evolution of emissions of greenhouse gases (i.e. optimistic scenario or Low emissions - RCP4.5, and pessimistic scenario or High emissions - RCP8 .5) were used. The set of results provided by the different models under different scenarios of greenhouse gas emissions, offers an estimate of the possible evolution of climate in Guinea-Bissau, but also the uncertainties that still exist about the future.

The climate change scenarios for Guinea-Bissau, are based on the climate profile of Guinea-Bissau prepared based on the normal climatological recommended by the IPCC, 1961-1990 (reference climate data set) through the observed data obtained in the Climatological Data Base of the National Institute of Meteorology of Guinea-Bissau. It was used as the least restrictive, setting appropriate RCP4.5, a socio-economic development which controls the increase in emissions of greenhouse gases, reaching a maximum concentration in the middle of the XXI century. In contrast, the most onerous RCP8.5 scenario is that of continued growth in emissions during the XXI century.

5.4.2 Changes Projected for the period 2016-2045

Mean Daily Temperatures (°C)

From the group of 14 Regional Climate Models that were used in the simulations (see Table 5.3), all scenarios project an increase of mean daily temperature of the order of 1.3°C [0.9°C to 1.7°C] for Scenario RCP4.5 (low emissions), and 1.5°C [1.0°C to 1.9°C] for RCP8.5 scenario (high emissions), compared to the average from 1961 to 1990. This means that even maintaining the current level of emissions, the heating will be in the range of approximately + 1°C, relative to the average 1961-1990, by 2045.

Table 5.3 - Matrix of Global Models / Regional used.

Global Climate Model (Institution)	Regional Climate Model (Institution)			
	RCA4 (SMHI)	RACMO22T (KNMI)	HIRHAM5 (DMI)	CCLM4-8-17 (CLMcom)
CanESM2 (CCCma)	X			
CM5 (CNRM-CERFACS-CNRM)	X			X
EC-EARTH (ICHEC)	X	X	X	X
MIROC5 (CCSR)	X			
HadGEM2-ES (MOHC)	X			X
ESM-LR (MPI-M-MPI)	X			X
NorESM1-M (NCC)	X			
GFDL-ESM2M (NOAA-GFDL-)	X			

Daily Maximum Temperatures (°C)

According to the results obtained from the regional climate models run under the RCP4.5 scenario (low emissions) for the period 2016-2045 relative to 1961-1990, the daily maximum temperature is projected to increase by +1.2°C [+0.8°C to +1.7°C] for the coastal areas (Bissau and Bolama) and by +1.4°C [+1.0°C to +1.6°C] inland and on the eastern regions of the country (Figure 5.17a). By contrast the temperature increase projected for the same regions under the RCP8.5 scenario (High emissions) for the period 2016-2045 vary from an increase

of +1.3°C [+ 0.9°C to 2.0°C] for Bissau and Bolama in the coastal areas and, up to +1.5°C [+1.2°C to 2.1°C] inland and the eastern areas (Figure 5.17b).

(a)

(b)

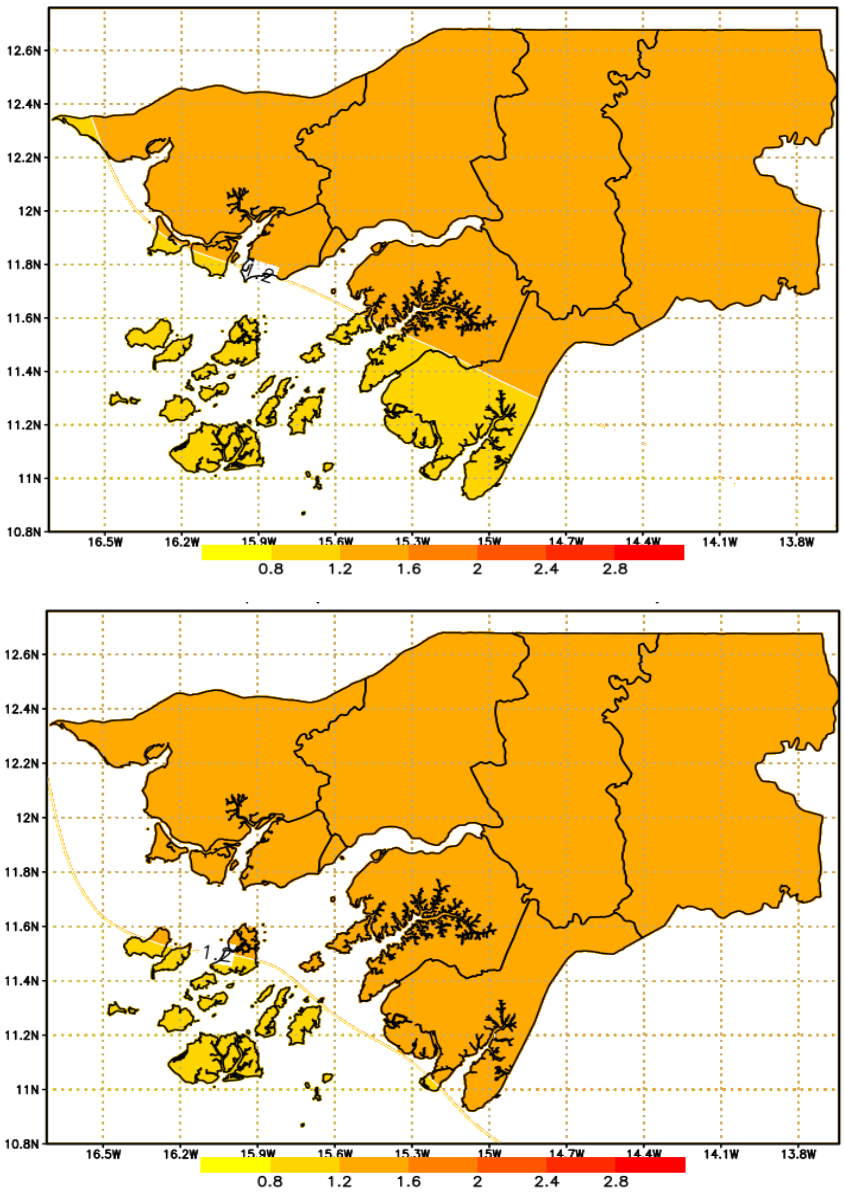


Figure 5.17 - Distribution of projected temperature changes for daily maximum temperature obtained from the regional climate models run under the (a) RCP4.5 scenario (low emissions) and (b) RCP8.5 scenario (high emissions) for the period 2016-2045 relative to 1961-1990, Source: (INM-GB, 2016)[115]

Daily Average Precipitation (%) 2016-2045

Under the RCP4.5 scenario (low emissions), the average values from the output of all models used in the simulations exercises project for 2016-2045 period a slight increase in the average daily rainfall of the order of + 3% [2% to + 5%] for almost the entire national territory, apart from the south-western part of the archipelago of Bijagós, where it is expected an increase ranging between + 5% and + 10% (Figure 5.18a).

Similarly, under the RCP8.5 scenario (high emissions) the models do not project for 2016-2045 period any significant changes in relation to the reference period: 1961-1990 with the exception of the south-western part of the archipelago of Bijagós and part Southern Region of Tombali (Cacine Sector) where it is expected a slight increase in the order of + 2% to + 5% (Figure 5.18b).

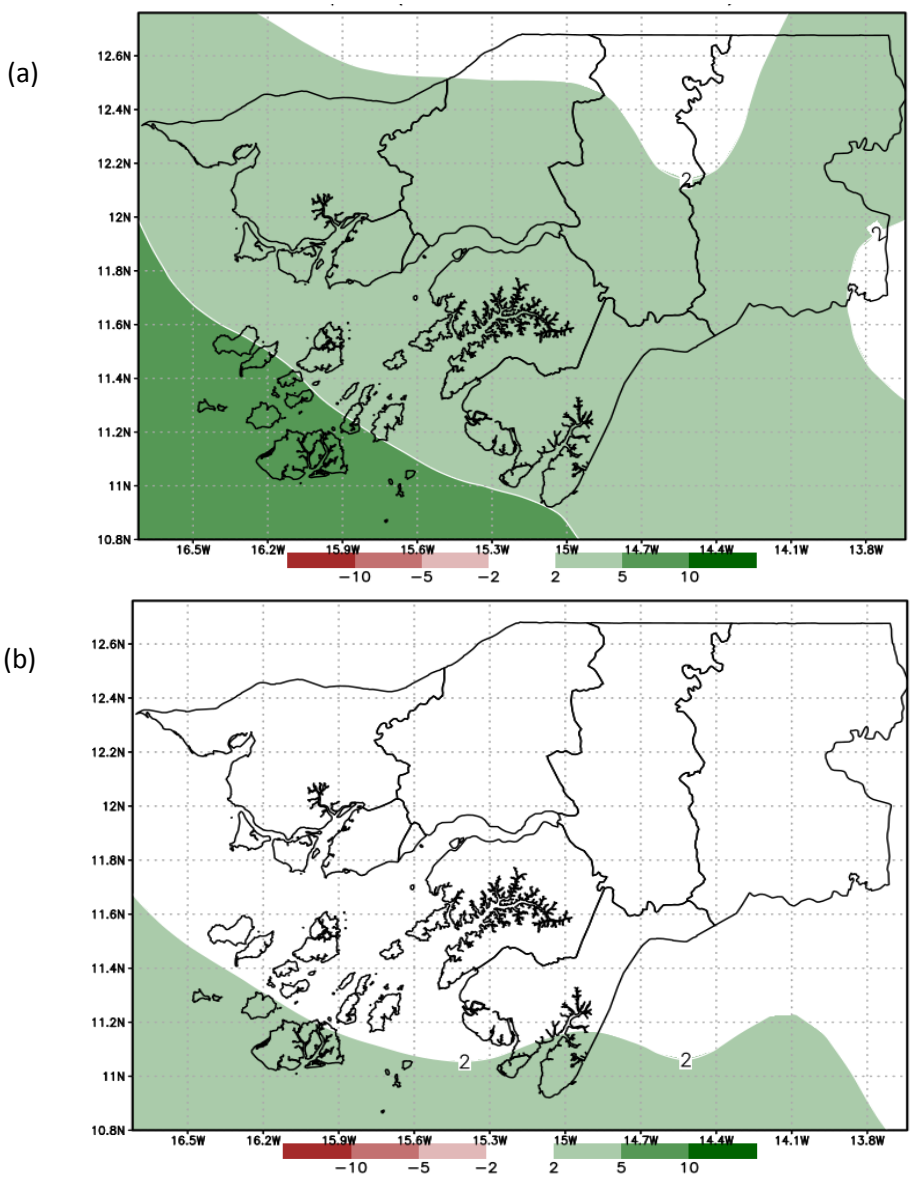


Figure 5.18 - Distribution of projected rainfall changes for average daily rainfall obtained from the regional climate models run under the (a) RCP4.5 scenario (low emissions) and (b) RCP8.5 scenario (high emissions) for the period 2016-2045 relative to 1961-1990, Source: (INM-GB, 2016)[116]

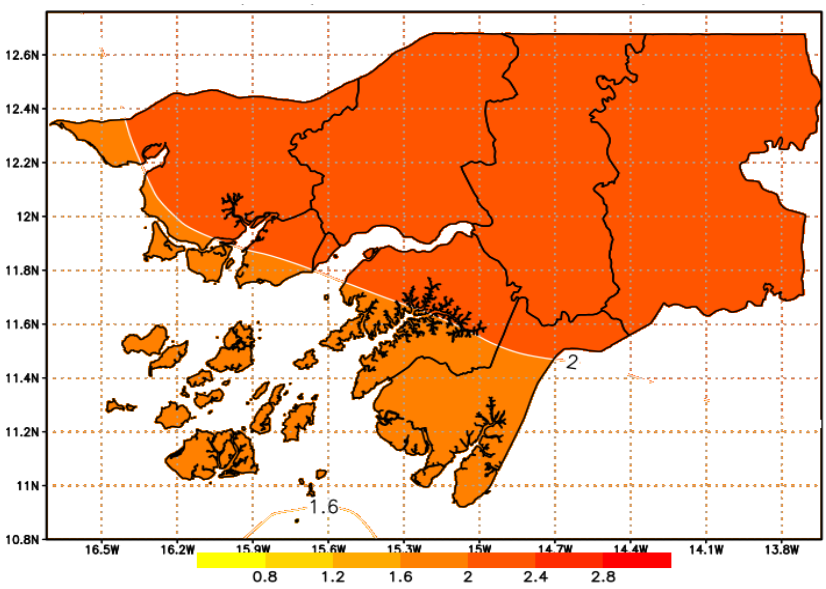
5.4.3 Changes Projected for the period 2046-2075

Daily Maximum Temperatures (°C)

Over the 2046-2075 period model simulations of mean daily temperature predict the mean temperature to increase by **1.5°C** [1.0°C à 1.9°C] (Figure 5.19a) under the RCP4.5 scenario

(low emissions) and **2.9°C** [2.1°C à 3.6°C] for high emissions scenario (RCP8.5) in relation to the average temperatures established for the period 1961-1990 (Figure 5.19b).

(a)



(b)

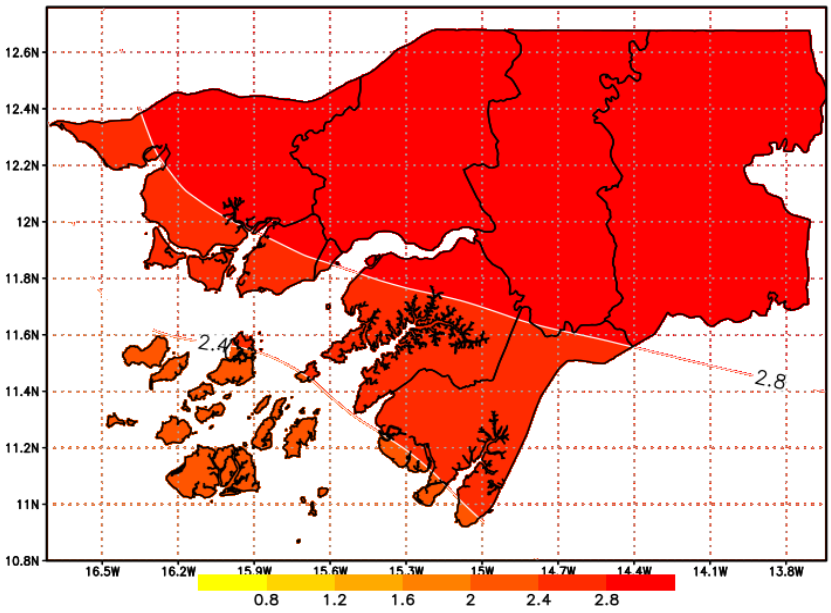


Figure 5.19 - Distribution of projected temperature changes for daily maximum temperature obtained from the regional climate models run under the (a) RCP4.5 scenario (low emissions) and (b) RCP8.5 scenario (high emissions) for the period 2046-2075 relative to 1961-1990, Source: (INM-GB, 2016)[117]

Daily Average Precipitation (%) 2046-2075

Looking at the 2046-2075 period all models run under the RCP4.5 scenario (low emissions) predict a more variable behavior for average daily rainfall in the country with reductions in the order of -2% to -5% in the north Cacheu region (Canchungo Sector, Caliquesse and Caió) and rainfall increases of the order of 5% to 10% in the southern regions (Figure 5.20a).

(a)

(b)

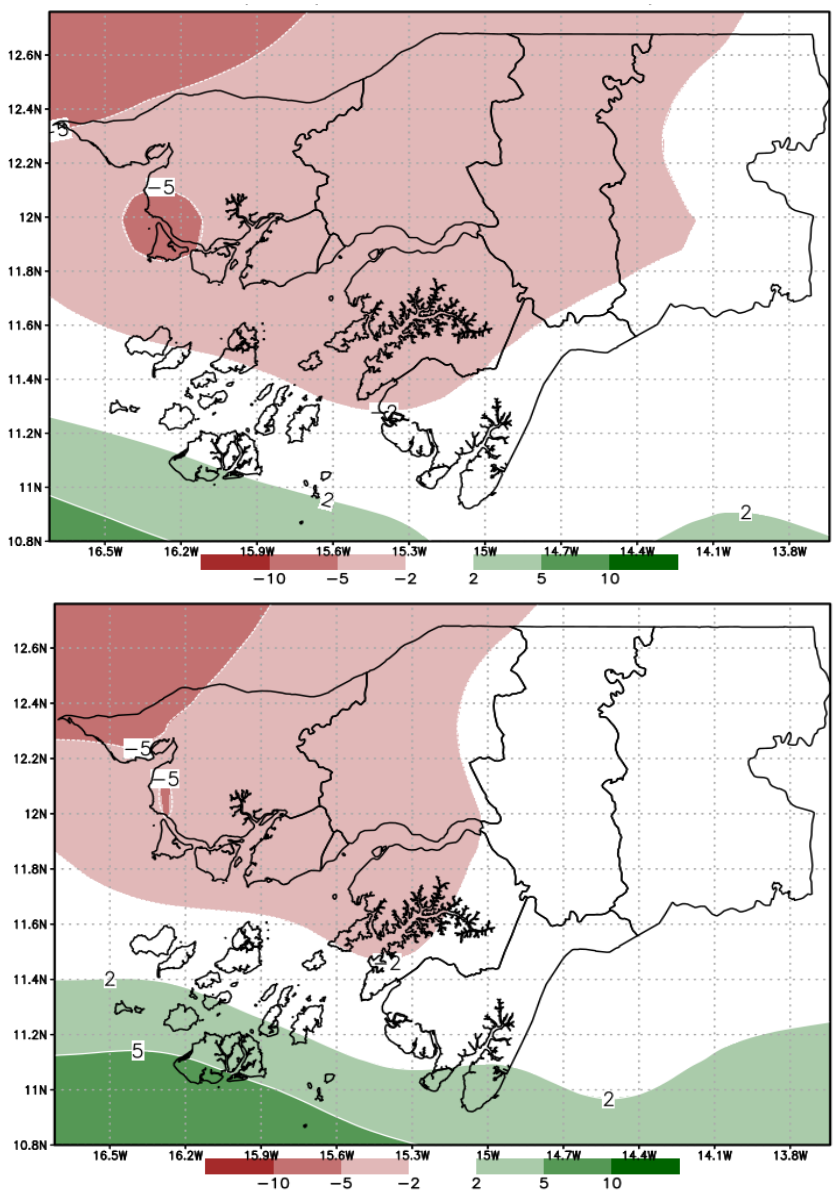


Figure 5.20 - Distribution of projected rainfall changes for average daily rainfall obtained from the regional climate models run under the (a) RCP4.5 scenario (low emissions) and (b) RCP8.5 scenario (high emissions) for the period 2046-2075 relative to 1961-1990, Source: (INM-GB, 2016)[118]

For the RCP8.5 scenario (high emissions) the models suggest the same increased rainfall variability, with a decrease (-2% to-10%) in the northern coastal areas, but with less coverage than in the previous scenario. Even for this scenario it is expected to see an increase in average daily rainfall (Figure 5.20b) of the order of + 2% to + 5% in the Southwestern areas of the islands and the southern parts of the country (Tombali Region - Cacine Sector).

Sea Level Rise

Regarding the sea level rise scenarios and according to the Model MAGICC SCENGEN, version 5.1, it is expected an increase of approximately 6.5 cm by 2020 reaching up to 20 cm in 2050.

These elevations from sea level combined with coastal erosion, could have drastic consequences for the countries of low altitude and small islands, such is the case of Guinea-Bissau, affecting particularly the country's economy, particularly the people living in coastal areas depending on coastal resources for their livelihoods.

5.4.4 Summary of Projected Climate Changes

The new climate scenarios project significant changes in the climate of Guinea-Bissau. These scenarios systematically indicate increases in average daily temperature up to + 1.4°C for the period 2016-2045 and which could potentially reach up to + 2.2°C in 2046-2075 horizon, per the low emissions scenario (CRP4.5). According to the RCP8.5 scenario (high emissions) the changes expected are still higher with temperature increases of the order of + 1.6°C to + 3.1°C for the period 2046 to 2075 respectively.

The ensemble means of the models used also points at significant increases in the daily maximum and minimum temperatures, of the order of +3.0°C and +3.2°C, respectively, particularly in the eastern part of the country. This increase in the maximum and minimum ultimately will lead to an increase in the overall average daily temperature of +3.1°C. If happening, these projected temperature changes will have a substantial impact on the water resources of a region, which is already under severe limitations in water availability for the agriculture sector which is the source of income for 85% of the population and accounts for over 98% of total exports of goods.

Regarding the precipitation, the average of fourteen models used in the simulations points at a slight increase in the average daily of + 3% [2% to + 5%] for almost the entire national territory per the RCP4.5 scenario (Low Emissions) for the period 2016-2045. For RCP8.5 scenario (high emissions) no significant changes are expected in relation to the reference period: 1961-1990. With the exception of the south-western part of the archipelago of Bijagós and part Southern Region of Tombali (Cacine sector) where + 5% increase is expected, projections under this scenario are generally characterized by a significant variability. Data from other international sources shown above indicate that this variability is not only in terms of intensity with more extreme events but also in relation to changes in the length of the rainy season and start and end of rainfall season.

These findings are not in line with current trend depicted from the PRCPTOT *Climate Indices RR1 & RR20* analysis (based on the number of days from 1971 to 2013) which shows an absolute maximum of the order of 110 humid days for the south and islands (Bolama) then decreasing to about 90 days in Bissau and 71 days in the eastern region of Bafatá. Again, there is a clear declining linear tendency between 1960 and 2010 from around 1,750 mm to ~1,450 mm annual rainfall for Bissau and from approximately 1,500 mm to ~1,250 mm annual rainfall for Bafatá. These tendencies are indicative of a much drier future environment across the central northern and eastern portions of the country. These findings are also supported by the current evolution of the more recent 1950-2001-time series which indicate a steady decrease of total rainfall in the eastern region of the country (Bafatá) throughout the years. Therefore, it is imperative to note that the current precipitation patterns to date have shown a clear tendency for a decline in precipitation amounts and variability in terms of onset and end of the rainfall season. This is in a clear contrast with the model's projections in both low and high emission scenarios for the southern part of the country where an increase

of wetter conditions is expected. Therefore, these model results should be interpreted with caution given the underlying uncertainties regarding the variability in the movement of the ITCZ and African monsoon circulation, and difficulties of incorporating these accurately into modelling processes. Other results from past recent model simulations of precipitation changes for the Sahelian regions of Africa (McSweeney et al., 2012)[119] indicates that they are strongly divergent results and with most models fail to reproduce realistic inter-annual and inter-decadal rainfall variability in the Sahel in 20th century simulations. The authors argue that current understanding of the processes causing tropical rainfall is insufficient to allow a prediction of the direction of change with any certainty. The IPCC identify this as an area requiring further research to understand the variety of model responses in this region. In addition, being Guinea-Bissau a small country, it is always difficult to carry out downscaling of global models to any useful level of analysis for national planners – the smallest unit of scale currently covers most of the country plus significant areas of other neighbouring countries. The climate scenarios presented in this paper involve projections of future climate based on simulation of the evolution of the climate system obtained from Global Climate Models and Models Regional Climate Models. They are not exactly predictions of the future climate, in strictly deterministic sense, since they depend on emission scenarios that contain an intrinsic unpredictability associated to human and social action.

In summary, climate variability will remain a dominant aspect of climate in Guinea-Bissau and therefore in light of these uncertainties, planning for increases in temperature alongside development of resilient planning for extreme events of drought particularly in the eastern portion of the country (Bafatá) and flood along the coastal zone and uncertainty over precipitation levels will be required. This is an analysis which will dealt with in the next Chapter.

Chapter 6: Vulnerability and Adaptation to Climate Change

6.1 Introduction

Guinea-Bissau is prone to climate risks due to its specific climatic, geographic and socio-economic context – agriculture, water and the coastal zones being particularly vulnerable. In the coming decades, a range of climate change projections predict that temperatures will rise, drought and flooding will likely become more extreme, while precipitation may become more volatile (i.e. increasingly frequent torrential and intense rains over a short time period). A higher frequency of extreme climatic events may result in more frequent catastrophes through loss of crops and infrastructure. Spatial and temporal variability of climate change events will also increase, further contributing to higher variability in existing and future availability of water resources in Guinea-Bissau[120]. Guinea-Bissau's NAPA concluded that climate change and climatic variability represent a threat to the country's development process, seriously affecting poor and vulnerable communities which comprise the majority of the population. The NAPA therefore concluded that climate variability will be significantly exacerbated by climate change in the coming decades. Contents of the earlier Chapter 5 has revealed that climate variability will remain a dominant aspect of future climate in Guinea-Bissau and the need for a proper planning anticipating frequent occurrence of extreme events such as droughts and floods. This chapter therefore addresses the current nature of vulnerability of the key economic sectors and their communities and the need for adaptation in Guinea-Bissau and highlights some prevailing gaps in adaptation that should be addressed in order to reduce the adverse impacts of climate change.

6.2 Analysis of Vulnerability to Climate Change

6.2.1 Conceptual Framework

The concept of vulnerability is an important extension of traditional risk analysis, which focused primarily on natural hazards (Turner et al., 2003[121]). This concept has also undergone a shift from research-based activities to a stakeholder-driven approach that can be anchored in the past and present (vulnerability assessments) and provide responses bearing in mind potential future scenarios. In the context of climate change, vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, people's sensitivity and their adaptive capacity (Figure 6.1).

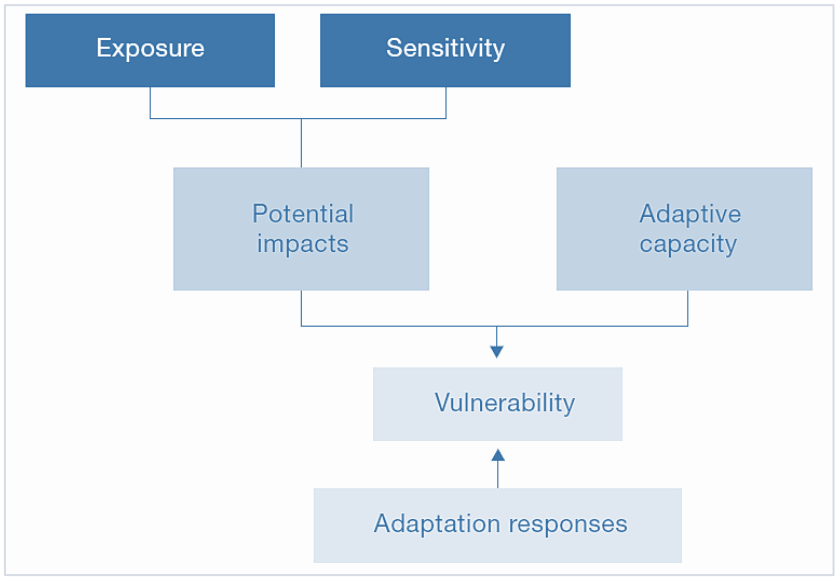


Figure 6.1 – Components of vulnerability to climate change[122].

Exposure could include geographical location, especially related to high exposure to risks (i.e., people living in the areas of natural disasters such as drought or coastal areas and river basins affected by floods). Sensitivity and adaptive capacity are context-specific and vary from country to country, from community to community, among social groups and individuals, and over time in terms of its value, but also according to its nature. A population could be considered sensitive based on their overall level of social development (i.e., a population containing people sick with malaria, HIV/AIDS, areas with rain-fed agriculture, people with higher level of poverty and food insecurity). Finally, adaptive capacity depends on access to resources that could help in responding to threats and exposures (i.e. functioning community networks, access to low-rate loans, accessible services such as health care and sanitation, irrigation systems and water storage, etc.) However, understanding vulnerability at a community level requires an integrative approach that looks at both the physical (external hazard/risk) and social dimensions (internal susceptibility/coping of different groups) of vulnerability. In addition, the drivers of vulnerability – i.e. the political economy of exposure, sensitivity and adaptive capacity – can also be different, but linked, in urban and rural settings. For example, increasing rates of rural-urban migration may result in the expansion of unregulated settlements in hazard-prone areas such as flood plains. In rural areas, a volatile global agricultural commodities market may lead to unpredictable income flows for farmers, leaving them less able to accumulate and diversify assets in order to prepare and cope for climate-related disasters. These aspects can be identified within the current Guinea-

Bissau's setting. Differences between rural and urban settings can also lead to different levels of adaptive capacity. That is, the resources needed and available to implement adaptation options may differ in each setting. For example, urban residents may have more access to economic infrastructure (roads, ports, and sewerage systems) or public services (telecommunications, health care, and electricity) than rural residents, who may rely more on the existing social networks and traditional knowledge to manage risk. Again, this diversity in adaptive capacity has been the challenge that the Government of Guinea-Bissau faces based on the limited resources available.

Vulnerability assessments were analysed with increasing accuracy using scenarios, developed from a set of 14 combinations of simulations of 4 Regional Climate Models (RCM's) conducted by 8 Global Climate Models (GCM's) based on two scenarios Representative Concentration Profile (RCP-Representative Concentration Pathways) using different assumptions for the expected evolution of emissions of greenhouse gases (i.e. optimistic scenario or Low emissions - RCP4.5, and pessimistic scenario or High emissions - RCP8 .5). The detailed assessments within priority development sectors were carried out following four major stages, namely:

1- The baseline assessment
2- The exposure assessment
3- Sensitivity and adaptive capacity assessments
4- Climate Change Impact and overall vulnerability ranking

1-The baseline assessment

The baseline assessment that took place during the TNC preparation (Stage 1) involved reviewing available scientific, socio-economic and development policies and publications, existing databases. During this stage there were consultations with local communities so to characterize the past and current situation in terms of climatic hazards and observed vulnerabilities of the selected sectors. This process also involved collecting the experience and perception of recent changes in the selected local communities and analysing existing coping practices/ strategies and their effectiveness under historical climate.

2-The exposure assessment

The assessment of climate exposure (Stage 2) of Guinea-Bissau entailed the identification of the main climate change-related hazards (e.g extreme rainfall, floods, high temperature occurrence, droughts, heat wave, increasing aridity, etc.) through an analysis of past extreme events and trends and through climate modelling and downscaling of future climate and environmental conditions against various scenarios. The study strongly benefited from the most recent developments in climate modelling research achieved through the use of IPCC's Representative Concentration Pathways (RCPs) 4.5 and 8.5. This allowed the generation of multi-model ensembles of projections and thus helping in the handling of possible uncertainties.

3-Sensitivity and adaptive assessments

Community participatory approach through field research, household surveys as well as GIS and modelling for areas such as climate, water and biodiversity were undertaken as part of the Sensitivity and adaptive assessments (Stages 3 and 5). Time constraints and limited data availability in the country, made difficult to develop future projections of sensitivity and

adaptive capacity using, for example, socio-economic scenarios. It was found that non-climatic (socio-economic) factors can strongly modify the impacts of climate change, hence implying that future vulnerability critically depends on the present adaptation processes. To overcome this limitation, it was decided to adopt the ''constant socioeconomic baseline'' approach, whereby actual development conditions are supposed to remain constant over time. This approach is considered an acceptable one by the internal climate change community when there are certain barriers to the development of socio-economic scenarios.

4-Impact and overall vulnerability ranking

By combining the results obtained from the exposure, sensitivity and adaptive capacity the impact and overall vulnerability ranking was carried out (Stages 4 and 6) leading to a comparative score for vulnerability. When quantitative information was not available, Guinea-Bissau made use of expert opinions of national and regional stakeholders, primary and secondary data as alternative sources of information. Secondary data included a review of various national climate change related documents, national climate change scenarios, national specific documents, previous national communications and other relevant sources. Finally, each component of vulnerability was ranked through expert judgment.

6.2.2 Guinea-Bissau Climate Change Exposure

Throughout the year the weather in Guinea-Bissau is mainly conditioned by the situation of the territory in relation to the ITCZ and the subsidiary actions of the semi-permanent High-Pressure cells, commonly known as anticyclone of the Azores in the Atlantic North and anticyclone of Santa Helena in the South Atlantic, and also by the summer thermal low that establishes over the Sahara Desert.

Table 6.1 – Main findings of RCPs scenarios for Guinea-Bissau.

Climate Change Projections (in 2100 horizon relative to 1961-1990)	Emissions scenario	PERIOD 2016-2045	PERIOD 2046-2075
Change in Average Temperature (°C)	RCP4.5 (low emissions)	1.3°C [0.9°C to 1.7°C] for Coastal areas	by **1.5°C** [1.0°C à 1.9°C]
	RCP8.5 scenario (high emissions)	1.5 ° C [1.0°C to 1.9°C] for Eastern Region	**2.9°C** [2.1°C à 3.6°C]
Change in Average Rainfall (mm)	RCP4.5 (low emissions)	+ 3% [2% to + 5%] National	-2% to -5% in the north Cacheu region
	RCP8.5 scenario (high emissions)	+ 5% and + 10% for Bijagós & Tombali	+5% to +10% in the southern regions
Change in Mean Sea Level (m)		6.5 cm by 2020	to 20 cm in 2050

Rainfall varies across the country from South: (Tombali, Quinara e Bolama-Bijagós Region >2000 mm / year) to Northwest Regions of Bissau (Biombo, Cacheu e Oio: 1400-1800 mm / year) and Eastern regions of Bafatá (and Gabú: 1300-1500 mm / year). About 80% of annual rainfall occurs during the months of July, August and September. During monsoon seasons precipitation can be intense, with 300mm per month recorded in August. The least amount close to zero (0.1 mm) occurs during the months of December to April (dry season).

Temperature in Guinea-Bissau is less variable than rainfall and monthly average temperature varies between 24°C and 30°C. Over the course of a year, the daily temperature typically varies from 18°C to 35°C and is rarely below 17°C or above 37°C. The country is exposed to a hot and humid air from the Atlantic Ocean when under the influence of the monsoon rainy season. By contrast a hot and dry air from the Sahara invades the country during the Harmattan dry season. These historical records are the current conditions at which Guinea-Bissau is exposed. The conditions that the country will experience in the future are reflected in the projections developed in Chapter 5 which provides a quantitative basis for estimating the likelihoods of many aspects of climate change that may impact on the country's economy sectors. A summary of the major findings of the study carried out of climate projection in Guinea-Bissau is shown in Table 1 above.

In summary, the results of the study indicate that the country is currently facing a threatening Sea Lever Rise with intense enhancement of coastal erosion and saline water intrusion as well as a considerable climate variability both in terms of temperature with clear trends for increase in the future and variable precipitation patterns complemented by extreme rainfall events. Authorities are already aware and concerned that even small long-term variations in temperature and precipitation could cause adverse effects on the country's key economic sectors owing to the fragility of the local ecosystems and communities' extreme poverty and low adaptive capacity as well as the regional and global economic dependency and climatic interconnectivity. Guinea-Bissau is a country in the process of development and as seen above extremely exposed to current and future potential climate variability. Indeed, Guinea-Bissau is vulnerable to various types of disasters, namely: tropical storms, floods, locust attacks, droughts, coastal erosion, fires, etc. For example, climate change induced event between 1987 and 2009, affected 132 000 people through droughts, 57 792 through floods and tropical cyclones caused 2 712 casualties[123]. As for epidemics, they affected 105 380 people, causing 3 032 deaths, while man-made accidents led to 7 000 casualties (OFDA/CRED)[124].

Due to the nature and pattern of climate exposure in Guinea-Bissau with distinct regional variation, Vulnerability was also assessed taking into account that vulnerability can vary considerably between regions within the country and therefore it was imperative to identify the main sectors and drivers of the vulnerability at country level which are described in the next Section. Results from participatory assessment on the degree of vulnerability of the main economy sectors carried out by the Vulnerability and Adaptation Multi-Stakeholder Task Team in the context of the TNC have overwhelmingly selected six key sectors that are important to Guinea-Bissau's economy and development, yet at risk of negative impacts of climate change. These six sectors are Agriculture & Livestock, Energy, Forestry, Biodiversity, Water Resources, and Fisheries.

6.3 Vulnerability and Adaptation of Key Sectors

6.3.1 Vulnerability of Agriculture & Livestock Sectors

The vulnerability analysis was based on the variation of climatic parameters (P, T, SLR) in the subsector of agriculture and livestock sub-sector for the three types of ecosystem under consideration (mangrove, bas-fond and plateau) and cultivated soils. The main impacts of climate change in the Agro-livestock sector range from: erratic rainfall in terms of intensity and onset/end of season, temperature increase, mean sea level rise, which unfold in adverse effects and sensitivities. The agricultural sector is the backbone of Guinea-Bissau's economy, and a source of earnings for 85% of the population. Agriculture also plays an important role in the country's external accounts, accounting for over 98% of total exports of goods[125], the major activities being of cashew nuts production and export and rice cropping coupled with extensive livestock. Cashew nuts represent over 90 percent of total exports and about 17 percent of government revenue, hence the vulnerability of the economy to cyclical fluctuations in the market price of cashews as well as climate variability impact.

Agriculture is developed in the country by two main categories of producers:

- Smallholders villages (tabancas), estimated at about 90 000, essentially made up by the rural population and account for about 90% of production; and
- Pointers (i.e."concessions" existing 2200 in total and of which only 1200 are actually producing), usually called modern farmers who have significant land concessions (with an average size of 136 ha, ranging from 20 to 3000 ha) provided by the state, covering 27% of the land arable (i.e. 9% of the total area of the country) and occupy the best agricultural land.

6.3.1.1 Climate Change Drivers, Adverse Effects and Sensitivity in the Agriculture Sector

The Agriculture sector is essentially dominated by two crops: Rice cultivated in different Agriculture systems and cashew nut. Rice in Guinea Bissau occupies a very important place in the agricultural and national economy of the country. Traditionally rice is the main staple food for Guinea-Bissau, accounting for 37% of the value of food consumption and about 40% of daily calorific intake of the average household. According to the International Rice Research Institute (IRRI), Guinea Bissau's rice consumption per person per year was estimated at 87.3 kg in 1999. With a population in 2015 estimated at 1.6 million and, using current rice at the time consumption rates per person per year, the country would require 139,680 tons of milled rice annually equivalent to about 235 000 tons of paddy to reach national rice self-sufficiency [126]. Rice is cultivated in different production systems (ecosystems) in Guinea Bissau from the traditional slash and burn system of *upland rice* production is practiced in all agro-ecological zones, the *lowland (bas-fond) or inland valley rice* production system which predominates in the Eastern agro-ecological zone, to the *Mangrove Swamp Rice* which is the most extensive system of rice cultivation in Guinea Bissau and is widely practiced in coastal regions.

<u>Extreme rainfall events</u>

Agriculture in Guinea-Bissau still relies heavily on rainwater as irrigation is still not widely practiced. Lately, the agriculture sector has been impacted by climate change related events: Rainfall in the country has declined in the last twenty years and this is mainly felt during the months of June and October, which results in water shortages, which impact is also felt in

rice production particularly in small upland valleys and in other cereals on different grounds. According to local climatic pattern the rain events are increasingly being accompanied by strong winds and intense rainfall bursts, especially during the months of July, August and September, leading to floods which affects the productivity of different crops including rice fields ("bolanhas") and cereal through waterlogging phenomena decimating small plants due to root rot and death at the stage of germination. Waterlogging (flooded/ponded/saturated soils) affects a number of biological and chemical processes in plants and soils that can impact crop growth in both the short and long term. The primary result of waterlogging in crop plants is oxygen deprivation or anoxia as excess water itself does not react chemically with the plant. Waterlogged conditions also reduce root growth and can predispose the plant to root rot[127].

Rising mean sea level has led to frequent events of coastal flooding which invariably results in significant losses in production in the lowlands (bas-fond) and in swamp rice fields implanted in soils of colonized mangrove practiced in coastal regions (Figure 6.2). Rice paddies in this production system are established by building anti-salt dykes along the banks and parallel to the estuaries with sluice gates. These anti-salt dykes prevent salt water intrusion into the rice fields and retain fresh water from rain necessary for the process of rice growth[128]. In recent times, with rising mean sea level there has been excessive salt water invasion in the mangrove swamp rice fields due to high and strong tides, the consequences of which has been the destruction of anti-salt dykes that prevents salt water intrusion into the rice fields and retain fresh water from rain necessary for the process of rice growth leading to substantial loss of productive capacity of rice crops and salinization soils[129].

Figure 6.2– Rice paddy fields in the *Mangrove Swamp Rice* production ecosystem along the along the two major coastal rivers, the Mansoa River (pictured) and the Geba River[9].

[9] NASA image created by Jesse Allen, using Landsat data provided by the United States Geological Survey. December 2, 2006.

Rising mean sea level and declining rainfall

In low rainfall areas of the north of the country, rising mean sea level land decreasing rainfall amounts lead to the excessive saline soils bordering the rivers, where rice fields are located in (associated mangrove swamps) and have to be impoldered to prevent incursion of saline water during the cropping season. Rice farming in these areas of the country are increasingly vulnerable to this climate induced events. The rice in the polders is nearly always planted on ridges. The ridges play important part in water control and leaching Salt and acids from the soils. In the high rainfall environments most of the mangrove swamp rice are cropped in the tidally flooded areas where impoldering and ridging are not required. However, in the wetter zones, salinity downstream along some rivers is high enough to warrant impoldering during cropping season[130].

Future projections of sensitivity and climate change drivers were developed using socio-economic scenarios and are shown for the four natural Agriculture Ecosystems namely the Mangrove ecosystem, the Bas-Fond Ecosystem (freshwater), the Plateau Ecosystem and the Backyard Farming Ecosystem (Table 6.2).

Table 6.2 – **Driver 1:** Simultaneous increase in temperature and rainfall

Ecosystems	Climate Change Impacts and sensitivity on the Agriculture Sector
Mangrove ecosystem	• Flooding events in "bolanhas" with destruction of boundary dikes; • Salinization / acidification phenomena through marine waters intrusion; • Sea erosion phenomena with siltation of the "bolanhas"; • Depleted soils with high acidification and low organic matter content; • Low soil productivity and lower agricultural yields, mainly cereals, the food base of the population.
Bas-Fonds Ecosystem (freshwater)	• Salinization / acidification phenomena in transition bas-fond (coastal) "bolanhas", but to a lesser extent in relation to mangrove soils; • Low soil productivity and lower agricultural yields, mainly cereals, the food base of the population.
Plateau Ecosystem	• Sudden onset and rapid propagation of wild fires, given the existence of a dry biomass substrate; • Soil erosion phenomena in naked soils under intense rainfall; • Landslides events and destruction of arable top soil horizon. • This ecosystem is probably the most vulnerable given the impossibility of reconstruction of arable land and soil organic matter content.
Backyard Farming Ecosystem	• Although the agriculture practiced in this ecosystem is of small scale, the simultaneous increase of the precipitation and the temperature causes negative impacts. In particular: • The increase in temperature stimulates the appearance of pests (grasshoppers) harmful to crops. • Increased precipitation induces seed rot during the germination phase. • In this situation, wherever this occurs, invariably leads to a food deficit in the backyard ecosystem.

Table 6.3 – **Driver 2:** Simultaneous decrease in temperature and rainfall

Ecosystems	Climate Change Impacts on the Agriculture Sector
Mangrove ecosystem	• Difficulty in plant fecundation (pollen sterilisation) and crop growth; • Low productivity and lower agricultural yields, mainly cereals, which are the staple food of the great majority of the population. • Food insecurity and episodes of hunger, which contributes to rural exodus, malnutrition, diseases; • Constant acidity of the mangrove soils making farming difficult in these "bolanhas".
Bas-Fonds Ecosystem (freshwater)	• The impact on this ecosystem is similar to that of the mangrove, lack of water that negatively influences the maturation of plants; • Low productivity and low income in the agricultural sector, malnutrition, etc
Plateau Ecosystem	• This ecosystem also suffers the same general impacts of the mangrove and bas-fond ecosystems. • Lack of water, with crop water deficit developing and negatively impacting productivity; • However, it is notorious the crop diversification carried out by farmers with crops requiring more water and that drought tolerant to overcome the difficulty of accessing food and avoid hunger.
Backyard Farming Ecosystem	• When this phenomenon occurs, water is the limiting factor hindering the normal crop growth translating in crop failure or productivity reduction.

Driver 3: Sea Level Rise (SLR)

The adverse effects on SLR is more striking in the mangrove ecosystem with the suffering from constant flooding and salt water intrusion particularly those bordering the coastal line, consequently leading to salinization and acidification phenomena. This situation makes these "bolanhas" to be poor in organic matter, eventually leading to their abandonment.

6.3.1.2 Climate Change Drivers, Adverse Effects and Sensitivity in the Livestock Sector

Driver 1: Increased temperature

Temperature increase invariably translates into widespread lack of water for pasture. The main consequences for the sector are:

- Decrease pasture areas and drying of watering points resulting in malnutrition and increased livestock mortality;
- Decrease in animals' body weight and fertility;
- Severe decrease in milk and meat production jeopardising food security of the population;

- Encouragement to transhumance in search of better pasture conditions, which can lead to social conflict between pastoralists and farmers;
- Increase multiplication vectors agents and increase of parasitic diseases in animals which can lead to their death.

Driver 2: Increased rainfall

Conditions where there is an anomalous increase in rainfall the livestock sector is impacted with:

- Loss of pasture areas arising from the flooding and riverbank flooding;
- Spontaneous increase in harmful weeds causing diarrheal diseases;
- Increase in respiratory diseases resulting from excess moisture in the stables and barns.

Driver 3: Decreased rainfall

The main impact of the reduction in rainfall is clearly the widespread increase in the transhumance phenomenon with animals being moved across large distance in search for better pasture conditions and a significant rise in social unrest and competition between the pastoralist and farming communities (Figure 6.3).

Figure 6.3 – Livestock being moved across large distance in search for better pasture conditions significant rise in social unrest and competition between the pastoralist and farming communities.

6.3.1.3 Adaptation of Agriculture & Livestock Sectors

Key Adaptation measures in the Agriculture Sector

Ecosystems	Climate Change Adaptation Measures of Agriculture Sector
Mangrove ecosystem	• Construction of micro dams and small dams for water retention • Enhance mangrove planting • Implement no take zones for mangrove management
Bas-Fonds Ecosystem (freshwater)	• Construction of micro dams and small dams for water retention • To improve current water management in small valleys; • Support small scale mechanization of agriculture particularly rice farming; • Support the development of small scale irrigation systems; • Provide incentives to farmers to farm in the basin of the Geba River.
Plateau Ecosystem	• Popularize new varieties adaptable to the environmental stresses, in particular seed varieties with shorter cycle, more productive and resistant to drought; • Improve the genetic material of vegetable and cashew trees and palm groves; • Develop and implement programs for water management that encompasses construction of micro dams, reservoirs and promotion of small irrigation systems; • Improve techniques and agricultural practices in order to intensify and diversify production; • Strengthen the research and dissemination of results;
Backyard Farming Ecosystem	• Develop and implement programs for water management namely increasing storage capacity at local level with construction of micro dams, reservoirs and promotion of small irrigation systems; • Improve techniques and agricultural practices in order to intensify and diversify production;

Key Adaptation measures in the Livestock Sector

- Develop a Master Plan for Livestock Management
- Encourage the breeding of short cycle species;
- Improve the system of management, biological capacity, creating conditions for safe production and improve the organization of producers;
- Promote the program for genetic improvement of traditional diets;
- Promote the training, information and awareness in the livestock sector;
- Support the creation of transhumance corridors;
- Support for intensive production of livestock;
- Develop actions for the protection of animal health and the improvement of animal feed;
- Develop small programs and projects that contribute to preserving genetic heritage through the implementation of characteristics which may provide better adaptability.

6.3.2 Vulnerability of the Energy Sector

The Energy sector in Guinea-Bissau is mainly driven by three different sources: biomass (90%), oil products (8%) and electricity (2%)[131]. Energy consumption in Guinea-Bissau is the lowest in the world with only 0.3 toe / person / year and this mainly based on oil products electricity. Only 40% of the population in the capital Bissau has access to electricity, while in the country as a whole, this proportion is 20%. Consequently, there is a strong dependence of these section of the population and services on energy imports (mainly petroleum products). However, the rest of the country's population strongly relies on biomass energy resources which includes wood, coal and agricultural/forest products. Climate change impacts on the energy sector will undoubtedly affect primarily the biomass energy component which the population uses as wood logs and production of charcoal needed for domestic consumption.

Guinea-Bissau's forest area was empirically assessed in 1999/2000 to be between 1.5 and 1.65 million hectares or 44% of the national territory, compared with 70% a fourteen years ago. The estimates made in 1990 for the preparation of the Guinea-Bissau Forest Action Plan and the various compilations (Atlanta Consult, 1986 and Cirad, 1990), provided an assessment of the forest area of about 2 284 000 hectares, 63% of the country's surface. Wood fuels account for around 95% of national energy consumption; 90% in the raw state in the form of firewood and 5% in the transformed state as coal. Country needs generate a flow of more than 1.2 million m^3 / year, accounting for more than 80% of the total value of forest production, which represents a daily consumption of about 1.7 to 2 kg of firewood per inhabitant. Indeed, in the countryside, firewood is by far the dominant fuel with a demand that probably exceeds 550 000 tons per year. Next comes the widely used fuel coal in the country's large cities (Bissau, Bafata, Gabu, etc.), which represents an important consumption of firewood estimated at 137 000 tons per year. Fossil fuels; oil LPG and butane gas, are of little used for cooking. LPG oil and diesel are mainly used in lighting.

6.3.2.1 Specific Vulnerability of the Energy Sector

Energy consumption in Guinea-Bissau is characterized by total dependence on petroleum-derived fuels imported to meet the needs of the transport, industrial, and lighting sectors. Only 19 percent of the population of Guinea-Bissau has access to electricity. The electricity grid in Guinea-Bissau is limited to the capital, Bissau, yet 75 percent of the population lives outside Bissau. Total electricity supply costs are exorbitant as EAGB is fully dependent on high cost imported liquid fuel, and technical and commercial losses are about 47 percent. Electricidade e Aguas da Guine-Bissau (EAGB) is the state-owned electricity utility providing services. The Ministry of Energy and Industry is responsible for oversight of EAGB. Despite high average tariffs of US$0.40 per kWh, EAGB is not able to recover costs making expenditure on maintenance difficult. Generation capacity is currently 11 MW (down from 25 MW in 2000), of which only 5.5 MW is available. The new government has made considerable efforts to increase the available capacity. Peak demand was estimated to be 58 MW in 2013[132].

The domestic energy consumption majority for the population depends primarily on firewood used as household fuel to meet the energy needs for cooking, traditional village activities, commercial and craft activities. That is, firewood constitutes and will be for a long time to come the main fuel for most families who cannot afford more modern fuels (butane

gas or electricity) given the high financial cost. Therefore, forest logging will be the prime source of domestic energy consumption. This vulnerable situation driven by poverty and low financial capacity of the Guinea-Bissau population becomes a stressor on the forest cover as the irrational use of woody resources for energy in Guinea-Bissau is a growing problem, especially in rural areas as there are no immediate alternative solutions leading to desertification threats in various parts of the country.

Finally, the vulnerability of the country in this sector is also driven by the weak institutional capacity of line ministries and departments overseeing the energy sector that are unable to put forward better energy policies nor are they able to carry out effective enforcement of already enacted laws to protect the forest or the rational use of the natural resources. Therefore, there is a clear need for strengthening these institutions not only with financial and logistic means to operate as they also require further training and capacity development.

6.3.2.2 Climate Change Drivers, Adverse Effects and Sensitivity in the Energy Sector

Fuelwood supplies about 90 per cent of the energy consumed in Guinea- Bissau. The country has about 2 million ha of forest. The yearly consumption of wood for energy is about 1.29 per cent of the available biomass resource, which is about 48.3 million m3 translating into a deforestation rate of 30 000 to 60 000 ha/year (AfDB, 2015[133]). Charcoal production doubled from 21 ktoe in 2010 to 50 ktoe in 2015 (AFREC, 2015).

This situation is compounded by climate change impacts caused by rising temperatures, the lack or irregularity of rains and rising sea levels can negatively impact the source and origin of the woody / forest energies. Thus, the resulting adverse effects include: biomass scarcity, greenhouse gas emissions and deforestation, loss of biodiversity, and poor reproductive capacity of some fauna and floristic species. Future projections of sensitivity and climate change drivers were developed using socio-economic scenarios (Table 6.4).

Table 6.4 – Future projections of sensitivity and climate change drivers were developed using socio-economic scenarios.

Energy type	Climate Change Drivers	Adverse Effects	Sensitivity
Woody Energy	• Temperature increase; • Irregularity of rainfall; • Droughts • Sea Level Rise	• Biomass scarcity, • Deforestation • Greenhouse gas emissions • Loss of biodiversity, • Poor reproductive capacity of some fauna and floristic species.	• Soil degradation caused by drought, pollution and erosion; • Raising the poverty level • Increased demand for Biomass; • Forced migration; • Land conflicts; • Food insecurity; • Loss of Biodiversity
Oil-Based Energy	• Poverty	• Pollution and greenhouse gas emissions; • Financial burden	• Acid rain Contamination of soil and sea; • Pulmonary diseases; • Acid rain.

6.3.2.3 Adaptation in the Energy Sector

The Ministry of Energy and Industry is in charge of both implementing policies in the energy sector as well as the regulatory process. The National Electricity and Water Corporation (EAGB) manages the electricity sector in Guinea Bissau. On a regional level, the country is a member of the West African Power Pool. One of the adaptation measures in the Energy Sector is the participation in The Gambia River Basin Development Organization Energy Project (OMVG Energy Project) involving the following four countries: Gambia, Guinea, Guinea-Bissau and Senegal. This sub-regional organization is the executing agency for integrated development programmes in the region and focuses particularly on the rational management of the joint resources of Rivers Gambia, Kayanga-Géba and Koliba-Corubal, whose basins have power-generating potential.

The 1 677 km-long interconnection line crosses the four OMVG countries: Guinea, Senegal, Gambia and Guinea-Bissau. The interconnection will supply the four-member countries with power generated by Sambangalou and Kaleta facilities and other power plants in the OMVG/ECOWAS zones. The population of the interconnection study area is estimated at 3 347 303 inhabitants, shared between Guinea (1 850 078 inhab.), Senegal (989 187 inhab.), Gambia (308 906 inhab.) and Guinea-Bissau (199 132 inhab.). Most of the project-affected persons live in rural areas on agricultural, livestock and handicraft production (AfDB, 2015). The power transmission line will pass through three provinces in Guinea-Bissau, namely the Northern, Eastern and Southern Provinces. In the provinces, the project will affect Oio, Bafatá and Tombali Regions respectively. More specifically, in each of these regions, the transmission line will cross the sectors shown in the table below (Table 6.5).

Table 6.5 - The provinces, Regions and Sectors affected by OMVG Energy Project in Guinea-Bissau

PROVINCE	REGION	SECTOR
NORTH	Oio	Farim
		Bissora
		Mansaba
		Mansoa
		Nhacra
EAST	Bafatá	Bambadinca
		Xitole
SOUTH	Tombali	Quebo
BISSAU	Bissau	Bissau

Source: Administrative Map of Guinea-Bissau

The OMVG interconnection represents a critical infrastructure for Guinea-Bissau to access competitively priced and clean base load generation. The OMVG interconnection contributes to the government of Guinea-Bissau's 2010 energy strategy. The strategy prioritizes increasing the capacity of electricity generation, and specifically highlights the OMVG interconnection as a medium-term priority to access lower cost electricity (access to lower cost base load capacity against an available supply of 5.5 MW)[134]. At commissioning of the OMVG interconnection, Guinea-Bissau will be able to import 28 MW[135] of capacity which will help to close the supply demand gap and substantially reduce the cost of generation. Access to imports via the interconnection is estimated to reduce cost of supply in Guinea-Bissau by

30-50 percent. The OMVG interconnection will also provide backbone infrastructure that will enable electrifying other parts of the country beyond Bissau. In addition, the OMVG interconnection will enable the development of domestic hydropower resources including the 20MW Saltinho Hydropower plant (Figure 6.4).

The pre-construction and construction activities of the Sambangalou hydroelectric plant are expected to last four years, with the filling and commissioning scheduled for 2017 and end-2018 respectively. Guinea Bissau's institutional arrangements on expropriation fall under the responsibility of the Ministry of Social Equipment. This Ministry is supported by the Ministry for the Interior, the Ministry of Environment, the Ministry of Agriculture, Forestry and Livestock, and the Ministry of Natural Resources and Energy (MNRE). Other State or non-State actors may be mobilized as required.

Figure 6. 4- Potential location (blue circle in the map on the left) of the Saltinho Dam construction in Corubal River (blue arrow showing the real image of the location in the River) in Bafatá Region of Guinea-Bissau[136].

Surface water resources in Guinea-Bissau are characterized by the existence of 2 major transboundary freshwater rivers shared with neighbouring countries, namely: Kayanga / Geba - covering an area of 14,900 km2 of which 10 thousand km2 in the territory of Guinea Bissau, 4,400 km2 in Senegal and 500 km2 in Guiné-Conacry and 335 km long, and Koliba / Corubal (with an area of 26 000 km2 of which 8 800 km2 in Guinea-Bissau, 17 200 km2 in Guiné-Conacry) and 384 000 km in length. Only the river basins of these two rivers have been subject to in-depth studies (several measurements) that allow quantitative and qualitative evaluation of these resources.

To date, river basin management in these rivers has been integrated, coordinated and concerted, through Action Plans based on Integrated Management of Water Resources (PAGIRA) within the framework of the Gambia River Basin Development Organization Energy Project. The Corubal River, with an average annual volume of 130 000 million m3 and significant drought flows (11 m3 / s on average), is the most important surface water resource in the country and has great hydroelectric potential. The physical characteristics of this river are quite favourable from the energy point of view, ie the great value of its annual average flow is about 425 m3 / s. Thus, it was proposed to build a 295 million m3 dam in Saltinho - located about 170 km from Bissau, near Xitole, on the road connecting Bissau to

Quebo- for the production of electricity. Studies carried out provide the indicators presented in Table 6.6.

Table 6.6 - Performance indicators of Saltinho Dam in Guinea-Bissau

Location	Given Flow (m^3/s)	Installed Power (MW)	Average Supply of Energy (GWh)	Maximum Supply of Energy (GWh)	Minimum Annual Energy (GWh)	Available Storage (hm^3)	Usable storage (hm^3)	Lower level at the source (m)	Upper Level at the source (m)
Saltinho	250	20	88,2	23,7	81,6	122	119	32,6	36

Presently the source of electricity production in the country is largely of thermal origin and minimally based on new and renewable energy (solar PV and biofuels). Despite the fact that global average electrification rate of the country is about 12%, Guinea-Bissau was, is and remains one of the countries facing the greatest need of access to modern forms of energy in Africa. In this sector an increase in electric power capacity of at least 90 MW 2020 using petroleum products (diesel and heavy fuel oil) is planned. However, in Guinea-Bissau, there is a strong dependence of communities in the rural environment to use the existing natural resources. Still, there are few alternative technologies that enable natural resources to be used rationally by these communities. Examples of alternative techniques of rational management of resources being vulgarized in the tabancas is the introduction of improved furnaces allowing only few quantities of firewood to be used reducing the quantities of wood to be cut. Following this approach and as part of a wider agricultural development project, ADPP Guinea-Bissau[137] is now implementing a firewood-saving cook stove initiative for women in Empada thanks to the GEF Small Grants Program, administered by the UNDP. The initiative is to train 80 women in the construction of firewood-saving cook stoves (Figure 6.5) and start the scaling up process.

Figure 6.5 – Local built firewood-saving cook stoves under GEF Small Grants Program.

The model used is a small portable version. The 80 women are trained to make these stoves themselves and the health and environmental benefits of using them are shared with the wider community. Although still being used as a primary fuel, the 20 kg of wood necessary per day to meet a family's need will be reduced with up to 70% (Table 6.7)

Table 6.7 - Performance indicators of firewood-saving cook stoves.

Activity	Traditional Cook Stove	Firewood-saving Cook Stove
Time collecting firewood	2-3 hours twice per day	2-3 hours twice per week
Quantity	50 pieces per day	15 pieces per day
Firewood used in stove	9-11 pieces per meal	3 pieces per meal
Time to cook 2kg of rice	3 hours	1 hour

Regrettably, the initial investment to implement a renewable energy programme in the sector is significant. However, the country's energy strategy pursues to increase reliance on local energy sources, by placing more emphasis on the utilization of renewable energies to gradually lessen the dependency on the traditional energy sources, especially oil importation. In this regard, the Government authorities have been promoting solar photovoltaic power plants the first of which a 314kW plant installed at Banbadinga Sector (Banbandinga castaclaro) to produce electricity. In addition, there are other pilot projects for energy cogeneration based on the use of cashew shells, whose energy sources or resources are abundant in the country. Finally, the use of biogas (from cow dung) is being also tested through a UNDP-supported Global Environment Facility-funded project in Gabú in the eastern province to build more resilience for smallholder ranchers and farmers in the region. The biogas generators not only lower carbon footprints and increase the ante to Guinea-Bissau's Nationally Determined Contribution, but they also provide valuable cooking energy that local people can use to cook meals, feed their families and light for the school and homes.

6.3.3 Vulnerability of the Forest Sector

For Guinea-Bissau the Forest is not only a reserve of arable land, it is also a pastoral area and critical area for collecting and hunting. So far, the Guinea-Bissau forest has been supported by a number of economic activities, including subsistence-oriented economies. This ancient practice, where the forest is the potential space for new areas of itinerant cultivation and pasture, is precisely considered as the main impact of degradation of forest stands in Guinea-Bissau (Forest Master Plan, 1992). Thus, through the years significant areas have been devastated by anthropic action (man) and climate change induced erratic rainfall patterns.

6.3.3.1 Main Drivers of forest degradation in Guinea-Bissau

Guinea-Bissau is a country rich in biodiversity. However, in recent years, driven not only by natural factors but above all by anthropogenic activities, its terrestrial ecosystems, especially forests, have been suffering from high levels of degradation, habitat fragmentation, soil erosion, reduction of available water resources, loss of ecosystem services and rapid decline in biodiversity, among others (Biai Justino, 2014[138]). Among the anthropic factors that contribute to the degradation of the vegetal cover, stand out among others, the i) traditional agricultural practices "itinerant agriculture"; ii) unrestrained extension of the area occupied by cashew monoculture; (iii) exploitation of woody materials for the construction and production of household energy through firewood and charcoal; (iv) Mangrove cutting; (v) anarchic exploitation of industrial wood; (vi) wild fires (illegal hunting, honey harvesting, deliberate setting of fires to catch wild animals and uncontrolled fires, etc.); (vii) mining sector (emerging); (viii) irrational exploitation of resources, etc. (Biai Justino, 2014). This

whole cluster of threats is also a direct menace to the survival of the majority of the rural population of Guinea-Bissau, whose survival is inextricably linked to the quality of ecosystems (Table 6.8).

Table 6.8 - Anthropogenic and Climate Change Drivers and Future projections of impacts and Forest Sector sensitivity developed using socio-economic scenarios.

Anthropogenic Drivers	Climate Change Drivers	Adverse Effects	Sensitivity
• Traditional agricultural practices "itinerant agriculture"; • Unrestrained extension of the area occupied by cashew monoculture; • Exploitation of woody materials for the construction and production of household energy through firewood and charcoal; • Anarchic exploitation of industrial wood; • Wild fires (illegal hunting, honey harvesting, deliberate setting of fires to catch wild animals and uncontrolled fires, etc.); • Mining sector (emerging); • Irrational exploitation of resources,	• Rising Temperatures . • Irregularity and reduced rainfall. • Droughts episodes. • Sea Level Rise	• CO2 release; • Destruction of habitat; • Enhancement of erosive process; • Elimination of micro-organisms; • Enhancement of desertification process; • Increased temperatures; • Decrease or increase in rainfall; • Increased epidemics; • Penetration of strong and violent winds; • Erosion and leaching of soils; • Disappearance of the woody species of human consumption.	• Increase in GHG; • Loss of biodiversity, natural resources and essential nutrients for the forest; • Decreased forest mass yield; • Increased hunger and forest loss; • Decrease of evapotranspiration, increase of vectors of epidemics; • Low yield in forest production; • Destruction of forests; • Decreased organic matter and soil impoverishment; • Decreased forest resources and ecosystem services; • Food insecurity.

The disconcerting marketing campaign for cashew nuts in the last two years, caused by the socio-political upheaval and negative influences on climate change, had very sharp negative effects on deforestation. As a result of this situation, there was an increase in demand for rainfed rice production done at the expense of large-scale deforestation of forest areas.

Traditional agriculture and the expansion of cashew monoculture

The rapid demographic growth of 2.4% per year (INE, 2010[139]), due to the high birth rate, reinforced by a runaway migration, associated to a decrease in the productivity of "bolanhas" (reduction and irregularity of rainfall and increasing salinization and acidification), increasingly involve the clearing of forests for shifting agriculture and, more recently, the setting up of private and family orchards. Deforestation and the use of fire in the preparation of crop fields for "subsistence" agriculture and the emergence of new "tabancas" (i.e. human settlements), associated with the emergence of new agricultural concessions, commonly known as "pontas", are the main environmental and land degradation factors in the country. In addition, deforestation of the higher topography areas for agricultural purposes has

contributed to the leaching of the soils and allows the transport by rainwater, organic matter and soil particles to the lower parts, silting up the river beds.

Exploitation of woody materials for the construction and production of household energy through firewood and charcoal

Due to its efficiency, the charcoal tree (Proposis africana) is considered to be the most appropriate forest species for the production of firewood and charcoal. This tree integrates a good crystallization capacity reflected in a slow combustion and low consumption, reason why it has undergone great pressures, being almost already in the way of extinction. For its replacement, the community uses other species such as Pau Sangue (Pterocarpus erinaceus), farroba (Dialium guineense), incense stick (Daniella oliveri), Bissilão (Khaya senegalensis), Mancone (Erithrophleum guineense, Mangueiro (Mangifera indica), Cajueiro (Anacardium occidentale) and mangroves (Avicennia and Rhizophora spp.) These species exhibit a rapid combustion as coal, reducing to ashes in much less time than in the case of charcoal, thus increasing the demand for these products (Biai Justino, 2014). Under these circumstances, woody material is obtained through (i) deliberate cutting of trees or mangroves, (ii) ringing i.e. annular incision in the trunks, and (iii) intentional burning, by means of fires placed around the base of the stems, burned for shifting agriculture, to obtain raw material for this extractive process, (Biai Justino, 2014). It is estimated that between 50 000 and 80 000 ha of forests in Guinea-Bissau are annually degraded by fires of different origins, such as those caused by roving crops, those used in the expansion of pastureland and the regeneration of "lalas", the hunting with the aid of fire, as well as the burnings by various origin (honey harvesting, carelessness, etc.), (BIAI, Justin, 2014).

Mangrove cutting

Mangrove destruction and deforestation are spreading in the country as people migrate towards the coastal locations attempting to obtain cultivable land, areas for development and fuelwood. The negative consequence is that thinning the mangrove barriers river waters flow faster over turbidity of both lagoon and river waters increase, flood events become more violent, and the low-water periods more severe. This clearing of mangrove stands leads to an increase of ground albedo giving rise to great losses of radiation and the subsidence of the lower atmospheric layers. Humidity equilibration is altered, and rainfall lessens. All of these processes and changes operate in favour of greater environmental variability, which is unfavourable to the long food chains that produce higher-value species. The shrinking of flood-prone areas also represents a loss of the habitat propitious to nursery-grounds[140].

6.3.3.2 Adaptation in the Forest Sector

On average, 60 000 hectares of land are cleared and/or burned every year in Guinea-Bissau, and the vast majority of the population still cooks on firewood and charcoal. The disappearance of the forest and mangroves, and the impact on sequestration of the GHGs produced through fires and smoke form charcoal and wood as household energy may probably lead to serious atmospheric consequences. For the moment, that impact of these practices may be residual, but within few years, if no measures are taken, the consequences could be dire.

Challenges of the Forest Sector

According to the Guinea-Bissau Forest Plan, several problematic actions of forest degradation have been identified in order to face the challenges of the strong pressure exerted on the ecosystem:

- Reduce uncontrolled and excessive clearing and the effect of forest fires on the vegetation cover;
- Protect forest ecosystems, taking into account their importance in preserving biodiversity and especially in water balance and river protection, of silting;
- Redefining forest concessions with the premise of better targeting logging in order to reduce negative impacts;
- Support and stimulate the creation of community forest reserves as a way to preserve and recover degraded forests and involve populations in the sustainable management of forest resources;
- Organize grazing and transhumance corridors to reduce negative impact on natural vegetation cover;
- Reduce the effects of shifting agriculture and the uncontrolled expansion of cashew plantations to the detriment of vegetation cover;
- Reduce the pressure on "cibe" and develop concrete plan of action on the planting and maintenance of natural regeneration.

Adaptation Measures

Examples of adaptation measures being pursued by the Government through the various Ministries and Civil Society Actors that can increase the adaptive capacity and resilient of natural ecosystems and also strengthen the resilience of local economies are shown below:

- Update and / or carry out new forest inventories;
- Expand National Protected Areas systems, covering more fragile and important ecosystems;
- Elaboration of a national list of species to be protected, taking into account their vulnerability;
- Review the Forest Law and improve regulations;
- Develop maps and carry out forests classification;
- Provision technical and material resources to the Directorate General of Environment and Forests and Wildlife for follow-up and monitoring actions;
- Carry out an inventory good practices, and local conservation initiatives in the different traditional communities and scale them up to other regions;
- Enhance South - South cooperation to strengthen national adaptation capacities;
- Elaborate Contingency and Strategic Plans for Forest Resources Management;
- Involve defence and security forces in reforestation and afforestation actions as a way to recover forest patrimony;
- Ensure Guinea-Bissau's participation in REDD + (carbon market);
- Develop programs to strengthen technical capacities and training for foresters;
- Develop and implement policies for shared management of forest resources;
- Implementation of an integrated approach to forest production in the processing sector;
- Carry out training and sensitization of actors and decision-makers on the management of forest resources in the country;
- Promote agroforestry techniques in already deforested lands;
- Produce vulnerability maps for extreme events;

6.3.4 Vulnerability of the Biodiversity Sector

There is now a growing degradation of biodiversity resources in the world in general and in West Africa in particular, mainly due to the abuse and destruction of vulnerable ecosystems. Guinea-Bissau is not an exception; however, the country plays an important role in the preservation of species of high ecological and heritage value at the national, sub regional and global levels. Indeed, the diversity of their ecosystems, which generally are in a still relatively preserved state, is a factor that contributes considerably to the survival of a large number of species considered as threatened and / or patrimonial.

The country is at the confluence of different ecosystems: open forest, dense forest, gallery forest, savannah, and mangrove. According to the preliminary data of the CARBOVEG-GB project, it is observed that between 1990 and 2007 the rate of deforestation of the open forest stand have been more noticeable and around 27,735 ha / year, contrary to the dense forest, which has recovered its growth in 651.70 ha / year (Table 6.9).

Table 6.9 - Evolution of the areas of the different ecosystems between 1990-2007.

Ecosystems	Areas 1990-2007 (ha)*			
	1990	**1994**	**2002**	**2007**
Dense forest	136,786	97,563	89,063	147,865
Open forest	1,109,853	759,827	784,288	638,350
Wooded savannah	1,232,883	1,521,518	1,578,993	1,582,289
Mangal	261,022	289,113	320,805	314,786

* Carboveg-GB Results

In the coastal zone of Guinea- Bissau, there are universal and exceptional natural values, including intertidal channels with a surface area of 160 000 hectares, in which the Bijagós Archipelago is placed in the first African continent ranking on this type of ecosystem. Bijagó is considered to be the second most important site for migratory bird worms after the Bank of Arguin in Mauritania and is home to around 1 000 000 waders per year.

Guinea-Bissau has also one of the most extensive mangrove areas on the Atlantic coast of Africa, covering about 9.37% of the national territory and a highly important habitat for reproduction, food, nutrition and the growth of a large number of species, including species with high commercial value throughout the sub region such as shrimp. In addition, The Bijagós archipelago is one of the richest biodiversity national areas, but it also has critically endangered and vulnerable species as shown (Table 6.10) according to the IUCN Red List and Categories.

Table 6.10 - Number of endangered, threatened or vulnerable species according to the IUCN Red List. CR (Critically endangered), EN (Endangered) and VU (Vulnerable)[141].

Species	Common Name	Categories (IUCN Red List)
Hippopotamus amphibius	Hippopotamus	VU
Trichechus senegalensis	African Manantim	VU
Sousa teuszii	Hunchback dolphins	VU
Dermochelys coriacea	Leather turtle	CR
Chelonia mydas	Green Turtle	EN
Eretmochelys imbricata	Scale turtle	CR
Lepidochelys olivacea	Olivacea Turtle	VU
Caretta caretta	Bigheaded Turtle	EN
Osteolaemus tetraspis	Black Crocodile	VU
Carcharhinus brevipinna	Weaver weaver	VU
Carcharhinus signatus	Night Shark	VU
Carcharhinus longimanus	Oceanic whitetip shark	VU
Carcharhinus obscurus	Dark Shark	VU
Carcharinus plumbeus	Gray Shark	VU
Mustelus mustelus	Smooth Emissole Common	VU
Carcharias taurus	Bull shark	VU
Sphyrna lewini	Scalloped hammerhead	EN
Sphyrna mokarran	Great hammerhead shark	CR
Sphyrna zygaena	Hammerhead Shark	VU
Pristis pectina	Sawfish	CR
Pristis pristis	Sawfish	CR
Rhinobatos cemiculus	Rays burrowing guitar	EN
Rhinobatos irvinei	Rays Irvine Guitar Strain	VU
Rhyncobatos lübberti	African straw fish	EN
Rhinobatos rhinobatos	Rays Common guitar string	EN
Gymnura altavela	Thorny butterfly squaw	VU
Dasyatis margarita	Daisy stingray	EN
Psittacus timneh	Gray Parrot	VU

6.3.4.1 Main Drivers of Biodiversity loss through forest degradation in Guinea-Bissau

Lately there has been a considerable reduction of areas occupied by dense forest, open forest, but in contrast there is a significant increase of wooded savannah and mangrove ecosystem thanks to the latest Government led interventions together with the international community. As described above this reduction is mainly due to the unsustainable anthropogenic activities (widespread illegal logging, deliberate willed forest fires, forest clearance for land use, etc.,) in the different forest ecosystems and an also thanks to the increase of demographic growth in which the communities put pressure on the natural resources coupled with inappropriate forest management programmes, and lack of law enforcement for forest protection. The current pressure of the timber industry is already reflected in the dense forests, particularly in the southern part of the country. Based on the Checklist developed to assess the flora of the country, it is possible to confirm that there are between 1500 and 1600 species and subspecies in the flora of Guinea-Bissau which represent a relatively large forest wealth, taking into account the size of the territory. All these

unsustainable actions and activities contribute for potential biodiversity loss in Guinea-Bissau. Main Drivers of Biodiversity loss through forest degradation in Guinea-Bissau as well as the expected adverse effects and sensitivity result of the sector is shown in Table 6.11.

Table 6.11 - Anthropogenic and Climate Change Drivers and Future projections of impacts and Biodiversity Sector sensitivity developed using socio-economic scenarios.

Anthropogenic Drivers	Climate Change Drivers	Adverse Effects	Sensitivity
• Widespread illegal logging • Deliberate wild forest fires • Forest clearance for land use • Demographic growth with communities pressurising natural resources • Widespread cut of mangrove for fish smoking activity	• Decrease aquifers reservoirs (phreatic sheets) • Degradation of ecosystems through extreme temperature and rainfall events • Appearance of Climate induced pests • Increase of Climate induced prolonged dry period; • Advance of desertification phenomena • Sea Level Rise • Saline water Intrusion in "lala"savannas • Increased salinity for mangrove species	• Migration of faunal species and disappearance of plants intolerant to high temperatures • Advancement of drought, desertification and possibilities of natural fires. • Enhancement of savannahzation with alteration of production modes • Water scarcity for plants and animals, and Water stress. • Decrease in agricultural production, reduction of arable land and food shortages • Loss of mangrove ecosystems and decline in biodiversity • Coastal flooding • Reduction of mangrove vegetation	• Extinction of some species of plants and animals • Emergence of genetically modified species • Mutations in flower formation • Decreased agricultural production and food shortages • Unproductiveness of the "bolanhas " and food scarcity • Fragmentation of habitats • Loss of natural habitat, species migration, loss of biodiversity and economic yield decline. • Escape of animals and disappearance of plants intolerant to droughts • Social conflicts for access to land

6.3.4.2 Adaptation in the Biodiversity Sector

The increase in temperature and rainfall reduction, will impact on salinity increase and may lead to the disappearance, distribution, dispersion and migration of species susceptible climatic change impact to a more adequate condition of subsistence and survival. And for endemic species of specific ecosystems, the effects of climate change may well contribute to the extinction of such species. For avifauna, climate change scenarios will influence their migration or dispersion to areas with better survival and reproduction conditions. Moreover, Sea Level Rise will lead to more frequent flooding of the coastal zone and river banks in Guinea-Bissau, which can lead to coastal erosion, loss of mangrove areas and low salinity for marine species. In addition, Sea Level Rise will affect the reproduction of sea turtles, using the beaches for spawning. In Poilão island (Bijagós archipelago) there is a significant loss of eggs during the high tide. This reduction in numbers of surviving turtles affect the ideal proportion between males and females.

High temperatures and rainfall induce increased salinity for mangrove vegetation, which may lead to the death of the plants that make up this ecosystem and loss of aquatic species. There is a need to support the stability of natural ecosystems to enhance the protection of

biodiversity. For the Government of Guinea-Bissau this endeavour is part of the economic growth planning policies. Therefore, amongst others, adaptation measures being currently sought include:

- Gradual replacement of species currently in existence by more resistant to drought
- Repopulation of degraded areas with emblematic species
- Awareness of environmental problems
- Training on sustainable forest management
- Increase environmental inspection and law enforcement
- Scientific study on genetic mutations
- Promote the production of forest nurseries
- Promote the recovery of degraded areas
- Promote non-woody forest products
- Promote cultivation in the "bas-fonds bolanhas"
- Support the small-scale mechanisation of the "bolanhas" agriculture
- Develop a National Plan for Reducing deforestation
- Promote the cultivation of "bolanha" rice
- Protection and conservation of fragile and sensitive ecosystems
- Elaboration of an Operational and phytosanitary Program.
- Dissemination of information on climate changes induced pests and diseases
- Awareness-raising on the effects of climate change on forests and promote reforestation
- Land use planning
- Create small processing units for local products
- Scientific research on species adaptable to climate change
- Create faunistic corridors
- Sensitization on impacts of climate change and its effects for biodiversity conservation.

Mangrove Adaptation

In relation to mangrove stands being affected both by anthropogenic and climate change induced impacts there are a number of adaptation measures being currently pursued which includes:

- Mangrove restauration in the degraded zone
- Use of Geographic Information System for mangrove management and dynamics
- Sustainable management of mangrove vegetation
- Improved fish smoking ovens
- Promote the practice of rice cultivation in "bas-fonds bolanhas".
- Promote awareness of environmental problems and their effects on mangrove forest resources and biodiversity

6.3.5 Vulnerability of the Fisheries Sector

Guinea-Bissau is also one of the richest countries on the West African Coast in terms of fishery resources. However, weak port services, obsolete cold storage facilities and governance gaps in fisheries have prevented fishing from becoming a value-added and job-creating activity[142] Thanks to coastal upwelling and extensive nutrients from river input, the

extensive continental shelves off Guinea Bissau – one of the largest in West Africa – within an Exclusive Economic Zone of 106 000 km2 is home to an estimated one million tonnes of fisheries resources, of which, optimistically, 350 000 to 500 000 tonnes can be extracted annually (Anon. 2009[143]). Meanwhile, fish biomass in the Exclusive Economic Zone (EEZ) of Guinea-Bissau appears to have declined to at least 50% of its value in 1963, when the first acoustic survey was conducted, by 'la Rafale' (Anon. 2009). Industrial fishing is principally conducted by foreign vessels which do business within the framework of fishing agreements.

6.3.5.1 Main Drivers of degradation of the Fisheries Sector in Guinea-Bissau

Fisheries in Guinea Bissau consist of two main sectors. The industrial sector consists of licensed foreign vessels, some of which are chartered and fly the flag of Guinea Bissau (Dia and Bedingar 2001). The other is the artisanal sector relies on dugout canoes called "nhominkas", of which about one quarter are motorized, and Senegalese-type pirogues of which 83% are motorized (Anon. 2009). However, within this sector there is the existence of other sectors, i.e., subsistence fishing, conducted mostly by women, occurring in over twenty islands of the Bijago Archipelago.

Taxonomically, catches from mangrove-rich areas and/or the Bijagós Islands constitute a significant part of subsistence fisheries. Therein, molluscs gathered by women, mainly wild oysters (Crassostrea gasar), arks (Anadara senilis) and murex shells (Murex spp.) represent the dominant taxa, assumed here to make up 80% of the catch, divided evenly by the three above taxa. The remaining 20% are assumed to have the same taxonomic composition as the artisanal catches (see Table 6.12), with shrimp catches (2%) consisting mainly of white shrimp (Farfantepenaeus notialis; 73 %) and tiger shrimp (Penaeus monodon; 26%).

Table 6.12 - Species composition of the artisanal sector catches in Guinea Bissau. Numbers from 1993 to 2003 converted to percentages and then averaged (ECOST 2007[144]).

Artisanal sector catches in Guinea Bissau		
Scientific name	**Common name**	**Percentage**
Ethmalosa fimbriata	Bonga shad	54
Argyrosomus regius	Meagre	17
Penaeidae	Shrimps	10
Cynoglossus spp.	Soles	9
Carlarius heudelotii	Smoothmouth sea catfish	6
Caranx spp.	Carangids (jacks)	2
Pomadasys jubelini	Sompat grunt	1

Fisheries, indeed could play a major role in rebuilding the country's economy. The majority, 70%, of the Guinean population lives in the coastal zone and the artisanal sector directly and indirectly employs more than 23 000 people. For 1979, Consumption rate in 1979 was estimated to be about 26 kg/person/year, relying mostly on artisanal and subsistence catches, complemented by occasional imported fish. It is thus important to re-iterate the vital role that fisheries play in Guinea Bissau: of the 120 000-people employed by this sector, 52% are women, and all depend on fish as a source of revenue and basic food stable[145]. Since many fishermen are poor, improving the performance of this sector should lead to poverty reduction.

Artisanal fisheries are concentrated along the coast, islands, and rivers constitute roughly 80 percent of the artisanal catch. A majority of this catch is taken during two periods of the year, from April to May (also coinciding with the dry/hungry season) and from October to December. Currently about 3,500 artisanal fishers are reported to be operating in the country, of which at least half are from Senegal and Guinea-Conakry.

Figure 6.6 - Women play a key role in the sector acting both in the marketing and processing of fish

In the handling the 80 percent of the artisanal catch women (called "bideira") play a key role in the sector and act both in the marketing and processing of fish (Figure 6.6). In the Bijagós archipelago in the islands, unlike on the mainland, fishing serves as a primary livelihood strategy. Nevertheless, households still pursue a mix of livelihood strategies, combining fishing with agricultural activities and the exploration of forest products.

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Fishing, extraction of palm oil and wine, and clearing and planting agricultural fields, are generally the main activities pursued by men. Women sell the fish and produce horticultural products for consumption and cash. Note that while Guinea-Bissau is endowed with an abundance of fish and seafood, it currently lacks a regulatory framework and mechanisms to monitor and to supervise this valuable resource. As a result, there is a danger that the country—and particularly the communities in the archipelagos who rely on fishing—will suffer from overuse and fishing by foreign industrial fleets and artisanal fishers from the neighboring countries. There are reports that people's livelihood strategies in the villages on the islands have already been negatively affected by this factor which compounds the already visible climate change induced impacts on fish stocks such as salinity and sea water temperature changes.[146] (Table 6.13). Climate induced events affects the process by which fresh and marine waters mix and the production that develops at this interface which depend on the amount of river outflow and on the morphology of the river mouths, which determines the transit time of inland waters to the sea. The nature of the soluble load and solid particles transported by river waters depends on the type of plant cover on the watersheds. Therefore, the productivity of these estuaries which usually highly depends on phytoplankton that can only develop when turbulence and turbidity diminish and there is sufficient mixture of fresh and seawater.

When the bed of a river is near sea level such is the case of north of the country the Cacheu also known as Farim River, The Monsoa and Geba Rivers, sea water may ingress during the low-water seasons. If the freshwater inflow is less than the loss through evaporation which has been happening during drought years, salinity becomes higher than in the sea. This leads to Hypersalinised estuaries affecting species productivity. This because the length of time the water remains at intermediate salinities greatly influences the ability of phytoplankton to

take up the nutrient salts brought down by the rivers (Eisma and van Bennekom, 1978[147]). The effluent outflows of Guinea-Bissau's rivers stretch over much of the shelf, where the salinity shows great seasonal variations (28 to 35.5‰). Climate variability is impinging this natural seasonal variation in salinity a driving force for reproduction with upstream displacement of large quantities of juveniles trawled up to 30 miles from the estuaries of the Cacheu and Geba rivers[148]. This mechanism being impacted by climate variability appears to be a very important nursery for replenishing the fish stocks of both Senegal and Guinea-Bissau.

Table 6.13 - Anthropogenic and Climate Change Drivers and Future projections of impacts on the Fisheries Sector sensitivity developed using socio-economic scenarios.

Anthropogenic Drivers	Climate Change Drivers	Adverse Effects	Sensitivity
• Widespread fishing • Overexploitation of fishing resources • Demographic growth with communities pressurising natural resources coastal environment • Widespread cut of mangrove for fish smoking activity	• Declining rainfall • Degradation of fishing ecosystems through polluted runoff from extreme rainfall events • Increase of Climate induced prolonged dry period; • Drought episodes • Sea Level Rise • Increased salinity for fishing species	• Migration of faunal species and disappearance of fish species to high salinity increase • Decrease in fish production	• Extinction of some species of fish • Fragmentation of habitats • Loss of natural habitat, species migration. • Escape of animals and disappearance of plants intolerant to droughts • Social conflicts for access to fishing resources

6.3.5.1 Adaptation in the Fisheries Sector

In order to contribute to food security, particularly for the artisanal fishermen and women dealing with fish processing and commercialisation and to build resilience to climate change through adoption of adaptive and mitigation measures, the sustainable management of fisheries resources must be assured. The options to attained this include:

Implementation of measures for sustainable management of fisheries protecting endangered species and using appropriate fishing methods through;

(i) Strengthening the Fisheries Department to improve its data base information and law enforcement towards stock control;
(ii) Production of national inventory to map/assess the size, length and weight of the fish stocks as there are global changes;
(iii) Promoting Capacity building and strengthening of fishing communities in “best practices” such as the concept of co-management and participatory research in the face of climate change impacts; and
(iv) Establish national mechanism to increase access to micro-finance facilities for artisanal operators constrained by high interest rates of loans, so to increase the resilience against climate change impacts artisanal fishermen and young women.

Strengthening the resilience of the Fisheries infrastructure against climate change impacts by:

(i) Upgrading all national Fishing Landing Points and Fish market and cold chain structures;

(ii) Establishment and operationalization of post-harvest value chain units at each landing site including transportation means, fish handling and processing section, cold room, ice making plant, rodent-free store for smoked fish, smoke ovens, training hall with the availability of water and hygienic facilities;

(iii) Develop participatory assessment towards the improvement of smoke ovens for drying fish catch from artisanal fishing to reduce the pressure on the mangroves for firewood;

(iv) Develop a coastal Early Warning System to support the fishermen to get Early Warning and Weather Alerts to cope with climate change induced extreme events (strong winds, extreme rainfall events, high tides, storms, etc.).

6.3.6 Vulnerability of the Water Resources Sector

Guinea-Bissau is covered by a hydrographic network and water resources consists of surface water found in the river Geba-Kayenga and the Koliba- Corubal and its tributaries, and multiple aquifers found at different depths throughout the country. Among the flowing streams, rivers and their tributaries are included the main rivers being from North to South, the Cacheu, Mansoa, the Geba, the Corubal, Rio Grande de Buba, the Cumbijã and Cacine Rivers branches and estuaries. The Geba-Kayenga and the Koliba- Corubal and its tributaries, are the only ones providing surface freshwater, therefore their management is challenging for agriculture and domestic use in the country. Specialized studies confirm the deep interpenetration of land and sea in a distance ranging between 150 and 175 km where saltwater goes inland under the influence of tides. This will characterize the existence of inverse estuaries in most cases. However, overall the country has significant water resources, according to the Headmaster Scheme DGRH 1997, estimated at 14 billion/ m3 per year, and renewable resources of the deep aquifers estimated to be between 8 to 29 billion m3 per year and surface aquifers in the hundreds of billions of m3/ year. Back in 1991, the exploitation of surface water from the Geba and Corubal Rivers was estimated at 1.5 million m3. According to the NAPA (2006), the rate of access to drinking water is only 45.3% for residents in rural areas, compared to 78.9% for the populations living in the Capital, Bissau City. Of the above there are 2 major transboundary freshwater rivers shared with neighbouring countries, namely: Kayanga / Geba - covering an area of 14,900 km2 of which 10 thousand km2 in the territory of Guinea Bissau, 4,400 km2 in Senegal and 500 km2 in Guiné-Conacry and 335 km long, and Koliba / Corubal (with an area of 26 000 km2 of which 8,800 km2 in Guinea-Bissau, 17,200 km2 in Guiné-Conacry) and 384 000 km in length. Only the river basins of these two rivers have been subject to in-depth studies (several measurements) that allow quantitative and qualitative evaluation of these resources. To date, river basin management in these rivers has been integrated, coordinated and concerted, through Action Plans based on Integrated Management of Water Resources (PAGIRA) within the framework of the Gambia River Basin Development Organization Energy Project. The Corubal River, with an average annual volume of 130 000 million m3 and significant drought flows (11 m3 / s on average), is the most important surface water resource in the country and has great hydroelectric potential.

6.3.6.1 Specific vulnerability of the Water Resources

Water resources show high vulnerability due to the irregularity of rainfall and high temperatures triggering decrease in river flow, a significant decrease in groundwater level and the progression of saline wedge. The current situation of the Geba River and adjacent aquifers sectors where this river maintains a hydraulic route serve as an example of this phenomenon.

Regular reports testify the change of parameters related to rainfall, temperature, relative humidity, average sea level and water resources. The population in the vicinity have noted (i) a late onset of the rainy season (mid-June) compared to the usual (early May), (ii) a less regular distribution of rainfall compared to the past, (iii) shortening of the period of mild temperatures, the so-called "cold weather season" from three months (December to February) to only two months (December to January), (iv) a warmer and drier environment, (v) occurrence of frequent dust clouds, (vi) more frequent occurrence of high-tides of greater magnitude destroying rice fields and dikes, (vii) decreased water quality, due to saline water intrusion and infestation of water points by aquatic plants, (viii) reduction of wetland surfaces, by resettlement of sands due to drought. Data from the three parameters (temperature, rainfall and flow) validate the vulnerability of water resources in the Eastern Province, in particular, in the Region of Bafata.

The temperature in the Region of Bafata increased by about 0.3°C during the periods of 1961-2003, precipitation fell as much in Bafata as in Gabu, during the periods (1961-2007). Flow rates decreased, i.e., there was regression in the flow of the river due to low rainfall areas of the Kaianga-Geba River system, and the infrastructure construction of water retention in its upstream part, Senegal in the framework of the transboundary OMVG Project.

6.3.6.2 Main Drivers of Water Resources degradation in Guinea-Bissau

If the future scenarios of increased temperature and decreased precipitation (according to the projected scenarios of climate in Guinea-Bissau for the time being shown in Chapter 5), are taken into account there will be a worsening of the adverse impacts associated with the decline of water resources, both in terms of surface as well as of underground aquifers. These impacts will result in a potential reduction in agricultural production, the decrease in pasture area and the increased rural exodus.

Other effects of climate change on water resources include the reduction of vegetation cover, desertification, increased evaporation and evapo-transpiration, soil erosion and soil loss. The decrease in water availability associated with changes in temperature, will also threaten the biodiversity of terrestrial Guinea-Bissau and their specifics.

Groundwater is the main source of drinking water for the population in the country, which is captured at depths of 30 m to 80 m. Recharge of the shallow to medium groundwater aquifers is directly dependent on precipitation during the wet season. The combination of reduced rainfall, increased temperatures and increased frequency of drought episodes could impact freshwater resources quantitatively and qualitatively. The anthropogenic and Climate Change Drivers and Future projections of impacts on the Water Resources Sector sensitivity developed using socio-economic scenarios are shown in Table 6.14.

Table 6.14 - Anthropogenic and Climate Change Drivers and Future projections of impacts on the Water Resources Sector sensitivity developed using socio-economic scenarios.

Anthropogenic Drivers	Climate Change Drivers	Adverse Effects	Sensitivity
• Traditional agricultural practices "itinerant agriculture"; • Exploitation of woody materials for the construction and production of household energy through firewood and charcoal;	• Rising Temperatures. • Irregularity and reduced rainfall. • Droughts episodes. • Sea Level Rise	• Displacement of the saline front upstream in the main Rivers, threatening a general salinization of coastal aquifers; • Enhancement of the risk of salinization of coastal aquifers; • Impact on surface water quality degradation linked to the export of nutrients from inundated areas under the effect of increased frequency of extreme events; • Shift the stability of ecosystems in connection by increasing biochemical activity in relatively warmer waters. • Reduction on the recharge capacity of aquifers, from which drinking water and water for small scale irrigation is obtained.	• Loss of biodiversity, natural resources and essential nutrients for the forest; • Yield reduction of main crops; • Potential hardship in livestock sector; • Decreased forest mass yield; • Increased hunger and forest loss; • Decrease of evapotranspiration, increase of vectors of epidemics; • Food insecurity.

6.3.6.3 Adaptation in the Water Resources Sector

Under the Climate Change framework, the adaptation strategies in the water resources Sector to be coherent and consistent should be based on its preservation, exploitation and rational use, applying the approach of integrated management of water resources. Adaptation options should include increase the storage of rainwater, for augmentation of the surface water and groundwater reserves, through following actions:

- Promote technical studies to assess the possibilities of dam's construction so to retain rainwater avoid the loss and enhancing the storage capacity;
- Conduct a comprehensive study on the capabilities and characteristics of the river system (tributaries and small flowing streams) so to assess the potential for irrigation
- Promote technical studies to assess construction of small dams to hold water for agriculture use and livestock breeding;
- Construction of small ramps on the banks of the tributaries of the Geba River, in order to facilitated drinking sources for livestock on these rivers;
- Promote ground cover in general through a large-scale forestation and afforestation programmes to increase the rainwater interception mechanism and reduce erosion phenomena;
- Prevent indiscriminate logging of riverine forest stands

To address and / or mitigate the vulnerabilities highlighted in the water sector, adaptation measures identified to alleviate the sufferings of people and create conditions for sustainable development can be grouped into the following four (4) categories:

1. Implementation of measures leading to the optimization of water resources. Highlighted are: the restoration and management of meteorological monitoring, hydrological and hydro-geological networks, creation of an integrated information system pertaining to water resources and modernization of tools for collecting, processing and operating an integrated data sector;
2. Implementation of measures aimed at strengthening the capacity of the water resources sector, including institutional and human capacity, as well as others.
3. Implementation of preventive measures for the protection of water resources;
4. Implementation of integrated water resources management

Huts in the savannha. Bula village in Cacheu, Guinea-Bissau – by Francofranco56 - https://commons.wikimedia.org/wiki/File:Villaggio_Guinea-Bissau.JPG.

Chapter 7: Limitations, Gaps and Related Needs of Financial and Technical Capacity

7.1 Introduction

The process that led to GHG inventory in Guinea-Bissau was developed as a "project based" with specific funds from United Nations Framework Convention on Climate Change (UNFCCC) and Government contribution. Therefore, there is not a sustainable national system to collect, process, archive, monitor and report on the sources of GHG emissions and their sinks. The preparation of this TNC was carried out on an ad-hoc basis, and most of the work was outsourced to consultants. Although significant progress has been made since the submission of the Initial National Communication to UNFCCC in 2003 and subsequent National Communication in 2008, the Intended Nationally Determined Contributions (INDCs) presented in 2015 has exposed some challenges and weaknesses.

The main constraints, shortcomings and related capacity building, financial and technical constraints encountered during the process of drafting the Third National Communication are numerous:

At institutional level

- Inefficiency of the National Climate Change Commission;
- Lack of instructional framework that would allow and facilitate a better coordination and systematic work regarding national inventories of greenhouse gases;

On the technical and financial level

- Weak national education, research and training capacity on climate change, particularly as regards to risk identification, vulnerability and adaptation issues;
- Weakness of national research institutions in the fields of systematic climate observation and water sciences (e.g. meteorological and hydrological services);
- Weak national expertise in using tools and methodologies for assessing climate change risks, vulnerability and adaptation to climate change;
- Weak national capacity for modelling local climate phenomena;
- Weak dominance by actors on issues related to the United Nations Framework Convention on Climate Change;
- Weak culture of documentation and archiving
- Insufficient reliable, accessible and structured data in key sectors;
- Lack of biophysical models
- Lack of capacity of assessing climate-related losses and damages Mechanism for Loss and Damage associated with Climate Change Impacts (Loss and Damage Mechanism), including extreme events and slow onset events;
- Lack of reliable documentation and archiving of data and information, taking into account the varied number of data holding structures;
- Ineffectiveness of climate and hydrological forecasting systems;
- Absence of a National Research Center dedicated to climate change;
- Insufficiency of material collection and archiving, analysis and communication (GIS, ICT, etc.) in the national data-producing services.
- Persistence of insufficient data and information and tools needed to improve the quality of inventories and analysis of greenhouse gas (GHG) mitigation, vulnerability assessment and adaptation (V & A) to climate change: GHG emissions factors and other modelling materials on climate change, etc., adapted to the national context;
- Lack of mastery of methodologies for the preparation of certain studies to be carried out in the framework of the preparation of TCN, namely in the V & A assessment of climate change;
- Weak financial means of producing and holding institutions to collect, archive and analyse data;
- Insufficient of financial resources to acquire certain data needed to assess vulnerability and adaptation;
- Insufficient financial resources to build capacity and establish a permanent system for assessing vulnerability and adaptation;
- Poor mobilization of resources to finance adaptation programs and strategies.

However, there are key areas which have been revealed crucial to the development of the process of the preparation of the TNC that should be addressed adequately in order to ensure the successful implementation of future national communications and other reporting systems including the Biennial Update Reports (BURs). These main gaps and constraints are discussed in some detail below.

7.2 Greenhouse Gas (GHG) inventory

The primary constraint identified and absolutely necessary to be able to develop a more robust GHG inventory in Guinea-Bissau, the following gaps need to be addressed:

1. *Trustworthiness and Quality of Data* – The data collection process was not carried out in a reliable format and there was little detail to enable estimation of emissions from personal vehicles and public-sector vehicles according to fuel type. In addition, data was not computerised and kept in hand writing requiring quality check. Data computerisation, should be enhanced to reach across all sectors of government, data collection and storage should be systematised.
2. *Data Gaps* - Some progress has been done through the various communication processes in addressing data needs for the GHG inventory. However, gaps in data remain an issue for all sectors. Training and capacity development to IT technicians should be implemented so to improve the understanding of the value of data and continuity of data series.
3. *Readiness and accessibility to private data* – Data series from private sector entities dealing with GHG sectors taking part in the inventory were not sufficiently reliable both in terms of continuity and quality.
4. *Data analysis and synthetisation* – Data analysis for GHGs projections in the energy sector did not include all sub-categories of the sector and the application of conversation factors were not properly applied which meant additional computational time.
5. *Solid waste characterization data* – Data on amount generated and waste water generated are not measured in many towns and had to be derived.

In this context, coordination among data providers needs to be strengthened to ensure that collection and reporting of data are done at a regular basis to support reporting responsibilities such as the National Communication process, Biennial Update Report and institutional needs.

Capacity building and training will be an on-going effort at the institutional and technical level. Institutions generating the activity data will need to be trained in GHG inventory and data formats. National experts lack technical capacity to estimate the inventory hence training of national experts on the IPCC 2006 guidelines and inventory software should be a priority before the next inventory is prepared. There was no continuity in the estimation of the inventory as there was no data updating from the last inventory calculation due to lack of an institutional framework for data base management, deficient archiving system.

Additionally, opportunities should be identified to link data collection needs with other data collection programmes such as REDD+ initiatives, “waste to energy” which has the potential to create renewable energy from waste matter, including solid waste, industrial waste, agricultural waste, and waste by-products. Institutionalizing linkages between GHGI estimation with broader Climate Change search is very much needed.

7.3 Adaptation and Mitigation Needs

Although some climate change mainstreaming has been done since the second national communication as part of the implementation of the GEF/UNDP project "Strengthening adaptive capacity and resilience to Climate Change in the Agrarian and Water Resources Sectors in Guinea-Bissau - PRRCASAHAC-GB" in which seven National Plan and Programmes were mainstreamed there is still a major challenge for the country, mainly due to urgent priorities related to other national communications and reports and also due to the absence of a national climate change policy to guide the implementation of this action. Therefore, it is necessary to create the enabling environment in the country to facilitate the mainstreaming of mitigation and adaptation measures to national development objectives and enhance the capacity of the Ministry of Environment and Sustainable Development (MADS) in particular the National GHG Inventory System (NIS) which includes all institutional and legal arrangements associated with the national greenhouse gas inventory preparation process, as well as reporting this information on the national and international level. In the NIS, the MADS /DGA – which is UNFCCC responsible entity and National lead institution in charge with preparation of the National Communication and of the GHG Inventories will need to benefit from further training and capacity development including the Expert Group Team Leader for GHG Inventory, the Advisory Panel and the Five Task groups (Industry, Energy, Agriculture, Land Use, Land-Use Change and Forestry (LULUCF) and Waste). The effectiveness of the implementation of mitigation measures and adaptation options is therefore dependent on the strength of the above institutions with technical, financial, and managerial capabilities. Any institutional weakness in these areas undermines the attempt to implement adaptation and mitigation measures effectively. Additionally, the country lacks a national institutional framework under which rigorous and science-based field determination of Climate Change Risk/Vulnerability assessment and mapping is systematically undertaken to feed the national strategy for adaptation and mitigation implementation and mainstreaming into national development programmes and integrated into national planning and budgeting. Under other challenges that the TCN was faced with include those shown in Table 7.1.

Table 7.1 - Summary of main technical capacity and training needs for the preparation of national communication.

Activity	Main areas of capacity needed
Sustainable GHG inventory management system	• Strengthening of Institutional arrangements for GHG data management • Development of a national GHG manual • Establishment of a national GHG sectoral data base • Lack of capacity in doing GHG inventory projections and use of the LEAP model
GHG Estimation	• Training and capacity development programme on the application of IPCC 2006 guidelines and software handling. • Use of satellite remote sensing and GIS based information for Risk and Vulnerability Mapping
Mitigation	• Training on the mastering of Long-range Energy Alternatives Planning System-LEAP programme as a Tool for Energy Planning and GHG Mitigation Assessment • Lack of national experts for mitigation assessment and estimation of abetment cost for mitigation action Training on developing mitigation baseline
Adaptation	• Lack of capacity to develop socio-economic scenarios for the vulnerability and adaptation component
Climate scenarios	• Training in downscaling of meteorological and climate modelling

	• Lack of national experts to do climate change scenarios and projections • Insufficient capacity of climate research experts for vulnerability and adaptation assessments
Climate assessments impacts	• Training on use of statistical and dynamic crop and hydrological modelling • Training on the development on Climate Change Scenarios in key sectors
Adaptation methods and tools	• Training on the use of different adaptation tools and methods applicable to different sectors including biophysical models and cost benefit analysis, Scenario development in different sectors
General	• Programme and project development in climate change Policy and Analysis

7.4 Vulnerability and Adaptation Assessment

For the Third National Communication (TCN) the V&A assessment was carried out by the Vulnerability and Adaptation Multi-Stakeholder Task Team through participatory assessment of the main economy sectors namely Agriculture & Livestock, Energy, Forestry, Biodiversity, Water Resources, and Fisheries which are sectors that are important to Guinea-Bissau's economy and development, yet at risk of negative impacts of climate change.

The major gaps identified during this exercise included also financial, technical and capacity needs to sustain infrastructure for implementation of climate actions. Other gaps pertained to inadequate capacity at district and community level on Climate Change impacts, insufficient use of economic instruments and lack of input data for some sectors and inadequate capacity for modelling. Therefore, the next steps for the Fourth National Communication should include, amongst others:

- Studies on the cumulative impacts of Climate Change and sea level rise on riverine zones of rice cropping and its associated costs;
- Spatial flood and drought risk maps
- Spatial vulnerability assessment included a desktop analysis of the six study areas;
- GIS-based preliminary flood and drought risk mapping;
- Field verification of the developed preliminary flood and drought maps, vulnerability assessment and stakeholders' validation workshop;
- The need and impact on Early Warning Systems for crop failure and the introduction of new adaptive agricultural practices particularly in rice farming and cashew nut production;
- Assessment of opportunities to meet of clean energy technology and promotion or renewable energy.

These key issues once tackled they can contribute to further mainstreaming of climate change adaptation concerns and issues into the planning processes over the long term. Specifically, Guinea-Bissau need to effectively engage in Early Warning Systems for crop protection, artisanal fishing activities, forest fire protection, livestock transhumance support, water resources management and the introduction of new adaptive agricultural practices particularly in relation to rice cropping and cashew nut production. These may, for example, require exploiting existing indigenous knowledge on adapting to climate change in rice cropping agriculture. The upscaling of awareness and outreach activities, which share

information about possible and current climate changes and these appropriate adaptive responses, would also be valuable.

The issue of clean energy technology and promotion of renewable energy require the consideration of the national energy policy, as well as legislation developed to include renewable energy independent power producers, which will be necessary to exploit this opportunity. Furthermore, Guinea-Bissau could explore the use of markets as provided in the article of the Paris agreement. There are potential monetary gains to be made from carbon markets through the sale of Certified Emissions Reduction credits to developed countries. There is also a need for an increased role of the private sector in addressing climate change concerns through direct investments and partnerships to support mitigation actions.

It is urgent and necessary to provide the necessary support to the national institutions to produce spatial flood and drought risk maps were developed for identified vulnerable districts at risk in the country. The main objective of the flood and drought risk mapping will be to contribute to the vulnerability assessment by identifying flood and drought high-risk areas and use the information to support effective community-based flood and drought risk reduction planning. By reducing flood and drought risk, the communities in the districts will build greater resilience to the negative impacts of climate change.

7.5 Financial Needs

The Government has indicated in its INDC that "…*The main mitigation measure to be adopted by the country is related to the forest sector responsible for emitting large amounts of CO_2 into the atmosphere which estimates show a decline of around 625 000 m^3 of wood per year followed by energy sector which despite the fact that global average electrification rate of the country is about 12%, Guinea-Bissau was, is and still remains one of the countries facing the greatest need of access to modern forms of energy in Africa and the world. In this sector an increase in electric power capacity of at least 90 MW 2020 using petroleum products (diesel and heavy fuel oil) is planned…*". To this end, it will require international support in its efforts to transition to a low-carbon development path through massive reforestation programme, greater utilisation of renewable sources of energy and to adapt to the negative impacts of climate change that affect several sectors of the economy. To fully realise its INDC, it will need international financial support:

(i) Establish and schedule a new forestry policy. The vision is of a sustainable management of forest resources - including through conservation and restoration of forests - to enhance a socio-economic balance that meets the needs of communities and ensures their accountability;

(ii) Conduct studies on the energy potential of the country and set the energy development incorporating the largest possible potential of renewable energies in the energy mix;

(iii) Develop and establish a legal framework through a national strategy for long-term low-carbon development.

The Means of Implementation advocated by the Government of Guinea-Bissau in its INDC to meet the above recommended goal will require an overall investment not less than 200 million USD by 2020 and 500 million between 2020 and 2030 as foreign aid.

Furthermore, on the adaptation front the nationwide adaptation cost-benefit analysis has not been undertaken yet. However, the Strengthening Resilience and Adaptation Capacity of Agricultural and Water Sectors to Climate Change in Guinea-Bissau Project (PRRCASAHAC-GB) has carried out a cost-benefit analysis to adaptation in the Gabu region, east of the country, taking into account as a reference the development trend. This analysis showed that Guinea-Bissau's efforts to adapt to climate change will be considerable. Guinea-Bissau requires approximately USD 42 million for the implementation of adaptation projects in all reference sectors in the two administrative sectors (Pitche and Pirada) in the Gabu region. It should be noted that the country has eight (8) administrative regions and all of them are equally vulnerable.

Capacity strengthening has a direct effect on improving decision-making and planning for comprehensive risk management for both public and private actors regarding events associated with climate variability and change in the sectors of forest, water and energy, agriculture and livestock, health, fishing and civil protection. Financial needs will also be required for promoting research and research for development, regional and international exchanges to improve and improve applicability of knowledge acquired by participants.

7.6 Capacity Building

Capacity-building for climate action is at the core of Article 11 of the Paris Agreement, and is fundamental in preparing communities for climate change and protecting them against its possible impacts. Various capacity- building initiatives have been undertaken by the Government of Guinea-Bissau to move forward with the sustainable development and climate change agendas. Increased emphasis is being placed on institutional strengthening and enhancement of human capital. Capacity-building for the mitigation of climate change and adaptation to it is being promoted in most socio- economic and environmental sectors.

This Section outlines examples of capacity building initiatives undertaken at the national level and identifies the needs and gaps. One significant capacity development initiative undertaken during the preparation on TCN and supported by the GEF project “Strengthening adaptive capacity and resilience to Climate Change in the Agrarian and Water Resources Sectors in Guinea-Bissau” was the capacity development intervention that took the form of a national workshop delivered in Bissau and eastern region of Gabú. Each of the workshops lasted for two days and a total of 16 hours of training, aimed at Senior Technicians and Trainers on Climate Change in Bissau de capital and directed not only to the Higher Technicians but also to the entire Livestock communities and its Associations as well as Non-Governmental Organizations related to Agriculture / Livestock, Forestry, Environment and Water Resources. A total of 36 senior technicians from several national governmental institutions and civil society attended and were successful capacitate in Bissau and an additional 56 farmers, technicians and officials from government institutions capacitated in Gabú.

Training in mainstreaming of climate change adaptation into the national Plans and Programmes was also carried out using the methodology referred as: "UNDP Quality Standards" or UNDP - QS (UNDP, 2012[149]). However, the interventions described above are negligible compared with what Guinea-Bissau needs for capacity building in carrying out GHG inventory, the establishment of a statistical system for GHG emissions, enhancing adaptation to climate change, and improving decision making for coping with climate change at local level. A sample of the most challenging areas for training and capacity development identified during the development of this TCN is shown in Table 7.2.

Table 7.2 - Summary of the most challenging areas for training and capacity development identified during the development of this TCN.

Priority	Barriers/Challenges	Need for capacity building and strengthening climate monitoring
Observations	• Outdated and incomplete meteorological and hydrological observations networks; • Lack of networks for maritime and altitude observations	• Resources and equipment to strengthen observation networks allow integration of all the critical parameters for monitoring the dynamics of climate and ocean.
	• Problems related to the availability and access critical climate data	• Data processing and data storage equipment
Research	• Lack of technical capacity for establishing data base to support climate simulations	• Acquisition of appropriate advanced workstations and GIS facilities to allow systematic storage of key climate information; • Adoption of Regional Climate Models (RCMs) to strengthen national climate impact assessments and weather prediction capacities.
	• Insufficient national experts to carry out climate modelling tasks	• Strengthen capacity for Training and Research at National Universities and Research Institutes

Education, training and public awareness will facilitate capacity building to participate and implement effectively the commitments to the Convention. This activity is also seen as a vehicle that can be used to drive support for actions regarding Climate Change issues nationally and encourage support for government policies and measures as well as influence change in habits. Despite moderate progress in this area, there is a need to improve public education and awareness and prepare communication strategies so as to make climate science accessible to the populace to enable them to reduce their vulnerability to the adverse effects of Climate Change. Besides awareness building at community and local levels, it is also important to involve high-level policy makers to ensure integration of Climate Change considerations into national development policies.

The country needs to put in place a comprehensive costed capacity building programme, aimed at involving a wide range of stakeholders. Such stakeholders could include government officials, the private sector and civil society organisations. Developing and implementing a resource mobilisation plan for capacitating key national institutions in climate change; data management and dissemination would also be extremely valuable. This would include strengthening the capacity of the coordinating institution, which is the Ministry of

Environment and Sustainable Development (MADS) in particular the National GHG Inventory System (NIS) and the National Institute of Meteorology under the Ministry of Transport.

To make the best use of the data collected as a result of improved finance, capacity and technology, close collaboration is required between and among climate change stakeholders in government, private sector, non-governmental organisations, international partners, donors, academia and communities. However, capacity building is still required in the specific areas of data analyses, management, information sharing and climate research and modelling. There is a need to improve the understanding of climate knowledge by downscaling global and regional models to the national and local circumstances. It would also be desirable to encourage the Meteorological Department and the Disaster Management Agency to work closely together, with regards to building and strengthening an integrated national early warning system for natural hazards. Beyond these, efforts should be made to share the collected data and projections with those in need of it, in agreed formats.

7.7 Solutions - Recommendations & Proposals

The proposals for solutions / recommendations formulated to address the various weaknesses and shortcomings previously enumerated are in particular:

At the Institutional level

- Operationalize the National Climate Change Commission;
- Create a Unit for the Evaluation of Financial Investment Flows in the field of Environment and in particular for climate change;
- Mainstream climate change dimension into public policies.

On the technical and financial level

- To rehabilitate and strengthen data collection networks and meteorological, climatological and Hydrological information, in order to better contribute in the accomplishment of studies essential to the assemblage of the National Communications;
- Provide sufficient human, material, logistical and financial resources for the collection, concentration, treatment, dissemination, archiving and security of data and information necessary for the preparation of studies on climatic risks;
- Prioritize sectors on the basis of criteria such as: contribution to development, vulnerability to variability and climate change, availability of sufficient data, etc., in allocating financial resources for conducting sectoral studies in the elaboration of national communications;
- Strengthen national capacity for modelling variability and climate change (training of human resources, procurement of models and other equipment, etc.);
- Strengthen national capacity for appropriate logics to conduct GHG emissions mitigation analysis;
- Create disaggregated, sufficient and complete databases on exposure units for sectors such as forests, fisheries, wildlife, wetlands, energy, etc.) in the V & A assessment framework for climate change;
- Establish an early warning and risk management systems.

Bijago archipelago warrior dancers.https://s-media-cache-ak0.pinimg.com/originals/a5/e5/ae/a5e5aed87abec55aaaa4d5a74dd29b4b.jpg

Chapter 8: Other information relevant to the achievement of the Convention

8.1 Introduction

The Parties to the United Nations Framework Convention on Climate Change have recognized since 1992 the importance of systematic research and observation for understanding climate change as an indispensable condition for reducing its harmful effects. The Parties have also noted that in many cases the geographic coverage of observations, the quantity and quality of the data produced at both global and regional level are inadequate. In this case, developing countries have more gaps, in particular the shortage of financial resources, modern infrastructures and equipment, and insufficient staff qualification.

This chapter aims to provide a description of the current and proposed enabling environment for the implementation of the TNC, the existing infrastructure supporting weather and climate monitoring and other national activities related to UNFCCC framework and climate change in general, as well as how Guinea-Bissau is integrating climate change and national communications findings in sustainable development programmes. It will also provide some recommendations at the national level for enhancing the legal, institutional and technical quality of climate change governance system to maximize the capacity of Guinea-Bissau to address the challenges of climate change, actively engage in global efforts to fight climate change and benefit from the opportunities for sustainable development present in the UNFCCC framework. It will also address the issue of using the results of the NC report in

order to assess new projects and to implement new climate change/green development national policies.

8.2 Systematic Observations and survey (ART. 5)

The enhancement of the reporting requirements demands for higher standards and permanent institutional framework to enable sustainable reporting while guaranteeing quality. Therefore, there is a need for the country to establish this permanent institutional framework that will be responsible for the production of weather and climate data and other ancillary information to feed the process of developing national communications. This will also facilitate the task of constant capacity building of government personnel and ensure continuity and continuous improvement of the reports.

There are various projects and initiatives related to the research and systematic observation of climate change related phenomena in Guinea-Bissau. A number of key government departments are tasked with research activities including the National Institute of Meteorology (NIM), which runs a country-wide network of meteorological stations that records, transmits and processes meteorological information, according to internal needs and the directives of the World Meteorological Organisation. While national climate and climate change research occurs in an ad hoc manner, mainly through the University of Guinea-Bissau and also through the National Institute of Meteorology Strategic Plan for the Development of Meteorological Activities in Guinea-Bissau (PEDAMGB).

The system of surface meteorological observations in Guinea-Bissau is of utmost importance for the Global Climate Observing System (GCOS) to monitor and understand climate change. Preparing for and adapting to climate variability, climate change and extreme weather phenomena are key considerations in pursuing sustainable development, preventing natural disasters, preserving human health and reducing poverty. For the development of the TCN the climate profile of Guinea-Bissau, was based on information provided through the NIM monitoring network made up of 26 stations integrated into the basic network of which: 4 Main Stations (Bissau / Observatory, Bissau / Airport, Bafatá and Bolama), and 22 rainfall stations (Bedanda, Bessan, Buba, Bula, Buruntuma, Cacheu, Cacine, Caió, Canchungo, Catia, Padova, Farim, Fulbunda, Gabii, Mansabá, Pirada, Porto-Gole, Sonaco, Tite, Varela and Xitole); for the period 1981-2010.

At present (2017), the base network of surface meteorological observations in Guinea-Bissau consists of:

- 07 Synoptic Stations; of which 3 (Bissau, Bolama and Bafatá) were partially operational. All these stations do not measure wind and 2 (Bafatá and Bolama) do not have barometers (atmospheric pressure measurement);
- 04 Main Climatological Stations, also partially operational;
- 12 Auxiliary Weather Stations - inoperative;
- 07 Agrometeorological Stations - inoperative; and
- 45 Rainfall stations, of which only 25 are operational.

The efficient operation of the system of surface meteorological observations is important for the achievement of GCOS objective of facilitating systematic observations of the climate with a view to:

- Monitoring of the climate system, better detection of climate change and better assessment of the impacts of climate change;
- Reliable data provision for socio-economic development;
- Research and climate modelling.

In Guinea-Bissau, the most common causes of system failure of the surface meteorological observation networks are mainly due to:

- Political instability with inherent lack of security;
- Material, technical and financial difficulties for provision of spare parts, repairs, logistic support, etc; and
- Insufficiency of qualified personnel to carry out regular maintenance.

Therefore, strengthening local weather-monitoring capabilities will significantly help Guinea-Bissau to meet national socio-economic and environmental needs for climate data, information and products; will contribute to global efforts to fight the adverse effects of climate change. The priority, constraints and capacity building needs in terms of systematic climate surveys and observations in Guinea-Bissau are shown in Table 8.1.

Table 8.1 - Priority, constraints and capacity building needs in terms of systematic climate surveys and observations in Guinea-Bissau

Priority	Barriers/Challenges	Need for capacity building and strengthening climate monitoring
Observations	• Outdated and incomplete meteorological and hydrological observations networks; • Lack of networks for maritime and altitude observations	• Resources and equipment to strengthen observation networks allow integration of all the critical parameters for monitoring the dynamics of climate and ocean.
	• Problems related to the availability and access critical climate data	• Data processing and data storage equipment
Research	• Lack of technical capacity for establishing data base to support climate simulations	• Acquisition of appropriate advanced workstations and GIS facilities to allow systematic storage of key climate information; • Adoption of Regional Climate Models (RCMs) to strengthen national climate impact assessments and weather prediction capacities.
	• Insufficient national experts to carry out climate modelling tasks	• Strengthen capacity for Training and Research at National Universities and Research Institutes

8.3 Development of climate change projections

Comprehensive climate change projection of critical meteorological parameters particularly rainfall and temperature are a vital input in various models used in impact studies of key socio-economic and environmental sectors.

For the development of the TNC climate change projections were developed specifically under the TCN project and were less extensively than what would be advisable for studies on impact of the adaptation options. Therefore, it is of utmost importance that climate change scenarios are updated uninterruptedly so to project the future climate and its impacts more realistically.

General circulation models (GCMs) can be taken into consideration to obtain climate change projections for hydro-meteorological variables. In spite of their practical usage, the main problem with the projections produced from GCMs is their coarse resolution. More recently, several studies in the literature have adopted RCP scenarios to assess possible climatic change effects on climate and hydrological variables. In the TCN the selected downscaling model structure for each station was then operated and new climate change scenarios for Guinea-Bissau for the horizons 2016-2045 and 2046-2075. In this exercise a new range of climate scenarios for Guinea-Bissau, based on the new IPCC emissions scenarios - RCPs (*Representatives Concentrations Pathways*) were prepared using regional climate models (CCCma, ICHEC, MIROC, MOHC, NCC and NOAA) the CORDEX (Coordinated Regional Climate Downscaling Experiment) project. *So,* new future scenarios RCP2.6, RCP4.5, RCP6.0 and RCP8.5 for the horizons 2016-2045 and 2046-2075 respecting the new principles of elaboration of Representative Concentration Pathways (CCP) emissions scenarios used by the IPCC were obtained for the climate change impact assessment. This work was supported and technically assisted by an Expert in Climate Modelling from the Regional Center AGRHYMET (CRA) of Niamey-Niger.

Therefore, it is important that the country through the National Institute of Meteorology and with support of AGRHYMET and other regional institutions can establish a national framework by which will enable the realization of the same sort of exercise in a continuously fashion to update the climate change scenarios for Guinea-Bissau looking particularly at projections for the 2050s when the climate starts to depart from natural variability, rather than the 2090s where uncertainties can be overwhelming and hamper the impact assessment and planning process.

8.4 Research, exchange of information and public awareness

As a Party to the UNFCCC, Guinea-Bissau is obligated to cooperate in climate change and related research, exchange of information, education, training, public awareness and report such activities to the Convention. In previous Communications to the UNFCCC, this has generally focused on highlighting Guinea-Bissau identified NAPA priority needs. The ability of Non-Annex I parties to conduct regular research and monitoring and build their internal capacity to carry out such research is not only vital to the implementation of the convention but also vital to the ability of said countries toward achieving and maintaining sustainable development goals.

Guinea-Bissau, like many SIDS, is recognized without question to be in the category of countries deemed most vulnerable to the negative impacts of climate change and Guinea-Bissau in particular with an insular part (the Bijagós Archipelago). However, being labeled as 'most vulnerable' does not provide policy makers, international development partners and other stakeholders with the information and tools necessary to develop effective programmes and projects to address issues of mitigation or adaptation. It is therefore imperative that Guinea-Bissau take a more practical approach to research, including the development of the capacity to conduct research through the Universities and other National Research Institutions.

Clearly, climate change research needs of the country are substantial and crucial but, apart from a nationally and internationally recognised institution — the IBAP, there is no clear research agenda yet and there is inadequate research capacity related to climate change. A research agenda is pertinent in as far as outlining the issues that need to be researched in order to produce an informed assessment of what strategies and policies the country should pursue with respect to climate change. Another main challenge that Guinea-Bissau is faced with climate change research is insufficient funding from the central government. Hence any current research is carried out on an *ad-hoc* basis through GEF and/or Adaptation Fund projects and other International institutions such as the World Bank and European Community Projects. Most research institutions and academics that are involved in climate change research rely on external funding sources. These external funding although useful in filling the research funding deficit in most cases the research areas they commit funding to, do not necessarily fit into national priorities. Nevertheless, most of the research carried out under different projects is useful in understanding localized climate change impacts e.g. GEF/UNDP project "Strengthening adaptive capacity and resilience to Climate Change in the Agrarian and Water Resources Sectors in Guinea-Bissau - PRRCASAHAC-GB".

Guinea Bissau's efforts investing in conservation and sustainable livelihood started in the early 1990s. The government developed a strategy to build a protected area network to conserve biodiversity. Many partners supported this vision such as the International Union for Conservation of Nature (IUCN) and the Swiss government. In 2005, the World Bank and the European Commission established the Coastal and Biodiversity Management Project (GEF: $4.8 million; co-financing: $6.31 million) which consolidated management responsibility for protected areas in Guinea-Bissau under a single umbrella: The Institute for Biodiversity and Protected Areas (IBAP). The project also funded local initiatives to create environmentally friendly development programs in communities in and around the parks.

Projects and Research

Institute for Biodiversity and Protected Areas (IBAP)

Since the 90s the United Nations Development Programme (UNDP) has been working with the Government of Guinea-Bissau, in particular with the Institute for Biodiversity and Protected Areas of Guinea-Bissau (IBAP, Portuguese acronym) in elaborating a National Biodiversity Strategy and its Action Plan, as well as assisting the authorities in mobilizing resources for preserving biodiversity. IBAP was established in 2005 by the Government of Guinea-Bissau with the mission of contributing to the conservation of biodiversity and ecosystems stability across the country. This involves the following:

- co-ordinating the management of existing protected areas;
- mapping out sensitive species and ecosystems for purposes of control;
- developing and implementing specific action plans for threatened species;
- identifying areas of recognised ecological value; and
- drafting submissions for the creation of new protected areas.

Therefore, through IBAP quite a number of initiatives have been taking place related to climate change impact and mitigation. Examples are those of the World Bank that has been supporting Guinea-Bissau in its conservation efforts since the early 2000s by supporting a number of coastal management and biodiversity projects to help establish IBAP and the protected area system. These efforts have contributed to preserving the rich biodiversity of the country while simultaneously improving the quality of life of local communities.

BioGuinea Foundation
BioGuinea Foundation was officially established with the objective of promoting the conservation, protection and improvement of the environment and biodiversity of Guinea Bissau prioritizing the country's national system of protected areas. The Foundation will serve as long-term financing mechanism for managing Guinea-Bissau's parks and biodiversity through a conservation trust fund, an idea long supported by the GEF

The World Bank Guinea-Bissau Biodiversity Conservation Project — supporting the country to: (i) strengthen the management of Guinea-Bissau's existing five national parks under the Institute for Biodiversity and Protected Areas, and (ii) pilot the operation of a sustainable financing mechanism for these parks. The support under this project will help ensure continuity to the previous conservation efforts and directly contributes to the Government's long-term vision for these parks and protected areas, namely, that they: (i) conserve valuable biodiversity and ecosystem functions and (ii) serve as sustainable development poles for the local communities and regions. The main Components of this project are:

Component 1: Consolidation and strengthening of capacity for management of coastal and marine protected areas and biodiversity.
Component 2: Pilot the operation of the BioGuinea Foundation.
Component 3: Project Management and Monitoring and Evaluation.

Projects sponsored by the European Union (EU) and by the World Bank in partnership with the Institute for Biodiversity and Protected Areas (IBAP).

World Bank sponsored Project:

1. (Wetland Carbon Market Development for Funding Coastal Communities' Adaptation to Climate Change in Sub-Saharan Africa), in partnership with the Institute for Biodiversity and Protected Areas (IBAP).

European Union (EU) sponsored Projects:

2. Sustainable Management of Forest Resources in the Tarrafes de Cacheu Natural Park (Gestão Sustentável dos Recursos Florestais no Parque Natural dos Tarrafes de Cacheu).

UNDP-GEF Project: Strengthening the financial and operational framework of the national PA system in Guinea-Bissau[150]

The project seeks to strengthen the financial sustainability and management effectiveness of the national PA system in Guinea-Bissau and has two components: 1) Strengthening the financial framework of the national PA system, and 2) PA and buffer zone management in Cantanhez National Park. The expected outcomes of this FSP are: 1.1 Initial capitalisation of the endowment of the BioGuinea Foundation (FBG) increasing sustainability of PA system and consolidating terrestrial PAs of Guinea Bissau; 2.1 Collaborative cost-effective management of Cantanhez NP and related buffer zones and forest areas improving management effectiveness at least 50% over baseline levels; 2.2 Improved management effectiveness reduces threats as measured by: the reduction in the illegal utilisation of woody vegetation and deforestation rates, and the recorded levels of poaching; 2.3 Collectively this reduces the loss of critically threatened W-African forest habitats across c. 106 000 ha of PAs and surrounding zones, and delivers improved protection to globally significant species and other key biodiversity resources in the forest belt biome. 2.4 Benefits to local communities.

8.4.1 Public awareness

Implementation of education, training and public awareness Programmes on climate change in Guinea-Bissau is coordinated through Article 6 of the convention which is anchored on the environmental education strategy of the Directorate General of Environment (DGA) — Ministry of Environment and Sustainable Development (MADS) – In fulfilling the provisions under Article 6, Guinea-Bissau appointed a national focal person to facilitate implementation of awareness and works closely with the Environmental Education. Climate change education and public awareness are important parts of the strategies that Guinea-Bissau undertakes to ensure that the wider society embrace changes that are needed to fight climate change. In this respect, many climate change education efforts have been implemented targeting formal and informal segments of the society. The education Programme at schools in urban and rural areas focus on increasing public awareness on climate change and emphasize behavioural change and community action.

Awareness of climate change amongst national level decision makers in Guinea-Bissau is gradually increasing, though remains low amongst other sectors of the population. Inclusive and consultative processes employed to develop the First National Communication on Climate Change and the NAPA have assisted this shift. As part of both processes, key decision-makers discussed climate-change-related challenges that the country will be likely to face in the future. Awareness of environmental considerations is also increasing: The Head of State has called for the inclusion of environmental considerations into all spheres of the country's governance and civil society activities. However, adaptation to climate change is not yet internalized or mainstreamed within key institutions at technical, strategic or political levels[151]. Low public awareness of climate change in Guinea-Bissau is a systemic capacity constraint with respect to adaptation. Public awareness programmes implemented up to now have been insufficient to meet the present climate change threat as a result of lack of resources. There is a need to develop a national strategic plan to enhance public awareness programmes to maximize outreach of climate change adaptation and mitigation, the final objective being to cover all segments of the population countrywide and key institutional decision makers.

With regard to information, education and public awareness, efforts have been made by the Directorate General of Environment (DGA) and other climate change related stakeholders and

its technical and financial partners. These efforts have been translated in multiple and varied initiatives carried out through training seminars, national conferences, radio interviews, production and dissemination of documents dealing with the issue of climate change in the framework of various projects and initiatives such as World Summit on the Sustainable Development, 2012[152] and the INDC.

8.5 Technology transfer

Achieving the ultimate objective of the Convention requires technological innovation and a rapid and wide-ranging implementation of technology transfer including know-how necessary for mitigation of greenhouse gas emissions; reducing vulnerability and ensuring adaptation to climate change.

Accordingly, under Article 4.5 of the Convention, "developed and other countries listed in Annex II shall take measures to encourage, facilitate and finance, as appropriate, the transfer or access to technologies and ecologically sound know-how to other Parties, and in particular those including developing countries, to enable them to implement the relevant provisions of the Convention ". Guinea-Bissau should carry out an initial assessment of its technology transfer needs to identify the technologies, practices and ways to be implemented in different sectors of the country to reduce GHG emissions as well as vulnerability to climate change and to contribute to sustainable development.

The activities that have been carried out so far in the context of some projects have brought together different partners in a consultative process to highlight barriers to technology transfer and propose sectoral measures. This process has helped to identify and analyse technology priorities and provide a set of proposals for project and program that will facilitate the transfer of environmentally sound technologies and know-how (e.g. energy efficiency, use of improved stoves, introduction of new varieties of short cycle crops and animals, improved seeds, etc ...). However, this does not invalidate the development of mitigation technology action plans for GHG mitigation measures identified in Chapter 4. For this endeavour the UNFCCC-supported Technology Needs Assessment process will be adopted using multi-criteria analysis and logical problem analysis. The resulting data and information will enable the development of an action plan with established technologies for the energy industries, transport, solid waste and AFOLU sectors. The proposed technologies are energy efficiency, wind energy (onshore), solar PV, waste to energy, biomass, improved fuel intensity, improved vehicle inspection, hybrid cars, ethanol blend, LFG capture, recycling of paper and textile waste, composting, compost used in bio-farming, crop burning, reduced use of chemical fertilisers (climate-smart agriculture), biogas digesters, fertigation and afforestation/tree planting.

8.5.1 Barriers to technology transfer for Adaptation and Mitigation

In addition to the barriers inherent in Human Nature, effective technology transfer does not always happen automatically and easily. In Guinea-Bissau, it faces institutional, legal, administrative, technical and financial obstacles. The main constraints, their consequences and some solutions are presented in the following Table 8.2:

Table 8.2 - Key obstacles, potential solutions for technology transfer

Main Barriers	Consequences	Potential Solutions
• Weakness of the legal system, absence of regulatory bodies in the Industrial, Energy and Transport sectors; • Relatively weak enforcement mechanisms for investment and industry legislation; • Insufficient fiscal incentives to stimulate investment in clean technologies;	• Discouragement of local and external investments; • Lack of trustworthy investors due to long arbitration process, property rights unclear.	• Reform of the legal and tax system that ensures compliance, property rights and transparency
• Monopoly structure of production and distribution by a single operator in the energy sector;	• Subjective evaluation system, no price signals and barriers to the introduction of energy efficiency measures;	• Reform and improvement of global performances in the sector
• Lack of appropriate small and medium-sized structures for subcontractors;	• Lack of information and knowledge related to adaptation to new technologies	• Establishment of multidisciplinary databases
• Absence of a system of assistance and advice in favour of small and medium-sized enterprises and small industries;	• Lack of competitiveness of costs of production factors compared to other competing countries;	• Development and operationalisation of a program for capacity building, training and continuous upgrading;
• The complexity and heavy bureaucracy of administrative procedures;	• Economic dependence on rural agriculture (markets limited to urban areas);	• Development of a critical mass of human capital through appropriate public policies;
• Lack of coordination between different users and institutions	• Poor productivity and lack of competitiveness;	
• The lack of database on new technologies (their costs, the advantages as well as their forms of implementation); • Insufficient domain of new technologies, methodologies and management tools of industrial units such as quality management; • Relatively low-level technological capability compared to other countries in the subregion due to lack of or inadequate technical workforce	• Lack of institutional framework and clear procedures to adapt new technologies to new situations;	
• Inadequate macroeconomic policies;	• Low rate of foreign investment due to transactional procedures;	• Major changes in the macroeconomic environment, improvement of financial and administrative efficiency

• Lack of appropriate financial systems	• Poor ability to access external funding for projects and other financial needs.	• Ensure support for productive activities in the economy.

This analysis shows that the process of adaptation and transfer of technology depends essentially on the Government, which has to create and maintain an environment conducive to the effective and efficient transfer of technologies through the implementation of incentive measures. It should also encourage and promote research organizations and institutions at the national level.

The Development of Renewable Energies is a major entry for vulnerable countries to climate change. Rationally valued, biomass and other renewable energy resources can be an important lever in the fight against poverty, particularly in rural areas, thus contributing to the improvement of quality of life and sustainable development.
Countries vulnerable to climate change like Guinea-Bissau should, with the support of the international community, continue researching solutions to limit the risks of increasing deforestation. This will include:

- Adoption of policies favouring a massive use of renewable energies;
- Promoting a real transfer of technology in favour of vulnerable countries for the development and access to renewable energies;
- Rational exploitation of forests and the promotion of restocking;
- Continuation and reinforcement of firewood reduction programs;
- Improvement of carbonization yield;
- Large-scale valorisation of agro-industrial waste for the production of coal, thus allowing large-scale replacement of coal from firewood;
- Increase in the use of other sources of renewable energy, namely solar, wind, biogas, micro hydroelectric power station, etc., whose considerable potential but little valued.

In the renewable energy sector, technology transfer is being carried out with installation throughout the country of photo voltaic (Solar photovoltaic power plant of 314kW to produce electricity in Banbadinga Sector (Banbandinga castaclaro)) and thermal solar systems for lighting and heating though not in an organised fashion.

Guinea-Bissau is very vulnerable to climate change and is considered one of the country exposed to climate change if there is an increase in mean sea level. After Bangladesh, Guinea-Bissau is the second country exposed to climate change vulnerability. The country does not yet have the potential to transfer technology in the forest, biodiversity and natural ecosystems sectors. Within the scope of technology transfer potential for adaptation and types of technology by forest sector, there is currently a lack of modern technologies or industries for the transformation of NTFPs, agricultural, agropastoral, fishing, etc. Most rural populations in Guinea-Bissau use firewood and coal as a source of energy at the national level, which means that the anthropic action has increased significantly in the forests. To reduce the impact on forests certain NGOs have introduced the technique of using improved kilns that reduce people's physical effort and even the number of trees cut to produce charcoal and firewood. However, it is important to promote restocking in some degraded areas for the production of charcoal, which will greatly contribute to minimizing the cuts of native species threatened by the production of coal.

Although the emergence of certain NGO's began in 1980 in the area of environment conservation and in the implementation of certain activities of sustainable development, in order to tackle the fight against poverty, even with the emergence of the Institute of Biodiversity and Areas Protected Areas (IBAP) as of 2005, there is still no improvement in the transfer of new technologies. None of these institutions has technologies to adapt to climate change. Guinea-Bissau has countless difficulties in acquiring new technologies for economic valuation of forest resources in order to contribute to food security, valorization and transformation of forest products and by-products and biodiversity in general.

While there is a need for improved technology transfer, its implementation requires an enabling policy framework and the strengthening of the institutional capacity for private sector and market led dissemination. Specifically, this can be enhanced through the finalisation of climate change policy and enactment of supportive legislation as well as the establishment of dialogues and increased dissemination of research findings, innovations and technologies within the country

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